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## Public Civil Action: Advances and Setbacks in its Evolution Legislative

## Ação Civil Pública: Avanços E Retrocessos na Evolução Legislativa

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**Keywords**—Public civil action; Diffuse  
rights; Collective rights; Homogeneous  
individual rights; Access to justice.

**Palavras-Chave**— Ação civil pública;  
Direitos difusos; Direitos coletivos;

**Abstract**— *The objective of this investigation is to propose a scientific analysis about the advances and setbacks of the public civil action legislation as an instrument of collective protection of rights. Thus, it makes healthy to understand the institute of Law n. 7.347/85 and make a comparison between the main points of the bill n. 5,139/09 and the new collective action law (PL n. 4,778/20) proposed by the representatives of the National Council of Justice and delivered to the president of the Chamber of Deputies on September 1, 2020, in order to verify that the new draft of collective actions innovative proposals something in relation to bill n. 5,139/09; as well as a brief analysis of the bills n. 1.641/21, a new proposal from the Brazilian Institute of Procedural Law with the aim of contributing to the advancement of the Brazilian collective process. It is important that the critical approach to the proposed investigation object took place through the research bibliographical, documentary and jurisprudential in addition to comparative, interpretative and systematic analyses.*

**Direitos individuais homogêneos;  
Acesso à justiça.**

**Resumo**— O objetivo desta investigação é propor uma análise científica sobre os avanços e retrocessos da legislação da ação civil pública como instrumento de proteção coletiva de direitos. Assim, torna salutar compreender o instituto da Lei n. 7.347/85 e fazer uma comparação entre os principais pontos do projeto de lei n. 5.139/09 e a nova lei de ação coletiva (PL n. 4.778/20) proposta pelos representantes do Conselho Nacional de Justiça e entregue ao presidente da Câmara dos Deputados em 1º de setembro de 2020, a fim de verificar se o novo anteprojeto de ações coletivas traz propostas inovadoras em relação ao projeto de lei n. 5.139/09; bem como uma breve análise dos projetos de lei n. 1.641/21, uma nova proposta do Instituto Brasileiro de Direito Processual com o objetivo de contribuir para o avanço do processo coletivo brasileiro. É importante que a abordagem crítica do objeto de investigação proposto tenha se dado por meio da pesquisa bibliográfica, documental e jurisprudencial, além de análises comparativas, interpretativas e sistemáticas.

## I. INTRODUCTION

The current legislation has been undergoing transformations caused by doctrine, legislation and jurisprudence, generating controversies that demand solutions to the failures of the legislation.

This scientific research aims to propose a discussion about public civil action as an instrument to control collective rights, as well as an analysis of the advances and setbacks of legislative evolution, performing a comparative analysis between the main points of the current institute of the civil action law public, the bill no. 5,139/09 and the new bill on class actions; in order to verify if the new draft of collective actions proposes something innovative in relation to the bill n. 5,139/09; and if it effectively responds to the claims of collective actions, which is access to justice for the hypo sufficient, thus advocating the true scope of action of collective protection; as well as carry out a brief analysis of the bill n. 1.641/21, a new proposal from the Brazilian Institute of Procedural Law with the aim of contributing to the advancement of the Brazilian collective process.

In this follow-up, we will present brief notes about the public civil action, as well as discuss the nature, object, legitimacy, competence and res judicata; before the bill n. 5,139/09 and the new draft bill of the collective action law; and finally, a small study about the new proposal made by the IBDP.

In order to reach the scope of this research, the theoretical-conceptual technique will be used, given the use of content analysis, through a bibliographic survey, jurisprudential and documentary data on the subject. According to the content analysis techniques, it is stated that

this is a theoretical research, so that the procedure adopted will serve to demonstrate the importance of public civil action as an instrument of control of collective protection.

## II. PUBLIC CIVIL ACTION: A LEGISLATIVE ANALYSIS

Provided for in Law no. 7.347<sup>1</sup>, of July 24, 1985, type of representative action; emerged as a procedural instrument to protect the diffuse interests of society; although the law of popular action already existed; it represented a major transformation in our national legal system; since it provided changes in collective actions, protecting liability actions for moral and property damage caused to the environment; to the consumer; to goods and rights of artistic, aesthetic, historical, tourist and scenic value; any other diffuse or collective interest; for violation of the economic order; to the urban order; the honor and dignity of racial, ethnic or religious groups; public and social assets, as set out in article 1º of the aforementioned Law; without prejudice to popular action. It is, therefore, a collective demand that aims to protect collective rights. Débora Vieira, Gisele Santos Fernandes and Ney Maranhão explain:

The Public Civil Action Law, thus, represented the paradigmatic turning point in the codification of collective protection in 1985, since, although the Popular Action Law had existed since 1965, the Public Civil Action Law expanded the matters subject to

<sup>1</sup>BRAZIL. Law no. 7,347 of July 24, 1985. Disciplines the public civil action of liability for damages caused to the environment, to the consumer, to goods and rights of artistic, aesthetic, historical,

tourist and scenic value (VETADO) and other measures. [http://www.planalto.gov.br/ccivil\\_03/leis/17347orig.htm](http://www.planalto.gov.br/ccivil_03/leis/17347orig.htm). Accessed on 7 Jun. 2021.

collective protection, listing them in your art. 1, without prejudice to popular action. With regard to jurisdiction, the Public Civil Action Law established the place of occurrence of the damage as the competent forum, in addition to restricting the active legitimacy for bringing public civil actions and defining the extent of res judicata.<sup>2</sup>

According to article 3, the public civil action law may have as its object the payment of money or the fulfillment of an obligation to do or not do to which the debtor of this obligation is legally bound.

According to the Minister Rapporteur Herman Benjamin in REsp 1.454.281/MG:

The cumulation of obligations to do, not to do and to pay does not constitute *bis in idem*, since the indemnity, instead of considering a specific injury already ecologically restored or to be restored, focuses on a portion of the damage that, although caused by the same past behavior of the agent, has deleterious effects of a future, irreparable or intangible nature<sup>3</sup>.

The Public Prosecutor's Office has legitimacy to propose the public civil action; the Public Defender's Office; the Union, the States, the Federal District and the Municipalities; the autarchy, public company, foundation or mixed capital company; being that the association has been constituted for at least 1 (one) year under the terms of civil

law and includes among its institutional purposes, the protection of public and social assets, the environment, the consumer, the economic order, free competition, to racial, ethnic or religious rights or to artistic, aesthetic, tourist and landscape heritage, in accordance with article 5 of the Law. The law provides that in relation to the Public Prosecutor's Office, if it does not intervene in the process as a party, it will necessarily act as an inspector of the legal system (art. 5, §1º). There is some discussion about the absence of the Public Prosecutor's Office in the intervention of the process if it would entail an absolute or relative nullity.

Let's see the note of Luis Antônio Souza:

I think that the understanding should be in the sense that the nullity must occur due to lack of subpoena, of not giving opportunity to the ministerial pronouncement, not the absence of manifestation, this because the ministerial representative can identify a hypothesis that does not challenge his intervention, which, logically, it should expose with reason<sup>4</sup>.

Pursuant to the prevailing jurisprudence of the Superior Court of Justice, the hypothesis of relative nullity, as it has been understanding that the absence of a summons from the Public Ministry, by itself, does not give rise to the decree of the judgment, unless the effective damage to the parties<sup>5</sup>; as well as shares the understanding that, in respect of the principle of instrumentality of forms, the nullity resulting from the lack of intervention, in the first degree, of the Public Prosecutor's Office, is considered resolved, if later the Parquet intervenes in the deed in the second degree of jurisdiction, without competition from any damage to the party<sup>6</sup>.

<sup>2</sup> VIEIRA, Débora. GOES, Gisele Santos Fernandes. MARANHÃO, Ney. Public civil action law: term of inadjustment of conduct in labor matters and community participation. In: Milaré Édis (coord.). Public civil action after 35 years (electronic book), 1st ed. São Paulo: RT, 2020.

<sup>3</sup> STJ. REsp no. 1.454.281/MG, rel. Min. Herman Benjamin, j. 08/16/2016 - DJ 09/09/2016. Available at [https://scon.stj.jus.br/SCON/jurisprudencia/toc.jsp?i=1&b=ACOR&livre=\(\(RESP'.clas.+e+@num=27%1454281%27'\)+ou+\(%27REsp%27+adj+%271454281%27.suce.\)\)&thesaurus=JURIDICO&fr-veja](https://scon.stj.jus.br/SCON/jurisprudencia/toc.jsp?i=1&b=ACOR&livre=((RESP'.clas.+e+@num=27%1454281%27')+ou+(%27REsp%27+adj+%271454281%27.suce.))&thesaurus=JURIDICO&fr-veja). Access in 7 Jun. 2021.

<sup>4</sup> SOUZA, Luis Antonio. In search of effectiveness in the collective process. In: Milaré Édis (coord.). Public civil action after 35 years (electronic book), 1 ed. São Paulo: RT, 2020.

<sup>5</sup> STJ. REsp no. 1450/982/MS, rel. Min. Gurgel de Faria, j. 01/07/2019-DJ 02/07/2019. STJ. REsp no. 1,324,693/MS, rel.

Min. Castro Meira, j. 9/10/2013 DJ 9/19/2013. available in [https://processo.stj.jus.br/processo/revista/inteiroteor/?num-Registro-201400967640&dt\\_publicacao=02/08/2019https://processo.stj.jus.br/processo/revista/inteiroteor/](https://processo.stj.jus.br/processo/revista/inteiroteor/?num-Registro-201400967640&dt_publicacao=02/08/2019https://processo.stj.jus.br/processo/revista/inteiroteor/). Accessed on 7 Jun. 2021.

<sup>6</sup> STJ. REsp no. 1703090/RJ, rel. Min. Mauro Campbell Marques, j. 04/24/2018 - DJ 05/03/2018. Available at <https://processo.stj.jus.br/processo/revista/inteiroteor/>. Accessed on 7 Jun. 2021. <sup>10</sup>STF. RE 470135, rel. Min. Cezar Peluso, j. 05/22/2007 DJ 06/29/2007. Available at [https://jurisprudencia.stf.jus.br/pages/search?base-agredaos&pesquisa\\_inteiro](https://jurisprudencia.stf.jus.br/pages/search?base-agredaos&pesquisa_inteiro). Accessed on 7 Jun. 2021.

STF RE no. 248191, rel. Min. Carlos Velloso, j. 10/01/2002 DJ 10/25/2002. Available in <https://jurisprudencia.stf.jus.br/pages/search?base=acordaos&p>



Another question is about the legitimacy of the Public Ministry in relation to homogeneous individual interests; and the Federal Supreme Court<sup>7</sup> has decided that certain homogeneous individual rights can be classified as collective interests or rights, or be identified with unavailable social and individual interests; in these cases, the public civil action serves to defend these rights, legitimizing the Public Ministry for the cause; the Federal Supreme Court argues that the public civil action serves the defense of homogeneous individual rights, with the Public Ministry being legitimized to enforce it, when the holders of those interests or rights are in the situation or condition of consumers, or when there is a relationship of consumption.

The Federal Constitution assigns to the Public Ministry the institutional function of ensuring for the rights guaranteed therein, also understood as the defense of social interests and unavailable individual interests, in addition to other diffuse and collective interests, being responsible for promoting the necessary measures to guarantee it, and even public civil action (arts. 127 and 129, ins. II and III, CF). In this sense, the Federal Supreme Court<sup>8</sup>, the Public Ministry has the legitimacy to file a collective civil action in defense of individual interests homogeneous objects of relevant social character, even if the object of the demand refers to available rights". Therefore, it is legitimate for the Public Ministry to act in the protection of public civil action and the protection of social rights, whether diffuse or collective,

according to the position of the Superior Court of Justice<sup>9</sup> "it is common in the Court that the Public Prosecutor's Office has active legitimacy to file a public civil action in defense of homogeneous individual rights, provided that there is a relevant social interest". Let's see Kazuo Watanabe's note:

In principle, only unavailable individual interests are under the protection of Parquet. It was the social relevance of collective protection of

homogeneous individual interests or rights that led the legislator to attribute to the Public Ministry and other public entities the legitimacy to act in this modality of molecular demand. Only the social relevance of the legal asset under guardianship or of the collective protection itself can justify the legitimacy of the Public Ministry for the filing of collective action in defense of available private interests.<sup>10</sup>

Ada Pellegrini Grinover points out that:

There is also the social relevance of collective protection itself due to the peculiarity of the conflict of interests. Imagine the case of an edible oil manufacturer that is harming consumers in a very small amount, insufficient to motivate one or more consumers alone to seek justice to claim compensation for their loss. If the individual injury is insignificant, it will certainly not be the injury in the collective perspective, which could be affecting millions of consumers. In such cases of very large dispersion of injured consumers and insignificance of the injury from an individual perspective, there will certainly be social relevance in collective protection, so that the supplier is prevented from continuing the illicit practice<sup>11</sup>.

[esquisa integer tenor=false&sinonimo=true&plural=](https://jurisprudencia.stf.jus.br/pages/search?base=agredaos&sinonimo=true&plural=). Accessed on 7 Jun. 2021.

<sup>7</sup> STF. RE 470135, rel. Min. Cezar Peluso, j. 05/22/2007 DJ 06/29/2007. Available at [https://jurisprudencia.stf.jus.br/pages/search?base=agredaos&pesquisa\\_inteiro](https://jurisprudencia.stf.jus.br/pages/search?base=agredaos&pesquisa_inteiro). Accessed on 7 Jun. 2021. STF RE no. 248191, rel. Min. Carlos Velloso, j. 10/01/2002 DJ 10/25/2002. Available in <https://jurisprudencia.stf.jus.br/pages/search?base=acordaos&pesquisa integer tenor=false&sinonimo=true&plural=>. Accessed on 7 Jun. 2021.

<sup>8</sup> STF. RE no. 401482/PR, rel. Min. Teori Zavascki, j. 06/04/2013 - DJ 06/21/2013. Available

in <https://jurisprudencia.stf.jus.br/pages/search?base=agredaos&sinonimo>. Accessed on 7 Jun. 2021.

<sup>9</sup> STJ. REsp no. 637332, rel. Min. Luiz Fux, j. 11/24/2004 - DJ 12/13/2004. Available <https://processo.stj.jus.br/processo/revista/inteiroteor/>. Accessed on 7 Jun. 2021.

<sup>10</sup> WATANABE, Kazuo. Brazilian consumer protection code commented by the authors of the draft bill. 11th ed. Rio de Janeiro: Forensics, 2017.

<sup>11</sup> GRINOVER Ada Pellegrini. The public civil action at the STJ. Available <https://www.stj.jus.br/publicacao/institucional/index.php/Dezanos/article/view/3396/3519>. Accessed on 7 Jun. 2021.

Finally, it is necessary to observe the recent judgment of the Federal Supreme Court<sup>12</sup> that highlights the legitimacy of the Public Ministry for filing a public civil action, in the context of General Repercussion in the examination of Extraordinary Appeal n. 605.533/MG, reported by Minister Marco Aurélio, who recognized "the legitimacy of the Public Ministry to file a public civil action with the objective of compelling federated entities to deliver medicines to people in need".

On the other hand, we must emphasize the impossibility of the Public Ministry's legitimacy to file a public civil action in the case of tax matters, according to article 1º, sole paragraph of Law 7. 347/85, which provides: "public civil action will not be applicable to convey claims that involve taxes, social security contributions, the Service Time Guarantee Fund - FGTS or other funds of an institutional nature whose beneficiaries can be individually determined", included by Provisional Measure n. 2.180-35, of 2001. However, according to the teachings of Luiz Manoel Gomes Júnior (2005, p. 41) "it cannot be forgotten, however, that if the objective of collective actions, in the case of homogeneous individual rights, is to resolve issues that interest an entire group, quickly, agile and effectively, what is the point of prohibiting question taxes through such means?" In this sense, the Federal Supreme Court<sup>13</sup> has already decided in RE n. 206.781-4 that the Public Ministry does not have the legitimacy to file a public civil action aiming to question the tax.

Pursuant to article 5, item II, Law no. 11,448, of January 16, 2007, conferred legitimacy on the Public Defender's Office. Harmoniously, there is no need to speak of usurpation of the Public Defender's competence in relation to the Public Ministry, according to a decision already rendered by the Federal Supreme Court<sup>14</sup>.

Furthermore, unanimously, the plenary of the Federal Supreme Court<sup>15</sup> dismissed the Direct Action of Unconstitutionality - ADI - and considered the Public Defender's attribution to file a public civil action constitutional.

It is a matter of giving the hyposufficient the possibility of promoting collective action from which they will benefit, either because, individually, they would not have the legitimacy to do so, in the case of diffuse or collective rights, or because they do not have the resources that allow it, in the case of homogeneous individual rights, which could be the object of individual actions filed by them, according to the position that prevails in the Federal Supreme Court<sup>16</sup> due to the final judgment, with general repercussion of RE 733.433/MG.

Thus, we observe, "the illegitimacy of the Public Defender's Office to file the public civil action can only be recognized in exceptional situations, in the light of the concrete case, in which the mismatch between the interests and rights defended through of public civil action and the institutional function of the Public Defender's Office established in the Federal Constitution"<sup>17</sup>.

Regarding the federal entities, Union, States, Federal District and Municipalities, as well as other legal entities governed by public law - indirect public administration - included in the list of article 5, items III, IV of the legal diploma, we perceive according to the understanding of José dos Santos Carvalho Filho that "territorial limitation must be imposed on the filing by federative entities, with the exception of the Union. Therefore, States, District Federal and Municipalities will only be able to file a public civil action for the protection of interests injured in their territorial constituencies."<sup>18</sup>

<sup>12</sup> STF RE no. 605533/MG, rel. Min. Marco Aurélio, j. 08/15/2018 - DJ 02/12/2020. Available

at <https://redir.stf.jus.br/paginadorpub/paginador.jsp?docTP=TP&docID=13021163>. Accessed on 7 Jun. 2021.

<sup>13</sup> STF. RE no. 206781-4, rel. Min. Marco Aurélio, j. 06/02/2001 DJ 29/06/2001. Available at [https://jurisprudencia.stf.jus.br/pages/search?base\\_acordaoes&pesquisa](https://jurisprudencia.stf.jus.br/pages/search?base_acordaoes&pesquisa). Accessed on 7 Jun. 2021.

<sup>14</sup> mSTF. RE n. 554088/SC, rel. Min. Eros Grau, j. 06/03/2008 - DJ 06/20/2008. Available at <https://jurisprudencia.stf.jus.br/pages/search?>. Accessed on 7 June 2021.

<sup>15</sup> STF ADI No. 3943/DF, Min. Lucia, J. 05/07/2015 - DJ 08/06/2015. Available at <https://redir.stf.jus.br/paginadorpub/paginador.jsp?docTP=TP&docID=9058261>. Accessed on 7 Jun. 2021.

<sup>16</sup> 19STF. RE 733433/MG, rel. Min. Dias Toffoli, j. 11/04/2015 - DJ 04/07/2016. Available at <https://redir.stf.jus.br/paginadorpub/paginador.jsp?docTP=TP&docID=10669457>. Accessed on 7 Jun. 2021.

<sup>17</sup> TJDF. Judgment no. 911115, rel. Des. Hector Valverde, J. 12/09/2015 - DJ 12/15/2015. Available in <https://pesquisajuris.tjdft.jus.br/IndexadorAcordaoes>. Accessed on 7 Jun. 2021.

<sup>18</sup> TJDF. Judgment no. 931786, rel. Des. Gislene Pinheiro, J. 03/30/2016 - DJ 04/08/2016. Available at <https://pesquisajuris.tjdft.jus.br/IndexadorAcordaoes-web/sisti?visaoid=tidf.sistj.acordaoeletronico.buscaindexada.apresentacao.VisaoBuscaAcordao&controleadorld=tidf.sistj.acordaoeletronico.buscaindexadaapresentacao.ControladorBusca&visaoAnterior=tidf.sistj.acordaoeletronico.buscaindexada.apresentacao.VisaoBuscaAcordao&nomeDaPagina=resultado&=abrirDadosDoAcordao&endereçoDoServlet=sistj&historicoDePagina=busca=buscaALivre%quantidadeDeRegistros>. Accessed on 7 Jun. 2021.

TJDF. Judgment no. 878662, rel. Des. James Eduardo de Oliveira, J. 06/03/2015 - DJ 07/07/2015. Available at <https://pesquisajuris.tjdft.jus.br/IndexadorAcordaoes>. Accessed on 7 Jun. 2021.

<sup>18</sup> CARVALHO FILHO, José dos Santos. Public civil action. 7<sup>th</sup> ed. Rio de Janeiro: Lumen Juris, 2009, p. 147.

It is worth noting that in the case of associations that have been legally constituted for at least one year and that include among their institutional purposes the defense of interests and rights protected by the Consumer Defense Code, authorization to assemble is waived. Furthermore, the pre-constitution requirement can be waived by the judge, when there is a manifest social interest evidenced by the dimension or characteristic of the damage, or by the relevance of the legal interest to be protected; in this sense, it corroborates the understanding of the Superior Court of Justice<sup>19</sup>.

That said, regarding the legitimacy of public civil action, as an instrument of collective actions, it is worth emphasizing the understanding of Luiz Rodrigue Wambier and Teresa Arruda Alvim Wambier:

In collective actions, in our view, we are not dealing with a hypothesis of defense of our own rights (ordinary legitimation) or even of extraordinary legitimation. It is correct to say, in our opinion, that the legitimation for the defence of diffuse rights, collective in the strict sense and homogeneous individuals, must be treated as a special legitimation, with its own contours, and which is the general rule in the scope of the collective process. In the doctrine, there are those who define this legitimation as generic collective legitimation or autonomous legitimation.<sup>20</sup>

In this sequence, article 2 of Law no. 7,347/85 states that "the actions provided for in this Law will be proposed in the forum of the place where the damage occurs, whose court will have functional competence to

prosecute and judge". According to Provisional Measure n. 2,180-35, of 2001, the filing of the action will prevent the jurisdiction of the court for all actions subsequently brought that they have to process and judge the cause.

It is an absolute competence, according to the teachings of Rodolfo de Camargo Mancuso, "non-extendable and non-derogable, because it is based on reasons of public order, where the interest of the process itself is prioritized; in principle, the interest of the parties prevails only when deals with territorial distribution of jurisdiction jurisdiction of the forum"<sup>21</sup>. Luiz Manoel Gomes Júnior makes an important questioning "if there is an interest from the Union or its autarchies, will there be a shift of competence to the Federal Justice"?<sup>22</sup> In this sense, according to article 109 of the constitutions, § 1<sup>st</sup>, "the cases in which the Union is the plaintiff will be granted in the judicial section where the other party is domiciled".

Still, from this perspective, the Federal Supreme Court<sup>23</sup> has already decided considering that the Federal Judge also has territorial and functional competence over the place of any damage, it is necessary to conclude that the removal of federal jurisdiction, in this case, could only take place by means of express reference to the State Court, such as the one made by the constituent in the first part of the mentioned article 109, § 3º, in relation to causes of a social Security nature. Therefore, the rule of competence of the Federal Court applies, when there is the interest of the Union or its autarchies.

It is very valid to emphasize that the competence in class actions uses the place of damage as a defining criterion, in order to provide greater speed in the processing, in the instruction and, therefore, in the judgment of the case, given that it is much easier to ascertain the damage and its evidence in the court in which the facts occurred is what the jurisprudence.<sup>24</sup>

However, let's see the notes of Ada Pellegrini Grinover:

Therefore, we affirm that it does not make sense, for example, that

<sup>19</sup> STJ. REsp n. 1121067, rel. Min. Massami Uyeda, j. 06/21/2011- DJ 12/03/2012. Available at [https://processo.stj.jus.br/processo/revista/inteiroteor/?num\\_registro=200900188584&dt\\_publication=02/03/2012](https://processo.stj.jus.br/processo/revista/inteiroteor/?num_registro=200900188584&dt_publication=02/03/2012). Accessed on June 7, 2021.

<sup>20</sup> WAMBIER, Luiz; WAMBIER, Teresa. **Anotações sobre as ações coletivas no no Brasil—presente e futuro**. Available <https://www.paginasdedireito.com.br/artigos/263-artigos-mai-2014/6562-anotacoes-sobre-as-acoes-coletivas-no-brasil-presente-e-futuro>. Accessed on 7 Jun. 2021.

<sup>21</sup> MANCUSO, Rodolfo de Camargo. **Ação civil pública**. São Paulo: RT, 2001, p. 65.

<sup>22</sup> GOMES JÚNIOR, Luiz Manoel. Course in collective civil procedural law. Rio de Janeiro: Forensics, 2005, p.123.

<sup>23</sup> STF. RE no. 228955-9/RS. relay Min. IlmarGalvão, j. 02/10/2000 - DJ 04/14/2000. Available at <https://jurisprudencia.stf.jus.br/pages/search?base=acordaos&p=esquisa>. Accessed on 7 Jun. 2021.

<sup>24</sup> STJ. AgRg no. 116815/DF, rel. Min. Humberto Martins, J. 03/28/2012 DJ 04/03/2012. Available at <https://www.stj.jus.br/websecsti/cgi/revista/REJ.cgi/ITA?seq=1135058&tipo=0&nreg201100862792&SeqCgrmaSessao=&CodOrgaoJgdr=&dt=20120403&formato=PDF&salvar=false>. Accessed on 7 Jun. 2021.

actions in defense of the homogeneous individual interests of pensioners and Social Security retirees upon receipt of the difference of 147% should be filed in the capitals of the various States, under the pretext of the territorial limits of the various organs of the Federal Justice. The problem is not one of competence: the federal judge, competent to prosecute and judge the case, issues a provision (early or definitive) that is effective *erga omnes*, covering all retirees and pensioners in Brazil. Either the demand is collective, or it is not, or the res judicata is *erga omnes* or it is not. And if the request is effectively collective, there will be a clear relationship of *lis pendens* between the various actions filed in the different States of the Federation.<sup>25</sup>

From this angle, the civil sentence will make res judicata *erga omnes*, within the limits of the territorial jurisdiction of the prosecuting body, unless the request is dismissed due to insufficient evidence, in which case any legitimate party may bring another action with the same foundation, using of new evidence, according to article 16 of Law no. 7,347/85. This follow-up corroborates the Superior Court of Justice<sup>26</sup>; once the General Repercussion in the Extraordinary Appeal was recognized in Theme 1075<sup>27</sup>, which deals with the constitutionality of article 16 of Law n. 7.347/85, according to which the sentence in the public civil action will be res judicata *erga omnes*, within the limits of the territorial competence of the prosecuting body.

However, in a recent (04/07/2021) judgment of Extraordinary Appeal n. 1101937<sup>28</sup>, with recognized general repercussion<sup>29</sup>, the plenary of the Federal Supreme Court dismissed the RE and maintained the extension of the subjective limits of the decision taken in the public civil action to the entire country; and declared the unconstitutionality of article 16 of the Public Civil Action Law, which limits the effectiveness of sentences handed down in this type of action to the territorial competence of the body that issues it.

It is important to remember that the RE originated in a collective action proposed by the Brazilian Institute for Consumer Protection (Idec) against several banking entities seeking to review housing financing contracts entered into by its members. In the first instance (Federal Court of São Paulo), the suspension of the effectiveness of the contractual clauses that authorized financial institutions to promote the extrajudicial execution of the mortgage guarantees of the contracts was determined. In analysis of an appeal filed by the banks, the Federal Regional Court of the 3rd (TRF-3) revoked the preliminary injunction and, later, ruled out the applicability of article 16 of the Public Civil Action Law. For the TRF-3, due to the breadth of interests, the right recognized in the case cannot be restricted to the regional scope. The STJ maintained the decision on this point, as it considered it undue to limit the effectiveness of decisions rendered in collective public civil actions to the territory of the jurisdiction of the adjudicating body. The banks then appealed to the STF seeking to reverse the understanding.

In his vote, followed by the majority, the rapporteur, Minister Alexandre de Moraes, pointed out that the device "came against the institutional advance of protection of collective rights"<sup>30</sup>; he also highlighted that in the protection of collective rights, res judicata is for everyone (*erga omnes*) or ultraparties, given that the subjective effects of the sentence must cover all potential beneficiaries of the judicial decision; there is no mention in the rule of territorial limitation.

<sup>25</sup> GRINOVER Ada Pellegrini. Ação Civil pública no STJ. Disponível <https://www.stj.jus.br/publicacaoainstitucional/index.php/Dezanos/article/view/3396/3519>. Accessed on 7 Jun. 2021.

<sup>26</sup> STJ. REsp. no. 1304953/RS, rel. Min. Nancy Andrighi, j. 08/26/2014 DJ 09/08/2014. Available in <https://processo.stj.jus.br/processo/revista/inteiroteor/?num>. Accessed on 7 jun. 2021. STJ. REsp. no. 897.165/PR, rel. Min. Teori Albino Zavascki, j. 02/1/2011. DJ 02/10/2011. Available at <https://scon.stj.jus.br/SCON/decisoas/toc.jsp?livre=>. Accessed on 7 Jun. 2021.

<sup>27</sup> STF. TEMA 1075, rel Min. Alexandre de Moraes. Available in <http://www.stf.jus.br/portal/jurisprudenciaRepercussao/verAndamento>. Accessed on 7 Jun. 2021.

<sup>28</sup> STF. RE no. 1101937, rel. Min. Alexandre de Moraes, j. 02/13/2020 - DJ 02/27/2020. Available at [https://jurisprudencia.stf.jus.br/pages/search?base=acordao&pesquisa\\_inteiro\\_teor=false&sinonimo=true&plural=true&radicais=false&](https://jurisprudencia.stf.jus.br/pages/search?base=acordao&pesquisa_inteiro_teor=false&sinonimo=true&plural=true&radicais=false&). Accessed on 7 Jun. 2021.

<sup>29</sup> STF. TEMA 1075. Constitutionality of art. 16 of Law 7,347/1985, according to which the sentence in the public civil action will be res judicata *erga omnes*, within the limits of the territorial jurisdiction of the prosecuting body. Available at <http://www.stf.jus.br/portal/jurisprudenciaRepercussao/verAndamento>. Accessed on 7 jun. 2021.

<sup>30</sup> STF. Territorial limitation of the effectiveness of judgment in public civil action is unconstitutional. Available at <https://portal.stf.jus.br/noticias/verNoticiaDetalhe.asp?idConteudo=463919&ori=1>. Accessed on 7 Jun. 2021.



The minister emphasizes that, by limiting the effects of the sentence to beneficiaries residing in the territory of the judge's competence, the article obliges the filing of several actions, with the same request and cause of action, in different counties or regions, allowing the occurrence of contradictory judgments.

It is important to mention that in relation to the definition of the judging body, the Plenary decided that, in the case of a public civil action with national or regional scope, its filing must occur in the forum, or in the judicial district, of the state capital or in the Federal District, pursuant to article 93, item II, of the CDC. And on jurisdiction, in order to prevent conflicting decisions handed down by different courts in public civil action, the competent judge who first hears about the matter will be prepared to process and judge all claims that propose the same object.

In this sense, the following thesis was approved<sup>31</sup>: I - art. 16 of Law 7,347/1985 is unconstitutional, amended by Law 9,494/1997; II- in the case of public civil action with national or regional effects, the jurisdiction must observe art. 93, II, of Law 8078/1990; III - Having filed multiple public civil actions of national or regional scope, the prevention of the judgment that first heard of one of them is signed, for the judgment of all related claims.

That said, it appears that, the decision of the Plenary in the judgment of RE 1101937, with known general repercussion, the extension of the subjective limits of the sentence must cover all potential beneficiaries of the judicial decision without any territorial limitation.

### III. DRAFT LAW N. 5,139/09 AND DRAFT LAW N. 4,778/20: A COMPARATIVE ANALYSIS OF THE INSTITUTES

As already highlighted in this research, Law n. 7,347/85, after 35 years of validity, is still facing major discussions regarding its legal content. Thus, on March 27, 2009, there was a presentation of the Bill n. 5,139/09<sup>32</sup> which regulates public civil action for the protection of

homogeneous diffuse, collective or individual interests and provides other measures for the National Congress to appreciate. Mentioned project was rejected on March 17, 2010<sup>33</sup>; however, it is necessary to draw a parallel between this project and the preliminary project presented on September 1, 2020 by the representatives of the National Council of Justice CNJ to the president of the Chamber of Deputies, a bill<sup>34</sup> to regulate collective actions.

The proposal between the comparative analysis is to verify if the new draft of the collective actions proposes something innovative in relation to the bill n. 5,139/09; creating a legal and institutional framework for collective actions.

Among the main points addressed by the bill n. 5,139/09 highlight: a) collectivization of rights - a general law on collective processes; b) a systematization of the Single Collective System with the adoption of a new law on public civil action and extensive modification of several provisions of Brazilian collective procedural law; c) transform the public civil action law into a general rule, becoming a Law of Introduction to the Single Collective System, with the specific discipline of the rules and forms of processing of Collective Actions.<sup>35</sup>

It is worth mentioning the advantages provided: a) it eliminates conflicts of interpretation, with only one discipline for processing collective actions; b) standardizes the application of norms and the processing of collective actions; c) makes the Single Collective System coherent.<sup>36</sup>

Still, we can mention: a) a forecast of a broader role (art. 1); b) more precise definition for homogeneous individual rights; c) establishment of principles relevant to the collective civil procedure (article 3); d) improvement of the rules relevant to competence (art. 4); applying the rules of prevention and absolute competence; e) more detailed indication of those entitled - collective procedural legitimacy (article 6); f) creation of national registers of collective proceedings, under the responsibility of the National Council of Justice, and of civil inquiries and commitments to adjust conduct, within the scope of the National Council of Justice of the Public Ministry (art. 53);

<sup>31</sup> STE. RE no. 1101937, rel. Min. Alexandre de Moraes, j. 02/13/2020 DJ 02/27/2020. Available at <https://jurisprudencia.stf.jus.br/pages/search?base=acordaos&p=esquisa>. Accessed on 7 Jun. 2021.

<sup>32</sup> BRAZIL. Bill no. 5,139, filed on April 29, 2009. Disciplines public civil action for the protection of homogeneous diffuse, collective or individual interests, and makes other provisions. Available at <https://www.camara.leg.br/proposicoes>. Accessed on 7 Jun. 2021.

<sup>33</sup> BRAZIL, Bill no. 5,139, filed on April 29, 2009. Disciplines public civil action for the protection of homogeneous diffuse, collective or individual interests, and makes other provisions.

Available at <https://www.camara.leg.br/propostas-legislativas/432485>. Accessed on 7 Jun. 2021.

<sup>34</sup> BRAZIL. Bill no. 4778, filed October 1, 2020. Available at <https://www.camara.leg.br/proposicoes>. Accessed on 7 June. 2021.

<sup>35</sup> GOMES JUNIOR, Luiz Manoel. FRAVETO, Roger. **O projeto da nova lei da ação pública: principais aspectos**. Collection of individual and collective fundamental rights. vol.1. Belo Horizonte: Arraes, 2010, pp. 220, 221, 222.

<sup>36</sup> GOMES JÚNIOR, Luiz Manoel. FRAVETO, Roger. **O projeto da nova lei da ação pública: principais aspectos**. Collection of individual and collective fundamental rights. vol. 1. Belo Horizonte: Arraes, 2010, pp. 221, 222.



g) positivization of the dynamic distribution of the burden of proof by the judge - readjustment of the burden of proof (art. 20); h) derogation from territorial limitation for res judicata (art. 32); i) determination of specialization of judicial bodies and legal priority for collective proceedings; j) strengthening of res judicata *pro et contras* in matters of law (art. 32); k) increase in the efficiency of class actions, with suspension of the relevant individual cases; l) extrajudicial program for the prevention or repair of damages that may exist before or during the course of the collective process; m) flexibilization of procedural rules; n) improvement of settlement and execution, which should preferably be collective (art. 40). We realize, therefore, that the bill n. 5,139/09 was a major proposal based on the protection of interests arising from mass conflicts in society, valuing trans-individual rights and access to justice for the disadvantaged; however, the project was unfortunately not received, which resulted in delays in the construction of a more agile, swift, effective and fair construction of a collective procedural mechanism in defense of individual rights.

In this context, the legislative suggestion of the law on collective actions aims to improve the performance of the Judiciary in actions for the protection of collective and diffuse rights, seeking to correct anomalies and inconsistencies that generate a lack of unity of law and potential legal uncertainty according to the draft presented<sup>37</sup>. The proposal revokes the current public civil action law, Law No. 7,347/85, some provisions of the Consumer Protection Code and Law No. 9,494/97.

Among the main points of the proposal for a bill on collective action according to the working group<sup>38</sup> established to present proposals aimed at improving the performance of the Judiciary in actions for the protection of collective and diffuse rights are: a) representativeness; b) simplicity and efficiency; c) adequately disciplines the legitimacy of associations (art. 4, V); d) prevalence of res judicata *rectibus*, scope of the sentence's effectiveness for the entire country, if this is the extent of the damage (arts. 25, 26); e) priority in the judgment of collective actions when there is an affectation to be as a paradigm case in an incident of repetitive demands resolutions or in a repetitive appeal (art. 3); f) use of the quantum obtained in carrying out works or activities aimed at restoring the damage

caused; g) the fund is subsidiary (art. 24); h) creation of a register for all collective actions existing in the Country (art. 11); i) figure of the *amicuscuriae* (art. 16); j) evidence produced in a civil inquiry is prohibited, unless carried out with the authorization of the judge and with contradictory (art. 20); k) evidence by sampling or statistics is allowed (art. 23); l) the res judicata "second event of the dispute" ends (arts. 26, 27); m) ends the discussion about the interruption of prescription in relation to individual actions (art. 26, § 4); n) the sentence of origin in a collective action becomes an enforceable title for individual executions (art. 26, § 7); o) if there is *lis pendens* between the class actions with the same request and cause of action, the second action must be dismissed without judgment on the merits (art. 27, § 5); p) encourages the execution of agreements through the conduct adjustment term (art. 29); q) encourages the judge to issue a liquid sentence (art.30).

In this interest, let's make an analytical comparison about such institutes. There was an expansion of collective rights that can be protected by public civil action already in the bill n. 5,139/09 in the list of article 1º, "the provisions of this Law are governed by public civil actions aimed at protecting: I - the environment, health, education, work, sport, public safety, public transport, of integral legal assistance and the provision of public services; II of the consumer, the elderly, children and youth and people with disabilities; III of the social, economic, urban planning, financial order, the popular economy, free competition, public property and the treasury; IV - of goods and rights of artistic, cultural, aesthetic, historical, tourist and scenic value; and V - of others interests or diffuse, collective or individual homogeneous rights. Therefore, allowing other categories of collective rights not yet admitted in Law n. 7.347/85, are defined and "defended through public civil action, enhancing their effects and, also acting as a way to encourage the specialization of entities legitimized to your judgment."<sup>39</sup>

On the other hand, the new bill of law on collective actions brings nothing new in relation to the protection of collective rights, as analyzed in art. 2, the defense of collective rights or the collective defense of homogeneous individual rights will be exercised in accordance with this law, in the case of: 1- diffuse rights, understood as such, for the purposes of this Law, the trans-individual rights, of an

<sup>37</sup> The Working Group was established through Ordinance No. 1562/2019, signed by the President of the CNJ, Minister Dias Toffoli. Main points of the proposed collective action bill - National Council of Justice. Available at <https://www.jota.info/wp-content/uploads/2020/09/acoes-coletivas-anteprojeto.pdf>. Accessed on 7 Jun. 2021.

<sup>38</sup> BRAZIL. Ordinance no. 1562 of September 30, 2019. Establishes a working group with the objective of presenting proposals aimed at improving the performance of the Judiciary in

actions to protect collective and diffuse rights. Available at <https://atos.cnj.jus.br/files/original193816201910245db1fda8b65ef.pdf>. Accessed on 7 Jun. 2021.

<sup>39</sup> GOMES JÚNIOR, Luiz Manoel. FRAVETO, Rogério. The project of the new public civil action law: main aspects. Collection of individual and collective fundamental rights. vol.1. Belo Horizonte: Arraes, 2010, p. 224.

indivisible nature, of which are holders of indeterminate persons and linked together by factual circumstances; II - collective rights in the strict sense, understood as such, for the purposes of this Law, trans-individual rights, of an indivisible nature, of which it is the group holder, category or class of persons linked to each other or to the opposing party by a basic legal relationship; III - homogeneous individual rights, understood as those arising from a common origin and which have a predominantly homogeneous character.

The bill no. 5,139/09 brought an adjustment of the list of legitimated, according to art. 6, are concurrently legitimated to propose the collective action: I - the Public Prosecutor's Office; II the Public Defender's Office; III- the Union, the States, the Federal District, the Municipalities and respective autarchies, public foundations, public companies, mixed capital companies, as well as their depersonalized bodies that have as institutional purposes the defense of diffuse, collective or individual interests or rights homogeneous; IV - the Brazilian Bar Association, including its headquarters and subsections; V- unions and inspection bodies of the exercise of the professions, restricted to the defense of collective and individual diffuse interests or homogeneous rights linked to the category; VI - political parties with representation in the National Congress in the Legislative or Municipal Assemblies or the Municipal Chambers, according to the scope of the object of the demand, to be verified when the action is filed; and VII - civil associations and private law foundations legally constituted and in operation for at least one year, for the defense of interests or rights related to their institutional purposes, exempt from the authorization of the assembly or personnel and the presentation of the nominal list of associates or members.

In this case, there will be a collective procedural legitimacy, that is, "the possibility of to aim for the protection of collective rights *lato sensu* (diffuse, collective and homogeneous individual), even if there is a coincidence between the interests of those who act with those who will, in theory, benefit from the decision to be handed down"<sup>40</sup>; it is worth noting that the special commission opted for the broadest legitimacy for the defense of collective rights, with an expanding role being certain.

On the other hand, the draft bill of the collective action law in its art. 4th outlines the list of those legitimated; "the following are legitimated for this action: 1. The Public Ministry; II. The Public Defender's Office; III. The Union,

States, Municipalities and the Federal District; IV. The entities and bodies of the Public Administration, directly or indirectly, even if without legal personality, specifically intended to defend the interests and rights protected by this Law; V. Associations, which have adequate representation and which include among their institutional purposes the defense of the rights protected by this Law being indispensable the previous statutory authorization or assemblers. No innovation the blueprint does; even the issue of waiver of statutory authorization or assembly is already present in the law n7.347/85.

In relation to competence, the bill n. 5,139/09 brought changes to the rules of jurisdiction, adopting a differentiated systematic position, privileging the defense of homogeneous diffuse, collective and individual interests; according to article 4º: "the court of the place where the damage or illicit occurred or should occur is competent for the case, applying the rules of prevention and absolute competence. § 1º - if the extent of the damage reaches the area of the state capital, it will be competent; if it also affects the area of the Federal District, it will be competent, concurrently with the courts of the affected capitals. § 2º - the extent of the damage will be measured, in principle, as indicated in the initial petition. § 3º - if, in the competent court, there are specialized judgments on the matter and judgments specialized in class actions, the former shall prevail over the latter". In this way, we perceive that the position of Law n. 7,347/85, was maintained, however, there was an improvement when the possibility of having jurisdiction not only occurs the damage, but where the damage or illicit act must occur.

The new law on class actions provides in its article 14 that: "the jurisdiction for processing the class action is the jurisdiction of the capital of the State and, preferably, of specialized courts, being possible for the creditor to choose the court of his domicile for the fulfillment of of the sentence", however, in view of Antônio Gidi's teachings, the creation of specialized courts in collective proceedings is not feasible, as it would concentrate power in a single judge<sup>41</sup>. Furthermore, it appears that it does not make sense to process the collective action in the forum of the state capital; let's imagine a municipality that is far from the capital; such a situation can become a major obstacle to proposing collective action.

With regard to collective res judicata, article 32 of bill no. 5,139/09 "the sentence in the collective proceeding will make res judicata *erga omnes*, regardless of the

<sup>40</sup> GOMES JÚNIOR, Luiz Manoel. FRAVETO, Rogério. The project of the new public civil action law: main aspects. Collection of individual and collective fundamental rights. vol.1. Belo Horizonte: Arraes, 2010, pp. 224,225.

<sup>41</sup> GIDI, Antônio. **Rumo a um Código civil coletivo**: a condição das ações coletivas do Brasil. Rio de Janeiro: Forense, 2008, pp. 240-243.

territorial competence of the prosecuting body or the domicile of the interested parties" There was an advance of the project in relation to Law n. 7,347/85, which provided in its article 16 "the civil sentence makes *res judicata erga omnes*, within the limits of the territorial competence of the prosecuting body". Thus, there was a proposal for the bill n. 5.139/09 to a *res judicata pro et contra*, let's see the teachings of Luiz Manoel Gomes Júnior and Rogério Fraveto:

Thus, in relation to homogeneous individual interests or rights, a *pro et contra res judicata* regime is proposed, restricted to matters exclusively of law, in order to reach the definitive solution of the controversy, prohibited the filing of new individual actions to re-discuss what was previously decided collectively, which will tend to avoid the indiscriminate repetition of individual demands with the same object, always with the exception of the possibility for the interested party to propose and proceed with their individual demand, before the final result.<sup>42</sup>

The new law on collective actions provides that the "effectiveness of the sentence and the *res judicata* will operate *erga omnes*, throughout the national territory", as provided for in its article 27. We perceive, therefore, that the mentioned article adopted the *res judicata pro et contra*, not bringing anything new in relation to the bill n. 5,139/09.

Therefore, in the face of such analyzes and not exhausting the topic, it is still worth emphasizing the notes made by Antônio Gidi:

The CNJ project contains dozens of poorly written, unnecessary and technical norms. Most represent setbacks for collective protection, in addition to being the loss of a historic

opportunity to improve the system" (...) "instead of making collective actions more effective, the CNJ Project restricts access to justice". points out: "a commission of notable jurists prepared the excellent Bill n. 5.139/09 filed for lack of political will. If the country had taken advantage of that opportunity and improved collective action ten years ago, our Collective Procedural Law would be on another level and the CNJ would not have room to try to empty it."<sup>43</sup>

It is also important to demonstrate the lucidity of Luiz Rodrigues Wambier and Teresa Arruda Alvim Wambier:

It is, in short, a significant effort to modernize the system of collective actions. With strengths and weaknesses, such novelties require internal dialogue (at different levels of Brazilian society), as well as the contribution of the experience of other countries, so that the best solutions are found, for the benefit of society, the ultimate recipient of the law. Everything must be done, register, with absolute respect for constitutional rules, under penalty of offending the Rule of Law. The importance of the care that must be taken with regard to respect for constitutional rules is the result of a posture resulting from the knowledge of the History of peoples and of Law, which makes evident how difficult the path was to reach the present moment. The temptation of passing needs

<sup>42</sup> GOMES JÚNIOR, Luiz Manoel. FRAVETO, Roger. **O projetoda nova lei da ação civil pública: principais aspectos.** Collection of individual and collective fundamental rights. vol.1. Belo Horizonte: Arraes, 2010, p. 230.

<sup>43</sup> GIDI, Antonio. **O projeto CNJ e a decadência das ações coletivas no Brasil.** Available in <https://www.conjur.com.br/2020-nov-05/antonio-gidi-projeto-cni-decadencia-acoas-coletivas>. Accessed on 7 Jun. 2021.

cannot make one give up constitutionally guaranteed and prestigious rights, which are the result of cultural achievements, obtained at great cost.<sup>44</sup>

That said, the entire exhaustion pre-stress did not occur; however, we analyzed the differences and similarities of the main points between the institutes of Law 7.347/85, the bill n. 5,139/09 and the new law on collective actions (PL n. 4,778/20).

#### IV. ADA PELLEGRINI GRINOVER PROJECT: A NEW IBDP PROPOSAL

After describing the main distinctions between the bill n. 5,139/09 and the project of the new Law on collective actions - Law n. 4,778/20, comparing them with Law n. 7,347/85; essential issues of the bill 1.641/2148 of the Brazilian Institute of Procedural Law - IBDP, presented by federal deputy Paulo Teixeira on April 29, 2021<sup>45</sup>, will be analyzed, in order to contemplate suggestions and innovations to the project of the new Law of collective actions.

It can be seen that the theme of self-composition (arts. 37 to 43) is one of the great highlights of the bill 1641/21, governed by transparency and publicity (art. 37, II); adequate representation (art. 37, IV); isonomy and legal certainty (art. 37, IX); being encouraged not only at the sanitation hearing, but also at all stages of the process; with the intention of incorporation into collective self-composition, consolidating gender as common to diffuse, collective and homogeneous individual rights (arts. 1º and 37, I). It is important to highlight the principles that govern collective protection, concomitantly with article 2º: I. broad and effective access to justice; II. social participation, through appointment of consultations, public hearings and other forms of direct participation; prevention and consensual and integral resolution of collective conflicts, judicial or judicial methods of solution such as conciliation, negotiation mediation and other extra means of negotiation considered via consensual; IV. reasonable collective duration of collective relief, with priority of processing and protection in all instances of duration V. effective precaution, prevention and comprehensive repair of property and moral damage, individual and collective; VI. Punitive-pedagogical responsibility and full restitution

of profits and advantages obtained unlawfully with the practice of illicit or related to it; VII. broad publicity of collective proceedings, through the appropriate social information regarding the filing of actions, decisions or collective protection agreements and their enforceability; VIII. duty of collaboration of everyone, including public and private legal entities, in the production of evidence, in the fulfillment of judicial decisions and in the effectiveness of collective protection, as well as in the respect for legal certainty; IX. primacy of the judgment of the merits, whenever possible, by means of the correction or integration of the conditions of procedure of collective demands throughout the procedure, at any time and degree of jurisdiction; X. effective dialogue between the judge, the parties, the other State Powers and society in the search for a plural and adequate solution. especially for complex and structural cases; XI. process flexibility and pragmatism, and the practical and legal consequences of judicial decisions and consensual solutions must be considered by all.

Thus, it is noted that the reinforcement of incorporating improvements in collective self-composition is clear when the project states as a principle of collective protection (art. 1º, §1º), the consensual and integral resolution of collective conflicts, through the use of conciliation, mediation, negotiation and other appropriate means (art. 2º, IV). Furthermore, participation is expanded, directly by those affected, according to articles 20 and 22, also for the conclusion of agreements; importing in the viability of the integral solution of the conflict and the best protection of the involved interests; providing in its article 22, §4º, that the judge may refer the dispute to Judicial Centers for Consensual Conflict Resolution or to an extrajudicial entity or to a qualified professional, considered appropriate by the parties.

It is important to emphasize, the flexibility of the process and pragmatism (art. 2º, XI), it is observed that the project works with general clauses and indeterminate terms, given the complexity of the situations object of collective processes; a positive sign, since the more legitimized the process is, the greater the chances that different perspectives will be taken into account, thus providing greater protection for the group (art. 37, V). In this aspect, the project reinforces the issue of adequacy of representation and expansion of legitimacy (arts. 7º and 38, §1º) for public civil action, including: unions, for the defense of collective or individual interests of the category; the Brazilian Bar Association including its sections, these for local or state

<sup>44</sup> WAMBIER, Luiz. WAMBIER, Teresa. **Anotações sobre as ações coletivas no Brasil**—presente e futuro. Available at <https://www.paginasdedireito.com.br/index.php/artigos/263-artigos-mai-2014/6562-anotacoes-sobre-as-acoes-coletivas-no-brasil-presente-e-futuro>. Accessed on 7 Jun. 2021.

<sup>45</sup>BRAZIL. Bill No. 1641, presented on April 7, 2021. Disciplines public civil action. Available at <https://www.camara.leg.br/proposicoes>. Accessed on 7 June 2021.



damages; political parties with representation in the National Congress; indigenous communities, quilombolas and traditional peoples to defend the rights of the respective groups in court. The court of the place where the action, omission, damage or illicit act, as alleged in the initial petition (art. 8º) took place or should occur, will be competent for the case: I. if there are several judicial districts or subsections equally competent, preference will be given to the forum that has the best structure; II. if the extent of the damage reaches the area of the capital of the State, this will be the competent one; III. if the extent of damage affects more than one State of the federation or has a national dimension, any capital of the affected State or the Federal District will be competent, concurrently, observing the prevention. Concern and care can be seen in the delimitation of competence, as well as in relation to conflicts of competence, with the objective of guaranteeing the facilitation of the exercise of fundamental procedural guarantees.

Another relevant point concerns the sentence (art. 26, §4º) which must provide for the form of execution, preferably without judicial proceedings, including, if necessary, with the constitution of a fund or entity with a specific infrastructure. Two main aspects can be seen: dejudicialization and the use of specific infrastructure entities.

Wide publicity (art. 11) is present in the structural procedure; in addition, the Public Prosecutor's Office may, under its presidency, initiate an administrative procedure or civil inquiry, request from any public or private body, certificates, information, examinations or expertise (art. 34); being certain that the administrative procedures and the civil inquiry are governed by the principles of publicity (art. 34, I), access to information to interested parties (art. 34, II), participation of the investigated in contradictory (art. 34, IV), and reasonable duration (art. 34, V). Thus, a dialogic process can be seen with the broad participation of those affected, with effective dialogue between the judge, the parties, the other State Powers and society in the search for a plural and adequate solution (art. 2, X). Furthermore, the sanitation decision should preferably take place in a shared sanitation hearing, in the which the parties will participate (art. 22, §4º). Finally, it is necessary to mention that the legal, judicial or business fund may be the recipient of amounts obtained by agreement or administrative sanctions (art. 48). Therefore, it is observed that bill n. 1,641/21 brings innovation in relation to structural processes, which have been gaining relevance in the resolution of multifaceted conflicts, with the objective of providing a fairer and more effective protection for the fundamental rights involved; the positive contributions arising from the bill n. 1,641/21.

## V. CONCLUSION

Over these thirty-five years the public civil action has undergone some legislative changes and is still suffering doctrinal and jurisprudential propositions in search of improvement of its ills. In this sense, a bill n. 5,139/09 was proposed by a special commission, through Ordinance n. 2,481/2008 instituted by the Ministry of Justice, with the purpose of presenting a readjustment proposal; the works of commission took place in the period from 2008 to the end of March 2009, when the text was sent to the Civil House and later to the National Congress on March 27 of this year; however, the bill was shelved in 2010. Therefore, in September 2020, a new proposal was sent by the representatives of the National Council of Justice to the Chamber of Deputies for analysis in order to improve Law n. 7,347/09. In addition, during this year the IBDP presented a new proposal, with the aim of contemplating suggestions and innovations to the project of the new Law on collective actions, which was presented by federal deputy Paulo Teixeira, as the project of Law n. 1,641/21.

In this context, the objective of this work was to analyze the legislative evolution, advances and setbacks, the differences and similarities of the main points between the institutes of Law 7.347/85, the bill n. 5,139/09 and the new law on collective actions; and finally, a brief analysis of the bill n. 1,641/21. Thus, it was possible to foresee that Law no. 7,347/85 is undoubtedly a great positive and contributory milestone in collective protection; however, it is necessary to adapt and adapt to the current reality, making access to justice broader and more appropriate to the community, to the countless interested parties, with low cost, simplicity of rites, celerity and efficiency of the jurisdictional provision.

In view of this, the proposal made by Bill n. 5,139/09, which aimed to privilege collective treatment, allowing access to judicial protection by individuals who were on the margins of the collective system; and that deserves applause and respect for all the wisdom of the project in recognizing a single collective system. However, we had the misfortune to have the project shelved.

Thus, the new law on collective actions brought with it some differentiated proposals, however, divergent and not very well received by most of the doctrine; in addition, compared to the bill n. 5,139/09 did not bring major legislative changes.

In relation to the bill no. 1.641/21, it appears that much remains to be discussed, however, the project brings positive contributions to the development of collective rights, in particular to the structural process, and it is certain that the proper use of the techniques provided for in the



aforementioned project will improve the provision of collective protection.

Therefore, we understand that it is necessary to improve the public civil action law; as well as the need for continuous improvement of collective protection for an effective contribution and a true consolidation in practice for the action of those legitimated in search of access to justice in the face of fundamental rights; ensuring due constitutional process to all interested parties, making the collective process more efficient and fair in the treatment of trans-individual rights.

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# The Quality of Drinkable Water using Machine Learning Techniques

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**Keywords—** Artificial intelligence, Artificial  
Neural Network, Big data, Prediction model,  
Water quality.

**Abstract—** Predicting potable water quality is more effective for water management and water pollution prevention. Polluted water causes serious waterborne illnesses and poses a threat to human health. Predicting the quality of drinkable water may reduce the incidence of water-related diseases. The latest machine learning approach has shown promising predictive accuracy for water quality. This research uses five different learning algorithms to determine drinking water quality. First, data is gathered from public sources and presented in accordance with World Health Organization (WHO) water quality standards. Several parameters, including hardness, conductivity, pH, organic carbon, solids, and others, are essential for predicting water quality. Second, Random Forest (RF), Support Vector Machine (SVM), Artificial Neural Network (ANN), Deep Neural Network (DNN), and Gaussian Nave Bayes are used to estimate the quality of the drinking water. The conventional laboratory technique for assessing water quality is time-consuming and sometimes costly. The algorithms proposed in this work can predict drinking water quality within a short period of time. ANN has 99 percent height accuracy with a training error of 0.75 percent during the training period. RF has an F1 score of 87.86% and a prediction accuracy of 82.45%. An Artificial Neural Network (ANN) predicted height with an F1 score of 96.51 percent in this study. Using an extended data set could improve how well predictions are made and help stop waterborne diseases in the long run.

## I. INTRODUCTION

### 1.1 Context

The Drinkable water quality prediction is essential to ensure safe public health. It is a very much serious issue for a person to survive healthy life. Polluted drinking water can cause various kinds of health diseases. According to the survey, almost 3,575,000 people are died every year due to water-related diseases [1]. Predicting drinkable water is difficult for those countries that have limited drinkable water sources. In the industrial revolution, chemical dust causes the most water pollution.

There is various kind of predicting methods to predict the drinkable water. Among those, neural network [2], gray theory [3], statistical analysis, and chaos theory [2] are the most useable techniques. For ideal model designing, statistical analysis is very much superior. For better prediction and research, a neural network delivers better performance [2]. Drinking water quality mainly depends on essential measures, such as pH, hardness, sulfate, organic carbon, turbidity, and a few more [4]. Machine learning techniques show significant prediction results in water quality prediction. Artificial neural network (ANN), Convolutional neural network (CNN),

Deep neural network (DNN), Random Forest (RF), Support vector machine (SVM) are the most popular machine learning algorithm for prediction [5].

### 1.2 Problem

Water pollution is becoming the most severe human concern affecting water quality. Various human activities render water unsafe for drinking and domestic usage. The primary causes of water pollution are chemical fertilizers and pesticides that enter rivers and streams as untreated wastewater and industrial effluents that run near cities and lowlands. Polluted water increases certain waterborne infectious illnesses, causing some severe diseases.

The issues that this study intends to solve are outlined below:

- a) misconception of WHO guidelines on drinkable water parameters;
- b) the lengthy clinical process of drinkable water prediction;
- c) lack of uses of machine learning on water quality prediction;
- d) key awareness factor that are unknown to rural people.

### 1.3 Objectives

The primary goal of this project is to develop a computationally competent and robust approach for estimating drinkable water quality characteristics to reduce the effort and expense associated with measuring those parameters. The WHO standards on drinkable water and the awareness factors that may reduce water pollution will be reviewed. This study is about underground water in the Bogura District of northern Bangladesh, where the quality of the water is always changing.

## II. REVIEW OF RELATED WORKS

A hybrid decision tree-based machine learning model was proposed to predict the water quality with 1875 data. In the evaluation process, six water quality parameters were used to predict the water quality. Extreme gradient boosting (XGBoost) and RF algorithms were applied that includes complete ensemble empirical mode decomposition with adaptive noise (CEEMDAN) along with six different algorithms. At first, raw statical data was collected. After CEEMDAN distribution, XGBoost and RF algorithms were applied in data distribution section. When training was completed, it shows the water quality along with prediction error [6].

A machine learning model was proposed with RF, Decision Tree (DT) and Deep Cascade Forest (DCF). The

first step of the prediction model was data processing. Data samples were divided into suitable and unsuitable section at data processing unit. After that, system calculated the water quality parameters for irrigation. Water quality was predicted by six levels of measure. Data was collected from Bouregreg watershed (9000 km<sup>2</sup>) located in the middle of Morocco. Data was divided into 75 percent for training and 25 percent for testing. In the data normalization and model building unit, system predict the water quality by data splitting.[5].

An author presented a data intelligence model for water quality index prediction. Support vector regression (SVR), adaptive neuro-fuzzy inference system (ANFIS), Back propagation neural network (BPNN) and one multilinear regression (MLR) algorithms are applied for prediction. The author collected the data from Jumna, the major tributary of the Ganga River. The length of the river is 1400 km. [7].

A hybrid machine learning approach was suggested for water quality prediction. RF, reduced error pruning tree (REPT), and twelve different algorithms were applied to analyze the water quality. The author divided the methodology into two sections are data collection and preparation. Eleven water quality indicators were applied to identify the water quality. In the model evaluation, the author took coefficient of determination (R<sup>2</sup>), mean absolute error (MAE), root-mean-square deviation, the percentage of bias (PBIAS), percent of relative error index (PREI), and Nash-Sutcliffe efficiency (NSE) for the performance measure of different algorithms. [8].

## III. PROPOSED METHODOLOGY

### 3.1 Introduction

Machine learning algorithms, classification algorithms, and regression algorithms all improve daily in our contemporary age, producing improved results. The most often used classification algorithms are ANN, CNN, DNN, DT and RF [5]. Using factors such as pH, conductivity, hardness, and so on, this proposed model predicts whether or not the water is safe to drink.

Numerous methods using activation functions are utilized in data processing and learning. RF, SVM, ANN, DNN and Gaussian Naïve Bayes are the suggested prediction algorithms in this proposed work.

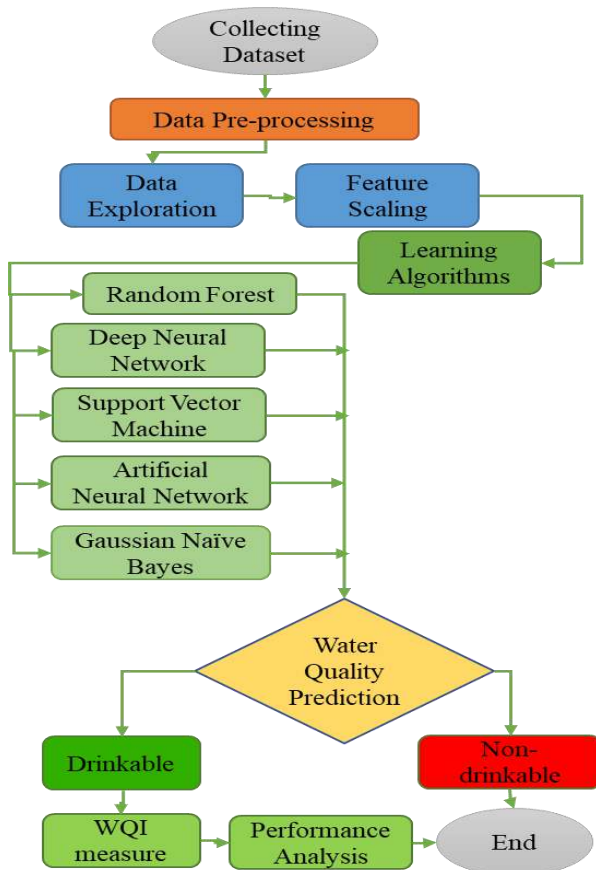


Fig. 1: Framework of proposed model

To begin, data are collected and data are distributed according to ten measurements shows in Fig. 1. Then, algorithms are developed according to literature analysis. After that, five distinct classifiers will be built to categorize the data and predict the class. Finally, the suggested study presents prediction findings together with a performance analysis. Performance analysis identifies the optimal method.

### 3.2 Dataset

This research is used a dataset from Department of Public Health Engineering (Rajshahi Branch, Bangladesh). It constituted 3276 samples. The dataset includes the following key metrics: pH, hardness, solids (total dissolved solids - TDS), chloramines, sulfate, conductivity, organic carbon, trihalomethanes, turbidity, and portability. The standard data rate established by the International Water Association ensures the quality of drinking water in Bangladesh [9].

### 3.3 Data Processing

The computation step is critical in data processing for improving data quality. In this step, data exploration and feature scaling being determined using the dataset's most

important parameters. The samples of water were then categorized based on the WQI values.

### 3.4 Water quality classification and index calculation

WQI measures water quality by factoring in factors that affect WQ [10].

$$WQI = \frac{\sum_{i=1}^N q_i \cdot w_i}{\sum_{i=1}^N w_i} \quad (1)$$

The WQI was determined using the formula:

$$q_i = 100 * \left( \frac{V_i - V_{ideal}}{S_i - V_{ideal}} \right) \quad (2)$$

Here,

N = No. of parameters

$q_i$  = quality rating scale

$w_i$  = weight of each parameter

K = proportionality constant

The proposed model is evaluated in this study using a public dataset and ten critical water quality indicators.

Table. 1: Drinkable Water Quality Standards

Parameters	Unit	Standards
pH		6.5-8.5
Hardness	mg/L	300
Solids (TDS)	ppm	<20000
Chloramines	mg/L	<4
Sulfate	mg/L	<250
Conductivity	$\mu$ S/cm	<400
Organic Carbon	ppm	<25
Trihalomethanes	$\mu$ g/liter	<37
Turbidity	NTU	<5

Note: World Health Organization water quality standard

In Table. 1. It shows the standard value of water quality index and those measurements are provided by World Health Organization (WHO) [11].

### 3.5 Machine learning algorithms

#### 3.5.1 Random Forest

Random forest is a Classification Algorithm extensively utilized in Multiclass applications. It constructs classification trees from several samples and uses their majority vote for classification and average for regression. Many of the most significant characteristics of the Random Forest Algorithm is that it can handle data sets with both continuous variables (as in regression) and categorical variables (as in classification). It outperforms



other algorithms in categorization tasks. Random forest actually uses two methods: Bagging and Boosting [12].

Some important feature that makes RF more accurate.

1. Diversity
2. Immune to the curse of dimensionality
3. Parallelization
4. Train-Test split
5. Stability [13]

In regression problems, the mean squared error (MSE) rate is an important parameter in the RF. For calculating the value of MSE [14],

$$MSE = \frac{1}{N} \sum_{i=1}^N (f_i - y_i)^2 \quad (3)$$

Here,

$N$  = No. of the total data points.

$f_i$  = Return value from the proposed model.

$y_i$  = Data point's actual value.

### 3.5.2 Deep neural network

A deep neural network is much more complex than the first. It can understand voice instructions, identify sound and images, conduct an expert assessment, and a variety of other tasks that involve foresight, creativity, and analytics. Only the human brain is capable of such things. Unlike feed-forward networks (FFNs), deep neural networks (DNNs) include connections between layers that are only one-way and can only send data forward. The results are produced via deep classification with knowledge datasets, with "what we want" defined through the hidden layer. An FFNN's taste is like a memory trace [15].

DNN has 4 layers of operation

1. Dataset
2. Local Receptive Fields
3. Sharing Weights
4. Pooling Layer

The deep neural network addresses the issue on a larger scale and may make judgements or make predictions based on the data provided and the intended outcome. Without a large quantity of labeled data, a deep neural network can solve a problem [15].

### 3.5.3 Support vector machine

The term "Support Vector Machine" (SVM) refers to a supervised machine learning method that may be used to solve classification and regression problems. It is, however, mostly employed to solve categorization issues. The SVM method displays each data item as a

point in  $n$ -dimensional space (where  $n$  is the number of features you have), with the value of each feature being the coordinate value [16]. To compute the norm of a vector, use the Euclidean norm formula [17].

$$x = (x_1, x_2, \dots, x_n) \quad (4)$$

If it defines  $x = (x_1, x_2)$  and  $w = (a, -1)$

$$w * x + b = 0 \quad (5)$$

The hyperplane may then be used to create predictions. The hypothesis function  $h$  is defined as follows [17]:

$$h(x) = \begin{cases} +1 & \text{if } m * x + b \geq 0 \\ -1 & \text{if } m * x + b < 0 \end{cases} \quad (6)$$

### 3.5.4 Gaussian naive bayes

The Naive Bayes method is a probabilistic machine learning technique that may be used to a broad range of classification problems. Filtering spam, categorizing documents, and predicting sentiment are examples of common uses. The term naive refers to the assumption that the characteristics that make up the model are unrelated to one another. That is, altering the value of one feature has no direct impact on the value of the other characteristics utilized in the algorithm [18]. The term naive refers to the assumption that the characteristics that make up the model are unrelated to one another. To calculate the mean and variance of  $X$ , the formula is [19],

$$P(X|Y = c) = \frac{1}{\sqrt{2\pi\sigma^2 c}} * e^{-\frac{(x-\mu_c)^2}{2\sigma^2 c}} \quad (7)$$

Replacing the appropriate probability density of a normal distribution and name it the Gaussian Naive Bayes if it assumes the  $X$ 's follow a Normal (aka Gaussian) Distribution, which is quite frequent [19].

### 3.5.5 Artificial neural network

The phrase "artificial neural network" refers to a sub-field of artificial intelligence influenced by biology and patterned after the brain. A computer network based on biological neural networks that build the structure of the human brain is known as an artificial neural network. Artificial neural networks, like human brains, contain neurons that are coupled to each other at different levels of the networks. Nodes are the name for these neurons [20].

### 3.6 Data distribution analysis

This study project includes ten measurements. Throughout the data distribution process, each statistic is shown individually to provide context for the drinkable water standard. pH is a unit of measurement that is used to indicate the acidity or basicity of an aqueous solution. In water, it indicates the alkaline measure. The WHO

recommends a pH range of 6.5 to 8.5 as the highest acceptable level [11]. Water hardness is the quantity of dissolved calcium and magnesium present in water that is measured as "water hardness." Hard water has a high

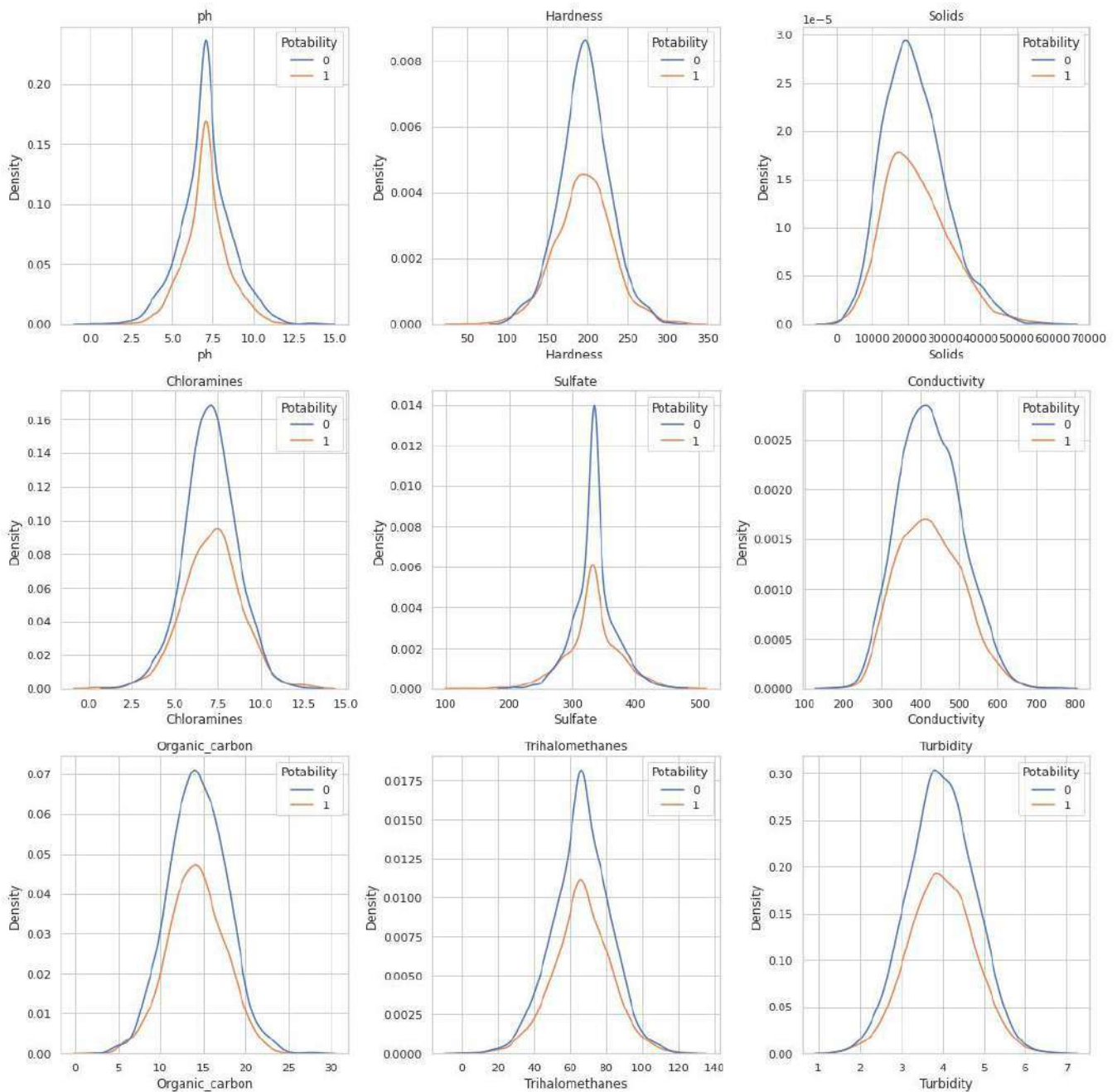


Fig. 2: Distribution of measuring parameters in terms of potability

concentration of dissolved minerals, primarily calcium and magnesium, and should be avoided. Standard water hardness by WHO is 300 mg/L [11].

Solids (Total Dissable Solids) refers to the inorganic salts and trace quantities of organic materials that are present in solution in water. Calcium, magnesium, sodium, and potassium cations are frequently present, as

well as carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions [21].

Chloramines is one of the important disinfectants that used in water potability. Fig. 2. shows the distribution of chloramines in the dataset. Under 4 mg/L is the standard rate of Chloramines in drinkable water. Sulfate may provide a bitter or medicinal flavor to water and has

laxative properties. Fig. 2. shows the distribution of sulfate in samples. The allowable sulfate in drinking water is under 250 mg/L [11].

In drinking water, electrical conductivity is a measurement of a solution's ionic mechanism that allows it to transfer electricity. Fig. 2. shows the distribution of conductivity. Based on WHO guidelines, the electrical conductivity value should not exceed 400 S/cm [11].

Organic carbon indicates organic matter in drinking water. It may have thousands of components, such as microscopic particles, dissolved macromolecules, colloids, and compounds [22]. The allowable rate of organic carbon in drinking water is lower than 25 ppm [11].

Trihalomethanes are disinfection byproducts formed when chlorine molecules combine with naturally existing substances in water. Trihalomethanes in drinking water have a standard value of 37 µg/liter [11]. They are colorless and will float on the surface of the water. The turbidity of water is determined by the amount of solid stuff suspended in it. The WHO recommends 5.00 NTU [11].

A correlation heatmap is a graphical representation of a correlation matrix that illustrates the relationships between different variables. The correlation coefficient may be anything between -1 and 1 [23]. Fig. 3 is a correlation heatmap created to illustrate the linear relationship between various variables on drinkable water quality in the dataset.

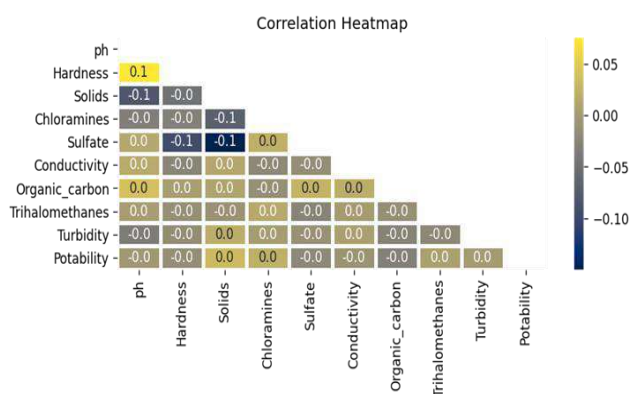


Fig. 3: Correlation Heatmap of ten variables in the experimental dataset

The dataset contains ten measurement parameters. When the value is 0.1 to 1, the correlation between two variables is considered to be positive. A positive value implies that when one variable rises, the other increases as well. Hardness and pH have a positive relationship shown

in fig 10. A negative correlation between two variables is defined as a value of -1 to -0.1. A negative value implies that as one variable goes up, the other goes down. In this dataset, solids and sulfate have a relationship valued at -0.1. There is no connection between the two variables if the value is 0, which implies that the variables vary randomly [23]. Sulfate and pH do not correlate between them in this experimental dataset.

### 3.7 Performance parameters

The confusion matrix is one of the characteristics that properly represents the true performance of a classification model and may be used to monitor the system's performance. For assessment, the confusion matrix contains True Positive (TP), False Positive (FP), False Negative (FN), and True Negative (TN) values.

The equation for calculating average accuracy,

$$Accuracy = \frac{TP+TN}{Total} \quad (8)$$

The equation for calculating Positive Predictive Value (PPV)/ Precision,

$$Precision = \frac{TP}{TP+FP} \quad (9)$$

For calculation True Positive Rate (TPR)/ Recall,

$$Recall = \frac{TP}{TP+FN} \quad (10)$$

To calculate the F1 Score,

$$F1\ Score = \frac{PPV \cdot TPR}{PPV + TPR} \quad (11)$$

F1 score is the performance measure over testing accuracy. It actually indicates that how stable the model is to predict the classes. If the F1 score is higher than the testing accuracy, then the system is more stable and accurate according to recall.

### 3.8 Model building

Random forest, deep neural network, support vector machine, gaussian naive bias and artificial neural network are applied for predicting the quality of drinking water. After the data visualization,

Table. 2: Model Building Parameter

Algorithms	Training accuracy (%)	Training error (%)
Random Forest	96	3.22
Deep Neural Network	94	4.5
Gaussian Naïve Bayes	98.59	1.77
Artificial Neural Network	99	0.75
Support Vector Machine	97	2.72

During model construction, the artificial neural network outperforms all other learning methods in terms of accuracy. Deep neural networks achieve 94 percent training accuracy with a 4.5 percent error rate, as shown in Table. 2. The artificial neural network has the lowest training error of any learning method, at 0.75 percent.

#### IV. SIMULATION RESULTS AND DISCUSSION

In this research work, PyCharm is used to analysis the data and predict the drinking water potability considering the ten measurements. During the prediction, WQI measured how safe the water was to drink. WQI informs that whether the water can be drunk or not based on WHO standards.

*Table. 3: Drinkable and undrinkable of this water quality dataset in terms of WQI*

Drinkable	Undrinkable
89.71 (%)	10.29 (%)

Figure. 3. shows that only a tiny amount of water is not safe to drink. When fertilizers, industrial waste, animal waste, chemical fertilizers, pesticides, and waste from landfills and septic systems leak into an aquifer, they pollute the groundwater [24]. Surface water gets polluted a lot when cities proliferate without planning. Good waste management, fair use of aquatic resources, and more public knowledge might reduce the pollution of drinking water. Five different machine learning algorithms are applied for prediction. Each of the algorithm is run for five times to get accurate and authentic performance measurement.

*Table. 4: Performance analysis of proposed learning algorithms*

Algorithms	Precision (%)	Recall	F1 Score	Testing Accuracy
Random Forest	91.65	84.38	87.86	82.45
Deep Neural Network	94	86.88	90.3	84.57
Gaussian Naïve Bayes	96.23	90.19	93.11	92.44
Artificial Neural Network	98.86	94.27	96.51	98.12
Support Vector Machine	92.55	90.72	91.63	93.17

Table. 4. shows that for the prediction of drinkable water, an artificial neural network obtains the highest

accuracy of 98.12 percent with 96.51 percent F1 Score. According to the F1 score, the random forest, deep neural network, and Gaussian naive bias have higher prediction stability when compared to actual accuracy. Random forest shows the lower accuracy of 82.45 percent along with 87.86 percent F1 score. Overall artificial neural network shows highest accuracy among those five learning algorithms. Other algorithm shows better stability in prediction that observed by F1 Score measure.

#### V. CONCLUSION

Predicting drinkable water is essential for environmental preservation and pollution prevention. It is necessary to provide clean drinking water in order to maintain excellent public health. Drinking water from safe sources can ensure the potability of the water. It becomes difficult to predict drinkable water accurately. The ideal learning algorithm is needed to prevent prediction errors. An intelligent model based on five different machine learning algorithms may be used to predict the potability of drinking water based on 10 standard parameters such as pH, hardness, organic carbon, and other factors. In this current work, artificial neural network achieved 98.12 percent accuracy with 0.75 percent training error. In future, the proposed model will be implemented to predict and analysis of different region drinking water along with IoT based quality detection model.

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# The Importance of the Training of Laypeople in Basic Life Support: An Integrative Review

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**Keywords—** Support, Life, cardiorespiratory,  
Empowerment, Education.

**Abstract—** The importance of qualification and training of lay people in Basic Life Support (BLS) leads to a reduction in deaths or irreversible sequelae in the population affected by a Cardiopulmonary Arrest (CPA), because in most emergency cases whoever is close is not a health professional. The purpose of this article is to analyze the importance of qualification and training in Basic Life Support for lay people. This is a descriptive, qualitative study carried out through an integrative literature review (ILR). To carry out the bibliographic review, searches were carried out in the following databases: repositories of Universities, Virtual Health Libraries, PubMed, Journals, Magazines, Federal Laws and Ordinances Scientific Electronic Library Online (SCIELO) and Online System of Search and Analysis of Literature Medical (MEDLINE). Articles related to the theme of the project, articles with Portuguese language, online and free access to the full text and from the year 2014 were included. The studies that constituted the units of analysis have a variety of authors, publication sources and countries of origin of the studies. The training and qualification of the BLS is of relevance for the knowledge of the lay population and should be applied even in the school phase, with

*theoretical-practical methods and repeated annually, for a better effectiveness in the initial care of a victim in CPA.*

## I. INTRODUCTION

In Brazil, there are an estimated 200,000 cases of cardiorespiratory arrest (CPA) annually, where 50% of cases occur in the out-of-hospital environment (FERNANDES et al., 2014, p. 594). Basic Life Support (BLS) teaches initial care in emergency situations, includes learning Cardiopulmonary Resuscitation (CPR) maneuvers in patients in cardiac arrest, the use of Automated External Defibrillator (AED) and airway opening maneuvers to foreign body clearance (CHEHUEN NETO et al., 2016, p. 444).

Second, CHEHUEN NETO et al., 2016, training and information from the BLS are important, as the first care can preserve life and reduce sequelae until the multidisciplinary team arrives at the event.

This factor leads to a reflection on the importance of knowledge for lay people, as a population well trained in BLS will contribute to the reduction of deaths from CRA, as well as the reduction of irreversible sequelae in the Brazilian population (MAIA et al., 2020).

Countries such as Portugal, India and the United States of America, already apply the knowledge and training of their students in the SBV in their schools and training centers, through theoretical-practical content, believing that the sooner this knowledge is applied, the better the results will be. results and the training of a lay population.

KuvaKi, Bahar says the training should be started in school age children for 2 hours every year and repeated annually, helping these children learn CPR better, thus saving more lives. In view of these findings, we ask: What is the importance of training the school community in BLS.

Through cardiopulmonary resuscitation (CPR) early and effective care can contribute to reducing mortality rates, as well as reducing neurological sequelae. The approach within this context becomes essential, since the initial maneuver used correctly and accurately after the CRA will increase the victim's chances of survival and prevent complications.

In addition, there are still some situations, such as when there is obstruction of the airways in conscious victims, in which the lay rescuer can reduce the chances of an eventual CRA. For this purpose, it is essential to know how to correctly apply the Heimlich maneuver (subdiaphragmatic pressure or abdominal pressure). In view of this, training projects for lay people in Basic Life

Support (BLS) are essential due to their relevance for rapid care for victims in an emergency situation, as it is currently represented as a policy strategy in the health care of populations.

According to the American Heart Association (2019), the BLS encompasses interventions that can be performed quickly by non-health professionals, provided they are trained, in this way, knowing the part of the population that is most vulnerable and by which factors it is affected makes if necessary for the organization to implement the practice of policies to prevent possible preventable deaths.

This work intends to seek evidence, through the available literature, about the effectiveness of BLS for laypeople, since knowledge, attitude and agility are essential to provide help to victims of CRA. Therefore, in view of the above and given that CRA is an emergency situation, the objective of this study is to analyze the importance of qualification and training in Basic Life Support for lay people.

## II. METHOD

This is a descriptive, qualitative study carried out through an integrative literature review (ILR). To carry out the bibliographic review, searches were carried out in the following databases: repositories of Universities, Virtual Health Libraries, PubMed, Journals, Magazines, Federal Laws and Ordinances Scientific Electronic Library Online (SCIELO) and Online System of Search and Analysis of Literature Medical (MEDLINE).

The study included articles related to the theme of the project, articles with Portuguese language, free online access to the full text and from the year 2014. As exclusion criteria, scientific productions with English and Spanish language and that were not complete and outside the established year were discarded. The descriptors used in the research were: basic life support, cardiopulmonary resuscitation, lay people, training, education.

When crossing the descriptors SBV, PCR, in-service training and education with filters, several articles were found, of these eighteen (18) references followed according to the inclusion criteria and which present as a theme the importance of knowledge and training of the SBV for lay people, reducing the incidence of death and irreversible sequelae in case of cardiac arrest.

The steps for the analysis and selection of articles were: elaboration of a guiding question (What is the

importance of training lay people?); literature search; data collect; critical analysis of included studies; discussion of results and presentation of the integrative review. The results were analyzed through content analysis which, according to Bardin (2006), should be developed from

three phases: 1) pre-analysis, 2) material exploration and 3) treatment of results, inference and interpretation.

The definition of references considered information related to descriptors, authors, year, search location, research title, research type, subjects and the described results (Table 1).

*Tabela 1: Referências utilizadas para elaboração da RIL*

Nº	Autor	Título	Local de busca	Tipo de pesquisa	Descritores	Ano
1	MAIA, SRT.; LEMONS, AM.; FRUTUOSO, MS.; JUNIOR, CWMR.	Conhecimento dos leigos acerca da ressuscitação cardiopulmonar em pacientes adultos no Brasil	Brazilian journals / Research Gate	Pesquisa Bibliográfica	Conhecimento, Ressuscitação Cardiopulmonar, Educação em Saúde. Adulto e Brasil.	2020
2	SILVA, JK.; CONCEIÇÃO, DMM.; RODRIGUES, GM.; DANTAS, GSV.	Suporte Básico de Vida para Leigos: Relato de Atividades Extensionistas	Repositório Institucional UNESP Revista Ciência e Extensão Unesp	Relato de Experiência	Educação em Saúde, Parada cardiorrespiratória, Ressuscitação cardiopulmonar, Suporte Básico de Vida, Universidades.	2017
3	MONTEIRO, AMS.; MOSCOPF, FJ.; SCHAFFAZICK, F.; BONDAN, FB.; TURRI, G.; SILVEIRA, LF.; DALL'AGNOL, MM.; AVILA.	Cartilha para leigos sobre reanimação cardiopulmonar	Repositório UFSM	Livro	Leigos, Reanimação cardiopulmonar, Parada cardiorrespiratória	2017
4	MIRAVETI, JC.	Suporte básico de vida para leigos: um quase estudo experimental	Repositório USP	Estudo quase experimental, quantitativa com delineamento tempo- série	Parada cardiorrespiratória, ressuscitação cardiorrespiratória, suporte básico de vida, leigo	2016

5	FERREIRA, MGN.; ALVES, SRP.; SOUTO, CGV.; VIRGÍNIO, NA.; JÚNIOR, JNBS.; SANTOS, AF.	O Leigo em Primeiros Socorros: Uma Revisão Integrativa	Revista de ciências da saúde	Revisão Integrativa	Revisão, primeiros socorros, conhecimento	2017
6	SILVA, LGS.; COSTA, JB.; FURTADO, LGS.; TAVARES, JB.; COSTA, JLD.	Primeiros Socorros e Prevenção de Acidentes no Ambiente Escolar: Intervenção em Unidade de Ensino	Revista Cofen	Relato de Experiência	Educação em Saúde, Saúde Escolar, Primeiros Socorros.	2017
7	Ministério da Saúde	Política Nacional de Promoção da Saúde	Biblioteca virtual em Saúde do Ministério da saúde	Pesquisa Documental	Portaria Nº 2.446	2014
8	Presidência da República	Lei Lucas	Presidência da República	Pesquisa Documental	Lei Nº 13.722, de 4 De outubro De 2018.	2018
9	FALKENBERG, MB.; MENDES, TPL.; MORAES, EP.; SOUZA, EM.	Educação em saúde e educação na saúde: conceitos e implicações para a saúde coletiva	Scielo	Relato de Experiência	Educação em saúde; Educação continuada	2014
10	TAVARES, A.; PEDRO, N.; URBANO, J.	Ausência de formação em suporte básico de vida pelo cidadão: um problema de saúde pública? Qual a idade certa para iniciar?	Revista Portuguesa de Saúde Pública	Pesquisa Bibliográfica	Suporte básico de vida Parada cardiorrespiratória, Formação, idade	2015
11	BERNOCHE, C.; TIMERMAN, S.; POLASTRI, TF.; GIANNETTI, NS.; SIQUEIRA, AWS.;PISCOPO, A.; <i>et al.</i>	Atualização da Diretriz de Ressuscitação Cardiopulmonar e Cuidados Cardiovasculares de Emergência da Sociedade Brasileira de	Scielo	Pesquisa Documental	RCP, PCR, saúde	2019



		Cardiologia – 2019				
12	NETO, J. A. C.; BRUM, I. PEREIRA, V. SANTOS, D. R.; L. G.; MORAES, S. L.; FERREI, R. E.	Conhecimento e Interesse sobre Suporte Básico de Vida entre Leigos	International Journal of Cardiovascular Sciences. 2016	Coleta de dados	Ressuscitação Cardiopulmonar, Coleta de Dados, Educação em Saúde, Serviços Médicos de Emergência	2016
13	FARIA, H. T.G.; SCHMIDT, F. M.Q.; GONÇALVES SILVEIRA, J. S. S;	Suporte básico de vida para alunos da rede municipal de ENSINO	Scielo	Relato de Experiência	Educação em enfermagem; Parada cardíaca; Ressuscitação cardiopulmonar.	2015
14	PEREIRA, K.C	A construção de conhecimentos sobre prevenção de acidentes e Primeiros socorros Por Parte do público leigo	BDENF	Estudo transversal	Prevenção de acidentes; primeiros socorros; Ensino.	2015
15	ROVISCO; et al	Assessment of Knowledge and Self Efficacy before and after Teaching Basic Life Support to Schoolchildren	Scielo	Estudo Prospectivo Longitudinal	Learning; Education; Cardiopulmonary resuscitation; Child	2020
16	Kuvaki, B.; ÖZBILGIN, Sule	School Children save Lives	PubMed CentralUS National Library of Medicine	Revisão Bibliográfica	School children, basic life support, education, cardiopulmonary resuscitation	2018
17	COUTO, C. S.; NICOLAU, A.	Conhecimento do público Geral em Suporte Básico de Vida: Um Estudo Piloto com uma Amostra Portuguesa	Acta Med Port	Transversal, exploratório e descritivo	Conhecimentos, Atitudes e Prática de Saúde; Reanimação cardiopulmonar/educação; Sistema de Suporte de Vida	2019
18	GONÇALVES, J. M., et al.	Ensino de Suporte Básico de Vida para Alunos de	Scielo	Longitudinal e prospectivo	Ressuscitação Cardiopulmonar, Educação, SBV, Estudantes do Ensino	2014

		Escolas Públicas e Privadas do Ensino Médio			Médio	
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### III. RESULTS AND DISCUSSION

Among the references cited in table 1, in relation to the year of publication, there were three (3) articles from the year 2014 and three from 2015, in the years 2016, 2018, 2019 and 2020, two (2) articles from each year were found and four (4) articles from 2017. All the selected production is part of the health area, presenting diversity in relation to the research context, which involved the importance of qualification and training of lay people in the teaching of Basic Life Support (BLS), emphasizing special attention to community training. school, in the form of theoretical and practical training on the first care of a victim of cardiac arrest.

The reading of the entire scientific production chosen made it possible to contemplate the researchers' concern in the adoption and development of facilitating resources for the training of the school community and in the implementation of training as part of the first care for the victim of CRA and to reduce sequelae until the moment of arrival of a qualified professional.

The studies that constituted the units of analysis have a variety of authors, publication sources and countries of origin of the studies. As for the sources of publication, the concentration of articles in the journal "Resuscitation" stands out, where seventeen (94.4%) of the eighteen (100%) articles included in this study were found, only one article was found in the journal "American Journal of Emergency Medicine". The number of samples studied ranged from 09 to 823 subjects in studies that used applied methodology; in exploratory studies, 2932 subjects were investigated.

The study demonstrates that CPR is one of the most common causes of death in the world, affecting mainly adults with comorbidities or young people after trauma, and in children it is more associated with lack of oxygen due to respiratory problems (airway obstruction).

Lyra, Priscila et al; Monteiro Maria de Lourdes et al and Kuvaki, Bahar et al, believe that the earlier this knowledge and its applicability in Schools or Training Centers, the more effective the training will be, leading to a better awareness and acceptance of the population of the importance of this subject – save lives and reduce irreversible sequelae -. For this, this training must be applied annually for 2 hours and repeated every year with theoretical-practical classes.

Most authors analyzed that the lay population does not have sufficient knowledge about BLS or incorrect knowledge, which can lead to worse care and damage to life. Intensifying the importance and appreciation of educating a population about BLS for a better diagnosis of a patient in CRA and, therefore, a correct first care. They also report that everyone should be instructed that after the initial care they should call for help from a specialized support. When they present a correct sequence of care, the survival rate increases and consequently the risk of death.

Pergola, Aline et al; reports that many laypersons do not know how to position the victim for a correct external chest compression, as well as they are unaware of which region of the body to massage, further intensifying the need for training to act more effectively and increase survival.

Of the cited references, 18 (88.88%) cite that educational techniques with children and adolescents are exposed as measures to develop healthy behavior, which creates a field to be explored by health professionals. The advantage of training in BLS with children under fourteen is the fact that knowledge is introduced early, reducing their fear when performing maneuvers in an emergency situation in the community (FONTES; et al, 2010). In addition, 10 publications (55.55%) of the studies report that for adults, it was evidenced that training in basic life support reduces fear/anxiety, however, it is clear that practical updates need to occur regularly to preserve quality. of care with low retention of cardiopulmonary resuscitation knowledge and skills (CALLEGARO, 2018). The importance of training family members of cardiac arrest survivors was also highlighted, in order to seek to increase the safety and performance of cardiorespiratory resuscitation maneuvers.

In addition to the results obtained in the studies, there is evidence that a well-trained layperson can be as effective in cardiopulmonary resuscitation as any trained professional. In addition, they believe that courses lasting less than four hours are effective for training lay people, although studies highlight the need for periodic updates to maintain the skill (OLIVEIRA, 2018).

Of the publications mentioned in table 1, the majority state that the courses carried out in stages are more effective than the traditional ones where all the stages of the SBV are taught in a single class. In addition, theoretical-practical courses are more effective for training

lay people (CHEHUEN NETO; et al, 2016). The use of equipment with audible or visual alert, such as a dummy with software and an external automatic defibrillator with a visual or audible device, proved to be efficient for carrying out training after a theoretical course, and this fact contributes to the inclusion of citizens with hearing impairment.

According to Victorelli (2013) the training of lay people in basic life support is a concern of health agencies at an international level. The search for evidence of the effectiveness of BLS training presented by the researched studies becomes difficult to generalize due to the diversity among the populations studied. However, it should be noted that there are indications of effectiveness in the courses developed that were pointed out in the articles studied. Training in basic life support for the lay population increases their safety and attitude in the face of an emergency situation prior to the arrival of the professional team.

#### IV. FINAL CONSIDERATIONS

It is of fundamental importance to encourage and expand discussions for the creation of a subject in the curriculum of each country, on BLS. Thus, students would develop skills to face emergency situations (da Silva et al, 2017). This learning must be permanent, with theoretical-practical content and the construction of scenarios close to real situations. In order to further stimulate the teaching-learning process and absorption of lay people, by working and training various skills and competences of the public. (MAIA et al, 2020).

Health education is an instrument for exchanging knowledge between health professionals and the population. This leads to the search for the autonomy of the Being as a transforming element of its reality. This is a complex involving the biological Being and its social contexts. (PEREIRA et al, 2015).

The posture of an individual trained in BLS, in any emergency situation, will determine how the victim's recovery will be, making the difference between life and death. The importance of access to information on how to act in emergency situations and immediate care is concluded. (PEREIRA et al, 2015).

In view of the above, we can conclude that the knowledge and training of the population in BLS is of fundamental importance, to minimize the number of deaths and irreversible sequelae in case of CA. Such knowledge must be developed within the scope of the school community, which is the basis of education and training of

a Human Being, leading to a significant impact on the survival of the person who is suffering a CPA.

In this sense, qualified help with theoretical and practical training is necessary, including aspects related to the importance and way of functioning of assistance networks in case of emergency, such as the Mobile Emergency Care Service (SAMU). Bearing in mind that one of the principles of the Unified Health System (SUS) is popular participation for the promotion, prevention and maintenance of health, it is worth noting that training the population in first aid and risk assessment in emergency situations contributes significantly to the reduction of injuries and mortality of the very people who make up society.

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# PEU method: An analysis of its applicability and implementation limitations in Brazilian companies

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**Keywords** — PEU; Production Effort Unit;  
Equivalence Models.

**Abstract** — This study analyzes the intellectual production on the PEU Method in the last 20 years and seeks to identify the main characteristics related to the applicability and limitations of the PEU method in various national economic sectors. Consists of a revisionist study on the evolution and use of the PEU method in Brazilian companies, developed through the analysis of empirical studies published on the subject. analyzes are performed using descriptive statistics. The research results confirmed that the implementation of the PEU Method was possible in all economic activities (Bibliographic Portfolio) analyzed, whenever used in environments related to production, and that its implementation provided important information for management control. The relevance of the study is based mainly on the new economic contexts and the evolution of production processes, where the costing methods traditionally used have been shown to be inefficient in generating useful information for decision making.

## I. INTRODUCTION

In the process of management, control and measurement of results, accounting has always sought to adapt to market dynamics and new needs and informational speed, changes that resulted from the development of innovative and relevant practices for management and cost accounting.

Thus, cost accounting, which initially emerged for the evaluation of inventories and calculation of the result, was improving and started to be used also in the management field, helping control and decision making (Abbas et al., 2016).

With the emergence of a new production system composed of multiprocessor companies in an increasingly complex environment, with shared costs, the costing systems, which were originally concerned with distributing

direct and indirect costs to the products and services originated, began to prove inefficient in the process of measuring and comparing production costs.

In this context, new methodologies emerged with relevant approaches that foresaw the use of equivalence methods to measure production in multi-producer companies (Bornia, 2010; De La Villarmois & Levant, 2007; Levant, 2001). Among such methods, the Time-Driven Activity-Based Costing - TDABC, the Unité de Valuer Ajoutée - UVA and the Method de Georges Perrin - GP can be found in the literature, the latter being a precursor in Brazil of the Production Effort Units method. – PEU, which aim to enable a single comparison of production, regardless of the items produced in terms of variety and quantity (Ferrari & Borgert, 2015). Later, in view of the limitations of some costing methods, the

literature began to show evidence of the need to use hybrid models that contain more than one costing methodology.

The emergence of new costing methods, understood as something inherent to the evolution of organizational reality, has still encountered some barriers in their use, such as their applicability, limitations, doubts about compliance with tax legislation and especially, the habitual use of traditional methodologies.

Some studies have tried to mitigate these factors, some comparing the applicability of costing systems (Wernke et al., 2019; Abbas et al., 2016; Wernke et al., 2015; Machado et al., 2006), evaluating its applicability in conjunction with other methods (Kremer et al., 2012; Silva et al., 2009; Sabadin et al., 2007) and verifying the adequacy of costing methodologies to tax legislation (Schultz et al., 2012).

However, it is noted that the amount of research on the use of the PEU methodology is still very limited when compared to other costing methods, such as ABC costing (Zanievycz et al., 2013), making it a very promising field in terms of research opportunities (Ferrari & Borgert, 2015), mainly regarding its applicability and implementation possibilities in different economic sectors.

Thus, in order to contribute to the literature on equivalence methods, this study aims to investigate the main similarities related to the applicability and limitations in the process of implementation or execution of the PEU method in Brazilian companies. The analyzes were developed from research with a qualitative approach carried out through the review of a Bibliographic Portfolio (BP) composed of 39 articles published in the main national cost accounting journals and congresses.

The relevance of the study is based mainly on the new economic contexts and the evolution of production processes, where the costing methods traditionally used have been shown to be inefficient in generating useful information for decision making.

At another point, the work is justified by the low representation of publications on the PEU in journals in the Accounting and Production Engineering areas (Wernke & Rufatto, 2019), where searches carried out with the descriptors "PEU", "unit of production effort", "units of production effort", "equivalence models" and "equivalence methods" on the CAPES journal portal resulted in only 19 results (within a horizon of 20 years), pointing to a vast field of research opportunities, mainly due to the need for a better conceptualization of the method (Ferrari & Borgert, 2015).

Finally, this study hopes to contribute to a greater diffusion of the PEU method beyond the southern region of the country.

## II. THEORETICAL REFERENCE

Costing methods are sets of techniques – or models – used to determine the costs of products and services (Schultz et al., 2012) and, consequently, measurement of business results. There are several approaches for determining the costs incurred, where the literature has classified them as traditional or contemporary.

Among the traditional methods, Johnson & Kaplan (1987), Brimson (1996), Kaplan & Cooper (1998) and Meglioni (2012) mention Absorption Costing, Homogeneous Section Methods – RKW and Variable Costing; and as contemporary methods, the Costing per Production Unit - PEU, the Activity-Based Costing - ABC and more recently (in 2001), the Time-Driven Activity-Based Costing – TDABC (Abbas et al., 2016).

Accounting practice has shown greater preference for the use of Absorption Costing, ABC Costing and Direct Costing (Silva et al., 2009), with emphasis on the first. Although the literature points to criticisms regarding its use, mainly due to the low quality of the information provided when compared to other costing methodologies (Kaplan & Cooper, 1998) and its inefficiency for decision making, the Absorption costing has some advantages.

Among them are: being a method that meets fiscal requirements, its low implementation complexity when compared to other methods, having its applicability increased as the proportion of indirect costs decreases, having increased applicability as the The number of products decreases, which tends to explain why the method is still the most used by medium and large companies in Brazil (Abbas et al., 2015; Frezatti, 2005).

Several factors may have contributed to the preference for using Absorption Costing in financial accounting, among which the literature points out (i) the divergent understanding of concepts and terminologies, (ii) the tradition of its use and (iii) the scarcity of studies on other methods for tax purposes (Schultz et al., 2012).

As for the first factor, the cost area has two distinct approaches: the managerial one, which provides information for planning and controlling costs; and the fiscal, which provides information for valuing inventories and determining the result.

It happens that this last approach, as it establishes that both direct and indirect costs must be allocated to the products and services produced or performed (Schultz et al., 2012), tends to appropriate some expenses that are not

directly related to its elaboration (or realization). This creates conflict with a series of concepts and terminologies that shape cost accounting, which is why it is common for there to be discrepancies between the results reported by management and fiscal reports.

As for tradition, until the 1970s, Brazilian accounting still had a discussion about the adoption of two costing methods, Absorption Costing, which allocates both direct and indirect costs to products and services; and Variable Costing, which allocates only variable or direct costs to products and services, treating indirect costs, even if linked to production, as expenses for the period (Schultz et al., 2012).

With the enactment of Law No. 6,404/76 and Decree-Law n°. 1,598/77, Brazilian accounting was faced with new accounting and tax guidelines, especially with regard to the concepts of product costs (which, according to the rule, include both direct and indirect production) and control and evaluation of stocks. Due to the fact that it does not foresee the appropriation of indirect costs to products, Variable Costing became incompatible with the tax rules in force, Brazilian accounting chose to use the “only” method that met the legislation: Absorption Costing (Schultz et al., 2012).

It is important to note that tax legislation provides for the incorporation of indirect costs into products, but does not require the use of a specific method, that is, it does not require the use of Absorption Costing.

However, even after other costing methods were disseminated in Brazil (Contemporary Methods), the tradition and preference for the use of Absorption Costing remained (Abbas et al., 2015; Silva et al., 2009; Frezatti, 2005).

Finally, there is the lack of studies on the use of other methods. The increase in competitiveness among global companies verified from the 1980s and during the 1990s, the growing demand for more accurate information in response to the problems generated by the continuous expansion of the proportion of fixed costs resulting from the modernization of industrial parks (Schultz et al., 2012) made other costing methods (PEU, ABC and TDABC) appear and started to be disseminated and used by management accounting. Although these methods bring managerial advantages and innovations, and make it possible to absorb costs (which makes them susceptible to use by financial accounting for the purpose of valuing product inventories and, consequently, the result for the year), as they were introduced in parallel with the

Absorption costing (as it satisfactorily meets the needs of financial accounting), little has been invested in studies on the use of contemporary costing methodologies for tax purposes.

Following this line, the Brazilian literature in the area of costs, when it comes to analyzing and comparing costing methods, has prioritized comparisons involving the most known methodologies (Absorption costing, Variable/Direct and ABC), with little attention to other contemporary methodologies (TDABC and PEU methods) in terms of comparative studies (Wernke et al., 2019), although there has been an increasing use of these new models in companies. In this context, there is a need for more studies that explore the use, applicability and limitations of contemporary costing methodologies in business environments.

Finally, considering the fact that the ABC method is much better known and disseminated in the literature and in organizations than other contemporary methods, and because TDABC represents only a new approach to ABC, this work chose to investigate the only equivalence model proposed by the methodology of the PEU, analyzing in a revisionist way its applicability and limitations in several sectors of the Brazilian economy.

## 2.1. Origin and Development of the Production Effort Unit – PEU.

Predecessor of the GP and UP methods, the PEU method had its emergence linked to the theoretical concept of unifying the measurement of industrial production through a single unit of measurement, the production effort (Sakamoto et al., 2001; Allora & Allora, 1995). It seeks, in short, to create a unit of measure common to all the company's products and processes (Wernke et al., 2013), able to quantify products of different natures as if they were the same (Silva et al., 2009), allowing to compare the degree of efforts needed to complete them (Wernke & Rufatto, 2019).

Its theoretical conception is based on the notion of production effort, that is, effort performed by a working machine, human effort, capital effort, applied energy effort and others directly and indirectly applied (Sakamoto et al., 2001).

In this way, the PEU is basically concerned with the transformation costs (Wernke et al., 2019; Bornia, 2010), based on 03 (three) principles: (i) Consistency of Relationships, (ii) Stratifications and (iii) Added Value (Allora & Oliveira, 2010), as shown in figure 01.

Principle of Consistency of Relationships	•It is assumed that "a strictly defined operational post has a certain productive potential, which will not vary over time if the post's characteristics remain the same".
Principle of Stratifications	•It defines that "for the calculation of the productive potential of the operational stations, only cost items that provide some degree of differentiation between these productive potentials should be considered".
Added Value Principle	•He asserts that the "product of a factory is the work it performs on raw materials and is reflected in the value that is added to these raw materials during the production process, with profit being the amount of money more than the company he earns by selling his work".

Fig.1. Characterization of the principles of the PEU method.

Source: Allora & Oliveira (2010).

Finally, regarding the PEU implementation process, the literature states that it occurs in six stages, as shown in

Figure 02, which include the calculation of the factory's total production in the period in terms of PEUs.

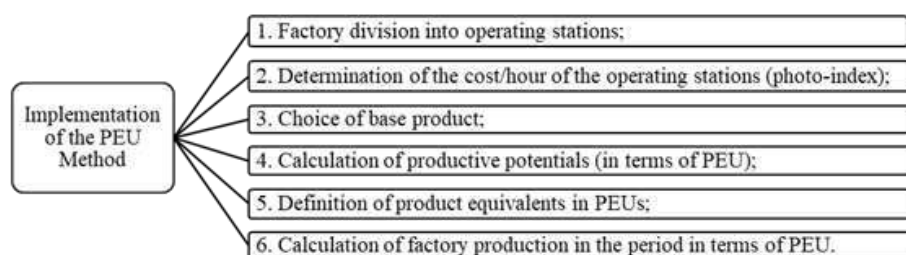


Fig.2. Implementation Steps of the PEU method.

Source: Bornia (2010). Adapted by the authors.

2.2. Characteristics of the PEU Method to be analyzed.

At this stage, some questions were formulated in order to make it possible to investigate, in a revisionist way, the applicability and limitations/difficulties of the PEU method in national companies.

First, it should be noted that the Production Units system deals with the introduction of a Production Effort Unit in the company, through which it measures the efforts of all productive activities in the factory (Allora & Allora, 1995). In this way, the PEU only works with the transformation costs (Bornia, 2010), tending to be applicable only to the industrial environment (Pereira, 2015). Thus, regarding the applicability of the PEU, it is expected to verify, in a revisionist way, whether it is also applicable to other economic segments, evaluating the following point:

*Q1: Based on the BP, did the PEU prove to be applicable to other economic segments?*

The implementation of the PEU method, according to Wernke et al. (2019), Wernke et al. (2018), Guimarães Filho et al. (2016), Pereira (2015) and Souza & Diehl (2009) takes place in six phases: (1) division of the factory into operational stations; (2) determination of the cost/hour per operating station; (3) choice of base product; (4) calculation of the value of the PEU/hour of each operating station; (5) definition of product equivalents in PEUs and

(6) calculation of total factory production in the period in terms of PEUs.

In this implementation process, the literature has alerted for greater attention to the first three stages, since the process demands the team's ability to analyze, due to the particularities of each company (Oenning et al., 2010) and the need to determine the base product, where the subjectivity of the method is (Malaquias et al., 2007). In this context, in order to evaluate the level of detail of the application of the method in the analyzed companies (BP), the following research question arises:

*Q2: Based on the BP, did the studies consistently show the stages of implementation of the PEU method, with strong attention to the first three stages of implementation?*

Evaluating the characteristics of the PEU methodology, its contribution to production management is noted. The method is useful for analyzing and managing production processes and evaluating performance (Martins & Rocha, 2015) and provides information on the use of productive capacity in terms of efficiency and effectiveness and productivity (Bornia, 2010; Biasio & Monego, 2005), making it possible to maximize production, manage physical constraints and analyze product profitability (Werne, 2012).

The definition of operational stations and the measurement of production in PEU's allow the generation



of indicators of installed capacity and idleness (Confessor et al., 2015), offering subsidies for carrying out simulations of scenarios (Nascimento, 2012), comparing its historical evolution. In this way, other questions for investigation arise:

*Q3: Based on BP, did the PEU method provide relevant information for management control with regard to performance analysis (Efficiency, Effectiveness and Productivity)?*

*Q4: Based on BP, did the PEU method make it possible to perform scenario simulations, making the decision-making process more effective?*

On the other hand, the PEU method is more applied as a costing tool that supports production management, providing better control and planning of manufacturing processes, cost reduction and, consequently, a more competitive sales price (Biasio & Monego, 2005). It is useful for evaluating performance, costing products and even setting sales prices (Martins & Rocha, 2015) and analyze and profitability of products (Werne, 2012). In view of the above, the following propositions arise to be tested on the applicability of the PEU in national companies:

*Q5: Based on the BP, did the PEU method provide relevant information for management control with regard to the pricing issue?*

*Q6: Based on the BP, did the PEU method provide relevant information for management control with regard to the costing item?*

Another point to be highlighted is that the PEU encounters problems with regard to the total cost of products, since it does not apply to the measurement of operations that are not directly related to the production process (Beuren & Oliveira, 1996). Thus, by working only with the transformation costs, it may present problems in defining the total cost of the products, which could be mitigated by the implementation in conjunction with other costing methodologies.

In this optics, Silva et al. (2009) and Beuren & Oliveira (1996) comment that for a Costing System to meet the needs of generating information in organizations, it is necessary to use a Costing Method or the combination of more than one of them. Thus, with a view to evaluating the possibility of integrating the PEU together with another costing methodology, the following question arises:

*Q7: Based on the BP, have the studies proven the joint applicability of PEU with other costing methods (Absorption, ABC, TDABC, etc)? Which one(s)?*

Analyzing the limitations/difficulties of use/application of the PEU method, the literature cites that,

as it focuses only on the determination of the transformation cost, it is difficult to apply in companies that have a significant portion of administrative expenses (Werne, 2012). In this context, we have the following research question:

*Q8: Based on the BP, did the PEU method encounter difficulties in use / application due to the relevance of administrative expenses compared to total expenses?*

Other limitations of the PEU method include its high complexity and cost of implementation (Pereira, 2015), requiring a specific system to support the processing and data, in addition to not identifying the portion of costs associated with process losses. Therefore, we have the following questions to check:

*Q9: Based on BP, did the PEU method present high implementation complexity?*

*Q10: Based on BP, did the PEU method present a high implementation cost, either due to the need to formulate usual procedures or due to the need for a specific system to support data processing and information analysis?*

*Q11: Based on the BP, did the PEU method present difficulties in the treatment of waste?*

One of the foundations of the PEU methodology is the “principle of constant relationships”, which states that an operational post has a certain productive potential that does not change over time, as long as its characteristics remain constant (Kliemann Neto, 1994). Thus, the PEU presents difficulties of application in companies where the products vary regularly and needs constant revision of the calculations and the production structure (Pereira, 2015). In this way, industrial companies with production to order, whose products are NOT repetitive, where it is not possible to establish a common unit of measurement of production, are unable to use the PEU (Bornia, 2010).

Other limitations of the method reside in the difficulty of finding (determining) the relationships between the work required by the various products of the company and of measuring the production efforts, as it is an abstract concept (Bornia, 2010), and by the subjectivity present in the determination of the base product (Malaquias et al., 2007), although recent works indicate that, regardless of the base product chosen, there is no change in the final value allocated to each product in terms of unit cost of transformation (Moterle et al., 2020). In this context, the last questions to be analyzed are formulated:

*Q12: Based on the BP, did the PEU method present difficulties arising from the preservation of the 'principle of constant relations' and the need for constant revision of the calculations arising from changes in the production structure?*

*Q13: Based on BP, did the PEU method encounter difficulties in using / applying the method due to product variability?*

*Q14: Based on BP, did the PEU method find it difficult to measure production efforts?*

Finally, Appendix 01 presents a summary of the issues evaluated regarding the applicability and limitations of the PEU methodology in various sectors of the Brazilian economy.

### III. METHOD

The methodology adopted in this work consists of a revisionist research on the use of the PEU method in Brazilian companies, developed through the analysis of empirical studies published with the theme "Production Effort Unit" between 2001 and 2020, available on the CAPES journal portal and in cost congresses.

As for the approach, it is a qualitative research with a descriptive approach, and seeks to identify the main characteristics and similarities related to the applicability and limitations of the use of the PEU method in various national economic sectors.

In the data collection stage, articles published in journals and in national congresses were selected. To this end, a systematic review was carried out in the Capes journal databases, especially the "Web of Science" and "Scopus", using the following search words: "unit of production effort", "PEU", "equivalence models", "equivalence methods" and "hybrid costing", being necessary that, in the process of searching in the journals, these words were found either in the title, or in the abstract or in the keywords of the studies related to the topic.

As a cut-off criterion, only national case studies that dealt with the PEU theme published in the last 20 years (from 2001 to 2020) with an empirical approach were selected. The choice of empirical national studies was due to the fact that its purpose was to be able to review and evaluate the evolution of the use of the PEU method in Brazil and other characteristics such as applicability and limitations in the national market.

The preliminary survey provided an initial base with 65 works, including 46 case studies, which were filtered in order to parameterize the Bibliographic Portfolio (BP) to be analyzed, resulting in 39 distinct economic activities composed of 19 works published in several national magazines, 14 works published in the Brazilian Congress of Costs, 02 works published in the International Congress of Costs and other 05 works presented in events.

Once the BP was defined, it was sought through the theory of measurement to attribute objective properties to

the characteristics found in the analyzed journals. Thus, it was decided to map and measure the descriptive elements present in the text, using the measurement theory, transforming the observations reported in the texts into Nominal Scales.

In order to parameterize the criteria for measuring the applicability and limitations of the PEU method in various economic sectors, a research guide was developed to collect information, in an electronic form, where the authors, responsible for the interpretations, at the end of reading the journal they had to enter their perceptions in the collection form, following a Likert scale of options.

For the elaboration of the research guide (form) for collecting the information, a preliminary literature review on the topic was carried out (PEU method), generating an initial instrument with 39 investigation items. Then, the instrument was submitted to the analysis of 2 experts with solid knowledge in the PEU methodology for content validation, generating a final instrument with 14 investigation items, in addition to other items necessary to identify other characteristics relevant to BP, such as identification of the sector or economic activity analyzed, for example.

As it deals with the researcher's perceptions and interpretations regarding the content present in the text of the articles, one of the limitations present in this research was the evaluator's subjectivity regarding the interpretation of the item and its measurement. However, in order to reduce this limiting factor, the information collection script had a three-level response scale, detailed in Appendix 03, in addition to the option "not applicable", when there were no reports about a certain item studied in the article.

Finally, once the information was collected, a descriptive analysis of the results was carried out, where it was possible to review the evolution of the applicability of the PEU method in recent years in Brazil, presented in the next section.

### IV. RESULTS AND DISCUSSIONS

4.1 Results of the Analysis of the Applicability of the PEU method in national companies

The first stage of analysis focused on evaluating similarities regarding the applicability / use of the PEU method in the economic activities (BP) analyzed.

A preliminary analysis showed that, although the literature points out that the method shows a strong tendency to be applicable only to the industrial environment, the research results revealed the existence of its applicability in other economic sectors (especially in the service sector), as can be seen visualized in Figure 03,

especially when Transformation Costs represent the largest proportion of Total Expenses, as shown in Figure 04.

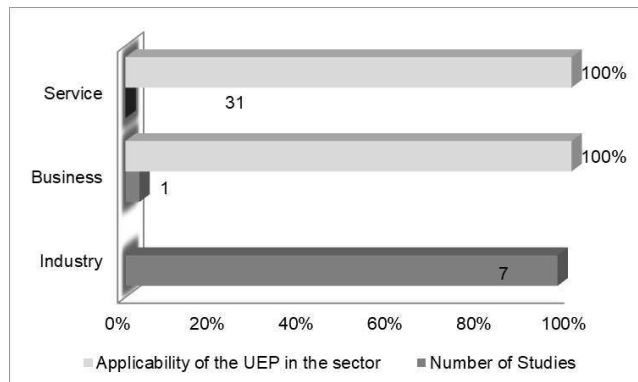


Fig. 3. Assessment of the Applicability of the PEU Method in other economic segments.  
Source: Prepared by the authors.

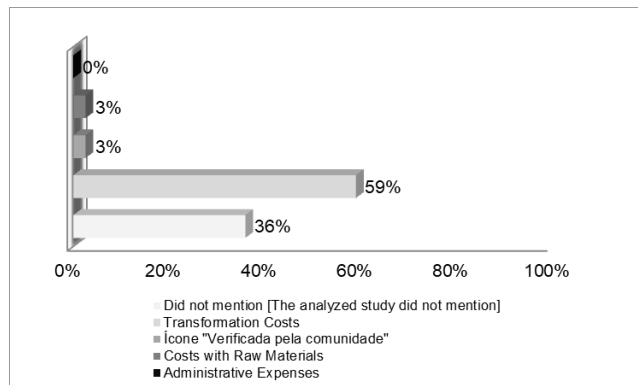


Fig.4. Breakdown of Total Expenses  
Source: Prepared by the authors

As can be seen in Figure 03, there is a predominance of studies on the use of PEU in the industrial sector (31 articles or 79% of the BP), followed by the services sector (7 articles or 18% of the BP) and an insignificant number of studies that assess its applicability in commerce (1 article or 3% of the BP). However, all studies indicated its applicability (100%) in the analyzed economic sector.

In the analyzes referring to the service providers, the operational stations were replaced by “activity effort measures (MEA)” of each sector, enabling the implementation and application of the PEU method.

Another characteristic found in the research was that the enterprise analyzed in the “commerce” segment tested the applicability of the PEU in only one department of the company, the pizza preparation sector, as it has the desirable characteristics for the application of the method (transformation process).

Figure 04 complements the analysis by providing the relative percentage of the composition of expenditures on its total structure. It is noted that, of the economic activities analyzed, 59% have greater representation of

transformation costs in their expenditure structure; 35.9% of the studies did not mention this composition; 2.6% have the three types of expenses in similar proportions and 2.6% have a greater representation of raw material costs.

None of the studies indicated the applicability of the PEU method in economic activities with greater representation of administrative expenses over the others, corroborating the theory. It is also worth mentioning the expressive proportion of studies that did not mention this composition explicitly or implicitly (35.9%), which makes a deeper analysis difficult.

Evaluating the consistency of the methodology implementation process in the analyzed enterprises and the applicability of the method in conjunction with other costing methods, this research found the following results (figures 05 and 06).

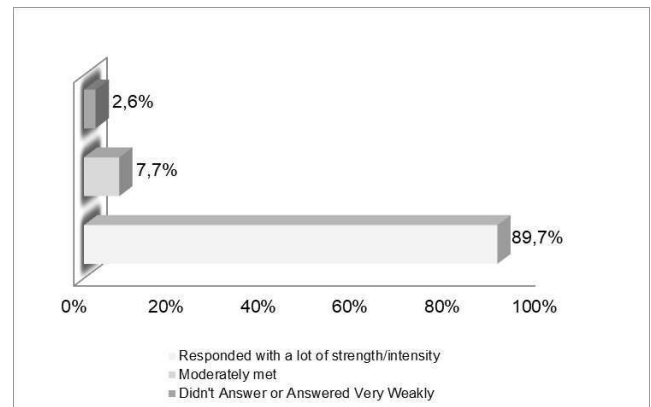


Fig.5. Evaluation of the consistency of the implementation steps of the PEU method.  
Source: Prepared by the authors.

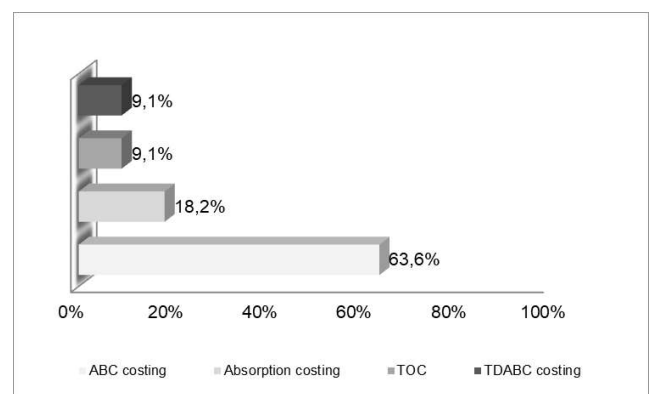


Fig.6. Assessment of applicability in conjunction with other costing methods.  
Source: Prepared by the authors.

As can be seen in Figure 05, most studies (89.7%) consistently showed the stages of implementation of the PEU method, with strong attention to the first three stages of implementation; 7.7% presented them in a moderate way (without much emphasis or in a summarized way) and

only 2.6% did not give much importance to reporting or describing the implementation stages in the enterprise object of study.

The results obtained regarding the consistency of the stages of implementation of the PEU demonstrate the feasibility of future research in the segments included in this work (BP), with the possibility of replication in other segments, enriching the literature on the PEU Method.

Regarding the aspect of its applicability in conjunction with other costing methods, the results showed that 71.8% of the studies did not attempt to carry out this evaluation and 29.2% had this objective. Of this contingent, the results presented in Figure 06 show that 63.6% of the studies evaluated its applicability in conjunction with the ABC method; 18.2% evaluated its applicability in conjunction with Absorption Costing and 9.1% evaluated its applicability in conjunction with the TOC method or TDABC Costing.

In this way, it is noted that there is a greater concentration in studies that evaluate the use of the PEU in conjunction with the ABC Costing, and if we consider its new approach (TDABC), this percentage reaches 72.7%, all these contemporary methodologies of cost.

Evaluating the quality of the information generated by the PEU for the evaluation of business performance and simulation of scenarios, the following results were found (figures 07 and 08).

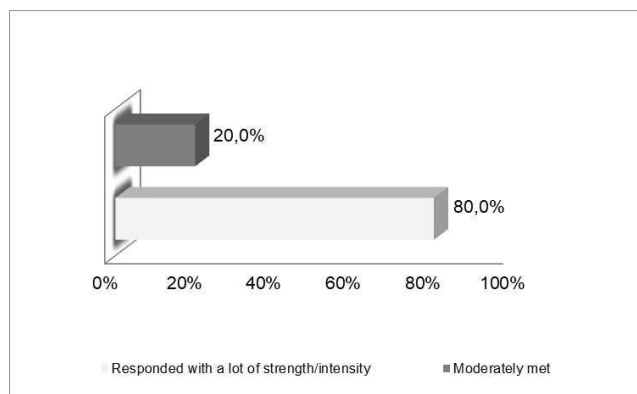


Fig.7. Assessing the applicability of PEU information for performance analysis.

Source: Prepared by the authors.

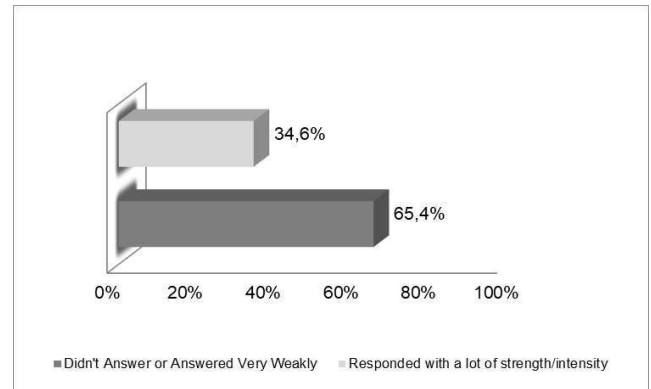


Figure 08. Evaluation of the possibility of performing scenario simulations.

Source: Prepared by the authors.

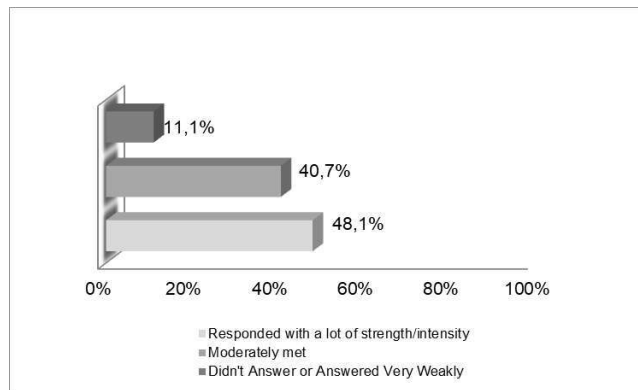
Regarding the aspect of information generated by the PEU for performance analysis, 23.1% of the studies did not attempt to carry out this evaluation. Of the works that were proposed (76.9%), presented in Figure 07, the results indicate that in 80% of the studies, the quality of the information generated by the PEU had strong applicability for the analysis of performance; another 20% pointed out that the information generated partially met.

The possibility of carrying out this analysis with the wealth of data from the calculations at the operating stations is one of the strengths of the PEU method and shows, in a substantial way, its importance for the management of the company.

As for the possibility of simulating scenarios, 33.3% of the studies did not attempt to carry out this evaluation and 66.7% had this objective. Of this contingent, figure 08 shows that in 34.6% of the cases, the studies reported that the implementation of the PEU made it possible to significantly simulate scenarios; another 65.4% pointed out that the information generated did not meet or met very poorly.

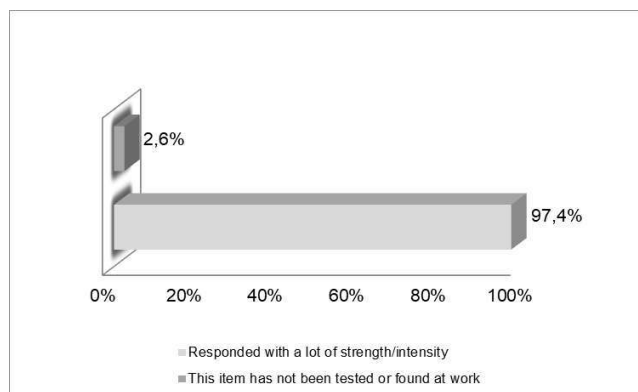
What was verified in the vast majority of articles was the analysis of data from a company with the authors' option of not simulating scenarios. That is, the focus was always directed to the data obtained in a given production process.

The results obtained regarding the analysis of the quality of information for the management of the sales price or costing of products/services are presented in figures 09 and 10.



*Fig.9. Assessment of the ability to generate information relevant to Pricing.*

Source: Prepared by the authors.



*Fig.10. Assessment of the ability to generate information relevant to Costing.*

Source: Prepared by the authors

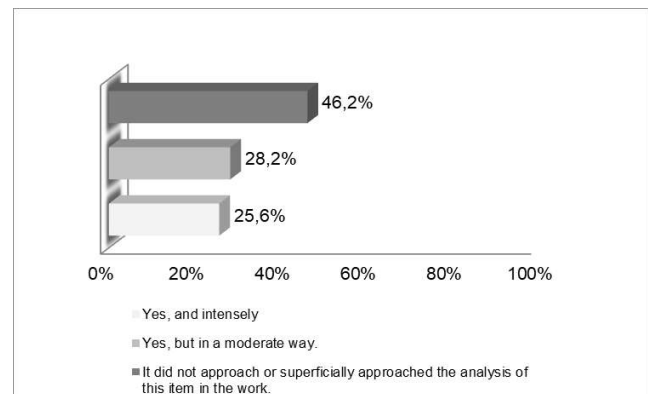
The results obtained found that in 69.2% of the studies, the information generated by the implementation of the PEU was used for pricing (the other 30.8% did not analyze this item). Of this contingent (69.2%), figure 09 shows that 48.1% strongly complied with this requirement; 40.7% responded moderately and 11.1% did not respond or responded very poorly.

Analyzing the method's ability to generate information relevant to costing, the results presented in Figure 10 demonstrate that in 97.4% of the studies, the PEU method met this requirement very intensively and in only 1 case (2.6% of the sample ) this item did not generate such information, since the implementation work could not be completed, as they were waiting for the availability of a database for management reports.

Finally, the results found related to these two items, Costing and Pricing, clearly demonstrate the wealth of information generated by the implementation of the PEU and its strong contribution to the decision-making process.

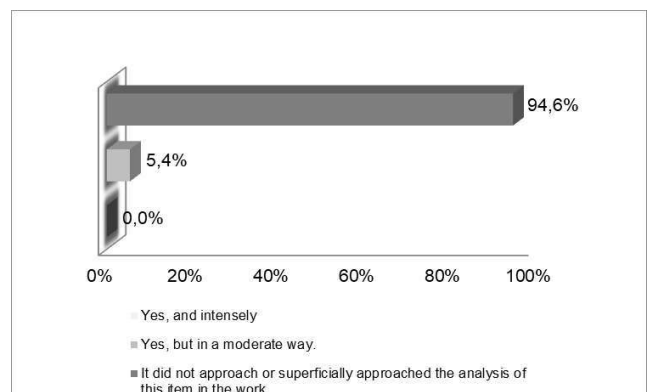
#### 4.2 Results of the Analysis of Limitations / Difficulties of the PEU method.

The second stage of analysis focused on evaluating the main difficulties in implementing the PEU method in various national economic sectors. The results regarding the analysis of the level of complexity and cost of implementation can be seen in figures 11 and 12.



*Fig.11. Assessment in the level of Complexity of implementation of the PEU in the analyzed companies.*

Source: Prepared by the authors



*Fig.12. Evaluation of the cost of implementing the PEU in the analyzed companies.*

Source: Prepared by the authors

Analyzing the results presented in figure 11, note that 46.2% of the studies did not or only superficially approached the analysis of this item in its scope. Of the studies that had this concern (54.8%), almost half of the studies (25.6%) indicated that the method had high implementation complexity in the studied enterprise and the rest (28.2%) indicated moderate complexity.

With regard to the cost of implementing the PEU (figure 12), most of the studies analyzed (94.6%) did not or only superficially approached the analysis of this item and the rest evaluated these costs as moderate.

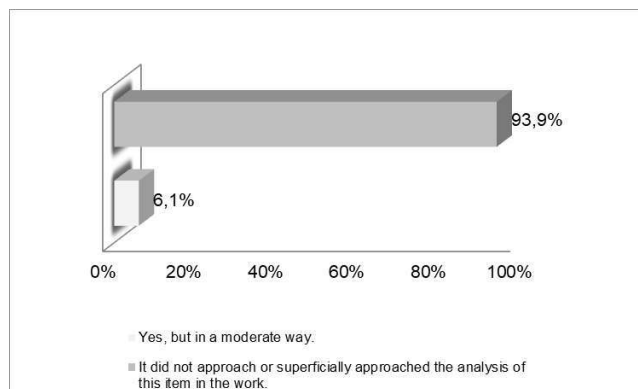
It is worth noting that the disparity between the two results obtained: while the complexity in the implementation proved to be high or moderate in all the cases that addressed it, proving to be one of the main



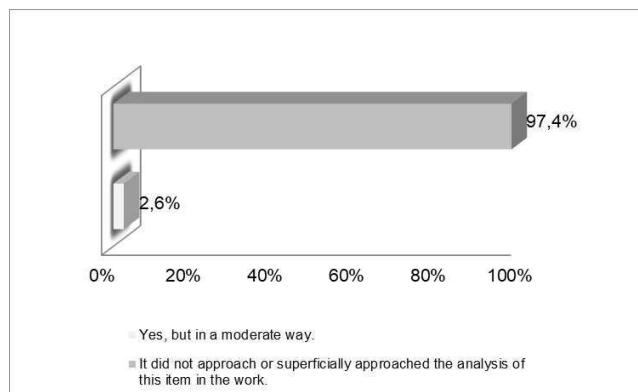
difficulties for the implementation of the PEU method, mainly due to the need for measurement of the operative stations, on the other hand, the cost of this implementation was moderate, but with an unrepresentative sample (5.4%).

Despite this result found, this cost should not be discarded, as it is believed that implementation costs are proportional to the level of complexity, mainly because it requires greater qualification and experience of the professionals involved in these consultancies.

The results regarding the analysis of the need to formulate usual procedures or the need for software and its contribution to the treatment of waste are presented in figures 13 and 14.



**Fig.13. There was a need to formulate usual procedures or a need for software.**  
Source: Prepared by the authors.



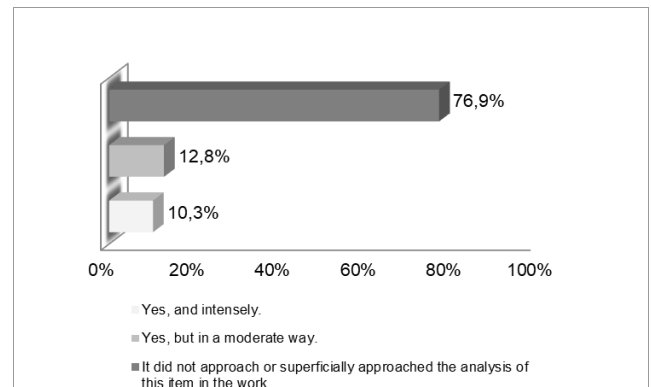
**Fig.14. Assessment of difficulties in the treatment of waste.**  
Source: Prepared by the authors

Analyzing the results shown in figure 13, it is noted that 93.9% of the studies did not address or superficially addressed the need to formulate usual procedures or the need for software for the implementation of the PEU method. Therefore, the spreadsheets used by the companies were sufficient for the implementation, not requiring a specific program.

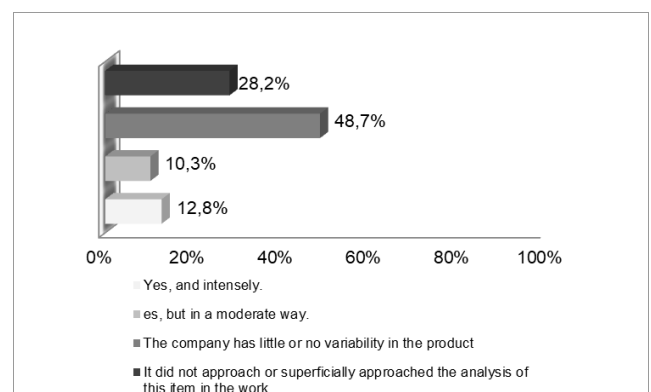
Of the studies that addressed this topic, none reported a strong need for these items. Analyzing the need for waste

treatment (figure 14), 97.4% of the studies did not address or superficially addressed this item in their scope.

Below we present the results of the evaluation of the difficulties arising from the preservation of the 'principle of constant relationships' and the use of the method due to the variability of the product (Figures 15 and 16).



**Fig.15. Assessment of the difficulty arising from the preservation of the 'principle of constant relationships'.**  
Source: Prepared by the authors



**Fig.16. Assessment of the difficulty of using the method due to product variability.**  
Source: Prepared by the authors

Regarding the aspect of difficulties arising from the preservation of the 'principle of constant relationships' (figure 15), the results showed that 76.9% of the studies did not attempt to carry out this evaluation. Of those who evaluated this item, 12.8% found moderate difficulties and another 10.3% reported strong difficulties in the analyzed company.

Regarding the difficulties in using the PEU method in the analyzed companies due to product variability (figure 16), 28.2% did not address this item or approached it superficially and almost half of the studies (48.7%) indicated little or no product variability in the analyzed company. Of the studies that reported this difficulty, 12.8% showed moderate difficulties and another 10.3% indicated strong difficulties.

The fact that most of the companies studied had a restricted line of products caused the lack of difficulty pointed out regarding the preservation of the 'principle of constant relationships' and variability. However, it should be noted that these companies could have several products in their production line, but the authors chose to study only one specifically.

Finally, the study showed that, in general, the analysis of the limitations/difficulties of implementing or using the PEU method proved to be a vast field for further research, since most of the works analyzed did not or only superficially approached these items.

## V. CONCLUSION

This article investigated, through revisionist research, the main similarities related to applicability and difficulties / limitations arising from the use of the PEU Method in national companies and institutions, based on the results of 39 articles (BP) published on the CAPES journal portal and other scientific platforms.

The main result of this article confirmed that the implementation of the PEU Method was possible in all the economic activities analyzed, whenever used in environments related to production, and that its implementation provided important information for management control. It also demonstrated the two ends of the implementation: the benefits and the difficulties, with the benefits being more evident due to the occurrence of several citations of several articles.

In the case of difficulties, a more thorough assessment was not possible, since most of the studies did not or approached the analysis of this item in its scope superficially.

In the analysis of the similarities in the application of the method in the analyzed works, the results showed a strong preference for using it to measure efficiency, pricing and costing, with this last item being the one with the highest intensity (practically all studies), reinforcing the wealth of information it can generate, especially when compared to that provided by traditional costing systems.

The main limitation of this research lies in the subjectivity of the authors' analysis, since the classification of "strong", "moderate" and "weak" depended on the intensity of the presence of phrases and words throughout the text of the article. Even so, some conclusions presented indicate a high degree of precision because of the high recurrence of positive statements in the vast majority of articles, such as the confirmation that the PEU method is applicable in the production process of industries, services and commerce.

Likewise, the lack of citations of certain variables creates a great opportunity for future research, mainly related to the limitations and difficulties present in the method.

Finally, in view of the large concentration of studies related to the PEU method having been carried out by educational institutions located in the southern region of the country, it is believed that a wide dissemination of the method in other HEIs can contribute to increasing the number of companies studied. , meet specific demands from other regions or economic sectors and expand and enrich the literature, disseminating knowledge on the subject.

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## APPENDIX 01

Summary of questions to be evaluated about the applicability and limitations of the PEU methodology.

Q1: Based on the BP, did the PEU prove to be applicable to other economic segments?	Q8: Based on the BP, did the PEU method encounter difficulties in use / application due to the relevance of administrative expenses compared to total expenses?
Q2: Based on the BP, did the studies consistently show the stages of implementation of the PEU method, with strong attention to the first three stages of implementation?	Q9: Based on BP, did the PEU method present high implementation complexity?
Q3: Based on BP, did the PEU method provide relevant information for management control with regard to performance analysis (Efficiency, Effectiveness and Productivity)?	Q10: Based on BP, did the PEU method present a high implementation cost, either due to the need to formulate usual procedures or due to the need for a specific system to support data processing and information analysis?
Q4: Based on BP, did the PEU method make it possible to perform scenario simulations, making the decision-making process more effective?	Q11: Based on the BP, did the PEU method present difficulties in the treatment of waste?

Q5: Based on the BP, did the PEU method provide relevant information for management control with regard to the pricing issue?	Q12: Based on the BP, did the PEU method present difficulties arising from the preservation of the 'principle of constant relations' and the need for constant revision of the calculations arising from changes in the production structure?
Q6: Based on the BP, did the PEU method provide relevant information for management control with regard to the costing item?	Q13: Based on BP, did the PEU method encounter difficulties in using / applying the method due to product variability?
Q7: Based on the BP, have the studies proven the joint applicability of PEU with other costing methods (Absorption, ABC, TDABC, etc)? Which one(s)?	Q14: Based on BP, did the PEU method find it difficult to measure production efforts?

Source: Prepared by the authors

## APPENDIX 02

Works published in journals analyzed in this research.

Year	Author	Title	Field of Activity	periodical
2001	Lembeck; Wernke	Application of the PEU method in the enamel industry	enameled	Brazilian Congress on Costs
2001	Sakamoto; Allora; Oliveira	Improvement in management tools: the implementation of the UP' - production unit - at Seara Alimentos S/A	SEARA – Poultry, swine and industrialize products	National Meeting of Production Engineering
2005	Borgert; Silva	Hybrid costing method for cost management in a service provider company	Services provision	International Cost Congress
2005	Sabadin; Grunow; Fernandes	Integration of ABC costing with the UP method: a case study	Food sector	Accounting Universe Magazine
2005	Farias; Lembeck	Application of the PEU costing method in a small industrial company	uniforms	International Cost Congress
2006	Machado Borgert; Lunks;	ABC and PEU - an essay in a software company	Software Company	Brazilian Congress on Costs
2006	Oenning; Neis; Mazzioni	Calculation and management of costs by the production effort units method - PEU	Mattresses and foams	Brazilian Congress on Costs
2006	Zanin; Oenning; Cortina	Cost management through the Production Effort Unit (PEU) - Case applied to a	furniture	Excellence in Management and Technology



		furniture industry		Symposium		Drebes	transformation costs of a bent glass industry for commercial refrigerators		
2006	Morozini; Gass; Carpenedo; Zuffo	Application of the PEU approach in a company in the manufacturing sector: a case study	wooden handles	S & G. Systems & Managem.					
2009	Silva; Borgert; Schultz	Systematization of a hybrid costing method for the costing of medical procedures: a joint application of the ABC and PEU methodologies	Universitary hospital	Journal of Management Sciences	2012	Belli; Andruchec hen; Richartz	Structuring a hybrid costing system in a company providing forest harvesting services	Company providing forest harvesting services.	Brazilian Congress on Costs
2009	Montini; Loyal; Mareth	Comparison between costing methods: productive effort unit (PEU) and traditional simple apportionment	Milk Processing Plant	Context (UFRGS)	2012	Wernke; Junges; Claudio	Non-financial indicators of the PEU method applicable to small industry management	electrical resistors	Iberoam. Journal Of Industrial Engineering
2010	Novaski; Assunção	An application of value analysis in a manufacturing company through PEU.	Manufactur.	GEPROS	2012	Wernke; Mateus	Cost worksheet by the PEU method applied in a small animal food industry	pet food	Brazilian Congress on Costs
2010	Wernke; Mendes	PEU method applied in a small frame factory	frame factory	RC&C	2012	Rocha; Pereira; Ritta; cittadin	PEU Costing Method: A Case Study in a Rice Processing Company	Rice processing	UFSC Congress of Controllersh p and Finance
2011	Kremer; Richartz	Development of a hybrid costing model for companies providing services on demand	accounting service provider	Brazilian Congress on Costs	2012	Nascimento	Measurement of production costs: Use of the PEU method in a case study	Metallurgica l (parts for construction equipment)	UFSC Congress of Controllersh p and Finance
2011	Luiz; Gassparetto; Schnorrenberger	Calculation of costs based on the Production Effort Unit Method (PEU): study in a cosmetics company	cosmetics	Brazilian Congress on Costs	2013	Souza; Ferrari; Reis	Application of statistics in the distribution of weights for activities in the provision of telecommunications services	Provision of telecommunication service	Brazilian Congress on Costs
2011	Kunh; Francisco; Kovalski	Application and use of the unit of production effort (PEU) method for management analysis and as a tool to increase competitiveness	Fridge	Online Production Magazine	2013	Giasson; Pacheco; Camargo; Motta; Zanandrea	An application of the PEU method: case study in an automotive parts company	Automotive parts	GEINTEC Magazine
2012	Milanese; Salazar; Cittadin; Ritta	PEU costing method: a proposal for a poultry agroindustry	Poultry Agroindustry	Santa Catarina Journal of Accounting Science	2013	Wernke; Lembeck; Junges; Ritta	PEU Method: Case Study on the Applicability in a Small Women's Clothing Factory	Women's Clothing	Iberoamer. Journal Of Industrial Engineering
2012	Souza; Figueiredo Junior	Determinants of the diffusion of the 'unit of production effort' (PEU) costing method in the textile industry of Ceará	Textile industry	Industrial Management Magazine	2015	Fontoura; Cardoso	Costing method changes and the impact on the management information system: a qualitative study	food	CEPE studies
2012	Zonatto; Silva; Toledo Filho;	Use of the unit of production effort (PEU) method to determine the	Glass Industry	Industrial Management Magazine	2015	Wernke; Junges; Lembeck	Comparison between PEU and TDABC methods: case study	Sewing (Outsourced Industrial Sewing)	Accounting Environment Magazine
					2015	Confessor; Walter; Freires; Oliveira;	Application of the PEUS method for production management: a	bags and shoes	Tekhne and Logos

## APPENDIX 03

Amorim case study					Response levels present in the survey script.
Year	Authors	Method	Industry	Conference/Journal	
2016	Batista; Walter	Application of the PEUS method for the cost of a pizzeria	Pizzeria	Brazilian Congress on Costs	Tightly: Strong - clear indication of the proposition in the text, leaving no doubt of its importance for the article studied.
2017	Battini; Marian; Boff; Pletsch	PEU costing method: application in a continuous production system.	Mechanical metal	Brazilian Congress on Costs	Partially: Partial - even if the proposition is not clearly informed in the text, through the result found, the authors of this article assume its importance for the article studied.
2017	Vichinhesky; Bendlin; Ferreira; Ferreira	Costing Method PEU - Production Effort Unit: Case Study in a Ceramic Industry in the North Plateau of Santa Catarina	ceramics	Brazilian Congress on Costs	Weak / Null: Weak/Null - Did not address or superficially addressed this item at work. Not applicable: This item has not been tested or found at work Source: Prepared by the authors.
2017	Lacerda; Schultz; Walter	The applicability of the production effort units method in a bakery: evidence from a case study	Bakery	Systems & Management	
2017	Carraro; Souza; Ribeiro; Freitag; Saints; Pinheiro	Combined use of PEU and TOC in a fitness industry	fitness equipment industry	Brazilian Congress on Costs	
2018	Silva	Implementation of the PEU Method in a Small Palm Heart Processing and Packaging Industry in Northern Santa Catarina.	Palm heart processing and packaging	Brazilian Congress on Costs	
2019	Wernke; Junges; Zanin	Measurement of factory idleness by the ABC, TDABC and PEU methods	Laundry	Contemp. Accounting Magazine	
2019	Wernke; Rufatto	Adoption of a Single or Segmented Cost Spreadsheet by Factory Sectors: Interventionist Study on the PEU Method	clothing factory	Brazilian Congress on Costs	
2020	Moterle; Wernke; Zanin	Influence of the choice of base product of the units of production effort (PEU) method on the unit cost of transformation	Refrigerator (Sausage)	Exact (Online)	

# Quality Assessment of the Pulp Chamber Floor Refining by Different Ultrasound Devices

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**Keywords—** Dentistry, Endodontics,  
Ultrasound.

**Abstract** — Access surgery is an important procedure performed during endodontic treatment as it allows the dental surgeon to access the pulp chamber and locate the root canals. During this procedure, spherical and conical stem diamond tips with inactive end are used to remove caries, establish a contour shape and refine the walls of the pulp chamber. Inserts coupled to dental ultrasound are constantly used to help refine the floor of the pulp chamber. However, depending on the vibration provided by the ultrasound device and incorrect handling of the insert, it will cause depressions and perforations in the floor of the pulp chamber. Given the context, this research aims to assess the quality of pulp chamber floor refinement by different ultrasound devices. This is a research with the principle of applied investigation, qualitative and quantitative approach, with an exploratory character, where 100 upper and lower human molars will be selected distributed in 4 groups, where the floor refinement will be carried out with TRA 24 ultrasound insert ( Trinks, São Paulo, Brazil) however, coupled to different ultrasonic devices: G1 (No. 25) CvDentus, G2 (No. 25) Sonic Plus Ecel, G3 (No. 25) Sonic Air Scaler and G4 (No. 25) Denshine . After completion of the access surgery, a visual inspection will be performed to assess the presence of excessive wear, depressions and identification of root canals. The results were tabulated, analyzed and it was found that there was no significant difference between the groups regarding the presence of excessive wear, depressions and identification of root canals. Thus, it is possible to conclude that all ultrasonic devices showed satisfactory results in the refinement of the floor of the analyzed teeth.

## I. INTRODUCTION

“The main threat to the health of dental pulp is dental caries” (TORABINEJAD and WALTON, 2010, p. 21). There are other threats like trauma and fracture. Faced with the injury, the pulp organ may develop an inflammatory process. Consequently, necrosis and emergence of periradicular pathology may be installed. While this situation does not cause discomfort and is generally ignored, this type of injury can result in damage or loss of dental components. That's why endodontic treatment is important.

Valdivia et al. (2015), states that "A fundamental prerequisite for the success of endodontic treatment is the adequate preparation of the access surgery, the location and identification of the entrance of the root canals". As mentioned above, it is important that all stages of the endodontic treatment are carried out properly.

Access surgery performed improperly makes endodontic treatment difficult. The size and shape of the cavity performed should follow the group and internal anatomy of the pulp chamber. Thus, the quality of the

mechanical chemical preparation of the root canal is associated with root access (MIRANZI et al. 2011).

According to the author Miranzi et al. (2011), the objectives of access surgery are: to be straight, preserve the tooth structure and remove the roof of the pulp chamber. The intention is to allow direct access to the apical region, and not just the entrance of the conduits. The purpose of access surgery is to make the instruments pass through the pulp chamber and enter the root canal without blocking, as well as to reduce the damage caused to the instruments, allowing the operator to act on the walls without modifying the internal anatomy.

It must also remove the material from the pulp chamber and its final shape must allow the endodontic instruments to come into contact with the root canal surface and reach the apical region without interfering with the tooth wall. (MIRANZI et al., 2011)

Sometimes, access surgery may be unsuccessful, where the operator is unable to remove the roof of the pulp chamber completely, causing the root canals not to be visualized and located, thus the cutting instrument will not correctly enter the root canal.

For years, ways to facilitate and improve mechanical chemical preparation to access the pulp chamber in an effective and minimally invasive way have been tested. The use of ultrasound is one of them. It facilitates procedures at different stages of the endodontic treatment, such as cleaning the canals, eliminating pulp residues and refining the pulp chamber. Acting in little space and have good cutting precision. As a way to reduce errors during access surgery, ultrasound provides benefits to obtain an optimal area of visualization of the root canals, a good refinement of the pulp chamber and adequate space to use cutting instruments (RAMOS; NETO, 2019).

Found in the endodontics field, there are a variety of inserts that differ in the shape, length, size and construction that they are used. It is important that the ultrasound source is specifically dedicated to endodontics, or at least that it is a multidirectional unit offering an "endo" application (an operative mode, in which the amplitude of vibrations is limited) (IANDOLO, et al. 2015).

The aim of this study is to compare the efficiency of three ultrasound devices in the refinement of the pulp chamber floor.

## II. MATERIALS AND METHOD

It is a research with the principle of applied investigation, qualitative and quantitative approach, with an exploratory character. One hundred maxillary and mandibular molars with similar sizes and diameters in the

coronary and radicular region, donated by patients in need of extraction for reasons of orthodontic treatment or periodontal involvement, were selected.

Root scaling was performed with periodontal curettes (Duflex – SS White – Rio de Janeiro – Brazil), removing any dirt on the external surface. The specimens were submitted to prophylaxis with pumice stone (SS White – Rio de Janeiro – Brazil) and water, using Robinson brushes (KG Sorensen – Rio de Janeiro – Brazil) coupled to a contra-angle micromotor (Kavo, Joinville – SC, Brazil). Subsequently, they were placed in 0.1% Timol (Manipulation Pharmacy – Formula and Action – São Paulo – SP) and preserved for a maximum period of three months (Silva et al., 2006; Marending et al. 2007).

Access surgery was performed on all dental elements with the 1014 diamond tip (coupled at high rotation (Kavo, Joinville - SC, Brazil)) (to remove caries or permanent restorations), along the tooth axis, until reaching the pulp chamber. Soon after, a 3082 diamond tip (coupled at high speed (Kavo, Joinville – SC, Brazil)) was used to refine the pulp chamber walls. After completing these steps, a visual inspection was carried out in order to locate the root canals and a photographic record will be taken of the pulp chamber. Afterwards, the teeth were randomly distributed into 4 groups so that the floor could be refined using a TRA 24 ultrasound insert (inserting lateral movements) coupled to the ultrasound device:

G<sub>1</sub> (n=25) CvDentus calibrated at power 2

G<sub>2</sub> (N=25) Sonic Plus Ecel calibrated at power 2

G<sub>3</sub> (N=25) Sônico Air Scaler calibrated at power 2

G<sub>4</sub> (N=25) Denshine calibrated at power 2

Subsequently, a visual inspection was carried out in order to locate the root canals and a photographic record will be taken from the pulp chamber.

## III. RESULTS

Among the four ultrasounds used in this study, the findings obtained showed that there was no difference between them. In the refinement of the pulp chamber, a pattern was observed between them (Figure 01, 02, 03 and 04).



*Fig.1: G<sub>1</sub> CvDentus*  
Source: Own Authorship



*Fig.4: G<sub>4</sub> Denshine*  
Source: Own Authorship



*Fig.2: G<sub>2</sub> Sonic Plus Ecel*  
Source: Own Authorship



*Fig.3: G<sub>3</sub> Sônico Air Scaler*  
Source: Own Authorship

#### IV. DISCUSSION

There are two methods for producing ultrasound. The first is magnetostriction, which converts electromagnetic energy into mechanical energy. The second is based on the piezoelectric principle, in which a crystal is used that changes dimension when an electrical charge is applied. The deformation of this crystal is converted into mechanical oscillation without producing heat. This method of ultrasound production is used in Endodontics, as it works in a linear fashion, with reciprocating movements, being ideal in this area (Plotino et al., 2007). The ultrasounds used in this study are all piezoelectric.

While obtaining the results, all the difficulties faced by dental surgeons in accessing and refining the pulp chamber floor were taken into account. Thus, the use of ultrasound in the research facilitated access and inspection of root canals in molar teeth analyzed.

The preparation of access cavities is often complicated by the presence of pulp chambers that over time, calcify and cause deposition of secondary dentin formed that obstructs the canal, totally or partially, altering its anatomy. These situations become complex because it is difficult to make a correct cavity access, respecting the original anatomy, not altering the chamber floor and allowing the location of all the entrances to the canal. The control provided by ultrasonic tips is preferable as it has a slower and more controllable cutting power than rotary instruments (Iandolo et al. 2015). While obtaining the results, all the difficulties faced by dental surgeons in accessing and refining the pulp chamber floor were taken into account. Thus, the use of ultrasound in the research facilitated access and inspection of root canals in molar teeth analyzed. However, there is no difference between the ultrasounds used to refine the floor.



The results of this study demonstrated that the choice of ultrasonic devices for the refinement of the pulp chamber floor is valid, as they perform the same function, providing a smoothness of the pulp chamber floor at the same level and enabling a better visualization of the entrances to the root canals.

## V. CONCLUSION

Thus, it is possible to conclude that all ultrasonic devices showed satisfactory results in the refinement of the floor of the analyzed teeth.

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# Importance of Digital inclusion of Students in Proeja If-Sertão Pe Campus Petrolina Rural Zone

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**Keywords—** Knowledge, Information, Digital Inclusion, Information Technology.

**Abstract—** The study aims to discuss the importance of digital inclusion PROEJA students to transform the educational model so that the process of knowing and acting is stimulating, challenging and appropriate to the times. With the evolution of technology, society has lived continuously the impacts of these technological advances in their daily lives. Teaching cannot be oblivious to this reality; the teacher has the primary role of contributing to the dissemination of ICT'S in the school context. In this context, the study outlines the following objectives: Diagnosing the level of students and factors that hinder access to information technology students PROEJA. Adopts as a qualitative methodology, critical and reflective research participant. Thus, the principle performs a literature search and field, searching the literature documents that may help to answer the demands the questions raised in the problem of the subject under study. It is noticed that the technological development has profoundly modified the daily lives of people, and the school cannot be oblivious to this reality, it needs to adapt and introduce the student to live with these new technologies ICT, also within the school, so it can act as a participating citizen within and outside the educational context.

## I. INTRODUCTION

The new model of organization of societies, called the information society, brings new responsibilities for all the people in them. All this denotes the provision of a constant flow of information, enabling the generation of new knowledge and decision making in the various instances. Thus, seen from a functional point of view, information

can be understood as a resource that reduces uncertainties, enabling the elaboration, implementation, and evaluation of public policies with a greater degree of effectiveness and efficiency, based on the analysis of the social complexity in their demands and contradictions.

Considering that the penetrability of information technologies is one of the main indicators of development

of the information society and advocates the installation of Internet access points in public and school libraries, as well as stimulating the development of the production of content and knowledge.

With the emergence of the Internet (World Wide Web), the communication system saw the emergence of a new media that, among other transformations, inserted the concept of interaction in the sender-receiver relationship. While the first ways to put the so-called interactivity into practice appeared on the Internet, traditional vehicles, especially TV, were looking for ways to insert this element in their relationship with the public, creating programs in which the public interacted through telephone voting.

Even if this participation was not limited to having and exercising only the right to vote, but also the expression of opinions and the discussion those was and are until today essential for the exercise of democratic learning. PROEJA (National Program for the Integration of Youth and Adult Education) with basic education in the form of youth and adult education plays, a very important role in the dissemination of education.

Currently, information has assumed a role of great social relevance since the advances of science have become solutions for our daily lives and is present from a productive sector to our most ordinary and private activities. The ability to communicate through conversation is atrophying because of daily living with the machine. Increasingly, large corporations invest more in the search for information systems, aiming to interact quickly and dynamically in all possible areas of knowledge.

In this sense, it is important to point out that the use of these technologies in the teaching and learning process in PROEJA can leverage educational development. Therefore, a proposal for pedagogical intervention must give the activity of learning a new meaning, in which the learning needs appear in attempts to solve problematic situations. And avoiding the problem can harm the student and perpetuate a passive subject inserted in an insignificant space.

Technological development has profoundly modified people's daily lives, and the school cannot remain oblivious to this reality, it needs to adapt and present to the student how to live with these new technologies ICT (Information and Communication Technology) also within the school, to that he can act as a participating citizen inside and outside the educational context. For this, the computer, with its software, can contribute to the establishment of this new paradigm, if the teacher's performance implies the need for a new posture and acquisition of new skills.

The motivation of the research for this theme arises as a way of collaborating to solve the school needs in the face of the current demands of social life: to form citizens and to offer the possibility of apprehending the necessary skills and abilities that facilitate social insertion. In addition, it means contributing in a concrete way to the school education sector, while encouraging students to think and organize their positions to be able to take part in management situations that will appear throughout their lives.

However, the problem that involves the study deals with the possibilities of inserting PROEJA students in digital inclusion? How to overcome resistance and promote the digital emancipation of young people and adults excluded from the knowledge society? The idea of accepting the new, in the exercise of changing the ways of learning, must be present in the school routine. Trying to break with the conventional teaching schemes, meet the so-called prior knowledge of reading and writing, in addition to being necessary to put students in contact with a tool that is present in the scenarios of work, leisure and daily life (ATM, supermarkets, hospitals, schools, election etc.). In short, digital inclusion should be seen as a tool to help the didactic process.

Thus, this study has the general objective of analyzing and presenting a scenario of digital inclusion of PROEJA students at the Federal Institute of Education, Science and Technology of Sertão Pernambucano, Campus Petrolina Zona Rural, to later implement it to adapt to the reality of students to the model of digital inclusion in the classroom. In addition to having the specific objectives of diagnosing the level of students and factors that hinder access to information technology of PROEJA students; understand the reasons that motivated PROEJA students to seek information technology resources; understand the consequences that computer resources bring to the social life of PROEJA students.

Methodologically, the research is exploratory, following the bibliographic procedures, which consist of the investigation of systematized knowledge, using field research by careful observation. Soon after, data collection was carried out through observation and informal conversations, using a questionnaire and interview instrument, used according to the stages and purposes of the research.

## II. THEORETICAL REFERENCE

### A history about the EJA in Brazil

Since the time of catechization, Brazil has been trying to insert illiterate adults in the context of schooling, this

insertion is strictly linked to social transformations, economic and political conditions that our country has gone through. Today this insertion is based on the LDB n° 9394/96 [1], which reaffirms the constitutional text and guarantees “EJA” (Education of Youth and Adults).

[...] the offer of regular evening education suited to the conditions of the student and the offering regular school education for young people and adults, with characteristics and modalities suited to their needs and availability, guaranteeing those who the conditions of access and permanence in the school are workers [...] [2].

According to Pinto [3], the EJA's proposal is precisely to guarantee access and permanence of these young people and adults in school so that they can become autonomous beings, the author also emphasizes that the lack of formal education is not felt by the adult worker as an annihilating deficiency, when the other education provides the foundation for political participation, the performance of the individual in their midst [3].

In view of the above, a devaluation of formal education itself is perceived, since it does not provide learning that is healthy in the day-to-day of these students. That most seek at school is training for the search for a job and not their autonomy itself, which strengthens the myth that education will solve the problem of unemployment and will provide opportunities for social ascension these students, to the true meaning of education and school that is the transmission of historically accumulated knowledge. In this way, the school is privileged training institution, since the contents, especially in the EJA, in their methodological, must be strictly linked with the social facts that mark each historical moment, to be directly associated with the daily lives of these students, thus valuing their culture and their community, which will lead to an appropriation of content in a critical and constructive manner.

Another factor to be pointed out in the EJA is that, in common sense, it is believed that it is enough to give the contents in a superficial way so that they cover the dormant schooling, when in fact in the process of initial schooling it is necessary for teachers to select the contents to be covered and consult the expectations and needs of the students, in order to that have a real north that will produce significant results, not characterizing simplified, reduced and condensed cuts of scientific knowledge.

In modern society, we perceive governments in a hurry to form these individuals. This can be evidenced in Pinto's statement of society rushing into educate people not to create participation, which already exists, but to allow it to take place at higher cultural levels and more identified with the standards of the ruling area [3]. One fulfills what

one considers a moral duty, when in fact it is nothing more than a requirement economy of the current globalized society [3]. In this way, there are government programs “forming” masses with merely statistical and economic, seen as an effort, when in fact the Education of Youth and Adults must awaken in them the awareness of the need to be educated and literate, awakening the criticality that he is part of society, and he must know this so that he can intervene in your world.

Telles [4] regarding the presence of technologies in the labor market in Brazil, warns that a duality is being institutionalized between what he calls “*integrated workers*” in the modern circuits of the economy, because they learned in courses formal or even in everyday practice to use these technologies to maximize the productivity of the processes and products involved, and what he calls “*workers non-integrated*”, because they have not developed concrete conditions to use them with this purpose.

It is noteworthy that within the group of “*workers non-integrated*”, there are those that have not even developed conditions to use them to solve every day problems immersed in social relations culturally mediated by technologies, such as operating: electronic machines that sell passes for the use of collective buses; a cashier bank electronics; an electronic ballot box used during elections, among others.

According to the data obtained during the collection of this research, we observed that the great most of the young people and adults concerned have difficulties in accessing and using the digital technologies. In view of the pedagogical assumptions of the curricular proposal of the Education of Youth and Adults, the use of the computer is proposed as part of the reality of the world of work, in the classroom, which will be used as a facilitating and motivating instrument of learning.

The computer follows the rhythm of each student and allows redoing the activities as many times as necessary. It is also worth mentioning the readiness factor with which the student receives feedback on your interactions. It is still considered an ideal instrument of motivation. Thus, it is believed that the computer is the instrument that contributes, effectively, to overcome the difficulties in the student's learning Youth and Adults and assists them in improving their qualifications for work [5].

Today, we live in a world dominated by information and processes that occur very quickly and imperceptibly. Therefore, instead of memorizing information, the students must be taught to look for it and use it. These changes can be introduced with the presence of the computer, which should provide the conditions for students to exercise their



ability to search and select information, solve problems, and learn regardless.

### PROEJA History

In 2005, MEC gave birth to PROEJA (National Education Integration Program Professional) and with Basic Education in the Modality of Youth and Adults - instituted by the Decree N° 5478/05 of 06/25/2005, later revoked by Decree N° 5840/06 of 07/13/2006. PROEJA is structured from the training of professionals [6].

The proposals concerning the integration of technical vocational education to the education of youth and adults began the moment legal obstacles were removed, that impeded the expansion of the Federal Network of Vocational and Technological Education. The current Government rescued the articulation of professional education with secondary education and, in addition, through the Ministry of Education, under the coordination of the Secretariat of Vocational Education and Technological, implemented a policy of expansion of the Federal Network of Vocational Education and Technological, such Public Policy aims at the multiplication of schools and courses and the offer of courses, within the scope of PROEJA [5].

The educational task needs to introduce values and motivations that constitute a stimulus for the student's development. As well as cultivating thinking and reasoning, the ability to develop ideas and stimulate the imagination creator. The school is a learning environment that has become a center of cultural irradiation of the community that is included. Therefore, it must be entered. Thus, it is necessary that educational institutions are diversified according to the characteristics of the social environment and clientele and in the permanent training of teachers, the fundamental moment is critical reflection on practice.

According to Freire [6] it is critically thinking about today's practice or yesterday that the next practice can be improved, the transformations in the field of Vocational/Technological Education began in 2004, by Decree N° 5154/04, which regulated some articles established by the Guidelines and Bases of National Education and revoked Decree N° 2208/97, which had a negative impact on the CEFET (Federal Center for Technological Education) Decree N° 5154/04, determines that the professional education is developed through courses and programs of initial and continuation of workers; of technical vocational education at medium level and education undergraduate and graduate technological professionals [2].

According to this Decree, secondary technical vocational education must be developed in conjunction

with high school, and can be developed in an integrated, concurrent, or subsequent. In 2005, Decree N°. 5478/05 instituted, within the scope of the Federal Institutions of Technological Education, the Education Integration Program Professional to High School in the Youth and Adult Education Modality o which defined that PROEJA should cover courses and programs of initial and continued formation of workers and mid-level technical vocational education [6].

In this way, the school is seen as capable of developing functions that facilitate new knowledge in the face of economic, social, and cultural transformations, so that educators need to be inventors and introducers of new knowledge, to meet the expectations of today's society. Change means that the educator needs to acquire new techniques and methodologies capable of transforming the learning environment of the apprentice, into something dynamic, meaningful, and participatory.

Education presupposes educators who approach theory and practice with an attitude innovative, stimulate and facilitate the student's learning, provide subsidies for young people can create and develop possibilities, centered on reality. In summary, Moreira and Silva [8] emphasize that not incorporating the understanding of these transformations to critical theorization, means that the curriculum will act with restricted objectives of the implementation, without incorporation of any school activity.

[...] will be able to adopt courses, in the scope of PROEJA, public institutions of the of federal, state and municipal education, national private service entities social, learning and professional training linked to the union system and entities linked to the National Service for Industrial Learning (SENAI), National Service for Commercial Apprenticeship (SENAC), Social Service for Industry (SESI), Social Service of Commerce (SESC), Social Service of Transport (SEST), National Rural Apprenticeship Service (SENAR) and the Brazilian Support Service for Micro and Small Enterprises (SEBRAE) [...] [9].

The Initial and Continuing Training Courses for Workers, at PROEJA, have the maximum workload of 1,600 hours, with 1,200 hours for general training and 200 hours, at least, dedicated to professional training. For education courses mid-level technical professional, the maximum workload is 2,400 hours, ensuring cumulatively, the allocation of at least 1,200 hours for general training is a charge minimum hour established for the respective technical professional qualification.

In 2006, this Decree was revoked by Decree N° 5840/06, which defined that PROEJA would be a National



Program. According to this Decree, PROEJA courses and programs should consider the characteristics of young people and adults served and can be articulated to the elementary school or high school, with a view to raising the worker's level of schooling. The courses must also be linked to secondary education, in an integrated or concomitant.

The program aims to provide comprehensive training through studies, focusing on under six specific principles: the first principle is the inclusion of the population in opportunities offered; the second consists of the organic insertion of the EJA modality, integrated to professional education in public systems, based on the concept of education as a citizen's right; the third principle is the expansion of the right to basic education, for the universalization of secondary education. The fourth principle understands work as a principle educational and this allows linking the high school with the perspective of work; the fifth principle, establishes that research must be one of the foundations of the formation of the subject, and, therefore, brings the intellectual autonomy of the students as it is built; and the sixth principle considers the generational conditions, of gender, of ethnic relations as foundations of the human formation and the forms of production of social identities.

Diversity proposes that the school makes possible different arrangements in the dynamics of learning, seeks to establish contacts outside the school routine and create possibilities for students to develop significant knowledge. The effectiveness of diversity presupposes the school autonomy to implement educational policies, which reflects the commitment in the face of issues capable of mobilizing student learning in the pedagogical proposal.

In summary, the PCN'S (National Curriculum Parameters) address that the exercise full autonomy is centered on a pedagogical proposal, specific to the institution, which must reflect in the provision of human, financial, educational, and physical resources that enable the use balance of time and physical space, interaction situations and forms of learning organization that favor the acquisition of knowledge, according to the guidelines presented in the proposal.

The education system, based on the analysis of the curricular proposal, must enjoy autonomy and self-initiatives to create programs that go beyond practice conventional. The classroom is an environment conducive to the daily construction of knowledge, in that teachers and students can exchange relevant educational experiences. For take advantage of the possibilities of this space (classroom) it is necessary to transform the educational activities in competent and playful classes.

The teacher must always be able to way means following the activities carried out by the students, identifying their possible difficulties in proposing innovative solutions in educational practice. Therefore, see that it is always possible to transform the pedagogical work from creative ideas; Students should be actively involved in the development of the necessary guidelines for the conduct of pedagogical actions.

In which school environments need to be flexible, to avoid monotony, in which students would be more interested in learning about the construction and reconstruction of meanings. It is believed that innovations in the school environment can transform the educator into a competent communicator, with reconstruction activities continues to be innovative, with theoretical basis capable of assimilating theory and practice with autonomy and diversity. The school must characterize environments so that their values and competences can flow continuously. These school environments will bring positive impacts on the teaching-learning process, as the change in pedagogical work provides opportunities in the construction of knowledge.

Educators must investigate and clearly define the educational action, considering it as a social action, proposing a curricular proposal that considers the school-community, producing an educational practice that articulates theory and practice, having as a subject of the learning process.

### **The Importance of Digital Inclusion in PROEJA**

The development of actions aimed at digital inclusion is a necessity and, in turn, one of the emergencies of the postmodern world. The implementation of a project educational informatics aimed at the education of young people and adults aims to provide the social inclusion of subjects, associating the rescue of a right that was denied to them at some point in life – the continuation of their school life – with the action of information technology in education of youth and adults (EJA), as a different and, increasingly, necessary way of knowledge production.

In this way, a project that seeks to collaborate to rescue their citizenship, in addition to integrating information technology into the education of young people and adults, inserting subjects into cyber culture, and expanding the scope of possibilities for development and systematization of their educational process, considering their different life contexts, and aiming to develop autonomy for navigation in cyberspace.

Rezende [10] places new information technology technologies as a factor that cannot be ignored in the formation of a current Education project, which uses a perspective of construction of knowledge, bearing in mind

that “educational technology must adapt to the needs of a particular pedagogical political project, placing them at the service of their objectives and never determining them.

This author emphasizes the importance of taking advantage of the opportunity generated by the entry of new technologies to review traditional teaching concepts, as these technologies provide new approaches in the teaching-learning process, however, care must be taken not to think that the mere entry of new technologies will provide renewal of concepts and traditional practices, which can mean a throwback to Skinnerian technicality.

Still, highlights that there is no close relationship between new technologies and new pedagogical practices, despite the contribution that the former can make to the latter, and that the creation of teaching materials based on new technologies capable of assisting in the transformation of Education depend on of the effort to link the design of these materials to new theoretical approaches.

[...] Research also confirms that the transfer from theory to practice of instructional design is neither easy nor obvious, and often initiatives to use the constructivist assumptions in the development of technological environments of teaching-learning fall short of the initial intention [...] [10].

For Almeida [11], computer technology at school is fundamental, both for students and students for teachers. This new technology has become an important means of study and research. You elementary and high school students, when using the computer, enter a multidisciplinary and interdisciplinary environment, instead of just receiving information, the students also build knowledge, thus forming a process where the teacher educates the student and when educating is transformed through the dialogue with the students.

Each generation invents, creates, innovates and Education also has its process of creation, invention, and innovation, mainly in the field of knowledge. Information technology, then, at the service of an educational project, provides conditions for students to work from themes, projects, or extracurricular activities. The computer is only and only a means to promote the development of intelligence, flexibility, and creativity.

According to Levy [12], new ways of thinking and living are being developed in the world of communications and IT. The relationships between men, the work, intelligence itself depends, in fact, on the incessant metamorphosis of informational devices of all kinds. Writing, reading, seeing, listening, creating, and learning are captured by increasingly advanced Informatics.

Borba and Penteadó [13] still indicates that Access to Information Technology should be seen as a right and, therefore, in public schools and private, the student must be able to enjoy an education that at the present time include, at the very least, a ‘technological literacy’. Such literacy must be seen not as a course in Informatics, but rather as learning to read this new media.

Thus, the computer must be inserted in essential activities, such as learning to read, write, understand texts, understand graphics, count, develop notions space etc. And, in this sense, Informatics at school becomes part of the answer to issues related to citizenship. The insertion and use of computers and the development of software in the Educational Institutions respond to the needs of a globalized society that demand from their members a social interaction and faster problem solving presented cooperatively.

Léa Fagundes [14], in an interview with Revista Nova Escola, Edition 184: *“Digital inclusion is not only the broad access to technology, but the appropriation of it in solving problems and that the school practices digital inclusion when incorporates into its practice the idea that one educates by learning when using technological resources”*. Faced with this new situation, it is important that the teacher can reflect on this new reality, rethink its practice, and build new forms of action that allow not only dealing with this new reality, as well as building it.

### III. MATERIALS AND METHODS

The importance and interest achieved by the treatment of information aimed at the process of digital inclusion consists of the investigation of systematized knowledge, through the study of some theorists. At first, a study was carried out, following the bibliographic procedures, which, as Ferreira [15] recalls, are recognized for *“carrying out an inventory and descriptive research of the scientific production on the subject that seek to investigate”*. According to the author, in general, research tries to answer: what aspects and dimensions have been highlighted and privileged in different times and places? In what ways and under what conditions has certain knowledge been produced? What have been the spaces for disseminating the productions of the chosen field?

Bibliographic research is used to support the literature and theoretical support in the analysis and interpretation of data. According to Gil [16], bibliographic research is part of the theoretical framework of research, a requirement in scientific works, pointing out the need to carry out a bibliographic survey to identify the view of the subject by other researchers and the way or method of focusing or interpreting the subject. Theme, to incorporate concepts

and know points of view. This research to compose the theoretical foundation analyzes and presents a scenario of digital inclusion of PROEJA students at the Federal Institute of Education, Science and Technology of Sertão Pernambucano, Campus Petrolina Zona Rural.

The research subjects were 100 students who agreed to participate in the research through the Free Informed Consent Term – TLCE. Questionnaires were applied to diagnose the current situation of PROEJA IF Campus Petrolina Zona Rural students. The list of questions was designed to report the level of Digital Literacy of students in the Field. To fill it out, the team responsible for and Coordination for PREJA of the IF Sertão Pernambucano – Campus Petrolina, Zona Rural and the respective person in charge of the IT Information Technology area and responsible for the Computer Laboratories collaborated. Subsequently, a model of Digital Inclusion Course was elaborated.

Procedures, control forms and quantitative and qualitative data were developed to assist in recording the reality of PROEJA students when the questionnaire was applied, which are within each reality of students in the Rural Area.

#### IV. RESULTS AND DISCUSSION

The field research, carried out with the objective of seeking a theoretical basis for a deeper foundation about the raised problematization, made the importance of digital inclusion in PROEJA more explicit. Also providing the recognition of important references, such as the various knowledge, considered essential for teacher training, and the quality categories of teaching action.

The reflection on the immediate factors and the major conditioning factors, associated with the problem, led to highlight, for the present study, some essential aspects originated from the interview applied to students. Below are the results of the questions asked:

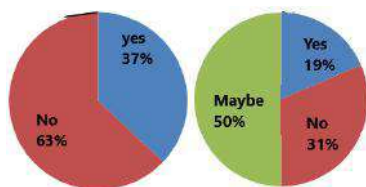


Fig.1 and 2. Results of the sample that is considered digitally literate

Question 1 and 2: Do you consider yourself "digitally literate"? If you consider yourself, do you intend to improve?

Source: Own authorship, 2022.

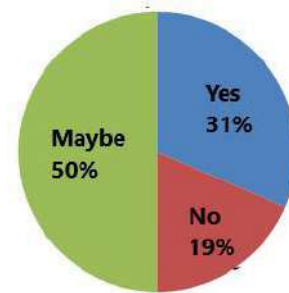


Fig.3. Results of the sample that intends to become digitally literate

Question 3. If you are not "digitally literate", are you interested in being?

Source: Own authorship, 2022.

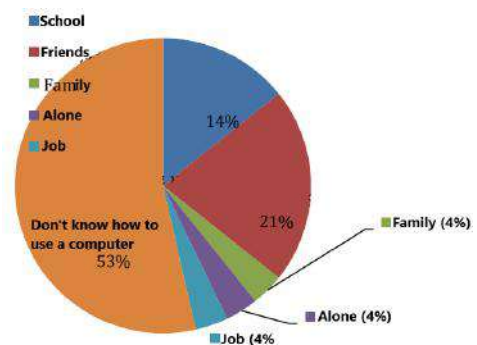


Fig.4. Shows the percentage of origin of learning how to use computers.

Question 4. How did you learn to use computers?

Source: Own authorship, 2022.

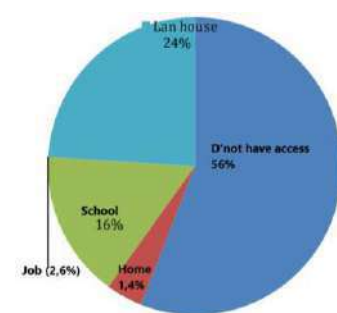


Fig.5. Shows the distribution of access locations to microcomputers

Question 5. Where do you have access to a microcomputer?

Source: Own authorship, 2022.

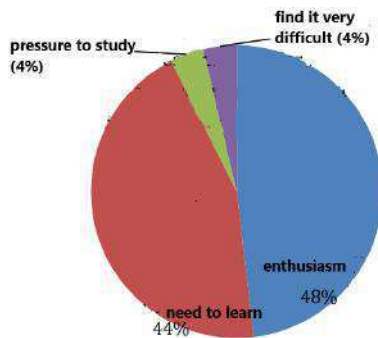


Fig.6. Represents feelings towards computing

Question 6. How do you feel about computing and Information Technology?

Source: Own authorship, 2022.

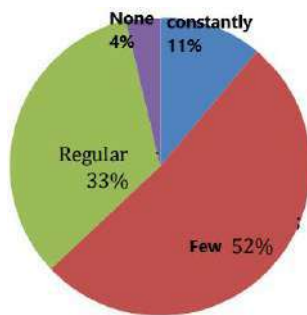


Fig.7. Displays the frequency of access to the computer

Question 7. How often do you have access to the Computer?

Source: Own authorship, 2022.

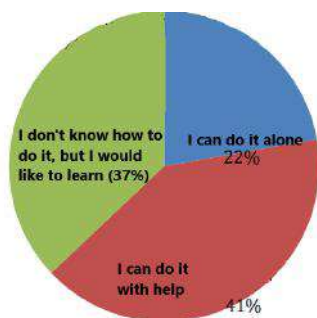


Fig.8. Presents the domain over the word processor tool

Question 8. Use a word processor (Ex.Word)?

Source: Own authorship, 2022.

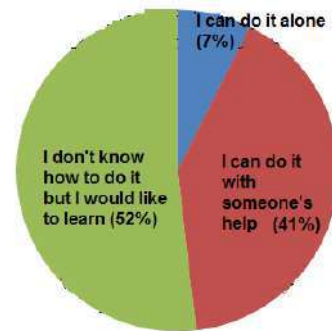


Fig.9. Shows mastery of the spreadsheet processor tool

Question 9. Use a Spreadsheet Processor (Ex.Excel)?

Source: Own authorship, 2022.



Fig.10. Presents the domain of search engines

Question 10. Use search engines (Google)?

Source: Own authorship, 2022.

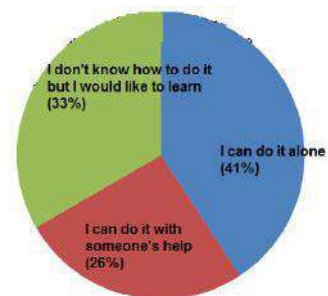


Fig.11. Shows the domain on the use of social networks

Question 11. Use real-time communication programs or Social Networks. (MSN, ORKUT, Facebook, and others)?

Source: Own authorship, 2022.

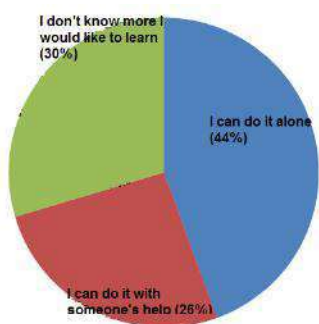


Fig.12. Displays the domain over file execution

Question 12. Run/Open a file?

Source: Own authorship, 2022.

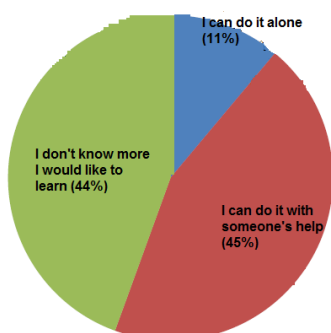


Fig.13. Presents the domain on the use of media for copying files

Question 13. Copy file to CD/Pendriver?

Source: Own authorship, 2022.

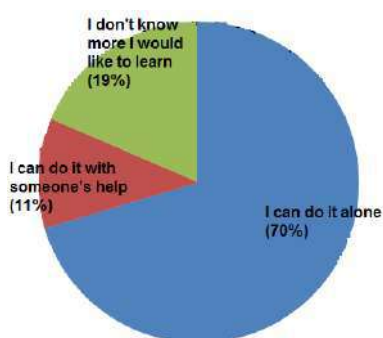


Fig.14. Displays the domain on Internet access

Question 14. Access the Internet?

Source: Own authorship, 2022.

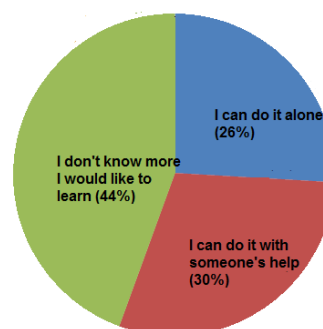


Fig.15. Presents the domain over writing and sending electronic messages (email)

Question 15. Write and send emails?

Source: Own authorship, 2022.

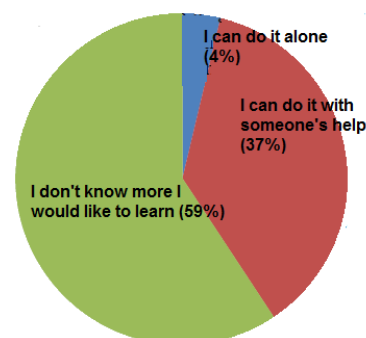


Fig.16. Presents the domain on the activity of attaching files to email

Question 16. Attach a file to the email?

Source: Own authorship, 2022.

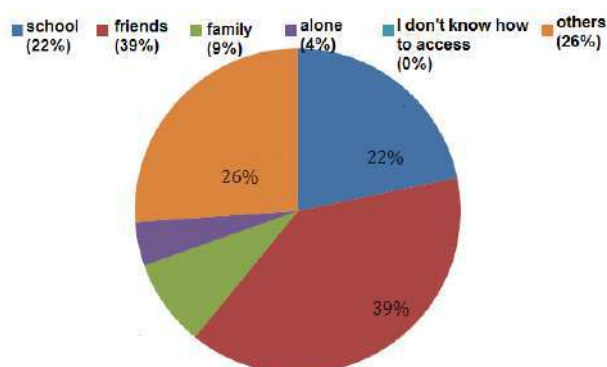


Fig.17. Presents the origin of learning to use the Internet

Question 17. How did you learn to use the Internet?

Source: Own authorship, 2022.



Education has as its essential basis the way to prepare the individual, forming his personality, improving it, preparing him in the physical, moral, and intellectual aspects. It is important that teachers act as mediators between theory and practice, so that they facilitate the interaction of the teaching-learning process.

In this perspective, after the evaluation and analysis in research on access to Information Technology resources in PROEJA of IF Sertão PE (Unit Petrolina Zona Rural), it was found that the area of democratization of resources of new information technologies does not meet the requirements of a globalized and interconnected world in digital knowledge.

EJA students end up being excluded again from digital inclusion programs, since even basic education is still difficult for them. The portion of the human contingent that seeks education is considerable and it is necessary to solve their educational difficulties. Thus, there is an urgent need for a program that includes education and technology as a facilitator of this task that belongs to everyone, a commitment of citizens to the construction of citizenship for students.

It was observed in the face of the study, how much technologies are present in the daily lives of our students, young people, and adults, that is, in all segments of their lives, in their daily tasks, in their relationships with social life, students encounter, in some way, with the technologies. This does not mean that they have mastered this technological knowledge. IT'S

It is therefore necessary to provide this student with the autonomy so that he becomes a being able to go, for example, to the bank and carry out the necessary banking transactions, in a virtual way, without having to ask the bank employee or anyone else for help. The acquisition of this autonomy, of this knowledge, is the responsibility of the school.

The challenge that arises is for the school institution to promote favorable conditions for the mastery of instruments related to pedagogical practices to work in the classroom. Adapting schoolwork to a new reality, marked by the presence of a globalized world. However, it is important to verify the potential of expanding the use of technological resources in the education of young people and adults. The use of ICTs contextualized with the culture of the students becomes a collection of knowledge that will contribute to the construction of a teaching and learning environment in which competencies and skills can collectively thrive.

Therefore, enabling the development of peculiar ways of thinking, which deals with the fundamental capabilities to accompany the globalized world, is part of the

construction of knowledge, which means favoring the development of certain attitudes, such as positioning oneself critically, making predictions and making decisions, before the information conveyed in the educational process and others.

#### IV. FINAL CONSIDERATIONS

According to the field research carried out at the Institute Federal Sertão Pernambucano – Campus Zona Rural, the information obtained contemplates rethinking the digital inclusion of PROEJA students in a situation of reflection and criticism. During all the technology that the world offers, there are those who are excluded from the digital age. During social exclusion is the digital exclusion, in which there are people from underdeveloped levels of life, who do not have access to the basic means of social rights, in addition to being far from access to the means of digital computing.

It is important that digital inclusion be a tool to help the didactic process, and never as an end. The teacher should encourage the student to give opinions, debate and question about the results that are being found. Digital Inclusion is the universalization of access to the means, tools, contents and knowledge of the information and communication society through telecommunications and information technologies.

The primary solution for inclusion in the digital world, as is the case of PROEJA, IF SERTÃO PE students, is the awareness of everyone and everywhere. It is by embracing this cause that it is society's duty to see everyone having access to new technologies, regardless of race, color, social level, or disability. We must strive to make more and more inclusion projects grow and strengthen, whether by disseminating, creating tools, or working concretely on projects.

Being aware of changes and following each step of evolution is crucial for today's professionals. Thus, as information technology advances every day, it is important to train people who are aware of the importance and the right for this progress to reach everyone without distinction.

It is necessary to encourage digital inclusion as an opportunity to grow knowledge, create and expose innovative ideas, in addition to encouraging sustainability, efficient communication between people, as well as many other possibilities that are still poorly explored. It is necessary to educate the individual so that he can understand that the computer and the internet are not just tools for accessing chat and relationship sites but provide the improvement of the quality of life for all of us, by

expanding the world view and connection with diverse cultures.

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# The fragility of interpersonal relationships evidenced in the pandemic period with COVID-19

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**Keywords—** Pandemic, Social Isolation,  
Interpersonal Relationships, Liquidity,  
Fragility.

**Abstract—** The pandemic with Covid-19 established a social chaos on the planet, which required extreme changes in order to contain the large-scale contamination of the disease. Social isolation, adopted as one of the restrictive measures, generated other problems with high repercussions in the indices of domestic violence, femicide, divorces, among others, highlighting the fragility of interpersonal relationships and the consequences for society. The present study aims to present how interpersonal relationships were affected during social isolation. As methodology, the research was based on a literature review based on theorists such as Bauman (2001; 2004), Forbes (2010; 2019), in the approach about liquidity in contemporary relationships; in studies on the subject available in scientific and research platforms, college observatories and analysis of statistics about problems instaurated from relational conflicts during the pandemic period. As a result, it became evident that sudden changes in the rhythm of life, such as residential confinement, contributed to increase the rates of domestic violence, consumption of alcoholic beverages, psycho-emotional diseases and divorce among couples. Evidence that human beings need to detach themselves from the liquidity and fluidity that contemporary immediacy adds to interpersonal relationships and reinforces the need to undertake more solid and effective relationships so that they can face crisis situations without destabilizing family ties and, thus, have more serenity and collaboration in solving challenges, such as the pandemic with Covid-19.

## I. INTRODUCTION

From the beginning of 2020, the world population was suddenly affected by the dissemination of the new coronavirus (SARSCOV-2), accentuating in a pandemic

that would drastically mark the lives of human beings all over the planet. Changes in habits and social organization became urgent in the race to stop the spread of the virus and the number of deaths.

The protocols designed to contain the transmissions and mitigate a catastrophe imposed social isolation as an urgent and necessary measure at first, followed by the gradual return of face-to-face activities, maintaining the social distance between individuals. The isolation determined the changes in routines, mainly altering the family life.

People who spent most of their time at work had to live together 24 hours a day, often in small spaces, performing professional activities. The new format of work assumed in an emergency (Home Office) was a strategy so that the society didn't stop, a way of minimizing the damages resulting from a general paralyzation of the social segments.

In this way, homes with their particularities (children, elderly people, pets, among others), became offices, classrooms, extensions of factories, changing interpersonal and work relationships. Allied to this, the insecurity in relation to the situation faced, the fear of contagion by the virus and the pain of loss in many families worked as stressful and sickening elements in the world population.

Interpersonal relationships were highly affected, whether by isolation, distance from loved ones, or by the change in routine, with the uninterrupted coexistence in the same space, without options of leaving home even for a short period.

Immersed in this context, there has been in Brazil an increase in domestic violence, femicide, as well as in divorces between couples. The pandemic, brought to the surface, the fragility in human relationships, based on liquidity, according to studies by Baumann (2001; 2004) and the disorientation of contemporary man stated by Forbes (2010).

This article aims to present through a literature review, how interpersonal relationships were affected in the context of social isolation, in the pandemic with Covid-19. For this, it was based on studies that deal with contemporary relationships and in recent publications that deal with the period of social isolation and the reflections on human relationships.

## II. METHODOLOGY

The present research is characterized as an integrative literature review, with exploratory descriptive objective, anchored in the theory of fluidity of human relationships in contemporary society of Bauman (2001; 2004) and Forbes (2010; 2019). Based on the theory of these researchers, a search was conducted for scientific productions focused on the theme of interpersonal relationships in the pandemic, establishing an analysis with some data presented by

Brazilian statistics, with close connection or as consequences of problems of interpersonal relationships in coexistence during confinement.

The option for integrative review focuses on the intentionality of presenting a broader approach on the subject, relating current data, available on public platforms or reports in the media.

## III. CONTEMPORARY MAN AND SOCIAL RELATIONS

Bauman (1925 - 2017), a Polish sociologist, has shown great concern for the individual and social relationships. According to Bauman (2001), modern society has already been forged in the liquefaction of patterns of dependency and interaction. "They are now malleable to a degree that past generations neither experienced nor can imagine; but, like all fluids, they do not keep their shape for long" (BAUMAN, 2001, p. 12).

The changes in consumer relations, in the forms of work, after industrialization, have changed the form of social coexistence. The Western contemporary ideals "of efficiency (performance and competitive success) and immediacy (intolerance to uncertainty and impulsive activity) and change and body manipulation (alteration of somatic and sexual skills)" (GUEDES, 2020, p. 392), have directly interfered in the formation of the personality of individuals and the relationship with the other.

The advent of the internet with its dissemination at the end of the XXI century favored the increase of contact between people from distant geographical spaces, optimized opportunities for different work strategies and social interaction. In this context, the daily flow in the lives of individuals, especially in large cities, is immediacy, excessive attributions and goals to be achieved in order to maintain the desired status of life and the demands of a society based on profitability and accumulation of property for some and the fight for daily survival for others.

The psychoanalyst and psychiatrist Jorge Forbes, a researcher of subjective changes in contemporary society, states that due to the changes brought about mainly by the emergence of the Web in the 1990s, postmodern man is "disoriented", without direction, turned upside down, like a castaway carried away by a torrent, trying to cling to the first trunk to try to save himself. According to him, "from birth to death, passing through all the stages of life, such as love, family, work, health, leisure, education, nothing is as it used to be" (FORBES, 2019, digital document).

The frenetic pace is not only limited to adults, it extends to the universe of children, young people and



adolescents. All phases have different commitments: schools, language classes, sports practice, various activities offered in community institutions. It is not common to find someone living in total idleness nowadays.

Thus, the contemporary homes, in its majority, unlike the reality of past generations, are points of meetings and coexistence only at some specific times of the day, usually at meals, night shift, weekends and holidays.

Another aspect that should be highlighted regarding the current family nuclei is the permanence for a longer period of time of adult children at home. Young people are postponing leaving their parents' home, which changes the dynamics in families and brings new standards to family behaviour (HENRIQUES; FÉRES-CARNEIRO; MAGALHÃES, 2006).

The way of structuring, the relational behaviours in the family nucleus and in the society were totally affected in the pandemic with Covid-19. The unexpected and sudden ordering of social isolation changed the routines, requiring a new format of emergency adaptation in the homes.

#### IV. THE PANDEMIC WITH COVID-19 AND SOCIAL RESTRUCTURING

The sudden establishment of the pandemic with SARSCOV-2, named as Covid-19, from the beginning of the year 2020, led almost the entire planet to a health and humanitarian crisis, testing the human species in several dimensions (LIMA; BUSS; PAES-SOUSA, 2020).

According to the Pan American Health Organization (PAHO, 2020a), seven types of human coronavirus (HCoV) have already been identified: HCoV-229E, HCoV-OC43, HCoV-NL63, HCoV-HKU1, SARS-COV (causing severe acute respiratory syndrome), MERS-COV (causing Middle East respiratory syndrome) and the most recent, SARS-COV-2, responsible for causing Covid-19.

A disease that rapidly evolves into a severe acute respiratory syndrome, Covid-19 has become a tragedy, filling hospitals, requiring the expansion of the number of health teams, medication and Intensive Care Units (ICUs), in addition to countless other demands. Several countries have experienced chaos in the health system and an alarming number of deaths.

Data from the World Health Organization (WHO) confirm that by March 17, 2022, 462,758,117 cases were confirmed worldwide, with a total of 6,056,725 deaths. In Brazil, on the same date there were 29,432,157 confirmed cases, adding 655,585 deaths (WHO; WHO, 2022).

In Brazil, the health systems were not prepared to face the pandemic situation, especially in the Unified Health System (SUS) network. There was a lack of beds, ICUs, medication, human resources and investments in vaccine procurement. There was also dissemination of false news that confused the population about the risks of the disease and the importance of prevention; conflicts generated from the divergence of ideas between political leaders and doctors, hindering investments in the preparation of policies to confront the disease, as well as the acquisition of vaccines to immunize the entire population.

A highly contagious disease, due to the ease of spread of the virus through coughing, speaking or breathing, when larger droplets are expelled that settle on people, objects, or surfaces and also through smaller aerosols that can float in the air (BVMS, 2021), Covid-19 spread rapidly throughout the Brazilian territory.

In order to quickly reduce the number of infected people and transmitters, since there were still those who hosted the virus asymptotically, Brazil adopted the restrictive measures proposed by the WHO. Thus, in addition to the use of masks, constant hand washing with soap and water, use of alcohol 70 to disinfect hands, objects and surfaces and the use of personal safety equipment (PPE), the WHO recommended social isolation. People should stay in their homes until the virus was contained or the contamination rates were significantly reduced (flattening of the curve).

The decree of social isolation caused changes in all social spheres, since it closed schools, businesses, colleges, suspended elective care in health, remaining only the services considered essential and the character of urgencies and emergencies.

##### 4.1 - Restrictive measures and the repercussions on interpersonal relations

With the determination of social isolation, the residences, which used to have fixed times for the family members to meet due to the daily routine (school, work, leisure, etc.), started to reoccupy the function of full-time shelters. The family had to reorganize itself to stay at home and also transform its spaces into a classroom, office, gym and above all, into a place of continuous coexistence, of re-adaptation.

As an aggravating factor, many were the people who lost their jobs, adding another problem to the family routine. The vulnerability of finding oneself unemployed or losing one's source of income characterizes as a stressful element in interpersonal relationships, a fact accentuated in a pandemic context in which the possibility of finding work opportunities was reduced due to the closing of companies and suspension of services.



Therefore, the determination of the "Stay at Home", conveyed in social media campaigns carried in itself a weight of requirements ranging from the reorganization of physical spaces to the restructuring of life as a whole, especially for those living in situations of social vulnerability. Therefore, the human being needed to change the way of relating to himself and with the daily challenges imposed by the pandemic in living with others.

The forced isolation is a sickening psychic experience, it puts us in a series of questions and anxiogenic situations, of continuous stress and affective helplessness, puts us in front of issues that perhaps we would not want to get in touch with now, challenging us in many issues (TELLES, 2021, p.37).

As pointed out by Telles (2021), the fact of being stuck in a single space for a long period, causes anxiety, continuous stress and awakens affective needs. Factors that arise due to the social nature of the human being. In this way, the abrupt reduction of life to the spaces of the house may constitute a risk for psychological and physical illness.

Among the consequences that were being disseminated in the society during the aggravations of the pandemic were the fear of contracting the disease, or a relative, a close friend; the intensification of loneliness for those who lived alone; the insecurity about the future; the financial instability, and for many, the pain of losing loved ones. The mourning that entered thousands of homes worldwide. Canuto (2020) reinforces that among the social impacts of the pandemic with Covid-19, social isolation is capable of drastically changing the routine of individuals by developing feelings such as stress, fear, instability and distrust.

All these situations affect relationships directly, especially in the context of the proximity and continuous coexistence of several people in the same place. In this scenario, respect for otherness, for differences, needs to be practiced in daily relationships, since when it doesn't happen, conflicts are inevitable.

The contemporary technological apparatus and the internet have contributed to the communication process of the confined, helping to shorten the distances, through messages, meetings and virtual encounters. However, the virtual cannot meet the human need for physical contact and moments of face-to-face meetings and festivities among friends and relatives.

Magalhaes (2020) when discussing relationships in the pandemic period emphasizes that meetings through social networks and the existence of a virtual world without borders do not satisfy, or replace the body of the other, the physical presence, the relationships of affection, not even

using the highest definitions and pixels. In this sense, physical distance interferes directly in the quality of interpersonal relationships.

Studies such as the one conducted by Baltor and Oliveira (2021) prove that human relationships can be directly affected in periods of social isolation. In their research they interviewed 120 people of whom 75% declared that their friendships were distanced or ended during the pandemic. In this sense, the results converge with Bauman's theory (2001) when he states that one of the characteristics of contemporary human bonds is fragility. According to the sociologist, there is a dubious feeling for the insecurity that fragility inspires and the conflicting desires to tighten ties and at the same time keep them loose. The liquidity of relationships becomes evident in moments and situations that will require greater efforts or resilience in overcoming great challenges, as in the case of the pandemic with Covid-19.

#### 4.2 - Interpersonal relationships in isolation and the escalation of conflicts

The forced isolation, triggered a series of problems related to the failure of harmonious confinement for a long period of time. In many homes, "what used to be supported, easily becomes intolerable and a feeling that something is going very wrong takes over the relationship" (MAGALHÃES, 2020, p. 192).

The experience of living in isolation interfered directly in the increase of several indices of social destabilizers due to relational problems, among them the increase in the consumption of alcoholic beverages, in the number of divorces, domestic violence and in the appearance of psychic and emotional diseases.

##### 4.2.1 - Domestic violence in the pandemic

The restrictive measure of social isolation reflected directly on the increase in the rates of domestic violence in Brazil. The greatest victims were children, women, the elderly and people who present some vulnerability such as those with special needs.

The sharing of the family environment for a long period of time, the stressful factors of confinement for adults and children, as well as the reconfiguration of the roles of fathers and mothers, especially mothers, whose routines began to involve the professional exercise (Home Office) and family responsibilities in the same place, contributed to the intensification of behavioural changes in people, exposing them to the practice or victimisation of violence. The isolation also favoured the forced presence between potential aggressors and their victims.

(...) this environmental configuration seems to generate, on one hand, an increasing absence of intra-

family management of rules and intrusive "affectionate" behaviours of parents towards their children (i.e., the parental figure that sets aside the function of becoming the other "friend", implementing leniency in basic routines, such as bedtime, nutrition and hygiene) or, in the other polarity, excessive discipline or the use of violence as a regulatory mechanism (GUEDES, 2020, p. 394 - author's emphasis).

Raciunas and O'Kuinghttons (2021) mention that the closing of schools during the pandemic contributed to the increase of violence against children and adolescents, however, the isolation itself makes it difficult to report, generating the underreporting of cases. Also according to the article published by these researchers, during the period of social isolation, the channel for complaints of human rights violations had received, until May 2021, 25.7 thousand complaints of physical violence and 25.6 thousand of psychological violence. Of this total, 59.6% referred to children and adolescents.

Women and the elderly are also found as victims of violence in rates that have risen significantly in the period of social isolation. The Brazilian Yearbook of Public Safety (2021), reports that Brazil recorded 3,913 homicides against women, with 230,160 cases of malicious bodily injury due to domestic violence, according to civil police records. There were 1,350 feminicides, 61.8% of them committed against black women. The data also indicate that the aggressors are people they live with, as shown in figure 1.

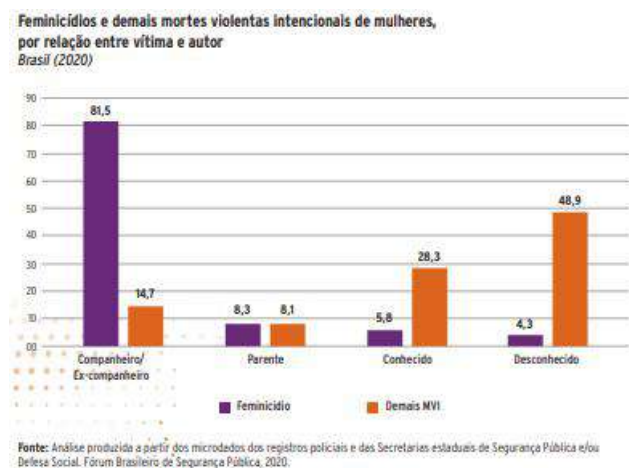


Fig. 1: Identification of Perpetrators of Women - victims of femicide and violent deaths

Regarding this increase in domestic violence during social isolation, Piccini and Araújo (2020) point out some factors that corroborate the increase in cases: loss or reduction of family income due to unemployment, suspension of work activities, overload of domestic

activities, including caring for the children, isolation of the victim from family and friends, increased consumption of alcoholic beverages, and other situations that increase the tension in domestic relationships.

It is observed in these environments the absence of dialogue or of an assertive and non-violent communication, based on affection and respect for the other. The vulnerability of the victims who are forced to live with their aggressors for a longer period of time also contributes to this high rate. In the case of feminicides, there is still the pressure suffered by many women in sexist relationships in which the woman is considered an object of belonging to her partner.

#### 4.2.2 - Increased consumption of alcoholic beverages

Another aspect that directly interferes in human coexistence, causing interpersonal conflicts with serious consequences, is the consumption of alcoholic beverages. Recent research, such as that conducted by the Pan American Health Organization (PAHO) in 33 countries and two territories of the Americas, revealed that alcohol consumption increased considerably globally during the pandemic.

According to PAHO (2020b), Brazil presented the highest prevalence of the factor "heavy drinking", known as "Binge" episode, among all countries surveyed. The survey also revealed that the country also had the highest rate of severe anxiety in relation to other countries.

These results are ratified by the research conducted by the Brazilian Liver Institute (Ibrafig), published in December 2021. The study evidenced that 55% of the Brazilian population has the habit of consuming alcoholic beverages. Of those interviewed, 17.2% declared having increased their alcohol consumption during the pandemic. From the total of 1.9 thousand people who participated in the survey (from the five regions of the country), 18.8% reported to have made abusive consumption of alcoholic beverages in the pandemic (JANONE, 2021).

The reasons mentioned for the increase in consumption were the difficulties in dealing with the changes arising from the pandemic context, such as: stress, job loss, anxiety crises, fear, relationship difficulties at home, among others. "As the rates of anxiety, fear, depression and uncertainty became more commonly reported during the pandemic, alcohol consumption also increased. The presence of severe anxiety disorders increased the chance of more frequent drinking by 73%" (DAHL, PAHO, 2020, Webinar).

Due to social isolation, closing of bars, beer halls and similar establishments, online sales have increased, proving that people have started consuming drinks at

home. According to a survey conducted by Plataforma Compre & Confie, a market intelligence company focused on e-commerce, the online sale of alcoholic beverages rose 93.9% with 248.9 thousand purchases made in the period from 24 February to 3 May 2020 (NEVES, 2021).

The close relationship of the increased consumption of alcoholic beverages in the pandemic with Covid-19 and the reasons given by the interviewees are anchored in the theory of liquidity of relationships advocated by Bauman (2001; 2004) and the unbussed man of Forbes (2010; 2019). The man who guides his life in the automatic of immediacy, who does not worry about sedimenting relationships, so at the moment when he needed to be reclusive in the family space and deal with a period of crisis, he became disconnected from the automated and fluid self, generating many other conflicts. To cope with the chaos, drinking became an escape strategy, which culminates in the appearance of many other problems for oneself and for society.

#### 4.2.3 - Fragile couple relationships in the pandemic: "until the pandemic breaks them apart"

The fragility in relationships, according to Bauman (2001), is directly linked to the consumerist practice of contemporary liquid society in which getting rid of things has priority over acquiring them. Concept also adopted in relationships, which leads to the constant exchange of partners, relationships are called "connections", so it is easier to break, to disconnect.

In his work "Liquid Love" (2004), Bauman discusses the patterns of relationships between contemporary couples. According to the sociologist, people want to interact, they seek the experience of affection, however, they do not want to commit themselves. They change partners constantly and easily.

During the social isolation in the pandemic with Covid-19, families faced challenges focused on coexistence in the homes. There was a disorganization of routines, requiring the obligation of sharing longer periods in the same physical environment "and most were not prepared for this reconnection" (GUEDES, 2020, p. 394 - emphasis added).

Thus, many people took advantage of the pandemic period to try to reconnect with family members, experience experiences that the routine of working away from home did not allow before the pandemic, however, many were also the cases of shattered relationships.

The increase in stress and anxiety crises due to the multiplicity of problems during the pandemic period generated consequences in interpersonal family relationships, increasing the number of separations and divorces among couples.

In 2021, the number of couples who made their separation official in a registry office broke a record surpassing 77,000 cases. A survey by the CNB (Brazilian Notarial College) recorded that 77,112 consensual divorces were carried out in Brazil in 2021. One of the main causes alleged for the separations was social isolation at home, relational differences (R7, 2022).

The confinement potentiated the crises and fragilities exposed daily in conjugal relationships such as emotional exhaustion, fights, unemployment, infidelity, addictions, domestic violence (SILVA; LOPES; ROCHA, 2021). In this context, conflicts have triggered a high rate of disagreements and separations.

It is important to observe that the number of separations can be much higher due to the cases that are not notified, case of stable unions, concubinages not regulated in registry office, generating underreporting.

Behind the divorces there are, besides the behavioural changes and the daily difficulties, the difficulty in the communication process. The absence of assertive and non-violent communication, of the respect for otherness, reinforce the inter-relational conflicts, potentiating domestic violence, the appearance of psycho-emotional, psychosomatic diseases, the use of licit and illicit drugs.

When couples divorce, they generate other problems for themselves and for their children, when they have them, and for society, since the difficulties in dealing with the rupture of the bond may cause greater upheavals in many situations. A problem that originates other destabilizing problems for social harmony.

## V. FINAL CONSIDERATIONS

The changes in the social life and organization forced by the pandemic with Covid-19, due to its high potential for contamination, triggered several problems not only in the health area.

Interpersonal relationships were greatly affected by the restrictive measures for the removal of relatives, boyfriends and friends who did not live together. On the other hand, the obligation of isolation increased the interpersonal conflicts of people who, with the abrupt routine change, needed to live in the same space for a long period.

The context of the modified and adapted homes for a multiplicity of functions, the work overload, unemployment, financial difficulties were the apex for the outbreak of high rates of domestic violence, divorces, increasing consumption of alcoholic beverages and psycho-emotional diseases.

The fragility of human relationships was bluntly evidenced. The scenario of fear, insecurity, pain of unexpected losses altered behaviour, reinforced situations of oppression, aggravating social problems and the relationship of man with others and with himself.

Contemporary man, despite the numerous technological advances and the agility of communication via information technology, has become accustomed to relationships at the fingertips of mobile phone screens and computer keyboards, however, the data confirm that they need to learn to live together at close quarters, in a concrete, more tangible way.

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# Computer simulation of reinforced concrete columns confined with CFRP

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**Keywords—** CFRP, Columns, Finite  
Element, Reinforced Concrete,  
Reinforcement

**Abstract**—Carbon Fiber Reinforced Polymer (CFRP) reinforcement of reinforced concrete (RC) columns has become increasingly common. This work presents a finite element computational model capable of representing the structural behavior of CFRP-confined square RC columns. Data and results from experimental research available in the literature are used to assess the ability of the proposed model to represent the test results. It is possible to observe that the models were able to represent, with adequate precision, the structural behavior of columns with different configurations of longitudinal reinforcement, stirrups spacing, number of CFRP layers, and type of load.

## I. INTRODUCTION

Due to the aging of buildings or even the change in use of the structure, reinforcing RC structures can become the most economical and viable option to be carried out. According to Souza and Ripper [1], the reinforcement of columns is always more problematic than beams and slabs. The columns are the last elements of support of the structure before the loads reach the foundations and have to obey safety and economic criteria in any situation.

Among the existing methods, the reinforcement of columns with CFRP (Polymer Reinforced with Carbon Fiber) has become increasingly common. Saadatmanesh and Ehsani [2] state that the growth in the use of composites is mainly due to their high tensile strength,

high modulus of elasticity, and excellent corrosion resistance.

This reinforcement technique in columns works due to the lateral confinement promoted by the CFRP. However, according to Carrazedo [3], confinement is only appropriately enabled with the development of microcracks at a high-stress level since the lateral deformation of concrete is very small before the beginning of microcracking. Therefore, this reinforcement technique is classified as a passive form of confinement.

Several experimental works in the literature address the reinforcement of RC columns with CFRP wrap. However, elaborating all the procedures of experimental research can become onerous. Therefore, using computational methods

capable of representing the structural behavior of columns can be considered an interesting alternative.

Computer simulations of concrete structures, for the most part, are with the finite element method (FEM). Real *et al.* [4] explain that in the FEM, the structure is divided into small elements that are linked together through nodal points. This method solution is determined through the displacements, which are the unknowns of the problem. The internal stresses of the element and the reactions at the supports are calculated from these displacements.

In Brazil, the Brazilian Standard (NBR) that deals with reinforced concrete elements' design and structural behavior is the NBR 6118 [5]. However, this standard still does not provide prescriptions regarding the design and construction procedures of CFRP reinforcements. Therefore, conducting research in this area is essential in the national context.

Most Brazilian research on carbon fiber reinforced structures is based on international normative recommendations. Therefore, this research aims to demonstrate the computational simulation of RC columns reinforced with CFRP to contribute to the scientific community as a technical asset for future Brazilian standardization of this reinforcement technique.

## II. METHOD

This work was carried out using the experimental results of research by Wang *et al.* [6], Atheer *et al.* [7], and Souza [8] as a reference in terms of comparison to validate the computational model used. The computational modeling was performed using the Ansys Workbench 17.1 software, which performs simulations using the finite element method.

### 2.1 – Finite element analysis (FEA)

The SOLID65 element was used to represent the concrete. According to ANSYS [9], SOLID65 is a 3D element, with eight nodes, with a material model capable of cracking under tension and failure by crushing in compression and having the ability to suffer creeping. This element supports up to four different materials for each finite element, with one being the principal material and the reinforcement bars distributed inside the element volume, being ideal for representing the reinforced concrete

The linear element LINK180 represented the longitudinal reinforcement and stirrups of the columns. According to ANSYS [9], the LINK180 element can be used to model cables and bars and has two nodes with three degrees of freedom at each node. This element resists only axial forces and considers the steel reinforcement's

elasticity, plasticity, and creep characteristics. In addition, its cross-section can increase or decrease when the element is subjected to compression or tension.

The SHELL 181 element was used for the CFRP, which is capable of considering the change in the thickness of the CFRP in nonlinear analysis, a characteristic that makes it able to evaluate the internal stress distribution during the study of the structure where it is associated. According to ANSYS [9], it is a four-node element with six degrees of freedom at each node (translations in the x, y, and z directions and rotations about the x, y, and z axes). Fig. 1 represents the elements used.

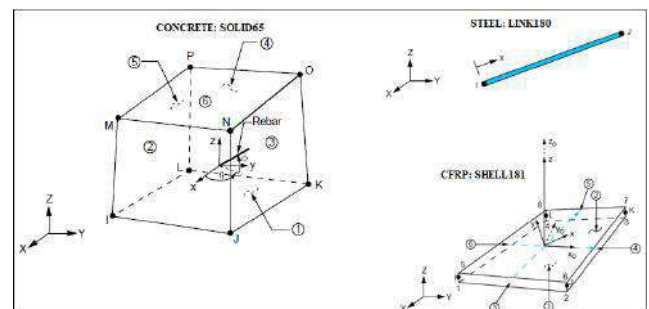


Fig. 1- Types of the elements used in the FEA

The failure mode of the SOLID65 element used is based on the criterion of William and Warnke [10]. These equations consider both the crushing and cracking failure of the concrete. Poisson's coefficient was 0.2 in all columns, while the hydrostatic, shear transfer coefficients for closed cracks and shear transfer coefficients for open cracks were defined as 1.0, 0.3, and 1.0, respectively.

A discrete model was used to idealize the stiffness of the steel. According to Ayala [11], it is a model that requires that the nodes of the SOLID65 and LINK180 elements coincide. This element combination is the ideal model for the constitutive equations of William and Warnke [10].

A mesh convergence test was performed to determine the best mesh configuration. For the columns of Wang *et al.* [6], meshes of 7,625 mm were used in x and y directions for concrete, while for CFRP, a mesh of 20 mm was employed. In the columns of Atheer *et al.* [7], meshes of 7.5 mm were adopted in x and y directions for concrete, and a mesh of 12.5 mm was defined for CFRP. Finally, in the columns of Souza [8], were used meshes of 6.25 mm in the x-direction and 28.52 mm in the y-direction for concrete and a mesh of 12.5 mm was defined for CFRP. The meshes used are shown in Fig. 2 - 4.

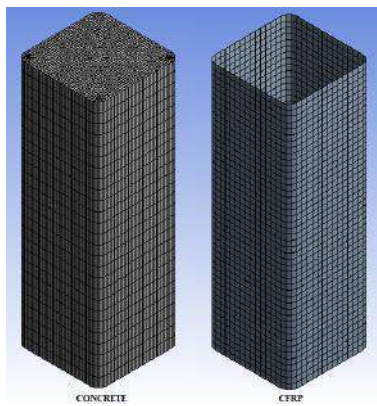


Fig. 2 – Mesh of the columns by Wang et al. [6]

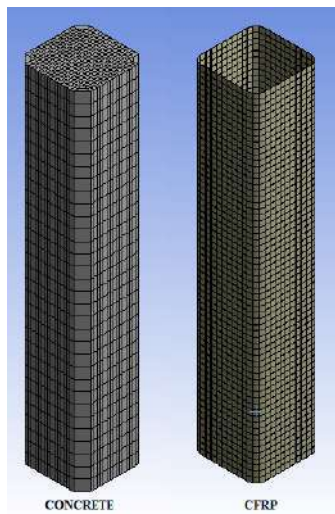


Fig. 3 – Mesh of the columns by Atheer et al. [7]



Fig. 4 – Mesh of the columns by Souza [8]

The analysis was performed considering the lower face of the columns fixed in the Y direction to represent the models' reaction. In contrast, the upper face was considered free to move. A displacement in the Y direction was applied in this region to represent the load action. This action was subdivided into "substeps" adjusted for each model. Like the mesh convergence test, the appropriate number of "substeps" depends on tests and the geometry of each model.

The Newton-Raphson method, which was used in this analysis, is one of the ways used by ANSYS [9] to solve nonlinear analyses. According to Pivatto [12], this method approaches the equilibrium trajectory of the structure by its tangents until reaching convergence. The displacement increments were applied until the column load capacity had been exceeded.

### III. RESULTS AND DISCUSSION

#### 3.1 – Experiments by Wang et al. [6]

The experimental work by Wang et al. was carried out to study the influence of the variation of the stirrups spacing and the number of layers CFRP in columns of larger dimensions than are generally found in the literature. The authors tested 34 columns with two identical specimens; there were 17 column configurations. One column of each format was tested for a monotonic load, and the other was tested for a cyclic load. Fig. 5 presents the dimensions of the columns and the details of the longitudinal reinforcement and stirrups.

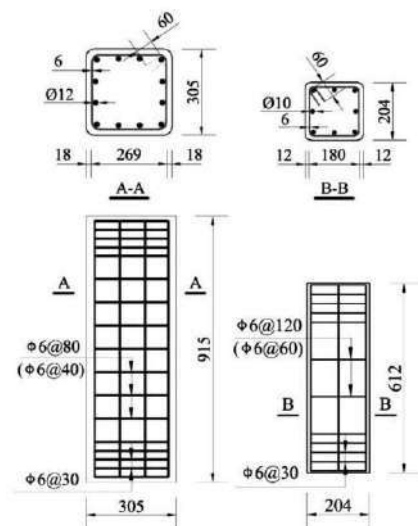


Fig. 5 – Specimen dimensions and reinforcement details of the columns by Wang et al. [6]

Table 1 – Characteristics of the materials used by Wang et al. [6]

Material	Diameter/thickness (mm)	Yield/peak strength (MPa)	Ultimate strength (MPa)	Elastic Modulus (MPa)
Longitudinal steel	10	312	484	200,000
	12	340	520	200,000
Stirrups steel	6	397	623	200,000
CFRP wrap	0.167	-	4,340	240,000

The models are characterized as follows: The letters S1 and S2 represent the dimension of the analyzed cross-section, and the letter H represents the stirrup rate used, which can be 0 for simple concrete, 1 or 2 for a stirrup steel rate of 0.5% or 1% respectively. The letter L represents the number of CFRP layers, which can vary from 0 to 3 layers, and finally, the letter M represents the type of load used, which would be monotonic. Fig. 5 illustrates the dimensions of the tested columns and the reinforcement details. For example, the model S1H1L3M has a square cross-section of 305 mm, a stirrup steel rate of 0.5%, 3 layers of CFRP, and has been subjected to a monotonic load.

The columns received a rounding of the corners to mitigate the effects of stress concentration at the corners. It was used a rounding with a radius of 30 mm for the S1 specimens and 20 mm for the S2 specimens, keeping a ratio of twice the rounding radius per cross-section side at 0.2 so that the two models receive the same influence. The compressive strength of the concrete was 25.5 MPa on the day of the tests.

The stress was obtained by dividing the maximum load by the cross-sectional area as in the experimental results. The deformation was calculated by the ratio between the axial displacement and the height of the analyzed column. For the simulation of the columns by Wang et al., axial displacements on the Y-axis were applied to the upper face of the columns. This displacement was subdivided into 200 substeps.

In terms of comparison, only the results of simulations performed with monotonic loads, i.e., continuous loading, were used. On the other hand, cyclic loads are variable loads, i.e., successive loading and unloading until the element under study fails. Furthermore, the authors did not find significant differences between the results obtained between the different types of loading. Table 2 demonstrates the comparison between experimental and computational results.

The authors reported that the confinement distribution of the CFRP was not uniform around the perimeter of the columns. The CFRP was not efficient in confining the concrete in the region in the middle of the lateral face of the columns. On the contrary, the corners were responsible for promoting the observed confinement. Therefore, the mean strain value obtained overestimated the failure stress and the effectiveness of the confinement of the CFRP. Wang et al. [6] concluded that the corners were the most critical points and that the CFRP strain efficiency factor was about 0.4 for the larger columns (S1) and 0.6 for the smaller columns (S2).

As in the experiments by Wang et al. [6], the computer models showed a more significant deformation in the middle of the lateral faces of the CFRP. Furthermore, the models with a smaller cross-section presented a greater lateral deformation when compared to the models with a larger cross-section, which is in line with the results given by Wang et al. [6]. Figs. 6 – 8 represent the strain on CFRP of the larger (S1) and smaller (S2) section models.

The other columns showed the same strain distribution pattern in Figures 6 - 8. Wang et al. [6] reported that the models suddenly failed in the mid-height region regarding the failure mode. Furthermore, the RC columns also showed buckling in the longitudinal reinforcement bars between the stirrups, and the concrete had been severely crushed. Fig. 9 represents the stress in the longitudinal steels and stirrups of the computational models S1H1L3M and S2H2L2M.

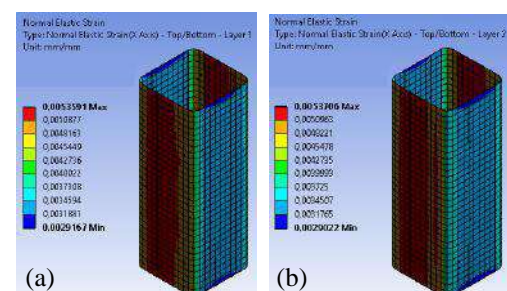


Fig. 6 – Lateral strain S1H0L2M (a) 1° layer (b) 2° layer



Table 2 – Comparison between the results of Wang et al. [6] and the proposed model

Specimen	Experimental		Computational		Variation between stress
	Axial strain (mm/mm)	Axial stress (MPa)	Axial strain (mm/mm)	Axial stress (MPa)	
S1H1L0M	0.00373	32.10	0.00241	32.79	+2.15%
S1H2L0M	0.00412	34.70	0.00249	34.77	+0.20%
S1H0L1M	0.00313	29.40	0.01090	28.60	-2.72%
S1H0L2M	0.00393	32.30	0.01311	29.73	-7.96%
S1H1L1M	0.00428	35.10	0.00459	36.43	+3.79%
S1H1L2M	0.00434	34.90	0.00361	36.70	+5.16%
S1H1L3M	0.00428	36.90	0.00448	37.60	+1.90%
S1H2L2M	0.00416	35.50	0.00426	37.50	+5.60%
S1H2L3M	0.00529	37.20	0.00535	38.50	+3.50%
S2H1L0M	0.00364	29.90	0.00359	30.24	+1.14%
S2H2L0M	0.00406	32.50	0.00327	32.89	+1.20%
S2H0L1M	0.00391	28.70	0.00817	28.69	-0.25%
S2H0L2M	0.02287	31.40	0.01307	31.98	+1.85%
S2H1L1M	0.00704	35.50	0.00653	35.00	-1.41%
S2H1L2M	0.03588	40.00	0.01471	39.996	-0.01%
S2H2L1M	0.00465	33.00	0.00474	34.77	+5.36%
S2H2L2M	0.04230	40.80	0.01634	40.76	-0.10%

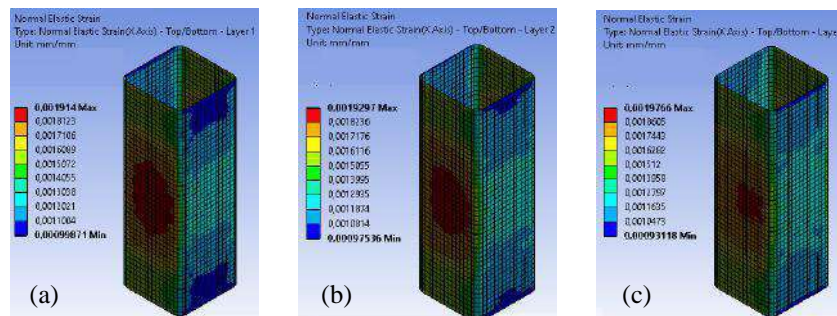


Fig. 7 – Lateral strain S1H1L3M (a) 1° layer (b) 2° layer (c) 3° layer

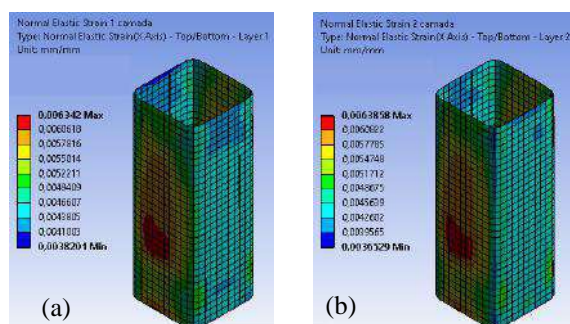


Fig. 8 – Lateral strain S1H1L3M (a) 1° layer (b) 2° layer

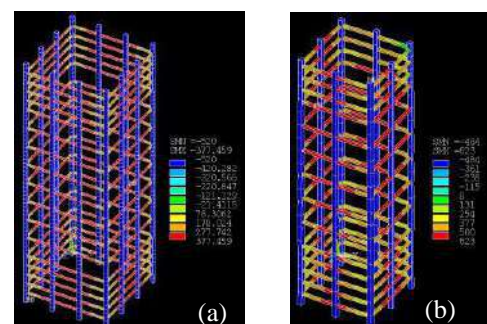
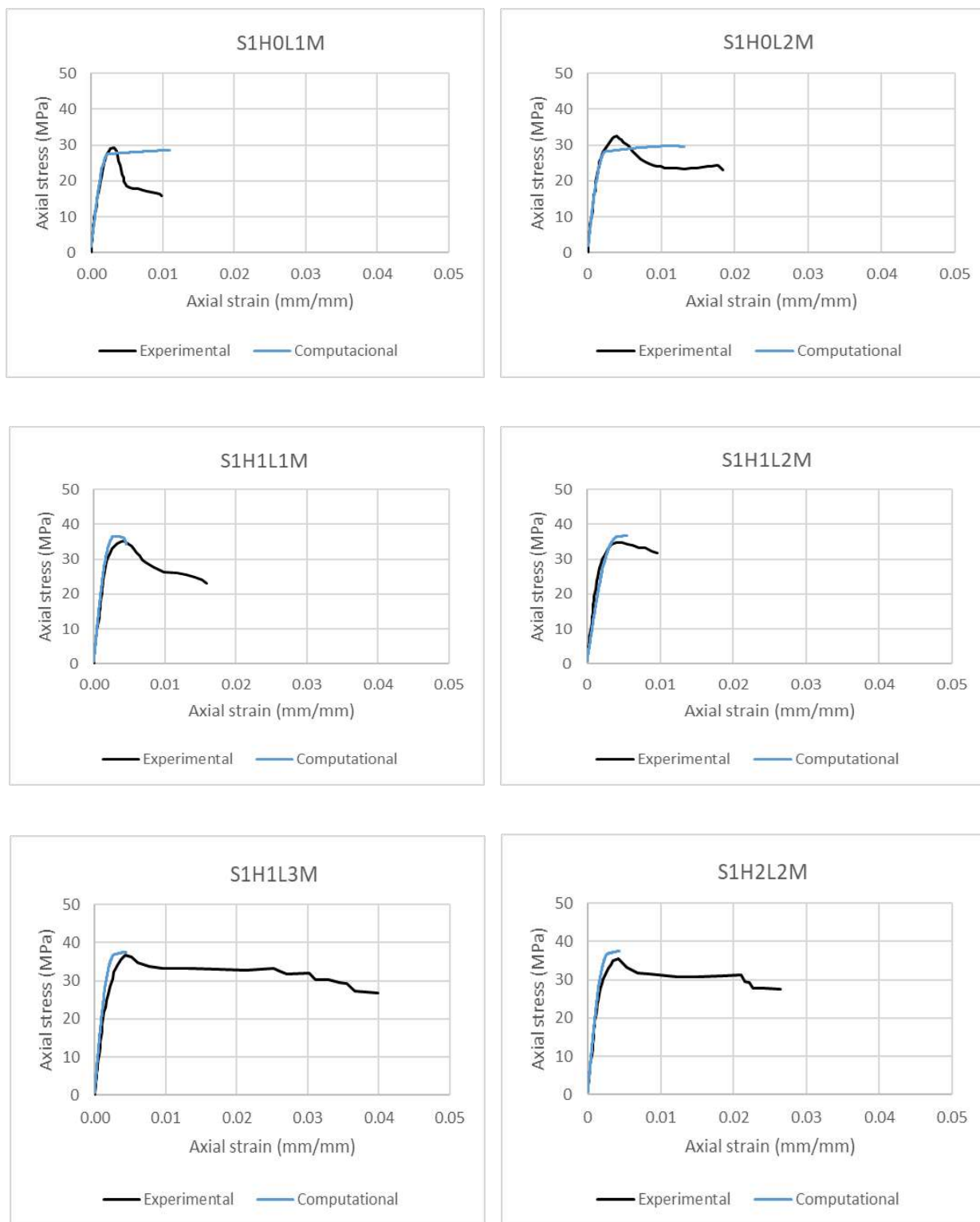


Fig. 9– Stress in the steels (a) S1H1L3M(b) S2H2L2M

As seen in Fig. 9, the longitudinal steels reached the rupture stress specified in Table 1, presenting the same failure characteristics as the RC columns tested by Wang *et al.* [6]. In addition, the authors reported that some of the columns with the largest section (S1) showed post-peak softening, which can also be observed in models

S1H1L1M and S1H1L2M in the stress-strain curves of Fig. 10. In addition, the smaller section models (S2) showed an upward behavior, as can be observed in the S2H1L2M and S2H2L2M models, which was also reported by Wang *et al.* [6] in their experiment.



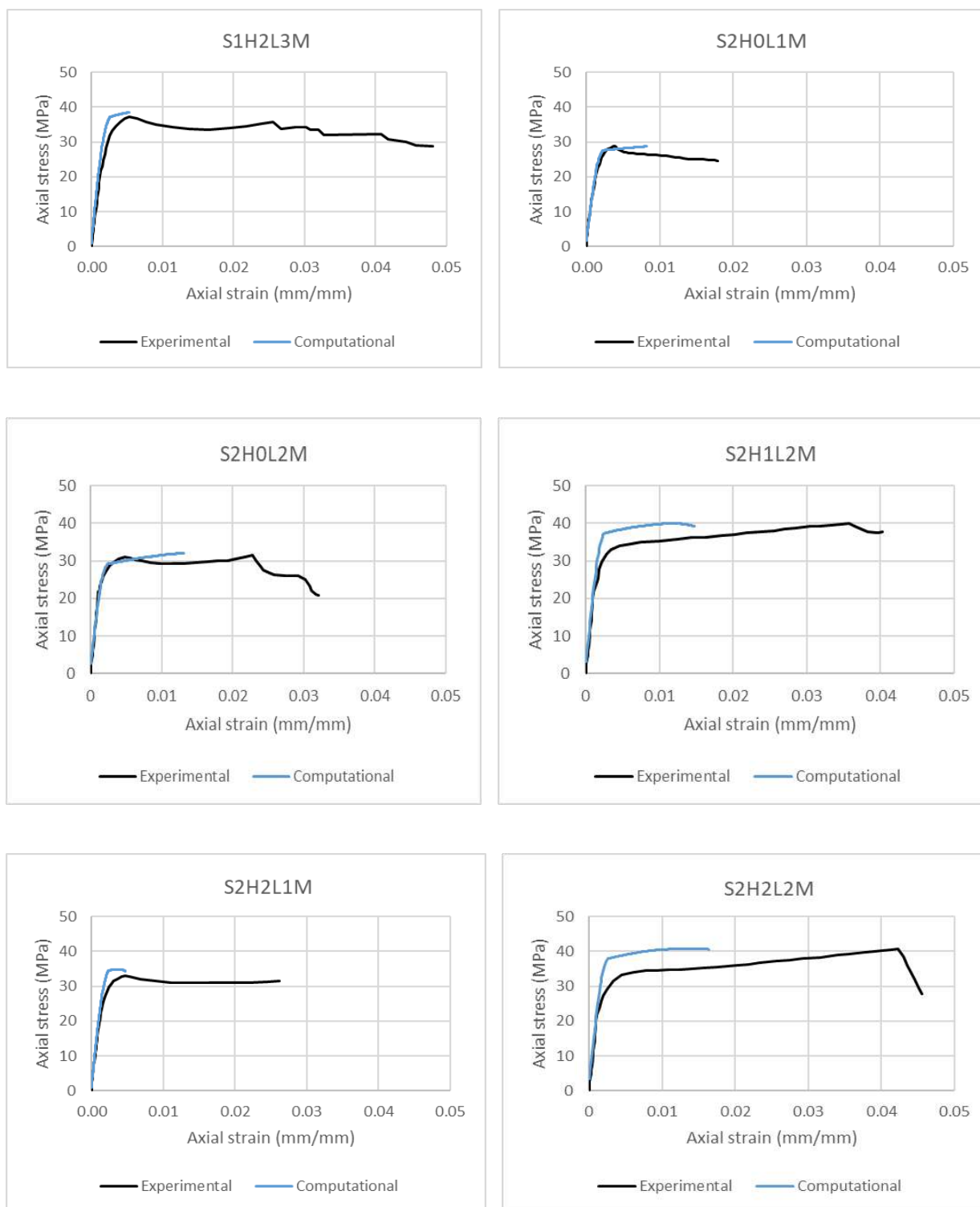


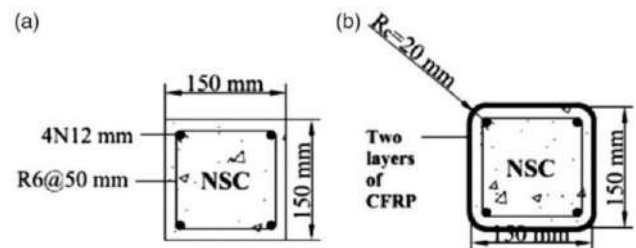
Fig. 10 – Stress-strain graphs of the computational model for the columns of Wang et al. [6]

3.2 – Experiments by Atheer *et al.* [7]Table 3 – Characteristics of the columns by Atheer *et al.* [7]

Specimen	Section (mm)	Height (mm)	Longitudinal steel (mm)	Stirrups (mm)	N° CFRP wrap	Eccentricity (mm)
SF0	150 x 150	800	4 Ø 12	Ø6 c/50	2	0
SF20	150 x 150	800	4 Ø 12	Ø6 c/50	2	20
SF40	150 x 150	800	4 Ø 12	Ø6 c/50	2	40

The authors carried out an experimental study proposing a new form of reinforcement. For this, experimental simulations of CFRP-confined square RC columns were carried out to serve as a benchmark. Subsequently, circularization by concrete based on reactive powder was performed in models identical to the square ones, increasing the cross-section and changing the shape of the section of the column studied.

For the simulations, only the reference specimens were selected, that is, the CFRP-confined square models without performing the circularization, which were subjected to concentric and eccentric loads. In addition, all the columns have the same configuration, differing only by the eccentricity used. The characteristics of these columns can be seen in Fig.11.

Fig. 11 – Cross-section of columns (a) S and (b) SF (Atheer *et al.* [7])

For the columns by Atheer *et al.* [7], the displacement applied to the upper face was subdivided into 75 substeps for model convergence. The corners received a rounding radius of 20 mm to alleviate the stress concentration in this region. Table 3 presents the details of the columns tested by Atheer *et al.* [7], while Table 4 presents the characteristics of the materials used.

Table 4 – Characteristics of the materials used by Atheer *et al.* [7]

Material	Average compressive (MPa)	Ultimate strength (MPa)	Elastic Modulus (GPa)	Average tensile (MPa)	Ultimate strain (%)
Concrete	25	-	-	-	-
Longitudinal steel	-	634	-	-	-
Stirrups steel	-	613	-	-	-
CFRP wrap	-	-	291	2,668	2.47

It was reported in the research that the CFRP-confined model subjected to concentric load (SF0) failed due to fragmentation of the cover due to stress concentration near the corners in the mid-height region. Fig. 12(a) shows these stress concentrations. In addition, it was reported that the longitudinal reinforcement bars buckled, as shown in Fig. 12(b).

In the specimen subjected to an eccentric load of 20 mm (SF20), fragmentation of the cover on the

compression side was observed due to stress concentration. The buckling of the reinforcement bars on the compression side of the column was also observed. Figs. 13 (a) and (b) illustrate the stresses on concrete and steel reinforcements. In addition, there were cracks between the CFRP strips on the tensioned side with CFRP rupture on the compression side.

The failure mode of the model subjected to 40 mm eccentricity (SF40) was similar to that of the SF20 model,



showing fragmentation of the concrete on the compression side and cracks between the CFRP strips on the tensioned side. Fig. 14 illustrates the stresses in concrete and reinforcement steel bars.

The summary of the simulation results can be seen in Table 5, where the maximum load of the computational models is compared to the results obtained by Atheer *et al.* [7].

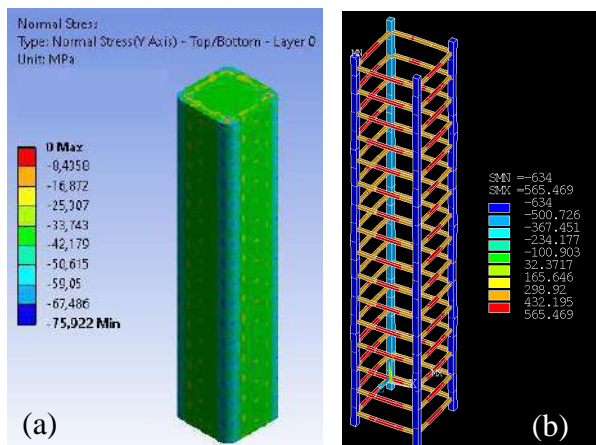


Fig. 12 – SF0 (a) stress in the concrete (b) stress in the steel reinforcements

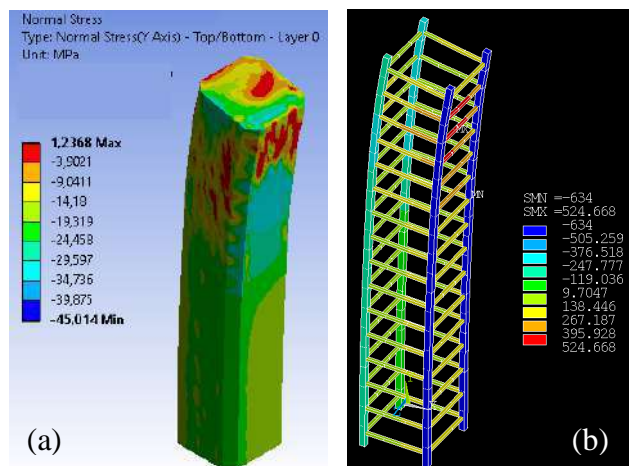


Fig. 13 – SF20 (a) stress in the concrete (b) stress in the steel reinforcements

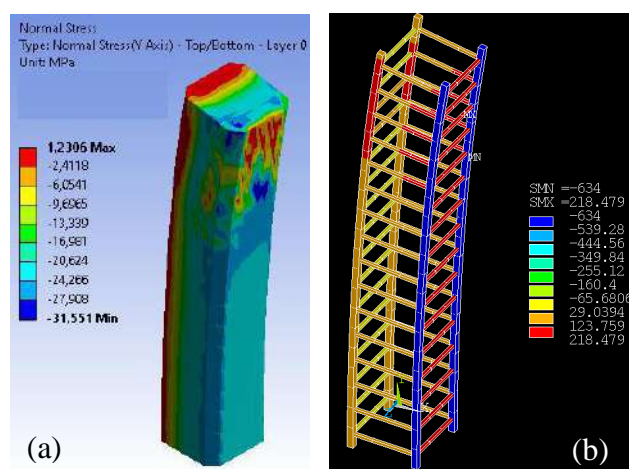


Fig. 14 – SF40 (a) stress in the concrete (b) stress in the steel reinforcements

Table 5 - Comparison between the results of Atheer *et al.* [7] and the proposed model

Specimen	Experimental		Computational		Variation between axial forces
	Axial displacement (mm)	Axial force (kN)	Axial displacement (mm)	Axial force (kN)	
SF0	30.50	1,462	30.00	1,466.2	+0.29%
SF20	9.10	650	3.03	670.11	+3.09%
SF40	8.9	429	2.70	462.69	+7.85 %

## 3.3 – Experiments by Souza [8]

Table 6 - Characteristics of Souza's [8] columns

Specimen	Section (mm)	Height (mm)	Longitudinal steel (mm)	Average compressive (MPa)	N° CFRP wrap
G1	150 x 150	713	4 Ø 10	41.2	-
G2	150 x 150	713	4 Ø 10	23.0	-
G3	150 x 150	713	4 Ø 12.5 + 4 Ø 16	41.2	-
G1R	150 x 150	713	4 Ø 10	41.2	1
G2R	150 x 150	713	4 Ø 10	23.0	1
G3R	150 x 150	713	4 Ø 12.5 + 4 Ø 16	23.0	1

In his doctoral thesis, Souza [8] carried out experimental tests of 6 columns, being 3 CFRP-confined. The columns had the same geometric characteristics, varying only the longitudinal reinforcement steel rate and the compressive strength of the concrete. The characteristics of the columns can be seen in Table 6.

In the G3R model, the author used concrete with lower strength than his reference model to simulate a situation in which the column had a bearing capacity lower than the

designed one. This situation can be found in structures of very advanced ages. Table 7 shows the characteristics of the other materials used in Souza's experiment [8].

For the columns by Souza [8], the displacement applied to the upper face was subdivided into 50 substeps for model convergence. The corners received a rounding radius of 25 mm to alleviate the stress concentration in this region.

Table 7 - Characteristics of the materials used by Souza [8]

Material	Ultimate strength (MPa)	Elastic Modulus (GPa)	Average tensile (MPa)	Ultimate strain (%)
Longitudinal steel	615	-	-	-
Hoop steel	797	-	-	-
CFRP wrap	-	231	4,205	1.8

It was reported by Souza [8] that the failure mode of the unreinforced models occurred initially in the cover region. Later there was the crushing of the concrete core, with buckling of the longitudinal steel bars. The models CFRP-confined showed rupture of the concrete core but without showing fracture of the CFRP.

The computer models showed similar behavior. The CFRP did not reach its maximum tensile capacity in any of the models (Fig. 15). The distribution of compressive

stresses (Fig. 16) was also shown to be similar to the reports by Souza [8]. Therefore, the computational model failure also occurred due to the crushing of the concrete core of the column. Table 8 combines the experimental and computational simulation results, comparing the results obtained.

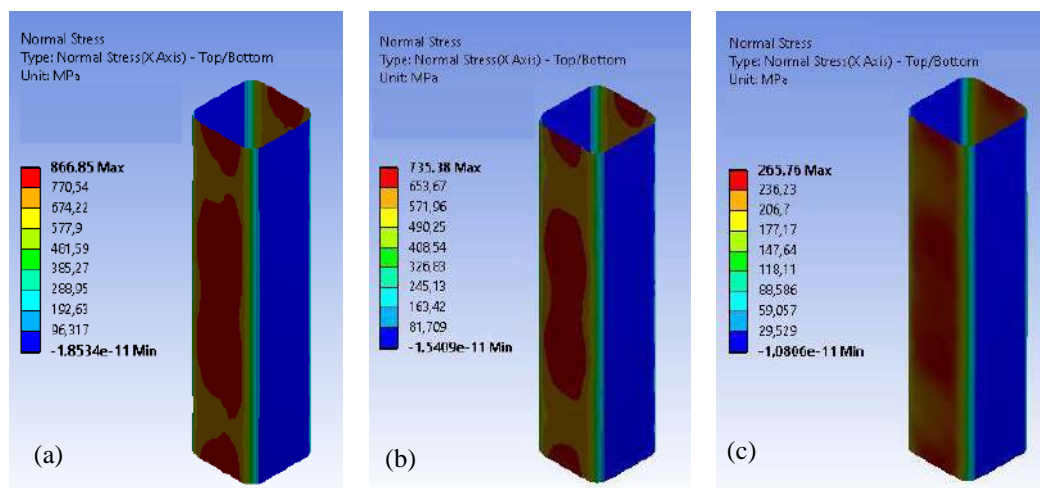


Fig. 15 – Stress in the CFRP (a) G1R (b) G2R (c) G3R

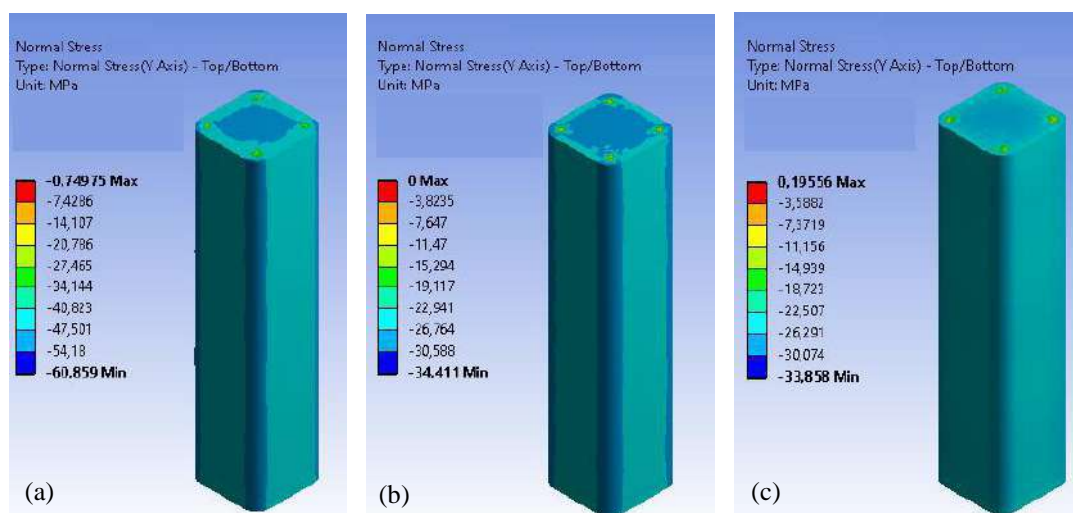


Fig. 16 – Stress in the concrete (a) G1R (b) G2R (c) G3R

Table 8 - Comparison between Souza's [8] results and the proposed model computational

Specimen	Experimental		Computational		Variation between axial forces
	Axial strain (mm/mm)	Axial Force (kN)	Axial strain (mm/mm)	Axial force (kN)	
G1	0.002423	1013	0.002104	1042.3	+ 2.89%
G2	0.001852	613	0.002524	600.4	- 2.05%
G3	0.002061	1444	0.002384	1377.9	- 4.58%
G1R	0.004600	1417	0.008415	1324.2	- 6.55%
G2R	0.005586	927	0.007010	861.26	- 7.09%
G3R	0.005653	1303	0.004909	1401.3	+ 7.54%

#### IV. CONCLUSION

The proposed computational model demonstrated satisfactory performance. It showed good behavior in the stress-strain graphs compared to the columns of Wang *et al.* [6]. Still, on the columns of Wang *et al.* [6], it presented good agreement in the ascending branch of the models of smaller cross-sections and the post-peak softening of some models of the larger section.

In the Atheer *et al.* [7] columns, the simulation presented maximum loads close to the experimental results, mainly in the concentric load model. However, it showed a different axial displacement in the models with eccentric loads.

Finally, in the columns tested by Souza [8], the model also had satisfactory results, demonstrating that the high rate of longitudinal steel of the G3R column reduced the lateral expansion of the column, which reduced the contribution of the CFRP in the final axial capacity of the column.

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# Aracoiaba Dam: Pollution factors and environmental degradation in the surrounding and Upstream Area

## Açude Aracoiaba: Fatores de poluição e degradação ambiental no entorno e a Montante

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**Palavras-chave—** Açude Aracoiaba, Maciço  
de Baturité, Poluição e degradação  
ambiental,

**Abstract—** The late 1990s, the Aracoiaba city experienced a crisis of drinking water shortages, which required the construction of the Aracoiaba Dam, which began in 2000. This research aimed to verify the existence of pollution and degradation factors environment around and upstream of the Aracoiaba Dam, as well as the characteristics of its waters, and the impacts of pollution and environmental degradation on the sustainability and quality of the water in that dam. The investigation was developed according to a basic and exploratory nature, with a qualitative approach through a case study. Research confirms the existence of sewage points, which the city of Aracoiaba itself and other surrounding cities, discharge directly into the bed of the Aracoiaba River, impairing its quality, which was confirmed through changes in the quality of these waters, when compared with Brazilian legislation. It was also confirmed the existence of environmental degradation in the surroundings and upstream of this dam, which also corroborates to compromise the quality of these waters. The great social and economic importance of the Aracoiaba Dam imposes the need to adopt mitigating measures to remedy the problems encountered.

**Resumo—** No final dos anos 90, o município de Aracoiaba vivenciou uma grave crise de escassez de água potável, o que requereu a construção do Açude Aracoiaba iniciada no ano 2000. Esta pesquisa teve por objetivo verificar a existência de fatores de poluição e degradação ambiental no entorno do Açude Aracoiaba e a montante deste, bem como as características de suas águas, e os impactos da poluição e degradação ambiental para a sustentabilidade e qualidade da água desse açude. A investigação foi desenvolvida conforme natureza básica e exploratória, com abordagem qualitativa por meio de estudo de caso. As pesquisas confirmam a existência de pontos de esgoto, que a própria cidade de



*Aracoiaba e outras cidades circunvizinhas, lançam diretamente no leito do Rio Aracoiaba prejudicando sua qualidade, o que foi confirmado através das alterações na qualidade destas águas, quando comparadas com a legislação brasileira. Também foi confirmado a existência de degradações ambiental no entorno e a montante desse açude, o que também corroboram para comprometer a qualidade dessas águas. A grande importância social e econômica do Açude Aracoiaba impõe a necessidade de adoção de medidas mitigadoras para sanar os problemas encontrados.*

## I. INTRODUÇÃO

No final dos anos 90, o município de Aracoiaba vivenciou uma grave crise de escassez de água potável, dada a irrefutável importância da utilidade da água para a existência da vida, é compreensível que a falta dela possa causar preocupações e problemas à população. Na cidade de Aracoiaba, os munícipes viveram esse drama por muitos anos. Mas entre os anos de 2000 a 2002 o Governo do Estado do Ceará construiu o Açude Aracoiaba, que aos olhos da população aracoiabense iria solucionar todos os problemas com a escassez de água potável da cidade.

A construção do Açude Aracoiaba minimizou o problema da escassez de água potável do município e de cidades vizinhas, e proporcionou o desenvolvimento socioeconômico local. Por outro lado, a área do entorno do Açude Aracoiaba como terra fértil, livre de fiscalização e propícia ao plantio, se tornou um negócio atrativo e lucrativo para aqueles que começaram a utilizá-la de diversas maneiras tais como: agricultura, olericultura e criação de gado, entre outras atividades produtivas, e para isto, desmataram, queimaram e usaram agrotóxicos em suas atividades agrícolas. As águas desse açude também proporcionaram a criação de peixes em gaiolas, produção de camarão de água doce e ainda o lazer em locais improvisados.

A intensificação do uso das águas desse açude de forma indiscriminada, a falta de monitoramento das atividades praticadas dentro e no entorno desse açude, bem como dos fertilizantes e do controle biológico realizado nas atividades agrícolas, acrescido dos esgotos que a própria cidade de Aracoiaba e outras cidades da região, jogam diretamente no leito do rio que abastece este açude, podem estar afetando a qualidade destas águas. Atualmente a possibilidade de poluição e contaminação da água desse açude, é fato que gera questionamentos a respeito da qualidade destas águas, e preocupações com a saúde de seus consumidores.

O reconhecimento da grande importância que o Açude Aracoiaba representa para o desenvolvimento de atividades econômicas e principalmente para o consumo diário dos aracoiabenses, como também para o consumo de cidades vizinhas, e ainda, o receio de que a poluição e

degradação ambiental existentes no entorno deste açude e a montante, possam afetar a qualidade dessas águas e comprometer seu uso, foram fatores determinantes na escolha deste tema, e para o estudo e realização desta pesquisa.

Este trabalho foi realizado com objetivo de verificar os fatores de poluição e degradação ambiental existentes no entorno do açude e a montante dele, e identificar quais ações estão sendo realizadas para resolver problemas ambientais, caracterizar o nível de qualidade da água disponibilizada pelo Açude Aracoiaba e analisar as influências desses fatores da qualidade da água para a sustentabilidade socioambiental local.

## II. METODOLOGIA

O presente trabalho é baseado em pesquisa qualitativa, com investigação exploratória e bibliográfica. Foram realizados observações e registros do Açude Aracoiaba, entrevistas com produtores agrícolas das comunidades onde o açude está inserido, empresas e outros consumidores de suas águas, além dos órgãos de fiscalização, controle e manutenção do açude pesquisado. Foi realizado também um estudo comparativo da qualidade da água desse açude com a legislação brasileira vigente, e com as águas de outros açudes da região.

Segundo Minayo (1994), a obtenção dos dados foi realizada com abordagem qualitativa com estudo exploratório, pois trata-se de um fenômeno amplo, abrangente e não quantificável. Também foi quantitativa ao utilizar os valores dos parâmetros de qualidade da água, conforme Resolução do Conama Nº 357/2005. Foi desenvolvida por meio de estudo de caso com fundamentação em Yin (2005), e utilizado a coleta e geração de dados como técnica de análises. Esta pesquisa foi organizada em três etapas.

A primeira etapa foi realizada pelo estudo a respeito da relação do uso e manejo do solo e da água nas atividades do campo com a qualidade da água, as definições da literatura a respeito da qualidade da água, dos fatores de contaminação com suas causas e efeitos, sobre o que versa a legislação brasileira quando se trata do

uso e dos parâmetros de qualidade, além de obter mais conhecimento a respeito da poluição e degradação ambiental, e seus efeitos para a saúde humana e para o meio ambiente.

A segunda etapa do trabalho foi realizada pela pesquisa de campo com a obtenção dos dados *in loco*, através de observação e registros fotográficos da área ambiental, de maneira que se permitiu o seu amplo e detalhado conhecimento sobre o objeto de estudo (GIL, 2007); Realizou-se durante as entrevistas virtuais e presenciais, organizadas com os respectivos objetivos de investigação dedicados aos setores relacionados, conforme apresentado no Quadro 1.

O primeiro grupo entrevistado foi composto por cinco pequenos produtores, contemplando o principal produtor irrigantes de cada localidade do entorno do açude, que estava acessível e disponível no período das

entrevistas. No setor empresarial foram entrevistadas todas as empresas encontradas que utilizam as águas do Açude Aracoiaba em suas atividades laborais. Quanto aos órgãos de fiscalização, gestão e controle do Açude Aracoiaba, foram entrevistados todos aqueles que se tem conhecimento que desenvolvem estas funções.

Foram empregados questionários, abertos e semiestruturados, dedicados especificamente para cada setor de interesse no estudo, resguardados os direitos de anonimato conforme especificado no Termo de Consentimento Livre Esclarecido - TCLE. As entrevistas foram aprovadas pelo Comitê de Ética em Pesquisa - CEP, conforme o Parecer de N° 4.645.575, de 13 de abril de 2021. As respostas das entrevistas foram colocadas em tabelas, com o objetivo de organizar as informações e permitir o acesso mais rápido às respostas, e com isto, facilitar um comparativo entre os resultados encontrados.

*Quadro 1 – Entrevistas aos setores envolvidos com o Açude Aracoiaba para diagnosticar os impactos sociais e ambientais*

Objetivo	Setores Entrevistados	Entrevistados
- Mapear as principais atividades econômicas desenvolvidas no entorno do Açude Aracoiaba	Empresas privadas com atividades econômicas e pequenos produtores agrícolas e comerciante.	- Empresas de pescado, alimento e ração; - Empresa de criação de aves; - Empresa de captação de água; - Pequenos produtores agrícolas; - Comerciante
- Verificar os fatores de poluição e degradação ambiental existentes no entorno do açude e a montante dele, e quais ações realizam para resolver o problema. - Caracterizar o nível de qualidade da água disponibilizada pelo Açude Aracoiaba e analisar as influências desses fatores para a sustentabilidade socioambiental local	Órgãos de fiscalização, controle e manutenção do açude Aracoiaba e órgão de assistência técnica aos produtores rurais.	- COGERH- Companhia de Gestão dos Recursos Hídricos. - Comitê de Bacia - Órgão colegiado regional. - Comissão Gestora do Açude Aracoiaba. - Secretaria de Meio Ambiente de Aracoiaba. - Ematerce - Empresa de Assistência Técnica e Extensão rural do Ceará.

A terceira etapa foi dedicada à organização do material coletado nas pesquisas bibliográficas, nas observações, nos registros e nas entrevistas, somando com os parâmetros de qualidade da água obtidos através da COGERH, para analisar estatisticamente os dados colhidos e o material coletado a luz do conteúdo pesquisado, a fim de comparar os resultados e registrar as conclusões elaboradas a partir da realização das atividades planejadas e descritas nos objetivos neste trabalho.

### III. RESULTADOS E DISCUSSÕES

Os resultados apresentados neste trabalho são frutos de pesquisas bibliográficas, entrevistas e observações realizadas no Açude Aracoiaba, no seu entorno e a montante deste, com registros fotográficos dos pontos e situações consideradas relevantes para este estudo. As entrevistas foram divididas em grupos organizados por categoria, a saber: empresários, cooperativas, associações e pequenos produtores que utilizam as águas do Açude Aracoiaba em suas atividades

produtivas; órgãos de gestão, fiscalização, controle e preservação do açude como a Comissão Gestora do Açude Aracoiaba, o Comitê de Bacia da Região Metropolitana, a COGERH, a Ematerce e a Secretaria do Meio Ambiente de Aracoiaba.

Para mapear as atividades econômicas desenvolvidas no entorno do Açude Aracoiaba, e que atuam utilizando as águas deste açude em suas produções, foram realizadas entrevistas com questionários específicos para os tipos de atividades desenvolvidas no setor econômico local. De acordo com as pesquisas realizadas, dentre as categorias que utilizam as águas do Açude Aracoiaba em suas atividades laborais, foram encontrados

Quadro 2 estão as perguntas e respostas resumidas dos empreendedores **E.A**, **E.B** e **E.C**, e a da associação **A.D**.

*Quadro 2 – Questionário e respostas esquematizadas das empresas e associação que usam a água do Açude Aracoiaba para produção agrícola.*

PERGUNTAS	E.A	E.B	E.C	A.D
Nome da empresa/associação /cooperativa?	-----	-----	-----	-----
O que produz?	- Criação e engorda de alevinos de Cará Tilápia.	- Produz silagem de sorgo, feijão de corda em grãos, feijão verde, milho para grão, milho verde e pasto para a criação de bovinos.	- Criação e engorda de frangos	- Engorda de alevinos de Cará Tilápia
Usa produtos químicos?	Não	Sim	Não	Não
Qual?	---	- Adubos químicos; - Glifosato; -Inseticidas (não especificados) para combater pulgões e lagartas.	---	---
Qual a sua contribuição para manter adequada a qualidade da água do Açude Aracoiaba?	- Ensinou outros produtores de tilápia a forma correta de fazer a evisceração dos peixes; - Utilizou as vísceras dos seus peixes e dos peixes dos outros produtores de tilápia para produção de óleo e adubo orgânico.	- Faz a conscientização dos ribeirinhos para que não lavem carros, nem coloquem animais dentro do açude, e para que tomem os devidos cuidados para que as embalagens não sejam levadas até o leito do rio.	-Nenhuma ação informada.	- Os funcionários são orientados a fazer monitoramento e limpeza da área do açude utilizada por esta associação.

grandes e pequenos produtores agrícolas, empresa, cooperativa e associação responsáveis pela criação de peixes e camarões em gaiolas, estabelecimento comercial, proprietário de granjas e CAGECE entre outras, proporcionando a geração de empregos e rendas.

#### **Entrevistas com empresas, associações e entidades de fiscalização e controle do Açude Aracoiaba**

##### **I) Empresas produtoras e Associações**

Para as atividades econômicas desenvolvidas no entorno do Açude Aracoiaba, foram entrevistadas empresas produtoras e uma associação no formato de cooperativa. No

Qual a sua contribuição para a preservação e conservação do meio ambiente no entorno do Açude Aracoiaba?	- Disponibiliza vigias para fiscalizar o açude inclusive à noite, com o objetivo de impedir que qualquer pessoa possa colocar alguma sujeira nestas águas.	- Vem lutando para garantir a educação ambiental dos seus funcionários.	- Faz monitoramento do nível da água do açude para não retirar além do que é permitido; -Faz a captação da água do açude com motor a energia que não deixa resíduo de óleo no ambiente.	- Os funcionários são orientados para monitorar toda a área do açude e do seu entorno onde desenvolvem a produção de peixes.
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Fonte: Autora, 2020.

De acordo com estas entrevistas, os produtores são fiscalizados pela COGERH, que através da Comissão Gestora do Açude Aracoiaba libera a outorga para que os produtores possam utilizar as águas deste açude, e pela Secretaria do Meio Ambiente do Ceará – SEMACE, responsável pela liberação da licença de funcionamento dos produtores, que também orienta estes produtores a fazer a análise das águas a cada 3 meses, o que nem sempre acontece pois os laboratórios particulares cobram cerca de R\$ 390,00 por cada análise. Afirmaram ainda que a SEMACE realiza análise química destas águas a cada seis meses e que cobra mais de mil reais por estas análises.

## II) Agricultores familiares

As entrevistas aos pequenos produtores foram realizadas de acordo com o questionário, apresentado no Quadro 3 juntamente com o resumo das respostas dos produtores. Nesta categoria foram ouvidos cinco produtores que contemplam as localidades do entorno do açude pesquisado, e todos garantem o sustento de suas famílias através das atividades desenvolvidas, o que nos permite dizer que todos eles fazem parte do grupo da agricultura familiar. Estes produtores estão identificados nestes relatos pelas letras **AF.A**, **AF.B**, **AF.C**, **AF.D** e **AF.E**.

*Quadro 3 – Resultados da entrevista aos agricultores familiares que fazem uso das águas do Açude de Aracoiaba.*

Perguntas	AF.A	AF.B	AF.C	AF.D	AF.E
1. O que é produzido em sua atividade agrícola?	-Milho -Feijão	-Milho -Feijão -Cheiro verde -Maracujá	-Feijão -Milho -Pimenta de cheiro -Pimentão -Cheiro verde	-Mamão -Caju -Hortaliças -Pimenta de cheiro -Goiaba -Coco -Ata -Quiabo -Macaxeira	- pimenta de cheiro e tomate.
3. Usa produtos químicos?	Sim	Sim	As vezes	Não	Sim
4. Qual?	-Não especificou	-Não especificou	-Não especificou	---	- Decis; -KarateZeon; - Manzate
5. Qual a sua contribuição para manter adequada a qualidade da água do Açude	-Nenhuma	-Nenhuma	-Fiscaliza a inserção de lixo dentro do açude -Faz a limpeza da área utilizada	-Utiliza bomba a energia para evitar derramamento de óleo na água do açude	-Nenhuma

Aracoiaba?					
6. Qual a sua contribuição para a preservação e conservação do meio ambiente no entorno do Açude Aracoiaba?	-Evita o desmatamento	-Nenhuma	-Faz a limpeza no entorno da área utilizada	-Evita a poluição da água e do meio ambiente	-Nenhuma

Fonte: Autora, 2021.

Com relação à qualidade da água do Açude Aracoiaba, (100%) dos entrevistados demonstram preocupação com a qualidade das águas do açude Aracoiaba, no entanto, dos cinco pequenos produtores entrevistados, quatro deles representando 80%, confirmam que fazem o combate às pragas das lavouras através do uso de agrotóxicos. Eles demonstram não saber que os agrotóxicos utilizados em suas plantações podem estar contaminando o solo e a água do açude, e quem tem este conhecimento justifica que esta é a única maneira de se livrar das pragas, salvar as plantações e fugir do prejuízo.

### III) Órgãos de fiscalização e controle do açude Aracoiaba

As entrevistas elaboradas para representantes destes órgãos foram realizadas de acordo com o questionário demonstrado no **Error! Not a valid bookmark self-reference.** e as respectivas respostas esquematizadas. Na transcrição dos resultados destas entrevistas, **C.A** representa um membro da Comissão Gestora do Açude Aracoiaba. Nesta comissão ele é representante do Sindicato dos trabalhadores rurais de Aracoiaba. O **C.B** é um membro do Comitê de Bacia. Neste comitê ele é representante da Associação do Desenvolvimento Comunitário de Lagoa de São João, no segmento Sociedade Civil. O **C.C** é um funcionário da COGERH e o **S.D** se refere ao secretário de meio ambiente do município de Aracoiaba.

Quadro 4– Questionário e resumo das respostas de órgãos e entidades de fiscalização e controle do Açude Aracoiaba.

Perguntas	C.A	C.B	C.C	S.D
1. Nome do órgão entrevistado?	Comissão Gestora do Açude Aracoiaba	Comitê da Bacia Metropolitana de Fortaleza	Companhia de Gestão dos Recursos Hídricos-COGERH	Secretaria do Meio Ambiente de Aracoiaba
2. Cargo desempenhado pelo entrevistado?	Secretário da Comissão Gestora do Açude Aracoiaba	Membro	Coordenadora do Núcleo de Gestão da Gerência Metropolitana	Secretário de meio ambiente e urbanismo da cidade de Aracoiaba.
3. Este órgão tem conhecimento de todas as atividades econômicas desenvolvidas no entorno do Açude Aracoiaba?	Todos os membros da Comissão Gestora do Açude Aracoiaba são conhecedores das atividades produtivas desenvolvidas no entorno deste açude	O Comitê nem sempre tem o conhecimento de todas as atividades desenvolvidas no entorno do Açude Aracoiaba porque algumas delas são clandestinas.	Através da existência do feedback entre Secretaria Executiva e Comissão G, a COGERH tem conhecimento das atividades realizadas no entorno do Açude Aracoiaba.	A Secretaria do Meio Ambiente tem conhecimento das atividades através de um funcionário que é membro da Comissão Gestora do Açude Aracoiaba
4. Este órgão tem conhecimento do uso de	Sim	Sim	Não especifica	Sim



agrotóxico nas atividades agrícolas no entorno do açude Aracoiaba?				
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Fonte: Autora, 2021.

As entrevistas realizadas juntos aos órgãos de gestão, controle e fiscalização do Açude Aracoiaba, revelaram que estes órgãos possuem conhecimento da importância social e econômica e hídrica deste açude tanto para o município de Aracoiaba, como também para as cidades circunvizinhas, e para a Região Metropolitana de Fortaleza. Além de que esses órgãos conhecem as atividades produtivas realizadas no seu entorno e das condições em que estas atividades são realizadas. Têm conhecimentos inclusive da existência do uso de agrotóxicos nas atividades agrícolas.

#### **Fatores de poluição e degradação ambiental no entorno do Açude Aracoiaba e a montante.**

Em um dos objetivos desta pesquisa, se propõe identificar os fatores de poluição e degradação ambiental, existentes entre a sede deste município e o açude em estudo. Nesta tarefa, foram encontrados vários pontos que representam situações prejudiciais ao equilíbrio do meio

ambiente, a qualidade das águas do Rio Aracoiaba, e consequentemente ao reservatório do Açude Aracoiaba, além da possibilidade de afetar a saúde e o bem-estar das populações que dependem dessas águas para o desenvolvimento de suas atividades produtivas e de consumo diário. Através das observações *in loco*, foram encontrados e registrados os seguintes fatores:

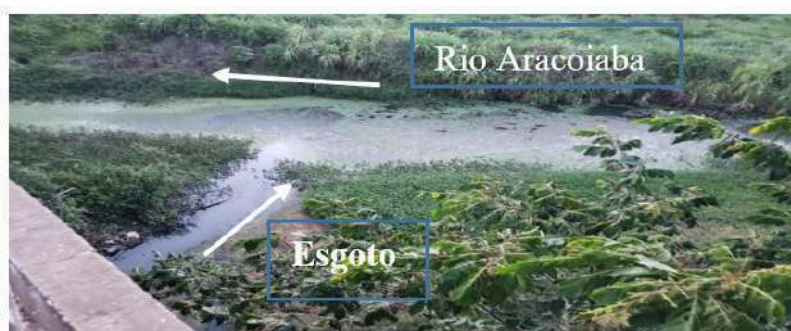
##### **I) Esgoto a céu aberto**

Esgoto a céu aberto ao lado direito da ponte que liga a cidade de Aracoiaba a cidade de Baturité. Os esgotos das residências e do comércio, de uma parte do centro desta cidade, são lançados em um canal coberto, que se inicia na Avenida Tiradentes e se estende pela lateral desta avenida até o final da Praça da Vitória, no centro da cidade. Deste ponto em diante, o esgoto segue a céu aberto até encontrar o leito do Rio Aracoiaba, e sem nenhum tratamento são lançados diretamente neste rio, como mostra Fig. 1 e 2.



*Fig.1–Esgoto que sai do canal coberto e segue até o leito do Rio Aracoiaba: A) Imagem do canal de esgoto aberto abaixo de uma residência no final da Praça da Vitória, no centro da cidade. B) Final da Avenida Tiradentes e continuidade da CE 060 no sentido sul da cidade.*

Foto: Autora, 2021.

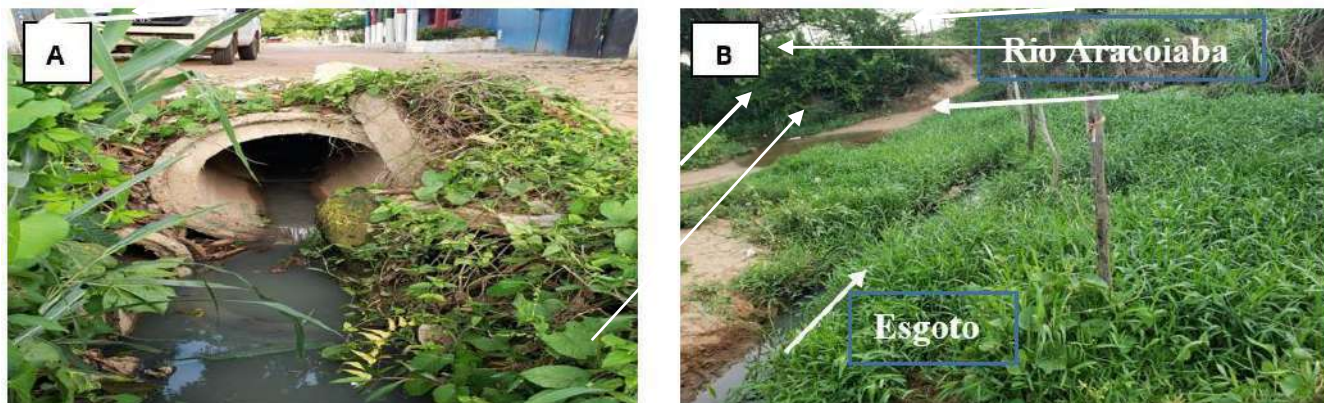


*Fig.2 –Ponto de encontro entre o esgoto do canal a céu aberto com as águas do Rio Aracoiaba.*

Foto: Autora, 2021.

Outro registro foi observado ao final da Rua Santos Dumont, o encontro de esgoto a céu aberto seguindo sentido ao Rio Aracoiaba, no centro da cidade. Neste ponto, os esgotos que saem de uma manilha de

concreto, Fig. 3A, seguem expostos por uma vala na lateral da estrada de carroçalque atravessa o Rio Aracoiaba, onde estes mesmos esgotos sem nenhum tratamento são lançados diretamente neste rio como mostra a Fig. 3B.

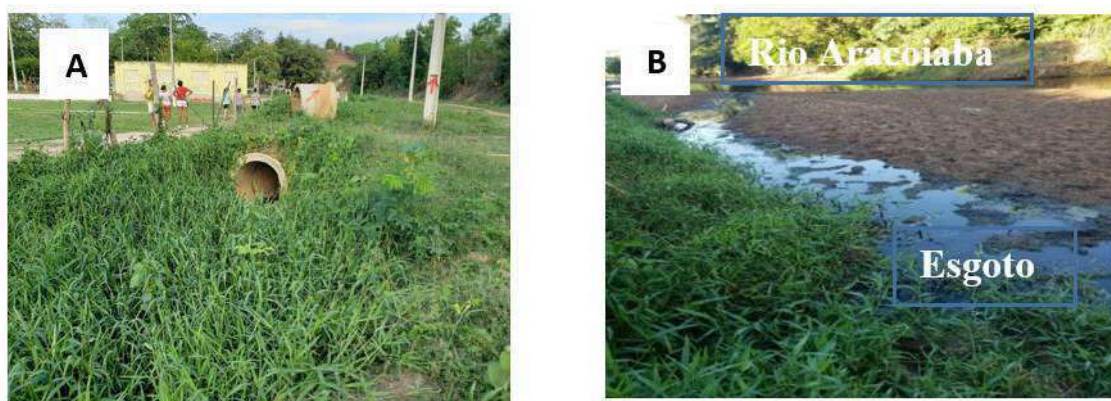


*Fig.3 – Localização de esgotos a céu aberto seguindo percurso em direção ao Rio Aracoiaba: A) final da Rua Santos Dumont no sentido Rio Aracoiaba no centro da cidade e B) manilha de concreto existente no final da Rua Santos Dumont.*

Foto: Autora, 2021.

Mais dois pontos de esgoto a céu aberto foram encontrados em uma das partes do Polo de Lazer da cidade de Aracoiaba, localizado no Bairro São José, próximo ao centro da cidade, Figura 4. Estes dois pontos de esgoto encontrados exatamente ao lado de um espaço de lazer, além das possibilidades de prejudicar a saúde de quem

utiliza este espaço, também causam mau cheiro e incômodo aos jovens, idosos, adultos e crianças que encontram neste espaço, um lugar para brincar com amigos, se distrair, se divertir, ou simplesmente para praticar suas atividades físicas.



*Fig.4 – A) Esgoto saindo de uma manilha como ponto final de saneamento básico, localizado na lateral da parte de baixo do polo de Lazer de Aracoiaba. B) Esgoto saindo da manilha localizada logo abaixo do calçadão no polo de Lazer de Aracoiaba indo em direção ao Rio Aracoiaba.*

Fotos: Autora, 2021.



### **Desmatamento, plantios e criação de animais na APP.**

Alguns agricultores, localizados no percurso do Rio Aracoiaba da sede da cidade até o Açude Aracoiaba, ainda praticam o desmatamento para extração e venda de madeira ou para a produção de carvão, ou apenas para utilizar estas terras para o plantio. Neste sentido, os

agricultores além de desmatar, captam a água necessária para irrigar seus plantios através de motores que são colocados em poços feitos nas margens deste rio. A área desmatada é utilizada por estes agricultores em plantios de capim, milho e feijão entre outros cultivos (Figura 5A), e em criação de animais (Fig. 5B).



*Fig.5 –Imagens da Comunidade de Baixo às margens do Açude Aracoiaba com: A) com plantação de milho e B) criação de animais.*

Foto: Autora, 2021.

### **Uso de agrotóxicos nos plantios cultivados na APP**

O desrespeito a estas áreas de proteção permanente ainda maior, na medida em que alguns dos agricultores que utilizam esta área para a produção agropecuária ou simplesmente agrícola fazem uso de agrotóxicos para matar as ervas indesejadas, com a

impensada prática capitalista de adquirir mais lucros, gastando menos com a preparação das terras. A Figura 67 tem imagens de degradação ambiental como resultados do uso de agrotóxicos na plantação de capim às margens do Açude de Aracoiaba na comunidade de Arraial Santa Isabel.



*Fig.7 – Resultados do uso de agrotóxicos na plantação de capim nas margens do Açude Aracoiaba – Comunidade de Arraial Santa Isabel.*

Foto: Autora, 2021.

### Queimadas realizadas dentro da APP

Outra degradação ambiental existente nas margens do Açude Aracoiaba (Fig. 7) que também é resultante do pensamento capitalista de limpar as terras para o plantio com um menor custo, é o uso do fogo onde as queimadas destroem não apenas a vegetação, mas também prejudicam

o meio ambiente como afirma Fearnside (2020) quando diz que “Quando o fogo entra na floresta, ele mata as árvores, aumenta a carga de combustível e seca o sub-bosque, elevando o risco de futuros incêndios e da completa degradação da floresta”.



Fig.7 – Foco de queimada na localidade de Encosta, município de Aracoiaba.

Fonte: Imagem Google Earth, 2021.

### Caracterização da água do Açude Aracoiaba

As águas do Açude Aracoiaba representam relevante importância para o desenvolvimento social e econômico do município de Aracoiaba e para alguns municípios da região do Maciço de Baturité, além da dessedentação de animais. Dada a fundamental importância destas águas principalmente para o consumo humano em suas diversas formas de uso, tem-se uma preocupação constante com a qualidade destas águas, pelo receio de que fatores de poluição e degradação ambiental possam afetar seu estado, e consequentemente prejudiquem a saúde de seus consumidores.

Tabela 1.

Tabela 1 – Características físico-químicas da qualidade da água do açude Aracoiaba nos meses de janeiro, fevereiro e maio de 2021

Padrões de qualidade	Resolução CONAMA 2005	Análise realizada em jan./2021	Análise realizada em fev./2021	Análise realizada em mai./2021
Água doce	Salinidade $\leq 0,5$ ‰	0,27	0,29	0,27
Cor verdadeira:	Nível de cor natural do corpo de água em mg Pt/L	Pardacenta 35,00	Pardacenta 20,00	Pardacenta 35,00
Cloreto	250mg/L	116,84	115,95	Não informado
Clorofila a	10µg/L	29,00	31,58	29,00
DBO 5 dias a 20°C	Até 3 mg/L O <sub>2</sub>	14,540	12,670	4,510
Densidade de cianobactérias	20.000 cel/mL	701.713,0	500.844,0	280.508,0
Ferro	0,3mg/L	< LQ	< LQ	< LQ

Neste sentido, procurou-se identificar quais são as características das águas do Açude Aracoiaba, e fazer um comparativo das características encontradas com os padrões de lançamento de efluentes estabelecidos pela Resolução CONAMA Nº 357, de 17 de março de 2005, que representam a qualidade adequada que a água deve possuir para atender às necessidades humanas. Os padrões de qualidade estabelecidos pelo CONAMA e as características da água do Açude Aracoiaba estão demonstrados na

Fósforo total	0,020mg/L	0,037	0,035	0,037
Nitrogênio amoniacal	1,0 mg/L para $8,0 < \text{pH} \leq 8,5$	0,499	0,211	0,499
Nitrogênio total/ambientes lânticos	$\leq 1,27 \text{ mg/L}$	1,100	1,075	1,100
OD, oxigênio dissolvido	Não inferior a 6 mg/L O <sub>2</sub>	7,32	6,64	6,90
pH	6,0 a 9,0	8,24	8,05	8,24
Sólidos Dissolvidos Totais (SDT)	500mg/L	346	373	346
Sulfato	259mg/L	14,08	14,01	14,08
Turbidez	Até 40 unidades nefelométrica de turbidez (UNT)	9,36	7,62	9,36

Fonte: Adaptado de Resolução CONAMA 2005 e Dados fornecidos pela COGERH 2021

Comparando as características da água do Açude Aracoiaba, contidas nas análises realizadas pela COGERH entre os meses de janeiro a maio de 2021, com os padrões de qualidade estabelecidos pelo CONAMA 2005, é possível pontuar algumas divergências entre estas duas fontes de informações:

- I. A cor da água do Açude Aracoiaba se manteve em pardacenta nas três análises da COGERH, quando deveria apresentar cor natural de acordo com a resolução do CONAMA 2005. No entanto, o período em que as análises foram realizadas, coincide com o período chuvoso, o que pode justificar a cor pardacenta encontrada.
- II. A quantidade de Clorofila a encontrada nas análises apresentaram valores entre  $29 \mu\text{g.L}^{-1}$  e  $31,58 \mu\text{g.L}^{-1}$  enquanto que a resolução do CONAMA 2005 estabelece que este valor deveria ser  $10 \mu\text{g.L}^{-1}$ . A alta quantidade de Clorofila a encontrada nestas águas, pode resultar na eutrofização deste ambiente, e consequentemente diminuir o nível de oxigênio da água, prejudicando a vida de espécies animais e vegetais. Este processo de eutrofização pode ter relação com os esgotos *in natura* que são lançados no leito do Rio Aracoiaba.
- III. O valor da Demanda Bioquímica de Oxigênio (DBO) da água do Açude Aracoiaba, também apresentou um nível acima do valor estabelecido pela resolução do CONAMA 2005. Isto fortalece a constatação do baixo nível de oxigênio nas águas analisadas pela COGERH,

além de reforçar a comprovação da existência de poluição nestas águas.

- IV. O parâmetro de densidade de cianobactérias apresentou valor bem acima dos padrões estabelecidos pelo CONAMA. A presença de um alto nível de cianobactérias em um ambiente aquático, pode comprometer a qualidade da água através da produção de cianotoxinas. De acordo com o Ministério da Saúde (2006) "...as toxinas neurotóxicas e hepatotóxicas são os principais agentes tóxicos produzidos pelas cianobactérias, e causam sérios danos à vida animal e a saúde humana, quando presentes em águas de recreação e/ou consumo.

Ainda sobre as cianobactérias, o Ministério da Saúde através da Portaria de Nº 2.914, de 12 de dezembro de 2011, conhecida como portaria de potabilidade, estabelece no Art. 40 - § 4º desta Portaria "Quando a densidade de cianobactérias exceder 20.000 células/mL, devem ser realizadas análises de cianotoxinas na água do manancial, no ponto de captação, com frequência semanal". Esta medida visa analisar a qualidade da água com a finalidade de avaliar os riscos à saúde humana.

- V. A água do Açude Aracoiaba também apresentou um nível de fósforo total acima dos padrões recomendados pelo CONAMA. O excesso de fósforo no ambiente aquático pode causar a proliferação de algas, acender o processo de eutrofização deste ambiente, e propiciar a produção de cianotoxinas que



representam riscos para a saúde dos usuários destas águas.

As alterações encontradas na qualidade das águas do Açude Aracoiaba, proporcionaram preocupações a respeito do nível trófico destas águas, considerado alto para um açude que só tem 18 anos de existência. Estas informações nos remetem a necessidade de averiguar a qualidade das águas dos demais açudes da região, para verificar semelhanças e diferenças ou mesmo para compreender os resultados encontrados, considerando que reservatórios como o Tijuquinha, deságuam no rio que

abastece o Açude Aracoiaba, nos períodos em que estão sangrando.

A Secretaria dos Recursos Hídricos do Estado do Ceará, através da COGERH, divulgou relatórios da qualidade das águas dos açudes monitorados pela COGERH, referentes aos meses de abril e maio deste ano de 2021. Os documentos mostram o estado trófico das águas dos açudes, assim como os parâmetros de qualidade encontrados em suas águas, e utilizados na classificação do estado de trofia das águas desses açudes. O Quadro 1 mostra a classe trófica da água dos principais açudes próximos ao Açude Aracoiaba.

*Quadro5 - Classes tróficas dos principais açudes próximos ao Açude Aracoiaba nos anos de 2020 e 2021.*

Açude	Município	Classe Trófica Nov. 2020	Classe Trófica Fev. 2021	Classe Trófica Mai. 2021
Acarape do Meio	Redenção	Oligotrófica	Hipereutrófica	Eutrófica
Aracoiaba	Aracoiaba	Eutrófica	Eutrófica	Eutrófica
Batente	Ocara	Eutrófica	Eutrófica	Eutrófica
Castro	Itapiúna	Mesotrófica	Mesotrófica	Eutrófica
Germinal	Palmácia	Eutrófica	Mesotrófica	Eutrófica
Pacoti	Horizonte	Eutrófica	Eutrófica	Eutrófica
Pesqueiro	Capistrano	Hipereutrófica	Hipereutrófica	Hipereutrófica
Tijuquinha	Baturité	Eutrófica	Eutrófica	Oligotrófica

Fonte: Adaptado de SRH/COGERH 2021

Para o entendimento da qualidade das águas nestes estados tróficos, o mesmo relatório da COGERH traz a definição da situação das águas de acordo com a classificação de cada estado trófico. Segundo esse documento:

1 - Estado Trófico Oligotrófico - Possuem águas limpas, de baixa produtividade, em que não ocorrem interferências indesejáveis sobre os usos da água, decorrentes da presença de nutrientes.

2 - Estado Trófico Mesotrófico - São águas com produtividade intermediária, com possíveis implicações sobre a qualidade da água, mas em níveis aceitáveis, na maioria dos casos.

3 - Estado Trófico Eutrófico - São os corpos de água com alta produtividade, com redução da transparência, em geral afetados por atividades antrópicas, nos quais ocorrem alterações indesejáveis na qualidade da água e interferências nos usos múltiplos.

4 - Estado Trófico Hipereutrófico - Águas afetadas significativamente pelas elevadas concentrações de matéria orgânica e nutriente, com comprometimento acentuado nos seus usos, associado a episódios de florações de algas ou mortandade de peixes, com comprometimento acentuado nos seus usos.

De acordo com os resultados demonstrados na Tabela 2, em novembro de 2020 a maioria dos açudes (62,5%), estavam com suas águas no nível 3 da classificação trófica, confirmando alteração na qualidade de suas águas. Em fevereiro de 2021, estão 50% dos açudes neste nível 3, e em maio deste mesmo ano, tem-se 75% dos açudes demonstrados com suas águas no nível trófico 3, indicando motivo para preocupações com a qualidade das águas destes açudes. Os dados desta tabela são mais alarmantes para o Açude Pesqueiro, que mesmo após o período chuvoso, se manteve no mais alto nível da classificação trófica.

Segundo o referido relatório da COGERH, foram realizadas análises laboratoriais nas águas dos açudes próximos ao Açude Aracoiaba, entre os meses de maio e

junho deste ano de 2021. Os parâmetros de qualidade encontrados nessas análises estão organizados na Tabela 2.

*Tabela 2 – Características físico-químicas da qualidade das águas dos principais açudes próximos ao Açude Aracoiaba nos meses de maio e junho de 2021*

Açude	Município	Data	N total (mg N/L)	P total (mg P/L)	Clorofila-a (µg/L)	Cianobactérias (Células/ml)
			CONAMA ≤ 1,27 mg/L	CONAMA 0,020mg/L	CONAMA 10µg/L	CONAMA 20.000 cel/mL
Acarape do Meio	Redenção	12/05/21	1,250	0,048	40,78	500.844
Aracoiaba	Aracoiaba	13/05/21	1,100	0,037	29,00	280.508
Batente	Ocara	23/06/21	1,490	0,055	41,27	391.119
Castro	Itapiúna	16/06/21	2,150	0,137	43,57	72.207
Germinal	Palmácia	11/05/21	1,000	0,082	33,11	62.296
Pacoti	Horizonte	18/05/21	1,290	0,086	24,38	155.740
Pesqueiro	Capistrano	26/05/21	2,760	0,088	13,68	2.003.375
Tijuquinha	Baturité	26/05/21	0,880	0,068	4,55	19.762

Fonte: Adaptado de SRH/COGERH 2021

Os resultados das análises dos padrões de qualidade das águas dos principais açudes próximos ao Açude Aracoiaba, revelaram divergências significativas nos padrões de qualidade encontrados, quando comparados com os padrões recomendados pelo CONAMA 2005. Com relação ao nível de nitrogênio, 50% dos açudes se encontram fora dos padrões do CONAMA. Com relação ao fósforo, 87,5% dos açudes apresentam valores acima do esperado. Sobre o nível de clorofila-a encontrado nas águas destes açudes, também 87,5% dos açudes apresentam divergências nos valores encontrados. O caso é ainda mais preocupante, quando se trata do número de cianobactérias presentes nas águas analisadas, 100% dos açudes mencionados na Tabela 3, possuem elevada quantidade de cianobactérias em suas águas, com destaque mais uma vez para o açude Pesqueiro, que apresenta um resultado mais de 100 vezes acima dos valores recomendados pelo CONAMA.

Ainda com relação a quantidade de cianobactérias presentes nas águas desses açudes, os dados da Tabela 3 revelaram que o açude Acarape do Meio

ocupa a segunda posição mais crítica, apresentando um resultado mais de 25 vezes acima dos valores recomendados pelo CONAMA. Entre 2012 e 2016, Berthyer Peixoto Lima realizou uma pesquisa sobre a Bacia Hidrográfica desse açude e de acordo com a pesquisa o autor afirmou:

O reservatório Acarape do Meio apresenta uma entrada de carga de fósforo atualmente em 13,7 ton/ano, segundo o modelo QUAL-UFGM, o que proporcionou uma concentração de fósforo na bacia hidráulica de 0,193 mg/l ou 193 mg/m<sup>3</sup>, portanto muito acima dos 30 mg/m<sup>3</sup> estabelecido como limite máximo para a classe 2, conforme resolução CONAMA 357/2005. (LIMA, 2016)

Considerando os resultados apresentados por Lima (2016), e sabendo que o principal efeito do elevado nível de fósforo presente na superfície das águas, é o processo de eutrofização com a proliferação desenfreada de algas e o surgimento de cianobactérias e, considerando ainda os resultados apresentados nas Tabelas 2 e 3, percebe-se que o Açude Acarape do Meio é carente de atenção e de cuidados, pois mesmo não se apresentando em nível crítico contínuo, esse açude, assim como os demais que se encontram no nível 3 de eutrofização e que ultrapassaram os limites dos valores recomendados pelo CONAMA, podem chegar a situações piores e

comprometer ainda mais a qualidade dessas águas e consequentemente, o seu uso.

Os resultados encontrados nas Tabelas 2 e 3, nos remete a algumas indagações a respeito dos motivos pelos quais, em alguns açudes a qualidade das águas estão mais alteradas do que em outros. E considerando que, alguns rejeitos poluentes vão se acumulando nos reservatórios ao longo dos tempos, se fez necessário saber o tempo de construção desses açudes, para saber a idade de cada um, e a forma de uso de suas águas, informações que se encontram na Tabela 4.

Tabela 4 - Idade dos principais açudes próximos ao açude Aracoiaba e a utilização de suas águas.

Açude		Capacidade m <sup>3</sup>	Ano de construção	Idade em 2021	Forma de uso das águas									
					Dessedentação Animal	Usos Domésticos Locais	Recreação de Contato Primário	Recreação de Contato Secundário	Usos Públicos (Empresas Concessionárias)	Irrigação	Piscicultura Intensiva (criação em gaiolas)	Indústria	Balneário	Agricultura de vazante
Acarape do Meio		31.500.000	1924	97 anos	EJ		E	E	J	J	-	J	J	EJ
Aracoiaba		170.700.000	2002	19 anos	EJM	E	E	E	EJ	EJ	E	-	J	E
Batente		28.900.000	1998	23 anos	E	E	-	-	-	E	-	-	-	E
Castro		63.900.000	1997	24 anos	EJ	E	E	E	E	EJ	E	-	E	E
Germinal		2.014.427	2017	4 anos	E	J	-	-	-	-	-	-	J	E
Pacoti		380.000.000	1981	40 anos	E	-	-	-	E	-	-	J	-	-
Pesqueiro		8.200.000	2008	13 anos	EJ	E	E	-	-	EJ	E	-	-	EJ
Tijuquinha		881.235	1917	104 anos	E	J	-	-	-	-	-	-	-	E

Presença da atividade: E – No entorno do açude J – A jusante do açude M - A montante do açude

Fonte: Adaptado de Matriz dos Usos Múltiplos dos Açudes - Portal Hidrológico do Ceará, e Atlas Eletrônico dos Recursos Hídricos do Ceará. 2021

As informações contidas na Tabela 4 nos permite fazer algumas pontuações que possivelmente sejam

responsáveis, pelos motivos das divergências detectadas pela COGEHR, na qualidade das águas desses açudes.

1. No Quadro 5, notou-se que dos 8 açudes caracterizados, o Açude Pesqueiro foi o único a se apresentar no Estado Trófico Hipereutrófico, o maior nível das Classes tróficas, mostrando que as águas estão significativamente afetadas por elevadas concentrações de matéria orgânica e nutrientes. Entre os possíveis motivos que justificam esta situação, estão o uso domésticos, recreação, irrigação, piscicultura intensiva e agricultura de vazante, em que todas estas atividades estão sendo realizadas no entorno do açude. Acrescente-se a isto, o fato de que a montante deste açude existem muitas comunidades e ainda a cidade de Aratuba e que, em nenhum desses povoados, ou na cidade, existe saneamento básico, e portanto, os resíduos produzidos por eles, escoam para o rio que abastece esse açude. Entende-se que o Pesqueiro é um açude razoavelmente novo para estar com a qualidade de suas águas tão alteradas, mas também é preciso considerar que ele é um açude pequeno, e sua pouca capacidade de acúmulo de água, favorece uma maior contaminação em menos tempo.
2. Verificando o Quadro 5 e a Tabela 2, foi possível observar que na última análise, o Açude Tijuquinha foi classificado no menor nível das classes tróficas, o Estado Trófico Oligotrófico onde as águas são consideradas limpas. Analisando o conteúdo da Tabela 4, vemos que esse açude é o menor de todos os 8 açudes analisados, e também é o mais velho dessa lista, dois fatores desfavoráveis à sua situação atual, no entanto, a mesma Tabela 2, mostra que das dez formas de uso das águas contidas nesta mesma tabela, o Tijuquinha possui apenas três, e destas, apenas duas são praticadas no seu entorno. Ainda é preciso ressaltar que esse açude está localizado acima do nível da cidade de Baturité e, portanto, não recebe os esgotos produzidos por esta cidade.

Outro fator a ser considerado é que, sendo o Tijuquinha um açude bem pequeno, ele pode transbordar com mais facilidade, e com isto, renovar as águas acumuladas.

3. A classificação do Açude Germinal no terceiro nível trófico, também é motivo de preocupação. Esse açude possui apenas 4 anos de existência, e está na mesma classificação trófica que os outros açudes de mais 20 anos e até de quase 100 anos como o Acarape do Meio. A situação ainda piora quando se percebe que apenas duas atividades são realizadas em seu entorno. O entendimento da condição das águas do Germinal passam então a percorrer pelos possíveis fatores: a) Com relação aos demais açudes pesquisados, o Germinal é considerado um açude bem pequeno, com isto, a quantidade de água que pode acumular é pouca, e isto possibilita a contaminação de suas águas em menos tempo; b) Uma das atividades realizadas no seu entorno, é a agricultura de vazante, e essa atividade normalmente é realizada com o uso de agrotóxicos e fertilizantes, produtos que escoam até os reservatórios de água, e alteram sua qualidade; c) Outro fator agravante nos municípios dessa região, é a falta de saneamento básico, e nesse contexto, todos os resíduos produzidos pela população, são lançados em lixões ou no leito dos rios, e em ambos os casos, chegam até os açudes que recebem as águas de rios, riachos e córregos, muitas vezes já contaminadas.

Com o intuito de verificar quais ações estão sendo realizadas para garantir a preservação e conservação do meio ambiente, e da qualidade das águas consumidas pela população de Aracoiaba, e também de alguns municípios vizinhos, foram realizados novos questionários com os órgãos e entidades de fiscalização e controle da qualidade da água do Açude de Aracoiaba, perguntas e respostas organizados no Quadro 6.

*Quadro 6 – Questionário da Comissão Gestora do Açude Aracoiaba; Comitê de bacia; COGERH; Ematerce e Secretaria do Meio Ambiente de Aracoiaba.*

	<b>C.A</b>	<b>C.B</b>	<b>C.C</b>	<b>S.D</b>	<b>Entrevistado D</b>
1	Comissão Gestora do Açude Aracoiaba	Comitê da Bacia Metropolitana de Fortaleza	COGERH	Secretaria do Meio Ambiente de Aracoiaba	Ematerce
	-Fiscalizar desmatamentos e outras degradações na área de APP; -Conscientizar a	- Diz que as ações desenvolvidas pelo Comitê de	-A COGERH é secretária executiva do Comitê de Bacia	-No momento, a Secretaria não está desenvolvendo nenhuma ação	- Presta assistência e acompanhamento aos agricultores, propriedades e



2	<p>população para que não poluam o açude;</p> <p>-Fazer palestras com o objetivo de conscientizar os munícipes a respeito do valor deste açude;</p> <p>-Fiscalizar e zelar pela qualidade da água do açude;</p> <p>-Fazer o monitoramento da qualidade das águas do açude;</p> <p>-Zelar pela preservação ambiental da área do entorno do açude;</p> <p>-Deliberar sobre a liberação da outorga para os usuários das águas do açude;</p> <p>-Tomar decisões a respeito da quantidade de água que deve ser liberada para outros municípios.</p>	<p>Bacia são pensadas em nível macro, e portanto, são relacionadas aos recursos hídricos de todos os açudes que compõem a Região Metropolitana de Fortaleza e não especificamente sobre o Açude Aracoiaba.</p>	<p>que é responsável pelo gerenciamento dos recursos hídricos junto a COGERH;</p> <p>-Trabalha com as Comissões Gestoras que são braços dos Comitês de Bacia em cada reservatório.</p>	<p>relacionada ao Açude Aracoiaba.</p> <p>-Está aguardando as ações do Governo do Estado relacionadas a liberação do Projeto AJA – Agente Jovem Ambiental, para desenvolver projetos ambientais, acompanhar o desenvolvimento das atividades agrícolas na área do entorno do Açude, e fazer a fiscalização das degradações existentes no Rio Aracoiaba</p>	<p>comunidades;</p> <p>- Faz o acompanhamento do plantio, do plano de manejo, e desenvolvimento das plantações;</p> <p>-Intervém junto com os agricultores no combate de pragas e doenças da lavoura;</p> <p>-Acompanha o processo de colheita e pós colheita, tanto na produção vegetal como na produção animal;</p> <p>- Faz o acompanhamento das famílias no acesso às políticas públicas, como a assistência ao Programa Ora de Plantar.</p>
3	Sim	Sim	Sim	Sim	Sim
4	Sim	Sim	Sim	Sim	Sim
5	<p>-Fez denúncia ao Ministério Público, e na Delegacia Ambiental</p>	Denúncias	<p>Quando recebem denúncias, encaminham uma fiscalização, e se necessário recorrem à secretaria ou a SEMA, ou IBAMA.</p>	<p>- Faz a autuação da infração;</p> <p>-Lacra a área que está sendo degradada;</p> <p>-Suspende o serviço irregular.</p>	<p>-Orienta.</p> <p>-Aconselha;</p> <p>-Compartilha as experiências exitosas fazendo intercâmbio de agricultores com áreas cultivadas de forma correta.</p>

Fonte: Autora, 2021.

Dos cinco órgãos entrevistados, três deles vem desenvolvendo ações diretas relacionadas aos cuidados com o Açude Aracoiaba. De acordo com as informações fornecidas por estes órgãos, todos eles conhecem a respeito das poluições e degradações ambientais existentes neste município, e todos afirmam que tomam as medidas cabíveis quando informados da existência delas, como também reconhecem os danos causados por estes fatores e a necessidade de se tomar medidas urgentes para solucionar o problema.

#### IV. CONSIDERAÇÕES FINAIS

Os fatores de poluição e degradação ambiental encontrados causam impactos negativos no meio ambiente e contribuem com a perda da biodiversidade local, e consequentemente também prejudicam a sustentabilidade de algumas famílias que dependem de um ambiente equilibrado e saudável para produzir seu sustento, como é o caso do mel de abelha que era produzido por agricultores familiares neste município, e era fornecido para as escolas através da agricultura familiar, e que a destruição das matas impossibilitou a continuidade desta atividade tão importante.

Pela caracterização físico-química do Açude de Aracoiaba e demais açudes próximos é patente a

necessidade de implantação de saneamento básicos nas cidades, destacando a necessidade de sistema de tratamento de esgoto antes de envio aos leitos os rios. Espera-se que este trabalho possa colaborar com os órgãos municipais e estaduais do Estado do Ceará nas medidas de proteção das águas desses açudes para que mantenham sua importância socioeconômica para a região.

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# Microbiological diversity aspects and hygienic-sanitary conditions of mussels sold in the Municipal market in the municipality of Belém do Pará

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**Keywords—** current legislation, mussels,  
microbiological standards

**Abstract—** Foodborne Diseases are caused by the ingestion of food that is unsafe for consumption, occurring at any stage in the production chain or even in the preparation phase of the final product at the consumer's home. . A mussel marketing product in the State of Pará has an implementation and functioning to obtain this quality and insurance for public health. In order to identify the presence of *Escherichia coli* and coliforms for mussel mussels in natura in the Ver-o-Peso Belém do Pará market, microbiological examinations of the mexiethylene Kit Aquatest *coli*, and eosin blue culture medium were performed. The results show 100% of the samples confirms the presence of total coliforms and 90% of sample presence of *E.coli*, then the counts obtained results greater than > 100 CFU/ml. It is stated tat least 90% are outsideof the standards established by current legislation. The microbiological food standards of RDC 331 are indicated,In stages, microbiological food standards are indicated that are taken into account within the current legislation with a purpose of handling.

## I. INTRODUCTION

Mussel fishing is one of the most productive activities, being developed in various regions of the world, including Brazil and the State of Pará for production and consumption in different regions (Duarte et al., Rosa, 011). According to FAO (Food and Agriculture Organization of the United Nations), in 2009, the consumption and cultivation of bivalves had a relevant growth in the world.

For bacteria, the Brazilian legislation, through the Resolution of the Collegiate Directorate RDC 12/2001, of the Sanitary Surveillance Agency (BRASIL, 2001), demands sanitary microbiological standards for food, where coliforms must be tolerated at  $5 \times 10^5$  /g in temperature of 45 °C; Coagulase positive staphylococci/g: in quantity of

$10^3$ ; Absence of *Salmonella* sp. in 25g;., determining that *Escherichia coli* and/or total coliforms is an indicator of microbial contamination of fecal origin.

Fecal coliforms in water are highly correlated with fecal contamination by animals and humans, making them indicators of contamination, since mussels are filter feeders, concentrating microorganisms and are represented in particular by *E. coli*, whose presence corresponds to 90% of the checks (Lima, 2012).

According to the National Program for the Hygienic and Sanitary Control of Bivalve Mollusks (PNCMB) in conjunction with the Ministry of Fisheries and Aquaculture (MPA), it establishes analysis procedures in the collection of bivalve mollusk samples so that the food is



free of pathogenic microorganisms, toxins, or metabolites in quantities that cause damage to the consumer's health.

The genus *Mytella* belongs to the family Mytilidae and is native to Central and South America. They are filter-feeding organisms and, due to their physiological characteristics, are susceptible to the accumulation of various microorganisms and biotoxins (Martins, 2020).

Based on the above, the present work aims to evaluate the hygienic-sanitary conditions through microbiological analysis of fresh mussels sold at the Ver-o-Peso market in Belém, Pará.

## II. MATERIAL AND METHODS

### 2.1 Location and sampling

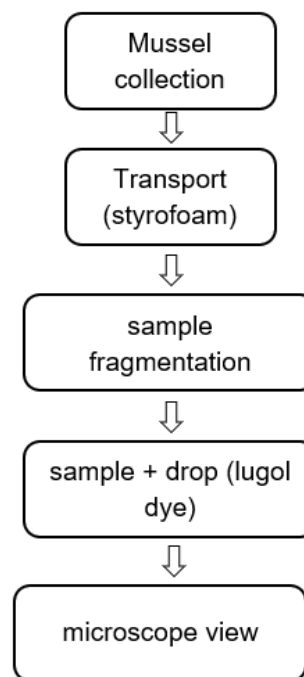
The present study was carried out at Ver-o-Peso Market, located in the city of Belém-Pará. 900 g of raw mussel material (*Mytella charruana*) were collected, packed in an isothermal box at 4°C and sent to the Bromatology and Clinical Analysis Laboratories of the University of Amazon - UNAMA (Belém-PA) and in the Rural Federal University of the Amazon for microbiological analysis.

### 2.2 Microbiological and parasitological analyzes

The presence and absence of total coliforms and *E. coli* in the water from the mussel raw material content (conservation ice + cell content), were evaluated with the Aquatest coli Kit, obtaining 25g of mussels in each sample and homogenized with 100 ml of saline water collected in sterile flasks added with 0.1ml of EDTA and incubated at 37°C in the oven chamber for 24 hours in the Bromatology Laboratory of UNAMA. Samples positive for Total Coliforms are visually detected by viewing the yellow coloration and the presence of *E. coli* is detected by the blue-green fluorescent coloration when the sample is exposed to UV light from the (Vilber Lourmat Transilluminator) and also for confirmation, the colonies were counted on eosin blue methylene agar - EMB (Laborclin) culture medium, Gram staining was performed later with viewing under a microscope.

Approximately 10 mL of the first dilution of distilled water was used for each sample for parasitological analysis. Initially, direct examination was performed. For this, a drop of the samples from the bottom - the Falcon tube

- was transferred to a glass slide, adding a drop of Lugol's dye, followed by observation under an optical microscope. Subsequently, The membranes were then washed by vigorous shaking with Tween 80 detergent and left to stand for three hours. The water resulting from washing the membranes was subjected to the centrifugation-flotation method in zinc sulfate (Faust's technique adapted for the investigation of parasites in water), and the floating material was stained with Lugol's stain and examined under a common optical microscope at 100- and 400-fold. The samples were taken in triplicate for reading by microscopy (FREITAS et al., 2015).



## III. RESULTS

### 3.1 Microbiology Analysis

The results obtained in the analysis with the Aquatest Coli kit, 100% of the samples visually presented yellow color confirming the presence coliforms and 90% of sample presented blue-green fluorescence color detecting *E. coli*, only the mex 6 didn't show this bacteria, as results in Figure I.

In the microbiological analysis by inoculation on EMB agar medium, all samples showed results greater than > 100 (CFU), as shown in Figure II.



Fig.I. Samples visualized through the Vilber Lourmat Transilluminator (UFRA)

Photo: The authors



Fig.II. Growth of sample colonies on EMB agar medium (Laboclin)

Photo: The authors

To confirm the colonies of *E. coli* bacteria, the colonies were viewed under a microscope, as the results showed that 100% had colonies of Gram negative bacteria, as shown in figure III.



Fig.III. Presence of Gram negative bacilli colonies visualized under the microscope

Photo: personal file

Table 2. Results of the 11 mussel samples for presence and absence of *E.coli*

ID Amostra	Presença de Coliformes totais	Presença de <i>Escherichia coli</i>	Contagem de colônias
MEX 1	YES	YES	>100
MEX 2	YES	YES	>100
MEX 3	YES	YES	>100
MEX 4	YES	YES	>100

MEX 5	YES	NO	>100
MEX 6	YES	NO	-
MEX 7	YES	YES	>100
MEX 8	YES	YES	>100
MEX 9	YES	YES	>100
MEX 10	YES	YES	>100
MEX 11	YES	<b>YES</b>	>100

Source: personal file

### 3.2 Parasitological Analysis

Presence of *Nematopsis* spp. belonging to the phylum Apicomplexa were observed in parasitophorous vacuoles of phagocytic cells (phagocytes), found mainly in the mantle of *Mytella charruana*.(figure IV)



Fig.IV: *Nematopsis* is a gregarine genus Apicomplexan in the family Porosporidae

Source: personal file

## IV. DISCUSSION

The samples analyzed are above the standards set by current legislation, which allows up to 7 CFU/g in one sample. According to the most current RDC 331 of 2019, it is mandatory to record the presence of *E. coli*, through an analytical report.

According to the PNCMB(National Program. Hygienic-Sanitary Control of Bivalve Molluscs), the Interministerial Normative Instruction No. 7, determines that thermotolerant coliforms are indicators of food contamination at room temperature, in addition to indicating in the temperature control during transport and storage processes (Oliveira, 2020).

Microbiological species included parasites and bacteria: *Nematopsis* and *E.coli*, respectively. As reported by Boehs 2012, parasites of the genus Apicomplexan and bacterial contaminants in culture water are commonly found in

mussels. The impacts of the presence of these contaminants can be significant to the sustainability of aquaculture production (SHINN, et al., 2015).

The presence of total and thermotolerant coliforms in the samples may be related to several factors, such as hygienic conditions, sanitary quality of the water from which the shellfish are taken, handling and conservation of the product (Nascimento, 2011).

Regarding microbiological diversity, many aquatic animals, when presenting parasitic infections, present bacterial infections. Bacteria in the liver have a symbiotic relationship with external and internal parasites, among the functions; nutritional role, immunomodulatory property and contribution to pathogenesis (Rausch et al., 2013)

## V. CONCLUSION

In view of the results found, it is suggested visibility in the Brazilian legislation on the criteria for evaluation of the quality of bivalves according to the PNCMB allied to ANVISA, regulatory bodies of sanitary production and evaluation at public health level, of animal products. It is recommended that this evaluation be based on analyses of the bacteriological contamination of these bivalves, both for exploitation and marketing and for consumption.

Since animals filtering biological particles from the water are possible, with bacteria and contaminants of superior quality to a microbiological quality.

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## INVERSE OF THE GENERALIZED VANDERMONDE MATRIX VIA THE FUNDAMENTAL SYSTEM OF LINEAR DIFFERENCE EQUATIONS

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**ABSTRACT.** In this study we display a process for inverting the generalized Vandermonde matrix, using the analytic properties of a fundamental system related to a specific linear difference equations. We establish two approaches allowing us to provide explicit formulas for the entries of the inverse of the generalized Vandermonde matrices. To enhance the effectiveness of our the approaches, significant examples and special cases are given.

**Key Words:** Generalized Vandermonde matrix; Inverse of the generalized Vandermonde matrix; Linear difference equations; Analytic formulas; Fibonacci fundamental system.

**2010 Mathematical Subject Classifications:** 11B99; 15B99; 65F05; 65Q10; 97N50.

### 1. INTRODUCTION

The usual Vandermonde systems of equations of order  $r$  is given by,

$$\sum_{i=1}^r \lambda_i^n x_i = v_n, \quad n = 0, 1, \dots, r-1, \quad (1)$$

where the  $x_i$  ( $1 \leq i \leq r$ ) are the unknown variables, the  $\lambda_i$  ( $1 \leq i \leq r$ ) are distinct real (or complex) numbers and the  $v_n$  ( $0 \leq n \leq r-1$ ) given real (or complex) numbers. Let  $m_i \geq 1$  ( $1 \leq i \leq s$ ) be  $s$  integers and  $\lambda_i$  ( $1 \leq i \leq s$ ) be distinct real (or complex) numbers. For a given real (or complex) numbers  $v_n$  ( $0 \leq n \leq r-1$ ), where  $r = m_1 + \dots + m_s$ , the related generalized Vandermonde systems of equations is defined as follows,

$$\sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} x_{i,j} n^j \right) \lambda_i^n = v_n, \quad n = 0, 1, \dots, r-1, \quad (2)$$

where the  $x_{i,j}$  ( $1 \leq i \leq s, 0 \leq j \leq m_i-1$ ) are the unknown variables. The generalized Vandermonde system of equations is also known in the literature as a nonsingular usual Vandermonde system. The generalized Vandermonde systems (1)-(2) appear in several topics of mathematics such that the linear algebra, numerical analysis and polynomial

approximation or interpolation. They also own several important applications in various areas of applied sciences and engineering like signal processing, statistics, coding theory and control theory (see for example [8, 10, 14], and references therein). In order to solve Vandermonde systems (1)-(2), several methods have been provided in the literature (see, for instance, [2, 6, 11, 12, 16, 20]). It was shown that solving these systems is related to the inverses of their associated matrices, called also usual and generalized Vandermonde matrix, respectively. For inverting the usual Vandermonde matrix, several methods have been considered in various studies (see [2, 6, 9, 11, 17, 19], and references therein). The search for an efficient approach for computing the inverse of the generalized Vandermonde matrix, is still an attractive topic, because of its interest in various topics of mathematics and applied sciences. Especially, two recent methods have been elaborated in [2, 12], for solving the generalized system (2). The process of [2] is based on the analytic formula (or the so-called analytic Binet formula) of the linear recursive sequences  $\{v_n\}_{n \geq 0}$  of constant coefficients and order  $r$ , defined as follows,

$$v_n = a_0 v_{n-1} + a_1 v_{n-2} + \cdots + a_{r-1} v_{n-r} \text{ for every } n \geq r \quad (3)$$

$$v_n = \alpha_n \quad \text{for} \quad n = 0, 1, \dots, r-1, \quad (4)$$

where  $a_0, \dots, a_{r-1}$  are the coefficients and  $\alpha_0, \dots, \alpha_{r-1}$  are the initial data. That is, the analytic formula of sequence (3)-(4), is given by,

$$v_n = \sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} \beta_{i,j} n^j \right) \lambda_i^n, \quad (5)$$

where the  $\lambda_i$  ( $1 \leq i \leq s$ ) are the roots of the (characteristic) polynomial  $P(z) = z^r - a_0 z^{r-1} - \cdots - a_{r-1}$ , of multiplicities  $m_1, m_2, \dots, m_s$ , respectively. The scalars  $\beta_{i,j}$  ( $1 \leq i \leq s$ ,  $0 \leq j \leq m_i - 1$ ) are obtained by solving a linear system,

$$\sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} \beta_{i,j} n^j \right) \lambda_i^n = \alpha_n, \quad 0 \leq n \leq r-1. \quad (6)$$

We show that the system of equation (6) is nothing else but a generalized Vandermonde system (2). Indeed, the unknown variables  $x_{i,j}$  ( $1 \leq i \leq s$ ,  $0 \leq j \leq m_i - 1$ ) are identified to the scalars  $\beta_{i,j}$  ( $1 \leq i \leq s$ ,  $0 \leq j \leq m_i - 1$ ), namely, the two systems (2) and (6) are identical. Therefore, exhibiting explicit compact analytic formulas (5) for the general term  $v_n$ , namely, explicit formulas for the scalars  $\beta_{i,j}$  ( $1 \leq i \leq s$ ,  $0 \leq j \leq m_i - 1$ ) without solving the generalized Vandermonde system (2), will permit us to establish explicit formula for the solution of this system, or equivalently, the entries of the inverse of the associated generalized Vandermonde matrix.

This study concerns the implantation of a process for computing explicit formulas for the entries of the inverse of generalized Vandermonde matrix, through knowledge of the analytic formulation (5) of the fundamental system related to Expression (3), considered as a difference equation. To reach our goal, we exploit the recent studies of [1, 3] in order to set up two approaches which make it possible to highlight a new explicit form of the analytical formula (5) of  $v_n$ , namely, we are going to exhibit new explicit formulas for the scalars  $\beta_{i,j}$  ( $1 \leq i \leq s$ ,  $0 \leq j \leq m_i - 1$ ), and by the way we set out the inverse

of the generalized Vandermonde matrix, or equivalently we solve the the generalized Vandermonde system (2). In order to better understand our results, we will exhibit some special cases and illustrative examples. Finally, we analyze and discuss the results issued from our two approaches, by comparing them with the literature, especially with results of [2, 12].

The remainder of this paper is organized as follows. Section 2 is devoted to the properties of the fundamental system of Equation (3) and its related dynamic solution. Some explicit compact analytical formulas of the dynamic solution are proposed. Section 3 concerns the process of construction of the inverse of the generalized Vandermonde matrix, with the aid of the analytical expression of the fundamental system of Equation (3). The two main results on the inverse the generalized Vandermonde matrix related to the the generalized Vandermonde system (2), are provided in Section 4. Analysis and discussion are considered in section 5. Finally, conclusion and perspectives are given in Section 6.

## 2. EXPLICIT ANALYTIC SOLUTION OF THE DYNAMIC SOLUTION OF (3)

**2.1. Fundamental system and its dynamic solution.** Let  $\mathcal{E}_{\mathbb{K}}^{(r)}(a_0, \dots, a_{r-1})$  be the  $\mathbb{K}$ -vector space of finite dimension  $r$ , of solutions of Equation (3) of coefficients  $a_0, \dots, a_{r-1} \neq 0$ . Let  $\{\{v_n^{(p)}\}_{n \geq 0}; 0 \leq p \leq r-1\}$  be the family of sequences of  $\mathcal{E}_{\mathbb{K}}^{(r)}(a_0, \dots, a_{r-1})$ , indexed by  $p$  ( $0 \leq p \leq r-1$ ) defined as follows,

$$\begin{cases} v_n^{(p)} &= a_0 v_{n-1}^{(p)} + a_1 v_{n-2}^{(p)} + \dots + a_{r-1} v_{n-r}^{(p)}, & \text{for } n \geq r, \\ v_n^{(p)} &= \delta_{p,n} & \text{for } 0 \leq n \leq r-1. \end{cases} \quad (7)$$

Namely, this family  $\{\{v_n^{(p)}\}_{n \geq 0}; 0 \leq p \leq r-1\}$  represents  $r$  copies of sequences (3) with mutually different sets of initial values, viz.  $v_n^{(p)} = \delta_{p,n}$  ( $0 \leq n \leq r-1, 0 \leq p \leq r-1$ ), where  $\delta_{p,n}$  is the Kronecker symbol. For every  $\{v_n\}_{n \geq 0}$  in  $\mathcal{E}_{\mathbb{K}}^{(r)}(a_0, \dots, a_{r-1})$  of initial data  $\alpha_0, \dots, \alpha_{r-1}$ . Let  $\{w_n\}_{n \geq 0}$  be the sequence defined by  $w_n = \sum_{p=0}^{r-1} \alpha_p v_n^{(p)}$ . Then, as

a linear combination of the  $\{v_n^{(p)}\}_{n \geq 0}$ , we can show that  $\{w_n\}_{n \geq 0}$  is in  $\mathcal{E}_{\mathbb{K}}^{(r)}(a_0, \dots, a_{r-1})$ , moreover we have  $w_k = \alpha_k$ , for  $0 \leq k \leq r-1$ . Therefore, using Lemma 2.1, we can verify that  $v_n = w_n$ , for every  $n \geq 0$ , namely,  $v_n = \sum_{p=0}^{r-1} \alpha_p v_n^{(p)}$ , for every  $n \geq 0$ . On

the other side, suppose that  $\sum_{p=0}^{r-1} \alpha_p v_n^{(p)} = 0$ , for every  $n \geq 0$ . Since  $v_n^{(p)} = \delta_{p,n}$ , for  $0 \leq$

$n \leq r-1$ , we show that  $\sum_{p=0}^{r-1} \alpha_p v_n^{(p)} = \alpha_p = 0$  for  $0 \leq p \leq r-1$ . Therefore, the family

$\{\{v_n^{(p)}\}_{n \geq 0}; 0 \leq p \leq r-1\}$  is a basis of the  $\mathbb{K}$ -vector space  $\mathcal{E}_{\mathbb{K}}^{(r)}(a_0, \dots, a_{r-1})$ . The family  $\{\{v_n^{(p)}\}_{n \geq 0}; 0 \leq p \leq r-1\}$  is known in the literature as the *fundamental system* of Equation (3), or the *Fibonacci fundamental system* of Equation (3).

For reasons of utility, we first state the following elementary lemma, concerning the equality of two elements of the space  $\mathcal{E}_{\mathbb{K}}^{(r)}(a_0, \dots, a_{r-1})$ .

**Lemma 2.1.** Let  $\{v_n\}_{n \geq 0}$  and  $\{w_n\}_{n \geq 0}$  be in  $\mathcal{E}_{\mathbb{K}}^{(r)}(a_0, \dots, a_{r-1})$ . If  $v_k = w_k$ , for  $k = 0, 1, \dots, r-1$ , then, we have  $v_n = w_n$ , for every  $n \geq 0$ .

The proof of this lemma is done by simple reasoning by induction.

Among the element of the fundamental system (7), the next theorem shows the closed relation between  $\{v_n^{(r-1)}\}_{n \geq 0}$  and the other elements  $\{v_n^{(p)}\}_{n \geq 0}$  for  $p = 0, \dots, r-2$ .

**Theorem 2.2.** Let  $\{\{v_n^{(p)}\}_{n \geq 0}; 0 \leq p \leq r-1\}$  be the fundamental system of Equation (3). Then, for every  $p$ , with  $p = 0, \dots, r-2$ , we have,

$$v_n^{(p)} = a_{r-p-1}v_{n-1}^{(r-1)} + a_{r-p}v_{n-2}^{(r-1)} + \dots + a_{r-1}v_{n-p-1}^{(r-1)}, \quad (8)$$

for every  $n \geq r$ .

**Proof.** Let first recall that the sequences  $\{v_n^{(p)}\}_{n \geq 0}$  are defined by (7), namely,

$$\begin{cases} v_n^{(p)} = \delta_{p,n} \text{ for } p, n = 0, \dots, r-1, \\ v_n^{(p)} = a_0v_{n-1}^{(p)} + a_1v_{n-2}^{(p)} + \dots + a_{r-1}v_{n-r}^{(p)} \text{ for } n \geq r. \end{cases}$$

Let  $\{w_n^{(0)}\}_{n \geq 0}$  be the sequence defined by  $w_0^{(0)} = 1$  and  $w_n^{(0)} = a_{r-1}v_{n-1}^{(r-1)}$ . We show that  $\{w_n^{(0)}\}_{n \geq 0}$  satisfies Equation (3), with initial data,

$$w_0^{(0)} = 1 \text{ and } w_n^{(0)} = a_{r-1}v_{n-1}^{(r-1)} = 0, \text{ for every } 1 \leq n \leq r-1.$$

Therefore, using Lemma 2.1, we derive  $w_n^{(0)} = v_n^{(0)}$ , for every  $n \geq 0$ , namely, we have  $v_n^{(0)} = a_{r-1}v_{n-1}^{(r-1)}$ , for every  $n \geq 1$ . For  $p = 1$ , let  $\{w_n^{(1)}\}_{n \geq 0}$  be the sequence defined by

$$w_0^{(1)} = 0, \quad w_1^{(1)} = 1 \text{ and } w_n^{(1)} = a_{r-2}v_{n-1}^{(r-1)} + a_{r-1}v_{n-2}^{(r-1)}.$$

It is clear that  $w_n^{(1)} = a_{r-2}v_{n-1}^{(r-1)} + w_{n-1}^{(0)}$ , thus the sequence  $\{w_n^{(1)}\}_{n \geq 0}$  satisfies Equation (3), with initial data,

$$w_0^{(1)} = 0, \quad w_1^{(1)} = 1 \text{ and } w_n^{(1)} = a_{r-2}v_{n-1}^{(r-1)} + w_{n-1}^{(0)} = 0 \text{ for } 2 \leq n \leq r-1.$$

Therefore, Lemma 2.1 shows that the two sequences  $\{w_n^{(1)}\}_{n \geq 0}$  and  $\{v_n^{(1)}\}_{n \geq 0}$  are identical, namely, we have  $v_n^{(1)} = a_{r-2}v_{n-1}^{(r-1)} + a_{r-1}v_{n-2}^{(r-1)}$ . More generally, with the aid of the similar argument, for  $2 \leq p \leq r-2$ , we consider the sequence  $\{w_n^{(p)}\}_{n \geq 0}$  defined by the initial conditions  $w_0^{(p)} = \dots = w_{p-1}^{(p)} = 0$ ,  $w_p^{(p)} = 1$ , and

$$w_n^{(p)} = a_{r-p-1}v_{n-1}^{(r-1)} + a_{r-p}v_{n-2}^{(r-1)} + \dots + a_{r-1}v_{n-p-1}^{(r-1)}.$$

We can observe that  $w_n^{(p)} = a_{r-p-1}v_{n-1}^{(r-1)} + w_{n-1}^{(p-1)}$ , where  $w_{n-1}^{(p-1)} = a_{r-p}v_{n-2}^{(r-1)} + \dots + a_{r-1}v_{n-p-1}^{(r-1)}$ . Hence, the sequence  $\{w_n^{(p)}\}_{n \geq 0}$  satisfies Equation (3), with initial data,

$$w_0^{(p)} = \dots = w_{p-1}^{(p)} = 0, \quad w_p^{(p)} = 1 \text{ and } w_n^{(p)} = a_{r-p-1}v_{n-1}^{(r-1)} + w_{n-1}^{(p-1)} = 0 \text{ for } p+1 \leq n \leq r-1.$$

Hence, by applying Lemma 2.1, we derive that the two sequences  $\{w_n^{(p)}\}_{n \geq 0}$  and  $\{v_n^{(p)}\}_{n \geq 0}$  are identical. Therefore, for every  $p$  ( $0 \leq p \leq r-2$ ), we have  $v_n^{(p)} = a_{r-p-1}v_{n-1}^{(r-1)} + a_{r-p}v_{n-2}^{(r-1)} + \dots + a_{r-1}v_{n-p-1}^{(r-1)}$ .  $\square$



The result of Theorem 2.2 can be also established by induction on  $p$ . However, we have used here an elementary process based on Lemma 2.1 and the fact that  $\mathcal{E}_{\mathbb{K}}^{(r)}(a_0, \dots, a_{r-1})$  is a  $\mathbb{K}$ -vector space

Expression (8) shows that the sequence  $\{v_n^{(r-1)}\}_{n \geq 0}$  will play a central role in the sequel. The sequence  $\{v_n^{(r-1)}\}_{n \geq 0}$ , is called *dynamic solution* of Equation (3).

For illustrative purpose, we propose the following special case.

**Example 2.3.** For  $r = 4$ , Expression (3) takes the form

$$v_n = a_0 v_{n-1} + a_1 v_{n-2} + a_2 v_{n-3} + a_3 v_{n-4} \text{ for } n \geq 4.$$

Therefore, the terms  $v_n^{(0)}$ ,  $v_n^{(1)}$ ,  $v_n^{(2)}$  and  $v_n^{(3)}$  of the fundamental system are expressed in terms of the dynamic solution  $v_n^{(r-1)} = v_n^{(3)}$  under the form,

$$v_n^{(0)} = a_3 v_{n-1}^{(3)}, v_n^{(1)} = a_2 v_{n-1}^{(3)} + a_3 v_{n-2}^{(3)}, v_n^{(2)} = a_1 v_{n-1}^{(3)} + a_2 v_{n-2}^{(3)} + a_3 v_{n-3}^{(3)},$$

for  $n \geq 4$ .

**2.2. Analytical formulas of the dynamic solution: First approach.** Let  $\lambda_i$  ( $1 \leq i \leq s$ ) be the roots of the characteristic polynomial  $P(z) = z^r - a_0 z^{r-1} - \dots - a_{r-1}$ , related to sequence (3), of multiplicities  $m_1, m_2, \dots, m_s$ , respectively. For every  $m_i \geq 1$  we set  $\mathcal{E}_k^{[i]} = \{(n_1, \dots, n_s) \in \mathbb{N}^{s-1}; n_1 + \dots + n_{i-1} + n_{i+1} + \dots + n_s = m_i - k - 1\}$ . In [5, Section 4.1], the following expression was considered,

$$\gamma_k^{[i]}(\lambda_1, \dots, \lambda_s) = (-1)^{r-m_i} \sum_{\mathcal{E}_k^{[i]}} \left( \prod_{1 \leq j \neq i \leq s} \frac{\binom{n_j + m_j - 1}{n_j}}{(\lambda_j - \lambda_i)^{n_j + m_j}} \right) \quad (9)$$

for  $0 \leq k \leq m_i - 1$  and  $1 \leq i \leq s$ .

**Example 2.4.** Let  $r = 7$  and suppose that  $s = 3$ ,  $m_1 = 2$ ,  $m_2 = 1$  and  $m_3 = 4$ . For  $i = 3$ ,  $k = 1$  we have  $\mathcal{E}_1^{[3]} = \{(n_1, n_2); n_1 + n_2 = 4 - 1 - 1 = 2\}$ . Therefore, we have,

$$\gamma_1^{[3]}(\lambda_1, \lambda_2, \lambda_3) = (-1)^3 \sum_{n_1+n_2=2} \frac{\binom{n_1 + m_1 - 1}{n_1}}{(\lambda_1 - \lambda_3)^{n_1 + m_1}} \cdot \frac{\binom{n_2 + m_2 - 1}{n_2}}{(\lambda_2 - \lambda_3)^{n_2 + m_2}}.$$

Therefore, since  $\binom{n_2}{n_2} = 1$  and  $\binom{n_1 + 1}{n_1} = n_1 + 1$ , we obtain,

$$\gamma_1^{[3]}(\lambda_1, \lambda_2, \lambda_3) = (-1)^3 \sum_{n_1+n_2=2} \frac{n_1 + 1}{(\lambda_1 - \lambda_3)^{n_1 + 2}} \cdot \frac{1}{(\lambda_2 - \lambda_3)^{n_2 + 1}}.$$

The analytic formula of the dynamic solution  $v_n^{(r-1)}$  related to the fundamental system (7), can be expressed in terms of the roots  $\lambda_i$  ( $1 \leq i \leq s$ ) of the polynomial  $P(z) = z^r - a_0 z^{r-1} - \dots - a_{r-1}$ , by the previous expressions (9) of the  $\gamma_k^{[i]}(\lambda_1, \dots, \lambda_s)$ . More precisely, we have the following result.

**Proposition 2.5.** *The analytic expression of the dynamic solution  $v_n^{(r-1)}$  is given by the following formula  $v_n^{(r-1)} = \sum_{i=1}^s \left( \sum_{k=0}^{m_i-1} \beta_{i,k}^{(r-1)} n^k \right) \lambda_i^n$ , for every  $n \geq r$ , where*

$$\beta_{i,k}^{(r-1)} = \sum_{t=k}^{m_i-1} s(t, k) \frac{\gamma_t^{[i]}(\lambda_1, \dots, \lambda_s)}{t! \lambda_i^t}, \quad (10)$$

and the  $s(t, k)$  are the Stirling numbers of the first kind.

Indeed, from [3, Theorem 2.2], we have  $v_n^{(r-1)} = \sum_{i=1}^s \left( \sum_{k=0}^{m_i-1} \binom{n}{k} \gamma_k^{[i]}(\lambda_1, \dots, \lambda_s) \right) \lambda_i^{n-k}$ ,

for all  $n \geq r$ . On the other hand, it is well known that  $\frac{n!}{(n-k)!} = n(n-1) \cdots (n-k+1) = \sum_{t=0}^k s(k, t) n^t$ , where the  $s(k, t)$  are Stirling numbers of the first kind. Therefore, the

combinatorial expression  $\binom{n}{k}$  can be also expressed in terms of the Stirling numbers of

the first kind as follows  $\binom{n}{k} = \frac{n(n-1) \cdots (n-k+1)}{k!} = \sum_{t=0}^k \frac{s(k, t)}{k!} n^t$ . Thus, we get

$$v_n^{(r-1)} = \sum_{i=1}^s \left( \sum_{k=0}^{m_i-1} \left( \sum_{t=0}^k s(k, t) n^t \right) \frac{\gamma_k^{[i]}(\lambda_1, \dots, \lambda_s)}{k! \lambda_i^k} \right) \lambda_i^n, \text{ for every } n \geq r, \text{ or equivalently,}$$

$$v_n^{(r-1)} = \sum_{i=1}^s \left( \sum_{k=0}^{m_i-1} \left( \sum_{t=k}^{m_i-1} s(t, k) \frac{\gamma_t^{[i]}(\lambda_1, \dots, \lambda_s)}{t! \lambda_i^t} \right) n^k \right) \lambda_i^n, \text{ for every } n \geq r.$$

Therefore, the results follows, namely, Expression (10) is established.  $\square$

More generally, the result of Proposition 2.5 allows us to determine the expressions of  $v_{n-d}^{(r-1)}$  ( $1 \leq d \leq r-1$ ). In summary, we have the following result.

**Proposition 2.6.** *Under the preceding data, for  $d = 1, \dots, r-1$ , we have*

$$v_{n-d}^{(r-1)} = \sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} C_{i,j}^{(d)} n^j \right) \lambda_i^n, \text{ for every } n \geq r,$$

where

$$C_{i,j}^{(d)} = \lambda_i^{-d} \sum_{k=j}^{m_i-1} (-1)^{k-j} \beta_{i,k}^{(r-1)} \binom{k}{j} d^{k-j}, \quad (11)$$

such that the  $\beta_{i,k}^{(r-1)}$  are as in (10).

Indeed, from Proposition 2.5, we derive,

$$v_{n-d}^{(r-1)} = \sum_{i=1}^s \left( \sum_{k=0}^{m_i-1} \beta_{i,k}^{(r-1)} (n-d)^k \right) \lambda_i^{n-d} = \sum_{i=1}^s \left( \sum_{k=0}^{m_i-1} \beta_{i,k}^{(r-1)} \sum_{j=0}^k \binom{k}{j} n^j (-d)^{k-j} \right) \lambda_i^{n-d}.$$

Therefore, we get  $v_{n-d}^{(r-1)} = \sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} \left( \lambda_i^{-d} \sum_{k=j}^{m_i-1} \beta_{i,k}^{(r-1)} \binom{k}{j} (-1)^{k-j} d^{k-j} \right) n^j \right) \lambda_i^n$ , which allows us to derive Expression (11).  $\square$

For reason of clarity, in the following corollary, we consider the special useful case, for illustrating Propositions 2.5 and 2.6.

**Corollary 2.7. Special case  $s = 2$ :**  $m_1 \geq 2$  and  $m_2 \geq 2$ . Under the data of Propositions 2.5 and 2.6, suppose that  $s = 2$ :  $m_1 \geq 2$  and  $m_2 \geq 2$ , then, we have,

$$v_n^{(r-1)} = \left( \sum_{k=0}^{m_1-1} \beta_{1,k}^{(r-1)} n^k \right) \lambda_1^n + \left( \sum_{k=0}^{m_2-1} \beta_{2,k}^{(r-1)} n^k \right) \lambda_2^n,$$

for every  $n \geq r = m_1 + m_2$ , where the  $\beta_{i,k}^{(r-1)}$ ,  $i = 1, 2$  are as in (10), namely,

$$\beta_{1,k}^{(r-1)} = \sum_{t=k}^{m_1-1} s(t, k) \frac{\gamma_t^{[1]}(\lambda_1, \lambda_2)}{t! \lambda_1^t} \text{ and } \beta_{2,k}^{(r-1)} = \sum_{t=k}^{m_2-1} s(t, k) \frac{\gamma_t^{[2]}(\lambda_1, \lambda_2)}{t! \lambda_2^t}, \quad (12)$$

and the  $s(t, k)$  are the Stirling numbers of the first kind. Moreover, for every  $d = 1, \dots, r-1$ , we have,

$$v_{n-d}^{(r-1)} = \left( \sum_{j=0}^{m_1-1} C_{1,j}^{(d)} n^j \right) \lambda_1^n + \left( \sum_{j=0}^{m_2-1} C_{2,j}^{(d)} n^j \right) \lambda_2^n,$$

for every  $n \geq r = m_1 + m_2$ , where the  $C_{i,j}^{(d)}$  are as in (11), namely,

$$C_{1,j}^{(d)} = \lambda_1^{-d} \sum_{k=j}^{m_1-1} (-1)^{k-j} \beta_{1,k}^{(r-1)} \binom{k}{j} d^{k-j} \text{ and } C_{2,j}^{(d)} = \lambda_2^{-d} \sum_{k=j}^{m_2-1} (-1)^{k-j} \beta_{2,k}^{(r-1)} \binom{k}{j} d^{k-j},$$

such that the  $\beta_{1,k}^{(r-1)}$  and  $\beta_{2,k}^{(r-1)}$  are given by (12).

**2.3. Analytical formulas of the dynamic solution: Second approach.** For a given sequence (3), it was shown in [13] that,

$$v_n = \rho(n, r) A_0 + \rho(n-1, r) A_1 + \dots + \rho(n-r+1, r) A_{r-1}, \quad (13)$$

for every  $n \geq r$ , where  $A_i = a_{r-1} v_i + \dots + a_i v_{r-1}$  ( $0 \leq i \leq r-1$ ) and

$$\rho(n, r) = \sum_{k_0+2k_1+\dots+rk_{r-1}=n-r} \frac{(k_0+k_1+\dots+k_{r-1})!}{k_0! k_1! \dots k_{r-1}!} a_0^{k_0} a_1^{k_1} \dots a_{r-1}^{k_{r-1}}, \quad (14)$$

with  $\rho(r, r) = 1$  and  $\rho(n, r) = 0$  for  $n \leq r-1$ . Let  $\lambda_i$  ( $1 \leq i \leq s$ ) be the roots of the polynomial  $P(z) = z^r - a_0 z^{r-1} - \dots - a_{r-1}$ , of multiplicities  $m_1, m_2, \dots, m_s$ , respectively. Using the divided difference techniques and Newton interpolation method, it was established in [1, Theorem 3.1] that Expression (14) of  $\rho(n, r)$ , can be formulated in terms of the roots  $\lambda_i$  ( $1 \leq i \leq s$ ) and their multiplicities  $m_1, m_2, \dots, m_s$  as follows,

$$\rho(n, r) = \sum_{i=1}^s \frac{f_{i,n}^{(m_i-1)}(\lambda_i)}{(m_i-1)!}, \text{ for every } n \geq r, \quad (15)$$

with  $\rho(r, r) = 1$ ,  $\rho(n, r) = 0$  for  $0 \leq n \leq r-1$ , and  $f_{i,n}(x) = \frac{x^{n-1}}{\prod_{k=1, k \neq i}^s (x - \lambda_k)^{m_k}}$ , where

$f_{i,n}^{(k)}(x)$  means the derivative of order  $k$  of the function  $f_{i,n}$ . Especially, when the roots  $\lambda_i$  ( $1 \leq i \leq s$ ) are simple, namely,  $s = r$  and  $m_1 = m_2 = \dots = m_r = 1$ , Expression (15) takes the form,

$$\rho(n, r) = \sum_{i=1}^s \frac{f_{i,n}^{(m_i-1)}(\lambda_i)}{(m_i-1)!} = \sum_{i=1}^r \frac{\lambda_i^{n-1}}{\prod_{k=1, k \neq i}^r (\lambda_i - \lambda_k)}, \quad (16)$$

Expression (16) has been also established in [2, 4]. In addition, let  $\{w_n\}_{n \geq 0}$  be the sequence defined by  $w_n = \rho(n+1, r)$ , then Expression (13) shows that  $\{w_n\}_{n \geq 0}$  satisfies the recursive relation (3), and its initial conditions are  $w_0 = \dots = w_{r-2} = 0$  and  $w_{r-1} = 1$ . Hence, the dynamic solution  $\{v_n^{(r-1)}\}_{n \geq 0}$  and the sequence  $\{w_n\}_{n \geq 0}$  satisfy the same recursive relation (3) and own the identical initial conditions. Therefore, Lemma 2.1 shows that,

$$v_n^{(r-1)} = \rho(n+1, r), \text{ for every } n \geq 0. \quad (17)$$

Therefore, taking into account Expressions (15) and (17), we derive that the analytic formula of the dynamic solution is given by,

$$v_n^{(r-1)} = \rho(n+1, r) = \sum_{i=1}^s \frac{f_{i,n+1}^{(m_i-1)}(\lambda_i)}{(m_i-1)!}, \text{ for every } n \geq r, \quad (18)$$

where the function  $f_{i,n+1}$  ( $1 \leq i \leq s$ ) are defined as by  $f_{i,n+1}(x) = \frac{x^n}{\prod_{k=1, k \neq i}^s (x - \lambda_k)^{m_k}}$ .

For  $m_i = 1$  we have  $m_i - 1 = 0$ , therefore, we get  $f_{i,n+1}^{(m_i-1)}(x) = f_{i,n+1}(x) = \frac{x^n}{\prod_{k=1, k \neq i}^s (x - \lambda_k)}$ .

For technical reasons, we set  $f_{i,n+1}(x) = q_n(x)H_i(x)$ , where  $q_n(x) = x^n$  and  $H_i(x) = \frac{1}{\prod_{k=1, k \neq i}^s (x - \lambda_k)^{m_k}}$ .

For  $m_i \geq 2$ , let compute the explicit formula of the derivative of order  $m_i - 1$  of the function  $f_{i,n+1}(x) = \frac{x^n}{\prod_{k=1, k \neq i}^s (x - \lambda_k)^{m_k}}$ . To achieve our goal, we will proceed in two

steps. First, let  $f, g$  two functions admitting derivatives of order  $m \geq 1$  on a nonempty subset of  $\mathbb{R}$ . It is well known that, we have  $(fg)^{(m)} = \sum_{d=0}^m \binom{m}{d} f^{(d)} g^{(m-d)}$ . Application of this former formula to  $f_{i,n+1}(x) = q_n(x)H_i(x)$ , we obtain,

$$f_{i,n+1}^{(m)}(x) = \sum_{d=0}^m \binom{m}{d} q_n^{(d)}(x) H_i^{(m-d)}(x) = \sum_{d=0}^m \binom{m}{d} (n)_d x^{n-d} H_i^{(m-d)}(x),$$

where  $(n)_d = n(n-1) \cdots (n-d+1)$ . Since  $(n)_d = \sum_{h=0}^d s(d, h)n^h$ , where the  $s(d, h)$  are the Stirling numbers of the first kind, we show that,

$$f_{i,n+1}^{(m)}(x) = \sum_{d=0}^m \binom{m}{d} (n)_d x^{n-d} H_i^{(m-d)}(x) = \sum_{d=0}^m \binom{m}{d} \left( \sum_{h=0}^d s(d, h)n^h \right) H_i^{(m-d)}(x) x^{n-d}.$$

Using the identity  $\sum_{d=0}^m \sum_{h=0}^d x_{d,h} = \sum_{h=0}^m \sum_{d=h}^m x_{d,h}$ , for a bi-indexed sequence  $x_{d,h}$ , we obtain

$$f_{i,n+1}^{(m)}(x) = \sum_{h=0}^m \left( \sum_{d=h}^m s(d, h) \binom{m}{d} H_i^{(m-d)}(x) x^{-d} \right) n^h x^n. \text{ Therefore, for } m_i \geq 2 \text{ we set } x = \lambda_i \text{ and } m = m_i - 1, \text{ thus we arrive to have,}$$

$$f_{i,n+1}^{(m_i-1)}(\lambda_i) = \sum_{h=0}^{m_i-1} \left( \sum_{d=h}^{m_i-1} s(d, h) \binom{m_i-1}{d} H_i^{(m_i-d-1)}(\lambda_i) \lambda_i^{-d} \right) n^h \lambda_i^n. \quad (19)$$

Second, to improve Expression (19), we will give the explicit form of the  $p$ -th derivative of the function  $H_i(x)$ . For this purpose, we use the following well-known formula,

$$(f_1 \cdot f_2 \cdots f_s)^{(m)} = \sum_{k_1 + \cdots + k_s = m} \binom{m}{k_1 \dots k_s} \prod_{j=1}^s f_j^{(k_j)},$$

where  $\binom{m}{k_1 \dots k_s} = \frac{m!}{k_1! k_2! \cdots k_s!}$  and  $f_j : E \rightarrow \mathbb{R}$  ( $1 \leq j \leq s$ ) are functions defined on a subset  $E \neq \emptyset$  of  $\mathbb{R}$ , which are  $n$  times differentiable, and  $f^{(p)}$  is the derivative of order  $p$  of the function  $f$ . Moreover, for every integer  $m' \neq 0$ , the derivative of order  $p \geq 1$  of the function  $f(x) = (x - \lambda)^{m'}$ , is given by  $f^{(p)}(x) = m'(m'-1) \cdots (m'-p+1)(x - \lambda)^{m'-p}$ , and when  $m' = -m$  with  $m \geq 1$ , we get  $f^{(p)}(x) = (-1)^p \frac{(m+p-1)!}{(m-1)!} (x - \lambda)^{-m-p}$ . Now, applying the above formulas to the function  $H_i(x)$ , written under the

form  $H_i(x) = \frac{1}{\prod_{j=1, j \neq i}^s (x - \lambda_j)^{m_j}} = \prod_{j=1, j \neq i}^s h_j(x)$ , with  $h_j(x) = (x - \lambda_j)^{-m_j}$ , we obtain

$$H_i^{(k)}(x) = \sum_{\hat{\varepsilon}_k^{[i]}} \binom{k}{p_1 \dots p_s} \prod_{j=1, j \neq i}^s h_j^{(p_j)}(x), \text{ where } \hat{\varepsilon}_k^{[i]} = \{(p_1, p_2, \dots, p_s) \in \mathbb{N}^{s-1}; p_1 + \cdots +$$

$p_{i-1} + p_{i+1} + \cdots + p_s = k\}$ . Since,  $h_j^{(p_j)}(x) = (-1)^{p_j} \frac{(m_j + p_j - 1)!}{(m_j - 1)!} (x - \lambda_j)^{-m_j - p_j}$ , for every  $j$  ( $1 \leq j \neq i \leq s$ ), we derive the following lemma.

**Lemma 2.8.** *For every  $k \geq 1$  and  $1 \leq i \leq s$ , we have,*

$$H_i^{(k)}(x) = (-1)^k \sum_{\hat{\varepsilon}_k^{[i]}} \binom{k}{p_1 \dots p_s} \prod_{j=1, j \neq i}^s \frac{(m_j + p_j - 1)!}{(m_j - 1)!} (x - \lambda_j)^{-m_j - p_j}. \quad (20)$$

Summarizing, through Expressions (16), (19) and (20), we can formulate the following result.



**Theorem 2.9.** Let  $\lambda_i$  ( $1 \leq i \leq s$ ) be the roots of the polynomial  $P(z) = z^r - a_0 z^{r-1} - \dots - a_{r-1}$ , associated to the recursive relation (3), of multiplicities  $m_1, m_2, \dots, m_s$ , respectively. Suppose that for every root  $\lambda_i$  the associated multiplicity  $m_i \geq 2$  ( $1 \leq i \leq s$ ). Then, the analytic formula of the dynamic solution is given as follows,

$$v_n^{(r-1)} = \sum_{i=1}^s \frac{1}{(m_i - 1)!} \sum_{h=0}^{m_i-1} \left( \sum_{d=h}^{m_i-1} s(d, h) \binom{m_i-1}{d} H_i^{(m_i-d-1)}(\lambda_i) \lambda_i^{-d} \right) n^h \lambda_i^n, \quad (21)$$

for every  $n \geq r$ , where  $s(d, h)$  are the Stirling numbers of the first kind and  $H_i(x) = \frac{1}{\prod_{k=1, k \neq i}^s (x - \lambda_k)^{m_k}}$

and the  $H_i^{(k)}(x)$  are as in (20).

Suppose that for every root  $\lambda_i$  the associated multiplicity  $m_i = 1$  ( $1 \leq i \leq r$ ). Then, the analytic formula of the dynamic solution is given as follows,

$$v_n^{(r-1)} = \sum_{i=1}^r \frac{\lambda_i^n}{\prod_{k=1, k \neq i}^r (\lambda_i - \lambda_k)}, \quad (22)$$

for every  $n \geq r$ .

We illustrate Theorem 2.9 by the following special case.

**Special case:**  $s = m_1 = m_2 = 2$ . Let determine the dynamic solution  $v_n^{(3)}$ , when  $s = m_1 = m_2 = 2$ . By using Equation (21), we infer that,

$$v_n^{(3)} = \sum_{i=1}^2 \frac{1}{1!} \sum_{h=0}^1 \left( \sum_{d=h}^1 s(d, h) \binom{1}{d} H_i^{(1-d)}(\lambda_i) \lambda_i^{-d} \right) n^h \lambda_i^n = \Omega_1(n) + \Omega_2(n),$$

where

$$\Omega_i(n) = \sum_{h=0}^1 \left( \sum_{d=h}^1 s(d, h) \binom{1}{d} H_i^{(1-d)}(\lambda_i) \lambda_i^{-d} \right) n^h \lambda_i^n = \beta_{i,0} \lambda_i^n + \beta_{i,1} n \lambda_i^n,$$

for  $i = 1, 2$ . Since  $s(0, 0) = s(1, 1) = 1$  and  $s(1, 0) = 0$ , a straightforward computation implies that  $\beta_{1,0} = H_1^{(1)}(\lambda_1)$ ,  $\beta_{1,1} = H_1^{(0)}(\lambda_1) \lambda_1^{-1}$ ,  $\beta_{2,0} = H_2^{(1)}(\lambda_2)$ ,  $\beta_{2,1} = H_2^{(0)}(\lambda_2) \lambda_2^{-1}$ . Applying Equation (20), we obtain,

$$\beta_{1,0} = \frac{-2}{(\lambda_1 - \lambda_2)^3}, \quad \beta_{1,1} = \frac{1}{(\lambda_1 - \lambda_2)^2 \lambda_1}, \quad \beta_{2,0} = \frac{2}{(\lambda_1 - \lambda_2)^3}, \quad \beta_{2,1} = \frac{1}{(\lambda_1 - \lambda_2)^2 \lambda_2}.$$

Therefore, for  $s = m_1 = m_2 = 2$ , the dynamic solution  $v_n^{(3)}$  takes the form,

$$v_n^{(3)} = \frac{-2}{(\lambda_1 - \lambda_2)^3} \lambda_1^n + \frac{1}{(\lambda_1 - \lambda_2)^2 \lambda_1} n \lambda_1^n + \frac{2}{(\lambda_1 - \lambda_2)^3} \lambda_2^n + \frac{1}{(\lambda_1 - \lambda_2)^2 \lambda_2} n \lambda_2^n,$$

for every  $n \geq 0$ .

Let  $\lambda_i$  ( $1 \leq i \leq s$ ) be the roots of the (characteristic) polynomial  $P(z) = z^r - a_0 z^{r-1} - \dots - a_{r-1}$ , associated to the recursive relation (3), of multiplicities  $m_1, m_2, \dots, m_s$ , respectively. Without loss of generality, we set,

$$\mathcal{Z}_1 = \{\lambda_i, \text{ root of } P(z) \text{ with } m_i = 1\}; \mathcal{Z}_2 = \{\lambda_i, \text{ root of } P(z) \text{ with } m_i \geq 2\}.$$

Then, combining the two cases (21) and (22) of Theorem 2.9, we get the following general result.

**Theorem 2.10.** *Let  $\lambda_i$  ( $1 \leq i \leq s$ ) be the roots of the polynomial  $P(z) = z^r - a_0 z^{r-1} - \dots - a_{r-1}$ , associated to the recursive relation (3), of multiplicities  $m_1, m_2, \dots, m_s$ , respectively. Then, the analytic formula of the dynamic solution is given as follows  $v_n^{(r-1)} = \Phi_n^{(r)} + \Psi_n^{(r)}$ , for every  $n \geq r$ , where*

$$\Phi_n^{(r)} = \sum_{i \in \mathcal{Z}_1} \frac{1}{\prod_{k=1, k \neq i}^s (\lambda_i - \lambda_k)^{m_k}} \lambda_i^n \text{ and } \Psi_n^{(r)} = \sum_{i \in \mathcal{Z}_2} \left( \frac{1}{(m_i - 1)!} \sum_{h=0}^{m_i-1} \Delta_{i,h}^{(r)} n^h \right) \lambda_i^n,$$

$$\text{where } \Delta_{i,h}^{(r)} = \sum_{d=h}^{m_i-1} s(d, h) \binom{m_i-1}{d} H_i^{(m_i-d-1)}(\lambda_i) \lambda_i^{-d}, \text{ with } H_i(x) = \frac{1}{\prod_{k=1, k \neq i}^s (x - \lambda_k)^{m_k}},$$

and the  $H_i^{(k)}(x)$  are as in (20).

Since the analytic expression of  $v_{n-p}^{(r-1)}$ , for  $p = 1, \dots, r-1$ , will be useful in the sequel, the result of Theorem 2.10 allows us to obtain,

$$v_{n-p}^{(r-1)} = \Phi_{n-p}^{(r)} + \Psi_{n-p}^{(r)}, \text{ for every } n \geq p,$$

where

$$\Phi_{n-p}^{(r)} = \sum_{i \in \mathcal{Z}_1} \frac{\lambda_i^{n-p}}{\prod_{k=1, k \neq i}^s (\lambda_i - \lambda_k)^{m_k}}, \quad \Psi_{n-p}^{(r)} = \sum_{i \in \mathcal{Z}_2} \frac{1}{(m_i - 1)!} \left[ \sum_{h=0}^{m_i-1} \Delta_{i,h}^{(r)} (n-p)^h \right] \lambda_i^{n-p}.$$

And a similar process used for establishing Proposition 2.6, shows that the expression  $\sum_{h=0}^{m_i-1} \Delta_{i,h}^{(r)} (n-p)^h = \sum_{h=0}^{m_i-1} \Delta_{i,h}^{(r)} \left( \sum_{k=0}^h \binom{h}{k} n^k (-p)^{h-k} \right)$ , can be written under the form  $\sum_{h=0}^{m_i-1} \Delta_{i,h}^{(r)} (n-p)^h = \sum_{k=0}^{m_i-1} \left( \sum_{h=k}^{m_i-1} (-1)^{h-k} \binom{h}{k} \Delta_{i,h}^{(r)} p^{h-k} \right) n^k$ . Therefore, we derive the following proposition.

**Proposition 2.11.** *Under the data of Theorem 2.10, for  $1 \leq p \leq r-1$ , we have,*

$$v_{n-p}^{(r-1)} = \sum_{i \in \mathcal{Z}_1} \beta_{i,p}^{(r)} \lambda_i^n + \sum_{i \in \mathcal{Z}_2} \beta_{i,k,p}^{(r)} \lambda_i^n, \text{ for } n - p \geq r$$

$$\text{where } \beta_{i,p}^{(r)} = \frac{\lambda_i^{-p}}{\prod_{k=1, k \neq i}^s (\lambda_i - \lambda_k)^{m_k}} \text{ and } \beta_{i,k,p}^{(r)} = \frac{\lambda_i^{-p}}{(m_i - 1)!} \sum_{k=0}^{m_i-1} \left( \sum_{h=k}^{m_i-1} (-1)^{h-k} \binom{h}{k} \Delta_{i,h}^{(r)} p^{h-k} \right) n^k,$$

$$\text{such that } \Delta_{i,h}^{(r)} = \sum_{d=h}^{m_i-1} s(d, h) \binom{m_i-1}{d} H_i^{(m_i-d-1)}(\lambda_i) \lambda_i^{-d}, \text{ and } H_i(x) = \frac{1}{\prod_{k=1, k \neq i}^s (x - \lambda_k)^{m_k}},$$

where the  $H_i^{(k)}(x)$  are as in (20).

For illustrative purpose of Theorems 2.9 and 2.10, we consider the special useful two cases:  $s = 2$  with  $m_1 \geq 2, m_2 \geq 2$  and  $s = 3$  with  $m_1 = m_2 = 1, m_3 \geq 2$ . For the first case we show that  $\mathcal{Z}_1 = \emptyset$  and  $\mathcal{Z}_2 = \{1, 2\}$ . Thus, we have the following first corollary.

**Corollary 2.12.** *Special case  $s = 2$ :  $m_1 \geq 2$  and  $m_2 \geq 2$ . Under the data of Theorem 2.10, we have,*

$$v_{n-p}^{(r-1)} = \frac{\lambda_1^{-p}}{(m_1 - 1)!} \sum_{k=0}^{m_1-1} \left( \sum_{h=k}^{m_1-1} \gamma_1(h, k) \right) n^k \lambda_1^n + \frac{\lambda_2^{-p}}{(m_2 - 1)!} \sum_{k=0}^{m_2-1} \left( \sum_{h=k}^{m_2-1} \gamma_2(h, k) \right) n^k \lambda_2^n,$$

for every  $n - p \geq r$ , with  $1 \leq p \leq r - 1$ , where  $\gamma_1(h, k) = (-1)^{h-k} \binom{h}{k} \Delta_{1,h}^{(r)} p^{h-k}$  and

$$\gamma_2(h, k) = (-1)^{h-k} \binom{h}{k} \Delta_{2,h}^{(r)} p^{h-k}, \text{ with } \Delta_{1,h}^{(r)} = \sum_{d=h}^{m_1-1} s(d, h) \binom{m_1-1}{d} H_1^{(m_1-d-1)}(\lambda_1) \lambda_1^{-d},$$

$$\Delta_{2,h}^{(r)} = \sum_{d=h}^{m_2-1} s(d, h) \binom{m_2-1}{d} H_2^{(m_2-d-1)}(\lambda_2) \lambda_2^{-d}, H_i(x) = \frac{1}{\prod_{k=1, k \neq i}^s (x - \lambda_k)^{m_k}}, \text{ and the } H_i^{(k)}(x)$$

are as in (20).

For the second, we show that  $\mathcal{Z}_1 = \{1, 2\}$  and  $\mathcal{Z}_2 = \{3\}$ . Thus, we have the following corollary,

**Corollary 2.13.** *Special case  $s = 3$  with  $m_1 = m_2 = 1, m_3 \geq 2$ . Under the data of Theorem 2.10, we have,*

$$v_{n-p}^{(r-1)} = \frac{\lambda_1^{-p}}{(\lambda_1 - \lambda_2)(\lambda_1 - \lambda_3)^{m_3}} \lambda_1^n + \frac{\lambda_2^{-p}}{(\lambda_2 - \lambda_1)(\lambda_2 - \lambda_3)^{m_3}} \lambda_2^n + \Omega_3(n),$$

for  $n - p \geq r$ , with  $1 \leq p \leq r - 2$ , where  $\Omega_3(n) = \frac{\lambda_3^{-p}}{(m_3 - 1)!} \sum_{k=0}^{m_3-1} \left( \sum_{h=k}^{m_3-1} \gamma_3(h, k) \right) n^k \lambda_3^n,$

$$\gamma_3(h, k) = (-1)^{h-k} \binom{h}{k} \Delta_{3,h}^{(r)} p^{h-k}, \text{ with } \Delta_{3,h}^{(r)} = \sum_{d=h}^{m_3-1} s(d, h) \binom{m_3-1}{d} H_3^{(m_3-d-1)}(\lambda_3) \lambda_3^{-d} \text{ and}$$

$$H_3(x) = \frac{1}{\prod_{k=1}^2 (x - \lambda_k)}, \text{ such that the } H_i^{(k)}(x) \text{ are as in (20).}$$

### 3. CONSTRUCTION OF THE INVERSE OF GENERALIZED VANDERMONDE MATRIX VIA THE ANALYTIC FORMULA (5)

We have exhibited the close relation between the analytical form of sequences (3) and the generalized Vandermonde systems, through the equivalence of the two generalized Vandermonde systems (2) and (6). This section is devoted to the process of constructing the inverse of the generalized Vandermonde matrix, using the analytic formula (5) of the elements  $\{v_n^{(p)}\}_{n \geq 0}$  of the fundamental systems (7).

We first introduce some useful notations, allowing us to introduce the generalized Vandermonde matrix and to study its inverse. Let  $\mathbb{C}$ -vector space of the polynomials  $\mathbb{C}[z]$ ,

and consider the derivation degree  $Dp(z) = z \frac{dp}{dz}(z)$ . Let  $p_0, p_1, \dots, p_{r-1}$  be in  $\mathbb{C}[z]$  and  $f : \mathbb{C} \rightarrow \mathbb{C}^r$ , the valued vector function defined by,

$$f(z) = (p_0(z), p_1(z), \dots, p_{r-1}(z))^T,$$

where  $(\gamma_0, \gamma_1, \dots, \gamma_{r-1})^T$  denotes a vector column. We extend the derivation degree to the preceding vector function as follows,

$$Df(z) = (Dp_0(z), Dp_1(z), \dots, Dp_{r-1}(z))^T.$$

More generally, we have  $D^{(k)}f(z) = (D^{(k)}p_0(z), D^{(k)}p_1(z), \dots, D^{(k)}p_{r-1}(z))^T$ , for every  $k \geq 0$ , where  $D^{(0)} = 1_d$ ,  $D^{(1)} = D$ , ...,  $D^{(k)} = D \circ \dots \circ D$ ,  $k$  times, for  $k \geq 2$ .

Let  $\lambda_1, \dots, \lambda_s$  be non-zero distinct  $s$  complex or real numbers, and  $s$  integers  $m_1, \dots, m_s$ , with  $r = m_1 + \dots + m_s$ . Let  $C : \mathbb{C} \rightarrow \mathbb{C}^r$  be the valued vector function defined by,

$$C(z) = (1, z, \dots, z^{r-1})^T, \text{ where } z \in \mathbb{C}.$$

For every  $k \geq 0$ , we consider the family of vector columns,

$$\begin{cases} c_i = C(\lambda_i) = (1, \lambda_i, \lambda_i^2, \dots, \lambda_i^{r-1})^T \text{ for } k = 0 \\ c_i^{(k)} = D^{(k)}C(\lambda_i) = (0, \lambda_i, 2^k \lambda_i^2, \dots, (r-1)^k \lambda_i^{r-1})^T \text{ for } k \geq 1. \end{cases} \quad (23)$$

The *generalized Vandermonde matrix* of order  $r$  associated to the preceding family of vectors column (23), is given by,

$$\mathbb{V} = [c_1, c_1^{(1)}, \dots, c_1^{(m_1-1)}, \dots, c_s, c_s^{(1)}, \dots, c_s^{(m_s-1)}], \quad (24)$$

According to [9], we have,

$$\det \mathbb{V} = \left( \prod_{i=1}^s \lambda_i^{m_i(m_i-1)/2} \right) \left( \prod_{i=1}^s [0!1! \dots (m_i-1)!] \right) \left( \prod_{j>i} (\lambda_j - \lambda_i)^{m_j m_i} \right).$$

This expression shows that  $\det \mathbb{V} \neq 0$ , because each  $\lambda_i \neq 0$ . Then, the generalized Vandermonde matrix  $\mathbb{V}$  has inverse  $\mathbb{V}^{-1}$ .

Let built the process of the inversion of the generalized Vandermonde matrix (24), by utilizing the analytic formula (5) of the sequences of the fundamental system (7). For reason of clarity and conciseness, let consider the following useful notations of the two vectors column,

$$\mathbb{B} = (\beta_{1,0}, \dots, \beta_{1,m_1-1}, \dots, \beta_{s,0}, \dots, \beta_{s,m_s-1})^T \text{ and } \Delta = (\alpha_0, \alpha_1, \dots, \alpha_{r-1})^T,$$

where the  $\beta_{i,j}$  ( $1 \leq i \leq s, 0 \leq j \leq m_i - 1$ ) are the scalars of the analytic formula (5) and  $\alpha_0, \alpha_1, \dots, \alpha_{r-1}$  are the initial data given of sequence (3). Therefore, the linear system (5) can be written under the matrix equation,

$$\mathbb{V} \cdot \mathbb{B} = \Delta. \quad (25)$$

Since the generalized Vandermonde matrix  $\mathbb{V}$  is invertible, we derive,

$$\mathbb{B} = \mathbb{V}^{-1} \cdot \Delta.$$

For every  $p, n = 0, \dots, r-1$ , we set  $\Delta_p = (0, \dots, 0, 1, 0, \dots, 0)^T$  where 1 is located at the  $(p+1)$ -th position, or equivalently  $\Delta_p = (\alpha_0, \alpha_1, \dots, \alpha_{r-1})^T$ , with  $\alpha_n = \delta_{p,n}$ . Then, the

$(p+1)$ -column of the inverse  $\mathbb{V}^{-1}$ , of the generalized Vandermonde matrix (24) is given by,

$$\mathbb{V}_{p+1}^{(-1)} = \mathbb{V}^{-1} \cdot \Delta_p \quad (26)$$

Furthermore, the scalar components of this column vector  $\mathbb{V}_{p+1}^{(-1)}$  are the solution of the linear system (5), defining the analytic formula of the linear recursive sequence (7), whose initial conditions are the entries of vector column  $\Delta_p$ . More precisely, for the sequence  $\{v_n^{(p)}\}_{n \geq 0}$ , defined as in (7), and whose initial conditions are the entries of the column vector  $\Delta_p$ , the analytic formula is,

$$v_n^{(p)} = \sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} \beta_{i,j}^{(p)} n^j \right) \lambda_i^n.$$

And by considering the vector column,

$$\mathbb{B}^{(p)} = (\beta_{1,0}^{(p)}, \dots, \beta_{1,m_1-1}^{(p)}, \dots, \beta_{s,0}^{(p)}, \dots, \beta_{s,m_s-1}^{(p)})^T,$$

we show that Expression (26) implies that the  $(p+1)$ -th column, of the matrix  $\mathbb{V}^{-1}$  inverse of the generalized Vandermonde matrix, is given by,

$$\mathbb{V}_{p+1}^{(-1)} = \mathbb{B}^{(p)} = (\beta_{1,0}^{(p)}, \dots, \beta_{1,m_1-1}^{(p)}, \dots, \beta_{s,0}^{(p)}, \dots, \beta_{s,m_s-1}^{(p)})^T$$

Therefore, the analytic formulas of the sequences  $\{v_n^{(p)}\}_{n \geq 0}$  ( $0 \leq p \leq r-1$ ), defined as in (7), provides us the columns of the inverse of generalized Vandermonde matrix  $\mathbb{V}$  given as in (24). In summary, we formulate the following fundamental result.

**Theorem 3.1.** *Let  $\mathbb{V}$  be the generalized Vandermonde matrix (24), related to the linear system (5), through the matrix Equation (25), namely,  $\mathbb{V} \cdot \mathbb{B} = \Delta$ , where  $\mathbb{B}$  is the vector column  $\mathbb{B} = (\beta_{1,0}, \dots, \beta_{1,m_1-1}, \dots, \beta_{s,0}, \dots, \beta_{s,m_s-1})^T$  obtained from the analytic expression (5) and  $\Delta = (\alpha_0, \alpha_1, \dots, \alpha_{r-1})^T$  is the vector related to the initial conditions of the sequence (3). Then, the inverse of the generalized Vandermonde matrix is given by,*

$$\mathbb{V}^{-1} = [\mathbb{B}^{(0)}, \mathbb{B}^{(1)}, \dots, \mathbb{B}^{(r-1)}],$$

where  $\mathbb{B}^{(p)} = (\beta_{1,0}^{(p)}, \dots, \beta_{1,m_1-1}^{(p)}, \dots, \beta_{s,0}^{(p)}, \dots, \beta_{s,m_s-1}^{(p)})^T$  is the vector column  $\mathbb{V}_{p+1}^{(-1)} = \mathbb{V}^{-1} \cdot \Delta_p$ , with  $\Delta_p = (\alpha_0, \alpha_1, \dots, \alpha_{r-1})^T$  with  $\alpha_n = \delta_{p,n}$ , namely,  $\mathbb{B}^{(p)} = \mathbb{V}_{p+1}^{(-1)} = \mathbb{V}^{-1} \cdot \Delta_p$ .

Taking into account Theorem 2.2 and Theorem 3.1, as well as the results of Section 2, concerning the explicit analytic form the dynamic solution  $v_n^{(r-1)}$ , we will give an explicit form of the vector column  $\mathbb{B}^{(p)}$ . Thus, we can establish an explicit form of  $\mathbb{V}^{-1}$  the inverse of the Vandermonde matrix  $\mathbb{V}$ .

In order to better grasp our process, let consider the special case of  $s = 2$ . Suppose that the characteristic polynomial of the sequence (3) is given by  $P(z) = (z - \lambda_1)^{m_1}(z - \lambda_2)^{m_2}$ , for the sake of generality we take  $m_1, m_2 \geq 2$ . First, the related generalized Vandermonde matrix of order  $r = m_1 + m_2$ , is given by,

$$\mathbb{V} = [c_1, c_1^{(1)}, \dots, c_1^{(m_1-1)}, c_2, c_2^{(1)}, \dots, c_2^{(m_2-1)}], \quad (27)$$



where the  $c_i$  ( $i = 1, 2$ ),  $c_1^{(k)}$  ( $1 \leq k \leq m_1 - 1$ ) and  $c_2^{(k)}$  ( $1 \leq k \leq m_2 - 1$ ) are defined as in Expressions (23).

Second, the analytic expression of each element  $\{v_n^{(p)}\}_{n \geq 0}$ , where  $0 \leq p \leq r - 1$ , of the associated fundamental system (7), can be written under the form,

$$v_n^{(p)} = \left( \sum_{j=0}^{m_1-1} \beta_{1,j}^{(p)} n^j \right) \lambda_1^n + \left( \sum_{j=0}^{m_2-1} \beta_{2,j}^{(p)} n^j \right) \lambda_2^n, \text{ for every } n \geq 0.$$

Third, the associated column vectors  $\mathbb{B}^{(p)}$ , where  $0 \leq p \leq r - 1$ , related to the former analytic formula of  $\{v_n^{(p)}\}_{n \geq 0}$ , are given by,

$$\mathbb{B}^{(p)} = (\beta_{1,0}^{(p)}, \dots, \beta_{1,m_1-1}^{(p)}, \beta_{2,0}^{(p)}, \dots, \beta_{2,m_2-1}^{(p)})^T. \quad (28)$$

In summary, we have the proposition.

**Proposition 3.2.** *Under the preceding data, the inverse of the generalized Vandermonde matrix (27) is given by,*

$$\mathbb{V}^{-1} = [\mathbb{B}^{(0)}, \mathbb{B}^{(1)}, \dots, \mathbb{B}^{(r-1)}],$$

where the  $\mathbb{B}^{(p)}$  are as (28).

The previous fourth steps investigated to exemplify the preceding special case  $s = 2$ , allow us to formulate the following general algorithm for constructing the inverse of the generalized Vandermonde matrix,

**Step 1. The generalized Vandermonde matrix.** Let  $\lambda_1, \dots, \lambda_s$  be in  $\mathbb{K}$  ( $\mathbb{K} = \mathbb{R}$  or  $\mathbb{C}$ ), and the integer  $m_1, \dots, m_s \geq 1$  and set  $r = m_1 + \dots + m_s$ . The associated generalized Vandermonde matrix of order  $r$ , is given by,

$$\mathbb{V} = [c_1, c_1^{(1)}, \dots, c_1^{(m_1-1)}, \dots, c_s, c_s^{(1)}, \dots, c_s^{(m_s-1)}],$$

where the  $c_i$  ( $1 \leq i \leq s$ ) and  $c_i^{(k)}$  ( $1 \leq i \leq s, 1 \leq k \leq m_i - 1$ ) are the vector columns defined by (23).

**Step 2. Analytic form of the associated fundamental system.** Let  $\{v_n^{(p)}\}_{n \geq 0}$  ( $0 \leq p \leq r - 1$ ) be the fundamental system (7), whose characteristic polynomial is  $P(z) = \prod_{i=1}^s (z - \lambda_i)^{m_i} = z^r - a_0 z^{r-1} - \dots - a_{r-1}$ . Suppose that, for each  $p$  ( $0 \leq p \leq r - 1$ ) the analytic formula of  $\{v_n^{(p)}\}_{n \geq 0}$  is computed under the form  $v_n^{(p)} = \sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} \beta_{i,j}^{(p)} n^j \right) \lambda_i^n$ .

**Step 3. Vectors column of  $\mathbb{V}^{-1}$ .** For each  $p$  ( $0 \leq p \leq r - 1$ ), we consider the vectors column  $\mathbb{B}^{(p)} = (\beta_{1,0}^{(p)}, \dots, \beta_{1,m_1-1}^{(p)}, \dots, \beta_{s,0}^{(p)}, \dots, \beta_{s,m_s-1}^{(p)})^T$ .

**Step 4. The inverse of the generalized Vandermonde matrix  $\mathbb{V}$ .** The matrix  $\mathbb{V}^{-1}$  is given by  $\mathbb{V}^{-1} = [\mathbb{B}^{(0)}, \mathbb{B}^{(1)}, \dots, \mathbb{B}^{(r-1)}]$ .

**Special case:**  $r = 3$  and  $s = 2$ . Let  $\lambda_1, \lambda_2$  be in  $\mathbb{K}$  and the integers  $m_1 = 1, m_2 = 2$ . Hence, we have  $r = m_1 + m_2 = 3$ . In this case, we have  $c_1 = (1, \lambda_1, \lambda_1^2)^T$ ,  $c_2 = (1, \lambda_2, \lambda_2^2)^T$  and  $c_2^{(1)} = (0, \lambda_2, 2\lambda_2^2)^T$ . Therefore, the associated generalized Vandermonde matrix is,

$$\mathbb{V} = \begin{bmatrix} 1 & 1 & 0 \\ \lambda_1 & \lambda_2 & \lambda_2 \\ \lambda_1^2 & \lambda_2^2 & 2\lambda_2^2 \end{bmatrix}.$$

The characteristic polynomial associated to  $\mathbb{V}$  is given by

$$P(z) = (z - \lambda_1)(z - \lambda_2)^2 = z^3 - a_0z^2 - a_1z - a_2.$$

Let  $\{v_n^{(p)}\}_{n \geq 0}$  ( $0 \leq p \leq 2$ ) be the fundamental system (7) related to the recursive relation  $v_n = a_0v_{n-1} + a_1v_{n-2} + a_2v_{n-3}$ , for  $n \geq 3$ . Suppose that the analytic formula of each  $\{v_n^{(p)}\}_{n \geq 0}$  is given by,  $v_n^{(p)} = \sum_{i=1}^2 \left( \sum_{j=0}^{m_i-1} \beta_{i,j}^{(p)} n^j \right) \lambda_i^n$ . Then, the inverse  $\mathbb{V}^{-1}$  of the matrix  $\mathbb{V}$  is as follows,

$$\mathbb{V}^{-1} = \begin{bmatrix} \beta_{1,0}^{(0)} & \beta_{1,0}^{(1)} & \beta_{1,0}^{(2)} \\ \beta_{2,0}^{(0)} & \beta_{2,0}^{(1)} & \beta_{2,0}^{(2)} \\ \beta_{2,1}^{(0)} & \beta_{2,1}^{(1)} & \beta_{2,1}^{(2)} \end{bmatrix}. \quad (29)$$

#### 4. THE EXPLICIT ANALYTIC FORMULA FOR THE INVERSE OF THE GENERALIZED VANDERMONDE MATRIX

**4.1. First approach.** The first approach of the dynamic solution of Subsection 2.2, allows us to exhibit explicit formulas for the entries of the inverse of the generalized Vandermonde matrix, using Propositions 2.5, 2.6 and Theorem 3.1. To reach our goal, we consider the following lemma, derived from Expression (8).

**Lemma 4.1.** Let  $\{v_n^{(p)}\}_{n \geq 0}$  ( $p = 0, \dots, r-2$ ) be the sequence of the fundamental system (7). Then, we have  $v_n^{(p)} = \sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} \beta_{i,j}^{(p)} n^j \right) \lambda_i^n$ , for every  $n \geq 0$ , where the  $\beta_{i,j}^{(p)}$  are written under the form,

$$\beta_{i,j}^{(p)} = a_{r-p-1}C_{i,j}^{(1)} + a_{r-p}C_{i,j}^{(2)} + \dots + a_{r-1}C_{i,j}^{(p+1)}, \quad (30)$$

such that the  $C_{i,j}^{(k)}$  are given as in (11).

Theorem 2.2 implies that  $v_n^{(p)} = a_{r-p-1}v_{n-1}^{(r-1)} + a_{r-p}v_{n-2}^{(r-1)} + \dots + a_{r-1}v_{n-p-1}^{(r-1)}$ , moreover, Proposition 2.6 shows that  $v_{n-k}^{(r-1)} = \sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} C_{i,j}^{(k)} n^j \right) \lambda_i^n$ , for  $1 \leq k \leq p+1$ , where the  $C_{i,j}^{(k)}$  are given as in (11). Therefore, we obtain,

$$v_n^{(p)} = \sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} \left( a_{r-p-1}C_{i,j}^{(1)} + a_{r-p}C_{i,j}^{(2)} + \dots + a_{r-1}C_{i,j}^{(p+1)} \right) n^j \right) \lambda_i^n,$$

for every  $p = 0, \dots, r-2$ . Hence, the result follows.  $\square$

By means of Theorem 3.1 and Lemma 4.1, we can exhibit the first result concerning the explicit expressions for the entries of the inverse of a generalized Vandermonde matrix.

**Theorem 4.2. Inverse of the generalized Vandermonde matrix**  $\mathbb{V}$ . Let  $\lambda_1, \dots, \lambda_s$  be non-zero distinct  $s$  real (or complex) numbers and  $s$  integers  $m_1, \dots, m_s$ . Let  $\mathbb{V}$  be the associated generalized Vandermonde matrix (24) of order  $r = m_1 + \dots + m_s$ . Then, the inverse  $\mathbb{V}^{-1}$  of the matrix  $\mathbb{V}$ , is given by,

$$\mathbb{V}^{-1} = [\mathbb{B}^{(0)}, \mathbb{B}^{(1)}, \dots, \mathbb{B}^{(r-1)}],$$

such that  $\mathbb{B}^{(p)} = (\beta_{1,0}^{(p)}, \dots, \beta_{1,m_1-1}^{(p)}, \dots, \beta_{s,0}^{(p)}, \dots, \beta_{s,m_s-1}^{(p)})^T$  ( $0 \leq p \leq r-1$ ), namely, the explicit formulas for the entries  $b_{uv}$  ( $u, v = 1, \dots, r$ ) of  $\mathbb{V}^{-1} = [b_{uv}]_{1 \leq u, v \leq r}$  are as follows,

$$b_{uv} = \begin{cases} \beta_{1,u-1}^{(v-1)}, & \text{for } 1 \leq u \leq m_1 \\ \beta_{2,u-(m_1+1)}^{(v-1)}, & \text{for } m_1 + 1 \leq u \leq m_1 + m_2 \\ \vdots \\ \beta_{s,u-(m_1+m_2+\dots+m_{s-1}+1)}^{(v-1)}, & \text{for } m_1 + m_2 + \dots + m_{s-1} + 1 \leq u \leq m_1 + m_2 + \dots + m_s \end{cases}$$

where the  $\beta_{i,j}^{(r-1)}$  are as in Expressions (9)-(10) and the  $\beta_{i,j}^{(p)}$  ( $p = 0, \dots, r-2$ ) are as in Expressions (30), with the  $C_{i,j}^{(k)}$  are given by (11).

For illustrating the result the former Theorem 4.2, we consider the following special case.

**Special case:  $r = 3$  and  $s = 2$ .** Let  $\lambda_1, \lambda_2$  be in two distinct complex numbers and the two integer  $m_1 = 1, m_2 = 2$ . Let  $\mathbb{V} = [c_1, c_2, c_2^{(1)}]$  be the associated generalized Vandermonde matrix of order  $r = m_1 + m_2 = 3$  defined by (23)-(24). Let consider the polynomial of degree 3 is given by,

$$P(z) = (z - \lambda_1)(z - \lambda_2)^2 = z^3 - (2\lambda_2 + \lambda_1)z^2 + (\lambda_2^2 + 2\lambda_1\lambda_2)z - \lambda_1\lambda_2^2.$$

Thus, we have  $P(z) = z^3 - a_0z^2 - a_1z - a_2$ , with  $a_0 = 2\lambda_2 + \lambda_1$ ,  $a_1 = -(\lambda_2^2 + 2\lambda_1\lambda_2)$  and  $a_2 = \lambda_1\lambda_2^2$ . Let calculate the entries of  $\mathbb{V}^{-1}$  the inverse of the generalized Vandermonde matrix  $\mathbb{V}$ . Taking into account  $s(0,0) = s(1,1) = 1$  and  $s(1,0) = 0$  and Equation (10) it follows

$$\beta_{1,0}^{(2)} = \gamma_0^{[1]}(\lambda_1, \lambda_2), \quad \beta_{2,0}^{(2)} = \gamma_0^{[2]}(\lambda_1, \lambda_2) \quad \text{e} \quad \beta_{2,1}^{(2)} = \frac{1}{\lambda_2} \gamma_1^{[2]}(\lambda_1, \lambda_2)$$

And, using the formula (9) we derive the  $\gamma_0^{[1]}(\lambda_1, \lambda_2) = \frac{1}{(\lambda_2 - \lambda_1)^2}$ ,  $\gamma_0^{[2]}(\lambda_1, \lambda_2) = \frac{-1}{(\lambda_1 - \lambda_2)^2}$  and  $\gamma_1^{[2]}(\lambda_1, \lambda_2) = \frac{-1}{\lambda_1 - \lambda_2}$ . Therefore, we reach the formulas,

$$\beta_{1,0}^{(2)} = \frac{1}{(\lambda_2 - \lambda_1)^2}, \quad \beta_{2,0}^{(2)} = \frac{-1}{(\lambda_2 - \lambda_1)^2} \quad \text{and} \quad \beta_{2,1}^{(2)} = \frac{-1}{(\lambda_1 - \lambda_2)\lambda_2}.$$

Equation (30) shows that  $\beta_{i,j}^{(1)} = a_1 C_{i,j}^{(1)} + a_2 C_{i,j}^{(2)}$  and  $\beta_{i,j}^{(0)} = a_2 C_{i,j}^{(1)}$ . Since  $a_1 = -(\lambda_2^2 + 2\lambda_1\lambda_2)$  and  $a_2 = \lambda_1\lambda_2^2$ , then, a direct computation, applying the formula (11), allows us to establish,

$$\beta_{1,0}^{(1)} = \frac{-2\lambda_2}{(\lambda_2 - \lambda_1)^2}, \quad \beta_{2,0}^{(1)} = \frac{2\lambda_2}{(\lambda_2 - \lambda_1)^2}, \quad \beta_{2,1}^{(1)} = \frac{\lambda_2 + \lambda_1}{\lambda_2(\lambda_1 - \lambda_2)},$$

$$\beta_{1,0}^{(0)} = \frac{\lambda_2^2}{(\lambda_2 - \lambda_1)^2}, \quad \beta_{2,0}^{(0)} = \frac{-2\lambda_1\lambda_2 + \lambda_1^2}{(\lambda_1 - \lambda_2)^2}, \quad \beta_{2,1}^{(0)} = \frac{-\lambda_1}{\lambda_1 - \lambda_2}$$

Therefore, using the expression (29), we derive that the inverse  $\mathbb{V}^{-1}$  of  $\mathbb{V} = [c_1, c_2, c_2^{(1)}]$ , is as follows,

$$\mathbb{V}^{-1} = \begin{bmatrix} \frac{\lambda_2^2}{(\lambda_2 - \lambda_1)^2} & \frac{-2\lambda_2}{(\lambda_2 - \lambda_1)^2} & \frac{1}{(\lambda_2 - \lambda_1)^2} \\ \frac{-2\lambda_1\lambda_2 + \lambda_1^2}{(\lambda_2 - \lambda_1)^2} & \frac{2\lambda_2}{(\lambda_2 - \lambda_1)^2} & \frac{-1}{(\lambda_2 - \lambda_1)^2} \\ \frac{-\lambda_1}{\lambda_1 - \lambda_2} & \frac{\lambda_2 + \lambda_1}{\lambda_2(\lambda_1 - \lambda_2)} & \frac{-1}{\lambda_2(\lambda_1 - \lambda_2)} \end{bmatrix}.$$

**4.2. Second approach.** Let consider the second approach of the dynamic solution of Subsection 2.3, for establishing the inverse of the generalized Vandermonde matrix, using results of Theorems 2.9, 2.10 and Theorem 3.1. To reach our goal, let consider the following theorem, derived from Expression (8).

In order to identify the explicit formulas of the entries of the inverse matrix of a generalized Vandermonde matrix (24), let recall hereafter, the result of Theorem 2.9 concerning the dynamic solution (21), which can be adequate for its application in this subsection.

**Lemma 4.3.** *The expression of the dynamic solution  $v_n^{(r-1)}$  is given by the following formula,*

$$v_n^{(r-1)} = \sum_{i=1}^s \left( \sum_{h=0}^{m_i-1} \hat{\beta}_{i,h}^{(r-1)} n^h \right) \lambda_i^n, \text{ for every } n \geq r, \text{ where}$$

$$\hat{\beta}_{i,h}^{(r-1)} = \frac{1}{(m_i - 1)!} \sum_{d=h}^{m_i-1} s(d, h) \binom{m_i - 1}{d} H_i^{(m_i-d-1)}(\lambda_i) \lambda_i^{-d}, \quad (31)$$

$s(d, h)$  are the Stirling number of the first kind and  $H_i^{(m_i-d-1)}(\lambda_i)$  are as in (20).

Moreover, as we will make use of the formula (8), we have also the following property.

**Proposition 4.4.** *For  $d = 1, \dots, r - 1$ , we have  $v_{n-d}^{(r-1)} = \sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} \hat{C}_{i,j}^{(d)} n^j \right) \lambda_i^n$ , for every  $n \geq r$ , where*

$$\hat{C}_{i,j}^{(d)} = \lambda_i^{-d} \sum_{k=j}^{m_i-1} (-1)^{k-j} \hat{\beta}_{i,k}^{(r-1)} \binom{k}{j} d^{k-j} \quad (32)$$

such that the  $\hat{\beta}_{i,k}^{(r-1)}$  are as in (31).

In the aim to utilize Theorem 3.1 for constructing the inverse of the generalized Vandermonde matrix (24), let now consider the following lemma, derived from Expression (8).

**Lemma 4.5.** *Let  $\{v_n^{(p)}\}_{n \geq 0}$  ( $p = 0, \dots, r - 2$ ) be the sequence of the fundamental system (7).*

*Then, for every  $n \geq r$ , we have  $v_n^{(p)} = \sum_{i=1}^s \left( \sum_{j=0}^{m_i-1} \hat{\beta}_{i,j}^{(p)} n^j \right) \lambda_i^n$ , such that  $\hat{\beta}_{i,j}^{(p)}$  are written under the form,*

$$\hat{\beta}_{i,j}^{(p)} = a_{r-p-1} \hat{C}_{i,j}^{(1)} + a_{r-p} \hat{C}_{i,j}^{(2)} + \dots + a_{r-1} \hat{C}_{i,j}^{(p+1)}, \quad (33)$$

where the  $\hat{C}_{i,j}^{(d)}$  are given as in (32).

As a result of the above data, we get the following result regarding the explicit formula for the entries of the inverse of the generalized Vandermonde matrix.

**Theorem 4.6. Inverse of  $\mathbb{V}$ .** Let  $\lambda_1, \dots, \lambda_s$  be non-zero distinct  $s$  complex or real numbers, and  $s$  integers  $m_1, \dots, m_s$ . Let  $\mathbb{V}$  be the associated generalized Vandermonde matrix of order  $r = m_1 + \dots + m_s$ , thus we have

$$\mathbb{V}^{-1} = [\hat{\mathbb{B}}^{(0)}, \hat{\mathbb{B}}^{(1)}, \dots, \hat{\mathbb{B}}^{(r-1)}],$$

such that  $\hat{\mathbb{B}}^{(p)} = (\hat{\beta}_{1,0}^{(p)}, \dots, \hat{\beta}_{1,m_1-1}^{(p)}, \dots, \hat{\beta}_{s,0}^{(p)}, \dots, \hat{\beta}_{s,m_s-1}^{(p)})^T$ , where the  $\hat{\beta}_{i,j}^{(r-1)}$  are given Expressions (31), with  $H_i^{(m_i-d-1)}(\lambda_i)$  are as in (20), and the  $\hat{\beta}_{i,j}^{(p)}$  ( $p = 0, \dots, r-2$ ) are given by Expressions (33), with the  $\hat{C}_{i,j}^{(d)}$  are as in (32). More precisely, the explicit formulas of the entries  $\hat{b}_{uv}$  ( $u, v = 1, \dots, r$ ) of  $\mathbb{V}^{-1} = [\hat{b}_{uv}]_{1 \leq u, v \leq r}$  are as follows,

$$\hat{b}_{uv} = \begin{cases} \hat{\beta}_{1,u-1}^{(v-1)}, & \text{for } 1 \leq u \leq m_1 \\ \hat{\beta}_{2,u-(m_1+1)}^{(v-1)}, & \text{for } m_1 + 1 \leq u \leq m_1 + m_2 \\ \vdots \\ \hat{\beta}_{s,u-(m_1+m_2+\dots+m_{s-1}+1)}^{(v-1)}, & \text{for } m_1 + m_2 + \dots + m_{s-1} + 1 \leq u \leq m_1 + m_2 + \dots + m_s \end{cases}$$

where the  $\hat{\beta}_{i,j}^{(r-1)}$  are given Expressions (31), with  $H_i^{(m_i-d-1)}(\lambda_i)$  are as in (20) and  $\hat{\beta}_{i,j}^{(p)}$  ( $p = 0, \dots, r-2$ ) are given by Expressions (33), with the  $\hat{C}_{i,j}^{(d)}$  are as in (32).

In order to better understand the general case of Theorem 4.6, we present below, a significant special case.

**Special case:**  $r = 4$  and  $s = m_1 = m_2 = 2$ . Let  $\lambda_1, \lambda_2$  be in two distinct complex numbers and the two integer  $m_1 = 2, m_2 = 2$ . Let  $\mathbb{V} = [c_1, c_1^{(1)}, c_2, c_2^{(1)}]$  be the associated generalized Vandermonde matrix of order  $r = m_1 + m_2 = 4$  defined by (23)-(24), namely,

$$\mathbb{V} = \begin{bmatrix} 1 & 0 & 1 & 0 \\ \lambda_1 & \lambda_1 & \lambda_2 & \lambda_2 \\ \lambda_1^2 & 2\lambda_1^2 & \lambda_2^2 & 2\lambda_2^2 \\ \lambda_1^3 & 3\lambda_1^3 & \lambda_2^3 & 3\lambda_2^3 \end{bmatrix}.$$

Consider the polynomial of degree 4 given by,

$$P(z) = (z - \lambda_1)^2(z - \lambda_2)^2 = z^4 - a_0z^3 - a_1z^2 - a_2z - a_3$$

where  $a_0 = 2(\lambda_1 + \lambda_2)$ ,  $a_1 = -(\lambda_2^2 + 4\lambda_1\lambda_2 + \lambda_1^2)$ ,  $a_2 = 2(\lambda_2^2\lambda_1 + \lambda_1^2\lambda_2)$  and  $a_3 = -(\lambda_1^2\lambda_2^2)$ . Using result of the special case illustrating Theorem 2.9, we have,

$$\hat{\beta}_{1,0}^{(3)} = \frac{-2\lambda_1\lambda_2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{1,1}^{(3)} = \frac{\lambda_1\lambda_2 - \lambda_2^2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{2,0}^{(3)} = \frac{2\lambda_1\lambda_2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{2,1}^{(3)} = \frac{\lambda_1^2 - \lambda_1\lambda_2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}.$$

From Equation (32) and Equation (33), and because  $a_1 = -(\lambda_2^2 + 4\lambda_1\lambda_2 + \lambda_1^2)$ ,  $a_2 = 2(\lambda_2^2\lambda_1 + \lambda_1^2\lambda_2)$  and  $a_3 = -(\lambda_1^2\lambda_2^2)$ , a direct computation shows that,

$$\hat{\beta}_{1,0}^{(0)} = \frac{3\lambda_1^2\lambda_2^3 - \lambda_1\lambda_2^4}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{1,1}^{(0)} = \frac{-\lambda_1^2\lambda_2^3 + \lambda_1\lambda_2^4}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{2,0}^{(0)} = \frac{-3\lambda_1^3\lambda_2^2 + \lambda_1^4\lambda_2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2};$$



$$\begin{aligned}\hat{\beta}_{2,1}^{(0)} &= \frac{-\lambda_1^4\lambda_2 + \lambda_1^3\lambda_2^2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{1,0}^{(1)} = \frac{-6\lambda_1^2\lambda_2^2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{1,1}^{(1)} = \frac{-\lambda_1\lambda_2^3 + 2\lambda_1^2\lambda_2^2 - \lambda_2^4}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \\ \hat{\beta}_{2,0}^{(1)} &= \frac{6\lambda_1^2\lambda_2^2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{2,1}^{(1)} = \frac{\lambda_1^3\lambda_2 - 2\lambda_1^2\lambda_2^2 + \lambda_1^4}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{1,0}^{(2)} = \frac{3\lambda_1\lambda_2^2 + 3\lambda_1^2\lambda_2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \\ \hat{\beta}_{1,1}^{(2)} &= \frac{-\lambda_1\lambda_2^2 + 2\lambda_2^3 - \lambda_1^2\lambda_2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{2,0}^{(2)} = \frac{-3\lambda_1\lambda_2^2 - 3\lambda_1^2\lambda_2}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}; \hat{\beta}_{2,1}^{(2)} = \frac{\lambda_1^2\lambda_2 + \lambda_1\lambda_2^2 - 2\lambda_1^3}{(\lambda_1 - \lambda_2)^3\lambda_1\lambda_2}\end{aligned}$$

Therefore, using Theorem 3.1, we derive that  $\mathbb{V}^{-1}$  the inverse of  $\mathbb{V} = [c_1, c_1^{(1)}, c_2, c_2^{(1)}]$ , is as follows,

$$\mathbb{V}^{-1} = \frac{1}{K} \begin{bmatrix} 3\lambda_1^2\lambda_2^3 - \lambda_1\lambda_2^4 & -6\lambda_1^2\lambda_2^2 & 3\lambda_1\lambda_2^2 + 3\lambda_1^2\lambda_2 & -2\lambda_1\lambda_2 \\ -\lambda_1^2\lambda_2^3 + \lambda_1\lambda_2^4 & -\lambda_1\lambda_2^3 + 2\lambda_1^2\lambda_2^2 - \lambda_2^4 & -\lambda_1\lambda_2^2 + 2\lambda_2^3 - \lambda_1^2\lambda_2 & \lambda_1\lambda_2 - \lambda_2^2 \\ -3\lambda_1^3\lambda_2^2 + \lambda_1^4\lambda_2 & 6\lambda_1^2\lambda_2^2 & -3\lambda_1\lambda_2^2 - 3\lambda_1^2\lambda_2 & 2\lambda_1\lambda_2 \\ -\lambda_1^4\lambda_2 + \lambda_1^3\lambda_2^2 & \lambda_1^3\lambda_2 - 2\lambda_1^2\lambda_2^2 + \lambda_1^4 & \lambda_1^2\lambda_2 + \lambda_1\lambda_2^2 - 2\lambda_1^3 & \lambda_1^2 - \lambda_1\lambda_2 \end{bmatrix},$$

where  $K = (\lambda_1 - \lambda_2)^3\lambda_1\lambda_2$ .

## 5. ANALYZE AND DISCUSSION

In view of their numerous applications, the usual Vandermonde systems and generalized Vandermonde systems, have been largely studied in the literature (see for example [6, 7, 10, 15, 17, 20] and references therein). In order to resolve them, the topic of the inverse of associated Vandermonde and generalized Vandermonde matrices continues to attract a lot of attention, and has been the subject of numerous research papers. Therefore, various approaches have been implanted for succeeding this inversion (see for example [2, 7, 11, 15, 16, 18, 20] and references therein). Especially, the technique of *LU* factorization of matrix (see [12, 15, 19]), has been examined in [12], for inverting the generalized Vandermonde matrices.

In our study, we have exploited the fact the resolution of the Vandermonde and generalized Vandermonde systems (1)-(2), is linked to the determination of the analytical formula (5) of the linear recursive sequences (3). Recently, such important relation has been exploited in [2] to develop a method for inverting the Vandermonde and generalized Vandermonde matrices. More precisely, Expression (13) from [2, Theorem 2.9] has been utilized in the aim to establish some explicit formulas of the  $\beta_{i,j}$  (see [2, Proposition 4.1]).

Regarding our results, we approached the inversion of the generalized Vandermonde matrix via the computation of the scalars  $\beta_{i,j}$  or  $\hat{\beta}_{i,j}$  ( $1 \leq i \leq s$ ,  $0 \leq j \leq m_i - 1$ ), by considering other explicit formulas for analytical expressions of the linear recursive sequences (3), and through another approach based on properties of linear algebra. More precisely, such explicit analytical expressions are applied to the fundamental system (7), which makes it possible to construct the vectors columns of the inverse of the generalized Vandermonde matrix  $\mathbb{V}^{-1}$ . This represents a new procedure, in the algorithmic construction of the matrix  $\mathbb{V}^{-1}$ , using Theorem 3.1. It is important to specify that, when all the roots of the polynomial  $P(z) = z^r - a_0z^{r-1} - \dots - a_{r-1}$  are simple Expression (16) and (22), permit to exhibit the inverse of generalized usual Vandermonde matrix as shown in [2, Theorem 3.3]. And by using our new process this result can be recovered easily.

## 6. CONCLUSION AND PERSPECTIVES

This study presents results regarding some explicit formulas for the entries of the inverse  $\mathbb{V}^{-1}$  of the generalized Vandermonde matrices. Our process based on the explicit analytic formula of fundamental system (7), and an algorithmic technique, for constructing the columns of  $\mathbb{V}^{-1}$ . In the best of our knowledge, the formulas of the entries of  $\mathbb{V}^{-1}$  are not current in the literature.

We do not claim that this study is a complete presentation of all methods for approaching the the inverse  $\mathbb{V}^{-1}$  of the generalized Vandermonde matrices. However, the material presented here is a reflection of our approaches concerning the inverse  $\mathbb{V}^{-1}$  of the generalized Vandermonde matrice, through the properties of fundamental system related to the associated to difference equations (3).

Finally, as there are other explicit analytic forms (5) of the general term of the linear recursive sequence (3), this opens up possibilities for obtaining other explicit formulas of the entries of the inverse  $\mathbb{V}^{-1}$  of the generalized Vandermonde matrices.

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# Water Quality Analysis (IQA) of Lake Uhe Lajeado in Porto Nacional- TO

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**Keywords—** *Water Resource, Hydrographic  
Basi, Water Quality Index.*

**Abstract**—*Water is a source of life and an essential element of nature for human survival. Currently, this water resource has gone through a constant crisis over the centuries, especially when it comes to crises caused by the pollution aspect that affects this water resource and affects its efficiency in terms of consumption. The use of water is a demand that is present in several areas, in agriculture it has a resource role with consultative use. The present study aimed to obtain qualitative information about the quality of the water resource available in the lake located in the Araguaia-Tocantins Hydrographic Basin. Monitoring has the purpose of obtaining biological, chemical, physical, ecological information and classification into classes specified in the NSF IQA. In the case study, the water quality monitoring procedure was carried out, through the water quality standards - IQA NSF, carried out with the samples collected at a point of the Lake UHE Lajeado in the municipality of Porto Nacional - TO. These analyzes are important because the site, in the future, will serve as a new point of water collection for public supply. The Water Quality Index was evaluated by permissible limits established by CONAMA resolution n° 357/2005 and NSF - National Sanitation Foundation, which was evaluated in 9 parameters that made it possible to calculate the IQA - Water Quality Index.*

## I. INTRODUCTION

Water is a source essential to life and is a necessary element for most human activities, that is, it is an integral part of the landscape and the environment. Because it is a necessary resource, it must be conserved and protected. It has the most diverse purposes, whether for domestic and industrial supply, power generation, irrigation of agricultural crops, recreation, navigation, fishing,

aquaculture, fish farming, and also for assimilation and removal of sewage (SETTI et al., 2001).

Over the years the water on the planet has remained the same, about 70% (seventy percent) of our planet is bathed by water, of this percentage only about 2% (two percent) is considered drinkable water, or in other words, fit for consumption. In this regard, it is possible that Brazil is considered a privileged country for the large amount of this resource available, it has the largest freshwater reserve in

the world, the Guarani Aquifer, and also has the largest hydrographic basin in the world, the Amazon River Basin (FREITAS, 2021).

From this perspective, the large amount of water present in Brazil could be seen as inexhaustible, however, a major problem that affects this abundance is the unrestrained use that generates waste. This unconscious use has also resulted in the amount of waste thrown daily into water bodies in a way that impairs its potability.

The IQA was created in the 1970s, after its creation in the United States by the National Sanitation Foundation - NSF and 5 years later CETESB - Environmental Company of the State of São Paulo started using it. Over the decades, other Brazilian states adopted the IQA, which is now the main water quality index used in the country (ANA, 2020).

For Soares (2001), water quality monitoring is the effort to obtain quantitative information on the physical, chemical and biological characteristics of water through statistical sampling. The type of information sought depends on the objectives of the monitoring network, and these objectives range from detecting violations of water body quality standards to determining temporal trends in water quality.

According to ANA (2013) basic monitoring is performed in strategic locations to monitor the evolution of water quality, identify trends, and support the development of diagnostics.

In this study, in particular, the quality of the water available in the lake of the UHE Lajeado in the city of Porto Nacional - TO was investigated. The city has a growing number of inhabitants due to the possibility of employment because of the advancement in agriculture that was leveraged by the expansion of soybean and corn plantations in the central region of the state. However, the available water resources have suffered the impacts of this economic expansion since its waste ends up affecting the waters and compromising water quality.

## II. METHODOLOGY

This was carried out through an in loco investigation, where the use and occupation of a specific point of the lake was investigated, which was characterized by the presence of the UHE Lajeado Lake. The water collected was analyzed through physical-chemical and microbiological tests, with the objective of calculating the IQA of the UHE Lajeado Lake in the municipality of Porto Nacional, the water quality was evaluated according to the parameters of the National Sanitation Foundation and Standard Methods (APHA, 2005).

### 2.1-STUDY AREA

The city of Porto Nacional is located in the central region of the state and is 63 km from the capital Palmas. It has a population of approximately 53,316 (IBGE, 2020) and is one of the largest agricultural centers in the state. The city is bathed by the Tocantins River, the main river of the state and is located in the Araguaia-Tocantins.

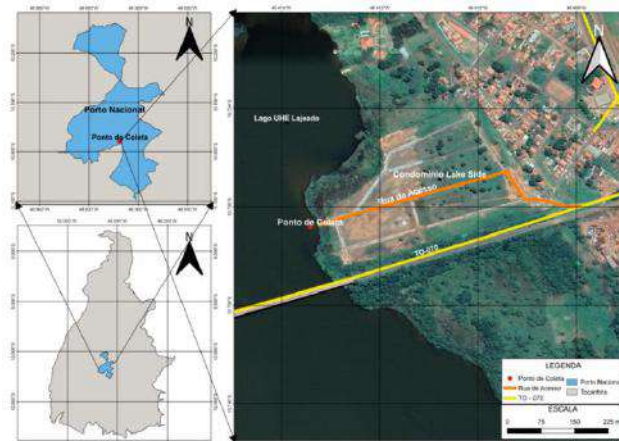


Fig.1 - Lake Side Clubhouse Location Map

Fonte: SEFAZ (2019).

### 2.2 FIELD METHODOLOGY

The method used for collecting the sample was in accordance with the technical specifications of NBR 9897/87, which deals with planning the sampling of liquid effluents and receiving bodies, and NBR 9898/87 on preservation and sampling techniques for liquid effluents and receiving bodies.

Sample collection and preservation were performed using convenient techniques so that the results would not reflect the conditions at the time the sample was collected. All necessary precautions were taken with the storage, maintenance, and transportation of the collection material. In total, 6 water samples (microbiological and physical-chemical) were collected.

The definition of the water quality index, IQA NSF, was based on monitoring the water on a timeline and for this purpose calculations and adaptation of the index were used for:

### 2.3 SAMPLE COLLECTION

The collection of water samples from the UHE Lajeado Lake were performed weekly, over a period of six weeks, between the months of August and September 2021. In total, six water samples were collected for each study (microbiological and physical-chemical), using 100 ml containers for microbiological samples and 200 ml for physical-chemical samples.



The containers were properly labeled and packed in a thermal box and taken to the IFTO's (Federal Institute of Education, Science and Technology of Tocantins) laboratory in Porto Nacional for processing.

## 2.4 LABORATORY METHODOLOGY

The samples were analyzed in the laboratory of the IFTO - Federal Institute of Education, Science and Technology of Tocantins, Porto Nacional campus, using the respective materials and application methods.

Table 1: Parameters and techniques used

Parameters	Analytical Technique	Unit
Turbidity	APHA (2005), Direct Measurement	NTU
pH	APHA (2005), Direct Measurement	Escala
BOD	APHA (2005), Differentiation	mg/L
Total Phosphorus	APHA (2005), Spectrophotometry	mg/L
Total Waste	APHA (2005), Spectrophotometry	mg/L
Total Nitrogen	APHA (2005), Spectrophotometry	mg/L
Fecal Coliforms	APHA (2005), Colilert	NMP/100 mL

Fonte: Balduino, 2019.

### 2.4.1 TURBIDITY ANALYSIS

To analyze the turbidity, the equipment was calibrated with 0.02 and 110 NTU solutions and 20 mL of the sample was placed in the turbidimeter cuvette to take the turbidity reading

### 2.4.2 PH ANALYSIS

The pH reading was taken with a pH meter calibrated with pH buffers 4 and 7. Then the sample was placed in the beaker and the electrode inserted to take the pH reading.

### 2.4.3 TEMPERATURE ANALYSIS

A digital thermometer was introduced directly into the point under study of the UHE Lajeado Lake, where the collection was made, for water temperature measurement.

### 2.4.4 FECAL COLIFORM ANALYSIS

To analyze the amount of fecal coliforms in the water, the reagent (Colilert) was placed in the sample and then loaded into the incubator for 24 hours at a temperature of 35°C, and then poured into the Quanti-Tray/2000 (count from 1 to 2,419 per 100 ml), and the result was read:

- Yellow cavities equals total coliforms;
- - Yellow/fluorescent cavities equals fecal coliforms/ E. coli.

The results of total coliforms and fecal coliforms were obtained simultaneously, by consulting the appropriate table of Hoskin in order to define the MPN of total coliforms and fecal coliforms.

### 2.4.5 DISSOLVED SOLIDS ANALYSIS

For the analysis of total dissolved solids biochemical oxygen demand, total nitrogen and total phosphorus were performed at LAPEQ - Laboratório de Pesquisa em Química Ambiental, also according to Standard Methods (APHA, 2005).

## 2.5 WATER QUALITY INDEX - NSF

The AQL was calculated by the weighted product of the water qualities corresponding to the parameters according to the following equation Heller and Padua (2010):

EQUATION 1:

$$IQA = \prod_{i=1}^n q_i^{w_i}$$

Where:

IQA - Water Quality Index (varies from 0 to 100);

Qi - quality of the i-th parameter, a number between 0 and 100, obtained from the respective average quality change curve (analysis result);

wi: weight corresponding to the i-th parameter or sublevel, a number between 0 and 1, assigned according to its importance for the overall quality conformation;

n - number of parameters (n = 9).

The number "n" will always be equal to nine, because, in the absence of the measurement of any of the parameters that make up the IQA, its calculation is unfeasible

Equation 2:

$$\sum_{i=1}^n W_i = 1$$

n: number of parameters that go into the AQL calculation.

The calculation of the IQA will be unfeasible in the case of not having the value of any of the nine variables. From the calculation made, it is possible to determine the quality of the raw water, indicated by the IQA, varying on a scale from 0 to 100, as shown in Table 1.

Table 1 - Water classification according to the IQA-NSF result

LEVEL OF QUALITY	BAND
EXCELLENT	$90 < IQA \leq 100$
GOOD	$70 < IQA \leq 90$
MEDIUM	$50 < IQA \leq 70$
BAD	$25 < IQA \leq 50$
VERY BAD	$IQA \leq 25$

The evaluation by means of the physicochemical and microbiological parameters of the water quality was established according to the weighting values, whose results fall into a category ranging from excellent to very bad.

### III. RESULTS AND DISCUSSION

The monitoring of the water quality was carried out during the rainy season. During the rainy season a dark coloration of the water was observed, which comes from the solids carried to the riverbed. It is important to point out that the darker coloration of the water does not indicate contamination, since colorless water can also be contaminated.

#### 3.1 WATER QUALITY PARAMETERS IQA NSF

The term water quality is subjective, since it does not refer to the purity of water, but to its physical, chemical and biological characteristics. In this perspective of IQA evaluation, nine parameters are selected for this study, namely: Water Temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Hydrogen Potential (pH), Turbidity, Total Dissolved Solids (TDS), Total Nitrogen, Total Phosphorus and Fecal Coliforms (FC) (ANA, 2020).

CONAMA (BRASIL, 2005) determines the classification of water according to Resolution 357/2005, which states that freshwater is classified into four classes and one special class, and in this study it was examined as being class 2 waters, which are waters that can be indicated for human consumption, after conventional treatment, the protection of aquatic communities, primary contact recreation, such as swimming, water skiing and diving, according to CONAMA Resolution No 274 (BRASIL, 2010), the irrigation of vegetables, fruit plants and parks, gardens, sports and leisure fields, with which the public may come into direct contact, and aquaculture and fishing activity.

##### 3.1.1 TEMPERATURE

Between the period February and March in the studied point was recorded an average temperature of 24.98 °C, the highest value was recorded in the second collection of February and the last collection of March, having been 25.3 °C, while the lowest was in the third and fifth collection of

March, having recorded a value of 24.8 °C, in view of the rainy period the values varied little.

According to ANA (2020) the temperature is among the most important parameters, since it directly affects the physical and chemical processes that are made in water sources. Thus, the existing organisms reach limits with upper and lower temperature ranges, since they undergo changes throughout the day and in the changing seasons of the year.

##### 3.1.2 DISSOLVED OXYGEN

Oxygen (O<sub>2</sub>) is a gas of great biological importance and participates in numerous chemical reactions in aquatic ecosystems. All heterotrophic organisms depend on oxygen to maintain the metabolic processes of production, energy, and reproduction. The main sources of oxygen for water are the atmosphere and photosynthesis. Otherwise, losses arise from the consumption and decomposition of organic matter (oxidation), by the atmosphere, respiration of aquatic organisms, and oxidation of metal ions, such as iron and manganese (ESTEVEZ, 2011).

The highest Dissolved Oxygen value occurred in the last collection of March, having a value of 5.11 mg.L<sup>-1</sup>, while the lowest was in the first collection of March, registering 4.98 mg.L<sup>-1</sup> and with an average value of 5.02 mg.L<sup>-1</sup>.

According to Resolution 357/2005 of the National Council of the Environment (CONAMA), it establishes that the concentration of dissolved oxygen should be equal to or greater than 5 mg.L<sup>-1</sup> for Class 2 waters, which means that the results obtained are on average within the standard, with some collections having presented values slightly below, a warning sign for the competent bodies.

##### 3.1.3 BIOCHEMICAL OXYGEN DEMAND (BOD)

The highest BOD (Biochemical Oxygen Demand) occurred in the second sample of February, with a result of 1.89 mg/L<sup>-1</sup>, while the lowest was in the first sample of February with 1.58 mg/L<sup>-1</sup>, resulting in an average value of 1.74 mg/L<sup>-1</sup>. The results obtained are within the parameters of CONAMA Resolution 357/2005, where for class 2 waters, the value has to be up to 5 mg/L<sup>-1</sup> O<sub>2</sub>.

The existence of high BOD values happens in the decrease of dissolved oxygen values in water, directly influencing the balance of aquatic life. In general, the high values of this parameter in a body of water are caused by the release of organic loads, especially domestic sewage (CETESB, 2009).

##### 3.1.4 HYDROGENIC POTENTIAL (PH)

For Vieira (2015) pH is apt to dominate several chemical and biological processes in water bodies, and of procedures associated with water supply and wastewater treatment. It

can be influenced by several aspects, such as dissolved solids and gases, hardness and alkalinity, temperature, and biotic factors.

The pH can vary between 0 (very acidic) and 14 (very alkaline), being a factor that interferes in the metabolism of the species CONAMA has determined a limitation for Class 2 waters, through resolution 357/2005 where the values must remain between 6 and 9 (ANA, 2020). The pH of the water in Class 2 waters, obtained an average of 7.03, with the highest value in the first week of March and the lowest value in the last week of March, being within the range stipulated by resolution 357/2005 of CONAMA.

During this period, the pH, went through oscillations, but remained within the range allowed by CONAMA Resolution 357/05, which recommends for springs pH values around 6.0 to 9.0. The maximum value of 7.19 indicated that it is slightly acidic.

### 3.1.5 TURBIDITY

Turbidity is the parameter that analyzes the water's ability to disperse solar radiation, being influenced mainly by suspended solids, which reduce the photosynthesis of submerged vegetation and algae. In general, turbidity comes from the erosion of large amounts of solids in the drainage area of the tributaries of the reservoir and the entire watershed (Tavares, 2005).

In the months of February the highest values were registered due to the large amounts of precipitations, presenting values of 6.28 NTU in the second week of February and 6.68 NTU in the second week of March, and the lowest value was registered in the first week of March due to the decrease in rainfall volume, registering a value of 4.13 NTU, with an average of 5.51 NTU.

After the analysis it is feasible to check the results with the highest values allowed, according to the Resolution 357/05 of CONAMA, in which the turbidity values are a function of water use, where the allowed value for raw water is up to 100 NTU. The turbidity variant in surface waters is interesting for the relationship with the dissolved oxygen content because the suspended solids hinder the penetration of solar radiation, which causes a decrease in photosynthetic activity (BRASIL, 2005).

Although the average shows a value above 5 NTU, maximum permissible value for the CONAMA Resolution 357/05 for waters at any point of the distribution network, it is important to emphasize the rainy season that may have influenced the values of some collections that are in disagreement.

### 3.1.6 TOTAL DISSOLVED SOLIDS (TDS)

With the exception of dissolved gases, all impurities in water favor the accumulation of solids in water bodies and are capable of being called residues, since, after evaporation of a sample and drying in the greenhouse, these materials persist. The smaller particles, which are able to pass through a specific filter paper relate to the total dissolved solids (VIEIRA, 2015).

An average of  $14.84 \text{ mg.L}^{-1}$  was obtained, having recorded in the second week of March the highest recorded value of  $19.27 \text{ mg.L}^{-1}$ , and the lowest in the second reading in February, having recorded  $9.84 \text{ mg.L}^{-1}$ , and averaged in the value of  $14.84 \text{ mg.L}^{-1}$ .

For Resolution 357/2005 the maximum value allowed for Class 2 waters is  $500 \text{ mg.L}^{-1}$ .

### 3.1.7 TOTAL NITROGEN

According to ANA (2015), water that has high concentrations of organic and ammoniacal nitrogen, and lower concentrations of nitrites and nitrates are unsafe, since they indicate that the site has been contaminated. Eutrophication is the problem factor that is related to high nitrogen concentrations, since they lead to an exacerbated growth of algae, inducing interference with the desirable uses of water (VON SPERLING, 2005).

The highest concentration of Nitrogen occurred in the second analysis in February having registered  $2.112 \text{ mg/L}^{-1}$ , while the lowest was in the last analysis in March, registering  $1.521 \text{ mg/L}^{-1}$ .

The element Nitrogen is essential for the life of organisms, since, it integrates the protein molecule, and as a consequence, of the protoplasm. Being equal to phosphorus, it is considered one of the most important and limiting to the life of freshwater organisms (BOLLMANN; CARNEIRO; PERGORINI, 2005).

The highest value of total nitrogen for Class 2 waters, according to CONAMA resolution 357/2005, can vary according to the hydrogenic potential (pH). For  $\text{pH} \leq 7.5$  the highest allowed value is  $3.7 \text{ mg/L}^{-1}$ , for  $7.5 < \text{pH} \leq 8.0$  the maximum allowed limit is  $2 \text{ mg/L}^{-1}$ , for  $8.0 < \text{pH} \leq 8.5$  the highest allowed value is  $1 \text{ mg/L}$ , and for pH greater than 8.5 the highest allowed value is  $0.5 \text{ mg/L}^{-1}$ . In this study, both the mean pH and the highest pH reading recorded are lower than 7.5, thus the maximum allowed value for Total Nitrogen is  $3.7 \text{ mg/L}^{-1}$ , thus the analyses of the six collections are within the parameter, and the highest analysis was  $2.245 \text{ mg/L}^{-1}$ .

### 3.1.8 TOTAL PHOSPHORUS

According to Vieira (2015), phosphorus is an essential nutrient to maintain the life of living organisms and, in

water, it is found in the form of phosphate, either in its dissolved form or as particulate material. Natural sources of phosphate are the chemical weathering of rocks, as well as the decomposition of organic matter. Sewage contributes greatly to the increased accumulation of phosphorus in water, a fact that, in case of high concentration of sewage in the water body, can lead the environment to eutrophication, because phosphorus is a limiting nutrient for the growth of algae.

The CONAMA Resolution 357/2005 for waters with class 2 lentic environments determines a limit of  $0.030 \text{ mg.L}^{-1}$  for lotic environments  $0.1 \text{ mg.L}^{-1}$ . The source of intense ecological interest in phosphorus results from its great need in the metabolism of the biosphere (BRASIL, 2005).

In the six analyses performed in February and March the values found for total phosphorus were all equal to 0, indicating that in the period studied there is no presence of such substance at the point where the collection was made.

### 3.1.9 FECAL COLIFORMS

According to CONAMA Resolution 375/2005, fecal coliforms, or thermotolerant coliforms, are:

Gram-negative, bacillus-shaped, oxidase-negative bacteria characterized by activity of the enzyme  $\beta$ -galactosidase. They can grow in media containing surfactants and ferment lactose at temperatures of  $44\text{--}45^\circ\text{C}$ , producing acid, gas, and aldehyde. In addition to being present in human and homeothermic animal feces, they occur in soil, plants, or other environmental matrices that have not been contaminated by fecal material.

The average of the values obtained from the analysis of fecal coliforms was 16.43 MPN/100 MI, which quantifies the presence of bacteria from the *Escherichia coli* group. However, in the second collection in February and the fifth collection in March, there was no presence of fecal coliforms. The highest value was obtained in the fourth collection in March, when a value of 70.1 MPN/100 ml was recorded..

### 3.2 WATER QUALITY INDEX (IQA-NSF)

The results obtained for the months of February and March 2020 served as a basis for calculating the IQA through the physical, chemical and bacteriological parameters of the surface waters of Lake UHE Lajeado in the municipality of Porto Nacional, using as parameters the classification of values by the National Sanitation Foundation. The calculation was performed using Excel as a support tool.

The lowest IQA value recorded was 76.21 in the second week, while the highest was 79.46 in the sixth week, very close values. The period under analysis obtained an average of 77.97, a value classified as good, where the National Sanitation Foundation's standard IQA value for such a

category is  $70 < \text{IQA} \leq 90$ . The little variation recorded during all collections shows that the point chosen for collecting water to supply the population of the municipality of Porto Nacional - TO was made in a very satisfactory manner by the company BRK (basic sanitation company operating in the region).

All the results of the parameters analyzed were within the allowed standards when analyzed separately, and were always within the limits established by CONAMA Resolution 274/00, 357/05 and NSF, with little variation in the samples collected during the 6 weeks. This factor contributed to a satisfactory final IQA value.

## IV. CONCLUSION

The result obtained from the water quality analysis was of great relevance, in which it was possible to analyze the real state of the water that is being used for public supply. Monitoring the AQL serves mainly to follow the evolution of the local water quality, making it possible to create a history for analysis, serving mainly as an alert to the population and the responsible bodies, so that preventive measures can be taken when necessary.

The results obtained during the study period regarding the alteration of the quality of the water, allowed a good analysis of the place studied and can conclude that the waters of the UHE Lajeado Lake in Porto Nacional - TO met the specifications of the CONAMA Resolution 357/2005 for class two waters, in almost all the 9 water quality parameters, except for turbidity, which was in disagreement. Thus, it was classified as good according to the IQA classification of the National Sanitation Foundation.

Despite the satisfactory result obtained with the study, it is worth pointing out that the care with the waters and soils of the hydrographic basin should be continuous, because even though most of the values were within the parameters, there were still those that came close to or exceeded the limit (Dissolved Oxygen and Turbidity), this shows that monitoring is of great importance and that precautionary measures should be taken so that the current situation does not worsen.

Another factor that may have influenced that made it possible to obtain good results is the fact that the analyzed point is located at the exit of the city in a condominium that has not yet been inhabited, and around it there are few residences. This situation can be changed if there is not a good management of urban expansion in the region, especially with the treatment of sewage and the disposal of solid waste, which are one of the causes that contribute to the pollution of watersheds.



The use of the IQA leads to the conclusion that its use is of fundamental character for the preservation of hydric resources, because with this important tool it will be possible to outline goals and management plans for a better preservation of this resource that is fundamental to life. Therefore, the point used to capture water for urban supply purposes at the UHE Lajeado lake in the municipality of Porto Nacional - TO is in good condition for use.

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# Implications of the rural territorial tax (RTT) on Brazilian functionalized property in light of the 1988 Constitution

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**Keywords**—Property, Rural land tax, Social Role, Tax extrafiscality.

**Abstract**—This article aims to explore the basic characteristics of the Rural Territorial Tax - RTT - in Brazil, with a focus on achieving the social function of property. For this, it aims to outline the main aspects of the evolution of property rights around the globe, as well as in Brazil, from the occupation of lands by the Portuguese Crown to modern times. The research method addressed is bibliographic, documentary, qualitative and primarily deductive. Meanwhile, it narrates the property with inspiration in the ideals of liberalism and what are the consequences arising from the development in the tax area. Therefore, it explores the main nuances of the State's power to tax, especially with regard to the RTT - when measuring the level of effectiveness of said tax, whether in its fiscal or extrafiscality aspect, within the fundamental bias of the Federal Constitution of 1988.

## I. INTRODUCTION

The property right, currently recognized by the Federal Constitution of 1988 as a fundamental right, had a long path of development in order to arrive at the interpretations that are correlated with it today. The owner-owner is guaranteed his rights to private property, with the powers that are inherent to him – to use, enjoy/enjoy, dispose of and recover the thing, while also being subject to a legal framework of duties to meet the so-called principle of social function of property.

The item II of this study proposes to delve into the preliminary aspects of the evolution of property around the globe, dealing with the main exponents of the theme in the modern age, from the philosophers John Locke and Rousseau, who detailed basic characteristics, although with their distinctions, about the guarantee from property

to man, its reflections on society, as well as revolving its inspirations in liberal ideas.

In the meantime, the item is also dedicated to highlighting how the occupation and distribution of land in Brazil, since the colonial period, had implications for property on national soil, permeating a study based on the Land Law, the Brazilian Constitutions and the Statute of Earth.

In the item III, once the premises of property consolidation are overcome, the article focuses on the tax issue inherent to it, specifically in rural property, through the institution, regulation and collection of the RTT - Rural Territorial Tax. For this, at first, it rescues concepts of taxation and its purposes in society, as well as the Constitutional prediction and the limitations of the State to the power to tax.

Next, it will be demonstrated, through studies and research, which are the criteria for measuring the tax due on rural property, legislation and regulatory evolution, in addition to inherent concepts, such as the definition of bare land value, degree of use of rural property, as well as the exceptions and incentives for the extrafiscality function of the tax: preservation of native forest or cultivation of these species, sustainable and adequate use of the environment, accessions (constructions, buildings), added to the fulfillment of the social function of the land /property.

In the item IV, as part of the conclusions, the paper analyzes the consequences and the possible (in)effectiveness of the Rural Land Tax in Brazil through data collected since the 1980s, to understand whether the tax is effective both in the fiscal and extrafiscality functions. For this, it is still based on comparative law research, in relation to the same type of rural tax, also imposed in other countries.

## II. PROPERTY RIGHTS: HISTORICAL DEVELOPMENT INCURSIONS

Man's relationship with the land goes back to the beginnings of organized civilizations, because when leaving the characteristic of nomads and settling in certain organized places for housing and cultivation, the nature of possession and occupation arises, which modernly develop in the right of property. that is conceived today. It is even verified that the idea of property, for some, exponent of the philosopher John Locke, is a natural right of man, as shown below.

Considering the modern age, Barcellos (2020, p.86) mentions that when Locke develops the theme of property rights, he does so with the understanding that property encompasses the individual himself, in an absolute bias, whose propagation takes place through the ideals of liberalism. On the other hand, in contrast, based on Rousseau's studies, Barcellos (2020, p.87) narrates that property is embodied by a positive act of someone who occupies and exercises dominion over something, attributing it as their own.

In this vein, it is also observed that Rousseau establishes a premise by which the domination and distribution of wealth, in greater or lesser amounts, to specific groups, give rise to social inequalities, when it is up to the State to intervene to balance the factual situation. Meanwhile, Locke develops an ideal of the guarantee of property as inherent to the human being, including itself along with the notion of life and freedom. Therefore, for Rousseau, property is only recognized within civil society, in such a way that there is no property without society. While Locke marks property as a natural right, unlinked

from the formation of society itself, and for that very reason, imposes a set of duties on the owner (BARCELLOS, 2020, p. 89).

From the definitions espoused by these two of the greatest exponents of the theory of property rights already in the modern age, it is inferred that, within civil society, with property there also emerges a question of entitlements, about who can have something, to whom it belongs the right of ownership, which, in turn, implies possible social inequalities that also permeate the tax system inherent to property (BARCELLOS, 2020, p. 78).

Locke's ideals emerge, as he understands that the ownership of goods and the organization of the Liberal State have freedom and equality as essential. When referring to capitalist society, it is notable that equality is a value that is at the heart of the concept of the Rule of Law, so that everyone must be treated equally before the law. In addition, private property proves to be fundamental for carrying out free commercial transactions, and for pure economic liberalism there should be no state intervention in the economy, under penalty of distorting freedom and private property (BARCELLOS, 2020, p. 93/96).

Turning our gaze to the development of property in Brazilian lands, it is necessary to pay attention to the peculiarities of the occupation of the territory by the Portuguese Crown. At the time of the "discovery" of Brazil, Portugal did not have enough dimension on the immense extension of land that covered the Colony, therefore, in order to clear, demarcate, occupy, explore and defend the new lands, a system of hereditary captaincies was installed in which the donee captains held power over a specific part of land.

Fourteen hereditary captaincies were established, distributed to those more fortunate and close to the Portuguese Crown, with sufficient prestige and economic power to try to carry out the mission that was incumbent on them. However, even with the division into fourteen portions of land, the territory was still more extensive than could be managed, which is why the captaincy system failed.

From then on, to resolve the imbroglio, the Portuguese Crown decided to import the Sesmarias institute to the Colony from its Empire, although with different characteristics, since on Brazilian soil, the Sesmarias letters were delivered so that new owners could occupy, explore, demarcate and defend the territory that was consigned to them, many times, until then, new and "virgin" lands. Once again, permeating the inequalities that are perpetuated until today, the letters of Sesmarias were delivered to the "friends of the King", people with considerable wealth and power.

The Sesmarias system was also not successful in Brazil, with sesmeiros who did not fulfill their obligations to the Crown and other irregular occupations that spread throughout the territory, until, shortly before the Independence of Brazil, still in 1822, Dom Pedro I suspended the concession of new Sesmarias until the regulation of land occupation by the Constituent Assembly.

Although the Imperial Constitution of Brazil, of 1824, dealt with the full right of property in its article 179, item XXII, and providing for compensation for expropriation, the fundamental letter did not effectively regulate the situations already consolidated. That said, there was a period of time in Brazil from 1822 to 1850, called the tenure regime, without land occupation legislation or property rights that would bring legal certainty.

It is in this period, with the Constitution of 1824, that the development of property rights in Brazil is understood, whose first regulation was promoted by Law n. 601/1850 (Land Law).

In the Brazilian context, the realization of lands also led to the concentration of wealth and power in a small part of society, since occupations and sesmarias had already been consolidated, a select elite group, which was more aligned with the interests of the King, ended up being the most benefited, even by the lack of inspection in the colonial period and the precariousness of dominion titles. This situation, which should have been resolved by the Land Law by promoting the right to property, did not obtain support from the agrarian elite, even because in the following Magna Carta, the Republican Constitution of Brazil of 1891, the legal tax on rural properties was provided for, a situation that was only addressed more comprehensively in the Land Statute in 1964 (SIQUEIRA, 2021, p.32/35).

In the meantime, around the world, due to the Second World War, a new model of constitutionalism, with a more social nature and, therefore, with room for interference in economic freedom, gained strength to be implemented, since it already had in the Mexican Constitution of 1917 and the German Constitution of 1919 (Weimar Constitution). From there, after the horrors of the world wars, the 20th century had implications of ideals rooted in social solidarity. That said, the paradigm of the Liberal State is changed to the Democratic State of Law, imbued with transforming society, in an egalitarian process, which became known as the Welfare State (BARCELLOS, 2020, p.101/102).

In terms of Brazil, with the enactment of the Land Statute, Law n. 4504/1964, there is a relevant regulation of the institute of the social function of the land, by which the

property must be subject to minimum criteria that serve the community, in addition to the owner himself.

Only after the Federal Constitution of 1988, however, the property right, now considered as a fundamental right, starts to have a socialized function with greater clarity and effectiveness regarding the measures to be taken by the State in the fulfillment and effectiveness of the aforementioned principle. The idea of democracy is strengthened, together with economic freedom and contracting, with the guarantee of private property, but as long as it is based on basic principles of human dignity, adequate exploitation of the environment and sustainable development. The right to guarantee private property is not withdrawn from the owner, but only combines the ideals of rights and duties of the individual with the community and which, therefore, justify the constitutional protection of the State for the common good. In this vein, it can be inferred that the social function of property promotes a change in the right from "having property" to "being an owner", with the subjection of the characteristics and powers inherent to the thing (BARCELLOS, 2020, p.113/115).

In summary, it appears that, in Brazil, following the parameters of implementation and development of property rights around the globe, despite the peculiarities of Portuguese colonization, there is currently the guarantee of property as a fundamental right, in the terms espoused in art. 5, XXII, XXIII and art. 170, II, CF/1988. That is, property must serve a social function, subjecting its owner not only to the rights inherent to it (use, enjoy/enjoy, dispose of, recover), but also to the duties that advocate social justice for the community, uniting the economic order, the environment, sustainable development, respect for neighborhood rights and tax and labor legislation.

For this reason, in terms of taxation, the institution and implementation of the Rural Territorial Tax - RTT, appears as an important instrument to coerce the owner in fulfilling the social function of the property, based on incentives to those who produce meeting the social function and, on the other hand, on the other hand, encumbrance to those who do not satisfactorily meet such criteria (D'AGOSTIN and CATAPAN, 2020, p.03).

### III. BASIC ASSUMPTIONS FOR REGULATION OF THE RURAL TERRITORIAL TAX – RTT

Taxation on immovable property, based on the right to property, or even possession, is an instrument used by various civilizations since ancient times. At that time, this type of tribute was generally instituted for purposes of tax collection and also for land management, in order to consolidate and maintain dominion over a certain territory, following the example of the Roman Empire and also,

more recently, by Napoleon. In Brazil, given the historical context of colonization and the resistance of the dominant agrarian elites, this type of taxation was postponed for a long time (SIQUEIRA, 2021, p.48).

Humberto Ávila (2008, p.06) teaches that when creating a tax there is a specified purpose within a fundamental legal framework of the Federal Constitution of 1988, which advocates standardization through law, guaranteeing legal certainty to the citizen by through the predictability and certainty of what will be charged (art. 50, XXXVI), and the definition of time frames, such as the limitation of the power to tax: the non-retroactivity of the tax (art. 150, inc. III, a). Furthermore, it advocates the principle of precedence: in the case of social contributions (art. 195, § 7), it is essential that they are instituted 90 days before collection (art. 195, § 7), while taxes can only be demanded if created until the end of the previous year (art. 150, item III, b). Complementarily, the author explains in more depth about the objectives of taxation:

Taxation seeks to achieve certain purposes. These purposes can be analyzed from an extra-legal perspective, when examining the causes that led the legislator to conform the taxation in this or that way, or from a legal perspective, in the event of investigating the validity basis used to justify the taxation or the distinction between taxpayers and the purpose that the distinction aims to achieve. This is because, since the justification and purpose of the distinction are different, the legal interests that affect the subjects will be different and, by implication, the rules and principles that will protect them will also be different. (ÁVILA, 2008, p.06)

Still in the objectification of taxes, Bach and De Andrade (2020, p.03) recall that the State, when creating a new tax, primarily has the configuration called taxation, that is, to seek collection purposes and with the purpose of raising funds. to promote public policies that are necessary. On the other hand, there is also parafiscality, when the tax is destined to the revenue of state-owned legal entities or linked to them. And yet, extrafiscality, when the tax goes beyond the fiscal criterion, serving as a means of State intervention in the private economy and in social relations, as is the case of the RTT - Rural Territorial Tax.

The idea of taxation related to the right to property dates back to the ideals set out in the Declaration of the Rights of Man and of the Citizen, dated 1789, in which it was already foreseen that all citizens, according to their possibilities, should contribute to the maintenance of

conquered rights: liberty, equality and property. In this vein, it is observed that property rights and taxation complement each other, since the State can only guarantee its own bases, such as fundamental rights, through the required taxes, which finance them (BARCELLOS, 2020, p. . 152 and 170).

In this wake, taxation should not be seen and rejected as depriving citizens of their rights, when, on the contrary, it is one of the ways to guarantee such foundations:

As seen, citizenship in the Democratic State of Law can no longer be understood only as the possession of rights, but rather as a relationship of rights and duties. Within the scope of such duties, the fundamental duty to pay taxes stands out, which has an intimate connection with fundamental rights, relating to them in three perspectives: the guarantee against state power, the role of financing the cost of rights and, finally, acting as a mechanism for the realization of fundamental rights. It can be said, then, that if democracy is compatible with the right to property, which legitimizes inequalities - but at the same time requires efforts to be made to reduce them -, there is no violation of the right to property by adopting inequalities. redistributive fiscal policies, as long as they are carried out in constitutional terms. The social function of property, which justifies the inclusion of collective interests, is reflected in tax law with the recognition of the need to pay taxes, adding to it a link to the constitutional project of transforming reality. (BARCELLOS, 2020, p. 186)

Having surpassed the basic premises in relation to property taxation, we have that the RTT – Rural Territorial Tax was instituted in Brazil in the first Republican Constitution in 1891 and today is based on art. 153, VI, of the Federal Constitution of 1988, and regulation in Law n. 9.393/1996. It is inferred that the RTT is imbued with both a taxation and extrafiscality function, since, in addition to raising funds, it also aims to encourage the owner in the proper use of the land, attending to the social function, in order to avoid latifundia without production, as well as as real estate speculation. For this very reason, there is a difference in the rates charged, so that unexplored rural properties have higher collection rates, according to criteria of degree of use (D'AGOSTIN and CATAPAN, 2020, p.03/04).

In order to understand the institution of the RTT in Brazil and the method of calculation, it appears that the tax



was effectively created only in the military period, through the Land Statute, already providing for the collection and extrafiscal character, in the sense that the progressiveness of the collection rates was stipulated by the size and use of the property. The creation of the RTT also aimed at a more effective land regularization by allowing the identification and expropriation of unproductive rural properties. However, the failures of the public power in the inspection did not favor the effectiveness of the established objectives (SIQUEIRA, 2021, p.15/16).

A brief historical review shows that the RTT was originally provided for by the 1891 Constitution, with instituting competence attributed to the federated states. In the 1946 Constitution, by Constitutional Amendment n. 5, the competence was conferred to the municipalities, but it was soon modified again in 1964, during the military period, transferring the competence of the RTT to the Union, which was maintained in the current Magna Carta of 1988. However, under the terms of art. 158, II, CF/1988, the inspection of the RTT is the responsibility of the Union, but half of the collection is the right of the municipalities (art. 158, II, CF/1988). Another relevant modification is the hypothesis that the municipalities and the Federal District establish an agreement with the Federal Revenue Service so that the federated entity itself inspects and collects the entire RTT (art. 153, §4, III, CF/1988), provided that it does not constitute tax waiver or tax reduction (BACH and DE ANDRADE, 2020, p. 05).

Regarding the incidence of the tax due, the provisions of Law n. 9.393/1996, which gives the guidelines in relation to the RTT:

Art. 1 The Tax on Rural Territorial Property - RTT, calculated annually, has as a triggering event the property, useful domain or possession of property by nature, located outside the urban area of the municipality, on January 1 of each year.

§ 1 The RTT is also levied on the property declared to be of social interest for the purposes of agrarian reform, as long as it is not transferred to the property, unless there is a previous imposition of possession.

§ 2 For the purposes of this Law, rural property is considered to be the continuous area, formed by one or more parcels of land, located in the rural area of the municipality.

§ 3 The property that belongs to more than one municipality must be classified in the municipality where the headquarters of the property is located and, if it does not

exist, it will be classified in the municipality where most of the property is located.

In addition, Cora et al (2020, p. 08) highlight the hypothesis of exemption from presenting the RTT for those farmers who exploit land in up to 100 hectares, in addition to the specific cases of lots and settlements destined for agrarian reform, provided that the requirements are met. basic legal criteria. Therefore, the author explains how to calculate the tax due:

In order to carry out the calculation basis, it is necessary to know what the Non-Taxable and Taxable Areas are, being able through this to identify means of how to carry out the calculation of the rural land tax. It is necessary to know what bare land is and the market value of the land, and bare land is the property by nature or natural accession, comprising the soil with its surface and the respective native forest, natural forest and natural pasture. The RTT legislation adopts the same understanding as the civil legislation (BRASIL, 2012). According to Law No. 9,393 (BRAZIL 1996) in its art. 8: "The Value of Terra Nua (VTN) is the market value of the rural property, excluding market values related to: I - constructions, installations and improvements; II - permanent and temporary cultures; III - cultivated pastures." The Non-Taxable Area is one that is determined by the Forests Code and is protected for environmental conservation. According to the Federal Revenue's normative instruction, number 256, (BRASIL, 2002) the non-taxable areas of rural property are: permanent preservation; of legal reserve; of Private Natural Heritage Reserves of ecological interest, thus declared by means of an act of the competent federal or state agency, which are: ; and b) demonstrably useless for rural activity; of environmental easement; covered by native, primary or secondary forests in a medium or advanced stage of natural regeneration and flooded for the purpose of constituting a reservoir for hydroelectric plants. According to Law No. 9,393, of 1996, arts . 10, § 1, I and III, the RTT calculation basis is the Taxable Bare Land Value (VTNt). The amount of the RTT to be paid is obtained by multiplying the VTNt by the corresponding rate, considering the total area and the degree of use (DU) of the rural



property. Degree of utilization is the percentage ratio between the area effectively used by the rural activity and the usable area of the rural property; constitutes a criterion, together with the total area of the rural property, for the determination of the RTT rates. (CORA et al, 2020, p.09/10)

According to the calculation base adopted, for the purpose of extrafiscality of the RTT, it is interesting to note that the occupied and preserved surface areas on the property are excluded from the taxable area, which should encourage the owner to maintain the native forest or even cultivate native species, regenerate areas that have suffered degradation, contributing to a sustainable and balanced environment. In addition, the progressivity of the RTT is also supported, since the rates are defined according to a proportionality between the size of the property and its productivity, giving the degree of use (UD) of the property (BACH and DE ANDRADE, 2020, p. 08/07).

For all the above, the institution of the RTT in the form of contribution with extrafiscality, shows itself as an alternative permeated with good objectives and "could promote environmental preservation, stimulate economic practices that generate income and work in the field, in addition to ensuring that the social function of the earth was fulfilled." However, it has proved to be inefficient in the Brazilian historical context, either due to the lack of regulatory legislation for long periods, the inefficiency in the inspection and collection of the tax due or even the transfer of the State to the pressure of the ruling elites who aim not to change this scenario. Furthermore, if there were effectiveness and efficiency in the inspection of the RTT, unproductive rural properties, kept for speculative purposes, could serve for expropriation for land regularization purposes (SIQUEIRA, 2021, p.39).

#### **IV. SCOPE AND (IN) EFFECTIVENESS OF THE RURAL TERRITORIAL TAX (RTT) IN BRAZIL: FROM TAXATION TO EXTRA-FISCALITY**

As previously exposed, the State's power to tax is constitutionally defined in specific situations regulated between articles 153 to 156 and other scattered ones. In the model of the federative pact adopted in Brazil, the competence to tax can be of the Union, federated states, municipalities or the Federal District. It is noteworthy that taxation must adopt parameters of reasonableness and proportionality, since it affects the legal circle of human rights, such as freedom and private property, even if it is in order to preserve them. Therefore, the legislator determines a minimum that is indispensable to the citizen

for his life and that of his family in a dignified way, while also conferring the contributory capacity of this citizen, substantiating and justifying the reason for a specific tax, with the purpose, need, adequacy and proportionality of choice (ÁVILA, 2008, p.08/10)

Considering these basic premises, when dealing with property rights, an approach that focuses on the scope of the principle of the social function of land and property is unavoidable. This is because functionalized property is built in accordance with the daily actions of people collectively, that is, at the same time that the Constitution guarantees the right to property, it subjects the owner-owner to a series of duties that meet, not only individual, but also benefits the whole society (BARCELLOS, 2020, p. 122).

With regard to rural property, the social function is embodied in allying the exploitation of the land in a sustainable way, harmonizing the relationship between man and nature in the achievement of agricultural or even industrial activity that is developed in the place. In this vein, the Citizen Constitution elevated environmental protection as one of its foundations, in such a way that sustainable development through a healthy and balanced environment must be shared with the economic order to meet the social function of property (CORA et al. al, 2020, p.03/04).

For this reason, the taxation concerning the RTT – Rural Territorial Tax, takes into account environmental and sustainability criteria, including the Brazilian Forest Code:

From the study carried out, it can be observed that through the Forest Code in relation to the Rural Territorial Tax, the evidence found is that when the farmer fulfills the obligations related to the environment, he can benefit from a reduction in taxes, especially the Tax Rural Territorial, thus being able to contribute to sustainability being of great value to contribute to society. In order to have these benefits, it is necessary to preserve the areas, considered non-taxable in the declaration of the territorial tax, being these areas the legal reserve and the permanent preservation areas - APP, provided that these reserves are proven by suitable and skillful documents, in addition to the presentation of CAR. In order to calculate the RTT calculation basis, it is necessary to know what the non-taxable and taxable areas are, thus being able to identify the possible means for quantifying the rural

land tax. It is necessary to know what bare land is and the market value of the land, bare land is the property by nature or natural accession, comprising the soil with its surface and the respective native forest, natural forest and natural pasture. The RTT legislation adopts the same understanding as the civil legislation. (CORA et al, 2020, p.11).

However, even with all the incentives, the RTT tax collection is very low in the national revenue, and still, taking into account its extrafiscality nature, it shows that the Brazilian taxpayer has not felt sufficiently stimulated, since they permeate unproductive properties and without developmental benefit, since the tax burden does not burden the taxpayer to the point of forcing him to meet the attributes of a social function. In addition, in environmental parameters, the taxpayer barely perceives the correlation between the preservation of green areas on his property and the value of the RTT, since these areas are subtracted, in proportion they occupy, for the calculation of bare land, and by in turn, it has little impact on the tax reduction value (BACH and DE ANDRADE, 2020, p. 12).

The low RTT collection does not refer only to the present day. As early as 1987, studies carried out by Giffoni and Villela, found that the tax was inefficient in its fiscal function because properties were declared at a value much lower than what they actually corresponded to on the market. In the same sense, with regard to the extra-fiscal function of the tax, even about 40 years after the aforementioned study, the situation remains deteriorated: there is no efficient inspection by the State, with the consequent low adherence to providing the fulfillment of the social function of property. So much so that, according to the 2017 Agricultural Census, 1% - one percent - of the establishments were large properties and corresponded to a total of 47.6% of the entire area that was analyzed. This means that large landowners continue to concentrate land, often without meeting the social function, and maneuvering them into real estate speculation (BARCELLOS, 2020, p. 220).

Furthermore, when approaching the collection of the RTT in its taxation function, Bach and De Andrade (2020, p.09/10) explain in their studies the low impact that the tax has on total national revenue, as well as, specifically, its relation with the agribusiness sector:

When analyzing the collection of the RTT over recent years, it is clear that this tax is among those that generate the lowest revenue for the State. According to data from the Brazilian Federal Revenue Service

(2018, 2014, 2006, 2002, 1998), in 2017 the collection amounted to R\$ 1.418 billion reais, which represents 0.06% of national tax revenue and 0.02% of the Domestic Product. Brazilian Gross Domestic Product (GDP). This quotient has fluctuated, since 1990, between less than 0.01% and 0.03% of GDP, a record maintained in the 1996-1997 biennium. [...] On the other hand, agribusiness, understood as the extension of the agricultural production chain, has great weight in the formation of state reserves, equivalent to 21.4% of GDP (CNA, 2020). So much so that the wealth generated by this productive set is not limited to the fruits and products of economic activity, but is reflected on the very surface on which it develops: in this context, rural property gains the quality of a speculative object.

The disparity in the amount of Brazilian collection, when it comes to the RTT, is even more evident when compared to taxation on rural lands in other countries. While in Brazil, the RTT collection does not correspond to more than 0.3% of the total, even in Latin America, Uruguay and Chile, they collect, respectively, 6% and 4%. In Anglo - Saxon America, both the United States and Canada collect, on average, 5%. In Europe, in countries like France and Italy, the amount reaches 3% of the total collected (D'AGOSTIN and CATAPAN, 2020, p.02).

The most diverse scholars on the subject attribute the low RTT collection in Brazil to inspection or administrative factors, as Siqueira (2021, p.50) explains well:

Thus, due to the persistent evidence of its low effectiveness, even after the different regulations, one of the main obstacles to the performance of the RTT is still associated with the self-declaration of the VTN by the taxpayer, as it directly compromises the amount collected and, therefore, the effectiveness of compliance of extrafiscality objectives. The declaration of the VTN by the taxpayer, in addition to compromising the collection of the RTT, also generates other systemic failures, since, even if the value is contested by public agents, resources are available in the legal sphere to try to reverse these charges.

Another approach that promotes failure in the approval of the tax is also necessary, with the imperative that the legislation authorizes the expropriation of unproductive

rural properties, according to art. 185, II, CF/1988. That said, there are taxpayers who tend to declare false information to increase the degree of use (DU) of the land and, thereby, prevent an expropriation procedure, which could even have the aim of promoting agrarian reform, under the terms of art. 6 of Law no. 8.629/1993 (BACH and DE ANDRADE, 2020, p. 15).

From this spectrum it is possible to conclude that the RTT also did not prosper in Brazilian lands in the sense of being used for land regularization, as allowed by the agrarian reform law. Considering that the concentration of land in the country remains practically unchanged, in addition to the fact that most of the national settlements did not materialize through consequences attributed to fiscal issues, there is also the fact that the collection is inexpressive due to the lack of a system or cadaster that integrate the characterization data of rural landowners and promote an efficient state inspection movement (SIQUEIRA, 2021, p.41/44).

Meanwhile, aspects that are interconnected with the rural land tax collection rates are also out of step with the evolution of Brazilian society over the decades, as demonstrated in the research by Bach and De Andrade (2020, p.15):

Regarding the indices, it appears that the same ones established in 1975 are in force, without changes, in total mismatch with the technological innovations of agribusiness and livestock activity (FRIAS; LEÃO, 2017, p. 15). As a result, it is possible to glimpse one of the reasons for the low collection and, at the same time, a disincentive to the rational use of land in these criteria established by the Federal Revenue Service. An update of the minimum yields by 40%, reaching an average of 1.37 AU/ha, understood as similar to the contemporary agricultural reality 32, without any other change in the rules governing the ITR, would generate a collection of R\$8.5 billion (INSTITUTO ECHOLHAS, 2019, p. 42-44).

In short, it is inferred that the Rural Territorial Tax - RTT - as established by Brazilian legislation, has a very small relationship with the total national tax collection, which, from now on, relatively mitigates its fiscal function in a country whose territorial vastness is continental. On the other hand, in the extrafiscality aspect, the tax is not more successful either, since, although wrapped in commendable grounds of adequacy of the land to a social function and allied to the sustainable use of the environment, the Brazilian State does not have inspection

instruments. effective in achieving the objectives assigned to the tax, failing in the related regulatory and administrative functions.

## V. CONCLUSION

Property consists of an essential right for the development and evolution of the human species in society, whereas, for the famous philosopher John Locke, property would be a natural right, prior to man himself, elevating it as a right embedded in life and in the freedom of man, which is denoted by influences of liberalism.

On the other hand, Rousseau, also in the modern age, attributes to man the possibility of appropriating things and having dominion over them, organizing himself in society, that is, property exists as a function of society.

Both thinkers played a fundamental role in the understanding of the aforementioned property right around the world, even after the rise of the Welfare State, a relevant model of State interference in private property through fundamental constitutional norms that aimed at an evolution in the human rights after the horrors of two world wars.

In Brazil, given the aspects of Portuguese colonization, with irregular land occupations and lack of effective rules, the right to property emerges in the constitutional texts from the Magna Carta of 1824, but takes greater emphasis with Law n. 601/1850 – Land Law.

In the following Magna Carta, of 1891, there was already a provision for the institution of a tax on rural properties, however, this rule did not really materialize until the enactment of the Land Statute in 1964. It is observed that the concentration of rural lands in the hands of an agrarian elite, with roots in the period of the Colony and Empire of Brazil, was fundamental in not achieving a tax collection on rural lands, since, with the political influence of these actors and for financial and power reasons, there was no interest in regularize the aforementioned taxation.

With the regulation of the Rural Land Tax - RTT - in the Land Statute, two functions are denoted: the fiscal one, with the purpose of collecting funds for State investment in public policies and the extra-fiscal function, by which the objective was to encourage landowners to produce and exploit their lands in a sustainable way and in line with the social function of property.

It turns out that studies on the subject demonstrate State failures in the inspection and collection of the RTT - Rural Territorial Tax, considering that the method of declaring the tax bases by the owner himself is deficient, often due to false information provided, in order to of

reducing the value of the tax or even inducing a false perception of a high degree of productivity of the property, which prevents an expropriation process for land reform purposes.

In an analysis of a study compared with other countries, whether in South America, North America or Europe, it appears that the RTT collection in Brazil is extremely small in relation to the total collected in the country, being only about 0.3 per percent, while in other nations, such as the United States and Canada, it is estimated, on average, 5%.

As an instrument to guarantee property and other fundamental rights, the State has the power to tax, with the constitutional limitations that are inherent to it, and the RTT - Rural Territorial Tax is an instrument for tax collection - monetary - and also extrafiscality, that is, aims at objectives other than financial ones, such as encouraging the rational and sustainable use of land.

That said, weighing all the studies and research carried out, it is observed that the State guarantees the right to property, as one of its foundations, as long as it serves a social function, serving the common good. However, when verifying the scope of the RTT's effectiveness in this context, normative and supervisory inefficiency is verified, mitigating the relevance of the tax in the national scenario as an instrument for tax collection or for the healthy promotion of the social function of property.

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# Management of occupational safety and health (OSH) in university chemical laboratories: A case study at a University Federal Public service in the interior of Paraná - Brazil

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**Keywords—** Management, OSH, university,  
chemical laboratories.

**Abstract—** The risks associated with academic research are often much lower than those in large-scale process industry operations. While inventories of hazardous materials are lower in the university environment and the number of hazards may be lower, factors such as chemicals used in laboratories and the proximity of researchers to their equipment can equate to a high individual risk for laboratory users. The number of reported laboratory accidents resulting in fatalities, serious injuries, and financial loss demonstrates a need for better risk management practices in academic teaching and experimental research laboratories. Academic and research labs at universities contain various risks, and the associated risks can be significant if not appropriately managed. The misperception that university labs are low risk is partly due to a lack of awareness of the hazards. This paper discusses an approach to applying health and safety practices to chemistry laboratories at a federal university in the interior of Paraná and discusses selected challenges and suggested solutions.

## I. INTRODUCTION

Safety and health have been significant issues developing in the social context due to the increased concern with preventing dangerous situations for people everywhere (Li et al., 2015). The point of safety does involve not only industries but also educational institutions that have laboratories whose users are highly exposed to various hazards such as chemical, biological, physical and radioactive hazards and musculoskeletal disorders (Fan et al., 2014). These hazards can be avoided because there are many factors capable of contributing to the safety and

health in the laboratory, such as the correct operation of instruments, stress management, handling of chemical or hazardous material, risk assessment, and emergency procedures (Reader et al., 2015).

State or federal regulations generally regulate safety and health practices that limit exposure to hazardous substances. Many educational institutions have developed their occupational safety and health programs approved and monitored by a management board (Liu et al., 2015).

However, even an almost perfect system can incur a breach; there is always the possibility that something will



not go as planned, exposing specific hazards through accidents and injuries to users. These undesirable possibilities can occur due to certain flaws in safety procedures or even lack of safety culture and awareness, careless attitude, poorly designed laboratories, and overcrowding (Reader et al., 2015). Regulatory bodies have noticed that many higher education institutions have studied workers' attitudes and perceptions of safety in many Western countries (Fan et al., 2014). Of these, the main factors for laboratory accidents stem from the human attitude and the accumulation of information and experiences, which lead individuals to act in a certain way when faced with a particular stimulus (Catino; Patriotta, 2013). Laboratory safety does not just involve strict adherence to regulations; it is also the result of everyone's attitude and commitment (Hajmohammad; Vachon, 2014). Students adhere to the rules only in some situations and may not follow all of them. The biggest challenge in educating students about safety is getting them to understand and recognize hazards rather than just following safety rules (Högström et al., 2010).

For Maksemiv and Michaloski (2016), safety is paramount in science teaching, and it is necessary to improve safety practices and culture in many universities. The importance of laboratory safety must be encouraged in students from the beginning, repeatedly, and must not be forgotten (Catino; Patriotta, 2013). However, universities can and should play a more active role in controlling risks to ensure the safety of students, faculty, staff, and even visitors. Occupational safety and health (OSH) should be practiced to increase awareness among laboratory users (Gonçalves Filho et al., 2013).

Indeed, OSH issues are as important as human rights and should not be considered another privilege (Oliveira et al., 2010; Nordlöf et al., 2015). To meet OSH requirements, universities must ensure that campuses are safe and conducive to these activities. Because of this, the Brazilian Association of Technical Standards (ABNT, 2011) recommends some recommendations for improving security in colleges and universities:

1. isolation, preventing access to personnel who do not work directly with the laboratory;
2. controls to provide a ventilated workspace that typically includes chemical fume hoods, biosafety cabinets for working with hazardous chemicals and pathogens;
3. administrative controls to provide safety training, access to risk information, and laboratory inspections by health and safety institutions to ensure a safe working environment;
4. Personal Protective Equipment (PPE) such as lab coats, eye protection, and gloves provide a direct

protective layer for researchers. Depending on the risk, additional equipment is often required.

These recommendations may include, for example, relevant guidance on the health of particular groups such as students, faculty, and staff; applicable legislation, such as health surveillance of researchers exposed to animals; and other information, such as the size of universities, the age distribution of university staff and students, and the pattern of employment at universities, which is determined by university funding arrangements (Hirata; Mancini Filho, 2002; Högström et al., 2010).

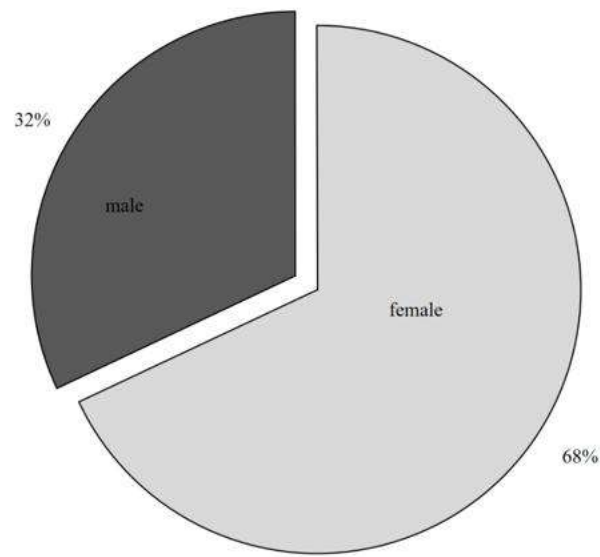
Taking the scenario presented as a reference, the present study addresses and assesses the level of safety and awareness among users of chemical laboratories at a federal public university in Paraná. In addition, the study describes the nature of OSH as a result of the challenges of its integration into university education. The way forward must be to develop an integrated university approach to creating a safe and healthy working and learning environment, combined with the inherent learning risks.

## II. METHODOLOGY

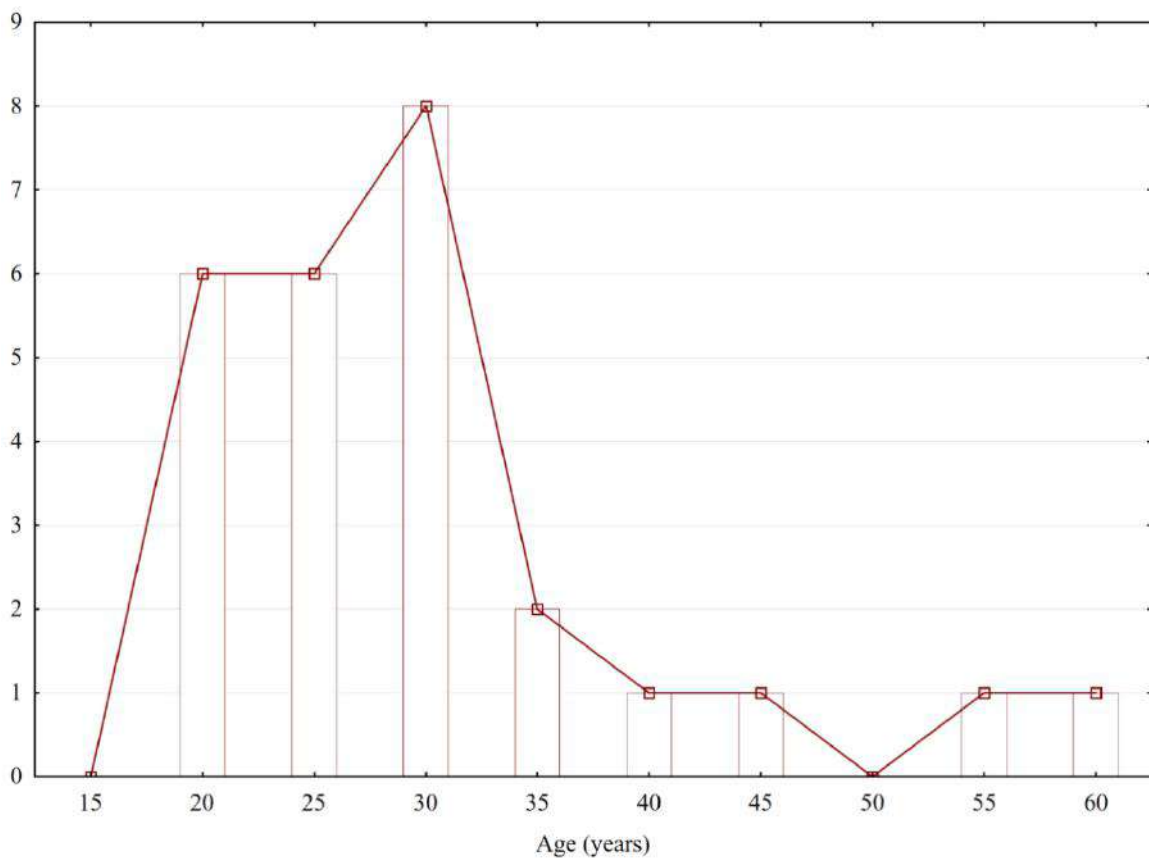
The study was carried out between December 2019 and January 2020 in three chemistry laboratories of a federal public institution in the interior of the state of Paraná. A total of 20 master's and doctoral students and five laboratory technicians participated in the study and received the questionnaire to answer. The questionnaire-based on the biosafety manual for chemical laboratories by Hirata and Mancini Filho (2002) was developed and designed in two parts: part A, composed of demographic data, and part B, consisting of 10 questions related to safety awareness in the laboratory and ten inquiries about laboratory safety practice. The questionnaire consisted of closed questions that should meet a Likert scale adapted to four points. Respondents would assign scores to each question if 1 - strongly disagree, 2 - disagree, 3 - agree, or 4 - strongly agree. The collected data were analyzed using the Statistica 10 software and considered Cronbach's Alpha as a reliability criterion (Leontitsis; Page, 2007). This section presents the results obtained in the survey with the 25 respondents. Initially, we have the demographic data referring to part A of the questionnaire, that is, sex, age, knowledge about safety standards, and time of experience in laboratories. Figure 1 (a) presents the percentage of respondents by gender and indicates that 32% are male and 68% are female. Figure 1 (b) shows the age of the respondents. It is worth noting that most master's students enter graduate school immediately after completing their undergraduate courses. And the highest age is precisely the technician with the longest time in the institution. Figure 2

(a) shows the percentage of respondents about the safety knowledge of the laboratory, and Figure 2 (b) shows the time they are in direct contact with the laboratories. From

the results, it is possible to verify that most of them know safety and health aspects; that is, of the 25 respondents, only one says they do not know.

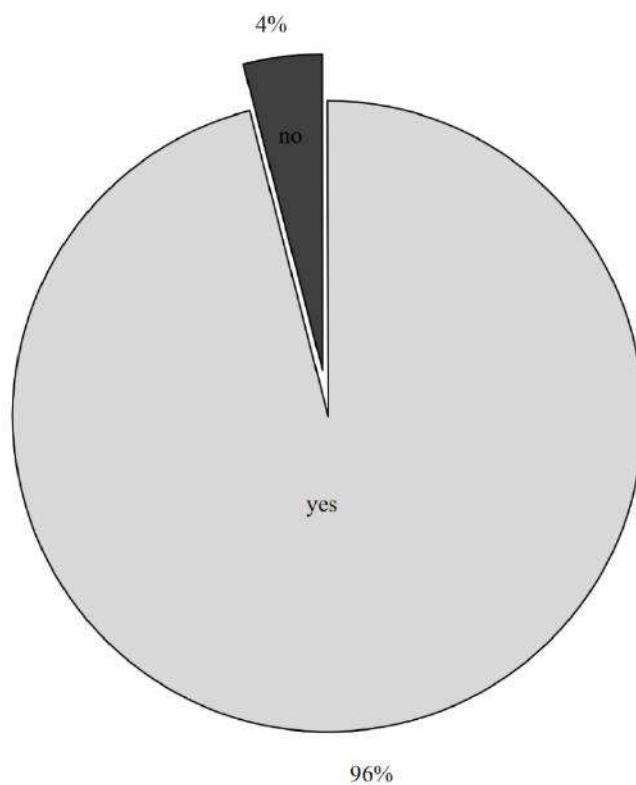


(a)

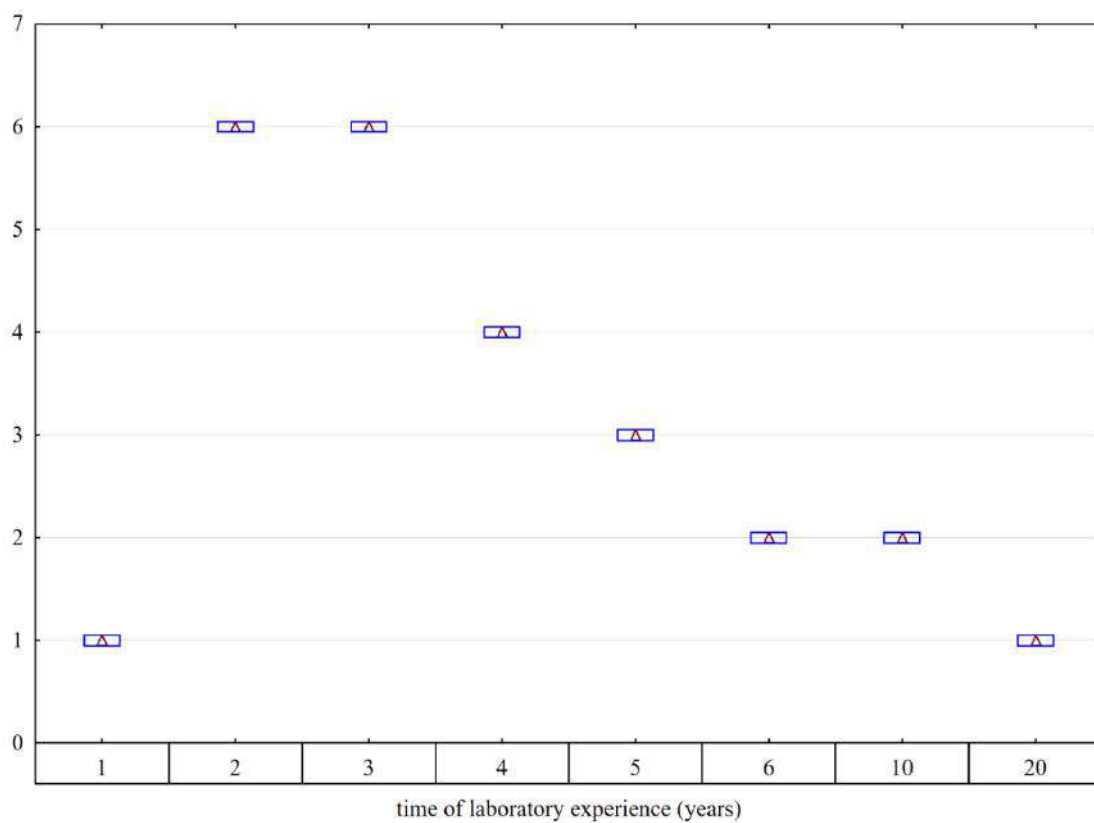


(b)

Fig.1 Percentages of respondents in relation to: (a) sex; (b) to age.



(a)



(b)

Fig.2 Percentages of respondents concerning: (a) knowledge of safety standards;(b) the time of trial.

In addition, Figure 2 (b) presents the percentage of laboratory experience among the respondent users. With the results, it is possible to verify that 8% of the team has ten years of experience and 4% more than 20 years, while the other 4% refers to the respondent who has only one year of experience. These two values refer to the technician with the highest age and the longest time in the institution and the master's student with the lowest age and the least experienced in the laboratory. The rest of the respondents had between 2 and 6 years of experience, accounting for 84%, of which 48% are respondents with 2 and 3 years of laboratory research.

To analyze the second part of the questionnaire (part B), it was necessary to establish a reliability criterion for the data. In the case of using the Likert scale, it is recommended to use Cronbach's Alpha at an acceptable value above 0.80 so that the data are well correlated (Leontitsis; Page, 2007). Table 1 provides reliability statistics for the questions used in this study. The result shows that Cronbach's Alpha was 0.82 and 0.87, respectively, for the ten questions related to safety awareness in the laboratory and the ten questions related to the safe practice in the laboratory, which is considered

reliable for the data (Leontitsis; Page, 2007). Table 1 also shows the mean and the respective standard deviations for the 20 questions.

Security awareness data among lab users are presented. The average score for each question was between 3 and 4, representing the respondents' agreement with the proposed statements. The most excellent awareness was related to the laboratory being well ventilated and knowledge of safety kits, which reflects the need to help some users if there is a need. Respondents gave it the lowest score regarding cleanliness and organization, representing a problem many universities face. After carrying out experiments, many students do not clean and organize the laboratories as they should. In this case, it is up to the technicians and the guiding teachers to reaffirm the importance of cleaning. It is essential to highlight the number of respondents who agreed with the extent of supervision while performing some practical work in the laboratory.

Appropriate supervision practice helps ensure a safe environment for all academics in their activities, including laboratory activities (Langerman, 2009).

*Table 1 Data related to security awareness and practice*

<b>Laboratory safety awareness</b>		
	Questions	Mean and standard deviation
Q1	Electrical wires are always arranged in their places.	3.60±0.50
Q2	Electrical equipment is turned off after use.	3.48±0.51
Q3	The laboratory is cleaned and organized after use.	3.24±0.44
Q4	All chemicals are labeled and stored.	3.78±0.51
Q5	The laboratory is well ventilated.	3.88±0.33
Q6	The fire extinguisher works and is in a suitable location.	3.53±0.51
Q7	Lab exits are accessible.	3.72±0.46
Q8	There are first aid kits in the lab.	3.88±0.33
Q9	The safe operating procedure (SOP) is visible on the equipment.	3.40±0.50
Q10	Supervision of laboratory technicians is essential.	3.85±0.50
Cronbach's alpha		0.82
<b>Laboratory safety practice</b>		
	Questions	Mean and standard deviation
Q11	Laboratory users can handle chemicals.	3.40±0.30
Q12	I know the danger I run in working with chemicals.	3.32±0.11
Q13	Laboratory staff knows the material safety data.	2.92±0.23
Q14	Use personal protective equipment (PPE)	3.40±0.62
Q15	I know how to use the fire extinguisher if necessary.	3.28±0.13
Q16	I know the rescue procedures.	3.06±0.45

Q17	I know how to label and classify a chemical.	2.72±0.38
Q18	I can identify hazards and risks in the laboratory.	2.88±0.34
Q19	I can locate the first aid kits.	2.60±0.48
Q20	I know how to give first aid.	2.40±0.49
Cronbach's alpha		0.87

Table 1 also presents data regarding safety practices implemented in the laboratory. As a result, the average score for each question varied between 2 and 3 and between 3 and 4. This means that some users agree, and others disagree with these questions. Behavior also plays a significant role in every organization, and many of the accident-causing factors are driven by individual attitudes towards safety and health issues (Langerman, 2009). If there is bad behavior regarding safety practices, there will not be a good functioning of an educational institution (Hirata; Mancini Filho, 2002; Penna et al., 2010). Based on the results, it is possible to verify that the highest score was given to qualified users to handle chemicals in the laboratory and protective equipment, followed by knowing how to identify the danger and use the extinguisher. The evolution of technological processes has led professionals involved in laboratory teaching activities to be exposed to various biological and chemical risks. According to Hirata and Mancini Filho (2002), the assessment and management of risks are mandatory for the definition of criteria and actions, aiming to minimize the hazards that can affect the health of teachers, technicians, students, and the environment. Regarding personal protective equipment, these are considered primary containment barriers and, together with good laboratory practices, aim to protect individuals and the laboratories themselves (Hirata; Mancini Filho, 2002; Penna et al., 2010). Together, these practices show a good attitude towards creating a safe laboratory environment.

The lowest grade was attributed to knowing how to provide first aid. This is a worrying factor, as several studies advocate that first aid training should be part of the school curriculum (Chima, 2016; Cave et al., 2011). In this way, it is recommended that employees and master's and doctoral students respondents undergo training to know how to act in emergencies. In laboratories, individuals need to be trained in safety and first aid techniques. Each unit must develop its safety manual, identifying risks and operational work procedures, which must be available to all site users (Penna et al., 2010).

### III. CONCLUSION

Based on the analysis of the results, it was possible to conclude that some users understand and practice safety and health. In contrast, others do not develop these practices while conducting activities in the laboratory. Unfortunately, this condition contributes to unplanned events to occur. Safety knowledge and exercise are necessary because they can create a safe workplace environment. For improvement, users must receive safety and health information and training that pay attention to the hazards present in the laboratory. Knowledge about safety practices is essential to avoid or minimize accidents. It is necessary to highlight that the research result was passed on to those responsible for the laboratories of the university participating in this study. They informed that in 2019 the Regulation of the Food, Environmental and Chemical Laboratories of the University was enacted to be implemented in 2020.

Culture must also be created that values health and prevention risks. It is essential to develop a culture of risk and prevention in training programs at all levels of education and in all areas. An educational institution must be a safe and healthy work environment appropriate for education. At the same time, the presence of vulnerable groups (e.g., very young students) and the needs of people with disabilities must be taken into account. The university sector is growing and needs to expose information on hazards and risks and relevant information for planning health provision. This information may include, for example, appropriate guidance on the health of particular groups such as students, faculty, and staff, relevant legislation, health surveillance of researchers exposed to chemicals, and other information such as the size of universities and age group. Of university staff and students.

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# The Importance and Challenges of School Feeding: Literature Review

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**Keywords**— School food, School health, Healthy eating, Nutritional education, School feeding.

**Abstract**— To select in the literature the importance and challenges of food for the development and potential of the individual related to growth, promotion, and health. Method: This is an Integrative Literature Review and 188 articles were selected for analysis. After applying the defined inclusion and exclusion criteria, 15 studies were included in the research. The studies showed that dealing with the subject is essential, allowing children and adolescents access to healthy and quality food, guaranteeing their right to food as provided for in the Statute of Children and Adolescents. Most studies concluded that several schools do not offer adequate food to their users, despite the importance of this practice being evidenced by the works. Therefore, implementing and implementing the guidelines that the National School Feeding Program legislation offers is essential to change this scenario in the school context.

## I. INTRODUCTION

According to the Food and Nutrition Security Law, Article 2, No. 11. 346, adequate food is considered a fundamental human right, inherent to the dignity of the human person and indispensable to the realization of the rights enshrined in the Federal Constitution, and the public authorities to adopt policies and actions that are necessary to promote and guarantee food and nutrition security for the population [1]. Food and nutrition are foundations for the promotion of the population's health, as well as for the protection of health. And together they help in the proper

human development, improving their potential and improving the quality of life.

Food is understood as a conditioning and determinant factor of health, food and nutrition actions are conducted to play their role in a transversal way to health actions, in a complementary character and with formulation, execution and evaluation within the activities and responsibilities of the health system [2].

Aiming at this scenario and due to the transformations that Brazil has been going through, such as the Food and

Nutritional Transition, the National School Feeding Program (PNAE) was created, aiming to offer school meals and food and nutrition education actions to students of all stages of public basic education. The PNAE works through the federal government, which transfers to states, municipalities and federal schools, financial amounts of a supplementary nature made in 10 monthly installments (from February to November) to cover 200 school days, according to the number of students enrolled in each education network [3].

Since school meals are important for the growth and health promotion of children and adolescents, thus providing greater learning, biopsychosocial development, promoting food and nutritional security, quality health, increasing school rates and ensuring that they become citizens with rights. For this, it is necessary that the State can intervene to guarantee this food, not only in the school environment, but in their homes.

However, the Program has been going through several challenges over the years and in 2020, these challenges intensified with the COVID-19 Pandemic, when adaptations were necessary for school meals to reach students, and the entire production chain as family farming has undergone changes so as not to interrupt its actions during the period of social isolation.

Considering the current conjecture, this literature review aimed to analyze studies on the subject: school feeding and its challenges and importance to society, seeking to contribute with a critical view on the subject.

## II. METHODOLOGY

The work consists of a bibliographic research carried out in the following databases: SciELO (Scientific Electronic Library Online) and Pubmed. The following descriptors in Portuguese were used for the research: School feeding, school health and healthy eating. These descriptors are listed in the descriptors tools in Health Sciences (DeCS) of the Virtual Health Library (VHL), articles written in Portuguese, available online in the selected databases and published between the periods from 2017 to 2022. It was adopted as inclusion criteria, which addressed the theme of the study at the national level. Among the exclusion criteria selected are studies that are duplicated in the aforementioned databases, gray literature, incomplete works, editorials and studies that are not related to the topic addressed in this article.

## III. RESULTS

The number of articles selected according to the eligibility criteria was 15 articles. Among the articles, all belonged to the Pubmed database and the SciELO database. The works were organized in a table containing the title of the article, authors, source database and conclusion, as described in Table 1.

Table.1: Summary of articles selected for review

Title	Authors	Data base/year	Conclusion
Background and elements of the link between Brazil's school feeding program and family farming. [4]	Schwartzman F; Mora C,A,R; Bogus C,M; Villar B,S.	SciELO/2018	The analysis of the articles showed that the purchase of family farming by the PNAE is a wide-ranging initiative, from the conceptual, execution and results point of view. It was also demonstrated that, for its success, a wide articulation between the actors and bodies of the various sectors involved is essential, as well as the implementation of multiple strategies by the different spheres of government. In this way, linking the education, agriculture, planning, procurement and civil society sectors, and should be articulated at national, state and local levels. The results of this study demonstrate that initiatives such as these, of institutional purchases of family farming, currently implemented in several countries, are configured as an

			important strategy for food and nutrition security, for fulfilling the human right to adequate food and for promoting sustainable development in long term.
It is necessary to continue with direct purchases from local family farming through the National School Feeding Program. [5]	Schwartzman F; Mora C,A,R; Bogus C,M; Villar B,S.	Scielo/2018	<p>The article presents a debate about the direct purchase of family farming by the PNAE, emphasizing its importance and advances, as well as the challenges linked to practice, such as infrastructure, technical training, technical assistance to farmers. In addition, it was presented that the purchase of family farming is just one of the strategies of the PNAE and must be accompanied by several other programs instituted by the PNAE, such as food and nutrition education, teaching of school gardens, strengthening of controls in a continuous, integral and integrated into social school curricula, etc.</p> <p>The authors also stated the importance of further research on the subject.</p>
The National School Feeding Program: the world is inspired, will we be able to maintain progress? [6]	Recine, E.	Scielo/2018	<p>The analysis of the article showed that budget availability is necessary, but not sufficient to maintain and expand the purchase of family farming. Measures, for example,</p> <p>of support and strengthening of the sustainable local production process, a priority for the most</p> <p>vulnerable, of structuring administrative processes compatible with the purchase objectives of family farming for the viability of food and nutrition education actions, in short, the</p> <p>set of aspects that configured the PNAE as an example to be followed, need to be kept and expanded.</p>
Evaluation of the National School Feeding Program: literature review. [7]	Nadinne D,F; Melo L,S; Silva F,A.	Scielo/2018	<p>The review highlighted the problems in the performance of the nutritionist and the School Feeding Councils, in the acquisition of food from family farming and in the composition of menus, with low content of fruits and vegetables. Emphasizing the need for greater attention related to the execution of the PNAE, aiming to guarantee school meals within principles that promote food and nutritional security. New evaluative studies on the Program were suggested, being fundamental for the supply of subsidies to public managers in</p>

			order to improve its execution.
School meals and the constitution of schoolchildren's identities: from meals for the poor to the right to food. [8]	Silva E,O; S Santos L,A; Soares M,D.	Scielo/2018	Initially, the study discusses the persistence of discourses and practices of an assistentialist nature that reduced school meals to food for the poor, which were observed in the studies. The meanings of this welfare character are in line with the understanding that it seems to work as a mechanism of power capable of inscribing, in schoolchildren, an identity of poverty and inferiority. This understanding is situated in the power relations existing in the school, in the exercise of disciplinary power and its potential to produce identities, as well as in the practices of resistance arising from these powers in the context of school meals. It is also considered that schoolchildren are agents of their own identity processes, and in their relationship with school meals, in addition to subjection processes, there are also processes of resistance and active construction of food identity, in which they add the traditional and the modern, the local and the global, among other aspects. Even if ambiguities are perceived in this scenario, it is understood that they are indications of changes in the paradigm of thinking about and making school meals, bringing elements to problematize it: on the one hand, still as a device for maintaining social inequalities and, on the other, , efforts and actions to promote it as a right and promoter of emancipatory identities.
National School Feeding Program as a promoter of Local, Healthy and Sustainable Food Systems: an assessment of financial execution. [9]	Soares P; Martinelli S,S; Fabri R,K; Veiros M,B; Blanes M,C,D; Cavalli S,B.	Scielo/2018	It was concluded that the financial complementation of the municipality denoted 65% of the total. The total amount used to purchase food was: 65.5% Recommended, 27.9% Restricted, 6.5% Other and 0% Prohibited. Spending on Recommended foods was higher ( $p < 0.001$ ) than with the other groups. AF exclusively provided Recommended foods, representing 12.1% of total investment (municipal and federal) and 29.5% of federal resources. The direct purchase of AF contributed to the acquisition of Recommended foods. The municipality's financial complementation was not directed to the AF, which could compromise the potential of the school feeding program in the promotion of sustainable, healthy and



			local agro-food systems.
Good Practices in School Food and Nutrition Units in a city in the state of Rio de Janeiro – Brazil. [10]	Soares D,S,B; Henriques P; Ferreira D,M; Dias P,C; Pereira S; Barbosa R,M,S.	SciELO/2018	The study can conclude that All UANE found to be partially suitable for the Thematic Block (BT) building. For BT handlers, processes/procedures, environmental hygiene and equipment for controlled temperature, most showed partially adequate and inadequate results. The majority of UANE was adequate for receiving BT. The results of the PF classified most of the UANE (66.7%) as a regular health risk, indicating the need to carry out corrective measures for the Good Practices in the UANE and offer safe meals to the school public.
Purchase of food from family farming by the National School Feeding Program (PNAE): cross-sectional study with the universe of Brazilian municipalities. [11]	Machado P,M,O; Schmitz B,A,S; Chica D,A,G; Corso A,C,T; Vasconcelos F,A,G; Gabriel C,G.	SciELO/2018	It was concluded through the study that, despite the widespread acquisition of food from family farming by the program throughout the country, 50% of the municipalities did not invest the minimum required by law, demanding educational and technical assistance actions, aimed at compliance legislation, especially in the states and regions that presented greater difficulties.
Food and nutrition education actions and nutritionists within the scope of the National School Feeding Program. [12]	Silva S,U; Monego E,T; Sousa L,M.	SciELO/2018	An association was found between the presence of the nutritionist in the school environment and the proper practice of EAN, under conditions that meet the legislation, enabling the fulfillment of their attributions, as defined by the Legal Framework of the PNAE and the Federal Council of Nutritionists.
Interactions between food practices and identities: resignifying the public school and school food. [13]	Silva E,O; Santos L,A; Soares M,D.	SciELO/2018	The discussion in the article showed how much the dialogue between the field of education and the field of food and nutrition can contribute to making school meals an integral part of school practices not as mere nutritional support, but as food that values public schools and their families subjects.
School meals and family farming: analysis of resources used to buy food. [14]	Araujo L,R,S; Brito A,N,M; Rodrigues M,T,P; Mascarenhas M,D,M; Araujo R,S,R,M.	SciELO/2019	The study concluded that in the period from 2011 to 2017, only a third of the evaluated capitals used the percentage of financial resources properly for the purchase of food from family agriculture, although a gradual increase in the purchase of these foods was observed, especially in the capitals of the North and Northeast of Brazil.

National School Feeding Program: a healthy public policy. [15]	Kroth D,C; Geremia D,S; Mussio B,S.	Scielo/2020	It was observed that the PNAE contributes to health promotion and can be understood as a Healthy Public Policy. The PNAE, by articulating actions from different sectors, makes public policy more effective and more efficient, as it generates positive results beyond health, maximizing returns for society. In this way, mechanisms are proposed for the improvement and strengthening of the PNAE, aiming to complement and reinforce actions carried out in the SUS.
Adherence to school meals and associated factors in adolescents from public schools in southern Brazil. [16]	Cesar J,T; Taconeli C,A; Osório M,M; Schmidt S,T.	Scielo/2020	The article showed a low rate of adherence to school meals, that is, the universality of care is not being achieved. The mentioned factors can help to improve the execution of the program.
Feasibility in meeting the rules of the National School Feeding Program and its relationship with the cost of menus. [17]	Junior E,V; Oliveira D,C,R,S; Pinto R,L; Marques E,S; Cunha D,B; Sarti F,M.	Scielo/2021	Through the results exposed in the study, it was concluded that it is unlikely to obtain menus that meet all the requirements of the PNAE.
Adherence to school meals by Brazilian adolescents: individual and school context determinants. [18]	Vale D; Lyra C,O; Santos T,T; Souza C,V,S; Roncalli A,G.	Scielo/2021	The results of the study demonstrate an important effect of the school context in determining the consumption of school meals by adolescents

Source: Authors, 2022

#### IV. DISCUSSION

The PNAE, as well as the various school feeding programs implemented since the 1940s in underdeveloped countries, underwent a period of significant transformations over the years, going from a purely welfare program to a public policy based on the right to quality food for all citizens. And today its role in boosting the local economy through the purchase of food from family farming makes this program essential for the maintenance and promotion of healthy eating habits [12]. And according to the discussions by Schwartzman et al; In 2017 [4], it was possible to identify that the objective of linking school meals purchases to local producers, and not only to large suppliers and producers from remote municipalities, goes far beyond the exchange of suppliers, since this approximation is not limited to the commercial relationship; it fits within a new intersectoral and comprehensive vision of school feeding policy that is being adopted in Brazil and in other countries.

However, the challenges faced by the Program and its link with Family Agriculture are notorious, reflected in the lack of logistics, difficulties in price

calculation and identification and registration of farmers, technical assistance to farmers, sanitary adequacy, training of nutritionists to work in the PNAE, lack of management by farmers, difficulty in preparing menus that reflect local production and the very strengthening of intersectorality, these points being presented in some discussions of this review.

Schwartzman et al. [5] in yet another study on the subject demonstrates the importance of strategies that link family farming to government purchases, especially the school feeding program, such as the PNAE. Representing a big step towards strengthening food and nutrition security, and guaranteeing human rights in adequate food for both farmers and school lunches.

Brazil was one of the pioneers in the initiative to link the school feeding program with the purchase of fresh food from family farming, serving as a model for other countries. And despite its indisputable importance, there are many gaps to be addressed, especially at the local level. It is essential to offer the social actors of this program the human and financial resources necessary to

continue to progress and ensure that there are no setbacks [9].

However, it is always important to point out the risks that the PNAE runs considering the institutional changes and budget cuts that have taken place since 2016. As described by Recine et al. [6] in his study, access to the PAA is at risk, both by the producing families of farmers and by individuals in situations of food and nutritional insecurity served. Given that, due to the new configuration, the PAA is no longer a structuring program aimed at strengthening family farming and becomes a Social Assistance program, with a 39% reduction in the budget compared to 2016, which will lead to a reduction the number of families served from 91.7 thousand to 41.3 thousand. And adding to this scenario, we also have the considerable impacts of the COVID-19 Pandemic in relation to the acquisition of food through family farming, as well as a decrease in production due to social isolation. Such factors significantly corroborate the decrease in the purchase of food by the PNAE.

Regarding the nutritionist's role in the Program, Silva et al. [13] in their study, pointed out that the presence of the nutritionist RT increases the chances of carrying out Food and Nutrition Education (EAN) actions in schools. However, the research results did not show statistical significance, and municipalities with a higher school population had a higher frequency of non-performance of EAN actions, which may be related to the fact that most of the investigated municipalities had an insufficient number of nutritionists in the Technical Staff of the PNAE. Implying the reduction of EAN actions in schools

## V. CONCLUSION

From the presentation of the data of this review, it was possible to perceive that the number of publications on the subject is small, however, the limitations of the research to obtain the data, the inclusion and exclusion criteria and the limited use of platforms are taken into account. of research.

However, according to the analysis of the present research, the importance of school feeding as a strategy for changing eating habits was noticeable, as well as the incentive to family farming, which is widely discussed as the subject of the articles, thus reinforcing the studies on the PNAE. These researches are crucial for the understanding of the food acquisition process.

In this way, it is concluded that implementing and executing the guidelines that the legislation of the National School Feeding Program (PNAE), especially in pandemic

periods, will always be a great challenge and to reinforce preventive studies that evaluate the mode of action during periods of crisis if necessary in order to guarantee citizens' right to food.

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## Factors associated with delay in the diagnosis of pulmonary tuberculosis in Belém/PA

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**Keywords—Delayed Diagnosis, Health Care, Health Services Accessibility, Primary Pulmonary Tuberculosis**

**Abstract—Introduction:** Tuberculosis control tools are a challenge to primary health care, due to the delay of people from the appearance of the first symptoms to the search for the first health-care service, and health-care services leading to difficulties and delay in establishing the diagnosis and initiation of treatment. **Objective:** to analyze the factors associated with the time from the identification of symptoms to the beginning of treatment for pulmonary tuberculosis and to measure the related time. **Materials and Method:** Quantitative, cross-sectional and analytical study, with 101 patients being treated for pulmonary tuberculosis, in five Basic Health Units. They were interviewed using an adapted and validated questionnaire. Data were analyzed using the G Test, in the BioEstat 5.3 Program. **Results:** 53.27% of patients were late to seek health-care services. The diagnosis was classified as “no delay” (50.5%). Male sex, complete high school education are factors related to delay in the diagnosis of tuberculosis, as well as the frequency of seeking health-care services for diagnosis showed statistical significance ( $p=0.0264$ ). **Discussion:** Men are the most affected by the disease, due to risk factors. There is a need to invest in the training of teams to carry out early diagnosis and rapid suspicion of the disease. **Conclusion:** There are important actors in disease control: the health-care service and the patient. The delay is related to the tuberculosis patient, with the need to speed up the diagnosis of the disease, so that the patient does not have to return to the service several times.



## I. INTRODUCTION

The main tool for controlling tuberculosis (TB) is the early diagnosis and initiation of treatment for people affected by the disease. For this, early detection of respiratory symptoms (RS) is necessary, those people who have persistent cough for two or three weeks [1]. The active search in the community then becomes an essential tool, strengthening the decentralization of TB control actions to primary health care (PHC) [2]; [3].

The scope of TB control tools is a challenge for the PHC health team, due to the delay of people from the onset of the first symptoms to the search for the first health-care service (HCS), caused by factors related to the patient's knowledge, perception, beliefs and coping with the disease. Aspects related to health services are also highlighted, such as: barriers to access; failures related to low resolution; and, fragmentation of care with referrals to specialized services, leading to difficulties and delay in establishing the diagnosis [4]; [5]; [6].

In Brazil, in 2021, 68,271 new cases of TB were diagnosed, which corresponded to an incidence coefficient of 32.0 cases/100,000 habitants. In the same year, the northern region of the country had the highest TB incidence coefficient among Brazilian regions (45.3/100,000 hab.), confirming the disease situation in the state of Pará, the sixth state in terms of incidence of the disease (42, 6/100,000 hab.) and the capital Belém the seventh capital in incidence in Brazil (67.5/100,000 hab.) [2]; [7]; [8].

The National Plan for the End of Tuberculosis as a Public Health Problem favors the decentralization of TB detection, diagnosis and monitoring actions for PHC, expanding the population's access, due to its proximity to the user and the hierarchy of the complexity of health care, speeding up the diagnosis and treatment of TB [9]; [10].

In this context, the behavior of the patient in the healing process must be valued by the health team, aiming at delaying the suspicion of the disease, with the intention of performing the treatment immediately and completely. Thus, the performance of nursing stands out in concentrating efforts around individuals or the community in order to protect, promote and preserve it, in order to allow users to perceive the meaning of the disease, developing self-care and, therefore, control. effective treatment of TB [11]; [12].

The study had as objective to analyze the factors associated with the time from the identification of symptoms to the beginning of treatment for pulmonary tuberculosis and to measure the time related to this.

## II. MATERIALS AND METHODS

Quantitative, cross-sectional and analytical study, carried out with 101 pulmonary TB patients undergoing treatment in five Primary health Care in the city of Belém of Pará, with the highest number of cases of the disease. The research comes from a master's dissertation, so the data were collected between November 2016 and March 2017.

New TB cases undergoing treatment for Pulmonary TB enrolled in the elected units were included in this research, regardless of gender, age and municipalities/neighborhoods of residence. Patients undergoing treatment for extrapulmonary TB in the isolated form, cases of recurrence and re-admission after abandonment were excluded. The sample complied with the sample calculation performed in the Epi Info 7.0 program, considering the population of 251 new cases for the year 2015, a frequency expectation of 50% and a confidence level of 99.99%, resulting in a representative sample of 101 patients.

To obtain data, a form adapted by the researchers was used, based on the "Questionnaire for the Evaluation of the Performance of Primary Care Services in TB Control in Brazil", validated by Brazilian studies [13]; [14]. Thus, the time elapsed between the identification of symptoms by users and the beginning of treatment for pulmonary TB was calculated and the factors associated with them were analyzed.

The independent variables were: sex, age group, marital status, education, occupation, income; and the dependent variables were divided into, related to the patient: the time elapsed between the patient's identification of the first symptoms of tuberculosis and; related to the HCS: the time elapsed for the diagnosis and the beginning of the treatment.

The data were organized in a spreadsheet in Microsoft Excel 2016. In the univariate analysis, the frequency distribution of the variables was carried out and the G Test was later applied using the BioEstat 5.3 program, considering a significance level of 0.05 ( $p < 0.05$ ) and 95% confidence interval (CI= 95).

Time analysis was performed in three strata: patient's time to seek HCS from the first symptoms; time required by the HCS to establish the TB diagnosis since the first consultation; and the time taken to start treatment after diagnosis. This study followed the recommendations of Resolution No. 466/12 of the National Health Council, being approved under opinion No. 1.715.457.

### III. RESULTS

The patient's time to seek health services from the first symptoms was classified as delay, as in 101 participants, it was observed that 57 (53.27%) had > 15 days to seek health services (Fig. 1).

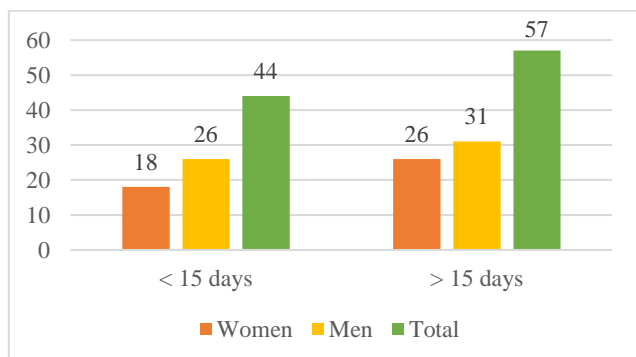


Fig. 1 - Time taken for patients to identify TB symptoms in UBS. Belém, PA, Brazil, 2017

There was no delay in diagnosing the disease. However, the results were practically similar, when compared to cases in which there were delays, 50 (49.5%) (Fig. 2). The time elapsed from the diagnosis of TB to the beginning of the specific treatment was between one and five days in 84 cases (83.16%).

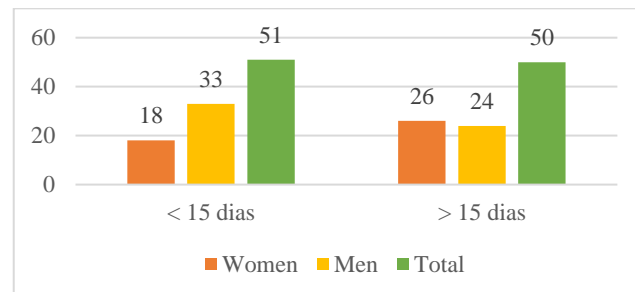


Fig. 2 - Time to TB diagnosis of patients in UBS. Belém, PA, Brazil, 2017

Table 1 - Sociodemographic and economic factors associated with the time for the identification of symptoms by the TB patient in the UBS. Belém, PA, Brazil, 2017

Variables	< 15 days		> 15 days		Total		p-value (G test)
Sociodemographic and economic	N	%	N	%	N	%	
<b>Gender</b>							
Masculine	26	45.6	31	54,4	57	100.0	0,8244
Feminine	18	40.9	26	59,1	44	100.0	
<b>Age range (Years old)</b>							
< 18	3	60.0	2	40.0	5	100.0	0,8691
18 a 29	11	39.3	17	60.7	28	100.0	
30 a 39	8	50.0	8	50.0	16	100.0	
40 a 49	10	50.0	10	50.0	20	100.0	
50 a 59	7	43.8	9	56.2	16	100.0	
> 60	4	28.6	10	71.4	14	100.0	
Not inform	1	50.0	1	50.0	2	100.0	
<b>Marital status</b>							
Married/stable union	13	44.8	16	55.2	29	100.0	0,7710
Widow/widower	2	28.6	5	71.4	7	100.0	
Sinle	24	44.4	30	55.6	54	100.0	
Separated/divorced	1	33.3	2	66.7	3	100.0	
Others	3	50.0	3	50.0	6	100.0	
Not inform	1	50.0	1	50.0	2	100.0	
<b>Educations</b>							
No schooling	1	100.0	0	0.0	1	100.0	0,8029

Incomp. Elementary School	10	37.0	17	63.0	27	100.0	
Comp. elementary school	5	35.7	9	64.3	14	100.0	
Incomp. high school	9	60.0	6	40.0	15	100.0	
Incomp. high school	1	33.3	2	66.7	3	100.0	
Comp. high school	15	44.1	19	55.9	34	100.0	
Comp. university education	3	42.9	4	57.1	7	100.0	
<b>Occupation</b>							
Unemployed	3	27.3	8	72.7	11	100.0	
Employee	12	44.4	15	55.6	27	100.0	
Housewife	4	40.0	6	60.0	10	100.0	
Autonomous	13	50.0	13	50.0	26	100.0	0,2522
Student	6	60.0	4	40.0	10	100.0	
Retiree	2	18.2	9	81.8	11	100.0	
Others	4	66.7	2	33.3	6	100.0	
<b>Income MW (1MW = R\$880,00)</b>							
< 1 MW	8	32.0	17	68	25	100.0	
1-2 MW	25	47.2	28	52.8	53	100.0	
3-4 MW	6	42.9	8	57.1	14	100.0	0,5128
> 5 MW	1	20.0	4	80.0	5	100.0	
Not inform	3	100.0	0	00.0	3	100.0	
No fixed income	1	100.0	0	00.0	1	100.0	

Source: By the author

Among the variables related to the HCS to perform the diagnosis, one presented a statistical association, corresponding to the frequency of looking for the health service to find out that he had TB ( $p=0.0264$ ), as shown in

Table 2. In this way, it was identified that TB patients who took more than 15 days to be diagnosed with TB were those who sought health services five times or more.

Table 2 - Factors associated with the time for the diagnosis of TB in UBS. Belém, PA, Brazil, 2017

	≤ 15 days		> 15 days		Total		
	N	%	N	%	N	%	p-value (G test)
Service that diagnosed TB							
Primary Health Care–Family	0	0.0	1	100.0	1	100.0	0,9921
Public hospital	6	50.0	6	50.00	12	100.0	
Private hospital	6	55.0	5	45.5	11	100.0	
Private office	3	50.0	3	50.0	6	100.0	
Urgency	6	60.0	4	40.0	10	100.0	
Primary health Care	30	49.0	31	51.0	61	100.0	
Time to get service							

5 days	5	55.5	4	44,5	9	100.0	0,8524
4 days	2	40.0	3	60.0	5	100.0	
3 days	1	20.0	4	80.0	5	100.0	
2 days	17	61.0	11	39.0	28	100.0	
1 days	24	46.0	28	54.0	52	100.0	
Not know	1	100.0	0	00.0	1	100.0	
Not answers	1	100.0	0	00.0	1	100.0	
Frequency of looking for the health Care to find out he had TB							
5 or more times	1	8.5	11	91.5	12	100.0	0,0264
4 times	3	50.0	3	50.0	6	100.0	
3 times	7	63.5	4	36,5	11	100.0	
2 times	25	54.5	21	45.5	46	100.0	
1 time	15	57.5	11	42.5	26	100.0	
Were diagnostic tests performed at the Primary health Care?							
Yes	33	50.0	33	50.0	66	100.0	0,5568
No	4	33.5	8	66.5	12	100.0	
In part	1	50.0	1	50.0	2	100.0	
Smear microscopy	4	66.5	2	33.5	6	100.0	
Culture	2	66.5	1	33.5	3	100.0	
X-ray	5	55.5	4	44.5	9	100.0	
Not answers	2	66.5	1	33.5	3	100.0	
Did you receive guidance on the proper way to collect the material?							
Never	2	100.0	0	00.0	2	100.0	0,595
Sometimes	2	100.0	0	0	2	100.0	
Ever	45	48.5	48	51.5	93	100.0	
Not answers	2	50.0	2	50.0	4	100.0	

Source: By the author

#### IV. DISCUSSION

The literature reveals that there is no consensual definition of what constitutes "acceptable" delay and it depends on the characteristics of the population, HCS, the local epidemiological situation and the study scenario, with a longer delay being expected when the incidence of the disease is high [15]; [16]. Thus, the study considered a delay of time > 15 days, both for the patient to seek the HCS after the symptoms, and for the service to establish the diagnosis, these criteria were established based on the time to consider a SR user and other research [11]; [17].

Among TB patients, time was classified as delay. This result is corroborated by other studies [15]; [18]; [19]; [20], which justify it due to financial difficulties, psychosocial problems, cultural characteristics of the

patients and for not recognizing the symptoms of TB, attributing it to other diseases with similar clinical conditions.

It is evident that patient delay has an influence on early diagnosis and disease control, showing that despite the decentralization of services to PHC, it is still partially effective. In this sense, it is shown that it is necessary to invest in PHC and in health education for the population, so that they identify the signs and symptoms of TB and seek HCS early.

Health professionals should approach TB patients and the community, seeking to recognize the factors that hinder self-care and adherence to treatment. Because the user's perception of the disease, that is, what he thinks about and his role in the face of it, configure essential

aspects for the development of self-care [12], as well as enabling a better and faster search for services.

Regarding HCS, there was no delay in making the diagnosis for TB, as most patients had a diagnosis with <15 days. However, the results are very similar to those with delay (49.5%), showing that there is still a need to invest in the training of health teams to carry out an early diagnosis, allowing the chain of transmission to be broken, since although the diagnoses were made at the UBS, the patients had to go to the services five times or more to find out that they were sick.

Despite the simplicity of the laboratory methods available to diagnose TB, delays in detecting the disease are still observed. The difficulties in performing an early diagnosis are related to the delay of the patient in the search for the HCS, the barriers in the functioning of the HCS, the passive search of the RS, as well as the lack of qualification of the health professionals(4,10) ,16).

It is noteworthy that delays in the diagnosis of the disease >15 days were identified in other studies, which increases the probability of TB transmission in the community, as well as the morbidity and mortality rate [16]; [21]; [22]; [23].

PHC is the key component of the health system and its organization takes place through the Primary Health Care–Family, which should prioritize actions to promote, protect and restore the health of individuals, especially in the TB program. However, these units have some difficulties due to the lack of professional qualifications for suspecting TB and providing care to the patient, because some symptoms are unspecific, preventing both the process of early diagnosis of the disease and the identification of the real needs of users [16]; [23]; [24].

There was no delay in starting treatment, as it took <5 days to start treatment with anti-TB drugs. Studies indicate that the median time to start treatment is 3 days [25]; [26].

However, there is still evidence that shows a delay >5 days to start the anti-TB therapeutic regimen [19]; [21]; [27]; [28], which is one of the main challenges for the prevention and control of TB in Brazil and in the world, since the beginning late treatment leads to increased morbidity and mortality and disease progression to severe and complicated forms, as well as increased TB transmissibility [21]; [28].

Despite the sociodemographic and economic variables not being associated with the identification of symptoms by the TB patient, the male sex is still the most affected, as men do not adequately take care of their health and are still more exposed to risk factors for the disease when compared women, due to the time devoted to work, going

out with friends, nighttime pleasures to poor diet, abusive use of alcohol, smoking and other drugs that with frequent use result in a decrease in immunity and, therefore, in the development of the disease [4]; [29].

Similarly, in a survey carried out in Zimbabwe, most of the study population had schooled up to secondary school, referring to high school in Brazil. The low education level of TB patients manifests a relationship with unstable socioeconomic determinants, which increase vulnerability to the disease and is responsible for the increase in its incidence and treatment dropouts [18]; [30], being a counterpoint of the study, in view of the evidence that most of the sample has completed high school.

The importance of searching for RS, of suspected cases, in addition to surveillance of contacts by the PHC, is highlighted, so that there is early detection of positive cases for TB and immediate initiation of treatment, as well as the need for a link between professionals of health teams and individuals for greater adherence to the care plan. These are the main TB control strategies, as they promote the breaking of the disease transmission chain and the consequent decrease in the incidence rate [19]; [21]; [28].

## V. CONCLUSION

There are two important actors in disease control: the health professional and the patient. The delay is related to the TB patient, corroborating the idea of the need to sensitize society about the disease and participation in PHC, allowing the blocking of TB transmissibility. However, the need to speed up the diagnosis of the disease is identified, so that the patient does not have to return to the service several times for the action to be effective. Thus, the importance of the multiprofessional team is seen in carrying out educational actions in the community so that they can become empowered about TB and seek health services early, thus allowing rapid diagnosis and immediate initiation of treatment, breaking the chain. of TB transmission.

PHC need to provide means to better understand and change the population's attitudes towards TB. For this, a reorientation of health services is recommended, with regard to the qualification and permanent and systematic training of these professionals, in order to collaborate to guarantee the knowledge, skills and competences of professionals and improve the suspicion and diagnosis of TB, as well as for the increase in the active search and decentralization of these services, in the sense of promoting greater access to health, increasing the number of individuals examined and reducing the time between the identification of RS and the beginning of TB treatment.



The present study has as limitations the memory bias regarding the dates of the first search for the health service; not assessing the degree of knowledge and beliefs about the disease; use of data from secondary sources. The study design also does not allow the assessment of patients who do not have access to the health service and the diagnosis of the disease.

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## Study on the Judicialization of Access to Health Services in The City of Araguaína - To

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**Keywords—** Access to health services,  
judicialization, Nucleus of Technical  
Support.

**Abstract—** The judicialization of health has been taking place in doctrinal and jurisprudential discussions, where individuals who need remedies or treatments have recourse to the judiciary to achieve their right to health. Justice has become the only solution, not having their rights guaranteed. Over the years, lawsuits have been increasing, and this is also happening in the municipality of Araguaína-TO. The objective of this study is to analyze and identify the judicial demand for health services related to primary care, in the municipality of Araguaína in the years 2016 and 2017, where a survey of data from the Technical Support Nucleus (NAT) of Araguaína-TO. In 2016, a percentage of 13.79% of the 429 consultations were obtained; already in 2017, an increase was identified from the previous year, thus there are 493 queries received at the NAT, where only 10.14% of these were judicialized and 89.86% resolved administratively. The numbers demonstrate high core resolvability. The data demonstrate the characterization of the majority of the demands,

*bringing medical consultations, and being in second place the medicines. We emphasize the effectiveness of NAT in resolving cases by avoiding higher costs to the public service.*

## I. INTRODUCTION

The discussion on the judicialization of access to health services has brought to the center of the debate the actions of the Judiciary about guaranteeing the right to health in Brazil. This whole process has gained theoretical and practical importance, involving growing debates among academics, law operators, public managers, and civil society.

An increasingly frequent phenomenon, the lawsuits about the judicialization of health have increased considerably after the promulgation of the 1988 Constitution and consequently the enforcement of the right to health. In this context, citizens resort to the judicial provision on an individual or collective basis, questioning the State to comply with the constitutional principle [1].

The search for better health services and actions leads people to seek private health plans and/or the judiciary, to guarantee the right assured in the Federal Constitution of 1988. Especially about the provision of medications, exams, consultations, surgeries, Out-of-Domicile Treatment (OHT), vacancies in the Intensive Care Unit (ICU), and non-drug inputs, such as disposable diapers, special food, etc. [2].

The increase in judicial demand has contributed to destabilizing and financially overloading the schedule of health regulatory agencies. However, the Unified Health System (SUS) operates with structural problems, insufficient assistance, and capacity to effectively realize the right to health, since often what has been requested is not included in the Ministry of Health's drug lists [3].

In general, studies on the judicialization of health emphasize more strongly the negative effects of this type of demand on the management of health policies and actions. One of the main justifications is that this type of intervention in the SUS would deepen the inequities in access to health, privileging a certain segment and individuals, with greater claiming power, to the detriment of others. To the extent that individual needs or needs of certain groups would be met to the detriment of the needs of other groups and individuals. This paper analyzes the phenomenon of health judicialization, having the city of Araguaína - TO as an analysis unit.

## II. HISTORY OF HEALTH JUDICIALIZATION IN BRAZIL

The lawsuit claiming medicines and medical procedures against public authorities began in the early

1990s for people living with HIV/Aids. Such manifestations are based on the constitutional right to health, which comprises, in an integral, universal, and free manner, the duty of the State to provide health care. The result of the actions filed by non-governmental organizations (NGOs) was the favorable jurisprudence to the accountability of the three spheres of government in the fulfillment of this state provision [4].

The lawsuits for access to medicines began with requests from HIV-positive patients, the medicines for this pathology were inaccessible and patients used the courts to have access to them. With the creation of a specific policy to control HIV/AIDS, the lawsuits turned to access to other classes of medicines [5].

The progress of HIV/Aids public policies has stimulated the population in general and other organized social movements to claim the right to health, because, in the last decades, the number of lawsuits related to health procedures and supplies against public entities has increased. Consequently, it is observed that the judicial claim becomes widely used as a tool to guarantee rights [6].

One of the motivations for the judicialization of health care was the negligence in updating the medications on the SUS list, due to the bureaucratic process for the acquisition and distribution of new medications. Moreover, the delay in the distribution of existing medications on the list, because it does not occur homogeneously, leads many patients to resort to the judiciary requesting these medications because they are not available at the health center where they were seen [7].

Of the most common characteristics in the different regions of Brazil, the first is that most requests are individual, in this sense the prescriber defines the treatment as the only one, in the function of this description the judicial request is configured as necessary; second, it highlights the fact that the prescription contains both drugs incorporated and not incorporated by the Pharmaceutical Assistance (PA) of SUS and some without registration in the country or without therapeutic indication described in regulatory agencies and the third feature highlighted by the authors is the increase in spending due to the growth of demands in all states of the federation [3].

## III. JUDICIALIZATION OF HEALTH CARE

The Right to Health that is expressed in the phenomenon of judicialization of health is how the State,



in the Executive, Legislative or Judicial Powers. It must promote the good of the people in the form of equality and without discrimination of any kind by promoting universal and equal access to advances in biological technology. The high intensity of judicial demand in the health area reflects the search for the effectiveness of one aspect of this right, access to the material means to achieve it. The phenomenon can be considered a legitimate resource for reducing the gap between the law in force and the law experienced [8].

The largest health-related judicial demand in Brazil is made up of requests - individual and collective - for medications, which are based on a medical prescription and the supposed urgency to solve a certain "health problem". Whether due to the refusal to provide the medication or to the time imposed on the individual, the Executive Branch agencies have failed in providing pharmaceutical assistance, especially in the dispensation of medications, which has been solved in these cases by resorting to the Judiciary Branch. As resources are finite, the supply of a certain drug, especially if it is not standardized, for an individual may represent the lack of other drugs for the rest of the community, thus contributing to the violation of the principle of isonomy, provided in Article 5, caput of the Federal Constitution, as well as to accentuate the inequities in the health system [9].

In SUS management, the growing Judicialization of Health disrupts management. Since decentralization - one of the principles of the SUS and one of the axes of the National Medicines Policy - is not recognized by the Judiciary, thus all federated entities are equally responsible in the process, whatever the medicine. Since decisions on medications are true allocations of resources, the limit of violations of the separation of powers is threatened [9].

The Federal Constitution of 1988 also brought the existential minimum, and with its fulfillment, to realize the right to health, we run into the insufficiency of financial resources of the State for its realization, that is, the reserve of the possible [10].

The current trend of judicialization of health reverses this logic when it disregards public policies and the SUS principles of universality, integrality, and equity [11]. As well, the SUS, which has the attribution of guaranteeing the right to health to all, has become a large consumer market for the new releases of the pharmaceutical industry, which do not always meet the collective health needs of citizens [12].

### 3.1 Financial Impacts of Legal Claims on the Public Budget

The increase in spending on the health system originated with the implementation of the SUS, accompanying the expansion of services offered, hospital structure, health surveillance, and public laboratories. The responsibility of providing universal and integral care to the population obliged the State to maintain the operation of basic prevention and cure services, in addition to providing recovery and health promotion services, considered more complex. Therefore, advanced exams and procedures, admissions in intensive care units (ICUs), and provision of high-cost drugs, among other services, were gradually incorporated into public health policies [13].

Despite the judiciary's premise of determining that the state performs its constitutional obligations, the fulfillment of judicial decisions that imply positive action by the state faces obstacles stemming from insufficient financial resources in the face of society's growing need for public policies, in their most varied forms. Thus, the effectiveness of social rights depends on the state's financial availability [14].

For the author [14] points out that the reception by the Judiciary of actions that aim to compel the government to bear the costs of health care that public policies do not cover. This has a direct result on the budgetary and financial programming of the State, which, consequently, affects the formulation of policies and the provision of goods and services in other areas demanded by society.

The use of the courts to provide medicines that are included in the official public lists is a legitimate way to guarantee the full exercise of the right to therapeutic assistance. The greatest difficulty for the full realization of this right, however, refers to the supply of medicines that are not part of these lists. There are specific aspects of this demand that require a differentiated way of acting by the manager to respond to judicial orders. This occurs because practically all the judicial demands presented are for the granting of preliminary injunctive relief, implying immediate delivery of the medication by the manager, without being heard beforehand [3].

## IV. METHODOLOGY

The study is retrospective research of data from the Technical Support Center (NAT) of Araguaína - TO, an agency of the Municipal Health Secretariat (SEMUS). The NAT reports were requested using a letter to SEMUS, and the use of the data was authorized by the organization.



## V. RESULT AND DISCUSSION

### 5.1 Municipal Technical Support Center

The city of Araguaína is located in the northern region of the state of the Tocantins, where it has the second largest population in the state of Tocantins, with 164,093 inhabitants, according to estimates from the Brazilian Institute of Geography and Statistics 2013 survey. It is part of the regional health region, called the Araguaia Medium North, with its strategic geographical position, allows the municipality to assume a role as a service provider, with a complex network of public health care references for several surrounding municipalities. Including for patients from other states, such as Maranhão, Pará, Mato Grosso and Piauí [16].

According to the author [16], among the cities located in the interior of the state of Tocantins, Araguaína is the city that has the largest number of establishments related to health care. With a total of 189, it is formulated as an important regional reference center in the provision of services related to medical and hospital care. In the field of public health care services, this municipality has basic health units, a Municipal Medical Specialties Outpatient Clinic, a 24-hour Emergency Care Unit (UPA 24h), a Mobile Emergency Care Unit (SAMU 192), a Municipal Hospital, a Workers' Health Reference Center (CEREST), Epidemiological Surveillance, Municipal Health Surveillance, Zoonosis Control Center, besides the services provided under state management, such as the Public Regional Hospital of Araguaína and the State Specialties Outpatient Clinic, among others, characteristics that, associated with easy access to the local Judiciary, favor the increasing judicialization [17].

The requests that arrive at the NAT follow the flowchart shown in the figure below:

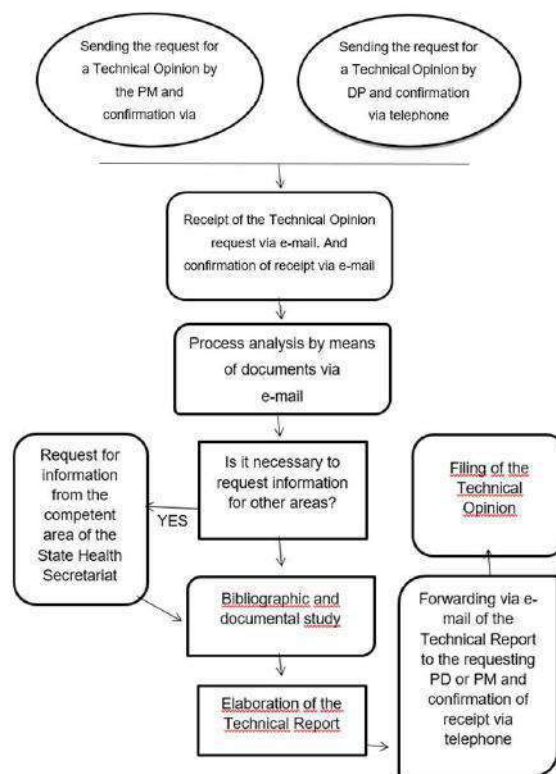


Fig.1: Flowchart of the handling of requests that arrive at the NAT

It is necessary to point out that the nuclei do not take the place of the judge in his decision. Because only the magistrate, in the case where the requested health services are not available on the SUS list, will be able to grant it or not, even though the opinion of the NAT, warns of the adequacy or unfoundedness of the fact in question. The opinion does not substitute the judge's action: it can only broaden his view of the situation.

### 5.2 Quantity of administrative demands consulted in NAT

The data provided by NAT obtained quantitatively the administrative demands consulted to the body, whose reference is argued from the period January to December 2017, as shown in table 01.

Table 01. Administrative demands were consulted to the Araguaína NAT in the period from January to December 2017.

PRE-PROCEDURAL RESOLUTIVITY					
Source	Administrative demands	Administrative resoluteness	Judicial claims	Injunctions granted	Injunctions denied
DP	310	282	28	18	10
MP	183	161	22	8	14
<b>TOTAL</b>	<b>493</b> 100,00%	<b>443</b> 89,86%	<b>50</b> 10,14%	<b>26</b> 52,00%	<b>24</b> 48,00%

Source: Municipal SUS Ombudsman/ NAT/ Araguaína-TO Municipal Health Secretariat.

The administrative demands consulted to NAT in the period from January to December 2017 according to table 1 report the actions by two judicial bodies, Public Defender's Office (PD) and Public Prosecutor's Office (MP). The PD obtained 310 administrative demands as a whole, 282 of which were resolved in the administrative area of the health secretariat. Of the demands that were judicialized, of the 310, only 28 were judged, 18 were granted and 10 were dismissed by the magistrates. About

the Public Prosecutor's Office, with a lower percentage than the PD, where 183 claims were brought, a good part was solved with the administration 161, however, 22 were in judicial terms, 8 were granted and 14 were dismissed. The PD causes this relevant number in its demands since the processes it provides are faster so that the claimant has greater preference due to the treatment it receives. The public agencies thus totaled 493 demands forwarded to the NAT in the period from January to December 2017.

### 5.3 Other judicial demands referred to the NAT

Table 02. Total demands according to related descriptions

	OVERVIEW		
	Judicial Processes	Granted Injunctions	Injunctions Denied
Demands without prior consultation to the NAT in the period	14	6	8
Cases judicialized in previous years referred to the NAT in the specified period.	22	3	19
Cases judicialized and forwarded to the NAT in previous years with granting of preliminary injunctions in the specified period	3	3	0
<b>TOTAL</b>	<b>39</b>	<b>12</b>	<b>27</b>

An overview of other demands sent to the NAT without administrative resolution is shown in the table above. These demands, without previous consultation in the NAT in the period, were 14 judicial processes, of which 6 were approved and 8 rejected. The lawsuits filed in previous years and forwarded to the NAT in the specified period were 22, of which 3 were granted and 19 rejected, a relevant number about those accepted by the magistrate. To the lawsuits filed and sent to the NAT in previous years with granting of injunctions during the specified period, 3 lawsuits were judged, and all of them were granted. Of the judicial demands sent to the NAT, there are a total of 39 judicial processes as a whole.

### 5.4 Overview of the judicialization against the Municipal Department of Health of Araguaína – TO

According to information provided by the Technical Support Center of the Municipality of Araguaína, with the demands for the years 2016 and 2017, comparisons show an increase in the year 2017 in administrative requests, with evolution of 14.92% compared to the previous year. Of these 493 demands, 443 were resolved in the administration of NAT, a number higher than in 2016, an evolution of 43.37%. The judicialized processes in the year 2016 were 120, already in the following year, it is observed the decrease of judicialized, where only 89 went through processes, a reasonably positive number with last year. Of the injunctions in these processes, 79 were granted and 41 dismissed in 2016, and in 2017 there were 38 granted and 51 dismissed, of the 89 judicialized processes, as shown in the figure below:

Table 03. Demands previously consulted by the Public Defender's Office and the Public Ministry, without prior consultation to the sector, and remaining demands.

Reference period	2016	2017	Evolution
<b>Administrative Requirements</b> (Public Defender's Office and Public Prosecutor's Office)	429	493	14,92%
<b>NAT's administrative resoluteness</b>	309	443	43,37%

<b>Judicial cases</b>	120	89	-25,83%
<b>Injunctions granted</b>	79	38	-51,90%
<b>Injunctions denied</b>	41	51	24,39%

Source: Municipal SUS Ombudsman/NAT/Municipal Health Secretary of Araguaína-TO

### 5.5 General analysis of the demands received at the NAT by classification

Table 04. An overall analysis of the demands received at NAT by classification in the period from January to December 2017/2016 respectively.

Reference period: <b>JANUARY - DECEMBER 2017/2016</b>										
	<b>Requests administrative</b>		<b>Resolutivity administrative</b>		<b>Judicial requests</b>		<b>Court-Ordered Requests</b>		<b>Requests denied by the court</b>	
Special food	18	27	17	24	1	3	0	0	1	3
Surgeries	42	50	42	48	0	2	0	0	0	2
Consultations	184	114	162	104	22	10	0	2	22	8
Correlates/supplies	35	34	22	16	13	18	13	18	0	0
Drug addiction	9	11	0	-13	9	24	3	18	6	6
Exams	98	71	78	67	20	4	3	1	17	3
Medications	110	130	87	95	23	35	17	29	6	6
Treatment	0	0	0	0	0	0	0	0	0	0
TFD	41	17	40	15	1	2	0	1	1	1
Internal transport	6	2	4	1	2	1	0	0	2	1
<b>TOTAL</b>	<b>543</b>	<b>456</b>	<b>452</b>	<b>357</b>	<b>91</b>	<b>99</b>	<b>36</b>	<b>69</b>	<b>55</b>	<b>30</b>
<b>Percentage %</b>	<b>100%</b>	<b>100%</b>	<b>83,24%</b>	<b>78,29%</b>	<b>16,76</b>	<b>21,71</b>	<b>39,56</b>	<b>69,70</b>	<b>60,44</b>	<b>30,30</b>

Source: Municipal SUS Ombudsman/NAT/Municipal Health Secretary of Araguaína-TO

With a broad and observant look, at the health services cited, consultations stand out as the leader in administrative requests in the year 2017 with a number referring to 184 administrative requests, of these, 162 were resolved in administrative analysis, compared to the previous year there was an increase, where they compete a total of 114 requests. In second place were the medicines, which in this context there was a reduction in requested requests. In the year 2016 130 were requested, already in the following year, with a reduction of 20 requests, where, 87 were solved by administrative terms of the health department of the municipality and 23 judicial arguments, then, in this same context 17 were granted and 6 dismissed.

It is important to point out that the number of requests presented indicates a margin of the situation of judicialization in favor of the Municipality, however, the volume of requests is much larger, because each demand request is presented for several items. Thus, it is in the interest of the NAT to present the total volume in a future report.

### 5.6 Comparative analysis of the demands consulted administratively in the years 2016 and 2017

The comparative analyses of the demands administratively consulted at NAT by the municipal SUS ombudsman in the period from January to December 2016 and 2017 are demonstrated by the flowchart below:

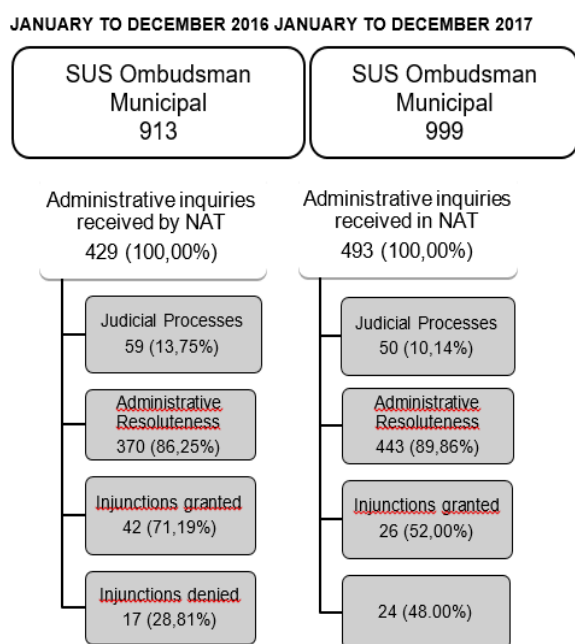


Fig.2. Flowchart of the comparative analyses of NAT demands between 2016 and 2017.

Source: Municipal SUS Ombudsman/NAT/Municipal Health Secretary of Araguaína-TO

In a comparison of the demands consulted administratively by the SUS ombudsman, there is an increase in demand in 2017, in the number of consultations to the SUS Ombudsman of the Municipality, which of 999, only 493 were received in the NAT, where 50 processes became judicialized and 443 resolved administratively. Data by which the effectiveness of the Ombudsman and the NAT is verified because a list that could be much longer was notorious in its administrative resoluteness gaining time in the health of the patient who needs it. Therefore, the number of people seeking their rights is still growing, comparing the two years analyzed in this study.

## VI. CONCLUSION

As a constitutionally guaranteed, fundamental, and immediately applicable right, the right to health implies the obligation of the Public Power to provide medicines, treatments, and equipment, among others, and to carry out public policies to realize it. However, failures in the execution of existing public agencies, as well as the scarcity of resources, lead to a phenomenon of judicialization of the right to health, where the Judiciary appears as an important means to guarantee this right, adding to the budget difficulties already experienced by the Public Powers.

According to the data presented in this research, one can observe an increase in demands from one year to another. In 2016, there was a percentage of 13.79% of 429 consultations; in 2017, there was an increase from the previous year, with 493 consultations received by the NAT, where only 10.14% were judicialized and 89.86% resolved administratively.

The presentation of the data shows the characterization of most of the demands, being in the first place the medical consultations, and in second place the medications in the two years analyzed in this study.

According to the data presented, the effectiveness of the center in solving the cases previously consulted is highlighted, as well as its resolving capacity in partnership with public agencies to fully serve the citizen and reduce costs for the municipality.

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# The Anti-Racist Compliance

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**Keywords—** *Compliance; Institutions;  
Humans rights; Right to development;  
Sustainable development.*

**Abstract—** *Anti-racist compliance is the appropriate set of integrity and compliance techniques for the creation of inclusive institutional environments, capable of diversity and free from racism. Understanding its constitution depends on recognizing the human right to development, in a practical way, and the role of institutions in its implementation, as well as the negative impacts of racism on corporate governance. Thus, it can be said that institutional designs of conformity and integrity committed to the fight against racism give rise to the achievement of sustainable development, human rights and democracy.*

## I. PREFACE

Achille Mbembe in *Critique of Black Reason* (2018, p. 305), when reflecting on democracy and a poetics of race, analyzes and criticizes democratic projects that coexist with racist structures, in the following terms: “The project of a common world based on the principles of ‘equality of parts’ and the fundamental unity of the human race is a universal project [...] Exclusion, discrimination and selection in the name of race remain, however, structuring facts – albeit often denied – of inequality, the absence of rights and contemporary domination, including in our democracies”. Along the same lines, the question is: is the performance of institutions democratic? Is there democracy when there is racism in your spaces? Such questions are essential to reflect on whether the assurance of (most) fundamental rights affects all citizens. In several environments, it is clear that black people are exposed to constant risks of death due to their race or color and face flagrant socioeconomic inequities<sup>1</sup> – which has indelible

reflections on institutional processes of integrity and conformity.

It is understood, in this sense, that one must understand how an ecosystem can be rhetorically committed to anti-racism, but, in practice, also be conniving with it; as well as that institutional relations must be subordinated to the anti-racist ideal, which is an inseparable component of the sustainable development of organizations and, consequently, of the establishment of environments in which a democratic culture prevails. The Sustainable Development Goals (SDG), present in the 2030 Agenda, proposed by the United Nations, in the same vein, help in the perception of the connections established between development as a human right and the

an intersectoral network of inequalities, so that if we were to divide the country in two, white Brazil would have an HDI of 0.814, and black Brazil, with a mixed and black population, would have an HDI of 0.703. If they were two different countries, they would be separated by 61 positions in the human development ranking” (AMORIM; MORAIS, *Strategic Litigation in the Public Defender's Office*, 2019, p. 21).

<sup>1</sup> For example: “[...] the black population of Brazil is poorer, has less access to essential services and education. Racism has fueled

organizational empowerment of black communities as an emerging demand.

Based on the premise that the aforementioned right suffers a deficit in effectiveness when faced with spaces in which racial equity and justice are not observed, it is essential to rethink corporate governance strategies to achieve anti-racism. Thus, anti-racist compliance emerges, as a set of integrity and compliance techniques suitable for the constitution of inclusive institutional realities, capable of diversity and free from racism, as an instrument that induces sustainable development.

The present study is developed with a view to defending the indispensability of the non-rhetorical affirmation of the right to development by institutions, the sensitive perception of the impact of structural issues involving racism, as a complex phenomenon, on the economic dynamics of organizations, and the need to provide opportunities for the full exercise of capacities and freedoms, in spaces without discrimination and free from negative racial stereotypes.

## II. HUMAN RIGHT TO DEVELOPMENT AND THE ROLE OF INSTITUTIONS IN ITS EFFECTIVENESS

The right to development was declared by the UN (1986) as a human right in the 1980s, and, from its enunciation, it is possible to identify projections of its impact aimed “not only at States and peoples, but also at certain collectives” (ANJOS FILHO, *Right to development*, 2013, p. 256). Through its legal constitution, it is clear that the adoption of measures aimed at eliminating or reducing structural inequalities is now recognized so that its vocation of guaranteeing well-being is effectively met, in a broad way, but also in a specific way for the vulnerable groups in institutional structures.

The normative affirmation that all people are qualified to participate in economic, social, cultural and political development, in order to contribute to and enjoy it, is a task shared by the totality of society. However, undeniably, it is observed that, in several contexts, organizations show little commitment, or even mistakenly threatened, by the recognition of rights to vulnerable collectives, both by an eventual ideological criticism, and by the fear of losing privileged positions in hierarchical systems, which, by itself, generates negative externalities and negatively impacts the effectiveness of the principles of diversity and inclusion inside and outside the institutions.

However, the right to development is an undeniable potentiality for achieving a sustainably developed society<sup>2</sup>, so without a cooperative and shared participation of institutions, it is difficult to reverse the structural conditions that impose obstacles to development, such as institutional racism<sup>3</sup>. The adoption of the SDG, as a corollary, as a form of strategic planning in guiding policies and institutional designs within the scope of the 2030 Agenda, serves precisely to induce the human right to development, establishing, among others, the following goals:

<sup>2</sup>Development as a human right provides opportunities for the self-development of individuals, that is, they provide them with the capacity for self-fulfillment. Changes in people are best achieved when they engage as partners in change processes. Thus, personal development intertwines with organizational development and the notion of participatory democracy, which serve to catalyze people active involvement (cf. TOCH, *Corrections: a humanistic approach*, 1997, p. 36).

<sup>3</sup>It is a phenomenon “that can be experienced and observed in the dynamics of institutions, it necessarily arises from the high degree of naturalization of the racial hierarchy and from the stereotypes that inferiorize a certain group while affirming the superiority of another” (PIRES; LYRIO, *Institutional racism and access to justice: an analysis of the performance of the Court of Justice of the State of Rio de Janeiro in the years 1989-2011*, 2019, p. 6).

Table I – SDG in perspective

SDG-08	Decent employment and economic growth	Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all	Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation
SDG-10	Reduction of inequalities	Reducing inequality within and between countries	Empower and promote social, economic and political inclusion for all, regardless of age, gender, disability, race, ethnicity, origin, religion, economic or other status
SDG-16	Strong institutions	Promoting peaceful and inclusive societies for sustainable development, providing access to justice for all and building effective, accountable and inclusive	Promote the Rule of Law, nationally and internationally, and guarantee equal access to justice for all; ensure responsive, inclusive, participatory and representative decision-

		institutions at all levels	making at all levels; promote and enforce non-discriminatory laws and policies for sustainable development
SDG-17	Partnerships for the SDG	Strengthen the means of implementation and revitalize the global partnership for sustainable development	Increasing policy coherence for sustainable development

The SDG-08, which establishes the promotion of sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, ratifies values contained in the Durban Declaration and Program of Action (UN, 2001). The aforementioned diploma affirms solidarity, respect, tolerance and multiculturalism as morals foundations and inspirations for the global fight against racism and racial discrimination, as well as recognizing that the processes of enslavement and trafficking of enslaved persons were crimes against humanity and are the major manifestations and sources of racism to the present day, inspiring disruptions and perversions of present labor relations.

The SDG-10, in turn, sets the goal of reducing inequalities, clearly aiming at the empowerment of citizens and the promotion of their social, economic and political inclusion. In the Brazilian context, for example, it is important to realize that “the present racial inequities go back to the segregationist model that consolidated and ensured the privileges of a white European dominant class to the detriment of the black and indigenous population” (GIACOIA; SILVA, *Social Exclusion and criminalization of the excluded: a reflection on the selectivity of the Brazilian penal system*, 2013, p. 05), which urges overcoming, within the scope of the integrality of relationships and institutions.

Already, the SDG-16 guides the promotion of societies without violence and with full access to justice, as well as the construction of effective, responsible and inclusive institutions, with breadth of transparency, guarantee of democratic decision-making and sensitive to the promotion and compliance of non-discriminatory laws and policies. Therefore, in line with the logic of disseminating sustainable reasoning, integrity and compliance with good practices of social responsibility and a careful look at the 2030 Agenda as a whole are sought, not only with a view to mitigating risks, but also to its service as an opportunity and performance, in a true process of organizational improvement.

The SDG-17, which establishes the strengthening of the means of implementation and revitalization of the global partnership in favor of the SDG themselves, in turn, is the guiding potential of the *ISO 37301 Certification* (2021), which standardizes

compliance management systems in organizations public and private. Prepared by the Technical Committee 309 of the International Organization for Standardization, the standard specifies requirements and provides guidelines for establishing, developing, implementing, evaluating, maintaining and improving effective integrity and compliance management systems within institutions, considering the needs and expectations for the scope of its sustainability and consolidating the promotion of values, among which anti-racism must appear (and be protagonists).

### III. HARMFUL IMPACTS OF RACISM ON CORPORATE GOVERNANCE

Fania Davis, in *The little book of race and restorative justice: black lives, healing, and US social transformation* (2019, p. 92) very well points out: “race is not real, but racism is very real”. According to past studies (MUNIZ, *Racism: because you cannot simplify a complex concept*, 2020), it is recalled that racism establishes a system of dominance of one race to the detriment of others in multiple fields, resulting in exclusions on access to goods and services and income (economic dimension), management and dynamics in power relations and spaces (political dimension), the construction of narratives and the reproduction of subjectivity in society (psychological dimension) and the regulation of normative mechanisms and the guarantee of rights (legal dimension). It is understood, therefore, that there is a historical point in which institutions are either “healed” or racial injustice “will continue to be replicated *ad nauseum*”.

Furthermore, if corporate governance is the set of leadership, strategy and control mechanisms put in place to assess, direct and monitor institutional management, it can be said that good governance is one that operates in order to achieve the SDGs. The UN that raised decent employment and economic growth, the reduction of inequalities and the constitution of strong institutions and cooperative partnerships as sustainable development goals, through its High Commissioner for Human Rights (OHCHR, 2022), presents the conception of good governance referring to those institutional, planning and execution practices, with full and complete respect for

human rights and the rule of law, characterized by transparency, responsibility, accountability, participation and responsiveness to people's needs. It is a concrete ethical intensification of organizational reality.

If, on the one hand, racism is a complex phenomenon, which imposes multiple forms of violence on the black population, on the other hand, good governance is capable of disseminating anti-racism in institutions, making them capable of empowering people, equity and sustainability, which, in itself, enables programs, projects and practices to combat racism. This possibility, in fact, corresponds to the active exercise of its own social responsibility.

The negative impact caused by the poor treatment of racial issues in the operation of organizations must be recognized and its inevitable repercussion on their own management, which has to (re)affirm their understanding and commitment to the unavailable fight against racism. It should be noted: racism is always a corrosive factor in institutional relations – in all of its environmental, social and economic pillars.

Victor Ray, in *A theory of racialized organizations* (2019, p. 46), argues that organizations are central structures for contesting the social construction of race and stability in the racialized order, since it is through everyday organizational processes and routines and their material resources, that racial schemes delineate subordination and ordering. Thus, it is organizations that expand or inhibit agency, legitimize the unequal distribution of goods, services and incomes, treat whiteness as a credential, and decouple institutional procedures in ways that, as a rule, benefit dominant racial groups.<sup>4</sup> Social movements and demands, together with more “mundane” interests, such as attempts to gain greater market share, can, however, creatively alter the connections between racial and organizational structures.

Therefore, it is asserted that an institutional design, preordained, led by its governance, endowed with real utility and practical applicability, allows progress from a paradigm of correction of racist misconceptions to the promotion of a set of values that ensures both rights as it transforms realities. In this sense, the institutionalization of anti-racist compliance preserves the physical and psychological integrity of employees, consumers and users, assists in the relationship with communities, preserves institutional reputation and image, identifies

commitment to combating racism, and fosters anti-racist ecosystems.

#### IV. INSTITUTIONAL DESIGNS OF ANTI-RACIST COMPLIANCE

Anti-racism is an axiological paradigm that makes institutional environments realize that in ESG, environmental, social and governance are necessarily interdependent and interconnected. And this is, in short, “an ontological choice, which stems from an epistemological choice”, as Michel Troper constructed in *The Philosophy of Law* (2008, p. 154). If the rational choice is to be an anti-racist institution, the way of being is precisely the institutional structuring of its integrity and conformity in a compatible way.

Going through the progression of the ethics paradigm as the foundation of compliance, as a consolidated and universalizable set of values, a sign of the historical and cultural development of organizations, since the 1960s and 1970s, when social movements brought up the struggle for civil rights of vulnerable groups, by gender parity and environmental preservation, we can see the common genesis and the approximation of the themes of sustainable development and human rights. The *Stockholm Declaration on the Human Environment* (UN, 1972), for example, already understood “the protection and improvement of the human environment” as “a fundamental issue” for the achievement of well-being and economic development.

In the same sense, the US normative frameworks that pioneered the concept of compliance as an instrument focused on preventing illegal activities, notably corruption in organizations and deviations in financial operations, introduced the need to rethink practices with a view to explaining truly solid missions and its internal and external realization. On the one hand, if the programs have always brought regulatory compliance as a guideline for their institution, functionally demanding compliance with the applicable norms, on the other hand, ethically sound management decisions have been demanded.

Michael Jensen and William Meckling in *Theory of the firm: managerial behavior, they talk agency costs and ownership structure* (1976), at the time, already taught that compliance can be understood as a cost capable of avoiding conflicts and monitoring actions and movements in the markets. Thus, institutions, incorporating such a cost, must respect the relevant legislation and make use of all appropriate means to positively impact their understanding and application. Therefore, mechanisms to protect the institutional board

<sup>4</sup>Along these lines, Emory University professor of African-American Studies, Carol Anderson (2020), adds: “the system creates winners and losers, regardless of what they do. And this is how he has been redistributing opportunities and resources based on nothing but privilege”.



and investments are constituted for the mitigation of risks due to the lack of understanding and non-compliance with normative and ethical impositions.

Designing a compliance program, in this context, presupposes that institutions create instruments to form a culture of compliance with legal and social norms that seek to eradicate all forms of corruption and ethical deviations and, consequently, corroborate with the elimination of obstacles to protection and improvement of the ecosystem in which they operate. Racism is undoubtedly one of these obstacles to be overcome.

The evolution of the paradigmatic structural vectors of such projects of organizational compliance and integrity, from the 1970s to the mid-2000s, included ensuring the commitment of leaders, directors and managers, the creation of codes of conduct, procedures, ethics and good practices, the training of workers and collaborators, the adoption of communication strategies, marketing and internal controls, the development of assessments and risk management mechanisms, the implementation of complaint channels and ombudsmen, the continuous monitoring, permanent and based on its own structure, internal investigations and disciplinary measures. In the same period, in which compliance was consolidated as a fundamental agenda in the structural changes of organizations, giving effect to the right to development within them, the *World Conferences Against Racism* (WCAR 1978, 1983, 2001 and 2009) marked the construction of a robust international agenda to combat racism, all forms of racial discrimination and xenophobia.

It is precisely the exchange between internal and external policies that raised the ESG to a level of mandatory compliance, so that ecological, economic and social components become equal and intertwined with the achievement of sustainable development. In this way, we can see the emergence of an anti-discriminatory compliance, which aligns organizational practice with the impositions of norms that specifically prohibit organizational discrimination (arising from discriminatory acts against a particular individual or group, based on knowable processes and institutional culture based on reproduction of patterns of excluding social interaction) and structural (originating in the social stratification resulting from the accumulation of socially excluding privileges by a hegemonic racialized group).<sup>5</sup>

Indeed, the global development and anti-racism agendas have contributed to institutional recognition of the negative economic, social and cultural consequences of discrimination and, consequently, to the institutionalization

of anti-discrimination compliance programs, allowing an ethical densification of the “ordinary” compliance strategy. Human rights and fullness of labor rights, environmental aspects, especially ecological and climate aspects, and socioeconomic components, such as financial transparency, the fight against corruption and anti-racist pro-activity, are now incorporated as internal and external relational guidelines in its development. Likewise, according to World Bank (FREDMAN, *Anti-Discrimination Laws and Work in the Developing World: A Thematic Overview*, 2013) notes a thematic risk management, actions for the prevention, detection and correction of inequities, and permanent mechanisms of eradication of discriminatory practices constitute good institutional anti-discrimination practices.

Thus, from the contemporary social and political needs and the assertion of a flagrant picture of racial violence, comes the unavailable concept of anti-racist compliance, “a set of conformity and integrity techniques that, qualifying compliance in general and intensifying anti-discrimination compliance, lead to the creation of inclusive institutional environments, capable of diversity and free from racism” (MUNIZ, *Anti-Racist and Anti-Discrimination Law*, 2021, p. 126).

Which, in turn, requires the training of human resources committed to combating racism, the addition to institutions of a broad understanding of structural racism<sup>6</sup>, and the effective construction of cultures of diversity and inclusion. In short, it is about conformity, with racially anti-discriminatory norms, which generates integrity, expressed in racial justice.

It is explained that such programs are structured in the triad *prevent-detect-response*. Violations of the anti-racist culture are prevented through policies and regulations that provide unequivocal principles and instructions for individual and collective conduct. Activities, operations and expressions of conduct are detected and monitored through audits, reporting channels and other monitoring procedures. We respond vehemently and unequivocally to racist violations, through specific internal and external processes, adoption of improvements and implementation of good practices, such as:

<sup>6</sup>“All racism is structural because racism is not an act, racism is a process in which the conditions of organization of society reproduce the subalternity of certain groups that are racially identified” (ALMEIDA, *Structural Racism*, 2021).

<sup>5</sup> See: MOREIRA, *What is discrimination?*, 2017.



Table II – Good practices for anti-racist organizations

01	Establishing racially diverse or racially and ethnically sensitive corporate leadership at the highest level
02	Treatment of all people, black and non-black, fairly in public and private spaces, respecting and supporting human rights and anti-discrimination
03	Ensuring the safety, well-being and health (especially mental) of all black people
04	Promoting education, training and professional development for black people and critical racial literacy for white people
05	Support and promotion of economic empowerment policies for black people through institutional structures and strategic design
06	Induction of racial equity through local, community-oriented and social activism-sensitive initiatives
07	Measurement, documentation and publication of institutional progress in promoting racial equality and in the effectiveness of anti-racism

Anti-racist compliance is developed in implementation (analysis of activities and risks, establishment of codes and penalties, establishment of a communication plan for constant dissemination of the anti-racist culture, development of training and efficient reporting systems, formation of independent committees), maintenance (advice with independent committees and thematic councils, regular training and permanent groups, development of monitoring systems, investigation and investigation of complaints, establishment of policies of consequences) and management (guaranteeing of necessary human and financial resources and establishment of continuous support from top management). And its positive externalities are perceived to be the preservation of the physical and mental integrity of employees, customers and users, the optimization of the relationship with communities and other organizations, the preservation of its reputation, image and mission, the strong impact on combating racism and the promotion of sustainable ecosystems.

## V. CONCLUSION

Returning to the preface quote, it is necessary, once again, to refer to Achille Mbembe (*Critique of black reason*, 2018, p. 305): “[...] as long as racism has not been eliminated from the life and imagination of our time, it will be necessary to continue to fight for the advent of a world beyond races. It will be necessary to learn to carry and share this burden better”.

Racism is a scourge that corrodes sociability, violates fundamental rights of black people, disrupts institutions and makes sustainable development unfeasible – and, of course, any possibility of implementing adequate

ESG practices in organizations. Therefore, the institution of a racialized compliance program with an express socially transformer objective, a responsive corporate governance and an efficient (and never conniving) management of potential racist events are instruments for inducing a better world and beyond races.

After all, starting from a strategic planning of effective implementation of SDG-08 (decent employment and economic growth), 10 (reduction of inequalities), 16 (strong institutions) and 17 (partnerships in favor of the SDG), one has a potential model of institutional design capable of promoting sustainable development, as well as the recognition of racial equity and justice as inseparable elements of the life of organizations. Finally, it is asserted that the dissemination of anti-racist compliance, in the civilizing development of institutions and of society itself, is a potential for the acceptance of the black community in leadership positions and with wage equity, the elimination of practical obstacles caused by the racist culture. and supremacist, the full socioeconomic development of blackness, and, unequivocally, the effectiveness of human rights and democracy.

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# A Study of the Impact of Multiple drilling parameters on Surface Roughness, Tool wear and Material Removal Rate while Drilling Al6063 applying Taguchi Technique

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**Keywords—** Drilling, Al 6063, Taguchi  
method, Regression analysis, ANOVA.

**Abstract—** The goal of this project is to see how different drilling parameters like spindle speed (600, 900, 1400 revolution per minute), feed rate (0.10, 0.16, 0.22 mm per revolution) and drill tool diameter (6, 8 mm) affect surface roughness, material removal rate and tool wear while drilling Al 6063 alloy with an HSS spiral drill using Taguchi method. The impact of different drilling settings on the accuracy of the drilled hole is analyzed using S/N (signal-to-noise) ratio, orthogonal arrays of Taguchi, regression analysis, and analysis of variance (ANOVA). CNC Lathe Machine is used to perform a number of experiments with the help of L<sub>18</sub> orthogonal arrays of Taguchi. MINITAB 19, a commercial software tool, is used to collect and evaluate the results of the experiments. For establishing a correlation between the selected input parameters and the quality aspects of the holes made, linear regression equations are used. The experimental data are compared to the expected values, which are quite similar.

## I. INTRODUCTION

In today's modern industries, the primary goal of engineers is to produce items at a lower cost while maintaining excellent quality in a short period of time. In a production process, engineers are encountering two very basic practical issues. The first one is to identify the best combination of input parameters which will result in the required quality of the product (fulfill essential requirements), and the other one is to increase production efficiency with the existing resources. Although advanced material cutting technologies have been developed in industrial sectors, but traditional drilling is still among the most practiced mechanical operations in the aerospace, aircraft, and automotive industries. L<sub>18</sub> orthogonal array of Taguchi is utilized to conduct the experiment. The significant drilling parameters are selected as rotation speed, rate of feeding and diameter of the drilling tool

respectively. The best combination of all the input parameters is selected to reduce the values of the performance attributes which are mentioned above. For the optimization of these parameters, Taguchi optimization method is used. ANOVA is also used to identify the extremely effective input parameter(s) which lead to a good quality product. Point angle and Helix angle are kept standard as 118 degree and 30 degree respectively.

## II. DRILLING

Making holes is among the most essential requirements in the industrial procedure. Drilling is the most popular and important hole-making method, comprising almost one third of all metal cutting operations. Drilling is the process of removing a volume of metal from a workpiece by using an instrument called "a drill" to cut a cylindrical hole.

Based on the material type, the hole's shape, the counting of samples, and the period of time it takes in finishing the work, several instruments and procedures are used for drilling. It is most commonly used in removal of material and as a pre-processing step for a variety of operations like spot facing, counter sinking, and reaming etc. A multipoint fluted end cutting tool is used to create or extend a hole at the time of cutting operation. Material is eliminated mostly in the chips shape which passes with drill's fluted shank as it rotates and penetrates into the work material. Figure 1 shows the drilling process on the job. Coolants are also used sometimes during the operation as per the requirement.

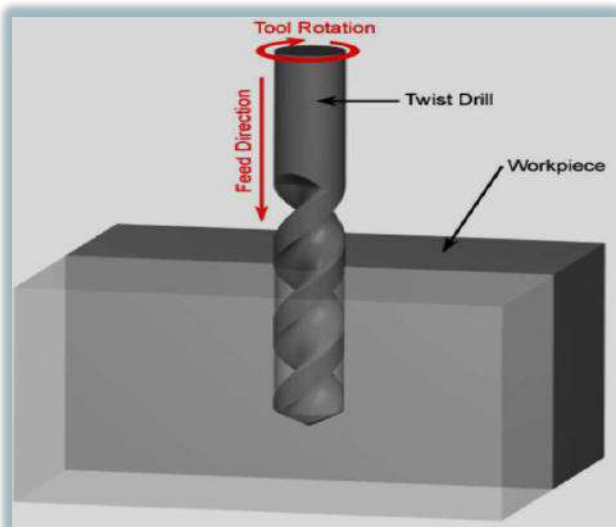


Fig.1: Drilling Operation

### III. METHODS USED

#### TAGUCHI APPROACH

The Taguchi technique is a statistical approach for estimating the response independently with the minimum number of trials. The Taguchi method can also be used to improve product quality. It is a proven method for generating high-quality industry goods. The Taguchi technique is a powerful tool for creating processes that perform reliably and ideally across a wide range of circumstances. The utilization of carefully designed tests is required to establish the best design. Taguchi proposed a novel concept called as Orthogonal Array, which aims to minimize the number of trials by taking specific control characteristics in to consideration. The orthogonal array allows for the least number of testing. The variation from a design experiment was measured using the Taguchi method's S/N (signal-to-noise) ratio. When the mean (signal) is divided by the standard deviation (noise) then

the value obtained is known as the S/N ratio. The procedure for determining the S/N ratio varies with each experiment performed. Three characteristics values are then changed into S/N (signal-to-noise) ratio using Taguchi technique. According to the problem's objective, these three values indicate various quality characteristics. "Larger is better", "Smaller is better", and "Nominal is the best" are the characteristic values of the S/N ratio. S/N ratio is estimated for every level of input parameters based on S/N analysis, with smaller being preferable. The quality characteristic employed in this study is "smaller is better" for surface roughness and tool wear but in case of material removal rate "Larger is better" is used.

Case 1: S/N ratio larger is better  
 $SN_L = -10 \log\left(\frac{1}{n} \sum_{i=1}^n \frac{1}{y_i^2}\right)$   
 Case 2: S/N ratio smaller is better  
 $SN_S = -10 \log\left(\frac{1}{n} \sum_{i=1}^n y_i^2\right)$   
 Case 3: S/N ratio nominal is best  
 $SN_t = 10 \log\left(\frac{\bar{y}^2}{s^2}\right)$

Fig.2 : Characteristic values for calculating s/n ratios

#### DESIGN OF EXPERIMENT (DOE)

Design of Experiment is a useful method for enhancing design of the product or procedure performance, therefore it is applied for speeding up the development of new goods or processes. A design of experiment is a test or set of tests that examines the drilling parameters of the procedure in order to detect and identify equivalent changes in the system response. The output obtained from the procedure is examined in order to establish the ideal value or factors with the greatest influence.

#### ANALYSIS OF VARIANCE (ANOVA)

The Analysis of variance (or, ANOVA) is a strong and widely used statistical analysis tool that is based on the law of total variance. It's a programme that determines the impact of specific elements. ANOVA is a set of statistical concepts and methods used in statistics where the observed variance is divided into sections because of several independent variables. In the simplest form or sentence, Analysis of variance is a statistical analysis tool that determines if the means of several groups are just the same, and hence generalizes.

#### REGRESSION ANALYSIS

A series of statistical procedures utilized during mathematical modelling for evaluating the linkage among the dependent variables and one or more than one independent variables is called as Regression analysis. The very basic type of regression model is linear type model, in

which we get a line (or, a more advanced linear combination) that perfectly represent the data according to a set of mathematical conditions. For prediction and forecasting, it is commonly used.

#### IV. EXPERIMENTAL SETUP

The current work used a CNC Lathe machine for drilling holes on Al 6063; the machine configuration is visualized in the picture below:



Fig.3: Experimental setup

#### WORK MATERIAL SPECIFICATION:

Work material - Al 6063  
Work material dimension -  $250 \times 20 \times 10$  mm<sup>3</sup>

Others	0.05
Aluminium (Al)	Remaining

#### WORK MATERIAL PREPARATION:

With the help of a power hacksaw, the material for the job has been cut to sizes ( $250 \times 20 \times 10$  mm<sup>3</sup>)“that are required” from Aluminium alloys base stock in order to execute drilling operations on that. Table 1 shows the chemical components of the work material:

Table1: Aluminum alloy's chemical components in percentage

Al 6063 alloy	Weight %
Magnesium (Mg)	0.45- 0.9
Silicon (Si)	0.2 - 0.6
Iron (Fe)	0.35 (Max)
Copper(Cu)	0.10
Zinc (Zn)	0.10 (Max)
Titanium (Ti)	0.10 (Max)
Manganese(Mn)	0.10 (Max)
Chromium (Cr)	0.10



### MEASUREMENT OF SURFACE ROUGHNESS :

The Surftest SJ-201P (Compact surface roughness testing machine) is a popular tool for determining component's shape and form. A tactile measurement principle is commonly used in profile measurement devices. On moving a stylus across the surface measures roughness, A transducer translates the movements of the stylus as it moves up and down along the surface into pulse, which is subsequently converted into a roughness value, which can be seen in a visible screen. A surface representation is often formed by combining many profiles. Figure 1 shows the Surftest SJ-201P.



Fig.4: Surftest SJ 201 P

### EXPERIMENTAL DATA:

Table 2: The values of input variables

Values	Input variables		
	Tool diameter (mm) (X)	Rotation speed (rev per min) (Y)	Feed rate (mm per rev) (Z)
1	6	600	0.10
2	8	900	0.16
3	-	1400	0.22

Table 3: Experimental result for Al6063 alloy (10 mmthick plate)

Serial number	Rotation Speed(rev per min)	Feed rate (mm per rev)	Tool diameter (mm)	Roughness (Ra) $\mu$ m	MRR (mm <sup>3</sup> /min)	Tool Wear (gm)
1	1	1	1	1.43	1235	0.235
2	1	2	1	1.46	1424.7	0.762
3	1	3	1	1.49	1556.2	1.011
4	2	1	1	1.42	1865.9	0.493
5	2	2	1	1.50	2078	0.922
6	2	3	1	1.52	2228	1.267
7	3	1	1	1.25	2864.4	0.715
8	3	2	1	1.24	3007.8	1.189
9	3	3	1	1.29	3231.5	1.458
10	1	1	2	1.26	1857.1	0.288
11	1	2	2	1.30	2026.3	0.797
12	1	3	2	1.34	2239.9	1.158
13	2	1	2	1.33	2455.7	0.612
14	2	2	2	1.47	2603.4	1.095
15	2	3	2	1.50	2819.2	1.414
16	3	1	2	1.22	3076.4	0.936
17	3	2	2	1.29	3398	1.345
18	3	3	2	1.35	3612	1.723

## V. ANALYSIS OF RESULTS

Table 4: S/N ratio's values of each outputs from the testing of Al 6063

Serial Number	Rotation Speed (rev per min)	Feed rate (mm per rev)	Tool Diameter (mm)	S/N response values for Roughness (Ra) in decibel	S/N response values for MRR (mm <sup>3</sup> /min) in decibel	S/N response value for Tool Wear (gm) in decibel
1	1	1	1	-3.10672	61.8333	12.5786
2	1	2	1	-3.28706	63.0745	2.3609
3	1	3	1	-3.46373	63.8413	-0.0950
4	2	1	1	-3.04577	65.4178	6.1431
5	2	2	1	-3.52183	66.3529	0.7054
6	2	3	1	-3.63687	66.9583	-2.0555
7	3	1	1	-1.93820	69.1407	2.9139
8	3	2	1	-1.86843	69.5650	-1.5036
9	3	3	1	-2.21179	70.1881	-3.2752
10	1	1	2	-2.00741	65.3767	10.8122
11	1	2	2	-2.27887	66.1341	1.9708
12	1	3	2	-2.54210	67.0046	-1.2742
13	2	1	2	-2.47703	67.8035	4.2650
14	2	2	2	-3.34635	68.3108	-0.7883
15	2	3	2	-3.52183	69.0025	-3.0090
16	3	1	2	-1.72720	69.7609	0.5745
17	3	2	2	-2.21179	70.6245	-2.5744
18	3	3	2	-2.60668	71.1550	-4.7257

Graph 1: Plot for surface roughness's main effect

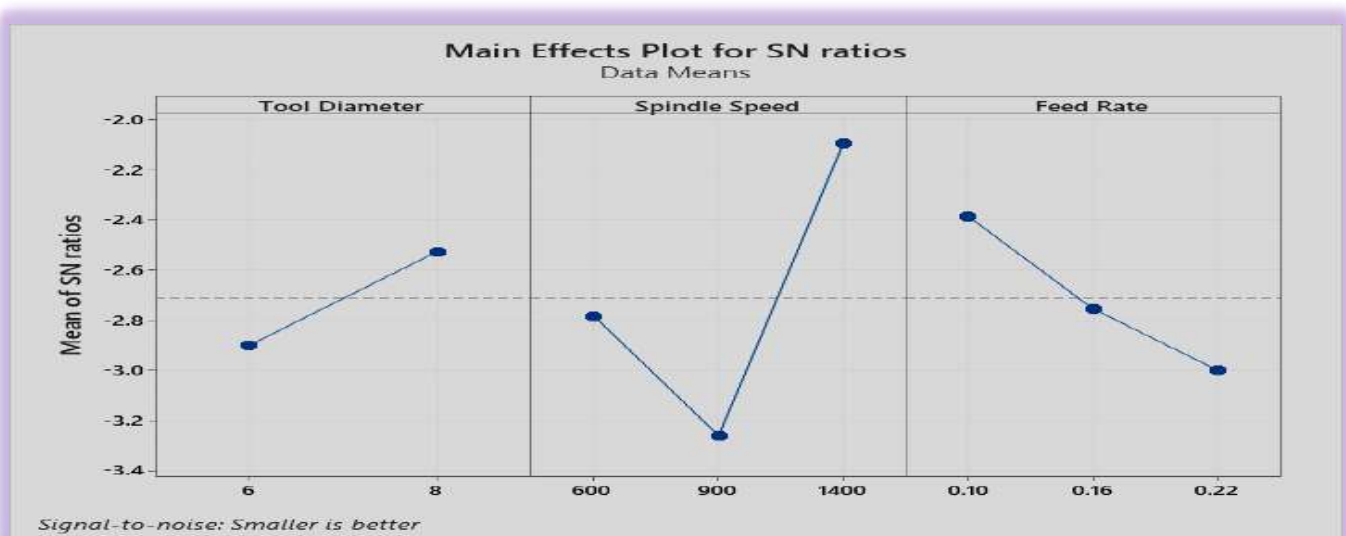


Table 5: Table containing responses for s/n ratios of surface roughness

Level	Tool Diameter (X)	Rotation Speed (Y)	Feed Rate (Z)
1	-2.898	-2.781	-2.384
2	-2.524	-3.258	-2.752
3		-2.094	-2.997
Delta	0.373	1.164	0.613
Rank	3	1	2

Table 6: Table containing responses for means of surface roughness

Level	Tool Diameter(X)	Rotation Speed (Y)	Feed Rate (Z)
1	1.400	1.380	1.318
2	1.340	1.457	1.377
3		1.273	1.415
Delta	0.060	0.183	0.097
Rank	3	1	2

Table 7: ANOVA outcome for s/n ratios of surface roughness (Ra)

Source	DF	Sum of square (S)	Variance (V)	F-ratio (F)	P-value (P)	Percentage(%)
X	1	0.6276	0.6276	5.34	0.039	8.61 %
Y	2	4.1105	2.0552	17.49	0.000	56.36 %
Z	2	1.1443	0.5721	4.87	0.028	15.69 %
Residual Error	12	1.4098	0.1175			19.33 %
Total	17	7.2922				100%

Table 8: optimal level values for roughness of Al 6063 from "Graph 1"

Input variables	Levels	Roughness response values	S/N response values
X	2	1.340	-2.524
Y	3	1.273	-2.094
Z	1	1.318	-2.384

Table 9: Validation of testing for Roughness of Al 6063 (10 mmthick plate)

	Optimal input variables	
	Estimated values	Experimented values
Level	X <sub>2</sub> Y <sub>3</sub> Z <sub>1</sub>	X <sub>2</sub> Y <sub>3</sub> Z <sub>1</sub>
Roughness	1.1916	1.22
S/N ratio of Roughness	-1.5799	-1.7272

Graph 2: Plot for Material removal rate's main effect

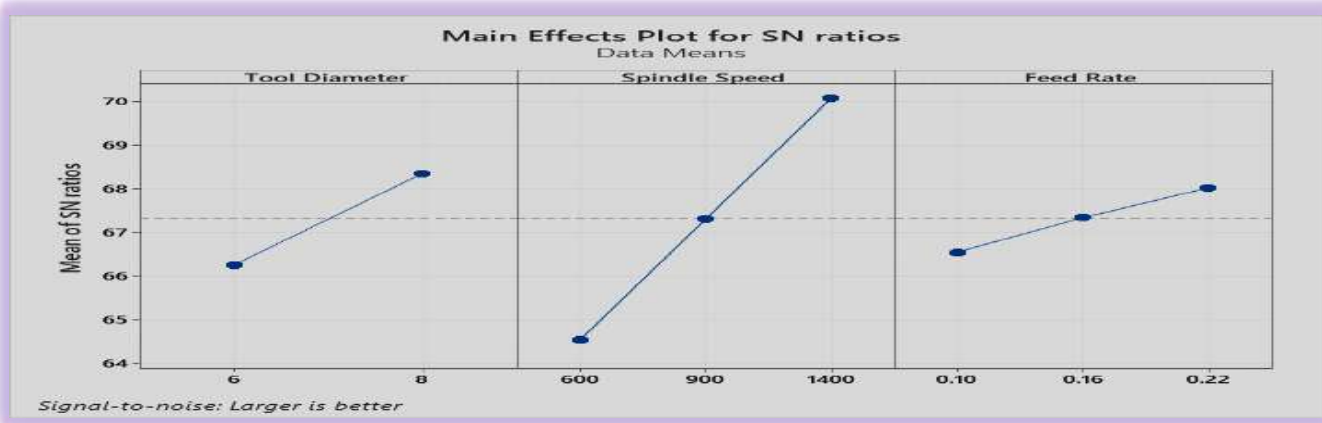


Table 10: Table containing responses for s/n ratios of MRR

Level	Tool Diameter (X)	Rotation Speed (Y)	Feed Rate (Z)
1	66.26	64.54	66.56
2	68.35	67.31	67.34
3		70.07	68.02
Delta	2.09	1.164	1.47
Rank	2	1	3

Table 11: Table containing responses for means of MRR

Level	Tool Diameter(X)	Rotation Speed (Y)	Feed Rate (Z)
1	2166	1723	2226
2	2676	2342	2423
3		3198	2614
Delta	511	1475	389
Rank	2	1	3

Table 12: ANOVA outcome for s/n ratios of Material removal rate

Source	DF	Sum of squares (S)	Variance (V)	F-ratio (F)	P-value (P)	Percentage (%)
X	1	19.637	19.637	51.30	0.000	16.04 %
Y	2	91.685	45.842	119.76	0.000	74.90 %
Z	2	6.490	3.245	8.48	0.005	5.30 %
Residual Error	12	4.593	0.3828			3.75 %
Total	17	122.405				100%

Table 13: optimal level values for MRR of Al 6063 from “Graph 2”

Input variables	Levels	MRR response values	S/N response values
X	1	2166	66.26
Y	1	1723	64.54
Z	1	2226	66.56

Table 14: Validation of testing for MRR of Al 6063 (10 mm thick plate)

	Optimal input variables	
	Estimated values	Experimented values
Level	$X_1Y_1Z_1$	$X_1Y_1Z_1$
MRR	1272.51	1235
S/N ratio for MRR	62.7471	61.83

Graph 3: Plot for Tool wear's main effect

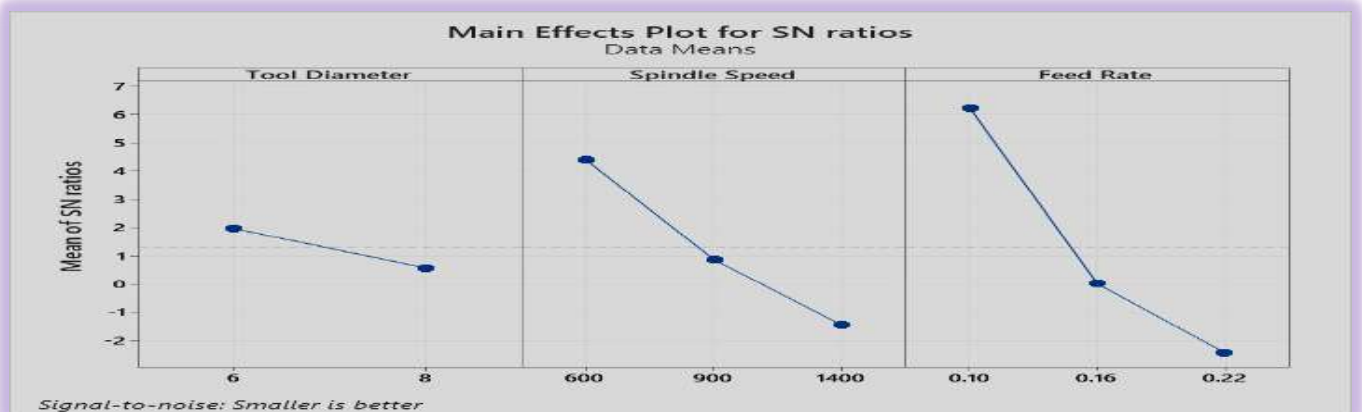


Table 15: Table containing responses for s/n ratios of Tool Wear

Level	Tool Diameter (X)	Rotation Speed (Y)	Feed Rate (Z)
1	1.975	4.392	6.214
2	0.583	0.876	0.028
3		-1.432	-2.406
Delta	1.391	5.824	8.620
Rank	3	2	1

Table 16: Table containing responses for means of Tool Wear

Level	Tool Diameter(X)	Rotation Speed (Y)	Feed Rate (Z)
1	0.895	0.708	0.546
2	1.041	0.967	1.018
3		1.227	1.338
Delta	0.146	0.519	0.792
Rank	3	2	1



Table 17: ANOVA outcome for s/n ratios of Tool Wear

Source	DF	Sum of squares (S)	Variance (V)	F-ratio (F)	P-value (P)	Percentage(%)
X	1	8.711	8.711	3.61	0.082	2.3 %
Y	2	103.213	51.607	21.40	0.000	27.31 %
Z	2	237.005	118.502	49.15	0.000	62.72 %
Residual Error	12	28.932	2.411			7.65 %
Total	17	377.860				100%

Table 18: optimal level values for Tool Wear of Al 6063 from “Graph 3”

Input variables	Levels	Tool Wear Response values	S/N response values
X	1	0.895	1.975
Y	1	0.708	4.392
Z	1	0.546	6.214

Table 19: Validation of testing for Tool Wear of Al 6063 (10 mm thick plate)

	Optimal input variables	
	Estimated values	Experimented values
Level	X <sub>1</sub> Y <sub>1</sub> Z <sub>1</sub>	X <sub>1</sub> Y <sub>1</sub> Z <sub>1</sub>
Tool Wear	0.2141	0.235
S/N ratio for Tool Wear	12.578	10.023

Linear regression equations obtained from the above data for finding out the relationship among the specified input parameters for drilling circumstances on Al 6063. For multiple input parameters, linear type models have been generated by commercial Minitab 19 software and are presented here:

$$\text{Surface Roughness(Ra)} = 1.603 - 0.0300X - 0.000157Y + 0.806Z$$

$$\text{Material removal rate} = -1654 + 255.4X + 1.8306Y + 3239Z$$

$$\text{Tool Wear} = -1.215 + 0.0731X + 0.000636Y + 6.600Z$$

## VI. CONCLUSION

In this project, Wear of the tool, Material removal rate from workpiece and Surface roughness of the sample at the entries and exits of the work material are measured using the rate of feeding, the rotation speed of the tool, and the diameter of the tool as input process parameters while drilling Al 6063 alloy with HSS spiral tool. Drilling conditions are adjusted with respect to a variety of performances in order to achieve better quality of the hole

while the process of drilling of Al 6063 alloy. The Taguchi technique was employed to optimize the drilling settings. A tool dia. of 8mm, rotation speed of 1400 rev per min, and a feed rate of 0.10 mm per rev were found to be the optimal combination of drilling conditions for producing a high value of s/n ratios for the surface roughness of the hole. While A tool dia. of 6 mm, rotation speed of 600 rev per min, and a feed rate of 0.10 mm per rev were found to be the optimal combination of drilling conditions for producing high value s/n ratios for Material removal rate as well as for Tool wear too.

Several factors [including angle of the drill point, angle of helix, no. of flutes in the drill, kind of drill tool etc.] can be included in future studies to investigate that how such factors influence the quality of the sample of other types of material or alloys.

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# Practical Model for Firm's Capital Structure

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**Keywords**— capital structure, debt, VaR, CVaR, value creation.

**Abstract**— Since they offer an opportunity to create value for shareholders, a company's capital structure decision is crucial for its existence and performance and, therefore, has been addressed by several studies in the finance area. However, there is no unanimous answer determining the most efficient capital structure for a given organization and there is a lack of evidence regarding the use of optimal structure models in the daily lives of companies. The methodology in this work is composed of four phases to propose a practical method for decision-making on a company's structure. First, it is defined the problem that will be simulated. Then, using the FCD and SMC techniques, the company's value is calculated and the insolvency risk is quantified. And finally, in the fourth phase, discussions are developed regarding the ideal capital structure for the company. The results simulated through the selection of an object study show the increase in the company's value from indebtedness, presenting opportunities to create value for its managers. The model has as a limitation the case study of only one segment, and can be expanded to other sectors in future works. Still, the proposal must be understood as beneficial for all stakeholders involved, since more competitive companies can provide products and/or services with superior quality and lower prices, being, therefore, a direct social contribution of the present proposal.

## I. INTRODUCTION

The capital requirement of a company can be met by external capital or internal capital and its proportions represent the capital structure of the company (Anastasia and Lorenza, 2019). According to Ehrhardt and Brigham (2011), a company's capital structure decision is crucial for its existence and performance.

Opler, Saron and Titman (1997) highlight that capital structure decisions offer an opportunity to create value for shareholders. Certain technical attributes are relevant when companies select their capital structure (Perobelli and Famá, 2003; Serrasqueiro, Armada and Nunes, 2011). For Perobelli and Famá (2003), among them are: the size of the company; degree of business growth; asset structure (tangible versus intangible); uniqueness of the products

offered; profitability; and volatility of operating results, among others. These attributes are capable of influencing the costs and benefits associated with the issue of shares or debt. In this context, it is noted that the optimal capital structure is highly complex and finding the structure that will minimize the company's cost of capital and, consequently, maximize the company's value has been debated by several authors since the pioneering work of Modigliani and Miller (1958).

Several approaches on the subject have been developed. Nevertheless, there is no unanimous response determining the most efficient capital structure for a given organization. For Graham and Leary (2011), research is being developed, mainly in two traditional views. The first concerns the trade-off theory in which companies seek the leverage that optimizes the benefits and costs of the debt. The second view refers to the pecking order of Myers and Majluf (1984) and Myers (1984), a theory that suggests that there is a hierarchy to minimize the costs of financing assets. Thus, Myers (1984) argues that companies initially prefer to reinvest their profits and, when these funds are exhausted, they resort to financing with bank debts and finally, to the stock market.

In relation to the trade-off theory, it is assumed that there is an optimal capital structure capable of maximizing the company's value, considering the tax benefits of debt and the costs of financial difficulties that may arise with indebtedness. This type of decision must take numerous factors into account, such as the direct and indirect costs of a possible bankruptcy (e.g. bankruptcy cost and operational weakness), conflict of information, tax savings provided by debt contraction and transaction cost, among others.

The contradiction created by the benefits and disadvantages of the debt opened the possibility for the present research to analyze the maximum level of indebtedness that would provide the optimization of the value of a firm. Therefore, the possible risk of bankruptcy is taken into account, which would result in extra costs for the company as well as a reduction in its value given the increased return required by the company's internal and external financiers in addition to its operational weakness.

Therefore, the objective of this article is to propose a practical method for decision making regarding the company's capital structure by using the Discounted Cash Flow (DCF) technique and risk quantification through the Monte Carlo Simulation (SMC). As the object of study and simulation of the proposed method, Grendene, a company listed on the Brazilian stock exchange inserted in the footwear segment, which features a low financial leverage policy with a debt level below 1%, was selected.

The main empirical contributions of this article refer to the methodology developed in order to assist managers in making capital structure decisions, using concepts of company valuation and respecting indebtedness limits while avoiding situations of financial difficulties and potential operational weakening. Methodologically, the article proposes a structure of wide application for all segments of companies, contributing directly to the reduction of the company's cost of capital and, development of more competitive companies in the creation of value. Therefore, this contribution favors consumers and society as a whole on another level, creating a sustainable synergy between institutions and consumers.

In addition, this article uses the concepts of risk, through Value at Risk (VaR) and Conditional Value at Risk (CVaR), in the context of the company's cash flow.

This article is divided as follows: in the second chapter, a review of the trade-off theory and studies using VaR and CVaR are presented. Then, the proposed model to aid decision making is presented in chapter three. In the fourth chapter, a study developed in order to test the applicability of the proposed model and its results are discussed. Finally, conclusions related to the proposed model along with its advantages and limitations are exposed.

## II. LITERATURE REVIEW

### 2.1 Trade-off

As previously mentioned, the trade-off theory assumes that there is an optimum level of indebtedness that maximizes the value of companies, considering the costs and benefits arising from indebtedness. According to Sardo and Serrasqueiro (2017), the trade-off theory suggests that companies adjust their debt level through an ideal debt target. Debts are usually less costly ways of financing the company than using equity since interest is tax deductible and dividends are not (Opler, Saron and Titman, 1997). However, Myers (1984) explained that despite the aforementioned tax benefit resulting from indebtedness, the increased cost of financial difficulty must be taken into account. In this context, Myers (1977) reports for a common mistake when underestimating such costs as compared with the costs saved with the indebtedness.

Despite the existence of numerous applied studies, empirical research generally diverges regarding the determinants of the capital structure regarding the trade-off theory (Bastos and Nakamura, 2009). One of the most famous discussions on the subject is reported in Modigliani and Miller (1958) and likewise in Modigliani and Miller (1963) years later. In the first approach, the authors considered that the market value of each company

is independent of its capital structure. However, in the article published in 1963, the authors relaxed the assumption of perfect competition and recognized the tax advantage caused by indebtedness as well as the existence of other relevant factors in financial decisions.

In their work, Opler, Saron and Titman (1997) sought the optimal capital structure of companies via a model that found the financing mix which minimized the discounted sum of future tax payments, costs of financial difficulties and costs of financing. 10,000 iterations were carried out through SMC with 20-year projections. The authors conclude that leveraged companies lose more value in the face of the market crisis when compared to conservative companies. In addition, Opler, Saron and Titman (1997) claim that the financial difficulties are reflected in the stakeholders (suppliers, workers, and customers) since suppliers do not extend credits to these companies leaving workers to require higher wages and customers are not willing to paying high prices for the product.

Serrasqueiro, Armada and Nunes (2011) used a sample of small and medium-sized companies (SMEs) and large companies to analyze whether there was a difference in their capital structure decisions through the theory of trade-off and pecking order. The authors concluded that capital structure decisions in SMEs are considerably different from other types of companies since SMEs resort to debt more as a consequence of the lack of internal cash for financing and less concern with the objective of reaching the ideal debt index. Therefore, SMEs are closer to the assumptions of the pecking order theory than the trade-off ones.

Through a link between agency theory and capital structure, Chang, Chou and Huang (2014) used dynamic models to examine the influence of corporate governance practices on the speed of adjustment of the capital structure in cases in which companies have a level of indebtedness that is far from ideal. Thus, using a regression model, the authors concluded that weak governance firms, whether over-leveraged or under-leveraged, adjust more slowly when compared to firms with strong governance.

In turn, Devos, Rahman and Tsang (2017) examined the speed of adjustment of the capital structure, conditioned to the existence of covenants related to a company's debt structure. The test results show that the speed of adjustment is hindered by the restrictive debt clauses. The authors find that the speed of adjustment in relation to the company's optimal debt ratio is about 10 to 13% lower when a company has covenants compared to companies that do not.

Fischer, Heinkel and Zechner (1989) developed a dynamic capital structure decision model taking into account

recapitalization costs. Therefore, capital structure decisions depend on the tax benefits of indebtedness and the potential cost of indebtedness in addition to financial difficulties, asset variability, interest rates and recapitalization costs.

## 2.2 VaReCVaR

The VaR measure was developed to obtain the maximum potential for a loss or worse outcome for an investment in a certain period of time within a confidence level of interest to the decision maker, such as 1% or 5% (Bilan et al., 2020 and Charnes, 2007). According to Charnes (2007), VaR can be used by both regulators and managers as a basis for risk-management decision making.

However, VaR does have some disadvantages. Sharifi, Kwon and Jardini (2016) highlighted that the referred technique presented limitations of applicability and difficulties in optimization scenarios. Charnes (2007) reported that the VaR did not present information on the extent of the loss that could occur above the threshold level. To overcome these limitations, CVaR can be used, especially in cases in which the analyzed returns are not normally distributed. CVaR can be simply defined as the average of all values in addition to VaR (Sharifi, Kwon and Jardini, 2016 and Charnes, 2007).

Additionally, there are several studies found in the literature that have used these techniques in the most varied objects of studies. Nakamura, Martin and Kayo (2004) proposed a practical model to be implemented by the financial managers of companies to find the level of indebtedness that maximizes the value of the company so as not to exceed the present value of the operating cash flow of the company for a given confidence level. In order to find the maximum loss expected from an investment given a confidence level of (95%) and a predetermined period, the authors used the concept of VaR in the context of the company's operational activity.

Based on the scenario of major crises faced by the real estate market, Barañano, De La Peña and Moreno (2020) assessed the risk of this market using an internal model in conjunction with VaR for a confidence level of 99.5%, obtained through SMC.

Li and Cai (2017) proposed a multi-objective optimization structure to determine the capital structure for private financing in infrastructure projects in order to align the interests of creditors and shareholders. The methodology used by the authors consisted of three stages. The first involved the use of SMC for project valuation and CVaR to measure project risk. In the second stage, the authors develop a multi-objective optimization problem in which the first objective is to maximize the net present value while minimizing the at-risk cash flow from the



shareholder's perspective. The second objective was to maximize the rate of return on loans while minimizing the risk of default by shareholders from the lender's point of view. In the third phase, the authors carried out a sensitivity analysis in order to provide managerial and financial information.

Sharifi, Kwon and Jardini (2016) presented a stochastic approach based on programming for the evaluation of performance-based contracts. In this study, VaR and CVaR risk measures were computed for different levels of budgets in order to provide estimates of the worst case of expected operational availability of contracts for certain confidence levels.

### III. RESEARCH METHOD

This section intends to describe the proposed method which, inspired by the work developed by Nakamura, Martin and Kayo (2004), consists of proposing a framework to find the capital structure that will allow the company to maximize its value, taking into account that excessive levels of indebtedness can cause high costs associated with financial difficulties and operational weakness. Thus, indebtedness must respect, within a degree of probabilistic confidence, the maximum level that ensures the company's solvency situation.

This approach aims to support decision making in providing a support structure for managers to find the level of capital structure that will allow maximization of the company's value while guaranteeing its solvency situation. Figure 1 presents a structure for the decision-making process. As can be seen, the first phase consists of defining the problem. In this phase, the variables that will be used in the model are defined. That is, which characteristics are selected to determine the ideal capital structure are defined. The second phase of the method consists of calculating the company's Free Cash Flow (FCFF). In the present study, the FCFF estimate takes the assumptions of Damodaran (2012) into account.

The next step consists of the selection and parameterization of the model's stochastic variables. Through the Monte Carlo Simulation, using the CrystalBall® software, the most sensitive variables of the model are analyzed and finally, the company's value for the 95% confidence level is found, this being the VaR of the Model. Still in the third phase, the expected average value at risk (CVaR) is calculated. Finally, the capital structure that would maximize the company's value is defined.

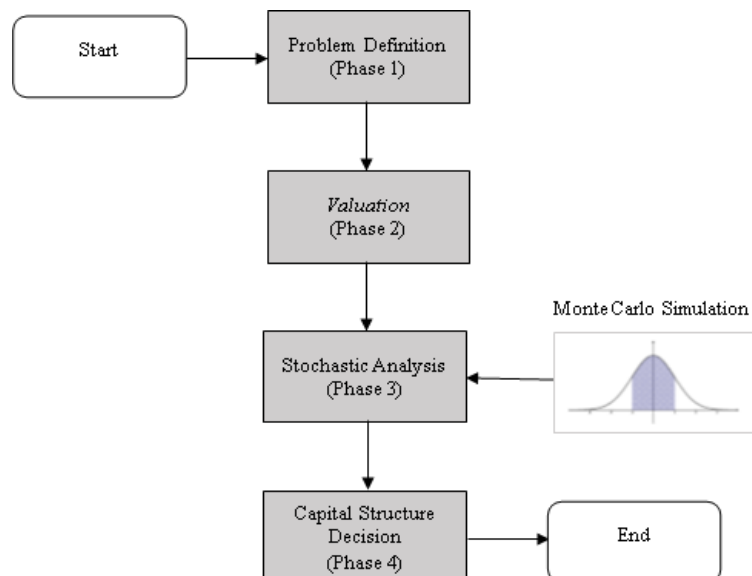


Fig.1: Decision-making process for capital structural

Source: Prepared by the authors

#### 3.1 Problem Definition

According to Martinez, Scherger and Guercio (2019), the capital structure decision is concerned with the way in which a company finances its operations using different sources of financing. However, determining the optimal

capital structure given the benefits and difficulties inherent in indebtedness has been widely discussed in the literature. In this sense, this research seeks to develop a framework for capital structure decisions in order to maximize the value of the company, taking into account the trade-off inherent in indebtedness. More specifically, it aims to

determine the maximum indebtedness that a company can contract in order to not incur financial difficulties.

### 3.2 Valuation

The next step consists of calculating the company's value (valuation) by using the DCF method, calculated according to Damodaran (2012). According to the aforementioned author, the value of a company that reaches a steady state after  $n$  years and grows at a steady growth rate of  $g_n$  after that can be written as:

$$\text{Firm Value} = \sum_{t=1}^{t=n} \frac{FCFF_t}{(1+WACC)^t} + \frac{\left[ \frac{FCFF_{n+1}}{(1+WACC-g_n)^n} \right]}{(1+WACC)^n} \quad (1)$$

$FCFF_t$ : Free Cash Flow of the Company in the period  $t$ ;  $WACC$ : Weighted Average Cost of Capital;  $t$ : period;  $g_n$ : Perpetuity Expected Growth.

This approach is used because according to Damodaran (2012), this is a good alternative when it comes to a company in the process of changing leverage, the central theme of this study. To calculate the WACC, the formulation used was that of Brealey et al. (2018).

$$WACC = k_d D(1-\tau) + k_e E \quad (2)$$

$k_d$  is the debt cost;  $D$  represents the indebtedness, or portion of the debt (third party capital) in the investment;  $\tau$  is the income tax rate;  $k_e$  is the cost of equity; and  $E$  represents the fraction of total capital represented by shareholders' equity (%).

For calculating  $k_e$  the Capital Asset Pricing Model (CAPM) is used, according to the following equation.

$$k_e = R_f + \beta(R_m - R_f) \quad (3)$$

$R_f$  is the risk-free interest rate;  $\beta$  is the non-diversifiable risk; and  $R_m$  the market rate of return.

According to Damodaran (2012), the most critical variable to be calculated, especially in companies that have high growth rates, is the growth rate of revenues and profits. According to the author, there are three ways that are most commonly used to estimate this growth rate. The first refers to the historical growth rate, which can be by means of arithmetic, geometric means or forecasting models. The second way is through studies developed by analysts who follow the company under analysis.

Finally, it was also possible to estimate the growth rate from the company's fundamentals. Essentially, according to this last theory, a company's growth rate depends on its reinvestments and their quality. There is consensus in some studies that expert analyses are usually more effective than predictions from historical data and that revenue growth is often more predictable than profit since accounting decisionmaking has less influence on revenue than on profits.

Thus, based on the company's fundamentals, the growth rate (TC) and operating profit (EBIT) can be described according to Equation 4 (Damodaran, 2012).

$$TC = RR \times ROC \quad (4)$$

$RR$  is the Reinvestment Rate, a measure to analyze how much the company is reinvesting to generate future growth and  $ROC$  is the Return on capital.

$$RR = \frac{CAPEX - Depreciation + \Delta \text{Necessity of Ret}}{EBIT(1-\tau)} \quad (5)$$

$$EBIT = \frac{(1-\tau)}{\text{Capital Invested}} \quad (6)$$

$CAPEX$  is the Capital Expenditure and  $\tau$  is the company's tax rate.

### 3.3 Stochastic Analysis

The third stage consisted of the identification of the model's stochastic variables and their probability distributions. In order to do so, the sensitivity of each variable in the company's value result is first analyzed by using the CrystalBall® software. Thus, the most impactful variables in the company's valuation are included in the VaR analysis.

The most impactful variables of the valuation result selected in the previous phase are inserted in the model for SMC and also through the CrystalBall® software. Thus, through the VaR theory used in the context of valuing companies, the worst result for the company's value is found at a 95% confidence level. In other words, the objective of this stage is to find the company's risk value for a 5% chance of occurrence. In addition, as a way of quantifying the average loss that occurs beyond VaR, CVaR will provide relevant information about the end of the distribution.

From the results found of the maximum level of indebtedness, confidence level, sensitivity of the variables and variation in the value of the company, it was possible to provide more accurate information that will assist the

financial manager in making decisions regarding the ideal capital structure of the company.

### 3.4 Object of the Clinical Study

In order to present the applicability of the structured model developed in the present work, a company that will be called object of study is selected. It is worth noting that the analyses were based on the financial statements, explanatory notes and comments on the performance of 2019 available on the B3 website.

Among the companies listed on the Brazilian stock exchange (B3), a company in the footwear segment draws attention due to its low level of indebtedness, justified by a low leverage policy instituted in the company. As a result, the company object of study is Grendene SA, which was founded in 1971 and is currently one of the largest producers of footwear in the world in addition to being the owner of brands such as Melissa, Grendha, Zaxy, Rider, Cartado, Ipanema, Pega Forte, Grendene Kids and Zizou.

## IV. RESULTS

After analyzing the company Grendene, it was possible to note that the company makes minimal use of third-party capital since its market debt ratio is approximately 0.74% and its Net Debt / EBITDA ratios were negative from 2017

to 2019, being -2.74 in 2017, -2.70 in 2018 and -2.68 in 2019. This shows that in addition to having little debt, the company retains a considerable amount of cash and financial investments.

In comparison with companies in the same segment (Alpargatas, Cambuci and Vulcabrás), it is observed that this policy of low financial leverage is recurrent in two of these companies (Alpargatas and Vulcabrás). On the other hand, Cambuci has a debt ratio of approximately 27.5%, a value significantly higher than that found in other companies in the segment.

Thus, in the following steps, we sought to investigate whether the company's capital structure significantly impacts the value result of Grendene SA and what would be an ideal level for the company to go into debt with a focus on maximizing value, considering the risk perspectives for using the VaR and CVaR theory.

### 4.1 Valuation

The first step developed to calculate the company's value was to develop the company's FFCF for the last 5 years (2015 to 2019) available in the databases of the B3 website, as shown in Table 1.

Table1: FFCF Grendene (in thousands of reais)

	2015	2016	2017	2018	2019
Sales revenue	2165.21	2013.87	2251.97	2333.45	2071.03
Cost of Sales (CMV)	1134.91	1048.58	1151.21	1227.32	1126.51
Gross profit	1067.88	996.52	1100.75	1106.12	944.52
Operational expenses	667.15	596.93	635.16	649.16	590.99
EBIT	400.73	399.59	465.59	456.96	353.52
(-) Taxes	43.76	34.15	43.18	30.31	36.64
Profit after Tax	356.96	365.43	422.40	426.65	316.88
(+) Depreciation	53.65	57.87	60.63	65.76	77.22
(-) Working Capital Need	38.57	37.19	136.96	64.38	19.90
(-) CAPEX	72.50	64.80	98.20	71.71	52.17
(=) Free Cash Flow	299.53	395.70	247.86	356.31	322.02

Source: Prepared by the authors

EBIT forecasts from 2020 to 2026 were based on the computed value for 2019 with EBIT growth rate forecast, calculated based on Equation 4. Thus, an average of the ROC and RR for the last three years was calculated, resulting in an average ROC value of 10.81% per year and RR of 19.67% per year. Therefore, the EBIT growth rate was calculated at 2.13% per year. In order to forecast tax

expenses, the average proportion of taxes paid in the last 5 years was considered. Finally, to forecast reinvestments in CAPEX and working capital, the proportion of 19.67% already calculated based on Equation 5 was established. It is worth noting that the free cash flow computed for 2026 will be used to calculate the net present value of the flow perpetuity cash flow.

Table 2: FFCF forecast (in thousands of reais)

	2020	2021	2022	2023	2024	2025	2026
EBIT	361.04	368.72	376.56	384.56	392.74	401.09	409.62
(-) Taxes	33.03	33.73	34.45	35.18	35.93	36.70	37.48
Profit after Tax	328.00	334.98	342.10	349.38	356.81	364.39	372.14
Reinvestment Rate	64.51	65.89	67.29	68.72	70.18	71.67	73.20
(=) Free Cash Flow	263.49	269.09	274.81	280.65	286.62	292.72	298.94

**Fonte:** Prepared by the authors

With regard to the estimate of the discount rate through the WACC, current values at the end of 2019 were considered, discounting the inflation for the parameters of the cost of equity calculated by the CAPM equation. The risk-free rate of NTN-B government bonds with a 15-year maturity was considered, whose value corresponds to 3.23% per year (TN, 2020). A beta parameter was additionally considered over 24 months for Grendene with a value of 0.65 extracted from the Economática® software. In turn, the market premium of 8.03% per year was considered for the month of December 2019 (CEQEF-FGV, 2020).

As for the debt cost, the value of 3.87% per year was found based on data published by the company in this period. After collecting and estimating all the data necessary to calculate the company's value through Equation 1, the result is R \$ 9.954 billion. When the cash value is added and the debt value is subtracted, the amount of R \$ 11.112 billion is earned. Given the number of shares

on 12/31/2019 of 902,160,000, the share value found was R \$ 12.32, a result very close to the market value quoted for Grendene's shares on 12/31/2019 of R \$ 12.28.

#### 4.2 Stochastic Variables

In this stage, probability distributions was assigned to the variables identified as having the greatest impact on the result of the estimated value for the company.

In the case of Grendene SA, the variables identified as the most sensitive to the company's present value result in decreasing order are: Perpetuity growth rate (denoted by Perpetuity Growth Rate in Figure 2), reinvestment rate (denoted by Reinvestment Rate in Figure 2), ROC, indebtedness (denoted by Debt Ratio in Figure 2) and tax rate (denoted by Taxes Ratio in Figure 2). Through the CrystalBall®, the sensitivity graph of these variables was obtained for the test intervals from 20% to 80%, as shown in Figure 2.

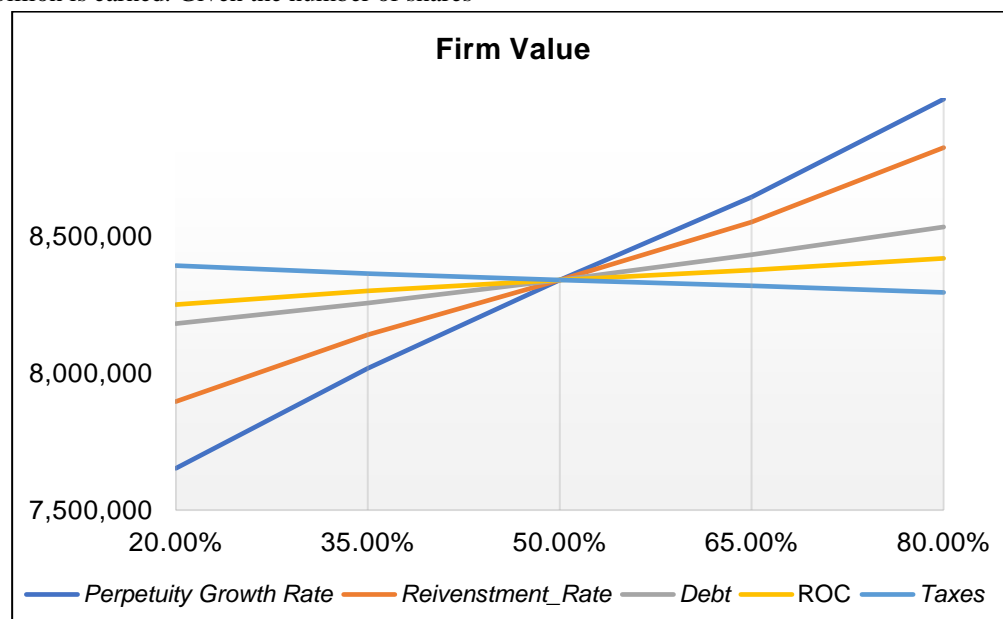


Fig.2: Sensitivity Graph.

### 4.3 VaR

After the previous step, the variables that had the most impact on the firm's value result were selected, and therefore only the tax rate variable was excluded from the simulation as it had little impact on the valuation results. Thus, the triangular distribution was attributed to the variables perpetuity growth rate, reinvestment rate and ROC since, according to Aouni, Martel and Hassaine (2009), such distributions can be used to insert the

uncertainty in the input parameters and output of a model as they represent human expertise well in correctly judging the behavior of common variables in different practical situations.

For the indebtedness variable, this study opted for the use of uniform distribution. Table 3 presents the selected variables and their respective distributions and parameters inserted in the analysis.

Table 3: Stochastic variables

Variables	Distribution	Parameters
Reinvestment Rate	Tringular	(-2%, 19.67%, 45%)
Perpetuity Growth Rate	Tringular	(0%, 1.37%, 2.13%)
ROC	Tringular	(8.32%, 10.81%, 12.65%)
Indebtedness	Uniform	(0%, 100%)

Source: Prepared by the authors

Thus, the aforementioned stochastic variables were inserted into the model and, using the CrystalBall® software, 10,000 iterations were simulated and the results can be seen in Figure 3. Based on the simulation shown in

Figure 3, we can define that that given a confidence level of 5%, the value that the company can reach is R \$ 5,793 billion.

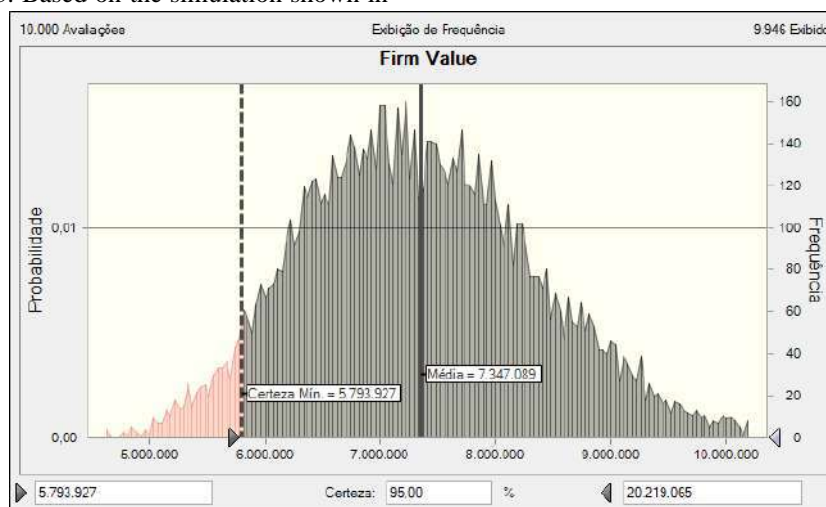


Fig.3 VaR (confidence level: 95%)

This result showed that in order to prevent a debt situation from affecting the company's equity solidity, the maximum that the company could borrow is approximately R \$ 5,793 billion. With this level of market indebtedness and keeping all other variables fixed, the company would increase its value by approximately 26.13%. However, this debt value of 52.02%, is significantly higher than that presented by companies in the same segment. In this context, in order to

analyze what would be the increase in value if the company were indebted to the most indebted company in the sector (Cambuci), a debt level of 27.50% was simulated for Grendene. The values found showed that such a change would result in an increase of 9.60% in the company's value. To identify the average loss that exceeds the VaR, the CVaR is calculated for the 95% confidence level, as shown in Figure 4.



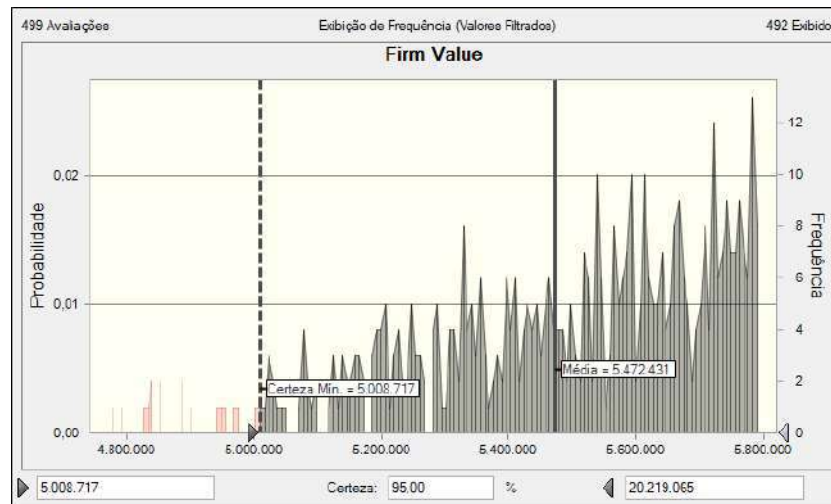


Fig.4 CVaR (confidence level: 95%)

Thus, it is possible to infer that the expected loss that exceeds the VaR is equal to R \$ 5,008 billion. That is, it is the average expected value that the company's value is subject to given a 95% confidence level. In addition, other simulations were carried out in order to analyze the risk

results for the different levels of indebtedness. In this context, the simulation results to find the VaR and CVaR for the 90% and 99% confidence levels are shown below in Figures 5 to 8.

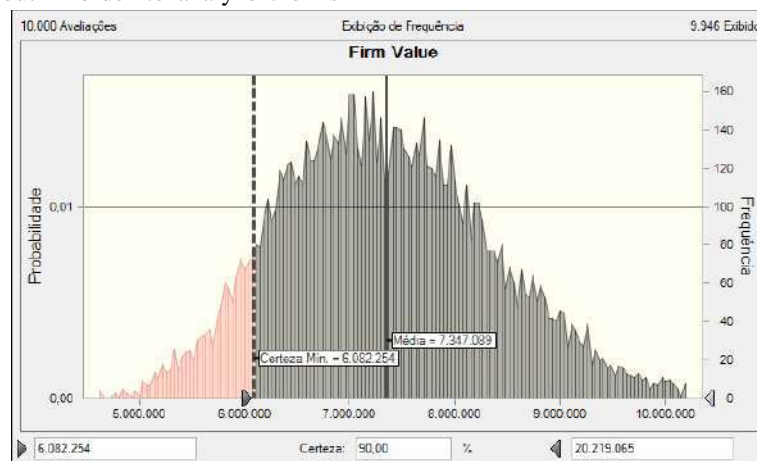


Fig.5 VaR (confidence level: 90%)

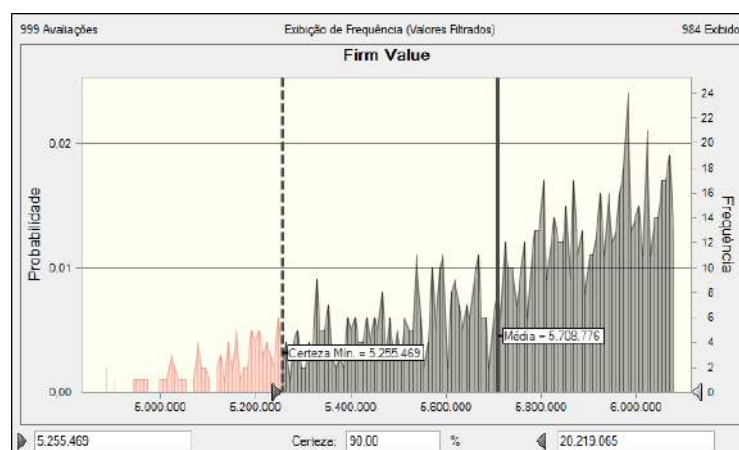


Fig.6 CVaR (confidence level: 90%)

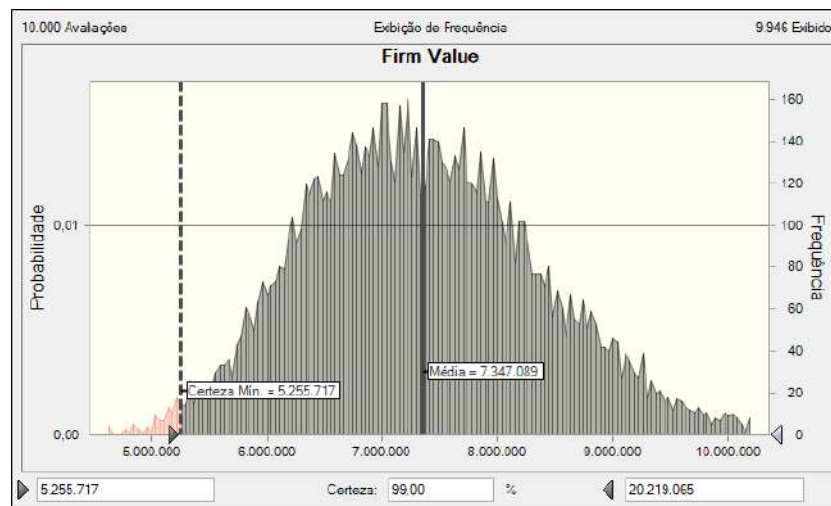


Fig.7 VaR (confidence level: 99%)

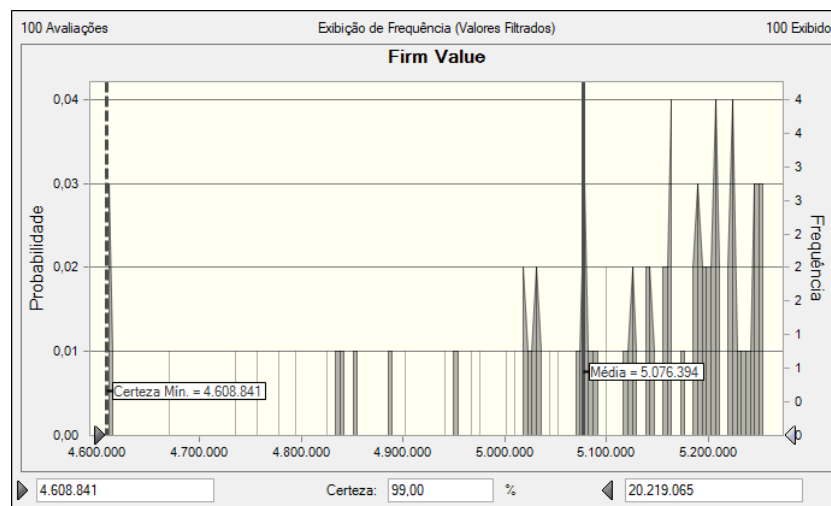


Fig.8 CVaR (confidence level: 99%)

It is observed that as the confidence level increases, the maximum level of indebtedness decreases and in this way, for the 90% confidence level, the maximum indebtedness level is R \$ 6,082 billion and for 99% the maximum indebtedness is R \$ 5,255 billion. That is, if it is the strategy of the company's managers to incur less risk of financial difficulties, despite the indebtedness creating value for the company, the results point to the adoption of a lower level of indebtedness.

#### 4.4 Capital Structure Decision

From the results observed in the simulation, the financial manager will be able to make decisions about the company's capital structure policy, aiming to maximize the creation of value and the risk reduction of an eventual bankruptcy. Therefore, in order to report on the results observed from different levels of indebtedness, Table 4 shows the maximum indebtedness levels and their

respective variations in the company's value for each confidence level.

Table 4: Indebtedness and change in company value

	99%	95%	90%
Indebtedness	47.33%	52.02%	54.60%
$\Delta$ Company value	+22.14%	+26.13%	+28.54%

**Fonte:** Prepared by the authors

As can be seen, the higher the level of confidence, the lower the maximum level that the company could be indebted to without compromising the company's equity situation. Thus, as in the simulated case, indebtedness offers the opportunity to maximize the company's value and thus the use of third-party capital can be a good strategy for the company's financial managers to adopt. However, it is important to point out that the greater the debt, the greater the risk of financial difficulties, and

therefore, if management has the premise of incurring lesser risks, as is the case of the company Grendene, adopting the 99% confidence level may associate value maximization with a low risk of insolvency.

#### 4.5 Discussions of Results

The simulation of 10,000 scenarios showed some evidence of the benefits inherent in indebtedness for the company. The result of indebtedness is an increase in systematic risk, represented by the leveraged beta parameter ( $\beta$ ) of the CAPM and with this, an increase in the cost of equity. However, the increase in indebtedness promotes tax benefits since interest is deducted for the purpose of calculating income tax in contrast to the payment of dividends. Mathematically, this effect can be seen in the calculation of third-party capital and consequently, in the results of WACC.

It is worth mentioning that the company's value is maximized with a level of indebtedness equal to the maximum loss amount, given a certain confidence level, since levels of indebtedness higher than this can affect the company's equity situation and lead them to difficulties with financial institutions. According to Opler, Saron and Titman (1997), these difficulties can affect the main stakeholders of the company (suppliers, workers and customers). Since suppliers tend to restrict credit to these companies, workers demand higher wages, and customers are not willing to pay a lot for the product. In addition, companies with high debt volumes tend to not fight for market position, reducing prices and investing in advertising as they seek to preserve cash in the short term.

Thus, despite the indebtedness being linked to the increase in the company's value, it is the managers' responsibility to find the optimum level of indebtedness that maximizes the company's value without compromising the operational activity and incurring insolvency situations while always respecting the policy of capital structure established in the company.

#### V. CONCLUSION

The capital structure policy of companies has been a widely debated subject in the literature. However, no evidence has been found in relation to models to assist managers in decision making regarding the optimal level of indebtedness. That is, the level of indebtedness that would maximize the company's value. In this context, this article aimed to develop a model to support this decision making while respecting the risk limits and possible financial difficulties proved by excessive leverage.

Thus, the proposed model seeks first to calculate the company's value and the impact of variables on the

valuation result and then to calculate the maximum loss value for a specific confidence level using VaR. The VaR value found is the maximum indebtedness suggested by the company and serves as a guideline for the decision making of the company's managers.

In the proposed simulation, the case of Grendene, whose policy is to operate with low financial leverage, was analyzed. The simulation results showed that this practice can be seen as debated from the point of view of creating value since higher levels of indebtedness increase the creation of value for the company. However, this low-leverage practice can be seen in other companies in this segment in Brazil with the exception of Cambuci, which operates at a level of indebtedness that, if practiced by the company Grendene, would increase the company's value by approximately 9.60%.

We do not prescribe, peremptorily, that the company in question changes its capital structure policy, but rather that it may feel motivated to reflect on the possible benefits and harms of adopting a more aggressive strategy. It is worth mentioning that proposals for adding value are beneficial not only for the company, but for all the chain and stakeholders involved, since more competitive companies can provide products and/or services with superior quality and lower prices, being therefore, an essential contribution of this proposal.

It is noteworthy that the effects of agency and transaction costs were not considered, but instead are recommended in the analyses of future publications. In addition, it is emphasized that other variables, distributions and parameters can be used to analyze the impact on the result of the company's value and increase the contributions of the method developed in the present study.

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# Breastfeeding and Emotional Aspects during the Covid-19 pandemic Period in two Counties in the Metropolitan Region of Belém/Pará, Brazil

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**Keywords** —Breast-feeding, Breast milk, Puerperium, Emotional stress, Anxiety.

**Abstract**—Introduction: The monitoring of women and guidance on the benefits of breast milk are of paramount importance for the mother to choose to breastfeed. It is necessary that the approach is effective and gradual so that she feels pleasure and well-being when practicing the act of breastfeeding. This activity is vulnerable to interference from multiple factors that encompass maternal principles, especially with regard to the conduct of each woman in these circumstances. Maternal insecurity was one of the factors that puerperal women reported presenting and influencing early weaning, since this insecurity may be related to the production of breast milk. Therefore, the present research aimed to describe which emotional aspects were reported by women who breastfed during the pandemic period in two municipalities in the metropolitan region of Belém. Methodology: Quantitative, descriptive and cross-sectional study with the application of an online questionnaire via Google forms. Conclusion: The research results reflect on the importance of investigating factors related to the emotional aspect of women during pregnancy and postpartum periods, in order to prevent and treat these changes or disorders, as they influence maternal health and consequently in the practice of breastfeeding. However, it is important that new research be developed to help health professionals in encouraging this practice that saves so many lives.

## I. INTRODUCTION

The act of breastfeeding has its nutritional, social, economic, cognitive and immunological benefits proven

by several studies, especially when this practice extends until the sixth month with exclusive breastfeeding and up



to two years of the child, being complemented with other healthy foods [1].

Monitoring the woman and providing guidance on the benefits of breast milk is of paramount importance for the mother to choose to breastfeed. It is necessary that the approach is effective and gradual so that she feels pleasure and well-being when practicing the act of breastfeeding. This activity is vulnerable to interference from multiple factors that encompass maternal principles, especially with regard to the conduct of each woman in these circumstances. Maternal insecurity was one of the factors that puerperal women reported presenting and influencing early weaning, since this insecurity may be related to the production of breast milk. In addition to the interferences that can occur during these phases, which also contribute to the nursing mother presenting some obstacle when breastfeeding and even in the production of breast milk [2].

During the lactation period in the puerperium, the benefits that breastfeeding brings to women's health are diverse and persist even after the interruption of milk production. However, it is important that breastfeeding continues until the child is two years old or more. The lactating women reported that they had fewer complications related to physical and mental health, such as postpartum depression, attenuation of stress and anxiety, in addition to helping to increase self-esteem [3].

The importance of breastfeeding is exposed in several studies, there are several benefits that this practice brings to maternal and child health. However, it is important that the woman breastfeeds the child exclusively for up to six months and up to two years of age in a complementary way. However, the suspension of breastfeeding may be related to emotional issues, thus leaving the mother and child vulnerable to various risks [4].

In the last two years we have been affected by SARS-CoV-2, which is the virus responsible for the Coronavirus pandemic, first, the virus was discovered in China. In Brazil, the first case was reported in February 2020. The Coronavirus has a high transmission capacity, especially between person-to-person contact, by respiratory droplets [5].

The elderly, those with chronic diseases and pregnant women, postpartum women and newborns are referred to as groups in which the coronavirus infection can manifest itself in a more aggravating way, bringing concerns, uncertainties and doubts regarding breastfeeding in mothers who were infected by the virus. However, research ensures that breastfeeding increases the immunity

of babies breastfeeding is recommended after delivery, but with health protocols being implemented so that there is no risk of infection [6].

Arrais et al. [7] carried out a survey with the intention of verifying what fears pregnant women had regarding the infection of the coronavirus and found that 73% were afraid of vertical transmission of covid-19 through breastfeeding, in this same survey there was an expressive percentage of mothers with the concern of not being able to make skin-to-skin contact, since this act is essential to create a connection between the mother and her baby, in addition to the first feeding in this experience. These concerns and fear can trigger psychopathological symptoms that may influence breastfeeding.

Considering these statements above, the objective of this research was to describe which emotional aspects were reported by women who breastfed during the pandemic period in two municipalities in the metropolitan region of Belém/PA.

## II. METHODOLOGY

### 2.2 Type of study

Quantitative, descriptive and cross-sectional study with the application of an online questionnaire via Google forms.

#### 2.2.1 Study Population

The population of this study consisted of mothers, reached through an internet questionnaire, after approval by the Research Ethics Committee/Platform Brazil (ICS-UFPA).

#### 2.2.2 Research Location

The research was carried out in the cities of Belém and Ananindeua – PA/Brazil.

#### 2.2.3 Sampling

The sample was simple random, constant of women, within the above criteria, who were reached by the form through the sharing of a link via the internet.

#### 2.2.4 Characterization of sociodemographic and economic variables

Schooling was classified into eight cut-off points: "Child school", "Incomplete elementary school", "Complete elementary school", "Incomplete high school", "Complete high school", "Incomplete higher education", "Complete higher education", "Postgraduate/ Masters/ Doctorate".

Age was grouped into four age groups: "under 18 years old", "18-24 years old", "25-34 years old" and "35

years old or older". Marital status in: "single", "married", "stable union", "widow" and "other".

The researches realized in City and neighborhood in Belém, not presented limits of neighborhood. Who participates in the monthly family income and the average income were divided into 5 cut-off points each. About her participation in government programs, the participant responded with "yes" or "no".

#### 2.2.5 Analysis of clinical complications in the mother

The presence or absence of anxiety, depression and compulsive disorder during the breastfeeding period was listed in multiple-choice questions. Contagion by COVID-19 was classified as "Yes" or "No", in cases of positive response, they were asked to inform the period in five cut-off points: "Before pregnancy", "During pregnancy", "During childbirth and up to seven days after birth", "From the 8th day afterbirth until six months later" and "I did not contract it". The question about month and year of contagion was open ended.

#### 2.2.6 Questionnaire

##### QUESTIONNAIRE ON PRENATAL CARE AND CHILDBIRTH

The prenatal care network was divided into "SUS" and "Private network". Regarding the presence of prenatal guidance on COVID-19 and pregnancy, the cutoff points were only "Yes" or "No", as well as the questions regarding the presence of guidance on breastfeeding in prenatal care and guidance on breastfeeding with suspected or diagnosed COVID-19.

##### QUESTIONNAIRE ABOUT THE PERIOD OF BREASTFEEDING

Regarding the duration of breastfeeding, there was a subdivision into four cut-off points: "Less than six months", "Six months or more", "I am still breastfeeding" and "Did not breastfeed". The presence of fear or anxiety about breastfeeding due to COVID-19 was characterized as "Yes" or "No". If so, they were asked about the reason for fear or anxiety in eight statements: "Transmit COVID-19 to the child through breast milk", "Transmit COVID-19 through pregnancy", "Transmit COVID-19 through normal birth", "Feeling unprepared to take care of the child", "Heard some information about breastfeeding in the pandemic", "Others" and "Did not feel fear or anxiety".

##### QUESTIONNAIRE OF POSSIBLE INFLUENCES

Regarding the presence of influence of the pandemic in the breastfeeding period, the participants answered between "Yes" or "No", in the affirmative cases, there was an open questioning about how there was influence. The presence of family guidance not to breastfeed due to COVID-19 was classified as "Yes" or "No", as well as the questioning about receiving

information about pregnancy or breastfeeding in the media during the pandemic, receiving information from the media advising breastfeeding and feelings of insecurity or fear of breastfeeding as a result of the media news.

#### 2.2.7 Statistical Procedures

The data were tabulated in the Microsoft Excel program, and analyzed using the BioEstat© 5.3 program. To verify the statistical difference between variables with two categories, the Mann-Whitney test was used, considering a confidence interval of 95% and a significance level of 5%.

#### 2.2.8 Inclusion and exclusion criteria

As inclusion criteria: women who breastfeed or who breastfed during the period of exclusive breastfeeding within the range of the COVID-19 pandemic, being residents of the cities of Belém and Ananindeua-PA/Brazil, and who agreed to participate in the research after signing the Free Informed Consent Term - TCLE.

Participants with incomplete questionnaires were excluded from this study.

#### 2.2.9 Data collect

Data collection began after project appraisal and authorization from the Research Ethics Committee of the Institute of Health Science - UFPA. Collaboration was requested to participate in the research, explaining the nature and purpose of the research. Then the researcher presented the TCLE, where they were explained about their rights and about the preservation of their anonymity. It was also explained that the fact of non-participation in the research will not imply any loss. Data collection was only performed after signing the informed consent.

#### Ethical aspects

Ethical evaluation process by the Research Ethics Committee

It followed the norms of the National Research Ethics Commission - CONEP, present in the CNS resolution 466/2012 and 510/2016 and its complementary norms, it was placed under consideration for approval or not by the Ethics and Research Committee of the Institute of Health Sciences – UFPA

The participants were informed in simple and accessible language: the research objectives, the data collection strategies, the reliability of the answers given, the right to refuse or withdraw consent at any stage of the research, the guarantee of preservation of the participant's identity and after other clarifications that emerged, the signature of the TCLE was requested.

Risk

The research requested, after clarification by the participant and signature of the consent form, the completion of the online questionnaire and did not use information that identifies the participants. However, during the filling, there may have been a risk of discomfort when reliving memories of the period of pregnancy and breastfeeding. To minimize this risk, the participant could withdraw from answering the questionnaire at any time, without harm to the interviewee. The confidentiality of their identity as well as that of the information provided was guaranteed, which were kept under the custody of the researchers. Such data were used in a codified form, with the only scientific purpose.

#### Benefits

The participant had the opportunity to contribute, anonymously, to the knowledge in the area of maternal and child nutrition, in this way, the research can collaborate with the availability of epidemiological data of fundamental importance for use by the competent authorities in the formulation of public policies that contribute to the resolution of the problems faced in the area, especially regarding the still little known scenario of COVID-19.

#### Financial support

The research was funded with resources from the researchers, with no conflict of interest by funding agents. The survey did not offer any type of compensation or reimbursement.

### III. RESULTS

In this research, 144 responses were obtained, however 2 were excluded. The socioeconomic and demographic characterization is shown in table 1. The sample was characterized with 59.86% from the city of Belém, and 40.14% from the city of Ananindeua. Most of these mothers are within the age group of 25 to 34 years, representing 52.11% (n=74). Among these, 26.76% (n=38) had completed high school as their level of education, followed by 23.94% (n=34) with graduate degrees, 21.13% (n=30) with incomplete higher education. Regarding marital status, 35.92% (n=51) women reported being in a stable union, 34.51% (n=49) and 28.17% (n=40) were married and single, respectively.

With regard to family income, 54.23% (n=77) reported income between 1 and 2 minimum wages, on the other hand, 74.65% (n=106) said they did not participate in any government program, as can be seen in table 1.

*Table 1 – Socioeconomic and demographic profile of the women surveyed.*

Data	N	%	p value *
<b>City</b>			
Belém	85	59.86	<0.0001
Ananindeua	57	40.14	
<b>Age</b>			
Under 18	2	1.41	
18 to 24 years	45	31.69	
25 to 34 years	74	52.11	
35 years or older	21	14.79	
<b>Education</b>			
incomplete elementary school	2	1.41	
Complete primary education	5	3.52	
Incomplete high school	11	7.75	
Complete high school	38	26.76	
incomplete higher education	30	21.13	
Postgraduate studies	34	29.94	
<b>Marital status</b>			
Single	40	28.17	

Married	49	34.51	
stable union	51	35.92	
Widow	0	0.00	
Other	2	1.41	
<b>Family income</b>			
1 to 2 minimum wages	77	54.23	
3 to 5 minimum wages	39	27.46	
6 to 10 minimum wages	19	13.38	
More than 10 minimum wages	7	4.93	
<b>Beneficiary in government programs</b>			
Yes	36	25.23	<0.0001
No	106	74.65	

Source: Authors, 2022.

\*p value obtained by the test Mann-Whitney

Table 2 presents the data found on breastfeeding. In the exclusive breastfeeding variable, 63.38% (n=90) mothers reported that they were still exclusively breastfeeding, followed by 23.24% (n=33) women who reported that they exclusively breastfed until the sixth month or more of the baby's life. 57.04% (n=81) said they

had used the SUS for prenatal consultations. Regarding what was addressed during prenatal care, 57.75% (n=82) received guidance on breastfeeding, despite this, 42.25% (n=60) did not.

Table 2 – Data referring to the breastfeeding period.

Data	N	%	p value*
<b>Exclusive Breastfeeding Period</b>			
less than 6 months	19	13.38	
6 months or more	33	23.24	
is still breastfeeding	90	63.38	
did not breastfeed	0	0.00	
<b>Care network used during prenatal care</b>			
SUS	81	57.04	<0.0001
private network	61	42.96	
<b>Guidance on breastfeeding in prenatal care?</b>			
Yes	82	57.75	<0.0001
No	60	42.25	

Source: Authors, 2022.

\*p value obtained by the test Mann-Whitney

Table 3 highlights data on how women had their routines changed and guided by the coronavirus pandemic. 55,63% (n=79) reported that they did not become infected with SARS-CoV-2. Among those who said they had contracted it, 16,90% (n=24) said they had it before pregnancy and 16,90% (n=24) during pregnancy.

Regarding the guidance received during prenatal care, 64,08% (n=91) said that there were conversations about pregnancy and the coronavirus, 82,39% (n=117) reported that they did not receive guidance on the act of breastfeeding with the diagnosis or suspected Covid-19 infection. 70,42% (n=100) reported that they noticed the dissemination of information addressing pregnancy and

breastfeeding within this pandemic period on social media. Already 92,25% (n=131) said they did not receive news that discouraged breastfeeding when linked to infection by covid-19 on media networks, 73,94% (n=105) said that the pandemic did not influence the period of breastfeeding.

*Table 3 – The pandemic and the life of women during and after pregnancy.*

Data	N	%	p value*
<b>Did you contract covid-19?</b>			
Yes	63	44.37	
No	79	55.63	
<b>In which period did you contract COVID-19?</b>			
before pregnancy	24	16.90	
During the pregnancy	24	16.90	
During delivery and up to 7 days after delivery	0	0	
From the 8th day after delivery to the 6 months after	14	9.89	
did not contract	80	56.34	
<b>Did you receive guidance on COVID-19 and prenatal pregnancy?</b>			
Yes	91	64.08	<0.0001
No	51	35.92	
<b>Have you received guidance on breastfeeding with suspected or diagnosed COVID-19?</b>			
Yes	25	17.61	<0.0001
No	117	82.39	
<b>Have you received information about pregnancy or breastfeeding on social media during the COVID-19 pandemic?</b>			
Yes	100	70.42	<0.0001
No	42	29.58	
<b>Have you received information in the media advising against breastfeeding due to COVID-19?</b>			
Yes	11	7.75	<0.0001
No	131	92.25	
<b>The pandemic influenced the breastfeeding period</b>			
Yes	37	26.06	<0.0001
No	105	73.94	

Source: Authors, 2022.

\*p value obtained by the test Mann-Whitney

Regarding the emotional aspects, 60,58% (n=86) reported that they did not feel anxiety, depression, compulsive disorder or had chemical dependence. However, it is important to note that 31.69% (n=45) reported that they suffered from anxiety symptoms and 4,93% (n=7) stressed that they suffered from depression

and anxiety. 74,65% (n=106) said they were not afraid or anxious to breastfeed during this period of the coronavirus pandemic, and 80,28% (n=114) reported that they were not afraid or insecure about breastfeeding due to the news that circulated about covid-19.

*Table 4 – Emotional aspects of the mother during breastfeeding in the pandemic period.*



Data	N	%	p value*
<b>During the period of breastfeeding, you had some of the problems below</b>			
Anxiety	45	31.69	
Depression	0	0.00	
compulsive disorder	0	0.00	
chemical dependency	0	0.00	
anxiety and depression	7	4.93	
Anxiety, Depression and Compulsive Disorder	1	0.70	
Anxiety and compulsive disorder	3	2.11	
No	86	60.58	
<b>You had fear or anxiety about breastfeeding due to covid-19</b>			
Yes	36	25.35	<0.0001
No	106	74.65	
<b>Did you feel insecure or afraid to breastfeed as a result of news in the media about COVID-19?</b>			
Yes	28	19.72	<0.0001
No	114	80.28	

Source: Authors, 2022.

\*p value obtained by the test Mann-Whitney

The results described in table 5 refer to the reasons that led women to have fear and anxiety when practicing breastfeeding during the pandemic. Most of these 59,86% (n=85) reported that they did not feel any of these characteristics, 11,27% (n=16) were afraid of feeling

unable to take care of their children, 8,45% (n=12) reported that this anxiety and fear appeared out of concern about transmitting the coronavirus to children through breastfeeding.

Table 5 - Reasons for fear or anxiety felt by mothers during the pandemic period.

Data	n	%
Transmit covid-19 to a child through breast milk	12	8.45%
Transmit covid-19 through pregnancy	7	4.93%
Transmit covid-19 through normal delivery	0	0.00%
Feeling unprepared to care for the child	16	11.27%
Heard some information about breastfeeding in the pandemic that made you insecure	1	0.70%
Did not feel fear or anxiety	85	59.86%
Feeling unprepared to take care of the child and heard some information about breastfeeding in the pandemic that made her insecure	6	4.23%
Others	15	10.56%

Source: Authors, 2022.

Table 6 shows the results that correlate between the variables age and emotional aspects. 62,16% (n=46) women between 25 and 34 years old reported that they did not present emotional factors in the postpartum period that could interfere with the period of breastfeeding. However,

31,08% (n=23) women reported having suffered from anxiety symptoms and 4,05% (n=3) with anxiety and depression.

In women between the ages of 18 and 24 years, 55.56% (n=25) said they did not have the symptoms described, on

the other hand, 33.33% (n=15) reported that they suffered depression.  
from anxiety and 06.67 % (n=3) with anxiety and

Table 6 - Age and emotional aspects of mothers during the pandemic period.

Age	Emotional aspects									
	No		Anxiety		anxietyanddepression		Anxiety, Depression, Compulsive Disorder		Anxiety, CompulsiveDisorder	
	%	N	%	n	%	N	%	n	%	n
Under 18										
	100,00	2	0,00	0	0,00	0	0,00	0	0,00	0
18 to 24 years										
	55,56	25	33,33	15	6,67	3	0,00	0	4,44	2
25 to 34 years										
	62,16	46	31,08	23	4,05	3	1,35	1	1,35	1
35 years or older										
	61,90	13	33,33	7	4,76	1	0,00	0	0,00	0

Source: Authors, 2022.

Table 7, referring to the relationship between schooling and emotional aspects, found that 65,79% (n=25) of women with complete high school education did not develop symptoms of anxiety, 31,58% (n=12) reported that they had anxiety.

On the other hand, 55,58% (n=19) mothers with graduate degrees said they had no psyche-related factors during the puerperium, however, 41,18% (n=14) reported having symptoms of anxiety.

Table 7 – Schooling and emotional aspects of mothers during the pandemic period.

	Emotionalaspects									
	No		Anxiety		anxietyanddepression		Anxiety, Depression, CompulsiveDisorder		Anxiety, CompulsiveDisorder	
Education	%	N	%	N	%	n	%	N	%	n
Complete primary education	80.00	4	0.00	0	20.00	1	0,00	0	0.00	0
Incomplete elementary school	100	2	0.00	0	0.00	0	0.00	0	0.00	0
Complete high school	65.79	25	31.58	12	2.63	1	0.00	0	0.00	0
Incomplete high school	63.64	7	36.36	4	0.00	0	0.00	0	0.00	0
Complete higher education	63.64	14	27.27	6	4.55	1	0.00	0	4.55	1

Incomplete higher education	50.00	15	30.00	9	10.00	3	3.33	1	6.67	2
Postgraduate/Masters/PhD	55.88	19	41.18	14	2.94	1	0.00	0	0.00	0

When related to marital status characteristics and emotional aspects, the following results were found. 67,35% (n=33) of married women said that there were no signs of these conditions, as well as 56,68% (n=29) in a stable relationship and 57,50% (n=23) single.

Regarding postpartum anxiety symptoms, 35,29% (n=18) women in a stable relationship reported having had symptoms of this disease, followed by 26,53% (n=13) married and 32,50% (n=13) single.

Table 8 - Marital status and emotional aspects of mothers during the pandemic period.

Marital status	Emotional aspects									
	No		Anxiety		Anxiety and depression		Anxiety, Depression, Compulsive Disorder		Anxiety, Compulsive Disorder	
	%	n	%	n	%	n	%	n	%	n
Single	57,50	23	32,50	13	7,50	3	2,50	1	0,00	0
Married	67,35	33	26,53	13	6,12	3	0,00	0	0,00	0
stable union	56,86	29	35,29	18	1,96	1	0,00	0	5,88	3
Other	50,00	1	50,00	1	0,00	0	0,00	0	0,00	0

Source: Authors, 2022.

The results found when correlating the variables family income and emotional aspects were that most women who developed emotional disorders had a family income of 1 to 2 minimum wages. Being, 35,56% (n=24) with a diagnosis

of anxiety, 17,78% (n=4) with depression combined with anxiety, and 11,85% (n=2) suffered from anxiety and compulsive disorder during the postpartum period.

Table 9 - Family income and emotional aspects of mothers during the pandemic period.

Family income	Emotional aspects									
	No		Anxiety		anxiety and depression		Anxiety, Depression, Compulsive Disorder		Anxiety, Compulsive Disorder	
	%	n	%	N	%	N	%	N	%	n
1 to 2 minimum wages	34,81	47	35,56	24	17,78	4	0,00	0	11,85	2
3 to 5 minimum wages	37,88	25	33,33	11	18,18	2	10,6	1	0,00	0
6 to 10 minimum	27,27	9	54,55	9	18,18	1	0,00	0	0,00	0

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wages										
More than 10 minimum wages			13,3							
	33,33	5	3	1	0,00	0	0,00	0	53,33	1

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**Source:** Authors, 2022.

#### IV. DISCUSSION

When verifying the sociodemographic profile of women who breastfed during the covid19 pandemic and lived in the metropolitan region of Belém, it was possible to identify that there was a higher incidence of women aged between 25 and 34 years. However, Santos *et al.*[8] in their research in Fortaleza, found 83,3% of women were aged between 18 and 35 years, with a different sample than that found in this study.

Moraes *et al.* [9] interviewed 185 postpartum women, most aged between 20 and 29 years, which characterized 69,7% in the city of Rio de Janeiro. Santos *et al.* [10] found a sample of 52,4% of women between 20 and 29 years old in the city of Cariacica-Es.

Loureiro *et al.* [11] found that women over 25 years old constituted the largest sample of breastfeeding women (57,5%). The predominant parity number of women over 18 years of age in the survey is reinforced by the results found in other studies. These percentages may show that women are choosing to have children after achieving other life goals, and this late option of becoming a mother is related to the level of education, financial independence and even having a steady partner to share the particularities that this new phase in life brings.

Regarding marital status, 35,92% (n=51) were in a stable relationship, 34,51% (n=49) were married, and 28,17% (n=40) were single. The study by Santos *et al.*[8] the categories were divided into with a partner and without a partner, with the variable with a partner being the predominant one (68,2%), as found in the current research (35,92%). Moraes *et al.* [9] found that 80% of the women studied reported that they lived with a partner, without specifying whether they were married or in a stable union, (93,2%) cohabited with a partner in the study by Mendes *et al.* [11] without specifying whether they were married in a stable union.

The Brazilian Institute of Geography and Statistics (IBGE) [13] in 2022 reported that there was a decrease in the number of divorces (13,06%) in 2020, the first year of the coronavirus pandemic, which corroborates the findings in the current study as in the aforementioned surveys. In the study by Coelho *et al.*[13], it was found that married women (56,04%) had a high percentage of unplanned pregnancies (69,03%), we can consider that

women who have a steady partner tend not to use contraceptive methods, an unplanned pregnancy can be undesired, making the woman not feel good about managing a child, and may develop a reluctance to breastfeed.

Regarding family income, the present research showed that most women (54,23%) lived with a family income between 1 and 2 minimum wages. This factor can influence the health, feeding conditions and well-being of these mothers. Santos *et al.* [8] found that 80, 03% of women reported receiving between 788 and 1.576. Moraes *et al.* [9] reported that 69% said they received more than one minimum wage. With women's reports indicating that family income ranges from 1 to 2 salaries, or even less than 1 salary, we can conclude that many families live in social vulnerability, and this amount of total family income is used to meet the needs of families of 3 or more people, having to be provided with food, clothing, personal hygiene and often housing.

It was found that 74,65% in this research reported that they do not receive assistance from government programs and many of them have a family income below 2 minimum wages. In agreement with what was found by Lopes *et al.*[15] who also surveyed women living in the metropolitan region of Belém. Thus, it is of fundamental importance to inform these families which government programs they have the right to be included in.

As for schooling, complete high school was the most mentioned level, with 26,76% (n=38). In the study by Loureiro *et al.* [11] it was also found that the variable complete/incomplete high school education had the highest percentage 42,05%. Furthermore, Alves *et al.* [15] in their study, found that 40% of the women interviewed said they had not completed high school. Thus, the level of education is an important variable to relate to breastfeeding, it is assumed that most women who have a higher level of education, want to practice breastfeeding, since they have more access to information about the benefits that breast milk brings to the health of newborns. Women who are more literate are looking for ways to learn about the characteristics in which breastfeeding is involved. Carreiro *et al.* [17] found that schooling is associated with the type of breastfeeding that will be

practiced, given that the greater the training, the more they will seek information, which may prevent early weaning.

About the service which was used in prenatal care, 57,04% performed through the Unified Health System (SUS). Loureiro *et al.* [11] researched which network was used during prenatal care, with SUS being the most used with 64,05%. Mendes *et al.* [11] in their sample found that 94,08% used the private network, however, it is important to highlight that the research was carried out with servants from a hospital.

Regarding the instructions received by mothers about breastfeeding during the prenatal period, 57,75% (n=82) reported having been guided by health professionals about breastfeeding. Loureiro *et al.* [11] also sought to find out if there were instructions on breastfeeding in prenatal care, with results of 64,05% being the majority of the sample, thus corroborating the findings of the current study. Other research has also shown that most women received guidance during prenatal care (9, 18).

In this way, attention to the prenatal period is of great importance to welcome and guarantee assistance during pregnancy and after the child's birth. In addition, consultations are a propitious moment to initiate guidelines on breastfeeding [19]. Guimarães *et al.* [20] sought to assess the compliance of prenatal care in Brazil and found that access to this service is deficient throughout the country, with the North region showing only 18% of adequacy in the infrastructure of the USF (Family Health Unit). Despite the evident importance of this orientation since prenatal care, 42,25% of the mothers in the present study did not receive any type of orientation. This factor can generate maternal insecurity, which can interfere with the period of exclusive breastfeeding.

For women who are diagnosed with covid-19 during labor, it is not recommended that the newborn be delivered to her, so that there is skin-to-skin contact, as the chances of the newborn being infected are high, given that it is first necessary to carry out the routine procedures. Regarding breastfeeding, it should be postponed until the recommended hygiene techniques are performed, so that the risks of transmission are reduced [21]. With this, it is important that women are informed during prenatal care of the importance of preventing themselves against the coronavirus, and what protocols will be adopted if birth occurs with a positive diagnosis.

Lins *et al.* [22] carried out a literature review with research that had a quantitative methodology, however, they did not find Brazilian studies. In the results, they found that the vertical transmission of the coronavirus through breast milk was not evidenced, however, the

studies emphasize the importance of hygiene protocols for the mother and baby before skin-to-skin contact, especially when there is an infection. Breastfeeding is extremely important for maintaining the health of women and children, as studies have found antibodies in breast milk that help fight the coronavirus.

Table 3 also infers about social media and its influence on breastfeeding in this pandemic period. Galvão *et al.* [23] carried out an integrative literature review on which means and subjects are most sought after by women who will or are in the breastfeeding phase, 80,03% reported that they used the internet not only to seek information about breastfeeding, but to help them obtain nutritional data, they also reported that they sought support in the media for the continuity of breastfeeding.

Moura *et al.* [24] researched the topics related to breastfeeding from videos posted on Youtube, and found that the majority addresses the topic of myth and truth (56,05%), 72,06% did not inform about breastfeeding techniques, 64,05% were not produced by health professionals and 53,02% had no scientific basis.

In the present research, 80,28% women said they were not afraid to breastfeed due to the media news about covid-19. The general population is more informed, either through social media or by using the internet to seek knowledge about subjects that interest them. Breastfeeding is a very widespread subject however it is important that this information comes from reliable websites and from health professionals, so that the veracity of the content learned is ensured.

Regarding the emotional aspects, although the majority did not suffer from these conditions, about 31,69% (n=45) reported that they had symptoms of anxiety and 4,93% (n=7) had depression and anxiety, and 20,11% (n=3) also had anxiety and compulsive disorder. Moraes *et al.* [9] also found that 58,03% suffered from anxiety symptoms in the postpartum period. It is possible that these numbers of women with anxiety are higher, as many women may be afraid to report that they have suffered from these factors. Melo *et al.* [25] found in their research, reports of low levels of anxiety (55,04%), this anxiety decreased over the postpartum period. This study correlated anxiety and breastfeeding self-efficacy, noting that the lower the anxiety levels, the greater the prevalence of breastfeeding.

Hessami *et al.* [26] when conducting a database survey on women, who reported anxiety before and during a pandemic, found that there was a significant increase in reports of anxiety symptoms. Nomura *et al.* [27] find in their research that 16,01% women reported having moderate anxiety, 11,05% said they had strong anxiety.



Living with a partner was a variable that reduced anxiety levels. This can demonstrate the importance of the support network in the postpartum period, bringing benefits to women's health, as well as breastfeeding.

With regard to the suspension of exclusive breastfeeding, it is important that there is an investigation into the reasons that led the woman to interrupt this practice. Anxiety was one of the main reasons that led mothers in the postpartum period not to intend to breastfeed exclusively, in the results obtained by Moraes *et al.* [9] women who experience anxiety during pregnancy are more likely to maintain this characteristic in the puerperium, with consequences for breastfeeding, as well as for their health and that of the baby [28].

In the study by Abuchaim *et al.* [29] found that 31,25% reported having symptoms of depression, with regard to breastfeeding self-efficacy, 39,09% had a median result and 36,06% had a high result.

Rocha and collaborators [30] found in their research that women who suffer a moderate degree of anxiety during pregnancy are more likely to use illicit drugs, and claim that the detection of this consumption is extremely important, so that the addiction does not last until the puerperium. Since the consumption of illicit drugs and a mental health weakened by stress and anxiety is harmful to the health of the mother and baby.

Maciel *et al.* [31] found in their research that social and economic factors of pregnant women contributed to them developing some mental change in the puerperium. He found that a properly developed prenatal care contributed to the reduction of future problems in the psychological area.

For Ballesteros *et al.* [32] it is important that there are more studies on the mental health of mothers and children so that interventions can be developed that health professionals can employ to help combat these pathologies. The benefits of breast milk are described in several studies and disseminated by health professionals from various areas, however, there are diverse factors that lead to weaning, with mental health being a constant variable in research.

## V. CONCLUSION

The women who breastfed during the Covid-19 pandemic involved in this research were between 25 and 34 years old, had completed high school and were in a stable relationship, lived with 1 to 2 minimum wages per month, without receiving government benefits. The largest portion of the sample was still in the period of exclusive breastfeeding at the time of the research, but did

not exclusively breastfeed until six months, as recommended by the Health Organizations.

Regarding the emotional aspects of these mothers, anxiety was the most mentioned condition during the breastfeeding period. Being mainly associated with the fear and insecurity of breastfeeding during the pandemic in addition to the fear of transmitting covid-19 to the child through breast milk, and the feeling of unpreparedness to take care of the child.

As for the relationship of emotional aspects with the sociodemographic profile, the age group from 18 to 34 years old was the one that had the greatest relationship with the development of anxiety. Regarding education, mothers who had a graduate degree also reported greater symptoms of anxiety during the pandemic period. The marital status that was most related to the development of emotional symptoms was stable union. In addition, mothers who lived with a family income of 1 to 2 minimum wages were the most affected by emotional symptoms.

In this way, the results of the present research bring a reflection on the importance of investigating factors related to the emotional of women in the periods of pregnancy and postpartum, in order to prevent and treat these alterations or disorders, as they influence maternal health, and consequently in the practice of breastfeeding. However, it is important that new research be developed to help health professionals in encouraging this practice that saves so many lives.

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## Brazilian Exports: Bibliometric Analysis from 2000 to 2020

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**Keywords** — *Export - Brazil - International  
Trade - Bibliometrics - SciELO*

**Abstract**— *This article aimed to analyze some characteristics of publications on Brazilian exports made available in the SciELO database from 2000 to 2020. Based on a bibliometric research, 64 articles were analyzed that met the search criteria and search filters. The results point to a greater volume of publication in 2011, with the cities of São Paulo and Rio de Janeiro as the main origins of publications in the period. 93.75% of publications originate in public institutions. 32.81% of the articles (21) are of double authorship, 21.87% (14) published with three authors and 15.62% (10) of single authorship. As for the thematic groups, there was a predominance of the “Economy” category, followed by “Agricultural Commodities” and “Services”, confirming the expressive participation of Brazil in the agribusiness segment.*

### I. INTRODUCTION

This paper analyzes the behavior of publications on Brazilian exports over the last two decades. The world economy has undergone significant changes in recent decades in response to major market and trade liberalization initiatives in many countries, with an increasing number of companies embracing international expansion through exports (Buckley & Strange, 2015). As the global economy has become more intertwined and interconnected, large companies from developed countries have shaped the globalization trend through their participation in international markets. Primary drivers of their increased participation have been the need to overcome intense domestic competition and exploit additional sales opportunities (Losilla, Engler & Otter, 2019).

Brazil has shown substantial growth in its exports, both quantitatively and qualitatively.

Quantitatively, it is considered the total volume of exported products, although considered, for the most part, products with low added value. Qualitatively, attention is drawn to the opening of new markets, especially in the last decade, serving countries that previously did not trade with the country.

This new configuration has aroused the interest of specialists from the most diverse areas of the market, in addition to growing interest as a research field in the academic environment.

It is known that the country has the great challenge, set for a long time, of enhancing the added value of its products; however, the use of new technologies in all stages of production and services has enabled the national industrial park to increase production capacity and efficiency. The abundance of natural resources gives Brazil an important competitive advantage, attracting the



attention of foreign companies that need these resources to function.

Other quite significant challenges facing Brazil are in the field of legislation. There is an urgent need to reduce the tax burden that weighs on producing companies and direct and indirect consumers, in addition to the high cost of labor that makes investments very unfeasible, increasing the risks considerably. That said, the present research aimed to analyze some characteristics of publications on Brazilian exports made available on the SciELO database from 2000 to 2020.

In addition to this introductory text, the article is structured in 4 more sections. Section 1 presents the theoretical basis; section 2 presents the methodological design of the study; section 3 presents the data and subsequent discussion; section 4 was reserved for the conclusion, followed by the references.

## II. THEORETICAL REFERENCE

Identifying the target market is one of the most important steps to export safely and involves issues that go beyond the price charged. The existence of trade barriers, the commercial risk presented by the country, the cost of freight, the prospect of establishing lasting commercial relationships and not just an eventual sale, the conditions that can contribute to consolidating your product and brand in that market, among others, are important aspects to be considered (Watson, 2016).

Knowing the real opportunities is something that can be developed and improved as your business grows; however, this development is unique and is linked to many years of trial and error (Siscomex, 2021). The objectives of market research are: to select markets for the sale of the product; detect trends and expectations; recognize competition; understand and assess opportunities and threats.

In general, there are five basic criteria that should be considered to assist in the selection of potential export markets: 1) geographic factors, for market selection, based on the many similarities between the domestic market and the target market, which makes it possible to expansion with minimal need for adaptation; 2) cultural factors, verifying to what extent the habits of people in the target market differ from the domestic market; 3) economic factors, asking about the economic situation of the target country and the consumer's purchasing power; 4) technological factors, which concerns meeting the technological standards of the target market and adequate design; 5) sociopolitical factors, since, in exports to

countries with which there are trade agreements, one can obtain advantages over competitors (Siscomex, 2021).

International Trade can be understood as the set of operations for the exchange of goods and services between different countries (Fundação Instituto de Administração, 2019). These exchange operations include manufactured goods, commodities, services, labor and even the movement of capital. Furthermore, it generates an increase in international barriers that help to protect the development of local companies and, in this way, contributes a large share of the Gross Domestic Product.

Some regions of the planet have an abundance of natural resources or better climate and soil conditions for certain crops, and there are countries that have specialized labor in a certain segment, while others have a deficit. For this reason, according to Bueno (2022), the main reason that leads countries to trade among themselves is the diversity of production, since no country is self-sufficient in everything it needs, therefore, it exports its main goods and services at the same time, while importing those whose domestic production is insufficient or non-existent.

The performance of a country's international trade can be viewed through its trade balance. This indicator records imports and exports of goods and services. If its balance is positive, it means that the country is exporting more than it is importing. If it is negative, the value of imports certainly exceeds that of exports. Due to the challenges of the Brazilian trade balance, it is argued that "it is necessary to achieve positive results in the trade account through the growth of exports, and not through the fall in imports" (Pinheiro, 2002, p. 7). Thus, Brazil should seek a large enough increase in exports, not only to generate trade balances, but also to enable an increase in imports, which will be necessary in a new cycle of investment and growth, stimulating efficiency, increasing productivity and reducing their external vulnerability in international trade.

Developing countries usually export many products with little added value, as is the case of Brazil, where the main products traded internationally are soy, oil, cellulose and iron ore. Meanwhile, developed countries, such as the United States, Germany and Japan, export products with high added value. The importance of international trade for a country's economy is due to several factors, the main one being the guarantee of selling the surplus production of a given country, while allowing the consumer market to have access to non-industrial goods available locally (Bueno, 2022).

From a historical perspective, for many years, the United States of America was Brazil's main economic partner. In 2000, around 23.9% of exports were destined



for the North American country; However, a new international reality was taking hold, the rise of emerging countries such as China, India, Russia, Brazil, which together with South Africa would become the so-called “BRICS” for having in common the characteristic of an accelerated development tending to present possible positive results compared to developed countries (OEC, 2022).

Between 2000 and 2012, world exports grew by 177%, corresponding to an annual average of 8.9%, with a reduction in absolute value in 2009 (Fligenspan, Cunha, Lélis & Lima, 2015). Exports of products from Brazilian agribusiness, in addition to showing significant growth, in two decades there was a change in the dynamics, especially regarding the countries of destination. Figures 1 and 2 present the volume (%) and the change in the dynamics of Brazilian exports of agricultural products at two different times (2000 and 2019).

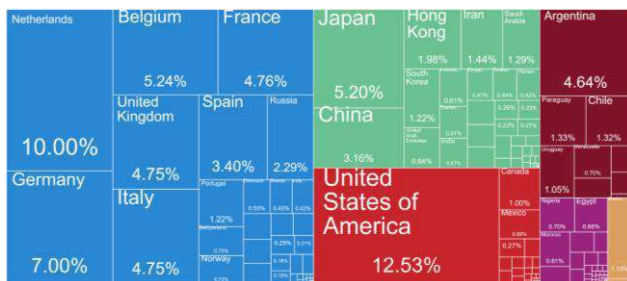
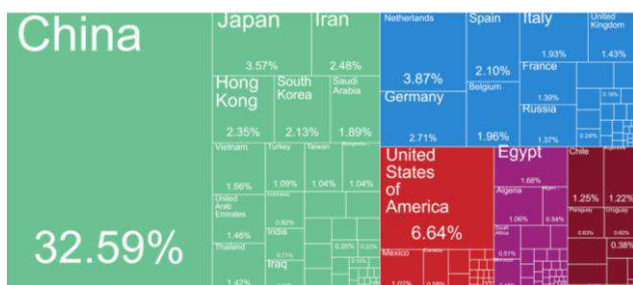


Fig.1. Destination of Brazilian exports of agricultural products – year 2000

Source: Atlas of Economic Complexity (2022).



This scenario put the Brazilian economy on a positive growth trajectory and influenced the improvement in socioeconomic indicators [...].

The country continues to experience sustained growth in the volume of commodity production and exports; the case of the agribusiness segment that has supported the national GDP for some years is emblematic. The Brazil exports low value-added products; however, studies have pointed to a quality exchange, where countries and development export a particular product with high quality in exchange for importing the same product in lower quality (Asche, Bellemare, Roheim, Smith & Tveteras, 2015). Krammer, Strange and Lashitew (2018) shown that political instability and informal competition have strong effects on the export propensity of emerging economy companies, while export intensity depends on the availability of skilled workers and access to external technologies via licensing.

The volume of products exported by the sector showed strong and practically continuous growth over time. Brazilian meat exports to China also increased, especially beef, making the Asian country's share of total Brazilian agribusiness exports reach 33.7%. In addition, soy beans continued to be the main product sent to the country, which purchased 73% of all soy beans exported by Brazil in the same year. China is the main destination for beef (48%) and pork (56%) and the second main destination for poultry meat (21%), being the main buyer of cotton lint, acquiring over 30% of the Brazilian product in 2020 (Cepea, 2020). China also stands out as the largest soy importer in Brazil (Péra, Bartholomeu, Su & Caixeta Filho, 2019).

In the case of cotton, studies show growth in Brazil in terms of export volume, in addition to vigorous growth in competitiveness in the international market. The data show that cotton exports are strongly directed to Asia (Sossa, 2022).

Also, according to Cepea (2020), the year 2020 was extremely favorable to agricultural exports, so that the exported volume of practically all Brazilian agribusiness products grew, except pulp, orange juice and corn, which showed drops of 3%, 10% and 19%, respectively.

The main products exported to Eurozone countries were forest products; coffee; fruit and orange juice. With an approximate share of 7% of total Brazilian commodity exports; the products most traded with the US are similar to the European case, with emphasis on the forestry, fruit, orange juice and sugarcane ethanol sector. On the Other hand, the trade in agricultural commodities—products including cotton, coffee, cocoa, grains, oilseeds, and livestock—is a mainstay of the global economy,

providing food, fuel, and fiber to consumers around the world. The long, complex supply chains that process and transport these products bridge the gap between producers and consumers but are criticized for masking negative socioenvironmental impacts and obfuscating the allocation of responsibility for these impacts. A particular concern for commodities produced in the tropics is habitat destruction—the loss and degradation of forests and other natural ecosystems to expanding agriculture (Ermgassen et al., 2022).

In the current world scenario, international trade plays a fundamental role in the development of countries (Silva; Lunelli; Cleto, 2020, p. 171), it is possible to understand the relevance of exports to the economy, so that in the Brazilian case they have the function to generate foreign exchange that are applied in the purchase of inputs for the industry and in the payment of external commitments (Abreu, 2015).

Since the colonial period, the country has been marked by the exploitation of metals and, in the agricultural area, by the planting of sugarcane and, later, by coffee (Contini, Pena Júnior, Santana & Martha Júnior, 2012). Thus, historically Brazil has a low volume of imports of agricultural products and exports are high, resulting in significant trade balances (Santos, Avelar, Shikida & Carvalho, 2016).

Brazilian agribusiness is the engine for the positive result in the trade balance, with the balance going from “approximately US\$ 11 billion in 1989 to US\$ 77.5 billion in 2011, in nominal values”, according to Contini, Pena Júnior, Santana and Martha Júnior (2012, p. 91-92). In this sense, the importance of commodity exports to the Brazilian economy in recent decades becomes evident (Silva, Lunelli & Cleto, 2020).

According to Abreu (2015, p. 5), “agribusiness exports solidified Brazil's presence in the international food, fiber and bioenergy market and created strong bonds and interdependencies”. Cooperatives have also exerted a strong influence, as they facilitate processes for producers, as they eliminate middlemen and reduce costs, consequently becoming an advantageous way of organizing that, in turn, impacts exports. As an example, between 2006 and 2007, exports from Brazilian cooperatives increased by 16.5%, equivalent to USD 3.3 billion (Araújo & Silva, 2011).

Therefore, “imports and exports provide an expansion of consumer markets and the monetary flow characterized by the inflow and outflow of foreign exchange” (Silva, Lunelli & Cleto, 2020, p. 172). Within this context, according to Contini, Pena Júnior, Santana and Martha Júnior (2012, p. 93) “Brazil has stood out as a

major global player in various agribusiness products, both in production and export". With this, it can be said that "exports have played a very important role in stimulating the growth of our agriculture, so that their dynamism has supplanted the growth of external and internal demands" (Abreu, 2015, p. 3).

### III. METHODOLOGY

Originally, bibliometric analysis started in information sciences (Osareh, 1996). Bibliometric methods provide scholars and researchers with several benefits. The most commonly mentioned advantage of bibliometric approaches is their objectivity (Kücher & Feldbauer-Durstmüller, 2019).

Bibliometric indicators are increasingly being used as a tool for research performance evaluation. These indicators are based on bibliographic databases, which are designed primarily for information retrieval (Hood & Wilson 2003). Bibliometric methods are quantitative by nature, but are used to make pronouncements about qualitative features. This is, in fact, the major purpose of all sorts of bibliometric exercises, to transform something intangible (scientific quality) into a manageable entity (Wallin, 2005). In general, bibliometric methods can be used for performance analysis and scientific mapping (Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2011a).

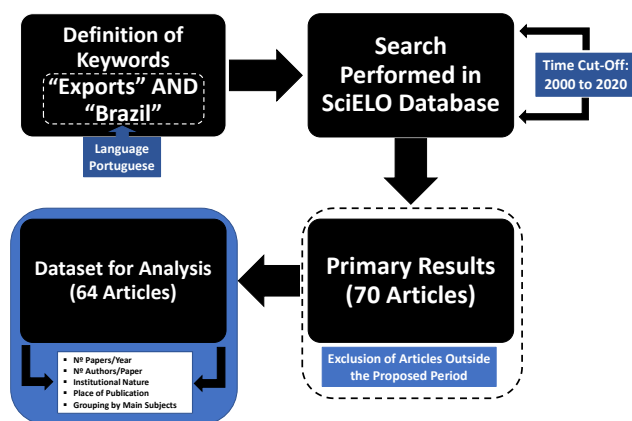


Fig.3. Methodological design of the Research

The present work used the bibliometric method and carried out a descriptive research, whose purpose is to describe the characteristics of a certain population, phenomenon or the establishment of relationships between variables (Gil, 1999). In addition, a qualitative-quantitative analysis was carried out, and according to Malhotra (2001, p.155), "qualitative research provides a better view and understanding of the context of the problem, while quantitative research seeks to quantify the data and apply

some form of statistical analysis". As for quantitative research, this seeks to identify common characteristics in scientific articles on a certain explored topic (Barros & Lehfeld, 2007). The keywords used in the search were "Export" and "Brazil". Figure 3 presents the methodological design implemented in the study.

The time frame adopted was the period from 2000 to 2020. Other filters applied were the type of document in the article format and the language Portuguese. The search resulted in 70 articles, of which 6 were excluded because they were outside the proposed period for the research, leaving 64 documents to be analyzed. The set of documents extracted from the SciELO database in March 2022 was analyzed with the following information: number of articles per year; institutional nature; place of publication; number of authors per article and grouping by subject.

As support for operationalization, systematization of information, organization and presentation of results, Google Sheets software was used.

### IV. DATA ANALYSIS AND DISCUSSION

The total number of articles published in the period under analysis is distributed over the years in a very heterogeneous way. Two opposite poles can be observed: the year 2002 with 0 publications and the year 2011 with 10 publications. Figure 4 shows the distribution of the number of articles over the years.

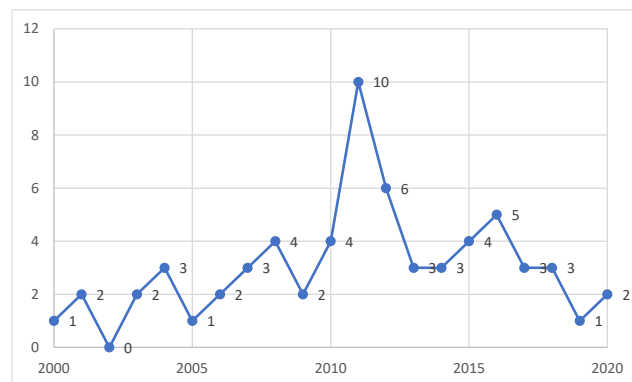


Fig.4. Articles published by year in the period (2000-2020)

Source: Research data.

Taking this asymmetry into account, the arithmetic average of publications was approximately 6 articles (5.82) per year, which is not very representative since there are strong outliers. Thus, it was decided to calculate the median value, obtaining a value of 3 for this measure. Of the 21 years analyzed, 9 are below the median, 6 are above the median and 6 are above the median. Of the set of articles analyzed (64), approximately

1/3, equivalent to 32.81% were prepared with double authorship (2 authors), followed by 14 with three authors (21.87%) and 10 with single authorship (15, 62%). Table 1 systematizes this information for better visualization.

Table 1. Number of articles and number of authors

n° Authors	n° Articles	%
1	10	15,62
2	21	32,81
3	14	21,87
4	9	14,06
5	5	7,82
6	2	3,13
7	1	1,56
8	2	3,13
<b>Total</b>	<b>64</b>	<b>100,0</b>

Articles with 4, 5, 6, 7 and 8 authors added together (19) reach 29.7% of the total published, still below the first place with double authorship (21 articles).

As for the nature of the institutions of origin of the publications, 60 (93.75%) come from public institutions and only 4 (6.25%) from private institutions, which are close to the parameters published by the Brazilian Academy of Sciences, which points out that 95% of publications originate from federal and state public universities (ABC, 2019). Table 2 summarizes this information.

Table 2. Number of publications by institutional nature

Institution	Number of Publications	%
Public	60	93,75
Private	4	6,25
<b>TOTAL</b>	<b>64</b>	<b>100,0</b>

As for the place of publication, 28 articles have the state of São Paulo as their origin, equivalent to 43.75%, followed by the state of Rio de Janeiro with 14 articles, corresponding to 21.87% and the state of Minas Gerais with 10 articles. (15.62%). Table 3 presents this information systematically.

Table 3. Number of articles published by municipality and Federation Unit (FU)

Counties	FU	Number of Articles
Belo Horizonte	MG	3
Botucatu	SP	1
Brasília	DF	1
Campinas	SP	3
Curitiba	PR	2
Fortaleza	CE	1
Goiânia	GO	1
Guarulhos	SP	1
Jaboticabal	SP	7
Lavras	MG	2
Manaus	AM	3
Manguinhos	RJ	1
Maringá	PR	1
Niterói	RJ	2
Piracicaba	SP	4
Recife	PE	1
Ribeirão Preto	SP	1
Rio de Janeiro	RJ	11
Salvador	BA	1
Santa Maria	RS	1
São Paulo	SP	11
Viçosa	MG	5
<b>Total</b>		<b>64</b>

The city of São Paulo, capital of the state, leads with 11 publications, followed by the cities of Jaboticabal (7) and Piracicaba (4). Similarly, in the state of Rio de Janeiro, the state capital, the municipality of Rio de Janeiro, tops the list, originating 11 articles, followed by the municipality of Niterói with 2 articles.

The articles were classified into 10 groups according to the theme of each paper: Agribusiness; Agricultural Commodities; Environmental Commodities; Mineral Commodities; Services; Economy; Fruit growing; weapons; Deforestation and Others. Figure 4 presents the results found in this grouping.

The “Economy” group leads with 13 publications, corresponding to 20.31% of the total; followed by the “Agricultural Commodities” and “Services” groups with



11 publications each, equivalent to 17.18%. The third place is occupied by the groups “Agribusiness” and “Fruticulture”, each with 8 publications, equivalent to 12.5%. However, for the purposes of analysis, one can consider the combination of the Agribusiness and Fruticulture groups, which would bring together 16 publications, comprising 25% of the total publications.

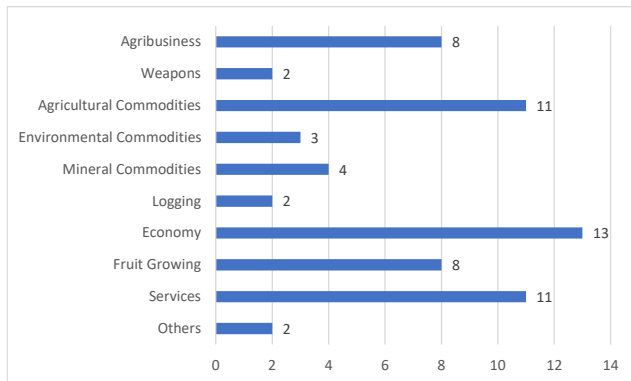


Fig.5. Grouping of articles by themes

The publications included in the “Economy” group included studies on foreign trade, exports, impacts of bilateral trade, international market trends, economic and industrial growth, among other similar topics.

As for the “Agricultural Commodities” group, topics such as technology and internet services, IT outsourcing, accounting, energy policy in Brazil, strategic planning of cargo flow, among others, were addressed. The “Services” group addressed more expressively the production of sugar, coffee, cotton, potatoes and eucalyptus.

The “Agribusiness” and “Fruticulture” groups addressed issues such as the management of phytosanitary products (pesticides), food production in general, with emphasis on chicken meat and potato production (Agribusiness) and the potential for fruit exports in general, diseases in citrus and product-specific diseases (Fruticulture). The “Mineral Commodities” group addressed topics such as cellulose, ethanol and aluminum production. “Environmental Commodities” focused on topics such as wood and water. The weapons group discussed the export of equipment for military use. “Deforestation” limited itself to discussing the degradation of pastures and deforestation. Finally, the “Others” group, which included studies on contemporary art exhibitions and the presence of salmonella in equine meat in northeastern Brazil.

## V. CONCLUSION

The study aimed to analyze some characteristics of publications on Brazilian exports made available in the

SciELO database from 2000 to 2020. After applying the search criteria and filters established for the collection, the search resulted in 64 articles that were analyzed in order to meet the research objective.

The year 2011 had the highest number of publications of the entire period, a period that coincided with the economic crisis of the European Union, a moment of direct interference in exports to Europe, a moment in which Brazil's commercial partnership with Asian countries gained strength, especially China, which continues to be the main destination for Brazilian products, followed by the United States.

Commodity exports, which in Brazil represent more than 60% of exported goods, are a predominant feature in underdeveloped countries, which provide low value-added products, while developed countries mainly export highly technological products. On the other hand, it is known that agribusiness has a significant share of the national GDP, with Brazil being one of the largest producers of agro-industrial products (Nyssen, Oliveira & Carraro, 2021; De-Carli & Oliveira, 2021).

The main limitation of this research resides in the fact that it uses a single database to collect documents, in addition to the restriction to only publications in Portuguese. As a suggestion for a future research agenda, the search scope can be expanded, including international journal indexing bases, in addition to the inclusion of theses and dissertations that often do not become articles published in journals/periodicals.

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# Spiraled Cultural Dialectics: *Construct* for Human and Social Sciences

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**Keywords—** *Concept, Dialectic, Culture,  
Spiral and Spiritism.*

**Abstract—** *The present study has as main concern to explain the need to create the construct "spiraled cultural dialectic" in order to better adapt the ideas worked on in the doctoral thesis, as well as its use in other research in the human and social sciences. To this end, I present formulations on the concept of concept on the initial pages. Then, there will be the decomposition of the terms in order to better clarify them, that is, to historicize the concepts, making, at the end, the methodological mortar of the theoretical explanation.*

## I. CONCEPT OF CONCEPTS

The designation of construct that is used here refers to the type of constructed concept that has a higher level of abstraction, different from the concept itself, which has its elements more easily observed or measured, thus coming to be constructed through the use of other minor concepts. José D'Assunção Barros focuses on the subject repeatedly in his books and articles. According to Barros,

In some cases, the researcher should not hesitate to reformulate some definitions himself, already reflected from what the specialized texts say, but adapting them based on his own critical sense. The need to create an unprecedented concept also occurs, and consequently, to define it in the most appropriate way possible for the reader.<sup>1</sup>

Assunção postulates that the term concept designates abstract and general formulations that individuals use in order to make something intelligible to their essential and everyday aspects. When formulating the

concepts, we observe that they respond to general notions in the sense of defining them, through representation or characteristics that identify them.

We constantly use several concepts in everyday life without paying attention, for example, that when we talk about family, we establish abstract and general formulations to explain about its meaning. Therefore, it will be observed that the concepts are instruments that serve not only the scientific community but are also fundamental in everyday life itself. Yet,

(...) scientific knowledge requires a second level vocabulary, that is, a technical vocabulary. For the theoretical thinking of science or philosophy, the immediate meanings of ordinary language are not enough. Concepts and terms acquire a unique meaning, very precise and well delimited. Sometimes the same terms are kept, but the meanings are changed to a well-defined understanding<sup>2</sup>.

<sup>1</sup>- BARROS, 2005, p.151.

<sup>2</sup>- SEVERINO, 1978, p.145.

Such assumptions are linked to the representations that we bring about the social environment to which we are inserted, without, therefore, being able to perceive that the definition meets only the historical period in which we live, disregarding the previous realities and other non-Western models.

We generally work with “imported” concepts, that is, generated by foreign intellectuals and adapt them to our realities and needs, aiming at formulating an object through a theoretical proposal. According to Antônio Severino, “the concept is the mental image through which an object is represented, an immediate sign of the object represented. The concept guarantees a direct reference to the real object”<sup>3</sup>. Because they are abstract, the concepts refer to a theory, being, therefore, a logical construction aiming at the construction of a certain knowledge of reality. It is clear here that without it a research could not be carried out. It is the theory that allows us to explain historical realities that are different from the one we live in. As Prost explains, “historical concepts have a wider scope: they incorporate an argument and refer to a theory”<sup>4</sup>. Within this same line of reasoning Koselleck<sup>5</sup> posits that

Under one concept, the multiplicity of historical experience, as well as a sum of theoretical and practical relations, are subsumed into a single set that, as such, is given and the object of experience only through this concept.

The two authors are unanimous in stating that a word to become a concept is necessary that it comes to have a range of meanings and experiences, becoming, therefore, polysemic.

Theories are part of the great framework of evolution<sup>6</sup> of human thought, going through different phases characterized by paradigms<sup>7</sup> diverse that reigned in

the most diverse fields of human knowledge, accumulating the knowledge of the previous ones (even with ruptures and permanences) and causing this knowledge to be gradually restructured, reformulating the old hypotheses, which are expressed in a new language, more adequate to the time in question. Thus, the bases that formulate new ideas are those that previously supported human knowledge, but understood in the light of new paradigms.

Each era has its theorists, who organize the knowledge accumulated in new lands and that, with this, cause ruptures with the “old”. As expressed by Tarnas<sup>8</sup>, “Each generation must examine and rethink, from its own privileged perspective, the ideas that shaped its conception of the world”. Every historical period, however “static” it may seem, was characterized by a certain change in its intellectual climate<sup>9</sup>. This constantly provides not just a simple crossing of novelties, but a profound transformation of thought, of how man sees himself and sees the world around him.

The history of man is, therefore, marked by several ideological transformations<sup>10</sup> that changed and shaped the course of its evolution forever. When looking back, it is proposed, with this, to understand what led man to rethink his way of living, tracing new routes, envisioning new convictions, establishing new ideas, concepts and theories. Such propositions are essential to a worldview that aims to embrace all the cardinal interests of man, transporting us through a universe of inconceivable cultural wealth<sup>11</sup> created by him.

According to Paul Veyne, “(...) each concept we conquer refines and enriches our perception of the world (...)”<sup>12</sup>. With this, the concept that I propose comes from the junction of dialectic, culture and spiral form. To better explain them, the terms will be decomposed in order to better clarify them, that is, historicize the concepts<sup>13</sup>, being aware that for each of them there is a plurality of definitions, not being able to examine them in their entirety, but according to the best understanding of the construct and a posteriori, its use in the development of the Thesis.

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knowledge”. ARÓSTEGUI also alludes to the concept of Kuhn's paradigm - Historical Research - Theory and Method., 2006, p. 99.

<sup>8</sup>- TARNAS, p.13.

<sup>9</sup>- TRATTNER, 1956.

<sup>10</sup>- For more information on the topic, check; CHAUI, 1995 and GEERTZ, 2008, chapter IV.

<sup>11</sup> - The whole framework built by man is part of his culture and in this context we include family life schemes, political debates, religious observances, scientific innovations, literature, arts, in short, aspects of human creation as opposed to physical and biological processes.

<sup>12</sup>- VEYNE, 1983, pg. 30.

<sup>13</sup> - PROST, 2008, p.128.

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<sup>3</sup>- Ibid., p. 144.

<sup>4</sup>- PROST, 2008, p.121

<sup>5</sup>- KOSELLECK, 2012, p.109.

<sup>6</sup>- The concept of evolution succumbs to several criticisms and interpretations since propagated by Charles Darwin, but what I postulate is spiritualist evolutionism, a theory that unites Darwinism with spiritualism, the belief in the existence of an immaterial and immortal being, the spirit as responsible for the conduct of biological forms. For further clarification on the subject, the following books are recommended; ANDRÉA, 1977. ELGIN, 2003. FREIRE, Gilson. vols 1 and 2, 2006. PINHEIRO, 2009. PIRES, 2005. UBALDI, 2001. About the cultural aspect, we can indicate: CHILDE, 1966 and FONTANA, 2004.

<sup>7</sup>- KUHN, 2000. The essay launched in 1962 by the physicist and historian of science advocates the exact and natural sciences, but the author gives a sociological aspect to the concept when referring to the paradigm as “a set of beliefs, values and techniques common to a group that practices the same type of

## II. DIALECTICS

Etymologically, dialectic<sup>14</sup> comes from the Greek *dia*, which expresses the idea of duality, exchange and *lektikós* means apt to the word, giving the understanding of dialogue, because in dialogue there is always more than one opinion, but which has taken on various meanings throughout history<sup>15</sup>.

Coming from the pre-Socratics as Heraclitus of Ephesus (6th century BC) and Zeno of Elea (5th BC), passing through the Sophists, Socrates, Plato, dialectics ended up being forgotten in the Middle Ages, coming to resurface in the Renaissance period. The notion of dialectic comes to the contemporary world through Georg Wilhelm Friedrich Hegel (1770-1831) who formulated the question around three movements. This structure of the real, understood as a process, involves the data, the thesis, the negation, the antithesis and finally the negation of the negation, the synthesis. Called idealistic dialectic, that is, "(...) at a certain moment of nervous maturation, which in its entirety, finds its cause in the preceding stage and which, despite everything, surpasses it and establishes a new way of being"<sup>16</sup>, because it is the set of knowledge, ideas and concepts elaborated and reworked by man, each one adequate to its historical moment. According to Mesquita,

Idealism is the current of thought that, giving primacy to consciousness, reduces the real to the idea, to the thought, or, in other words, that considers the idea, the thought, as being the essence of reality<sup>17</sup>.

Hegel was very influenced by Christianity and his interpretation demonstrates the revelation of the dialectic, one and triune God at the same time<sup>18</sup>. The Hegelian dialectic, although idealistic, gave rise to the materialist dialectic of historical materialism created by the German economist and philosopher Karl Marx (1818-1883), in collaboration with the German politician and thinker Friedrich Engels (1820-1895). According to Marcondes,

the Hegelian interpretation of the historical process and the formation of consciousness is restricted to the plane of ideas and representations, of knowledge and culture, disregarding the material bases of the society

in which this knowledge of this culture is produced and in which the individual conscience is formed<sup>19</sup>.

Unlike the proposal made by Hegel, the historical materialist dialectic comes to have the central core of analysis at work<sup>20</sup> "The auto transforming process of the human species is conditioned, which goes against the Hegelian idea of a movement of the Absolute"<sup>21</sup> giving dialectic a constant movement in the course of humanity. Mesquita also focuses on the materialist dialectic

it is the application of dialectics, from a materialistic point of view, in the analysis of the evolution of matter (nature), as well as in the development of human consciousness and society, an analysis on which dialectical materialism is based, of the Marxist theory<sup>22</sup>.

A final analysis on dialectics is that of Karel Kosik<sup>23</sup> (1926-2003), Czech philosopher with a Marxist tradition, where he postulates that dialectical thinking makes a distinction between representation (appearance) and concept (essence) of the "thing" (reality). The "thing in itself", which the dialectic deals with, does not immediately manifest itself to man, to his understanding, because his first attitude towards reality is not investigative or examining, but rather, a practical-sensitive exercise, making the individual creates "his own representations of things (common thought) and develops a correlative system of notions, which captures and fixes the phenomenal aspect of reality".

In conclusion, dialectics is the conception of reality that as a whole is in permanent transformation, its contradiction being decisive in the movement that conditions the whole process of human development.

## III. CULTURE

The term culture was "borrowed" from anthropology, coming to define the set of attitudes and codes of behavior itself, and the first definition of culture was formulated by E. Tylor, in the first paragraph of his book *Primitive Culture* (1871). According to Geertz,

Cultural patterns - religious, philosophical, aesthetic, scientific, ideological - are "programs"; they provide a template or diagram for the organization of social and

<sup>14</sup>. GORBY, 2007.

<sup>15</sup>. For a better appreciation of these changes, the following works are recommended: LUCE, 1994 - ARANHA, 1988, pp 49/50 and KONDER, 1987.

<sup>16</sup>. CHATELET, 1972, pgs, 22/23.

<sup>17</sup>. MESQUITA, 1985, p.19.

<sup>18</sup>. GRINGS, 1981.

<sup>19</sup>. MARCONDES, 1997, p.228.

<sup>20</sup>. MARX & ENGELS, 2001.

<sup>21</sup> - MARCONDES, 1997, p.229.

<sup>22</sup> - MESQUITA, 1981, p.61.

<sup>23</sup>. KOSIK, 1976, p. 14.



psychological processes, similar to the genetic systems that provide such a template for the organization of organic processes<sup>24</sup>.

Clifford Geertz defends the concept of essentially semiotic culture, man being tied to webs of meanings that he himself wove. Through a set of “intertwined systems of interpretable symbols”, social events, behaviors, institutions or processes have been historically constructed, reshaping “the pattern of established social relations”.

According to Marshall Sahlins<sup>25</sup>, culture is historically reproduced and altered in the action of its interlocutors. Therefore, the culture inserted in History is in constant movement, causing this movement to produce a “structural transformation”, since the alteration of some senses changes the position relationship between cultural categories, thus having “a systemic change”, being this historical process called by the author “functional revaluation of categories”. As a result, as there is contact between different cultures, they reproduce from the encounter with each other, effecting innumerable variations over time and in the space in which they met.

Ruth Benedict<sup>26</sup> explains that culture is like a lens through which man sees and sees the world around him. Men from different cultures wear different lenses and, for this reason, have different visions of the realities of things. According to Roque Laraia<sup>27</sup>,

The way of looking at the world, appraisals of a moral and evaluative nature, different social behaviors and even body postures are thus products of a cultural heritage, that is, the result of the operation of a particular culture.

To finalize the understanding of the concept of culture (without wanting to close the subject), Cassirer<sup>28</sup> expresses that

the most striking feature of man, the hallmark that distinguishes him, is not his metaphysical or physical nature - but his work. It is this work, the system of human activities, that defines and determines the circle of humanity. Language, myth, religion, art, science, history are the constituents, the various sectors of this circle.

Therefore, the entire framework built by man is part of his culture and in this bulge we include the schemes of family life, political debates, religious observances, scientific innovations, literature, arts, language, in short, aspects of human creation as opposed to physical processes and biological factors.

#### IV. SPIRAL

Finally, the spiral shape<sup>29</sup>. Supported by the concept of “circularity”<sup>30</sup> propagated by Ginzburg and Bakhtin, where both historians aim to demonstrate the movement of ideas in both popular and erudite culture, I see that although ideas circulate, the spiral shape designates how these same ideas reach different levels in the understanding of human beings, creating and expanding the new concepts embedded in the propositions of his time.

The spiral is a symbol of evolution and upward movement, progressive, normally positive, found in all cultures, related to the very progression of existence. Its shape is associated with the base of life<sup>31</sup> being found from the macro (galaxies) to the micro (DNA).

Therefore, the spiral is present throughout the Universe, being responsible for the symmetrical phenomenon of nature, be it in the flowers, trees, waves, shells, hurricanes, in the symmetrical face of the human being, in its joints, its heartbeat and in its DNA. Also in the refraction of the light provided by the electrons of the atoms, in the vibrations and in other more manifestations as in the galaxies of the immeasurable universe.

#### V. APPLICABILITY OF THE CONCEPT

When proposing the aforementioned *construct*, I see that its applicability does not necessarily have to be linked only to research itself, that is, to spiritism, but that it will also be useful for other researchers to use it in a fruitful way.

As explained, the Spiraled Cultural Dialectic aims to demonstrate how ideas were dialectically reworked creating a whole new conceptual universe. All this change is the result of the cultural process in which man is inserted and the way he interprets the environment in which he

<sup>24</sup>- GEERTZ, 2008, p. 123.

<sup>25</sup>- SAHLINS, 2011.

<sup>26</sup>- BENEDICT, 1972.

<sup>27</sup>- LARAIA, 1997, p. 70.

<sup>28</sup>- CASSIRER, 1972, p. 116.

<sup>29</sup> - When I use the geometric shape of the spiral to the detriment of the circular shape, I do not intend to establish the understanding in order to position it as positive / negative, ascending / descending or any other designation, as it has no evaluative connotation, but to explain the movement of the ruptures and permanences that happen in history and that with this open new conceptual horizon for men.

<sup>30</sup>- GINZBURG, 2011 and BAKHTIN, 2010.

<sup>31</sup>- MOORE, 1961.



lives. The spiral geometric shape only aims to give the view that these paradigmatic changes take knowledge to new levels of understanding of human thought, establishing new synapses and expanding their conceptual horizons.

The constant cultural dialectic aims to elucidate the different architectural constructions of the ideas elaborated within the proposed temporal cut up to the formulation of the Spiritist Pentateuch, comparing them to each other, or better, establishing the historical connective<sup>32</sup> that communicate with each other and end up establishing new perspectives, which are constantly reworked by circularity in a spiraling movement of knowledge<sup>33</sup> because in addition to circulating, ideas end up being transformed into something new, through a flat curve that revolves around a central point (called the pole), moving away or approaching it, in a constant grouping of ideas, effecting structural transformations in the Western society, leading man to weave the intertwining of ideas with culture in a constant symbiosis.

To give the methodological mortar, I will use the "Indigenous Paradigm"<sup>34</sup>, a term coined by the Italian historian Carlo Ginzburg, that through signs and signs it is possible to reconstruct cultural and / or social elements, thus resulting in an epistemological paradigm, allowing, from a scientific point of view, to (re) construct interpretive elements of culture from which they emerge. In addition, comparative activity<sup>35</sup> is an excellent methodological tool that allows, as explained by Detienne<sup>36</sup>, "Not to find or impose general laws that would finally explain to us the variability of cultural inventions of the human species, (...) but to build comparable ones (...)", carry out comparative analyzes between the different ideas that contextualized the environment European and their links with the spiritist proposal, seeing the connectivity between them and their meeting (dialectic) the birthplace of the vision brought about by this meeting.

In addition, the carpet metaphor allows us to understand the intertwining of the circularity of ideas with the culture that is historically altered, since analogously to the vertical and horizontal threads, which give total form to the piece, so also the signs or indications of historical investigation are assumed as elements revealing socio-cultural phenomena that emerged in European Latin Christian society, specifically focused on the period

between the second half of the 18th century until the advent of the spiritist proposal, through the figure of Allan Kardec and being all this ideological framework is provided by man, or that is, its culture, what it produces.

## VI. FINAL CONSIDERATIONS

Therefore, a spiraled cultural dialectic, different from the previous propositions, creates a new universe of understanding, a new type of dialogue through a "cultural tension", which generates processes of structural transformations that lead man to search for new symbolic frameworks, carrying out this same man reinterpretations of the reality in which he is inserted.

The sewing of ideas in the different fields of knowledge of man is accompanied, therefore, with the conceptual basis of the spiraled cultural dialectic, because, when reworking the way of thinking, these ideas are weaving a whole ideological framework, in a continuous movement, creating a set of incomparable beauty, which is the human being's journey towards self-overcoming.

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<sup>33</sup>- UBALDI, 2001.

<sup>34</sup>- GINZBURG, 1990, pages 143 to 179.

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## Relationship of Food Consumption and Family Income of Children under 2 Years Old in Three Counties in the Metropolitan Region of Belém

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**Keywords** — Food Consumption,  
Children, Income, Food Security.

**Abstract**—Objective: To relate the food consumption of the previous day and family income of children under 6 months to 2 years of age living in the metropolitan region of Belém, Pará. Methodology: Descriptive-analytical cross-sectional study with application of an online questionnaire via google forms, carried out in the metropolitan region of Belém-Pará, which covers 3 municipalities (Belém, Ananindeua and Marituba). The questions formulated in the food survey were based on food consumption markers from the SISVAN platform. Results: 221 responses from caregivers were obtained. Most declared to receive up to a monthly minimum wage. breast milk was consumed by all children younger than 6 months. In children aged over six months to two years, it was observed that breastfeeding did not occur continuously in children from groups with higher family income, and the ingestion of ultra-processed foods by children with lower incomes was observed. Conclusion: The data demonstrate dietary inadequacy, habits that are configured for the development of chronic non-communicable diseases throughout life. In addition, there is a low consumption of fresh and minimally processed foods, as well as an inadequate introduction of ultra-processed foods, especially in children belonging to families with lower incomes.

## I. INTRODUCTION

Inadequate nutrition in the first two years of life is associated with the development of chronic diseases, which compromise the health and life of children. In this way, children with inadequate habits are more vulnerable to infectious diseases, respiratory infections, malnutrition, obesity, dental caries and micronutrient deficiencies such as iron and vitamin A. In this way, ensuring adequate nutrition in the first two years, such as breastfeeding and a healthy complementary diet can contribute to reversing this scenario in addition to helping to reduce current nutritional problems [1].

The Food Guide for Brazilian children under two years of age recommends that a healthy diet should start in childhood, and that this diet starts with breastfeeding in the first six months, and after that period, being complementary to a diet with healthy foods with greater diversity of *in natura* and minimally processed foods. Breast milk, in addition to nutritional benefits, is also considered an economic food, since it is produced by the mother herself, requiring no extra preparation and expenses, ideal for families with low purchasing power. On the other hand, the supply of infant formula and other milks can compromise a good part of the family income, in addition to being associated with the illness of non-breastfed children, generating even more expenses [2, 3].

In this context, from the sixth month of life onwards, complementary feeding with healthy foods should be started, limiting the supply of processed foods and avoiding the consumption of processed foods, offering a greater diversity of foods so that the child knows the foods and develops healthier habits. In this sense, the supply of foods rich in fat, additives and sugary foods are strongly associated with maternal influence and family members with inadequate eating habits. In addition, such habits are configured for the reality of many families who are in food and nutritional insecurity, since these socially vulnerable groups have difficulties to buy fresh and minimally processed food and access to more affordable prices, factors that compromise the food quality [2].

In this sense, adequate food is a basic human right, which is guaranteed by law in order to ensure that people have access to quality food in sufficient quantity, as well as being adopted by the government through public policies and indispensable actions to promote and guarantee food and nutrition security for the population. In Brazil, advances in having access to adequate food have been the result of a set of actions to face and fight hunger and poverty, despite this, one of the indicators of poverty and extreme poverty has shown an important relationship between food security and nutritional status, since, in

Brazil and in other countries, the absence of income is the main factor that prevents people from having access to food [4].

According to the National Study of Child Food and Nutrition (ENANI, 2019), in which it evaluated 14,558 children living in the five macro-regions of Brazil, it was possible to verify that 47.1% of the evaluated households showed some degree of food insecurity, of these 38.1 % mild food insecurity, 5.2% moderate and 3.8% severe. Furthermore, it was found that the prevalence of food insecurity occurred in families that received some benefit from the government, with 61.4%, and in those that did not receive any benefit, it was 38.8%. In this sense, it was observed that the regions that presented the highest rates of receiving any benefit were the Northeast regions with 57.0% and the North with 53.5%, being the regions with the highest proportions of food insecurity. [5]

Considering the above, the objective of this study was to relate the food consumption of the previous day and family income of children less than 6 months to 2 years of age living in three municipalities in the metropolitan region of Belém, Pará.

## II. METHODOLOGY

Descriptive-analytical cross-sectional study with application of an online questionnaire via Google Forms, carried out in the metropolitan region of Belém-Pará, with the participation of 3 municipalities (Belém, Ananindeua and Marituba). The research sample was simple random, consisting of guardians and/or caregivers (over 18 years old), of children under 24 months of age who were reached by the form through sharing a link through the internet, from October to December 2021, in which 221 responses were obtained. Those responsible (over 18 years old) of the target audience of this study were included, who agreed to participate in the research after signing the informed consent form. Participants who did not fill in all the data for the survey were excluded.

The research protocol requested sociodemographic information from the children's caregivers. In addition, mothers and/or caregivers were asked about food being offered to the child.

The questions formulated in the food survey were based on food consumption markers from the SISVAN platform, plus questions regarding the use of artificial teats (pacifiers and/or bottle) and the offer of regional foods to the child. Being the children classified according to their age groups and answering questions related to these.

The variables studied were measured using the Microsoft Excel program, and analyzed using the Bioestat 5.3

program. For analytical statistics, the Kruskal-Wallis statistical test was used. An alpha at % was adopted as significance.

The evaluation process by the ethics committee followed the norms of the National Research Ethics Commission - CONEP, present in CNS resolution 466/2012 and 510/2016 and their complementary norms. The research was approved under opinion: 45110721.9.0000.0018.

### III. RESULTS

In this study, 221 responses were obtained from caregivers of children between 6 months and two years of age using the Google form. Table 1 shows the sociodemographic data of the interviewees, it can be seen

that in relation to the degree of kinship with the child, most participants were mother and/or father (80.89%), and most residents of the city of Belém, (49.32%)

In addition, most participants (58.37%) were between 18 and 30 years old, as well as most of these were single (45.70%) and had only one child (55.66%). As for the level of education, 40.72% had high school as the highest level. With regard to monthly family income, most of them reported receiving up to one minimum monthly wage (32.58%). Regarding the number of residents in the house, 34.84% stated that three people lived in the household.

Table 1 – Sociodemographic characterization of caregivers.

Sociodemographic data	N	%	p value*	
<b>Degree of kinship with the child</b>				
Mother or Father	177	80.89	p<0.0001	
Grandfather or Grandmother	6	2.71		
Uncle or Aunt	23	10.41		
Siblings	2	0.90		
Babysitter	2	0.90		
Others	11	4.98		
<b>Sex</b>				
Female	198	89.59	p<0.0001	
Male	23	10.41		
<b>City</b>				
Belém	109	49.32		
Ananindeua	73	33.03		
Marituba	39	17.65		
<b>Age Group</b>				
Between 18 to 30 years	129	58.37	p<0.0001	
Between 31 to 40 years	74	33.48		
Between 41 to 51 years	17	7.69		
More than 50 years	1	0.45		
<b>Race/color</b>				
White	59	26.70	p<0.0001	
Black	31	14.03		
Mixed race	127	57.47		
Asian	4	1.81		
Indigenous	0	0		
<b>Estado civil</b>				
Single	101	45.70	p<0.0001	
Married	95	42.99		



Legal separation	3	1.36	
Others	22	9.65	
<b>Number of Children</b>			
1 children	123	55.66	
2 children	61	27.60	
3 children	20	9.05	p<0.0001
4 children	5	2.26	
Don't Have children	12	5.43	
<b>Schooling</b>			
1st to 4th grade of Elementary School	1	0.45	
5th to 8th of Elementary School	15	6.79	
High school	90	40.72	
Higher Education	74	33.48	p<0.0001
Specialization	33	14.93	
Master Degree	7	3.17	
Doctorate degree	1	0.45	
<b>Family income (MW)</b>			
To 01 MW	72	32.58	
Between 01 and 02 MW	58	26.24	p<0.0001
Between 02 and 03 MW	36	16.29	
More than 03 MW	55	24.89	
<b>Number of residents in the house</b>			
2 people	20	9.05	
3 people	77	34.84	p<0.0001
4 people	61	27.60	
5 or more	36	28.51	

**Source:** Survey data, 2022.

**Caption:** MW: Minimum Wage

\*p value obtained by the Kruskal-Wallis test

As for the relation of food consumption on the previous day correlated with the family income variable of children under six months of age in the metropolitan region of Belém-Pará (Table 2), it is observed that all children under six months of age consumed breast milk being higher in families that received up to one minimum wage (56%); following (32%) above one to two salaries and (12%) above three.

Porridge consumption was present in the food consumption of children belonging to family members who received the lowest income, being (4%) in families with income of up to one salary, and (4%) above one to two salaries. In addition, the consumption of water and/or tea occurred in (8%) in the groups with up to one salary and above one to two, respectively. Likewise, the

consumption of cow's milk was (4%) in the groups that received more than one to two wages.

Regarding the consumption of infant formula, there was a consumption of (4%) of children in the group with up to one salary, (4%) above one to two and (4%) in those with more than three salaries. Fruit juice consumption was (4%) in families with an income of up to one salary and above one to two, respectively. Furthermore, the prevalence of fruit consumption occurred in (4%) of families with an income of up to one salary and (8%) in those that received more than one to two.

The family's food was given to (4%) of the children who were part of the classes with an income of one to two minimum wages. On the other hand, the consumption of other liquids and the consumption of flour

porridge (“caribé”) were not present in any of the social conditions. Differently from that, the consumption of Açaí berry was of (4%) in the families that received above one to two salaries minimums.

*Table 2 – Relationship of food consumption of the previous day and family income of “children under 6 months of age” residing in the metropolitan region of Belém-Pará.*

Consumption of the previous day	To 01 MW	Above 01to 02 MW	Above 02 to03 MW	More than 03 MW
<b>BreastMilk</b>				
Sim	56.00%	32.00%	0.00%	12.00%
No	0.00%	0.00%	0.00%	0.00%
<b>Porridge</b>				
Yes	4.00%	4.00%	0.00%	0.00%
No	52.00%	28.00%	0.00%	12.00%
<b>Water/Tea</b>				
Yes	8.00%	8.00%	0.00%	0.00%
No	48.00%	24.00%	0.00%	12.00%
<b>Milk</b>				
Yes	0.00%	4.00%	0.00%	0.00%
No	56.00%	28.00%	0.00%	12.00%
<b>Infant Formula</b>				
Yes	4.00%	4.00%	0.00%	4.00%
No	52.00%	28.00%	0.00%	8.00%
<b>FruitJuice</b>				
Yes	4.00%	4.00%	0.00%	0.00%
No	52.00%	28.00%	0.00%	12.00%
<b>Fruit</b>				
Yes	4.00%	8.00%	0.00%	0.00%
No	52.00%	24.00%	0.00%	12.00%
<b>Home food</b>				
Yes	0.00%	4.00%	0.00%	0.00%
No	56.00%	28.00%	0.00%	12.00%
<b>Consumptionofothersliquids</b>				
Yes	0.00%	0.00%	0.00%	0.00%
No	56.00%	32.00%	0.00%	12.00%
<b>Caribé (FloursPorridge)</b>				
Yes	0.00%	0.00%	0.00%	0.00%
No	56.00%	32.00%	0.00%	12.00%
<b>Açaí Berry</b>				
Yes	0.00%	4.00%	0.00%	0.00%
No	56.00%	28.00%	0.00%	12.00%

**Source:** Survey data, 2022.

Caption: MW: Minimum wage.

Regarding food consumption and family income of children from 6 months to 1 year of age (Table 3), it appears that children who did not consume breast milk on the day before the survey were higher in the groups that received more than three minimum wages (15%), of those who received up to 1 minimum wage (12.20%) and above two to three wages (10.98%).

Regarding the supply of food for the family, it is noted that the prevalence of this consumption was twice a day and the highest prevalence was among groups with lower incomes, with one to two salaries being higher (21.8%), up to one salary (18.75%), above three salaries (9.38%) and above two to three (6.25%).

The offer of fruit to children aged 6 months to one year was twice a day, being higher in groups with lower income, being (18.75%) up to one salary, (9.38%) above one salary and (6.25%) higher than three. In addition, it is observed that there was no offer of other types of milk in any of the family incomes.

Regarding porridge, consumption of (21.88%) is observed in groups with income above one to two minimum wages, with (15.63%) belonging to groups of up to one salary and above three salaries, respectively. In addition, yogurt consumption was prevalent in families with incomes greater than three minimum wages (15.63%) and (9.38%) belonging to groups that received more than one to two minimum wages.

With regard to the supply of vegetables, it appears that (12.50%) of the children whose group receives up to one minimum wage and (6.25%) above one to two minimum wages did not consume any type of vegetable. Furthermore, it can be seen that (6.25%) of these, whose groups received above one to two salaries, did not consume any type of orange-colored vegetable or fruit.

The consumption of leafy vegetables, it appears that most children from six months to one year, belonging

to families with lower purchasing power, being (25%) of the groups that received up to one salary and (18.75%) above one to two salaries, did not consume leafy vegetables.

As for the consumption of proteins, it is noted that (15.63%) of the children belonging to the groups of up to one minimum wage and (9.38%) of the groups that received more than one to two wages, did not consume meat or eggs, demonstrating that among families with lower income, there was a higher prevalence of children who did not consume any type of animal protein.

Regarding the consumption of rice, roots and tubers, among those who did not consume these foods, they belonged to the lower income groups, with (9.38%) up to one minimum wage and (6.25%) above one to two salaries.

Hamburgers and/or sausages were not consumed by children belonging to the income groups. On the other hand, sweetened beverages were consumed by (6.25%) children from families with an income of up to one minimum wage and above three wages, respectively. The consumption of instant noodles, packaged snacks or crackers was observed in the groups above one to two salaries (6.25%) and with higher income, respectively.

Regarding the consumption of stuffed cookies, sweets and/or sweets, it was observed that (3.13%) of the children belonging to the lowest income group, as well as the highest income group, consumed these items, respectively. In addition, most children who were part of the income groups did not consume flour porridge (caribé). Differently from this, the consumption of açai berry occurred in (12.50%) in the amima groups of one to two salaries; (9.38%) in the lowest and highest income groups, respectively.

Table 3 – Relation of food consumption from the previous day and family income of “children aged 6 months to 1 year” living in the metropolitan region of Belém, Pa.

Consumption of the previous day	To 01 MW	Above 01 and 02 MW	Above 02 and 03 MW	More than 03 MW
Breast Milk				
Yes	13.41%	19.00%	7.32%	15.0%

No	12.20%	6.1%	10.98%	15.%
Home food				
1 time/day	9.38%	9.38%	0.00%	6.28%
2 times/day	18.75%	21.8%	6.25%	9.38%
3 times or more	0.00%	3.13%	0.00%	3.13%
NO	6.25%	3.18%	3.13%	0.00%
Fruit				
1 time/day	6.25%	15.63%	0.00%	12.50%
2 times/day	18.75%	9.38%	3.13%	6.25%
3 times or more	6.25%	9.38%	0.00%	0.00%
No	3.13%	3.13%	6.25%	0.00%
Others kind of milk				
yes	0.00%	0.00%	0.00%	0.00%
No	8.54%	10.98%	5.49%	9.15%
Porridge				
yes	15.63%	21.88%	3.13%	15.63%
No	18.75%	15.63%	6.25%	3.13%
Yogurt				
Yes	6.25%	9.38%	0.00%	15.63%
No	28.13%	28.13%	9.38%	3.13%
vegetables				
yes	21.88%	31.25%	3.13%	15.63%
no	12.50%	6.25%	6.25%	3.13%
VegetablesoryellowFruits				
Yes	31.25%	31.25%	6.25%	18.75%
No	3.13%	6.25%	3.13%	0.00%
Verdure				
yes	9.38%	18.75%	3.13%	9.38%
No	25.00%	18.75%	6.25%	9.38%
meat and or eggs				
yes	18.75%	28.13%	6.25%	18.75%

No	15.63%	9.38%	3.13%	0.00%
rice, Potato, Yamor cassava				
Yes	25.00%	31.25%	3.13%	18.75%
No	9.38%	6.25%	6.25%	0.00%
Hamburger an or sausages				
yes	0.00%	0.00%	0.00%	0.00%
No	34.38%	37.50%	9.38%	18.75%
Sweetened Drinks				
Yes	6.25%	3.13%	0.00%	6.25%
No	28.13%	34.38%	9.38%	12.50%
Noodles, snacks, orcrackers				
Yes	0.00%	6.25%	0.00%	6.25%
No	34.38%	31.25%	9.38%	12.50%
Cookies and or candy				
Yes	3.13%	0.00%	0.00%	3.13%
No	31.25%	37.50%	9.38%	15.63%
“Caribé” (Flour Porridge)				
Yes	0.00%	3.13%	0.00%	3.13%
No	34.38%	34.38%	9.38%	15.63%
Açaí berry				
yes	9.38%	12.50%	0.00%	9.38%
No	25.00%	25.00%	9.38%	9.38%

**Source:** Survey data, 2022.

Caption: MW: Minimum Wage.

The food consumption of the previous day and the family income variable of children from one to two years of age (Table 4), it can be seen that with regard to the continued supply of breast milk, it can be observed that among the groups with greater financial conditions, there is no there was the offer of breast milk on the previous day, being (15.24%) greater than three minimum wages;

followed by (12.20%) those with the lowest income; (10.98%) with family income above two and three and (6.10%) above one to two salaries.

Regarding the consumption of other types of milk, it is observed that consumption occurred in children who are part of the groups with income above one to two salaries (10.98%), followed by (9.15%) those with income



greater than three salaries, (8.54%) up to one salary and (5.49%) above two to three minimum salaries.

The consumption of porridge was prevalent in children aged one to two years, who were part of families with lower income, being (17.88%) in the group with income of up to one salary, (17.07%) with income above one to two salaries, followed by higher incomes, with (11.59%) of those earning more than three salaries and (10.98%) those earning more than two to three salaries.

In this sense, it is observed that in relation to yogurt consumption, the prevalence was in children whose family has the lowest income, being (17.07%) up to one salary and (15.85%) with a greater gain of one to two, the other incomes were (10.98%) of those earning more than three minimum wages and (7.32%) those earning more than two and three minimum wages.

The consumption of healthy foods such as vegetables, it is observed that most children belonging to all incomes consumed this food, but it is possible to observe that (6.10%) of children belonging to groups with income above one to two salaries did not consume this food. this food, as well as (3.66%) of those earning more than three salaries and (3.05%) of those who received up to one salary, also did not eat vegetables.

The consumption of orange-colored vegetables or fruits, it is observed that (5.49%) of those who receive up to one salary and of those who receive more than two to three minimum wages did not eat this food, as well as (3.05%) of those who had a higher income of one to two salaries and those with income above three salaries also did not eat some of these foods, respectively.

Likewise, regarding the consumption of leafy vegetables, it is noted that children with income up to one minimum wage (15.85%) did not consume any type of food, as well as (15.24%) of those with higher incomes did not eat leafy vegetables (14.63%) of those with income above two and three salaries and (14.02%), demonstrating a low consumption of this healthy food.

Meat and/or eggs were consumed by most children belonging to family incomes, with a higher consumption (29.27%) in families whose income exceeds three minimum wages, however this consumption also occurred in children with lower incomes (24.39 %) of up to one salary, followed by (25%) of those who received above one to two salaries and (17.68%) above two to three salaries.

Regarding the consumption of rice, roots and tubers, it is noted that despite consumption being higher in all incomes, (3.66%) of the children whose family received up to one minimum wage did not consume any of these foods. On the other hand, it is observed that the consumption of hamburgers and/or sausages occurs in families of lower social status, being (6.71%) of those who received up to one salary and (6.10%) of those with income above one to two salaries minimum.

Sugar-sweetened beverages were consumed by (13.41%) children whose families had lower purchasing power, (10.37%) of those who received more than one to two wages, followed by a lower rate for families with higher incomes, being (7.32%) with salary gain above two to three salaries and (5.49%) of those who received more than three salaries.

Regarding the consumption of instant noodles, packaged snacks or crackers, it is noted that this consumption occurred in most families with lower incomes, with this rate (13.41%) of those who received up to one salary, following with (7.93%) of those earning more than one to two salaries, the other incomes were (4.27%) with a salary gain of more than three salaries and (3.05%) of those who earned more than two to three salaries.

Regarding the consumption of stuffed biscuits, sweets and/or sweets, it was found that the highest consumption occurred among children with lower family income, with (12.20%) of the families that received up to one salary, (7.93%) of those with income above one to two salaries, followed by the highest income (6.10%) of those earning above three salaries and (4.27%) with salary gain above two to three minimum salaries.

As for the consumption of flour porridge (“caribé”), it was noted that it was not present in the diet of most children belonging to all incomes. On the other hand, açai berry was consumed by (14.02%) of the children whose families received more than one to two salaries, (12.20%) of those with a higher family income of more than three salaries, of those with an income of up to one salary (11.59%) and those belonging to the group with earnings above two to three salaries was (6.71%).

The consumption of regional foods, most of the children belonging to the income, did not consume these foods. However, (1.22%) with an income of up to one salary and (0.61%) with a salary above one to two, consumed Vatapá and Maniçoba, respectively.

*Table 4 – Relationship of food consumption from the previous day and family income of “children aged 1 to 2 years” living in the metropolitan region of Belém, Pa.*

Consumption of the previous day	To 01 MW	Above 01 and 02 MW	Above 02 and 03 MW	More than 03 MW
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Breast Milk				
yes	13.41%	19.51%	7.32%	15.24%
No	12.20%	6.10%	10.98%	15.24%
Others kind of milk				
yes	17.07%	14.63%	12.80%	21.34%
No	8.54%	10.98%	5.49%	9.15%
porridge				
yes	17.68%	17.07%	10.98%	11.59%
no	7.93%	8.54%	7.32%	18.90%
yogurt				
yes	17.07%	15.85%	7.32%	10.98%
No	8.54%	9.76%	10.98%	19.51%
vegetables				
yes	22.56%	19.51%	15.85%	26.83%
No	3.05%	6.10%	2.44%	3.66%
Vegetable or yellow fruits				
yes	20.12%	22.56%	12.80%	27.44%
No	5.4.9%	3.05%	5.49%	3.05%
Verdure				
yes				
	9.76%	11.59%	3.66%	15.24%
No	15.85%	14.02%	14.63%	15.24%
meat and or eggs				
yes	24.39%	25.00%	17.68%	29.27%
no	1.22%	0.61%	0.61%	1.22%
rice, potato, yam or cassava				
yes	21.95%	25.00%	17.68%	29.27%
no	3.66%	0.61%	0.61%	1.22%
hamburger and or sausage				
yes	6.71%	6.10%	1.22%	1.22%
No	18.90%	19.51%	17.07%	29.27%
sweetened drinks				
yes	13.41%	10.37%	7.32%	5.49%
no	12.20%	15.24%	10.98%	25.00%
noodles, snacks or cracker				
yes	13.41%	6.71%	3.05%	4.27%
No	12.20%	18.90%	15.24%	26.22%
cookies and candy				

yes	12.20%	7.93%	4.27%	6.10%
No	13.41%	17.68%	14.02%	24.39%
“Caribé” (flour porridge)				
yes	0.00%	0.00%	1.22%	0.00%
No	25.61%	25.61%	17.07%	30.49%
Açaí berry				
yes	11.59%	14.02%	6.71%	12.20%
no	14.02%	11.59%	11.59%	18.29%
regional foods				
Vatapá	1.22%	0.61%	0.00%	0.00%
Tacacá	0.00%	0.00%	0.00%	0.00%
Maniçoba	1.22%	0.61%	0.00%	0.00%
Did no consume	24.39%	24.39%	18.29%	30.49%

**Source:** Survey data, 2022.

**Caption:** MW: Minimum Wage.

#### IV. DISCUSSION

When analyzing the family income of the children's families in the cities of Belém, Ananindeua and Marituba, it was observed that the majority (32.58%) lived with a monthly family income of up to one minimum wage, and their highest level of education was high school (40.72%). Schooling, family income, culture, and caregivers' workload influence the living, health and food conditions of these families [6].

Regarding food consumption, the prevalence of breast milk consumption among children less than six months of age occurred in families of lower social status, with 56% in families that received up to one salary, 32% above one to two salaries and only 12 % greater than three. This can be considered a protective factor for low-income children, as breast milk is economical and provides essential nutrients for the child's growth and development, and protects against infections. In addition to generating benefits for the mother during the puerperium [7].

The consumption of other foods and liquids in children aged 0 to 6 months was present in families with lower purchasing power who had from 1 to 2 minimum wages, and the consumption of porridge (4%); water and/or tea (8%), cow's milk (4%) and infant formula (4%). This factor is worrying, as the early introduction of food interferes with the period of Exclusive Breastfeeding (EBF), in addition to being associated with increased infant morbidity and mortality; in addition, such foods are expensive and may compromise family income.

The introduction of porridge and other milks is still frequent, due to family beliefs that lead to the understanding that breast milk is not able to meet the needs of children [8]. According to Sá [9] in her study, it was also found that before six months the children received food, such as: water (79.2%), tea (84.5%), porridge (55.6%) and other types of milk (57%), and that 77.8% of the families in which these children were part had an income below the minimum wage, corroborating the results of the present study.

Second, Oliveira et al. [10] in “Exclusive Breastfeeding and the introduction of industrialized foods in the first two years of life” found that the rate of breastfeeding at or above six months was lower in classes with higher incomes, 10.5% in class C1 (R\$2,705) and 5.3% in class C2 (R\$1,625). In this research, the rate of children who did not consume breast milk was higher in the groups that received more than three minimum wages (15%), of those that received up to 1 minimum wage (12.20%) and above two to three minimum wages (10.98%). Data that corroborate the findings of this author.

Fruit consumption in children between 6 months and 1 year, the offer of this group twice a day, was higher in groups with lower income, being (18.75%) up to one salary, (9.38%) above one salary. Demonstrating that a low number of children are consuming foods from this food group. From 6 months, other foods need to be offered to children, seeking a healthy and balanced diet. Flores et al. [11] in their study, it was observed that the supply of fruits in children aged 6 to 11 months and 29 days was 76.6%,

with the majority (27.3%) belonging to groups with lower income.

Yogurt intake was found to be higher (15.63%) by children from families with incomes above three minimum wages and (9.38%) by those with incomes above one to two minimum wages. However, Porto et al. [12] found that the majority (74%) of the children who ate this food had a family income greater than one minimum wage and 26% had an income less than or equal to one salary.

Regarding the consumption of leafy vegetables, most children aged from six months to one year, being (25%) of the groups that received up to one salary and (18.75%) above one to two salaries, did not consume any type of vegetable. This is worrying as such foods are sources of vitamins and minerals essential for child growth, so their absence in food contributes to the development of nutritional deficiencies.

In the research by Oliveira and Assis [13] 93.3% of children had an inadequate consumption of leaves, of these 16.6% were younger than six months and 53% belonged to families with income less than or equal to one minimum wage. Therefore, this may be related to low access to *in natura* food, due to the values that become inaccessible to the groups that are more socially vulnerable, associated with food and nutritional insecurity to which many of these families are subject, directly affecting their health and quality of life for these children.

With regard to the consumption of sweetened beverages, it was (6.25%) children from families with incomes above three minimum wages. Oliveira et al. [10] found that among children aged 6 to 11 months, the introduction of foods rich in sugar, such as chocolate drinks, soft drinks and artificial juices, was higher in the higher purchasing power classes, with 23.1% B2 (R\$4,852), and only 3.3% in the groups that received less than one minimum wage. The consumption of other ultra-processed foods, such as instant noodles, was prevalent in the groups that received more than one to two wages (6.25%).

This intake of ultra-processed foods is not recommended because it is associated with the development of childhood obesity and other nutritional problems, in addition to inducing their frequent consumption, and thus can lead to the child's lack of interest in natural or minimally processed foods [3].

Regarding the food consumption of children from 1 to 2 years of age, breast milk consumption was frequent in 15.24% of children from families with income above 3 minimum wages. This finding may be related to the mother's greater understanding of the importance of

maintaining breast milk, even after the period of food introduction. Giesta et al., [14] in their study, found that among children aged 4 to 24 months, 39.3% had their breastfeeding interrupted before six months and 9.3% after the sixth month of life, of these 65.5% had an average income, this value being higher than two minimum wages.

Regarding the supply of other milks to children aged one to two years, Gurmini et al., [15] in their research showed that the consumption of other milks such as cow's and artificial milk were consumed by 47.5 % and 15%, respectively, by children aged over or equal to six months, and among them 79.2% had less than three minimum wages. In this research, this rate occurred in children who belonged to groups with income above one to two minimum wages (10.98%), and with income above three minimum wages (9.15%). The data corroborate the findings of this author.

Porridge consumption was predominant in children whose groups were of lower purchasing power, with 17.88% of the income of up to one salary, 17.07% with income above one to two salaries, and for Flores et al., (2021) 54 were present, 5% in children aged 12 to 23 months and 29 days, with 25.2% being low-income. The data contribute to the findings of this study in question.

Likewise, the consumption of vegetables Oliveira and Assis [12] in their study, found inadequacy with regard to the consumption of this item, since 76.7% of children aged 6 to 36 months, most of them (53.3%) with income up to one minimum wage. On the other hand, in this research, the rate of those who did not consume vegetables was slightly lower, but prevalent in most family income groups, being (6.10%) with income above one to two wages; (3.66%) of those with income above three salaries and of those with lower purchasing power (3.05%). Despite this, most children consumed this food. Thus representing an inadequacy of food for this public.

Drinks rich in sugar were consumed by children of lower social status, being (13.41%) those who received up to one salary and (10.37%) those who received more than one to two salaries. In the study by Flores et al. [11] it was observed that the consumption of sugary drinks in children aged 12 to 23 months was higher than in this research, with 25.8% consuming soft drinks and 38.3% artificial juices, verifying these children were found to belong to groups with lower purchasing power. This prevalence demonstrates that the consumption of processed foods is associated with the socioeconomic level of greater vulnerability.

Regarding the consumption of instant noodles, packaged snacks or crackers, it can be observed that this consumption was predominant in families with lower

income, being (13.41%) of those who received up to one salary. Oliveira and Assis [13] found that 50% of children aged 6 to 36 months consumed instant noodles and 16.7% consumed some type of salty food, and most of these were part of incomes of up to one minimum wage. The findings reinforce the prevalence in the consumption of ultra-processed foods in groups with incomes below one salary.

Regarding the consumption of açai berry, a food that is part of the culture of Pará, it was consumed by (14.02%) of the children whose families received above one to two salaries, in those with a higher family income above three salaries (12.20%), of those with income of up to one salary (11.59%) and those with earnings above two to three salaries was (6.71%), being present in the consumption of all family income brackets.

The "Food Guide for Brazilian Children under the age of two" [3] recommends that the introduction of food be made with a wide variety of healthy foods, which respect the local culture. Regarding the fruit group, açai is a great option, due to the easy access of this food in the metropolitan region of Belém / Pará, and for its nutritional characteristics. The supply of fruits is essential during food introduction, as they are foods rich in fiber, vitamins and minerals.

## V. CONCLUSION

The children were cared for by their mother and/or father, were between 18 and 30 years old, and most of them were single and had only one child, and most declared that they had completed high school. Regarding monthly family income, the majority declared that they received up to a monthly minimum wage, which shows that most children belonged to families with lower purchasing power.

Regarding the children's eating practices, it was noted that although all children had received breast milk, there was an offer of non-recommended foods in the first six months, such as porridge, water, tea, fruit and fruit juice, demonstrating interruption early exclusive breastfeeding. Most of the children who received some food belonged to families with lower incomes, which demonstrates the lack of access to information and knowledge regarding the benefits of exclusive breastfeeding, as well as the promotion and protection of health and injuries that occur.

In children aged over six months to two years, it was observed that breastfeeding did not occur continuously in children from groups with higher family income. In this sense, it was observed that recommended foods such as *in natura* and minimally processed foods were little consumed by children whose families received

up to a minimum wage. In addition, non-recommended foods were offered, such as: sugary drinks, stuffed biscuits, sweets, instant noodles, snacks and salty biscuits, and this consumption occurred among children who were part of families with lower purchasing power.

These data demonstrate dietary inadequacy, habits that are configured for the development of chronic non-communicable diseases throughout life. In addition, there is a low consumption of fresh and minimally processed foods, as well as an inadequate introduction of ultra-processed foods, especially in children belonging to families with lower incomes.

It is also necessary to reflect that a more committed work process is essential to promote information about the benefits of exclusive breastfeeding, as well as adequate food, and it is up to the public power to regulate such actions, as well as to provide investments in public policies that act in the face of insecurity food and nutrition, in order to guarantee the right to quality food for the population.

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# Potential of Fruit Plants in the Yard to Support Urban Farming and Agroindustry in Madiun-City, East Java, Indonesia

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**Keywords—** *added value, city yard, fruit plants, urban agroindustry, urban farming.*

**Abstract—** Utilization of yard land is a management effort through an integrated approach to planting various types of plants, cultivating livestock and fish to ensure the continuous availability of diverse materials, and fulfilling family nutrition. Many fruit trees planted in the yard can manage more intensively to ensure the availability of raw materials for agro-industry development. The study aimed to identify the potential of fruit plants in the yard as agro-industry raw materials and to analyze the added value of processed products made from fruit plants. The method used in this study was a descriptive method carried out in three districts of Madiun-City, which empowered the yard as a provider of agro-industrial raw materials. The data analysis method uses the Value-Added Analysis method. The results obtained from the study showed that there were eight types of fruit plants planted in the yard in Madiun-City. Only four fruit plants were used as raw materials for processed products, namely Mango (*Mangifera indica*), Banana (*Musa sp*), Papaya (*Carica papaya*), and Guava (*Psidium guajava*). These are processed into Mango Syrup, Banana Chips, Papaya Sauce, and Guava Juice. The added value obtained by the Mango Syrup product is Rp.12500,-/kg (39.06%), Banana Chips Rp.23228.57/kg (50.03%), Papaya Sauce Rp.4452.14/kg (49, 10%), and Guava Juice Rp.21130,-/kg (58.29%).

## I. INTRODUCTION

Urban yards as urban farming areas have great potential if managed more intensively. Through the concept of the Sustainable Food House Area ("KRPL: Kawasan Rumah Pangan Lestari"), the potential for optimally utilized yard land will be able to support the fulfillment of household food needs as well as raw materials for supporting the urban agro-industry. The basic principles of KRPL are: (1) environmental utilization and designed for food security and independence, (2) food diversification based on local resources, (3) conservation of food genetic resources (plants, livestock, fish), and (4)

maintaining sustainability through village nurseries, (5) increasing community income and welfare [1]. The research results by Indah et al., 2020 also show that the empowerment variables (capacity, authority, empowerment) of urban farming community members have a real influence on increasing food security in Gending Village, Gresik Regency [2]. It is also stated that the community can take advantage of empty or abandoned yards combined with livestock/fish cultivation to obtain family nutrition and economic resources [3]

The utilization of the yard has many functions, especially in increasing family income. It needs to be

developed intensively in exploring its potential to become a profitable business, mainly if the types of plants cultivated can be used as raw materials for the agro-industry. It takes a strong will, patience, skill, and exceptional knowledge is needed to manage it. Daliani (2014) said that household knowledge of the cultivation of garden plants is still low, especially about cultivation techniques and the manufacture of planting media for nurseries [4]. As mentioned by the other researcher that using the yard through hydroponic cultivation, fresh vegetables will be produced continuously, on a scheduled basis, and add value to the community's income [5]. Another research conducted by Rahardjo et al. (2022) shows that yardland in Kuaken Village, North Central Timor Regency, has created independent food for families, has more diverse activities as housewives, saves time and energy can process rice husk and cow dung waste for household purposes. A mixture of planting media and making the yard has an aesthetic value [6].

Efforts to optimize the use of yardland to develop diversification of processed products as agroindustry have begun, but the continuity of supply of raw materials using local resources is inadequate. Following Wardhani's research which says that 20.3% of raw materials come from farmers in agro-industrial areas while 79.7% of raw materials come from traders outside the agro-industrial area [7]

As is the case in India, processed fruit and vegetable products are oriented for export, and dried & preserved processed fruit and vegetable products make up the largest share (47%). To achieve this export goal, companies must be innovative and need to anticipate and respond to consumer needs for survival and sustainable growth [8]. (Goyal, 2006). , The fruit agroindustry is gaining importance with the consumption and processing of exotic fruits increasing worldwide due to improvements in preservation techniques, transportation, marketing systems, and consumer awareness of the health benefits. All parts of exotic tropical fruits are rich in bioactive compounds, such as phenolic constituents, carotenoids, vitamins, and dietary fiber [9]. Maulaa's research (2021) in the Development of Urban Farming in the Railroad Border of Bangetayu Wetan Village, Genuk District, Semarang City, showed that the obstacles experienced were: the presence of pests, diseases, and weeds, as well as a lack of public knowledge. Meanwhile, the urban farming activities help meet food, ecological, economic, social, health, aesthetic, educational, and tourism needs [10].

The agro-industry is one of the agricultural development strategies is a significant effort to achieve several goals. These goals are attracting and encouraging new industries in the agricultural sector, creating a robust,

efficient, and flexible economic structure, creating value-added, increasing income foreign exchange, creating jobs, and improving income distribution [11]. The development of the agro-industry is an effort to increase the added value of primary products of agricultural commodities, which at the same time can change the traditional farming system to be more advanced. As stated by the other that various sizes and shapes of yards can be used to grow healthy fruits, such as longan [12]. The existence of agro-industry at this time is increasingly expected to play a role in improving the family economy and driving industrialization in the region. Many hopes are placed on the agro-industry, but the empowerment of existing potentials constrains its success. Utilization of the yard is expected to be a provider of agro-industry raw materials. In addition to increasing the community's entrepreneurial spirit, it also increases family income with commodities that support agro-industry as processed products. In general, the obstacles faced by the agro-industry are a) availability of raw materials that are not continuous, (b) processing processes that use simple technology so that they are not durable, and (c) limited capital of artisans for the provision of raw materials. Besides it, marketing is only done locally because artisans have not been able to expand the market because they cannot maintain production continuity.

From the above problems, to overcome the availability of raw materials for urban agro-industry development to maintain continuity. More serious attention is needed to empower commodities that support it through the use of yards around the house to create an adequate agribusiness and agro-industry structure through sustainable urban farming.

## II. METHOD

### 2.1. Place and Time

The research was conducted in Madiun-City, East Java, Indonesia, from July to September 2021. The climate is tropical, with an average daily temperature of 24-32°C and an average rainy day per year of about 100 days. A rainfall of 2000 mm per year. Generally, there are 4-5 dry months in a year, 2-3 wet months, and 5-6 wet months. The cardinal directions in Madiun-City are from south to north, an average of 78%.

### 2.2. Sampling Method

The research area was chosen purposively in Madiun-City, which consists of 3 sub-districts, namely Taman, Kartoharjo, and Manguharjo sub-districts, considering that each of these sub-districts has an agro-industry business. The determination of respondents was carried out by purposive random sampling. Each sub-district was taken

with a sample of 20 respondents at random who cultivate fruit plants in the yard, ensuring that segments of the population represented in 10 samples of 10% of the existing population.

a. Interviews technique

Interviews were conducted with questions and answers between researchers and farmers to obtain the necessary data based on direct answers from respondents using prepared questionnaires.

b. Data Recording

The recording is done to obtain data by recording information from various agencies from the sub-district level to respondents based on existing reports and records to get secondary data

c. Observation Technique

Observation aims to collect data without asking questions by observing the object under study. The observation here aims to match the data obtained from the interview with the previous situation and can be used to complement the existing data

### 2.3. Data Source.

Primary data is data obtained directly from respondents or people who grow fruit trees in their yards. The tools used are questionnaires or questions posed to respondents.

Secondary data is relevant documented data obtained from various sources that are trusted and can be accounted for starting from the sub-district level to the people who grow fruit trees in their yards.

### 2.4. Analysis Method.

The data analysis method uses the Value-Added analysis method using the Hayami method (1987), which helps know how much-added value is contained in one kilogram of processed products. This figure can be calculated how much income (labor income) shows how much one kilogram of a processed product provides revenue for its workers. If work income to value added (%) is high, then such agro-industry plays more in providing pay for its workers. Meanwhile, the remaining value-added, which is not used as a labor reward, is part of the profit of the artisans [13].

## III. RESULT AND DISCUSSION

### 3.1. Overview of the Research Site

Madiun-City is a lowland area with an average height of 70 meters above sea level, located at a position of 70-80 south latitude and 1110-1120 east longitude. Based on the geographical position, Madiun-City is surrounded by Madiun Regency with the following boundaries:

- Madiun sub-district in the north
- Geger sub-district in the south
- Jiwan sub-district in the west
- Wungu sub-district in the east

Madiun City is an urban area, so the dominance of land use is for built areas consisting of housing, public facilities, and others. The location of this built-up area in 2000 reached 55% of the total area or about 1,860,323 ha. The Madiun City area consists of 3 sub-districts, namely Manguharjo District (10.04 km<sup>2</sup>), Taman District (12.46 km<sup>2</sup>), and Kartoharjo District (10.73 km<sup>2</sup>) [14].

### 3.2. Cultivated Fruit Plants

The production of fruit crops in Madiun City in 2020 from 3 Districts is 9116 kg [15]. Fruit plants cultivated in their gardens by 20 respondents who grow fruit trees in Manguharjo, Taman, and Kartoharjo Districts can be seen in the picture 1-3.

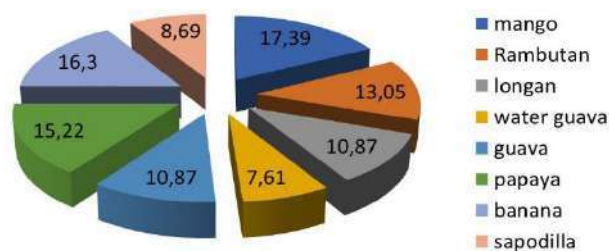


Fig.1. Percentage of Fruit Plants in Manguharjo District, Madiun City

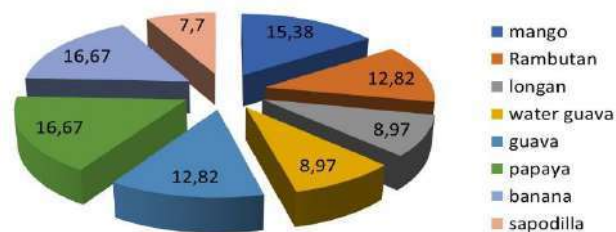


Figure 2: Percentage of Fruit Plants in Taman District Madiun-City



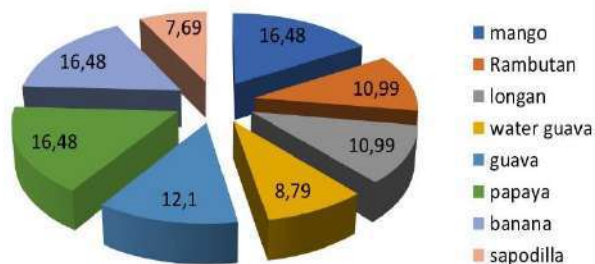


Fig.3: Percentage of Fruit Plants in Kartoharjo District, Madiun-City

Figure 1-3 shows that in three sub-districts in Madiun City (Manguharjo, Taman, Kartoharjo) there are 8 types of fruit plants planted, namely Mango, Rambutan, Longan, Guava, Guava, Papaya, Banana and Sawo. Of the eight types of fruit plants planted in the yard, there are four types plants, namely Mango (*Mangifera indica*), Banana (*Musa sp*), Papaya (*Carica papaya*), and Guava (*Psidium guajava*), which have the highest percentage in the number of plants and production. As for producing these fruit crops, some are sold in fresh form, and some are used as raw materials for processed products. This program is under the government's program by optimizing the use of yardland to develop diversification of processed products through programs such as P2KP ("Percepatan Penganekaragaman Konsumsi Pangan" / Acceleration of Food Consumption Diversification) and GPOT ("Gerakan Perempuan Optimalisasi Pekarangan"/Women's Movement for Garden Optimization). In addition, this program was developing MKRPL ("Model Kawasan Rumah Pangan Lestari"/Model for Sustainable Food House Areas). However, the results have not been satisfactory because, according to Ashari et al. (2012), the use of the yard is still part-time and not market-oriented yet [15].

### 3.2. Number of Agroindustry in Madiun-city

In Madiun-City, several home industries, both food and beverage industries, as processed product businesses utilize local resources and their surroundings. The following table shows the number of companies, workforce, and production value (thousand rupiahs) according to the industrial classification in Madiun-City

Table 1. Number of companies, employee, and production value by industry classification in Madiun-City.

No	Industry category	Number of establishment	Employee (person)	Production value (Rp.,000)
1	Food	43	355	11.089.829
2	Beverage	10	39	1024

Source : Madiun-City Departemen of Agriculture

Fruit crops are agricultural crop commodities that can be used as raw materials for processed products, such as mango syrup, banana chips, papaya sauce, and guava juice which have good market prospects as food substitutes in the future. As raw material for processed products, it is necessary to continue the availability of these fruit plants. With the existence of a food and beverage industry company in Madiun-City, it is a processed product business utilizing fruit plant resources around it. Increasing the cultivation of fruit crops in Madiun is expected to increase the development of existing industries because the food and beverage industry is highly dependent on the continuity of available raw materials.

Table 2. value added Analysis of the fruit plants. Raw

No	Value added component	Mango Syrup	Banana Chips	Papaya Sauce	Guava Juice
	<b>Output, input and price</b>				
1	Output result (kg/production process)	20	32	22	30
2	Raw material input (kg/production process)	50	44,8	84	60
3	Labor input (working days)	4	6	6	3
4	Conversion factor (kg output/kg raw material)	0,400	0,714	0,262	0,500
5	Labor conversion (working days/kg raw material)	0,080	0,134	0,071	0,050
6	Output Price (Rp/kg)	80000	65000	34620	72500



7	Wage mean of labor (Rp/production process)	25000	25000	20000	20000
	<b>income and profit</b>				
8	Raw material input price (Rp/kg)	17500	20000	4500	15000
9	Other contribution input Rp/kg)	2000	3200	115	120
10	Output price (Rp/kg)	32000	46428,57	9067,14	36250
11	<b>Value added (Rp/kg)</b>	<b>12500</b>	<b>23228,57</b>	<b>4452,14</b>	<b>21130</b>
	Value added ratio (%)	39,06	50,03	49,10	58,29
12	Labor benefit (Rp/kg)	2000	3348,21	1428,57	1000
	Labor share (Rp/kg)	16,00	14,41	32,09	4,73
13	Profit (Rp/kg)	10500,00	19880,36	3023,57	20130
	Profit share (%)	32,81	42,82	33,35	55,53
	<b>Remuneration for Factors of Production Margin (Rp/kg)</b>				
14	Margin (Rp/kg)	14500,00	26428,57	4567,14	21250
	a. Labor income (%)	13,79	12,67	31,28	4,71
	b. Other input contribution (%)	5120,00	6396,06	234,21	205,87
	c. Profit (%)	72,41	75,22	66,20	94,73

Source : Primary data analysis

### 3.4. Value-Added from fruit plants as processed products

The value-added of raw materials with fruit plants into processed products of Mango Syrup, Banana Chips, Papaya Sauce, and Guava Juice is presented in table 2. Shows that each raw material from fruit plants can be processed products with different added values. This case can be seen from the raw material of mango, which is used as mango juice with an added value of Rp. 12,500 - with an added value ratio of 39.06% of the processed raw materials. The raw material for Bananas which is used as a Banana Chips product, obtains an added value of Rp.23228.57/kg with an added value ratio of 50.03%. The raw materials from the Papaya plant can be used as Papaya Sauce products to obtain an added value of Rp.4452.14/kg, with a value-added ratio of 49.10%. Meanwhile, the raw material of guava, which is used as a guava juice product, gets an added value of Rp.21130-/kg, with an added value ratio of 58.29%. Following the opinion of Siebert J.W et al. (1997) suggests that the added value category, namely the added value, is said to be low if the ratio value is < 15%, moderate if the ratio value is 15 -40%, and high if the ratio value is > 40% [16]. However, according to

Wardhani (2017), the production of agroindustry capacity is strongly influenced by the availability of raw materials. The availability of raw materials is limited and discontinuous due to minimal raw material storage technology. As a result, in the months of the harvest season, the harvest will accumulate in the market [17].

From the table above, it can also be seen that the share of labor in the agro-industry obtained the highest percentage of fruit plants, namely papaya plants which are processed into papaya sauce by 32.09%, followed by mango plants which are processed into mango syrup, which is 16%, then banana plants. which is processed into banana chips by 14.41%, then guava plants which are processed into guava juice only provide a share of labor of 4.73%. This shows that the higher the percentage means the greater the share of the workforce in the agro-industry business.

## IV. CONCLUSION

From the research, it can conclude that the potential of fruit plants cultivated in Madiun-City are eight types of

plants, namely, Mango 16.48%, Bananas 16.48%, Papaya 16.1%, Rambutan 12.2%, Guava 11.9%, Longan 10.34%, Water guava 8.4%, and Sapodilla 8.1%. Therefore, the fruit plants used as raw materials for processed products are Mango, Banana, Papaya, and Guava. Meanwhile, the added value of the processed fruit trees are as follows: Mango syrup product Rp.12500,-/kg (39.06%), Banana Chips Rp.23228.57/kg (50.03%), Papaya Sauce Rp. 4452.14/kg (49.10%), and Guava Juice Rp.21130,-/kg (58.29%).

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# The Effects of Pesticides on Humans and the Environment

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**Keywords—** Environment, Agrochemicals,  
Agriculture.

**Abstract—** This article highlights the use of chemical agents in agriculture, which undoubtedly causes a series of environmental impacts when used improperly and puts health and human life at risk. In a methodological, qualitative, bibliographic and exploratory way, with research in magazines and books specialized in the subject, it shows the bottlenecks of pesticides, in addition to highlighting possible problems that the ecosystem faces in the face of the indiscriminate use of these products. The article also seeks to show the serious consequences that the indiscriminate use of agrochemicals can bring to the environment, when used without information and knowledge, showing in the conclusion the importance of having environmental awareness. The present study brings a review of scientific reports of impacts of pesticides on the environment and human health. Human beings are subject to direct and daily exposure to these chemical compounds in the areas of production, treatment and storage of products, and indirectly, but with no less serious consequences for being exposed to residues found in the environment and in products consumed, so in a clear and objective way environmental preservation and education are fundamental.

## I. INTRODUCTION

Work in agriculture can be considered a practice with some dangers. Among the various occupational hazards, agrochemicals/pesticides that are related to intoxication of living beings and various other environmental damages stand out. This work seeks to bring information to people about the importance of the correct use of agrochemicals and environmental awareness since the indiscriminate and often incorrect use of agrochemicals in Brazil, as well as in other countries, results in severe levels of environmental pollution and intoxication. human life causing major health and food safety problems. For Azevedo (2016), pesticides are products and agents of physical, chemical or biological processes, intended for use in the production sectors, in the storage and processing of agricultural products, in pastures, in the protection of forests, native or planted, and of other ecosystems and urban, water and industrial

environments, whose purpose is to change the composition of flora or fauna, in order to preserve them from the harmful action of living beings considered harmful, as well as substances and products used as defoliants, desiccants, stimulators AND growth inhibitors, also states that when used correctly, it helps and not destroys. The concern in this article is to confront information, with an exploratory methodology, in order to, in the final conclusion, show the possibility of using and strengthening the proper use of pesticides / agrochemicals.

### 1.1 Types of pesticides

Pesticides can be classified according to the pests they control, the chemical structure that composes them or the damage they cause to nature and human health. According to the type of pest controlled, pesticides are classified into:

- Herbicides → control invasive plants.
- Insecticides → control insects.

- Fungicides → control fungi.
- Bactericides → control bacteria.

### 1.2 Toxicological classification

Figure 1 below shows the toxicological classification according to the National Health Surveillance Agency

(ANVISA) which classifies pesticides into four classes of harm to human health: slightly toxic, moderately toxic, highly toxic and extremely toxic. On the labels of these products, in addition to the colors that represent each class, the lethality doses of each are also indicated.

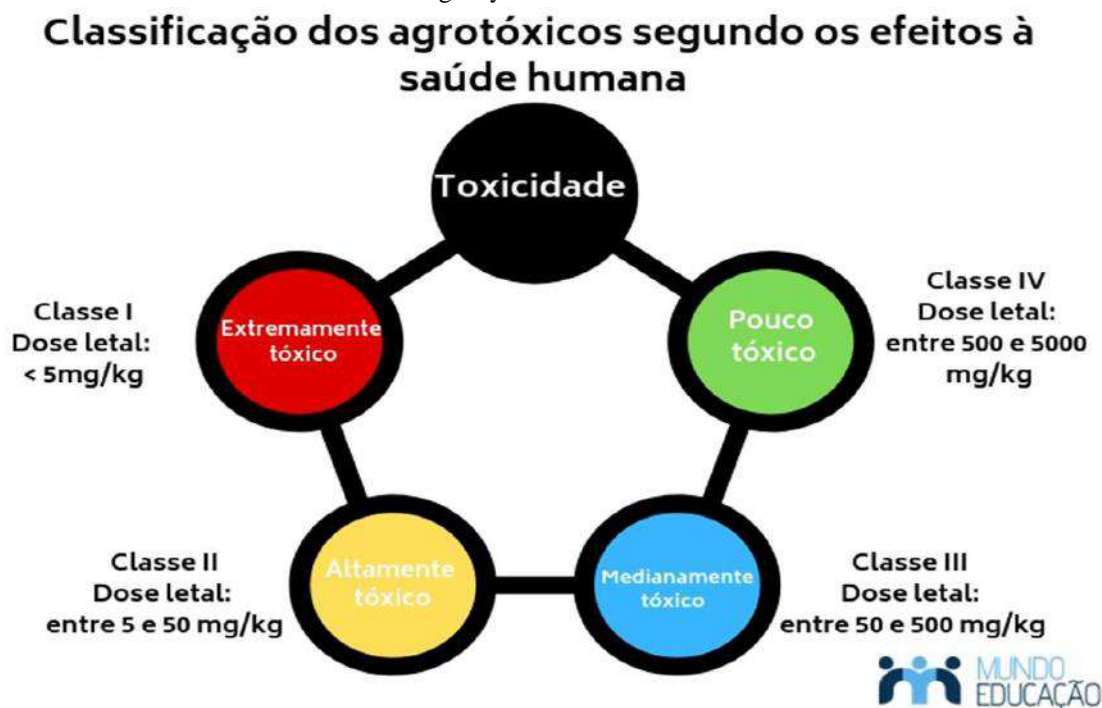


Fig.1: Shows the classification of the effects of pesticides on humans

Source: World of Education, 2009

### 1.3 Effects with the use of pesticides / agrochemicals

Parts of farmers are unaware of the risks posed by these products, consequently, they neglect some basic standards essential for safety at work, from that point onwards this work aims to show the importance of the correct use of these agrochemicals for the preservation of the environment and human health.

According to Azevedo (2016), agrochemicals can cause great economic and environmental damage to society. When used incorrectly, it causes contamination of water and soils, as it travels in the environment, through winds and rainwater to places far from the applied site. It can still be responsible for the high intoxication rates observed among rural producers and workers, in addition to causing food contamination.

The use of agrochemicals in the field primarily affects rural workers, who handle and apply these compounds. The World Health Organization estimates that around 4 million acute poisonings caused by these compounds occurred worldwide by 2000, with about 220,000 deaths per year. About 70% of the registered cases

occurred in developing or underdeveloped countries (JEYARATNAM, 1990, p.207).

The use of suitable protective equipment by the farmer can reduce exposure by up to 100% (BONSAL, 2015, p.13). However, due to economic, cultural or lack of information about the risk, the use of this equipment is often precarious or non-existent.

Also, according to Bonsal (2015), Some interrelated factors act as determinants of the amplification and reduction of the impact that the use of agrochemicals can have on the health of human populations, such as: a) low level of education; b) the lack of a more efficient monitoring/technical advice policy; c) the exploratory practices of advertising and sales, by the industries producing and distributing pesticides; d) lack of knowledge of alternative and efficient cultivation techniques; e) the little attention given to the disposal of tailings and packaging; f) the continued use/exposure of pesticides; g) the eminently technical content of the information material available to rural populations; h) communication difficulties between technicians and



farmers; i) absence of efficient government initiatives to provide continued technical assistance to rural workers; and j) the lack of efficient government strategies to control the sale of pesticides.

## II. DEVELOPMENT

Man has been learning since prehistory to practice agriculture in a more productive way in order to ensure his livelihood. However, he coexists with the problem of pests that destroy plants, crops and stored food, usually in large quantities. The fight against pests is old. The Chinese, about 1,000 years ago, already used arsenic compounds such as arsenic sulfide for this purpose. So, in order to protect their harvest, man developed agrochemicals also called pesticides, pesticides or agricultural pesticides, among others. These chemicals, or a mixture of these, are intended for the use, storage and improvement of agricultural products, in pastures, in the protection of forests and other urban, water and industrial ecosystems, in order to preserve them from the harmful action of living beings considered harmful, also used as defoliating substances and products, desiccants, stimulators, growth inhibitors and fertilizers for plants. For Rigoto (2014) its indiscriminate application causes numerous problems, both for the health of applicators and consumers, as well as for the Environment, contaminating the soil and water, leading to the death of plants and animals.

Brazilian agriculture has increasingly made use of these chemical inputs, mainly pesticides, and this causes a series of ecological problems.

According to Ferrari (1985, p.110) "until the 1950s, agricultural activities were directed towards the generation of products (coffee and cotton, mainly) for the self-consumption of the population residing in rural areas and a few urban centers", but with the increase in urban population, there was a need to increase agricultural production to supply urban centers, using pesticides to combat pests even without knowing the consequences that could be generated by these products.

Also, according to Ferrari (1985, p.111) food contamination, river pollution, soil erosion and desertification, intoxication and death of farmers and extinction of animal species, are some of the most serious consequences of industrial chemical agriculture and of the indiscriminate use of pesticides widely stimulated in the last 25 years.

Due to environmental contamination and pesticide residues in food, we can also estimate that populations living close to cultivation areas and urban dwellers are also

significantly exposed to the harmful effects of these chemical agents (CARVALHO et al, 2005, p 223).

### 2.1 The environmental impact

The consumption of pesticides generates a vicious circle: the more they are used, the greater the imbalances caused and the greater the need to use, in more intense doses, increasingly toxic formulations.

Fauna and flora are also largely affected by the use of indiscriminate chemical inputs. According to Ferrari (1985, p.112), the land carried by the rainwater takes pesticide residues to rivers, lakes and dams, compromising the aquatic fauna and flora, in addition to compromising the waters captured for the purpose of supply.

They can also cause an increase in pests instead of fighting them, because as chemical inputs are used, the pests become more resistant, requiring increasingly stronger pesticides, thus further harming the environment, decimating even the own natural predators of the pests.

Industrial Agriculture, labeled modern and advanced, based on economics and immediate results in protecting cultivated plants against the action of pests, pathogens and invasive weeds, has constantly failed.

For Industrial Agriculture, the objective is merely productivity, leaving aside ecological balance, such as: stability of agricultural systems: conservation of natural resources (water, soil and air) and food quality.

### 2.2 Contamination of water resources by excess water applied

Excess water applied in irrigation returns to rivers, through surface and surface runoff or goes to underground deposits, by deep percolation, dragging with it residues of fertilizers, pesticides, herbicides and other toxic elements, called soluble salts. Water resources thus contaminated require appropriate treatment when destined for the supply of potable water.

Contamination of surface waters, especially rivers and streams, is rapid and occurs immediately after irrigation. There have been serious problems arising from the application of herbicides in flood irrigation; in furrow irrigation, the applied water carries, in addition to herbicides, fertilizers, pesticides and sediments. It can also occur more slowly, through the subsurface water table, which receives fertilizers, pesticides and herbicides dissolved in the applied water. This contamination can be aggravated if there are soluble salts in the soil, because, when infiltrating, the water already containing the salts applied in the crop, will still dissolve the salts in the soil, becoming more harmful.

Groundwater contamination is much slower. The time required for percolation to the groundwater table increases with decreasing soil permeability and water table depth. To reach a water table situated at about 30 m deep, depending on the permeability of the soil, it may take from 3 to 50 years. Therein lies a serious problem, because it is only a long time later that it will be known that groundwater has been polluted; this problem worsens pollutants are dissolved salts, nitrates, pesticides and heavy metals.

A previous geological study can reveal the concentration of soluble salts in the soil profile and indicate the most favorable areas, that is, with less potential for contamination of water resources. The greater the percolation and surface runoff losses in irrigation, the greater the chances of contamination of springs and groundwater. It is increasingly necessary to dimension and manage irrigation systems with greater efficiency, as well as correctly dose fertilizers, herbicides and pesticides.

### 2.3 The bias

Intoxications caused by pesticides in Brazil are second only to those caused by narcotics, misused medicines and homemade cleaning products, mainly, as observed by Azevedo (2016), who has also pointed out in his works that the use of transgenic plants in agriculture drastically reduced the use of pesticides. It also states that the genetic improvement of plants is a powerful technical-scientific force for the success of agribusiness, in the way of a substantial increase in the production and productivity of cultivars, in addition to enabling environmental protection, reduction of the application of pesticides, fertilizers and correctives, considering precision agriculture.

### 2.3 Pesticides in Brazil

The use of pesticides in Brazil is related to climatic factors especially. Brazil is a tropical country, with no winter periods in some regions for the pest cycle to be interrupted, as occurs in temperate and subtropical climates. Another reason is linked to the evolution that took place in the field. The technology currently used in agriculture has allowed for an increase in production. Not to mention monoculture, widely practiced in Brazil, which also favors the cycle of pests. These factors may explain the need to use agrochemicals.

It is also worth mentioning that the National Agricultural Development Plan (PNDA) encouraged the use of pesticides and offered investments to farmers who used them, as well as to industries that produced them.

In the country, the registration, safety of pesticides and the feasibility of using pesticides are

attested by bodies such as the Ministry of Agriculture, ANVISA and IBAMA (agriculture, health and environment sectors) in order to guarantee the safety of the population regarding the use of pesticides. same. The commercialization of pesticides can only be carried out upon presentation of a prescription issued and prescribed by an agronomist, and the product must present on its label the indications of use and safety.

Currently Brazil, in addition to being considered one of the largest agricultural powers, is also one of the countries that consume the most pesticides in the world. According to Revista Pesquisa Fapesp, this market moves around US\$ 10 billion a year in Brazil. Data from the agricultural census indicate that there was a 20% increase between 2006 and 2017 in rural producers who use pesticides in their crops.

But it is necessary to say that although Brazil is among the biggest consumers of pesticides in the world, this consumption in relation to the cultivated area is relatively low. Thus, despite the reports pointing to an increase in the consumption of pesticides, at the same time there was an increase in productivity. According to SINDAG (National Union of Agricultural Aviation Companies) Brazil produced more food with less pesticides.

Brazil occupies the leadership of the world pesticide consumption ranking (BRASIL, 2015). It does not seem to do justice, as it should, to Law No. 7,802/89 (BRASIL, 1989) (regulated by Decree No. 4074/02), which provides for rules related to the pesticide chain (research, experimentation, production, packaging and labeling, transport, storage, commercialization, commercial advertising, use, import, export, final destination of waste and packaging, registration, classification, control, inspection and inspection).

There are reports that demonstrate the harmful effects of pesticides on the environment and human health, but despite this, of the various active ingredients banned in the European Union, still in the 1990s, few were banned in Brazil, and they were banned very recently, in last two or three years. However, some of these compounds are still freely traded. The Brazilian Association of Collective Health (ABRASCO) states that, of the 50 products most used in Brazilian crops, 22 are banned in the European Union and in other countries (DOSSIÊ..., 2012a). Although some active ingredients are banned in Brazil, their residues are still found in food. On the other hand, the indiscriminate use of pesticides, even with authorized use, has resulted in foods with high levels of contamination, above the maximum allowed (ANVISA, 2011).

One of the factors that further boosted the use of pesticides in Brazilian crops was the advent of genetically modified organisms. Transgenic crops, so called, end up contributing to the reduction of biodiversity (SIQUEIRA et al., 2004).

The artificialization system of nature causes the imbalance of ecosystems, promoting the emergence of new pests, which require the application of new pesticides, which can lead to the selection of those more resistant. These pests, in turn, will need more impactful pesticides, e.g. according to scholars on the subject, the use of transgenic causes a vicious circle from which agriculture cannot break free (LONDON, 2011). Thus, the Brazilian scenario is worrying, because behind the scenes of each production record, at the same time, there can be a great environmental impact caused by phytosanitary products, since agroecology and sustainability are interests of few.

## 2.4 Flexibility of the pesticide law in Brazil

The use of pesticides in Brazil is regulated by the Agrochemicals Law (Law No. 7.802, of 1989). In 2018, a proposed project was approved by the Chamber of Deputies that provides for the release of the use of pesticides by the Ministry of Agriculture without the interference of bodies such as IBAMA or ANVISA. The project revokes the 1989 law and promotes changes to the rules for the production, marketing and distribution of pesticides, making it more flexible.

This approval was the reason for intense debates between environmentalists, who defend the non-use of these chemicals, and ruralists, who say that it is inevitable not to use them, since Brazilian productivity in the agricultural sector depends on these substances.

In 2019, the Ministry of Agriculture approved the registration of highly toxic pesticides. Data from ANVISA reveal that Brazil is currently one of the main destinations for pesticides banned in several countries, such as the United States, China and European Union countries. In Brazil, at least ten products banned in these countries are used.

## 2.5 Advantages and disadvantages of using pesticides

Below we have some advantages and disadvantages, according to Azevedo, 2014, for the use of pesticides.

### 2.5.1 Advantages

- Pesticides, when used according to the recommended dose, act in the control of pests and diseases that harm plantations;
- By controlling possible damage to crops, pesticides ensure increased productivity;

- The prices of products with pesticides are cheaper than the prices of organic products.

### 2.5.2 Disadvantages

- The use of pesticides is associated with several chronic problems, such as chromosomal alterations, cancer, liver diseases, respiratory diseases, among others;
- Incorrect use of pesticides can cause damage to the environment, such as contamination of soil and water resources;
- The use above the allowed in food can bring risks to the health of consumers;
- There are risks of intoxication by workers who handle pesticides;
- Some pesticides are persistent in the environment, that is, they remain in them for a long time.

## III. CONCLUSION

With this research it is concluded that all the impacts caused by the incorrect use of pesticides result in direct or indirect damages to man. The contamination of soils, air, water, fauna and flora caused by its incorrect use brings numerous problems both for the environment and for the health of living beings.

Based on the above, it is evident the need and importance of an efficient environmental education of information for the general public, in the sense that the correct use of pesticides has its large and important part in the formation of an adequate cultural attitude of the users. Also, it is concluded that pesticides when used correctly can even be beneficial to man and the environment, but when used without knowledge it becomes the worst enemy of the human being.

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Posted by: Rafaela Sousa



Despite being harmful to health, pesticides are widely used in Brazil and worldwide to combat pests and diseases in plantations.\*

Photo and post by: Rafaela Sousa (2018)

# Prevalence of Apical Periodontitis in a Public Dental Service in Northern Brazil

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**Keywords—** Apical Periodontitis,  
Epidemiology, Periapical Lesion, Prevalence

**Abstract—** Apical periodontitis (AP) is characterized by a peri-root inflammatory process presented by the host's immune response, from infections that affect the root canal system. The objective of this study was to verify the prevalence of apical lesions in digital periapical radiographs performed in a public dental care service in the northern region of Brazil. To this end, 3967 digital periapical radiographs performed on patients seen in 2019 were analyzed and classified using the Ørstavik periapical index (PAI). A total of 7172 teeth were analyzed. Four hundred and twenty-one of these teeth had already received endodontic treatment with root filling. The prevalence of AP in teeth without endodontic treatment was equivalent to 14.6%. In teeth with TE, the prevalence was 33.5%. The overall prevalence, when at least one tooth of an individual had apical periodontitis, was 49.9%. The prevalence found was lower than the reported worldwide prevalence, but still considered high in this specific population and indicates the need for directing public policies to improve this condition.

## I. INTRODUCTION

Periapical alterations mostly come from aggression to the dental pulp due to unremoved chemical, physical or biological lesions. According to Leonardi *et al.* (2011) the pulp tissue can present interruption of its metabolic process, leading to pulp necrosis and consequently invasion of microorganisms to the root canals. Such microorganisms can reach the periapical region through the apical foramen or exposed dentinal tubules. In this way, an inflammatory process occurs from the immune response of the periradicular tissues, to prevent the spread of infectious processes to the bone and other regions of the body (Lopes & Siqueira, 2015).

Apical periodontitis (AP) is a result of the host immune response, and it is characterized by bone loss in the region of the tooth apex, which radiographically presents with a radiolucent appearance. In clinical practice, periapical radiography is the imaging resource most used to diagnose apical and root canal system lesions (Mendes, 2011).

Ørstavik *et al.* (1986) used the results of the Brynolf study to develop a periapical index (PAI), used as a method of radiographic interpretation in epidemiological studies. PAI consists of 5 categories, numbered 1 - 5. PAI 1 is considered as normal periapical structure, PAI 2 bone alteration without mineral loss, PAI 3 bone alteration with mineral loss, PAI 4 apical periodontitis, PAI 5 severe periodontitis (Mendes, 2011).



Knowing the periapical health status of a population is important for the improvement of public health policies as it enables better management of resources for the prevention and treatment of endodontic problems. Thus, the objective of this study is to verify the prevalence of apical lesions in periapical radiographs performed in a public dental care service in the northern region of Brazil.

## II. MATERIAL AND METHODS

The present epidemiological study has a retrospective descriptive observational character. The research project was approved by the Research Ethics Committee (CAAE 99151718.9.0000.0014). The methodology was based on the Periapical Index by Ørstavik *et al.* (1986), which considers five grades, from grade 1, which corresponds to healthy periapex, to grade 5, considered severe periodontitis. For the purposes of this research, PAI greater than or equal to 2 was considered apical periodontitis. The evaluators were trained and calibrated for this evaluation.

The sample consisted of all periapical radiographs requested by public health units, and which were performed digitally at the Public Center of Dental Specialties in the city of Palmas, Tocantins, Brazil, in 2019.

The criteria for exclusion of a periapical radiograph were: 1- Images obtained in a non-digital way; 2- Images of non-periapical radiographs; 3- Images that did not contain teeth; 4- Images that showed only deciduous teeth. The exclusion criteria for teeth in the images were: 1- Teeth that did not appear completely in the image; 2- Extra-numerary teeth; 3- Teeth that appear only in the form of root remains 4- Deciduous teeth.

All collected data were recorded in the Microsoft Excel database, and descriptive statistical analysis was subsequently performed.

## III. RESULTS AND DISCUSSION

The total number of radiographs analyzed was 3697. According to the exclusion criteria, 227 radiographs were excluded. In total, 3470 images, from 1125 individuals, were considered for the evaluation of the periapical index. When the same tooth appeared in more than one radiograph, it was considered only once. In total, 7172 teeth were evaluated. (Fig. 1).

The population of the present study consisted of patients treated at a public dental care center, not representing a random sample of the population of the city of Palmas. Nevertheless, the results of this study may provide useful data for evaluating trends on the prevalence

of apical periodontitis in teeth with and without filled roots, as well as on the general dental condition of the population.

Apical periodontitis, when asymptomatic, can be identified only by radiographic examinations from a visible periapical radiolucency due to bone loss. The most used means of diagnosing AP are conventional or digital periapical radiography, cone-beam computed tomography (CBCT) and panoramic radiography (Persoon & Ozok 2017).

Despite limitations such as the presence of distortions and ghost images, panoramic radiographs can be considered an acceptable diagnostic tool for the detection of periapical lesions (Llic *et al.*, 2014), however periapical radiographs are more accurate than panoramic in the evaluation of periapical lesions and provide better visualization of periodontal tissues (López *et al.*, 2012; Terças *et al.*, 2006). Several researches were carried out by the analysis of radiographs. Tibúrcio-Machado *et al.*, 2021, reviewed and included in a meta-analysis 114 studies that analyzed periapical, panoramic and CBCT radiographs. In our study, digital periapical radiography was used to score the periapical status of the analyzed teeth. The scoring method used was the Ørstavik PAI index, which allows comparison with other epidemiol studies. It is simple to reproduce and is widely used in the literature, both in periapical and panoramic images. (Al-Omari *et al.*, 2011; Llic *et al.* 2014; López *et al.*, 2012; Merini *et al.*, 2017; Terças *et al.*, 2006).

In our study, radiographs of 1125 patients were evaluated and 562 had at least one case of AP, which corresponds to a prevalence of 49.9%. Tibúrcio-Machado *et al.* (2021), in a systematic review and meta-analysis, reported an overall prevalence of 52% of individuals with at least one case of AP. The prevalence found in our study (49.9%) was lower than the global prevalence and even lower when compared to the prevalence among individuals coming from dental care services. Also relevant is that although the population studied was from a city in the North of Brazil (North and Northeast are the regions with the lowest Human Development Index in Brazil), the global prevalence was lower than that of developing countries (53%), in transition (80%) and developed (51%). Although in the studied sample the prevalence of AP (49.9%) was lower than the global one (52%), the studied population still has a very high prevalence, a fact that serves as a warning for the direction of mitigating public policies.

In the present study, the radiographs analyzed were periapical, performed using phosphor plates. When comparing the overall prevalence of AP of 49.9%, at the

individual level, it was also lower than that of other studies that used periapical radiographs (56%), but higher when compared to studies related to panoramic radiographs

(56%), a fact that may be due to the better detailing of periapical radiographs in relation to panoramic radiographs.

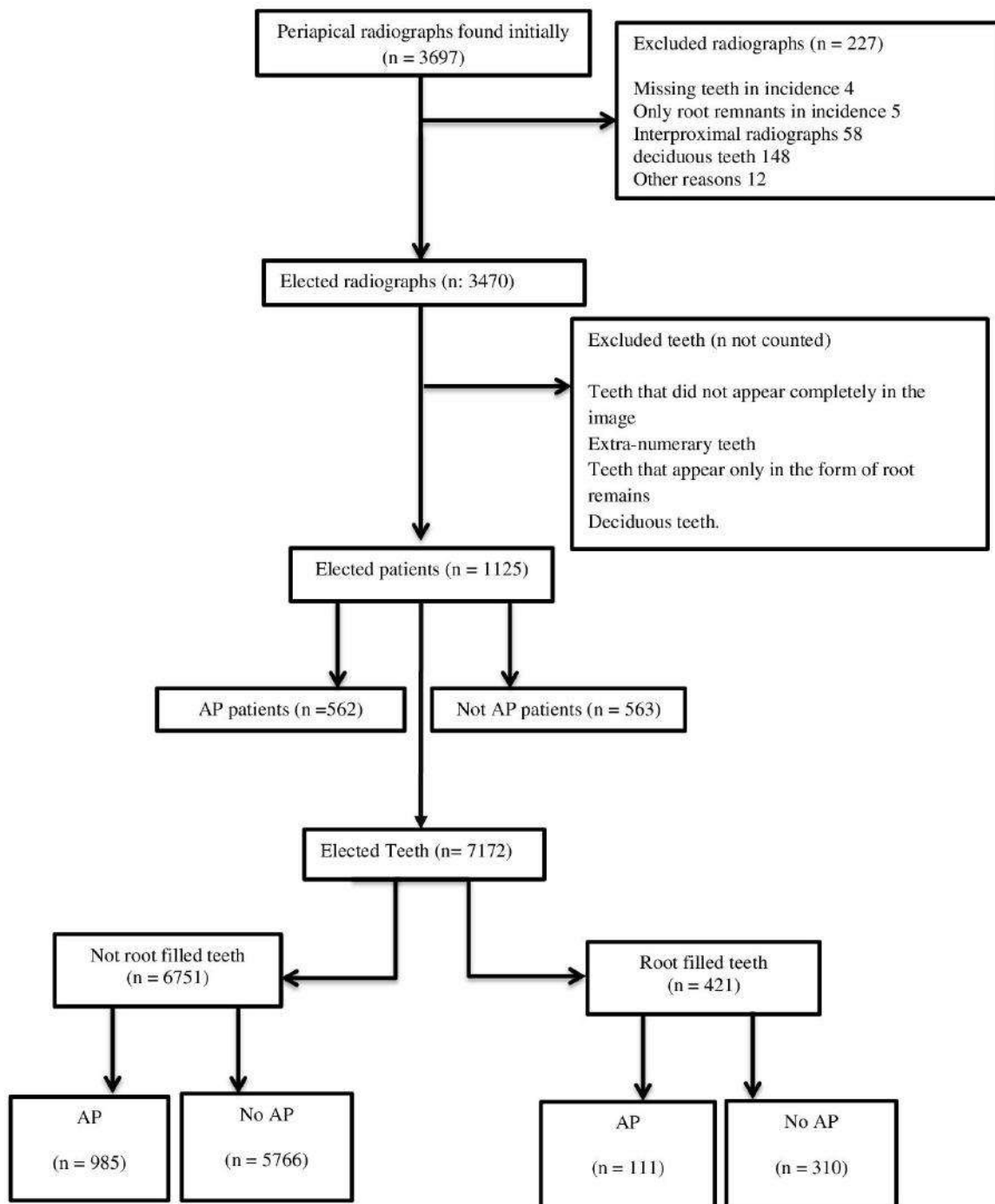


Fig.1: Flowchart of the selection process.

At the dental level, 1126 individual images of teeth (total of 7172 images) presented AP (Table 01), which corresponds to a prevalence of AP  $\geq 2$  of 15.7%.

Table 01: Total teeth analyzed

TOTAL TEETH		
PAI	n	%
1	6046	84,30
2	210	2,93
3	346	4,82
4	454	6,33
5	116	1,62
Total	7172	100

When analyzed at the individual level, 421 (5.87%) were teeth with root canal treatment and 6751 (94.13%) were nontreated teeth (Table 02).

Table 02: Root-filled teeth and nontreated teeth

TOTAL TEETH				
PAI	Nontreated teeth		Root filled teeth	
	N	%	n	%
1	5766	85,4	280	66,5
2	185	2,7	25	5,9
3	285	4,2	61	14,5
4	406	6,0	48	11,4
5	109	1,6	7	1,7
Totals	6751	100	421	100

The prevalence of PAI 1 was higher in nontreated teeth than in root filled teeth. However, for all other levels (PAI  $\geq 2$ ) root filled teeth had a higher prevalence of AP. Despite this difference, endodontic treatment cannot be credited as the cause of the higher prevalence, since the radiographic image only records the moment it was performed, and it is not possible to know if at a given moment the lesion was stabilized, regressing, increasing, or being just a scar mark, without biological compromise, as suggested by Kruse *et al.*, 2017.

#### IV. CONCLUSION

The prevalence of apical lesions identified in periapical radiographs performed in a public dental care service in a city in the northern region of Brazil was 49.9%. This prevalence is lower than the global prevalence, but still

considered high and indicates the need to direct public policies to improve this condition.

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# Production and Analysis the Properties of Mahua Methyl Ester

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**Keywords—** Mahua Biodiesel,  
Transesterification, Fourier Transform  
Infrared (FTIR), Gas Chromatography (GC),  
Thermo-Gravimetric Analysis (TGA).

**Abstract—** Chemically, the methyl ester is mono-alkyl esters of long-chain fatty acids derived from raw vegetable oils. Transesterification is a chemical process between triglycerides of vegetable oil and alcohol (i.e. methanol or ethanol) in the presence of a catalyst to obtain methyl or ethyl ester and glycerol as by-product. In this work, the extraction process adopted to obtain biodiesel from mahua seed oil and analyse the properties of mahua methyl ester (MME). For transesterification process, ethanol and KOH catalysts were used. After extraction of MME, analyse the thermo-physical properties and compared with diesel fuel. Also analyse the Fourier Transform Infrared (FTIR) spectroscopy, Gas Chromatography (GC) and Thermo-Gravimetric Analysis (TGA) were conducted.

## I. INTRODUCTION

One of the principal elements to affect the world economy and global politics is the sustainability of petroleum resources, which is a significant source of global energy resource. The world energy demand is increasing faster due to too much use of fuels [1]. The increase of demand forecast forces the researchers to develop the new technology in the field of automobile industry. Diesel engines have high thermal efficiency, high fuel economy, high durability and reliability which have resulted in them becoming the preferred engines in all heavy and many light duty vehicles [2-3]. The high thermal efficiency results from the high power output with lower fuel consumption due to a high compression ratio. However, diesel engines emit lower levels of emissions such as CO and HC when compared with gasoline engines [4]. The most challenging task in diesel emissions controls is the combination of smoke and NO<sub>x</sub> emissions. Much research has been done on biodiesel as an alternative renewable fuel since both fuels have similar characteristics to diesel fuel. Biodiesel has special advantages in terms of higher cetane number, lower sulphur, and lower aromatic

hydrocarbons. The biodiesel fuel is easy to combine with fossil diesel and can be used in diesel engines without requiring any engine modification [5-9].

Owing to depletion of fossil fuel and increasing environmental anxiety, alternative energy source like biodiesel has been developed. The history of biodiesel is as long as that of the diesel engine itself and the use of vegetable oils were investigated as early as the period when the diesel engine was developed [10]. From the early 1920s, several vegetable oils were investigated, including palm oil, mahua oil, cottonseed oil and castor oil. These early studies showed adequate performance of vegetable oil as fuel for diesel engines [11]. In spite of their performance in diesel engines, vegetable oils produce engine problems when used as fuel in diesel engines. The important drawback of vegetable oils is their high viscosity which produces choking and glazing formation on the injectors that consequence in poor atomization and leads to difficulties such as engine deposits [12-13]. Potential solutions to reduce the viscosity of vegetable oil include transesterification, thermal and catalytic cracking [14].

Therefore, much research has been done on biodiesel as an alternative renewable fuel since both fuels have characteristics similar to diesel fuel. Biodiesel has special advantages in terms of higher cetane number, lower sulphur and lower aromatic hydrocarbons [15-17]. The biodiesel fuel is easy to combine with fossil diesel and can be used in diesel engines without requiring any engine modification. In general, engines fuelled with biodiesel emit a lower level of emissions like HC, CO and smoke, except  $\text{NO}_x$ , when compared with fossil diesel fuel. In some biodiesel cases, the diesel engine emits high amount of smoke and particulates.

## II. TRANSESTERIFICATION

In the transesterification of vegetable oil mechanism, the carbonyl carbon ion (ester:  $-\text{RCOOR}^1$ )

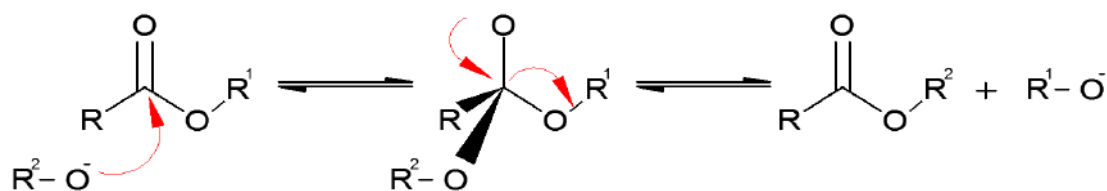


Fig.1 The mechanism of transesterification process

There are many accepted technologies that have been used for the production of biodiesel fuel. Vegetable oils are appropriate to be customized in order to reduce their densities and viscosities, so that the product obtained has appropriate properties to be used as fuels for diesel engine. Transesterification is the process of using an alcohol in the presence of a catalyst such as potassium hydroxide or sodium hydroxide, to break the molecule of the raw vegetable oil into ethyl or methyl esters, with glycerin as a by-product. Vegetable oils with a large amount of FFA are difficult to pass through the transesterification process because it will produce soap formation in the presence of the alkali catalyst. The FFA additionally prevents the separation of methyl ester from glycerol. The di-glycerides are the intermediates in this chemical process. The glycerol layer settles at the base of the container.

In this work, the potassium hydroxide is used as a catalyst and is dissolved into methanol in a reactor. Then, the catalyst/methanol mixture is mixed with the raw mahua

undergoes nucleophilic attack by the incoming electrophile of alcohol (alkoxide:  $-\text{R}^2\text{O}^-$ ). These combinations give tetrahedral intermediate, which on further proceeding gives ( $\text{RCOOR}^2$ ). The relative energies of the reactant and product determine the distribution of the intermediate equilibrium species. The mechanism of transesterification is shown in Figure 1. The presence of strong acids influences the reaction by donating a proton to the carbonyl group, making it a strong electrophile while bases present in the reaction removes a proton from the alcohol, making it a strong nucleophile. These formed ions have very much affinity towards each other and thus combine with each other and forms biodiesel and glycerin. The glycerin formed can be removed by water washing to obtain pure biodiesel.

vegetable oil. The final mixture is stirred vigorously for one hour at  $60^\circ\text{C}$  in ambient pressure. It produces two different liquid phases, methyl ester and crude glycerin. Crude glycerin is the heavier liquid and will accumulate at the bottom later after some hours. Phase separation completed within 2-3 hours of settling. Complete settling of methyl ester can take 8-10 hours. Washing the methyl ester is a two-step process. A water wash solution at the rate of 26% by volume of vegetable oil and 1 g of tannic acid/litre of water is added to the methyl ester and stirred. This process is continued until the methyl ester becomes clear. Prepared methyl esters were then blended with neat diesel in different concentrations for making methyl ester blends to be used in the common rail diesel engine for conducting engine tests. The physical and chemical properties of methyl esters and their blends were determined by using ASTM standard methods shown in Table 1. With the intention to measure the properties of the mahua methyl ester and its blend (MME20), the test methods used are as follows.



Table 1 Properties of biodiesel and biodiesel blend samples

Description	Viscosity @40°C (cSt)	Density @ 15°C (kg/m <sup>3</sup> )	Flash point (°C)	Calorific value, (kJ/kg)	Cetane number
Diesel fuel	3	815	56	42,000	47
Biodiesel standards(ASTM)	1.9-6	850-900	>130	≥36000	47 to 65
Mahua methyl ester (MME)	4.9	869.8	136	39,950	58

### III. FOURIER TRANSFORM INFRARED ANALYSIS

Fourier transform infrared (FTIR) spectroscopy spectra were recorded using a FTIR – Shimadzu 8400 spectrophotometer in the wave range of 4000-500 cm<sup>-1</sup> with a resolution of 2 cm<sup>-1</sup>. The mahua biodiesel and its blend were analysed using FTIR spectrophotometry. Figures 2 and 3 represent the spectrographic image of diesel and MME, respectively. From the spectrum, it is clear that the band located at approximately 2900-3000 cm<sup>-1</sup> is attributed to the C-H stretching of the double bonds of the C-H group which frame the olefins; the bands located at 2918 to 2854 cm<sup>-1</sup> are related to C-H vibrations of the methylene groups and to extending and reduction vibrations of the methyl group. Figure 4.3 indicate how water vapour absorbs IR between 4000 cm<sup>-1</sup> and 3500 cm<sup>-1</sup> and between 2000 cm<sup>-1</sup> and 1200 cm<sup>-1</sup>. The peaks for water vapour coincide with other peaks, such as -OH and -NH group peaks between 4000 cm<sup>-1</sup> and 3500 cm<sup>-1</sup> or C=O and -CH<sub>2</sub>- group peaks between 2000 cm<sup>-1</sup> and 1200 cm<sup>-1</sup>. The vapour peaks can affect when analysing infrared spectrum. From the spectrum, it is clear that the water vapour is present in the methyl ester. The extreme peak located at 1740 cm<sup>-1</sup> relates to the carbonyl radical and is characteristic of esters. The bands located at 1454-1457 cm<sup>-1</sup> correspond to the irregular stretching of the C-H bond and the irregular bending of the functional group. There is a customary of bands between 1000 and 1300 cm<sup>-1</sup> that are connected to irregular vibrations of the C-C(=O)-O and O-C-C bonds; the high intensity bands found between 1150

and 1170 cm<sup>-1</sup> are attributed to the stretching of the methyl group O-CH<sub>3</sub> and to the axially irregular deformation of the C-C=O bonds. The bands between 1100 and 1170 cm<sup>-1</sup> are related to the vibrations of the C-CH<sub>2</sub>-O group, the uneven stretching of C-O-C and C-C bond stretching. The high-intensity peak located at 721 cm<sup>-1</sup> corresponds to bends out of the plane of the C-O group and the one located at 1158 cm<sup>-1</sup> is attributed to the regular angular deformation of the C-H bond of olefins.

From spectrum in Figure 4.3, there are two bands that correspond to the methyl and methylene groups in the area between 2920 and 2870 cm<sup>-1</sup>; the first peak is recognized as the stretching vibrations of the terminal CH<sub>2</sub> group in the olefins. The second peak corresponds to the stretching vibration and contraction of the C-H and CH<sub>2</sub> bonds of the methylene and methyl groups. These bands show similarity between diesel fuel and methyl esters. The most pertinent folding vibrations of the methyl groups are consistent with the phase folding deformation (between 1350 and 1400 cm<sup>-1</sup> bands) and the beyond degenerate phase folding deformation (between 1450 and 1470 cm<sup>-1</sup> bands). The folding ascends from twisting and matching that are seen at low frequencies. The methylene group offers scissors vibrations at 1457 cm<sup>-1</sup>. Based on the above discussion, it is clear that both diesel and MME20 are saturated hydrocarbons and the presence of hydrocarbon group C-H indicates that it has a potential as a fuel for diesel engine. The range frequencies, bond type and associated families are given in Tables 2.

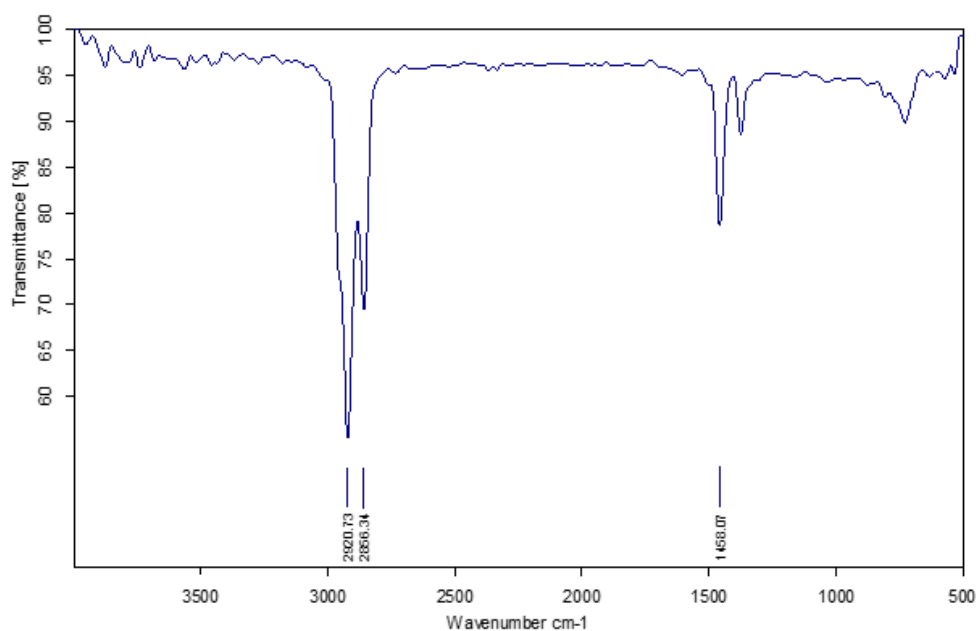


Fig.2 FTIR spectrum of diesel fuel

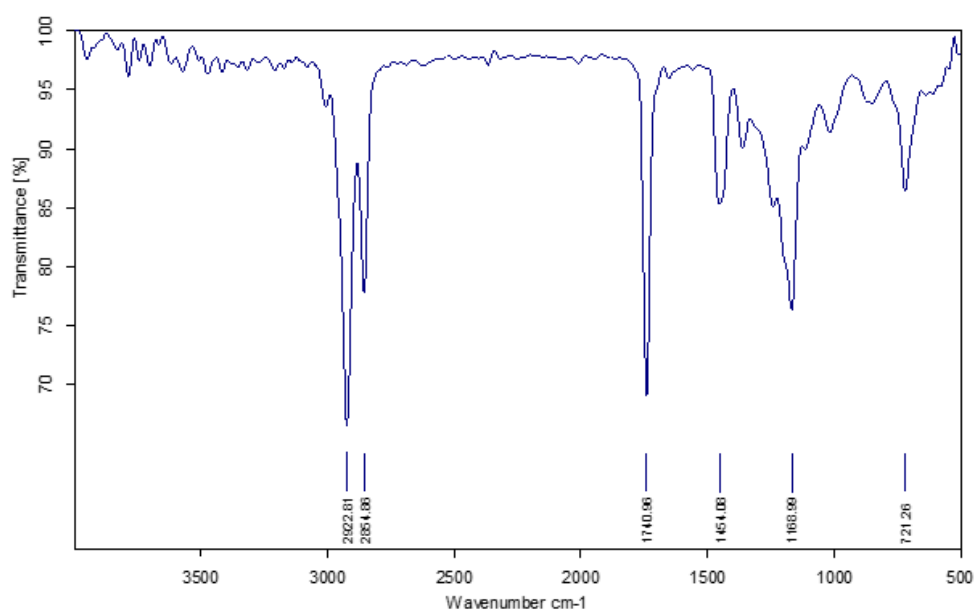


Fig.3 FTIR spectrum of mahua methyl ester (MME) fuel

Table 2 FTIR analysis of diesel and MME

Diesel fuel			Mahua methyl ester (MME)		
Frequency range (cm <sup>-1</sup> )	Bond	Family	Frequency range (cm <sup>-1</sup> )	Bond	Family
2899 – 2920	C-H stretching	Alkanes	2864-2922	C-H stretching	Alkanes
1458.07	C-H bending	Alkanes	1740	C=O stretching	Aldehydes/ketones
1382	C-X	Fluoride	1454	C-H Bending	Alkanes
716	=C-H bending	Alkanes	721	C-H out-of-plane bending	Alkanes

#### IV. GC-MS ANALYSIS

Fatty acid methyl esters composition was determined by gas chromatography. From Figure 4, we can see that there are five major peaks indicate the various important methyl esters present in the biodiesel. The first peak in the GC spectrum indicates the methyl hexadecanoate and methyl 14-methyl pentadecanoate in the second peak. Methyl *cis, cis*-9,12-octadecadienoate and methyl *cis, cis*-10,13-octadecadienoate are indicated in the third peak of the chromatogram while the fourth peak was methyl *cis*-9-octadecenoate. The fifth peak was recognized as methyl octadecanoate and methyl 16-methyl-

heptadecanoate. All the five components separated by GC are probably methyl palmitoleate, methyl linoleate, methyl palmitate, methyl stearate and methyl oleate. This means that the major fatty acids present in the mahua methyl ester are palmitic acid, palmitoleic acid, oleic acid, linoleic acid and stearic acid. The individual esters were determined from the retention time, noted above the peak of each compounds, with the standard database. Deeper scrutiny of their structure reveals that both are unsaturated hydrocarbon, perhaps with longer hydrocarbon chain length and inherent oxygen in their structure, in the likes of other contemporary biodiesel.

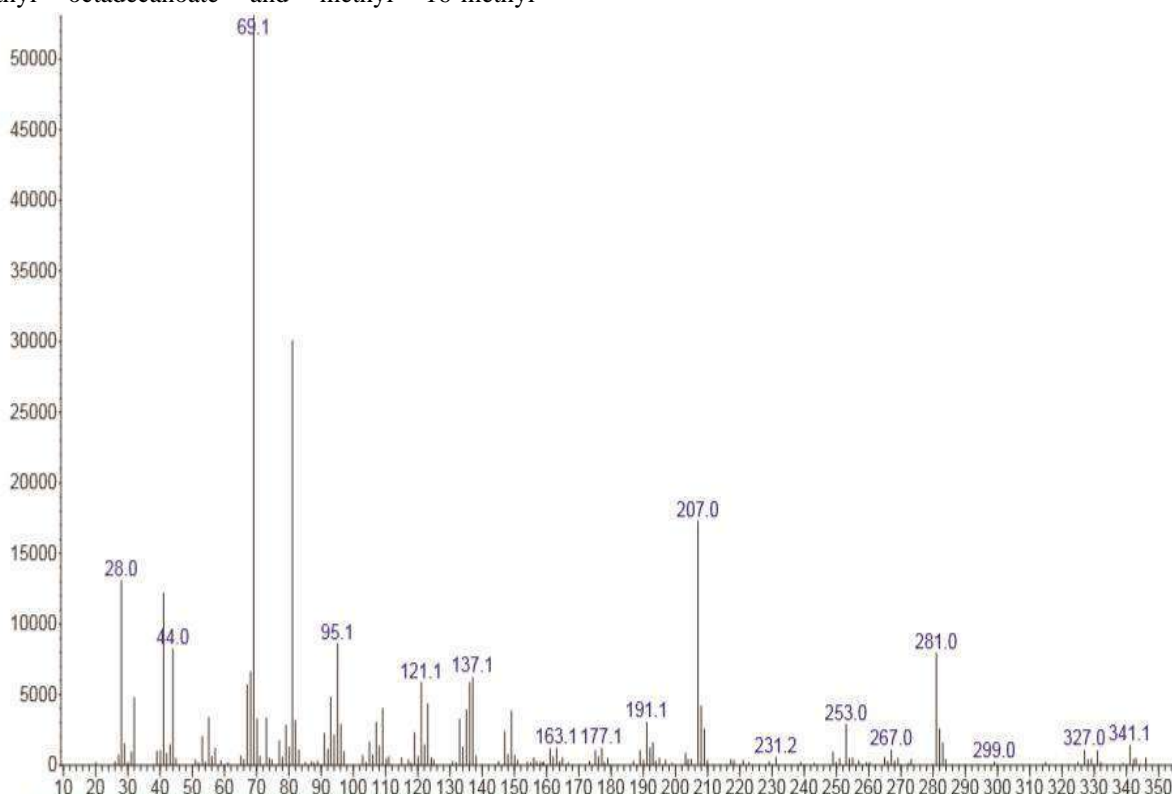


Fig.4 GC-MS of mahua methyl ester (MME)

#### V. THERMO-GRAVIMETRIC ANALYSIS (TGA)

The TG curve of mahua methyl ester is shown in Figure 5. It is evident that the phase change of mahua methyl ester mainly occurs in the temperature range 200°C-300°C. A huge mass change occurs in this temperature range which will help during the combustion. The DTG curve from first peak temperature (182.7°C) to

second peak temperature (287.5°C) confirms that the percentage of mass transfer per minute is considerably high. In general, fast thermal degradation characteristics can be helpful for thermo-chemical conversion process. The DSC curve also shown in Figure 6 indicates the heat absorption (endothermic) from 299 to 345°C with the area of 95.3J/kg for the mass change after mass change of 75%.

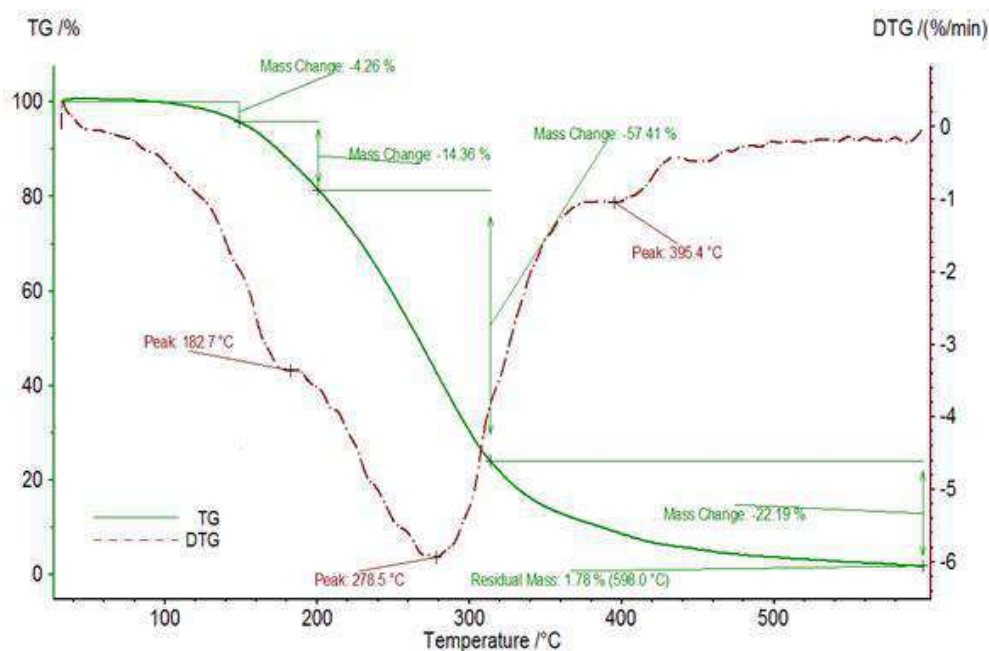


Fig.5 TG and DTG image of MME

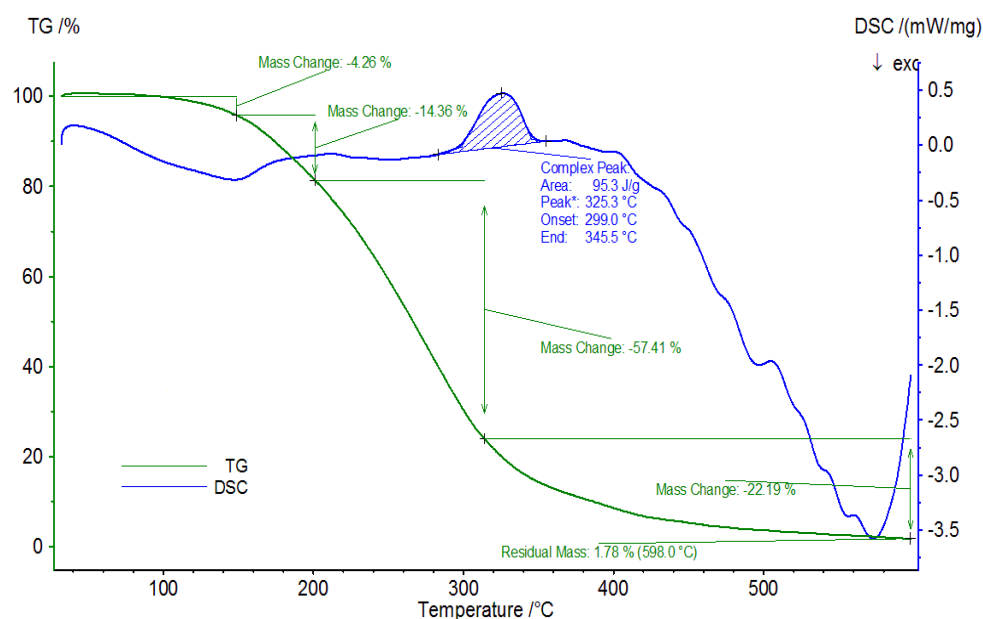


Fig.6 TG and DSC image of MME

## VI. CONCLUSION

In this investigation, Mahua methyl ester (MME) derived through catalytic transesterification using KOH as catalyst. The viscosity of the MME was slightly higher than that of diesel. The calorific value of MME was closer to the diesel and cetane index was slightly higher. The MME was expensive than diesel. From the results obtained, it is clear that the mahua biodiesel can use in diesel engine directly or blended with diesel. With the latest hikes in petroleum prices and worries regarding fuel

availability, there is revitalized interest in biodiesel for Diesel engines.

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# Shoaling-breaking Water Wave Modeling Using Velocity Potential Equation with Weighting Coefficient Extracted Analytically from The Dispersion Equation

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**Keywords**— *weighting coefficient, weighted kinematic free surface boundary condition, weighted momentum equation.*

**Abstract**— *A shoaling and breaking water wave model was developed in this study using the velocity potential of the solution of the Laplace equation. Formulation was carried out using Weighted Kinematic Free Surface Boundary Condition Equation, wave number conservation equation, and energy conservation equation. In the Weighted Kinematic Free Surface Boundary Condition equation, a weighting coefficient was used which needs to be determined. The value of the weighting coefficient was extracted from the dispersion equation. The dispersion equation was formulated using Weighted Kinematic Free Surface Boundary Condition and Weighted Momentum Equation to obtain weighting coefficient that meets the hydrodynamic equilibrium equation. By using the weighting coefficient, good shoaling and breaking results were obtained.*

## I. INTRODUCTION

This study is a follow up research of Hutahaean's (2021a) research. Previously, breaking equations were formulated, namely the equations to calculate the breaking wave height  $H_b$ , breaker wavelength  $L_b$  and breaker depth  $h_b$ . These breaking equations were formulated using weighted Kinematic Free Surface Boundary Condition Equation and the weighted momentum equation similar to this study. The weighting coefficient in that study was obtained by calibrating the breaker height  $H_b$  model with the breaker height from a number of empirical equations of breaker height index. Therefore, the value of the weighting coefficient was determined by the breaker index equations, instead of based on the hydrodynamic equation.

This study aims to obtain the value of the weighting coefficient analytically. The weighting coefficient was extracted from the dispersion equation formulated from the hydrodynamic equilibrium equations. Thus, it can be

said that the weighting coefficient is obtained analytically and fulfills the law of hydrodynamic equilibrium.

## II. POTENTIAL VELOCITY EQUATION

The total velocity potential equation obtained from solving the Laplace equation with Variable Separation Method (Dean (1991)) is,

$$\phi(x, z, t) = G(\cos kx + \sin kx) \cosh k(h + z) \sin \sigma t. \quad (1)$$

$x$  is the horizontal axis;  $z$  is the vertical axis;  $t$  is time;  $G$  and  $k$  are wave constants, where  $k$  is the wave number, where  $L$  is wavelength  $k = \frac{2\pi}{L}$ ,  $\sigma$  is angular frequency, for a period of wave  $T$ ,  $\sigma = \frac{2\pi}{T}$ . At (1) there are two wave constants for which the equation needs to be determined,  $G$  and  $k$ .

There is a value of  $kx$  where  $\cos kx = \sin kx$ . This point is called the characteristic point on the  $x$ -horizontal axis. The formulation of the wave constants  $G$  and  $k$  is carried out at the characteristic point, where the wave constants

obtained apply to the cosine component and the sine component. At this characteristic point, (1) can be written,

$$\phi(x, z, t) = G \cos kx \cosh k(h + z) \sin \sigma t \quad \dots(2)$$

It is important to note that there is a double value of  $G$  in (2).

### III. EQUATIONS OF CONSERVATION

There are conservation equations in velocity potential (1) and (2) (Hutahaeen (2020)), namely

The wave number conservation equation,

$$\frac{dk(h + \frac{A}{2})}{dx} = 0 \quad \dots(3)$$

$h$  is the water depth,  $A$  is the wave amplitude. In deep water, applies

$$\tan k \left( h + \frac{A}{2} \right) = c_h \approx 1 \quad \dots(4)$$

$$k \left( h + \frac{A}{2} \right) = \theta \pi \dots(5)$$

$$\tanh \theta \pi = c_h \approx 1 \dots(6)$$

$\theta$  is a positive number greater than one. The value  $\theta$  is determined in the shoaling-breaking condition, where  $\theta$  affects the breaker depth.

Keeping in mind (3), then (4), (5) and (6) apply to all domains, both in deep water and in shallow water.

The next conservation equation is the energy conservation equation, namely,

$$G \frac{\partial k}{\partial x} + 2k \frac{\partial G}{\partial x} = 0 \quad \dots(7)$$

And

$$\frac{\partial^2 G}{\partial x^2} = 0 \quad \dots(8)$$

Equation (8) shows that the wave constant  $G$  changes linearly with respect to the  $x$ -horizontal axis. While, the water depth changes with respect to the  $x$ -horizontal axis, then the wave constant  $G$  also changes linearly with respect to water depth. Furthermore, (7) and (8) indicate that the wave number  $k$  also changes linearly with water depth.

### IV. WAVE AMPLITUDE FUNCTION

Wave amplitude function is an equation that expresses the relationship between  $G$ ,  $k$  and  $A$ . This equation is formulated using the weighted kinematic free surface boundary condition (Hutahaeen (2021b)), which takes the following form,

$$\gamma \frac{\partial \eta}{\partial t} = w_\eta - u_\eta \frac{\partial \eta}{\partial x} \quad \dots(9)$$

$\eta = \eta(x, t)$  is water surface elevation equation to the still water level;  $w_\eta$  is vertical water surface particle velocity;  $u_\eta$  is horizontal water surface particle velocity;  $\gamma$  is weighting coefficient greater than one whose value will be determined.

From (2), the vertical particle velocity is,

$$w(x, z, t) = -\frac{\partial \phi}{\partial z} = -Gk \cos kx \sinh k(h + z) \sin \sigma t \quad \dots(10)$$

Vertical water surface particle velocity at  $z = \eta$  is,

$$w_\eta = -Gk \cos kx \sinh k(h + \eta) \sin \sigma t \quad \dots(11)$$

Horizontal particle velocity is

$$u(x, z, t) = -\frac{\partial \phi}{\partial x} = Gk \sin kx \cosh k(h + z) \sin \sigma t \quad \dots(12)$$

Horizontal water surface particle velocity at  $z = \eta$  is,

$$u_\eta = Gk \sin kx \cosh k(h + \eta) \sin \sigma t \quad \dots(13)$$

Substitution (11) and (13) to (9),

$$\gamma \frac{\partial \eta}{\partial t} = -Gk \cos kx \sinh k(h + \eta) \sin \sigma t - Gk \sin kx \cosh k(h + \eta) \sin \sigma t \frac{\partial \eta}{\partial x}$$

At the characteristic point where  $\cos kx = \sin kx$

$$\gamma \frac{\partial \eta}{\partial t} = -Gk \left( \sinh k(h + \eta) + \cosh k(h + \eta) \right) \frac{\partial \eta}{\partial x} \cos kx \sin \sigma t$$

Or,

$$\gamma \frac{\partial \eta}{\partial t} = -Gk \cosh k(h + \eta) \left( \tanh k(h + \eta) + \frac{\partial \eta}{\partial x} \right) \cos kx \sin \sigma t \quad \dots(14)$$

As a periodic function, then,

$$Gk \cosh k(h + \eta) \left( \tanh k(h + \eta) + \frac{\partial \eta}{\partial x} \right) = \text{constant}$$

Thus, (14) can be integrated with respect to time  $t$  by integrating  $\sin \sigma t$  only.

$$\eta(x, t) = \frac{Gk}{\gamma \sigma} \cosh k(h + \eta) \left( \tanh k(h + \eta) + \frac{\partial \eta}{\partial x} \right) \cos kx \cos \sigma t$$

For

$$A = \frac{Gk}{\gamma \sigma} \cosh k(h + \eta) \left( \tanh k(h + \eta) + \frac{\partial \eta}{\partial x} \right) \quad \dots(15)$$

The water level equation becomes

$$\eta(x, t) = A \cos kx \cos \sigma t \quad \dots(16)$$

The characteristic point in the time domain is the value of  $\sigma t$  where,  $\cos \sigma t = \sin \sigma t$ . Then, at the characteristic point in the  $x$  domain and in the  $t$  domain,

$$\eta = \frac{A}{2} \quad \dots(17)$$

$$\frac{d\eta}{dx} = -\frac{kA}{2} \quad \dots(18)$$

Substitution (17) and (18) to (15),

$$A = \frac{Gk}{\gamma\sigma} \cosh k \left( h + \frac{A}{2} \right) \left( \tanh k \left( h + \frac{A}{2} \right) - \frac{kA}{2} \right)$$

Substitution (5) and (6),

$$A = \frac{Gk}{\gamma\sigma} \cosh \theta\pi \left( c_h - \frac{kA}{2} \right)$$

Given that there is a double value in  $G$ ,

$$A = \frac{Gk}{2\gamma\sigma} \cosh \theta\pi \left( c_h - \frac{kA}{2} \right) \quad \dots(19)$$

This equation is the wave amplitude function, which can be written as the equation for  $G$ ,

$$G = \frac{2\gamma\sigma A}{k \cosh \theta\pi \left( c_h - \frac{kA}{2} \right)} \quad \dots(20)$$

## V. DISPERSION EQUATION

Surface momentum equation (Hutahaean (2021b)) ignoring convective acceleration,

$$\gamma^2 \frac{du_\eta}{dt} = -g \frac{d\eta}{dx} \quad \dots(21)$$

Substitutions (13) and (16). The equation is done at the characteristic point,

$$\gamma^2 \sigma G k \cosh k \left( h + \frac{A}{2} \right) = g k A$$

$k$  on the left and right sides cancel each other out, and the wave amplitude  $A$  on the right side is substituted by (19),

$$\gamma^2 \sigma G \cosh k \left( h + \frac{A}{2} \right) = g \frac{Gk}{2\gamma\sigma} \cosh \theta\pi \left( c_h - \frac{kA}{2} \right)$$

The  $G$  on the left and right sides of the equation cancel each other out. Keeping in mind (5), the terms of the hyperbolic function on the left and right sides also cancel each other out,

$$\gamma^2 \sigma = \frac{gk}{2\gamma\sigma} \left( c_h - \frac{kA}{2} \right) \quad \dots(22)$$

This equation can be written as,

$$\frac{gA}{4} k^2 - \frac{gch}{2} k + \gamma^3 \sigma^2 = 0 \quad \dots(23)$$

$$a = \frac{gA}{4} ; b = -\frac{gch}{2} ; c = \gamma^3 \sigma^2 ; d = b^2 - 4ac$$

$$k = \frac{-b - \sqrt{d}}{2a}$$

The minus sign used at  $\sqrt{d}$  is to make the obtained wavelength not too short.

Table (1) presents the results of the calculation of the wavelength with (23), where the wave height  $H$  from the Wiegel equation (1949,1964) is,

$$H = \frac{gT^2}{15.6^2} \quad \dots(24)$$

which is the maximum wave height in a wave period in deep water. Assuming a sinusoidal wave, the wave amplitude is half of the wave height.

The calculation was carried out using  $\gamma = 1.342$ , the determination of  $\gamma$  is aimed at getting wave steepness  $\frac{H}{L} = 0.17$  which is following the criteria of critical wave steepness from Toffoli et al (2010), where according to Toffoli et al, the critical wave steepness can actually reach more of 0.2.

Table (1) Wavelength calculation results using (23)

$T$ (sec)	$H$ (m)	$L$ (m)	$\frac{H}{L}$
6	1.451	8.516	0.17
7	1.975	11.591	0.17
8	2.579	15.139	0.17
9	3.265	19.161	0.17
10	4.03	23.655	0.17
11	4.877	28.623	0.17
12	5.804	34.064	0.17
13	6.811	39.978	0.17
14	7.899	46.365	0.17
15	9.068	53.225	0.17

Calculation of the wavelength in Table (1) was carried out using the value of  $\theta = 1.95$ , where the value of  $\tanh \theta\pi = 0.999990$ . However, the value of  $\theta$  does not really affect the wavelength. The effect of  $\theta$  is on the breaker depth, which is discussed in section (7).

## VI. DETERMINATION OF THE VALUE OF THE WEIGHTING COEFFICIENT

$\gamma$

Hutahaean (2021b) obtained the value of the weighting coefficient  $\gamma$  by using Taylor series on the function in the form (1), where the value of the weighting coefficient  $\gamma = 3$ . This coefficient is not yet a product of the hydrodynamic equilibrium equation.

In the previous section, it has been shown that the value of the weighting coefficient  $\gamma$  can also be obtained by adjusting the obtained wavelength with the critical wave steepness. However, the value of the weighting coefficient is the result of coercion, not naturally contained in the hydrodynamic equilibrium law.

In this section, the value of the weighting coefficient  $\gamma$  is determined analytically, extracted from the dispersion equation (23). This equation is derived from the hydrodynamic equilibrium equation. Hence, it can be said that it is another form of the hydrodynamic equilibrium equation. By extracting the weighting coefficient  $\gamma$  from (23), the value of the weighting coefficient  $\gamma$  is the product of the hydrodynamic equation.

The determinant  $d$  in (23) must be greater than or equal to zero.

$$d = \frac{g^2 c_h^2}{4} - 4 \frac{gA}{4} \gamma^3 \sigma^2 \geq 0$$

The amplitude of wave  $A$  is known variable which accordingly taking the equals sign will get the value of  $\gamma_{max}$ .

$$\gamma_{max}^3 = \frac{g c_h^2}{4 \sigma^2 A} \quad \dots\dots(25)$$

If  $\gamma$  from (25) is used, where the determinant  $d=0$ , then the wave number equation becomes,

$$k = \frac{c_h}{A} \quad \dots\dots\dots(26)$$

In (26), there is no longer a value of  $\gamma$ , but the equation is formulated based on the condition of the determinant value  $d = 0$ , then the value of  $\gamma$  in (26) is  $\gamma_{max}$ . It was found that in deep water, the wave-number is only determined by the wave amplitude. Meanwhile, the value of  $c_h$  is always close to or equal to one. Moreover, it is also found that the wave number is not determined by the wave period  $T$ .

Table (2) presents the results of the calculation of  $\gamma$  using (25), wave number  $k$  is calculated by (26) wave height  $H$  is calculated by (24), which assuming a sinusoidal wave, the wave amplitude  $A = 0.5H$ .

Table (2) Wavelength is calculated by (26),  $\gamma$  is calculated by (25)

$T$ (sec)	$\gamma$	$H$ (m)	$L$ (m)	$\frac{H}{L}$
6	1.455	1.448	4.55	0.318
7	1.455	1.971	6.193	0.318
8	1.455	2.575	8.089	0.318
9	1.455	3.259	10.237	0.318
10	1.455	4.023	12.639	0.318
11	1.455	4.868	15.293	0.318
12	1.455	5.793	18.2	0.318
13	1.455	6.799	21.359	0.318
14	1.455	7.885	24.772	0.318
15	1.455	9.052	28.437	0.318

Table (2) shows that value of the weighting coefficient  $\gamma$  is constant with respect to the wave period of  $\gamma = 1.455$ . The obtained wavelength is shorter than the previous calculation results because a larger weighting coefficient is used. the wave steepness obtained is constant for all wave periods with a value of  $\frac{H}{L} = 0.318$ , the value of this wave steepness is much greater than the critical wave steepness value of Toffoli et al. However, the critical wave steepness value is the natural value contained in (23).

Equation (26) obtained by working on the weighting coefficient of  $\gamma_{max}$  on (23). Therefore, the calculation of the wavelength with (26) at various wave amplitudes produce a wave steepness  $\frac{H}{L}$  of 0.318 as presented in Table (3).

Table (3) Wave steepness of (26)

$A$ (m)	$H$ (m)	$L$ (m)	$\frac{H}{L}$
0.1	0.2	0.628	0.318
0.2	0.4	1.257	0.318
0.3	0.6	1.885	0.318
0.4	0.8	2.513	0.318
0.5	1	3.142	0.318
0.6	1.2	3.77	0.318
0.7	1.4	4.398	0.318
0.8	1.6	5.027	0.318
0.9	1.8	5.655	0.318
1	2	6.283	0.318

## VII. FORMULATION OF SHOALING-BREAKING

### Equation

The shoaling and breaking equations are formulated using the conservation equations contained in (1), (Hutahaean (2020)) namely,

a. The energy conservation equation (7) which can be written as

$$k \frac{\partial G}{\partial x} = -\frac{G}{2} \frac{\partial k}{\partial x} \quad \dots\dots(27)$$

b. The wave number conservation equation (3), which can be written as

$$\left(h + \frac{A}{2}\right) \frac{\partial k}{\partial x} + \frac{k}{2} \frac{\partial A}{\partial x} = -k \frac{\partial h}{\partial x} \quad \dots\dots(28)$$

Equation (19) is differentiated about the  $x$ -horizontal axis and (27) is substituted for the product of the differential,

$$\frac{\partial A}{\partial x} = \frac{G \cosh \theta \pi}{4\gamma\sigma} \left(c_h - \frac{kA}{2}\right) \frac{\partial k}{\partial x} \quad \dots\dots(29)$$

To make writing easier, defined

$$\alpha = \frac{G \cosh \theta \pi}{4\gamma\sigma} \left(c_h - \frac{kA}{2}\right) \quad \dots\dots(30)$$

Thus, (29) becomes

$$\frac{\partial A}{\partial x} = \alpha \frac{\partial k}{\partial x} \quad \dots\dots(31)$$

Substituting this equation into (28), it is obtained,

$$\left(\left(h + \frac{A}{2}\right) + \frac{k}{2}\alpha\right) \frac{\partial k}{\partial x} = -k \frac{\partial h}{\partial x} \quad \dots\dots(32)$$

This equation is used to calculate  $\frac{\partial k}{\partial x}$ . After  $\frac{\partial k}{\partial x}$  is obtained,  $\frac{\partial A}{\partial x}$  can be calculated using (29).

Calculation steps:

1. At a point  $x = x$ , given  $h_x, A_x, k_x, G_x$ , will calculate  $A_{x+\delta x}, k_{x+\delta x}$  and  $G_{x+\delta x}$ , at point  $x = x + \delta x$

2. Calculate  $\alpha = \frac{G_x \beta}{4\gamma^2 \sigma} \left(c_h - \frac{k_x A_x}{2}\right)$

3. Calculate  $\frac{\partial k}{\partial x}$  with the following equation :

$$\left(\left(h_x + \frac{A_x}{2}\right) + \frac{k_x}{2}\alpha\right) \frac{\partial k}{\partial x} = -k_x \frac{\partial h}{\partial x}$$

4. Calculate  $\frac{\partial A}{\partial x}$  with the equation:  $\frac{\partial A}{\partial x} = \alpha \frac{\partial k}{\partial x}$

5. Calculate  $k_{x+\delta x}$  and  $A_{x+\delta x}$  :

$$a. k_{x+\delta x} = k_x + \delta x \frac{\partial k}{\partial x}$$

$$b. A_{x+\delta x} = A_x + \delta x \frac{\partial A}{\partial x}$$

6.  $G_{x+\delta x}$  is calculated analytically by integrating (27),

$$G_{x+\delta x} = e^{\ln G_x - \frac{1}{2}(\ln k_{x+\delta x} - \ln k_x)}$$

At the starting point, namely in deep water, wave number  $k$  was calculated by (26),  $G$  was calculated by (20) and wave amplitude  $A$  was calculated by (24).

Fig (1) visualizes the results of the shoaling-breaking model for a wave period of 8 sec., the deep water wave height  $H_0$  was calculated by (24) assuming a sinusoidal wave was  $A_0 = 0.5H_0$ . As a calculation parameter of  $\gamma$  (25) and the coefficient of deep water depth  $\theta = 1.95$  were used where  $\tanh \theta \pi = 0.999904$ . The results of the calculation of  $H_b$  are presented in Table (3), namely  $H_b = 2.987$  m while the results of the calculation using (33), namely the equation of Komar & Gaughan (1972), obtained  $H_b = 3.019$  m. Breaker depth index  $\frac{H_b}{h_b} = 0.78$ , according to Mc Cowan's (1984) breaker depth index equation.

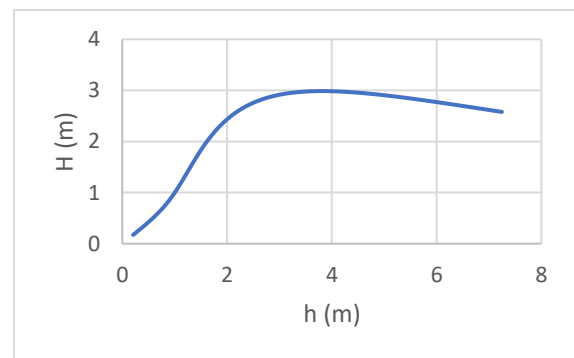


Fig (1) Example of a shoaling-breaking model result

The equation for breaking wave height  $H_b$  from Komar & Gaughan (1972) is as follows:

$$H_b = 0.39 g^{1/5} (TH_0^2)^{2/5} \text{ (m)} \quad \dots\dots(33)$$

This equation uses a primitive variable, namely the wave period  $T$ , making it very practical in its use.

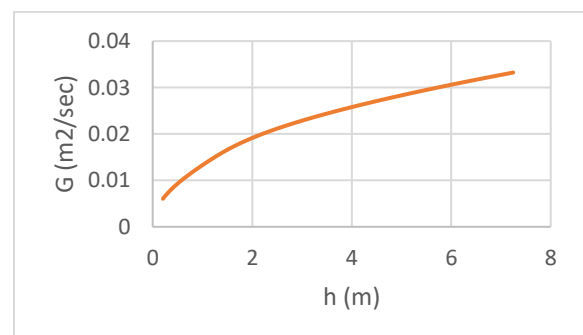


Fig.(2). Change of  $G$  with water depth  $h$

(8) shows that the change in the wave constant  $G$  with respect to water depth is linear. In Fig (2), the linear



nature only occurs before breaking, while after breaking, it is nonlinear, especially in very shallow waters.

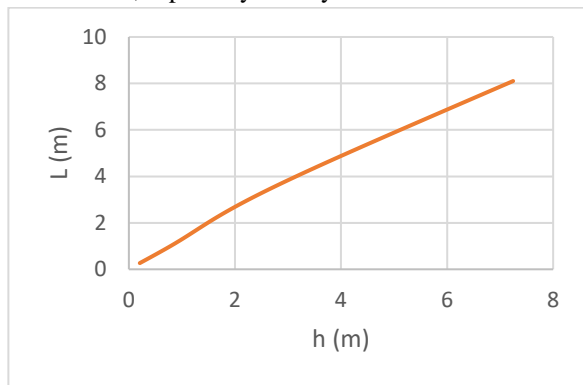


Fig.(3). Change of wavelength  $L$  with water depth  $h$

Using (7) and (8), it was found that the change in wave number on water depth is linear, the same with the one on wavelength  $L$ . Figure (3) shows that the change in wavelength  $L$  is linear, but slightly nonlinear in very shallow waters. With changes in  $G$  and changes in  $k$  as shown, further research and development is needed on wave conditions after breaking, especially in very shallow waters.

Table (4) Results of the shoaling-breaking model for a number of wave periods

$T$ (sec)	$H_0$ (m)	$H_b$ (m)		$\frac{H_b}{L_b}$	$\frac{H_b}{h_b}$
		model	K-G		
6	1.451	1.681	1.698	0.637	0.781
7	1.975	2.287	2.312	0.638	0.782
8	2.58	2.987	3.019	0.637	0.781
9	3.265	3.78	3.821	0.637	0.78
10	4.031	4.667	4.718	0.637	0.781
11	4.878	5.646	5.708	0.637	0.781
12	5.805	6.719	6.794	0.637	0.781
13	6.812	7.886	7.973	0.637	0.781
14	7.901	9.146	9.247	0.637	0.781
15	9.07	10.499	10.615	0.637	0.781

Note : K-G, Komar & Gaughan

The stability of breaking characteristics including  $\frac{H_b}{L_b}$  and  $\frac{H_b}{h_b}$  in the model on the wave period is shown in Table (4), indicating that both  $\frac{H_b}{L_b}$  and  $\frac{H_b}{h_b}$  can be said to be constant. The calculations in Table (4) were carried out using  $\gamma$  of (25), the coefficient of deep water depth  $\theta = 1.95$ .

To determine the effect of the deep water depth coefficient  $\theta$ , a calculation was carried out using  $\theta = 1.85$  with  $\gamma$  from (25).

Table (5) Results of the shoaling-breaking model with  $\theta = 1.85$

$T$ (sec)	$H_0$ (m)	$H_b$ (m)		$\frac{H_b}{L_b}$	$\frac{H_b}{h_b}$
		model	K-G		
6	1.451	1.681	1.698	0.639	0.835
7	1.975	2.287	2.312	0.638	0.833
8	2.58	2.987	3.019	0.637	0.832
9	3.265	3.78	3.821	0.637	0.833
10	4.031	4.667	4.718	0.638	0.833
11	4.878	5.646	5.708	0.637	0.831
12	5.805	6.72	6.794	0.637	0.832
13	6.812	7.886	7.973	0.637	0.832
14	7.901	9.146	9.247	0.637	0.831
15	9.07	10.499	10.615	0.637	0.832

The calculation results in Table (5) present that there is no change in the breaking wave height  $H_b$ , even though the deep water depth coefficient  $\theta$  was reduced. The changes that occur were the enlargement of  $\frac{H_b}{L_b}$  and  $\frac{H_b}{h_b}$ . This shows that the reduction of the deep water depth coefficient  $\theta$  causes the shallower breaker depth  $h_b$ .

## VIII. CONCLUSIONS

This study concludes that the weighting coefficient on the weighted kinematic free surface boundary condition and on the weighted momentum equation can be extracted from the dispersion equation.

The dispersion equation is formulated using hydrodynamic equilibrium equations. Accordingly, the value of the weighting coefficient obtained is to meet the laws of hydrodynamic equilibrium equations.

A good shoaling-breaking model is obtained using the weighting coefficient extracted from the dispersion equation. However, a large critical wave steepness is obtained both in deep waters and at the breaking point. Therefore, further research is still needed, both on the model and on the existing critical wave steepness criteria, both in deep water and at the breaking point.

In general, the results of the shoaling-breaking model provide good information regarding the height of the shoaling wave and the breaking wave height. However, further research is still needed on wave conditions after breaking, especially in very shallow waters.

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# Study of the hosting capacity of photovoltaic distributed generators in low voltage distribution networks: A probabilistic approach using Monte Carlo simulations

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**Keywords**—Distributed generation, Hosting capacity, Photovoltaic system, Power flow, Power quality, Voltage level, Voltage unbalance.

**Abstract**— This paper aims to present the study and quantification of the hosting capacity (HC) of a low voltage distribution network composed by photovoltaic distributed generation. The methodology used becomes possible through the implementation of the Probabilistic Method of Monte Carlo with the use of the Python programming language, where the connection point of the distributed photovoltaic generation, power of the generators and the amount of generation systems is randomly chosen. To perform the calculation of the power flow, it is used the OpenDSS software (Open Distribution System Simulator) integrated into the tool in Python from a DLL (Dynamic Link Library). After all the scenarios created, the power, imbalance and RMS voltage are measured in the loads that were installed at the photovoltaic generators and also in the secondary of the transformer. A statistical analysis is performed in order to determine the hosting capacity of the network, that establishes minimum parameters for the imbalance and RMS voltage level to maintain a good Power quality. And finally, since the hosting capacity is dynamic, and cannot be generalized, because at each point of the system has its characteristics and thus it is necessary to identify the HC separately for each busbar. However, it can be pre-established around 60% or 70% of photovoltaic penetration level, since power utilities can install battery banks or relocate consumers to other phases in order to mitigate impacts on the network.

## I. INTRODUCTION

With the search for methods of generating electricity from renewable sources, distributed photovoltaic

generators (DPVGs) connected to the distribution system have received worldwide prominence due to tax and financial incentives. In addition, investment and studies on these technologies have increased significantly in the last

decade due to the increased demand for clean energy. Thus, in Brazil, these technologies are encouraged and supported by Normative Resolutions (NRs) of the Brazilian Electrical Agency (ANEEL) such as NR 482/2012 that allows the Brazilian consumer to have their own generation of electricity in a sustainable way and inject the surplus of active power into the local distribution network [1], NR 687/2015 subdividing photovoltaic systems (PVs) connected to the microgeneration network characterized by having an installed power less than or equal to 75kW, mini-generation defined with power exceeding 75kW up to 5MW and generation plants above 5MW of installed capacity [2], and finally, NR 786/2017 which aims to complement NR 482/2012 and adds the right of installation or adequacy of equipment in distribution of existing electricity in order to maintain quality, reliability and/or increase distribution capacity, and also allowing sending or receiving credits to different Consumer Units (CUs) under the same ownership condition, ensuring shared generation and remote self-consumption [3].

In addition, on January 6, 2022, Law No. 14300 [4] was sanctioned, generating a new framework for Distributed Generation (DG) and changing some provisions of the NRs.

Moreover, Law No. 14300 does not annul regulation 482 of 2012, however, because it has a hierarchical higher power to the NR, it implicitly revokes all the provisions of 482 that opposes any provision presented by law, such as in NR 482/2012 classified distributed photovoltaic mini-generation up to 5MW, however, with Law No. 14300, there was a reduction of this power to 3MW involving all types of electricity generation from non-dispatchable sources, that is, sources that are not controlled by the ONS (Brazilian Electrical Operator) where its produced energy is injected directly into the network through its primary resource.

To define HC, electric power utilities need tools and methodologies that may be able to perform this work in order to ensure that Power Quality parameters are within the limits established by Module 8 of the Brazilian Electric Distribution Procedures (PRODIST) [5]-[6]-[7].

The distributed photovoltaic generation, although being beneficial to the electrical system, on a large scale can cause instability in the electrical power system (EPS) and may be accentuated, since the distribution networks use old topologies created before the possibility of the consumer being able to generate its energy and inject the surplus into the distribution network.

The techniques presented in this paper show ways to determine limits of the insertion of DGs in the distribution

network bypassing impacts, avoiding high investments made by the electric power concessionaire and allowing to reduce costs in electrical equipment and protections. Thus, through probabilistic studies, a simulation routine developed from the Python programming language is created and a series of scenarios are obtained, including the insertion of photovoltaic solar energy at different power levels and distinct points of the distribution network. Finally, statistical analyses are made aimed at changes in voltage levels in order to determine the hosting capacity of distributed photovoltaic generators.

The performance of this work is made possible by implementing a computational routine together with the EPS load flow simulation performed by OpenDSS DLL access with Python programming that can be better understood using the OpenDSS manual [8].

## II. IMPACTS CAUSED BY DISTRIBUTED GENERATION

The modeling of the Brazilian electrical system is part of the large power generating plants such as hydroelectric, thermoelectric, nuclear or other forms of generation, these are located in remote locations and far from urban civilization, because they present the need to be close to the natural resources used for the conversion of potential, kinetic or thermal energy into electricity. This electricity generation structure is called centralized and creates a one-way power flow, which originates in generating plants and has residential, commercial or rural consumers at the end point of the power supply. During this route, the transport of electricity passes through different subdivisions of the electrical system, starting in the generating plants, traveling through the transmission lines to lowering substations and / or elevators where are present conversion, protection and measurement equipment such as voltage transformers, relays and disconnector slats, PTs (Potential Transformers) and CTs (Current Transformers), and completing its journey in consumers who are at the end of the electrical system. Throughout the power delivery route, there are elements that have been sized by adopting the one-way flow of power through the model mentioned above. And with distributed generation this sense begins to change by bidirectional way.

Renewable energy sources in turn impact the electricity distribution network by changing its topology, since the actual distribution system is passive and is designed to have only one generating source and one-way power flow. Distributed generation systems are active and can act as generators and energy consumers and thus produce a two-way flow of power. And because actual electric systems

are not designed to receive this type of two-way power flow may present some problems due to DG [9].

According to Trevisan [10], a low insertion rate of distributed generators produces few impacts to the electrical distribution system if the system is not weak. Nevertheless, Brazil and the world have the propensity for growth of DG, thus making the emergence of a significant amount of this type of energy supply. And what will be addressed in this work is to quantify the hosting capacity through the massive insertion of distributed generation in particular photovoltaic and for this must be taken into account the impacts caused to the network. From this, some Power quality problems can be listed, such as: voltage swell, voltage regulation, frequency oscillation, voltage unbalance, harmonics, interruptions; besides short circuit parameters changing, power flow changes, and others.

### III. HOSTING CAPACITY OF A LOW VOLTAGE DISTRIBUTION NETWORK

The hosting capacity (HC) can be understood as the performance index of the electrical system showing the characteristic of including distributed generation without violations of power quality parameter limits. In order to calculate HC, it is necessary to identify and determine the performance indices that will be used. The calculation of these limits should not be defined as a definitive method to perform this evaluation, because it is a prediction of its value, since the hosting capacity is dynamic and the more indexes considered better will be its reliability in the results, however, it becomes more complex to find the hosting capacity.

The need to conduct studies on the electric systems behavior and, consequently, to quantify the impacts originated from the high level of photovoltaic generation concentration in the energy distribution system is a primary factor for the identification of HC. The impacts caused by photovoltaic generation connected to the DG, due to the two-way flow of power, have the property of causing the voltage variation at the connection point of the network where the photovoltaic system was installed [11] and may cause damage to electrical equipment installed in that location because it has higher limits than the rated ones supported. Thus, having a way to quantify the maximum distributed generation capacity connected to the distribution network respecting its limits of the reference indexes, the credibility and reliability of the regulatory agencies is obtained, allowing the accommodation of this technology in a conscious and appropriate way.

Overvoltage, voltage imbalance, power factor deterioration, electrical losses, transformer charging are

some indicators connected to the network and common DG coupling points. In this work will be used the indexes of allowed overvoltage and voltage imbalance for the determination of hosting capacity.

That said, whatever the performance index chosen there will be a limit that must be respected in order to accommodate the largest number of distributed generators. Thus, the performance of the system is inversely proportional to the number of DGs connected to the network. Fig. 1 shows the performance of the electrical system in a generic way, in relation to the increase in the number of generators.

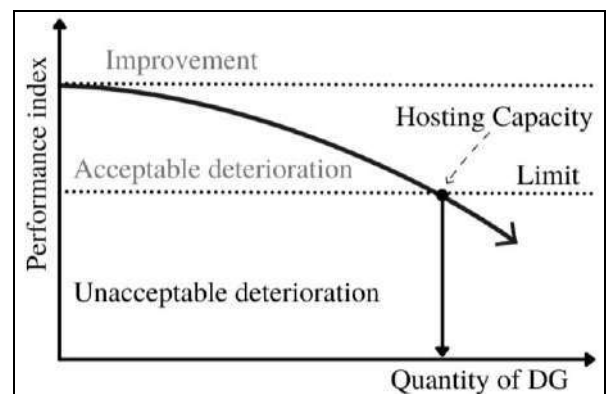


Fig. 1: Approximate hosting capacity according to high performance index [12].

In this model, it shows that the smaller the number of connections from DGs on the network, there will be few impacts on system performance. Therefore, it is understood that the maximum performance is found when there is no generation, and as generators are included its performance is attenuated. However, this methodology is not constantly applied because most ideal models address low performance values for better network performance.

Fig. 2 shows the calculation for hosting capacity making the use of acceptable overvoltage, showing that the higher the amount of distributed generation will mean a greater deterioration of the power quality provided and the increase in the performance index. Since, in places more distant from the power point of the network, a depreciation in the voltage magnitude is caused. That said, with small plots of distributed generator insertion the voltage increase will be low, already for large amounts of penetrations of DPVGs the voltage can rise a lot and becoming unacceptably high and thus there is violation of the limit of hosting capacity.



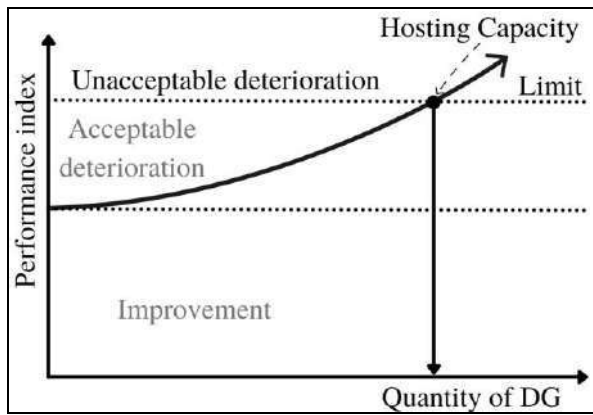


Fig. 2: Approximate hosting capacity according to low performance index [12].

However, there are specific cases that when inserting DGs will initially cause an increase in the performance index, but in large cases will deteriorate. In other words, it is possible to have more than one hosting capacity for the same system, represented in Fig. 3 where the first HC achieved presents acceptable deterioration, that is, lower quality when compared to the absence of generation, but still providing reliability in the supply from the insertion of generators. In the second HC, this deterioration becomes unacceptable, presenting the maximum supported limit. In both cases, there is an improvement in the index with the reduction of electrical losses and risks of overloads for small amounts of distributed generation, but if the number of DGs increases it will deteriorate performance making it unacceptable.

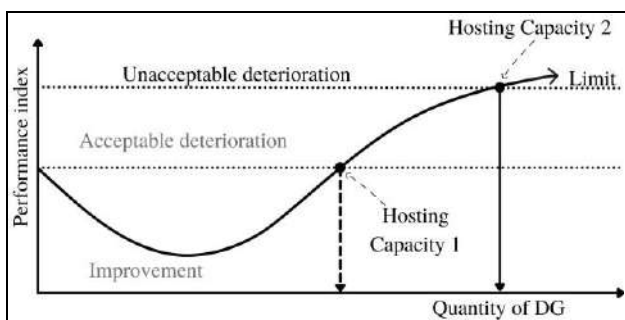


Fig. 3: Approximate hosting capacity with improved performance index [12].

According to Bollen and Hassan in [13], to determine the hosting capacity is required:

- Choose the type of phenomenon and the desired performance indices;
- Establish the appropriate limits for each event;
- Delimit performance indexes relative to the amount of distributed generation connected to the network;

- Perform the calculation of HC.

During the calculation process it may be that more than one hosting capacity is found in the choice of two or more phenomena or performance indices, thus it is essential to adopt the lowest value found, as it will ensure that for the worst case all parameters will be within acceptable limits. And, as stated earlier in this work, three electrical energy quality indexes will be used for the calculation of HC, they are: allowed overvoltage, voltage imbalance and transformer charging.

#### IV. MONTE CARLO SIMULATION

Monte Carlo Simulation (MCS) is a technique widely used in probabilistic analysis for a given system. This tool consists of a numerical manipulation to obtain the statistics of the output variables of a computational modeling. In each simulation, the input variables sampled through probability distributions are defined and thus the output values are calculated using the computational model. From the output variables, statistical analyzes are performed to interpret the problem faced [14]-[15].

This tool belongs to the collection of techniques called Monte Carlo Methods (MCM) which involves computational algorithms for the solution of several problems that require large random samples, prediction of possible future scenarios, integration and optimization of mathematical problems, generation of numerous possibilities for facilitating decision-making, asking prices and multiples related to the financial market, are some examples of the practical application of these methods.

MCS is commonly used in two circumstances, for the validation of descriptive analytical methods and for the solution of complex models that require a large number of calculations or that are not capable of being numerically solved, requiring analytical approximations that are difficult to perform. For the second case, the Monte Carlo Simulation performs several deterministic analyzes of the different scenarios created using probability distributions for the input variables.

The use of probabilistic simulations of a given system allows generating numerous occurrences of events regardless of the model. That is, no matter which problem is being faced, through the Monte Carlo Simulation it will be possible to create different types of scenarios, interpret the output variables in a statistical way and later take results based on the analyzes performed. Each simulation originates a new series, different from the previous one, but with the same statistical characteristics. As each scenario is different from each other, it is possible to obtain several results from each MCS, unlike the

deterministic approach where a single result is obtained. In this way, the probabilistic analysis of Monte Carlo Simulations allows the analyst to make decisions based, not on an isolated case, but through several studied events.

In this work, the Monte Carlo simulation has the role of enabling the creation of several scenarios, where the installed power will be chosen through a probability distribution constructed through the ANEEL database [17] and will be presented later in this chapter and also the PVs connection point chosen based on a uniform distribution.

## V. OPENDSS AND THE RIGGED DISTRIBUTION SYSTEM

The Open Distribution System Simulator (OpenDSS) is a software responsible for performing simulations that are linked to the electrical energy distribution system, published in 1997 with the intention of providing support and analysis of electrical systems. It was developed in three versions, the first being a standalone executable program (OpenDSS.exe) with a basic interface based on text commands and as help mechanisms to assist the user in the development of their code, the second, a COM server (Component Object Model) implemented through a DLL (OpenDSSEngine.DLL). Finally, the third version, a command DLL that provides all the functions of the COM server (OpenDSSDirect.DLL), can be used in high-level programming languages that do not support COM or require Thread-safe that request a lot of data and parts of the code using multi-threads. [7]

Thread-safe is a computer programming notion that applies to the context of multi-threaded programs. A fraction of the code is called Thread-safe when it works with shared data structures in order to guarantee safe execution by requesting multiple threads simultaneously. Initially, OpenDSS, just called DSS, was created by researchers and electrical engineers Roger Dugan and Thomas McDemontt, and its objective was to analyze the electrical distribution system from the insertion of distributed generation. However, in 2004 it was bought by the company EPRI (Electric Power Research Institute) and in 2008 it became a software with free license, receiving the name of OpenDSS. [7]

The software performs most of the analysis in the sinusoidal steady state, frequency domain, normally used to supervise and design electric power distribution systems. In addition to supporting modern forms of analysis that can meet future needs that are being mentioned by energy utilities around the world in relation to Smart Grids. Other supported features are energy efficiency and harmonic distortion analyses. OpenDSS was created with the mission to be expandable and can be

updated to meet many futures uses both in general and for individual users.

In this work, the third version was used through OpenDSSDirect.DLL, as this alternative was created to accelerate the simulation speed between OpenDSS and external programs. Normally, in programming languages that operate at a high level, they do not support connections with the COM server, which present late connections and, due to the delay of the information, overload the simulation process, especially when loops of repetitions are executed [17]. Python was connected to OpenDSS through the py-dss-interface module, created by Paulo Radatz, Ênio Viana and Rodolfo Pilar Londero. All documentation and information can be found in [7].

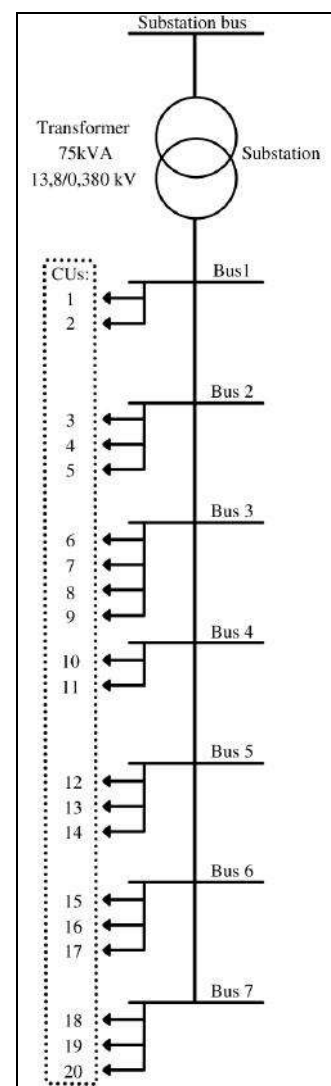


Fig. 4: Unifilar diagram of the electrical system used

Fig. 4 shows the electrical distribution system used and later modeled within OpenDSS. Composed of a 75 kVA transformer, with its high side connected to 13.8 kV and low side to 380/220 V, 7 busbar, 20 single-phase

consumers and a total line length of 885 meters. This information was made available by the electricity concessionaire CPFL Energia (Companhia Paulista de Força e Luz) from a branch supplied especially at this voltage level. All other manipulated system data and advanced computational modeling are described in [18].

In the simulations, in order to determine the hosting capacity of the distribution system, each consumer unit will receive a distributed photovoltaic generator randomly, with each consumer unit having the same probability of installing this distributed photovoltaic generator, until the predetermined value of the photovoltaic penetration level established in the program.

## VI. PROGRAMMING LOGIC

For the programming logic, an algorithm was developed in Python where it receives as data input: number of MCS (Monte Carlo Simulations), number of photovoltaic generators called PL (photovoltaic penetration level) and the number of CUs (Consumer Units) to be considered.

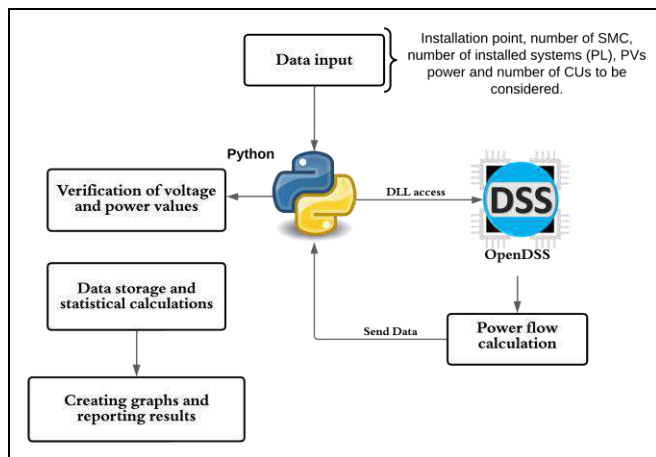


Fig 5: Flowchart of programming logic

In Fig 5, the programming logic is shown in the form of a flowchart in order to exemplify the method used. Through the Python-OpenDSS connection, some loops of repetition are created for the execution of the Monte Carlo simulation, such as: loops for counting and carrying out the MCS, implementation of different levels of photovoltaic penetration (NP), creation of different connection points of the PV generators and a loop to randomly select the PV power through a probability distribution constructed using the parameters obtained from the ANEEL database [15] for residential installations of up to 10 kW in the city of Itumbiara in the State of Goiás.

After data entry, this information is passed to the developed code and the creation of several photovoltaic generation scenarios begins, which are then inserted into the network. That said, the power flow calculation is performed in OpenDSS and each scenario goes through the voltage limit check among the values provided by ANEEL that are presented in Table. 1.

Table. 1: Connection points in Rated Voltage equal to or less than 1 kV (at the base of 380 V/220 V) [5]

VOLTAGE	RANGE OF VARIATION OF READING VOLTAGE (TL) IN RELATION TO THE REFERENCE VOLTAGE (TR)
Adequate	$(0.9210 \text{ TR} \leq \text{TL} \leq 1.05 \text{ TR}) / (0.9182 \text{ TR} \leq \text{TL} \leq 1.05 \text{ TR})$
Precarious	$(0.8710 \text{ TR} \leq \text{TL} < 0.9210 \text{ TR} \text{ or } 1.05 \text{ TR} < \text{TL} \leq 1.0605 \text{ TR}) / (0.8682 \text{ TR} \leq \text{TL} < 0.9182 \text{ TR} \text{ or } 1.05 \text{ TR} < \text{TL} \leq 1.0590 \text{ TR})$
Criticism	$(\text{TL} < 0.8710 \text{ TR} \text{ or } \text{TL} > 1.0605 \text{ TR}) / (\text{TL} < 0.9455 \text{ TR} \text{ or } \text{TL} > 1.0590 \text{ TR})$

In Fig. 6, the probability distribution constructed and later implemented in the Monte Carlo Simulation code is presented to ensure unpredictability and randomness of the created scenarios.

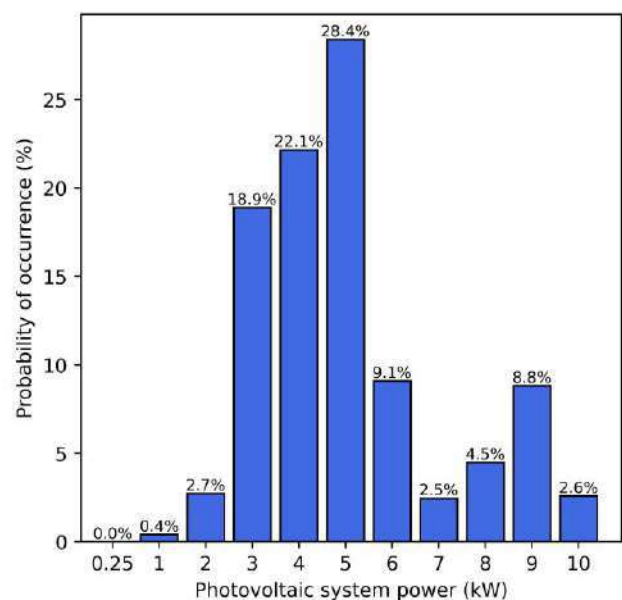


Fig. 6: Probability distribution according to photovoltaic systems installed up to 10 kW in Itumbiara - GO

As the Monte Carlo Simulation is a probabilistic method, it is necessary to identify some random variables, and in this case the choice of each photovoltaic system power is interpreted as one of the main randomness for the construction of this work, since the electric power utility has neither control nor certainty of the power value of a new customer's system. Therefore, it is essential to carry out statistical research in order to find a relationship between the installed power and the number of access requests with that specific capacity. From this, the ANEEL database was analyzed, filtering the installed photovoltaic systems of up to 10 kW in the city of Itumbiara, in the state of Goiás. This power value was established because all the DGs that will be installed are single-phase, and in the current market the availability of photovoltaic inverters for this type of connection is a maximum of 10 kW.

In addition to the uncertainty in the choice of PV power, the point or place of installation of the DPVGs, ambient temperature, solar irradiance and the customer's consumption profile are other random variables that neither the utility nor the customer has control over their values. And for that, the installation point is defined from a uniform probability distribution, that is, all customers present in the network have the same chance to install a PVs, in this way, it is guaranteed an approximation of the reality that the concessionaires are going through, where more and more customers want to have a type of DG installed in their home. The temperature is set for a clear day in order to guarantee ideal thermal balance for the rated operation of the modules, and also with a "perfect" irradiance, because if this occurs it will be the worst possible scenario for the power network when it comes to impacts. caused by DG.

## VII. RESULTS

Through the Monte Carlo simulation, several scenarios are generated through the different probability distributions for the connection points of the photovoltaic systems and the powers of the GDFVs. Thus, a large volume of data is obtained, which will be presented through graphic and statistical analyzes related to voltage amplitudes, voltage imbalance, both for the busbar and for the grid feeder and the photovoltaic power installed at the grid connection points. For the simulation process, the following input variables were used:

- MCS = 500 Monte Carlo simulations;
- PL = 0 to 100% with a step of 10%;
- CUs = 20 consumer units considered.

The measurement interval of electrical quantities was fixed at 1 minute, resulting in 1440 measurements during

the 24 hours of a day. With the intention of reducing the computational effort and accelerating the simulation process, the simulation day with the best solar irradiation shown in Fig. 7 is considered, as the irradiation coefficient implemented in OpenDSS, so the voltages generated by the photovoltaic modules will be the rated, therefore, this curve model is a conservative choice, and if this type of event occurs, it will result in the most worrying scenarios, considering the impacts caused to the distribution network.

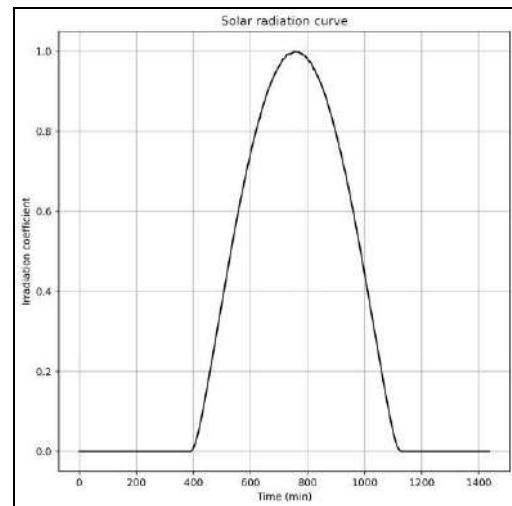


Fig. 7: Solar irradiation curve implemented in OpenDSS

Fig. 8 shows the load curve for residential consumers as a function of active power. This curve is said to be the typical behavior of each CU connected to the modeled electrical system and its function is to allow the temporal variation of energy expenditure interpreted by OpenDSS to occur.

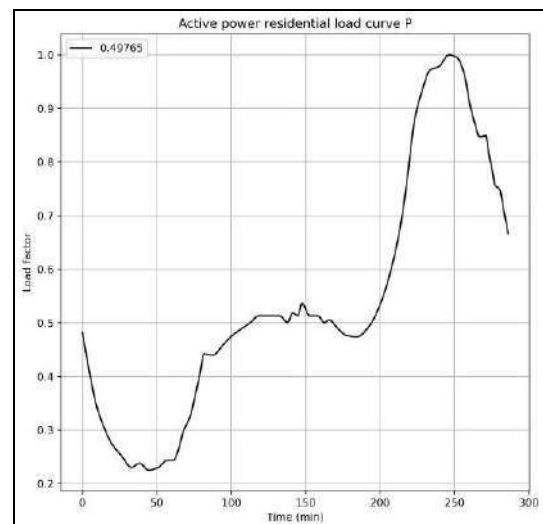


Fig. 8: Active power residential load curve P

A relevant factor of this work for the identification of HC is the use of the probabilistic technique, Monte Carlo



Simulation, which allows approaching the cases that will be presented as close to the reality that is happening with the electric energy concessionaires, since they do not know at which point the DPVGs will be allocated nor the power of these generators. Thus, when performing numerous simulations, great results are obtained. In order to justify the number of simulations chosen for this work, the Coefficient of Variation (CV) is calculated for some metrics by Equation (1).

$$CV = \frac{\sigma}{\mu \times \sqrt{n}} \quad (1)$$

Where:

$\sigma$  = Standard deviation of the chosen metric;

$\mu$  = Metric mean;

$n$  = Number of simulations performed.

The CV is calculated from the second MCS, as the intention is to find the variation that exists between one simulation and another, with the increase of the MCS value a new coefficient of variation is obtained and, thus, until the last simulation. These values are stored to be used in the generation of graphs for the purpose of being analyzed.

To facilitate understanding and reduce data presentation, only the data for the transformer and busbar 7, will be shown, as it represents the most worrying busbar related to voltage levels. In Fig 9, the coefficient of variation for the maximum stresses at busbar 7 in each PL (Photovoltaic Penetration Level) are presented in order to find the necessary amount of MCS that would converge the CV.

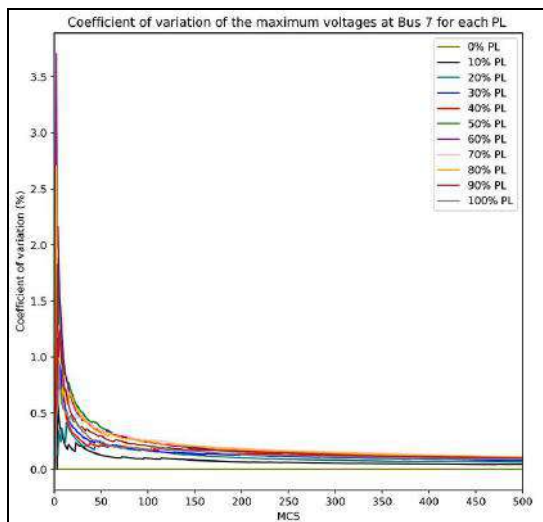


Fig 9: Coefficient of variation of maximum stresses in Busbar 7 for each PL

From Fig 9, it is noted that with 500 MCSs the value stabilizes, showing little variation. Thus, avoiding the need to perform more simulations and reducing the computational cost. However, with 300 MCSs, it would be enough to have good results and make reliable analyses, but this work has undergone some improvements in its code, thus being able to perform 500 Monte Carlo Simulations without harming the efficiency of the machine used.

In order to better understand the concept adopted for PL in this work, its value is directly related to the number of distributed photovoltaic generators that are installed in the consumer units present in the network, as shown in Table. 2. It is important have this knowledge, as there are standards from concessionaires in the United States and standards by the IEEE that determine the concept of photovoltaic penetration level as a percentage relationship with the rated power of the transformer. For this work, the PL is adopted as the number of GDFVs inserted in the network.

Table. 2: Equivalence of PL number

PL percentage	Number of equivalent PVs
0%	0
10%	2
20%	4
30%	6
40%	8
50%	10
60%	12
70%	14
80%	16
90%	18
100%	20

In Fig. 10, the evolution of the number of violations is shown for all penetration levels of photovoltaic generators and it is seen that in some cases the higher the PL the greater the number of violations and, in this way, it shows that busbar 5, 6 and 7, are the most problematic if a large volume of DPVGs is entered. Because when excess energy is injected into the system, the voltage at that point tends to increase and this effect is more pronounced when the short-circuit level in the busbar is lower, causing any voltage variation to reach high levels.



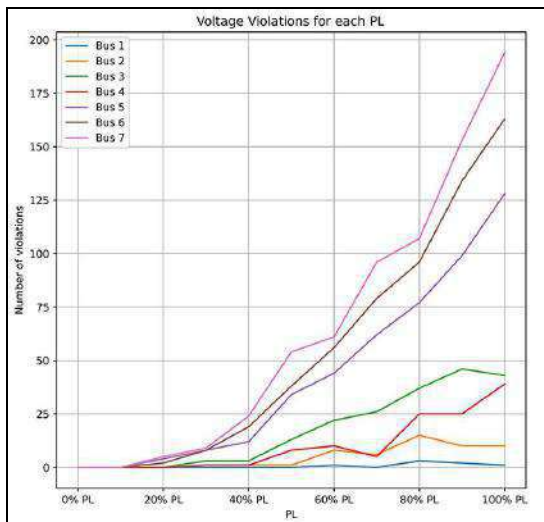


Fig. 10: Voltage violations for each PL

From the analysis of Fig. 10, it can be concluded that for the more distant busbar, the HC of the network is compromised, presenting a greater number of voltage violations. Thus, for this analysis methodology at 50% of photovoltaic penetration level, busbars 5, 6 and 7 began to show violations more frequently, since the other busbars remain with the number of violations below 50.

An important metric to analyze how worrying the overvoltage impacts caused to the network will be and making it possible to identify the HC of the network for a certain level of photovoltaic penetration is the cumulative criticality statement, shown in Fig 11.

This graphic methodology shows that if there is a penetration of DPVGs of 100%, there will be a 65.74% chance of a voltage rise greater than 1.05 p.u. at some system busbar is similar for the other PL values. It is worth mentioning that if there is, for example, 90% of PL in the network, the criticality potential of the previous PL is considered plus the value in question and works in the same way for all other percentages. In this way, the HC is identified from the percentage of occurrence of voltage violations. In Fig 12, the graph of the number of violations referring to voltage unbalance values greater than 3% measured in the 500 MCSs for each PL is shown.

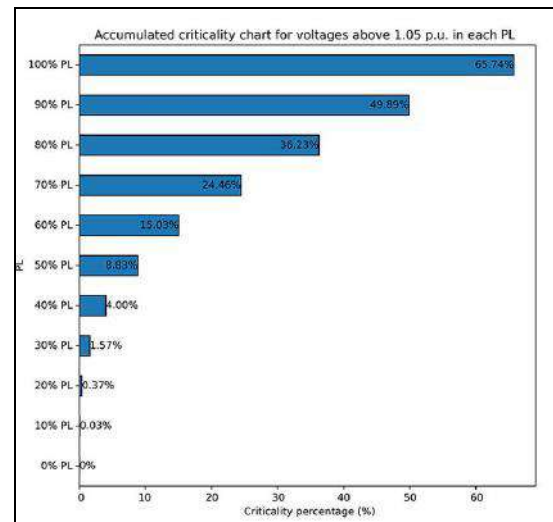


Fig 11: Statement of accumulated criticality for stresses above 1.05 p.u. in the bars in each PL

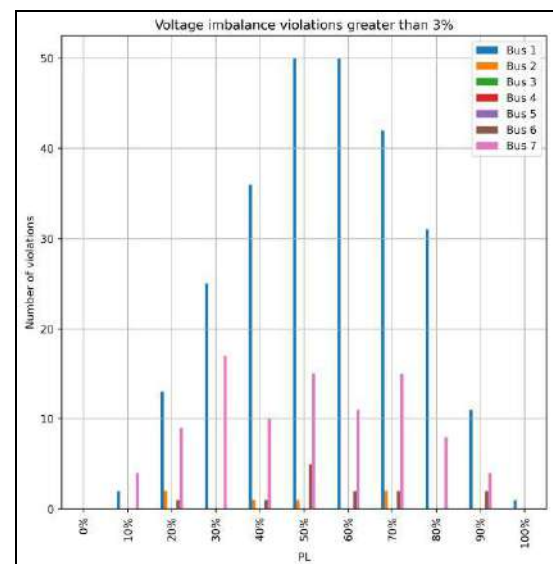


Fig 12: Voltage imbalance violations > 3%

In order to facilitate the analysis, Fig. 13 shows the maximum voltage obtained in the 500 simulations for each transformer phase and at which penetration level this value occurred.

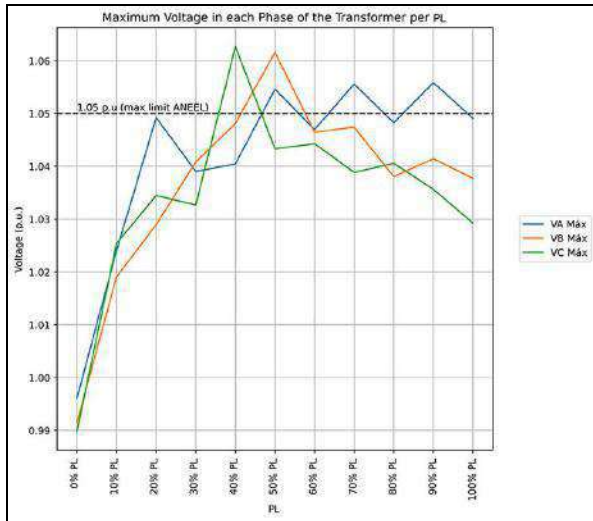


Fig. 13: Maximum voltage at each phase of the transformer per PL

It is important to know at what levels of penetration it becomes harmful to the network and to indicate to the electric energy concessionaire when they should make improvements in the network or techniques for relocating consumer units, since, for example, in 40% of PL in phase A the violation of 1.05 p.u. does not occur, but it already happens in phase C for that same level of penetration. Thus, a possible solution would be to migrate consumers from the problematic phase to another that is not or also carrying out the installation of battery at strategic points in the network based on the analysis of the busbars, for example, in order to store excess power flow avoiding voltage surges.

Next, in Fig. 14, the maximum voltage imbalance for each photovoltaic penetration level is presented, the imbalance index is another metric for the analysis of the network HC since the acceptable limit, in Brazil, is a maximum of 3%, defined in Module 8 of PRODIST [5].

In the Fig. 14, it is noted that there is no voltage imbalance above 3% and this is because the transformer is a robust equipment being powered at medium voltage and for having full influence on the distribution system and thus the amount of photovoltaic implemented in this network did not have the necessary power to unbalance the voltage in the transformer, but it was seen in the previous topics that in the busbar this effect occurs in a very accentuated way. Therefore, it could be said that in relation to the voltage imbalance in the feeder, this network has a considerable HC, starting from the point that the highest percentage of imbalance was from 1.5% to 40% and 60% of PL, but it is worth mentioning that the same HC should not be adopted for the entire network, through this analysis

index. In Fig. 15, the total result of the transformer loading is presented.

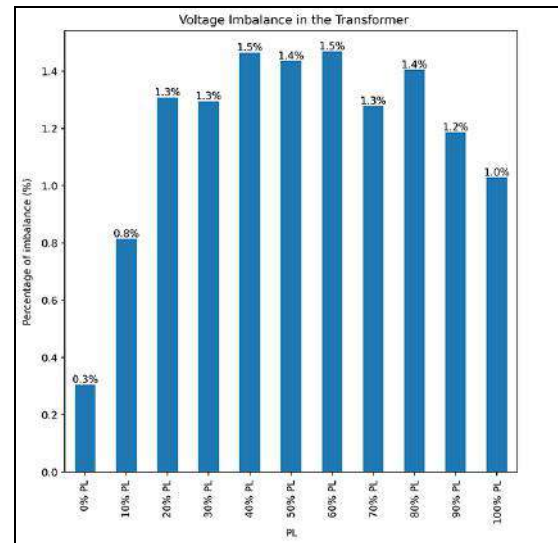


Fig. 14: Voltage imbalance in the transformer

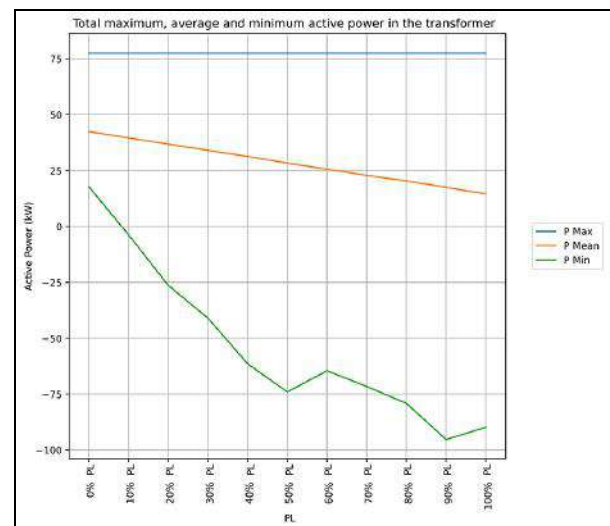


Fig. 15: Maximum, average and total active power in the transformer

From Fig. 15, it is noted that for 80%, 90% and 100% of PL, the rated power limit of the transformer is exceeded (75 kW, adopting unitary power factor for the analysis), but it is known that these can work oversized, however it is necessary that the electric power company is attentive and evaluates if excessive damage will occur to the feeder. By analyzing the transformer loading as shown, the hosting capacity is identified. It is worth mentioning that, in the graph, the power that must be used for analysis is the one that represents the minimum value, since OpenDSS adopts positive the flux that leaves the feeder to the network, and negative the flux that comes from the network and enters the transformer.

## VIII. CONCLUSION

This work presented a probabilistic approach to determine the HC of distributed photovoltaic generators in the electricity distribution system. The use of the Monte Carlo method for the analysis of HC is a differential factor of this work, and, in most cases, this is done in a deterministic way and thus ignoring data that should be present when performing this type of study.

Most of the published works are research focused only on the system transformer or only on the network connection points. And as it was seen, it is important to carry out both punctual and feeder analyzes and this is another differential of this work. As stated, all the research developed was based on real data for the probability distributions, making it gain strength and solidity to reach the conclusion of the exposed results.

It is important to point out that the HC is dynamic, as it depends on random variables and at each point of the electrical system there is its own characteristic, causing the HC to change from one point to another. Thus, it is not correct to generalize it to the entire EPS model, however, with the help of Fig 11, it can be concluded that the ideal HC for this distribution system would be between 60% or 70% of photovoltaic penetration level, because in these PL values there are not so many voltage violations, which as seen is the most worrying indicator, and thus the electric energy concessionaire will be able to use techniques to mitigate this and other impacts caused to the grid, through the installation of battery banks or reallocation of consumers to other phases, for example.

The simulation process was implemented through the Python programming language connected via DLL with OpenDSS and executed on an Intel® Core (TM) i7-2670QM CPU @ 2.2 GHz computer with 4 cores, 8 logic processors and 8.0 GB of RAM spending approximately 2 hours and 20 minutes for the total power flow simulation.

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# A CHF Model for Pool Boiling on Rough Surface under Exponential Heat Supply

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**Keywords**— surface roughness, transient heat transfer, heat transfer coefficient, hydrodynamic model

**Abstract**— In present study, the experiments are carried on sample of different surface roughness to investigate the transient heat transfer phenomenon at the saturated condition of the distilled water. The surface roughness ( $R_a$ ) ranges from  $0.106 \mu\text{m}$  to  $4.03 \mu\text{m}$ . The boiling crisis is observed during each transient heat supply. The high-speed camera of 1000 fps is used to observe the stages of boiling during different transient and to confirm the moment of critical heat flux (CHF). The empirical relation is presented for transient CHF and corresponding heat transfer coefficient (HTC). It is found that transient CHF is a function of both  $R_a$  and  $\gamma$ . The hydrodynamic model is developed for prediction of CHF at different rate of exponential heat supply for the wide range of  $R_a$  by incorporating  $\gamma$ .

## I. INTRODUCTION

The knowledge of boiling crisis in the nuclear reactors during exponential heat supply is important for the safety and efficient performance. The moment of critical heat flux (CHF) after which sharp reduction in heat transfer coefficient (HTC) is observed may lead to the rapid surge in the core temperature. Thus the formation of vapor blanket at CHF may lead to core meltdown accident. Hence understanding of the mechanism of transient CHF during exponential power escalation is of paramount importance. Researchers have contributed to explaining the CHF mechanisms by various approach viz. (i) Kelvin–Helmholtz instability between the upward flow vapor

columns and downward flow liquid, (ii) dry-out of the liquid layer i.e. micro/macrolayer dry-out. Kutateladze [1] and Zuber [2] considered the Kelvin-Helmholtz instability as surface-fluid interaction fails due to relative motion between vapor column and surrounding liquid. Chang [3] considered the forces acting on the bubble during lift off from the horizontal surface and claimed that the critical velocity of the upward moving bubble is responsible for CHF. Haramura and Katto [4] stated near field evaporation phenomena through the macrolayer evaporation model and estimated CHF at the dry-out condition of macrolayer.

Lay and Dhiri [5] and Pasamehmetoglu et al. [6] developed the theoretical model based on microlayer

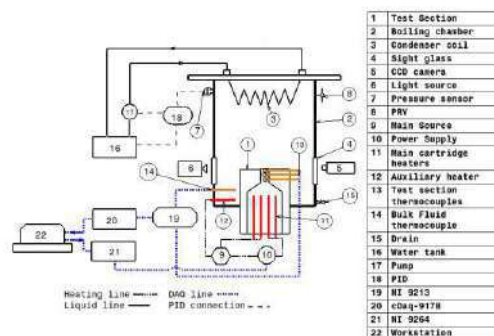


evaporation. Zhao et al. [7, 8] developed steady-state and transient CHF model by considering various boiling aspects like time variant microlayer thickness, microlayer evaporation, macrolayer evaporation and transient conduction over the entire period of boiling. Hence, hydrodynamic models were coupled with surface-fluid properties like contact angle [9], surface roughness [10,11] and heater orientation [12]. The effects of boiling surface properties must be included in a robust and widely applicable CHF model. Kandlikar [11] proposed a force balance model which includes the contact angle of the bubble. Ahn et al. [13] included the term for capillary wicking in the Kandlikar's model to estimate the CHF. Quan et al. [14] proposed the force balance model, which includes roughness factor ( $r$ ), to predict CHF for the micro structured surface. Kim et al. [15] developed the CHF model by considering capillary force, surface roughness ( $R_a$ ) and static contact angle. The capillary force through the unidirectional scratches was predicted by assuming number of capillary tubes underneath the growing bubble. It is noticed from the literature that theoretical model can be developed from force balance approach to predict the CHF. Far-field and near-field models are developed by considering surface roughness ( $R_a$ ), roughness parameter  $r$ , static contact angle, surface wetting property, surface orientation and heater size. In the present study, influence of surface roughness  $R_a$  and period of exponential heat supply on transient CHF is studied. A pioneering study is carried to include new term, so-called time constant  $\gamma$  in the CHF model.

## II. EXPERIMENTATION

## 2.1 Experimental Setup

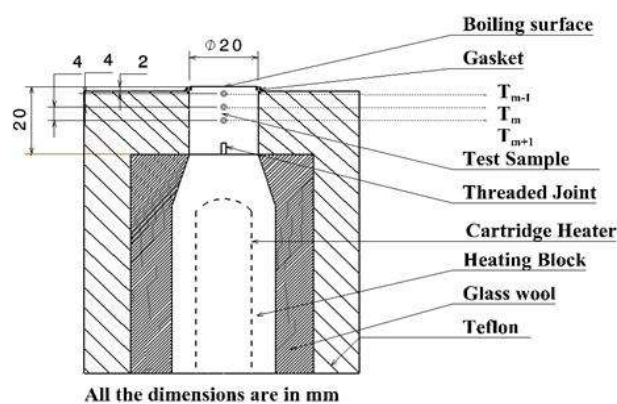
A boiling chamber with the test section and condenser assembly include in the experimental setup. The schematic of experimental setup and visualization unit is shown in Fig. 1. The detachable top and bottom flange are provided to the boiling chamber. The condenser coil is attached to the top flange whereas bottom flange can accommodate the test section assembly. The bulk fluid temperature ( $T_i$ ) and chamber pressure are measured by the thermocouple and pressure transducer, respectively. The transparent toughened borosilicate glass watch windows of 115 mm diameter and 15 mm thickness are provided to the wall of boiling chamber to conduct the visualization study by high speed camera. The saturation condition of the distilled water is maintained by the two high density cartridge heaters each of 1000W capacity. The setup is synchronized with high speed camera, NI-9213 temperature module and NI-9264.



*Fig. 1: Experimental Setup*

## 2.2 Test Section

Thick copper sample of 20 mm length and the diameter of 20 mm is prepared as shown in Fig. 2. The 840 W high density cartridge heater is used to supply the heat. The thermal paste is applied on both the contact surfaces and thereafter, sample is screwed with the heating block which ensures the perfect surface contact between them. The glass wool insulation is provided over the sample and heating block. An O-ring and high-temperature non-corrosive RTV silicone gasket ensures the leak proof assembly. Three K-type sheathed thermocouples of 1 mm diameter are implanted from the top of the sample surface at 2 mm, 6 mm, and 10 mm.



*Fig. 2 : Test Section*

## 2.3 Experimental Procedure

The assembly of test section is considered as the axisymmetric system. The uniform heat flux from the boiling surface is assumed due to uniform surface characteristics. The heat flux dissipated to the boiling fluid and the surface temperature can be measured using thermocouple.

The time variant heat flux from the boiling surface due to exponentially varying heat supply is calculated by Equation 1.

$$q_{ts}'' = -k_{cu} \frac{T_{m-1}^t - T_{m+1}^t}{2\Delta x} \quad (1)$$

where  $\Delta x$  is the gap between two adjacent implanted thermocouples.

The temperature of the boiling surface is calculated by using Equation 2.

$$T_w^t = T_{m-1}^t - q_{ts}'' \left( \frac{x_{m-1}}{k_{cu}} \right) \quad (2)$$

where,  $x_{m-1}$  is the gap between boiling surface and the thermocouple ( $T_{m-1}$ ), as given in Fig. 2.

Heat transfer coefficient (HTC) between the boiling surface and water is estimated by Equation 3.

$$h_{ts} = \frac{q_{ts}''}{(T_w^t - T_l)} \quad (3)$$

The values of uncertainty in the measured and estimated parameters are given in Table 1.

The values of uncertainty in the measured and estimated parameters are given in Table 1.

Table 1 : Uncertainties of measured and calculated parameters

Parameter	Uncertainty
$T$	$\pm 0.1^\circ\text{C}$
$x$	$\pm 0.0001 \text{ m}$
$P$	0.2 %
heat flux	11.91 %
HTC	16.20 %

### III. RESULTS AND DISCUSSION

The roughness parameters of the test sample, which were measured before and after boiling tests, are tabulated in Table 2. The  $R_a$  value of the test sample is considered as the roughness parameter in this study.

Table 2 : Roughness parameters in  $\mu\text{m}$

$R_a$	$R_z$	$R_q$	$S_m$
0.106	1.20	0.14	13.2
0.83	7.05	1.07	26.8
1.87	13.30	2.40	35.7
3.17	22.91	4.12	42.2
3.59	27.55	4.09	44.8
4.03	26.50	4.95	45.2

The experiments are conducted on different samples with exponentially varying heat supply and respective boiling

curves are obtained. Effect of roughness on transient boiling heat transfer is noticed in the boiling curves obtained for  $\gamma=3$ , as shown in Fig. 3. It is clearly found that boiling curves moves onto the left with increase in values of  $R_a$ , indicating that the heat transfer enhancement is due to the rough surface. The heat transfer enhancement due to rough surface can be justified by the mechanism of liquid replenishment and surface wettability. Unidirectional scratches made on the surface act as a passage for liquid supply to the nucleation sites. The wetting property of the surface also improved due to capillary wicking along the scratches. The irregularities increase with  $R_a$  which has more potential to be nucleation sites. Thus increased number of bubble and the improved liquid supply mechanism to the nucleation sites resulted in heat transfer augmentation. Also, the nucleation boiling temperature is found to be decreased with increase in values of  $R_a$ . The activation of pre-existing vapor in the cavities of rough surface results in formation of bubble at lower wall superheat.

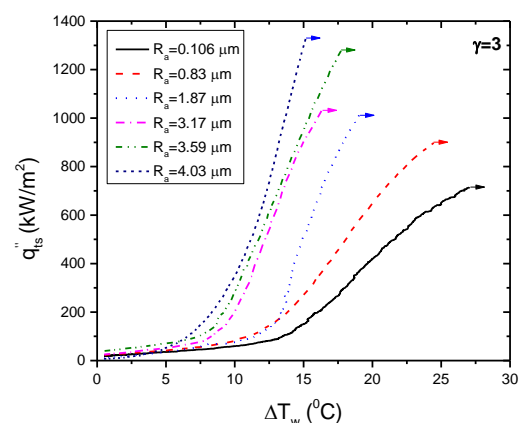


Fig. 3: Boiling curves of the test samples at  $\gamma=3$

It is observed during visualization study that exponentially increasing heat supply creates the instability in the bubble formation. The waiting period between two successive bubbles drops drastically with increase in rate of heating. Thus, sudden increase in the bubble frequency results in the vertical bubble coalescence. Formation of vapor column is observed during visualization at this stage, as shown in Fig. 4. This mechanism of bubble formation decreases the heat transfer rate from the surface. Hydrodynamic instability affects the liquid replenishment adversely which turn to horizontal bubble coalescence. Thus, the blanket of vapor occupies the entire boiling surface. The transition mechanism of nucleated bubble from the fully developed nucleate boiling (FDNB) regime to the film boiling results in drop of HTC. This transition point of boiling curve which corresponds to the maximum

HTC is identified as CHF. The transient CHF and corresponding HTC is presented in Fig. 5 and Fig. 6, respectively, at different  $Ra$  and  $\gamma$ . The values of  $q''_{CHF,ts}$  are plotted against  $Ra$  and  $\gamma$  separately and exponents are obtained. The final relation for  $q''_{CHF,ts}$  as a function of  $Ra$  and  $\gamma$  is derived as given in Equation 4 by least square regression. It is believed that  $h_{max,ts}$  is a function of  $q''_{CHF,ts}$ ,  $Ra$  and  $\gamma$ . The relation developed for  $h_{max,ts}$  is given in Equation 5.

$$q''_{CHF,ts} = 1031.9 (\gamma)^{-0.08} (Ra)^{0.14} \quad (4)$$

$$h_{max,ts} = 0.04 (\gamma)^{-0.07} (Ra)^{0.17} (q''_{CHF,ts})^{1.04} \quad (5)$$

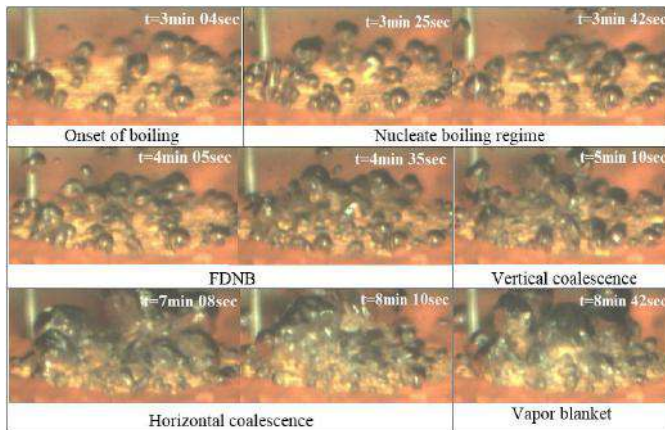


Fig. 4 : Boiling stages for  $Ra = 3.19 \mu m$  and  $\gamma = 1$

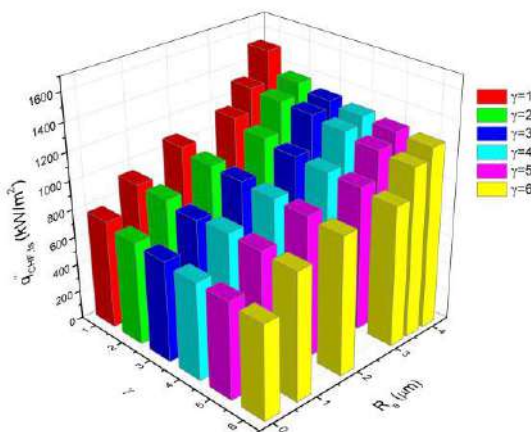


Fig. 5 Variation in  $q''_{CHF,ts}$  with  $Ra$  and  $\gamma$

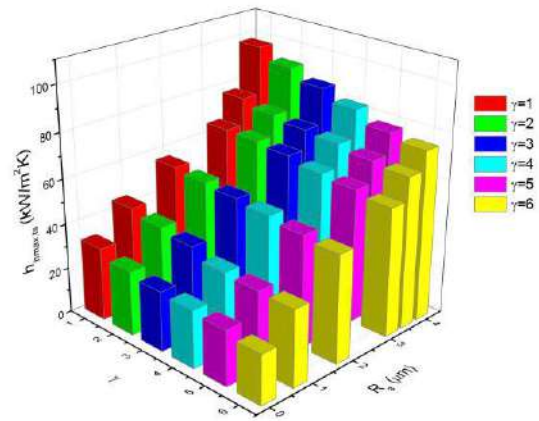


Fig. 6 Variation in  $h_{max,ts}$  with  $Ra$  and  $\gamma$

#### IV. HYDRODYNAMIC MODEL

The bubble formed on the upward facing rough surface experiences the forces as shown in Fig. 7. Force due to change in the momentum (FM) acts on the bubble circumference which pulls the bubble along the surface. Simultaneously, bubble position retains due to forces like surface tension force, gravity and capillary force acting on it. It is observed during present study that horizontal coalescence is responsible to turn FDNB to film boiling regime. This transition in phase of boiling occurs when FM surpasses the sum of drag forces. The moment of CHF is identified by the force balance as given in Equation (6).

$$F_M = F_{s,t} + F_{s,b} + F_g + F_c \quad (6)$$

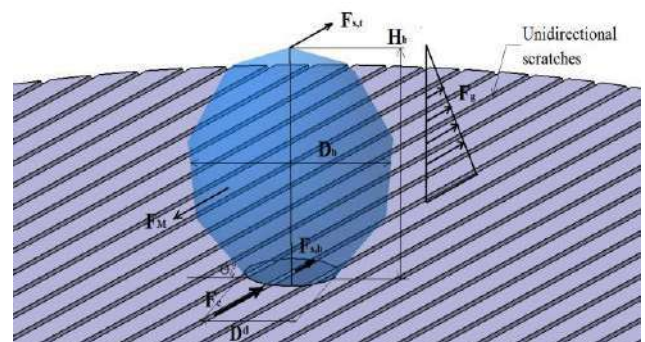


Fig. 7 : Forces acting on the bubble along the surface

A developing bubble, due to its change in momentum, experiences a force on its meniscus. The change in momentum ( $F_M$ ) causes due to continual liquid is estimated as given in Equation 7.

$$F_M = \frac{1}{\rho_v} \left( \frac{q''_l}{h_{fg}} \right)^2 H_b \quad (7)$$

The surface tension forces acting at top ( $F_{s,t}$ ) and bottom ( $F_{s,b}$ ) of the bubble, are given in equation 8, respectively.



$$F_{s,t} = \sigma; F_{s,b} = \sigma \cos \theta \quad (8)$$

The gravity force ( $F_g$ ) which acts on the boiling surface is given in Equation 9.

$$F_g = \frac{1}{2} g(\rho_l - \rho_v) H_b^2 \quad (9)$$

The capillary force ( $F_c$ ) which acting on the bubble, as given in Equation 10, for capillary pressure acting inside the small tube of radius  $R_c$ . It is assumed that unidirectional scratch is a capillary tube and many such capillary tubes may lies below the growing bubble.

$$F_c = 2\pi C \left( \frac{R_a}{S_m} \right) \sigma \cos \theta \quad (10)$$

Combining all the above forces,  $q''_l$  is expressed by Equation 11.

$$q''_l = h_{fg} \rho_v^{0.5} [\sigma g(\rho_l - \rho_v)]^{0.25} \left[ \frac{2}{\pi} + \frac{\pi}{4} (1 + \cos \theta) + \frac{4C \cos \theta}{1 + \cos \theta} \left( \frac{R_a}{S_m} \right) \right]^{0.5} \quad (11)$$

Steady-state CHF can be obtained by the Equation 12 as suggested by Kandlikar [11]

$$q''_{CHF,ss} = \left( \frac{1 + \cos \theta}{16} \right) q''_l \quad (12)$$

The relation developed between steady-state CHF and  $R_a$  is given in Equation 13.

$$q''_{CHF,ss} = 1280.8 \times R_a^{0.14} \quad (13)$$

The relation between  $q''_{CHF,ts}$  and  $q''_l$  is obtained and the final form of CHF model for exponential heat supply ranging from  $\gamma=1$  to  $\gamma=6$  for wide range of surface roughness  $R_a$  is given in Equation 14.

$$q''_{CHF,ts} = \left( \frac{0.81}{\gamma^{0.08}} \right) \left( \frac{1 + \cos \theta}{16} \right) \{ h_{fg} \rho_v^{0.5} [\sigma g(\rho_l - \rho_v)]^{0.25} \} \left[ \frac{2}{\pi} + \frac{\pi}{4} (1 + \cos \theta) + \frac{4C \cos \theta}{1 + \cos \theta} \left( \frac{R_a}{S_m} \right) \right]^{0.5} \quad (14)$$

Fig. 8 illustrate the comparison between experimental data and the predicted transient CHF values obtained from Equation 14 and mean absolute error (MAE) is estimated which found to be 4.05%. The term of  $\gamma$  present in the denominator suggest that difference between steady and transient CHF will increase with increase in the  $\gamma$ .

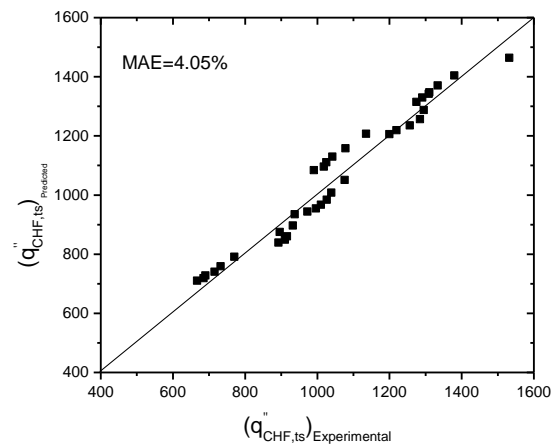


Fig.8 Comparison of  $q''_{CHF,ts}$  obtained by present model with experimental  $q''_{CHF,ts}$

## V. CONCLUSION

An extensive study of pool boiling on copper surface with wide range of surface roughness  $R_a$  under different rate of exponential heat supply was carried to understand the physical mechanism and parametric dependence of transient CHF. It is observed that transient CHF increases with increase in  $R_a$  whereas it decreases with increase in  $\gamma$ . A transient CHF model is developed by including time constant  $\gamma$  to account for the influence of exponential heat supply on the CHF. The present model predicts the experimental values of transient CHF with MAE=4.05%.

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## Educational and informative booklet on the perioperative period of bariatric and metabolic surgery: An integrative review

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**Keywords** — *Bariatric Surgery, Health Education, Booklet.*

**Abstract**— According to the World Health Organization (WHO) (2020), obesity is considered a global public health problem and relates to the death of 2.8 million people per year. Bariatric and metabolic surgery proves to be a great ally against obesity, however, it needs more studies to reaffirm its condition of offering safe treatment and good results in the short and long term. The objective of this study is to analyze the importance of building and disseminating a booklet on the perioperative period of bariatric and metabolic surgery. This is a descriptive, qualitative study carried out through an integrative literature review (ILR). Databases were used: University repositories, VHL, PubMed, Journals, Magazines, Federal Laws and Ordinances, SCIELO, Online Search System and MEDLINE. The study included articles related to the theme of the project, articles with Portuguese language, online and free access to the full text between the years 2012 to

2022, with sixteen (16) references being found. The reading of all the scientific production chosen made it possible to contemplate the researchers' concern in the adoption and development of resources that facilitate communication and in the implementation of effective care surgery in the perioperative period of bariatric surgery for assistance. In view of the above, we can conclude by saying that knowledge and information is of fundamental importance and training of the patient in the preoperative period of bariatric surgery.

## I. INTRODUCTION

According to the World Health Organization (WHO) (2020), obesity is considered a global public health problem and relates to the death of 2.8 million people per year. Despite showing stories from the Paleolithic Era about "big men", the prevalence of obesity is still at an epidemic level across all continents (GONÇALVES, 2010).

Furthermore, worldwide, more than 1.9 billion people over the age of 18 are overweight. Furthermore, 650 million people are obese and more than 340 million children are overweight or obese, according to the WHO (2020).

The successive rise in the prevalence of obesity in the world is a reflection of modern society such as economic growth, change in society's lifestyle, and the modernization of interpersonal relationships promoted by globalization and urbanization (SIPPEL; et al, 2014).

Faced with globalization, food quality has undergone a major transformation, including an abusive increase in the consumption of free sugars and fats, a high disproportion of saturated fats and products of animal origin with insufficient fruits and vegetables (SANTOS, 2012). The tendency towards a sedentary lifestyle, due to great technological advances and modernization, also promotes the advancement of obesity (SANTANA, 2014).

Obesity is seen as a chronic condition, with a predicted evolution (hypertension, type II diabetes mellitus), where multiple factors participate in its etiology. Furthermore, the treatment must go through several approaches, including nutritional, drug and, above all, physical activity (SANTOS, 2012). Despite this, most individuals are not responsive to more conservative treatments, thus requiring a more effective intervention such as bariatric surgery, due to all attempts at the aforementioned methods having been exhausted (SOUSA, 2019).

In addition, there is the Metabolic Syndrome (MS) that has been increasing its prevalence due to the increasing lifestyle and obesity in the world. Despite its importance in the context of metabolic and cardiovascular diseases, few studies in Brazil have evaluated its

prevalence and its determinants, restricting the quality of information on the magnitude of the problem in the country (SCHILD; SANTOS; ALVES, 2013).

Aligning the treatment of obesity and Metabolic Syndrome (MS) has high social relevance as it directly impacts quality of life, family, work and the expenditure of avoidable expenses and suffering (DINIZ and GONÇALVES, 2020). MS is a complex of interrelated risk factors for cardiovascular disease, type II diabetes mellitus, arterial hypertension, dyslipidemia and increased abdominal circumference, thus increasing the risk of death (BEZERRA and OLIVEIRA, 2013).

The correlation between bariatric surgery, type II diabetes mellitus and MS needs to be detailed, as there are patients with metabolic syndrome who are still prediabetic, and the long-term results point to a very complete resolution of comorbidities. Changing habits with healthy diets, regular physical exercises and monitoring by a multidisciplinary team should be emphasized as a continuous process (BORDALO; et al, 2011).

Bariatric and metabolic surgery proves to be a great ally against obesity, however, it needs more studies to reaffirm its condition to offer safe treatment and good results in the short and long term. Therefore, the perioperative period represents the starting point for sensitizing patients to the future changes that will occur (CUNHA et al, 2020).

Several surgical techniques have been developed in the last 50 years and the advent of laparoscopic surgery has increased its safety and efficacy (SANTANA, 2014). Currently, the increasing and successful use of new techniques and maneuvers has been responsible for several changes in established treatment paradigms (ARAÚJO, 2022).

The surgical treatment of obesity and MS is based on the principle of precise indication within the parameters already defined by the Ministry of Health via the National Health Agency and corroborated by the Brazilian Society of Bariatric and Metabolic Surgery (BRASIL, 2018). Also guided by the Federal Council of Medicine, which approved the surgery as no longer experimental, for type II diabetes mellitus, indicated for patients with a BMI between 30 and 34.9 kg/m<sup>2</sup>, therefore being able to

encompass a large number of patients with MS, resulting in thus having a positive impact on the future (SILVA, 2021).

To maximize the results of bariatric surgery, it is necessary to position a coherent multidisciplinary team, in which all members decide holistically and in agreement with the patient's psychological, nutritional and health conditions, whether or not to recommend surgery (REZENDE, 2011). In addition, the team must be in constant communication to exchange information, since the isolated work does not process the objective achieved, as it does not conceptualize all the individual's points of view, which makes the evaluation and performance of all qualified individuals essential. of the team to monitor the client as a whole from the preoperative period.

Given this context, the repercussions of bariatric surgery in morbidly obese and, due to the lack of publications on surgical treatment in obese individuals and, related to the preoperative period, the objective of this study is to analyze the importance of the construction and dissemination of a booklet on the perioperative period of bariatric and metabolic surgery.

## II. METHOD

This is a descriptive, qualitative study carried out through an integrative literature review (ILR). To carry out the bibliographic review, searches were carried out in the following databases: repositories of Universities, Virtual Health Libraries, PubMed, Journals, Magazines, Federal Laws and Ordinances Scientific Electronic Library Online (SCIELO) and Online System of Search and Analysis of Literature Medical (MEDLINE).

The study included articles related to the theme of the project, articles with Portuguese language, free online access to the full text between the years 2012 to 2022. As

exclusion criteria, scientific productions with English and Spanish language and that were not complete and outside the established year were discarded. The descriptors used in the research were: bariatric surgery, health education, health booklet.

When crossing the descriptors, bariatric and metabolic surgery and health education with filters, several articles were found, of these sixteen (16) references followed according to the inclusion criteria and that present the importance of knowledge about bariatric and metabolic surgery in the perioperative period, as well as a report of several experiences that resulted in a framework to build a booklet aimed at eligible bariatric surgery patients.

## III. RESULTS

The results were analyzed through content analysis according to Bardin (2006). The RIL should be developed from three phases: pre-analysis, exploration of the material and treatment of results, inference and interpretation.

The essence of the integrative review is the categorization of studies. In this sense, the results are presented and the information discussed in a descriptive way and through the construction of synoptic tables (BARBOSA et al., 2011). Thus, for a better analysis, the data were synthesized from their characterization of the themes that emerged from the scientific evidence found, with the description and classification of each article in order to gather the knowledge produced on the theme explored in the review (POLIT; BECK, 2011).

The definition of references considered the information related to the descriptors, authors, year, research title, type of study, subjects and the results found described in table 1.

Table 1: References used to prepare the RIL

AUTOR	TÍTULO	TIPO DE ESTUDO	DESCRITORES	ANO
GOZZO. T.O	Informações para Elaboração de um Manual Educativo as Mulheres com Câncer de Mama	Descritivo exploratório	Neoplasia De Mama, Enfermagem, Cirurgia, Educação Em Saúde	2012
OMS	World Obesity Federation. Obesity and overweight	Descritivo exploratório	Obesity, Overweight.	2012
DODT, RCM.; XIMENES, L B; ORIÁ, MOB.	Validação de Album Seriado para Promoção do Aleitamento Materno	Estudo de Validade Aparente e De Conteúdo.	Materiais de Ensino, Aleitamento Materno, Estudos de Validação, Alojamento	2012

			Conjunto	
FELIX, L. G.; SOARES, M.J. G. O.; NÓBREGA, M. L.	Protocolo de Assistência de Enfermagem ao Paciente em Pré e Pós-Operatório de Cirurgia Bariátrica	Estudo Transversal	Enfermagem, Auto- Cuidado, Cirurgia Bariátrica, Protocolos de Enfermagem	2012
MOREIRA. LB.	Construção e Validação de uma Cartilha Educativa Sobre Cuidados no Perioperatório de Cirurgia Bariátrica	Pesquisa Bibliográfica	Obesidade, Cirurgia Bariátrica, Educação em Saúde.	2015
KELLES, S. M. B., DINIZ, M. D. F. H. S., MACHADO, C. J., & BARRETO, S. M.	Perfil de Pacientes Submetidos a Cirurgia Bariátrica, Assistidos pelo Sistema Único de Saúde do Brasil: Revisão Sistemática	Revisão Sistemática	Cirurgia Bariátrica, Derivações Gástricas, Perfil de Saúde.	2015
SOUZA, V. E. C.	Desenvolvimento e Validação de Software Para Apoio ao Ensino Aprendizagem Sobre Diagnósticos em Enfermagem	Dissertação	Enfermagem, Diagnóstico de Enfermagem, Tecnologia, Validação de Programas de Computador,	2015
MOREIRA. LB.	Efetividade da Cartilha “Cirurgia Bariátrica:Cuidados Para Uma Vida Saudável” no Preparo Pré- Operatório: Ensaio Clínico Randomizado Pragmático	Ensaio Clínico Randomizad o Controlado	Obesidade, Cirurgia Bariátrica, Enfermagem, Tecnologia Educacional, Educação em	2017
TUCCI, M.M.	Comunicação e Saúde: Percepções Sobre a Cirurgia Bariátrica na Esfera Pública e Mídias Digitais.	Dissertação	Cirurgia Bariátrica, Comunicação Pública, Relações Públicas, Mídias Digitais.	2017
BEAMISH, A. J.; REINEHR, T.	Should Bariatric Surgery be Performed in Adolescent?	Descritiva	Bariatric surgery, Severe Obesity	2017
CHAIM,E.A.; PAREJA, J.C.; GESTIC, M.A.; UTRINI,M.P.; CAZZO, E.	Programa Multidisciplinar de Assistência Pré- Operatória para Cirurgia Bariátrica: Uma Proposta Para o Sistema Público de Saúde do Brasil	Estudo Prospectivo Comparativo	Obesidade, Cirurgia Bariátrica, Derivação Gástrica, Saúde Pública.	2017
BRASILIA	Política Nacional de Promoção da Saúde	Documental	Política Nacional de Promoção da Saúde	2018
TEIXEIRA, B. N.; DE RESENDE, L.	Relação Entre Cirurgia Bariátrica e Fertilidade	Revisão	Hormônio anti- mulleriano; Fertilidade;	

C., BIGNOTO, L. L. C.; BATISTA, M. M., & TURCI, M. A	Feminina: Uma Revisão Sistemática	Sistemática	Cirurgia Bariátrica; Mulheres	2019
MINISTÉRIO DA SAÚDE	Vigilância de Fatores de Risco para Doenças Crônicas por Inquérito Telefônico nas capitais dos 26 estados brasileiros e no Distrito Federal	Documental	Doenças Crônicas, Vigilância Sanitária, Serviços de Saúde.	2019
SOEIRO, R. L., VALENTE, G. S. C., CORTEZ, E. A., MESQUITA, L. M., XAVIER, S. C. D. M., & LOBO, B. M. I. D. S	Educação em Saúde em Grupo no Tratamento de Obesos Grau III: um Desafio para os Profissionais de Saúde	Revisão Integrativa	Obesidade Mórbida, Enfermagem, Educação Em Saúde, Atenção Primária a Saúde.	2020
CUNHA, C. S. O.; CUNHA, T. A. S.; LIRA, R. B.; SOUZA, L. L. B., & RODRIGUES, T. C. M. M	Impactos Psicológicos em Pacientes Submetidos à Cirurgia Bariátrica	Pesquisa Bibliográfica Tipo Exploratória	Cirurgia-Bariátrica, Impactos Psicológicos, Psicologia	2020

#### IV. DISCUSSION

Among the references cited in table 1, in relation to the year of publication, there was one article from 2018, two articles from 2019, two from 2020 and three articles from 2015, four from 2012 and four articles from 2017, all published in Brazil. All the selected production is part of the health area, presenting diversity in relation to the research context, in which the theme involved the importance of building and disseminating a booklet on the perioperative period of bariatric and metabolic surgery. In addition, publications with health professionals and the multidisciplinary team being cited.

The reading of all the scientific production chosen made it possible to contemplate the researchers' concern in the adoption and development of resources that facilitate communication and in the implementation of effective care surgery in the perioperative period of bariatric surgery for assistance.

It was evidenced in the references found that the highest prevalence, between genders, was female (76.6%), although, according to WHO data (2018), the increase in the incidence of obesity is occurring in both sexes, regardless of the social class and cultural level.

With regard to comorbidities associated with obesity, all studies (9 100%) refer to Diabetes Mellitus type

II as the most prominent, followed by systemic arterial hypertension and smoking. According to Mayrink (2021), obesity determines important functional implications in the population, more recent studies indicate that insulin resistance is associated with abdominal obesity.

Regarding the age group, 81.25% of the publications mention that the average age group is 40 years old, although in recent decades, with the changes, obesity has advanced in all age groups and social classes, with a significant impact on women inserted in the strata. with lower income (GONÇALVES; ASCIUTTI & CAVALCANTI, 2010).

As for the presence of MS, of the studies studied, it was evidenced that 52.2% consider Diabetes Mellitus (DM) to be a condition with a strong correlation with MS, obese people have a good knowledge of the problems that obesity can cause them, however, have unhealthy behaviors, such as sedentary lives and poor eating at irregular times (KLIER; ARCANJO & DE SOUZA, 2021).

Similar to what is observed in the literature, the prevalence of comorbidities was high. Rangel et al (2020), reported percentages of AH in 60%, followed by DM 2 in 10% of patients. However, Soero et al (2020) revealed higher values in DM 2 with 35%. One aspect that deserves to be highlighted is the considerable improvement in the



conditions of the operated patients. In addition, 13 references cite that the vast majority of patients can discontinue the use of antihypertensive drugs and all had normal levels. Confirming these findings, Moreira (2015) reports that with a follow-up of at least one year, they reported cure in 72.7% of DM 2 and 65.4% of AH. The improvement in glucose metabolism can be explained by the severe nutrient deprivation that occurs after surgery, providing weight loss and negative energy balance, conditions that classically improve glucose tolerance (BORDALO; MOURÃO & BRESSAN, 2011).

The main doubts and fears are related to the operating room, how the surgery is performed and what the anesthesia is like. Another strongly present concern is the fear of weight regain and the occurrence of complications in the postoperative period (BELELI, 2011). In the weight loss analysis, a reduction compatible with literature data was identified. In an evaluation, a weight reduction of 37.5% was observed after the first year of surgery. On the other hand, they found lower percentages in this period (30.69%). Several researchers found that weight reduction is greater in the first six months, becoming slower and more continuous, until reaching an average loss of 35 to 40% of the initial weight between the 12th and 24th month of the surgery (COELHO; FONTELA; WINKELMANN, 2016).

Regarding the practice of physical activity, none of the conditions may be occurring regularly before the surgery. Another highlight refers that after the surgical procedure, 34.4% of the patients performed physical activity in relation to the cited publications. In addition, only 15% of the studies showed that according to the postoperative period and the closer the weight loss to the desired ideal activity, the greater the lack of interest of this population in the practice of physics.

Therefore, patient education is important to help them make decisions about bariatric surgery (GOZZO, 2012). Several studies have reported the effect of preoperative education on lifestyle changes after surgery (CHAIM et al, 2017). It is worth mentioning that educational strategies as a measure of health promotion make it possible to carry out self-care, considering that patient education in preoperative preparation allows for the identification of individuals' needs, in addition to representing the opportunity to resolve doubts and assist them. him to deal with his expectations regarding the surgical procedure and with the challenge of experiencing the postoperative period (CAMBI; MARCHESINI & BARETTA, 2015).

The level of evidence of the studies must be evaluated in order to determine the confidence in the use

of their results and to strengthen the conclusions that will generate the current state of knowledge of the investigated topic (POLIT; BECK, 2011). These results confirm that bariatric surgery was an effective procedure to promote weight loss and its maintenance for two years, without the occurrence of low weight, as well as improvement of biochemical parameters and comorbidities, with clinical and nutritional symptoms reduced and/or avoided by monitoring specialized nutrition.

It was found that most studies were intended to contribute to increasing knowledge about obesity, bariatric surgery and perioperative care. A better qualification of the health professional implies a more effective assistance in which the patient is attended according to his needs and is able to make decisions about the treatment and the performance of self-care throughout the perioperative process. It is also imperative to highlight that the articles infer the importance of patient education to achieve good results throughout the postoperative period and the prevention of complications with greater well-being and a better quality of life.

In view of the presentation of the results obtained from the analysis of the studies selected for the integrative review, the role of each professional in the bariatric surgery team in guiding and educating the patient about the implications of the surgical procedure and the necessary care in each phase of the perioperative period is evident. In order to enable a better experience of each stage of treatment.

## V. CONCLUSIONS

This booklet should serve as educational and informative parameters for patients eligible for bariatric surgery, and should be widely disseminated in the relevant medical societies and serve as a reference for all who are interested in the subject. In addition, it must be updated periodically, as the subject evolves every year, shaping the growing changes in the scenario of world bariatric surgery. In order to further stimulate the continuous learning process, access will be free of cost to all.

Health education is an instrument for exchanging knowledge between health professionals and the population.

This leads to the search for the autonomy of the Being as a transforming element of its reality.

This is a complex involving the biological Being and its social contexts. (PEREIRA et al, 2015).

The attitude of an individual informed about their procedure, being guided and well informed, provides a

safer and more aware of the advantages and disadvantages of bariatric surgery and all the benefits that surgery brings.

In view of the above, we can conclude by saying that knowledge and information is of fundamental importance and training of the patient in the preoperative period of bariatric surgery. It is considered that the constructed product can also serve family members and health professionals who work with the subject or who are unaware of the subject, given that its content addresses the main information about bariatric surgery and perioperative care, being a reliable source of information. In this sense, the expectation is that the booklet constructed will be made available, disseminated and used by patients, family members and health professionals, being an instrument that enables health promotion, the development of skills and the favoring of autonomy and empowerment.

It is suggested to carry out other studies that aim to implement the educational booklet in consultations as an auxiliary method to provide information about the surgery and the necessary care, as well as to evaluate if the educational technology really allows learning, if it promotes behavior change, desired and whether the available content encourages the search for material to resolve doubts and favors adherence to treatment and postoperative follow-up.

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# The Brazilian criminal recidivism: Reflections under the perspective of the comparative law

## A reincidência criminal brasileira: Reflexões sob a perspectiva do direito comparado

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**Palavras-chave—** Reincidência Criminal, Aplicação Automática, Criminalidade, Direito Comparado, Reflexos, Direitos e Garantias Fundamentais.

**Abstract—** The criminal recidivism, aggravating circumstance of the penalty, is one of the oldest institutes of the Brazilian legal order and, although the uncouneted reforms on criminal and criminal procedural law in the course of history, it has suffered very few changes, predominating the automatic imposition in miscellaneous process stages under the justification of crime fighting, without a detailed analysis about the *modus operandi*, the real objectives and elements. Thus, the following study aims to address the thematic from the study of comparative law in order to demonstrate how the criminal recidivism is applied on the selected countries in this opportunity, what demonstrates several ways to ponder this penalty aggravating, that must be compatible with the respect to the democratic essence of the criminal procedural law, especially the Brazilian one, based on the prevalence of the fundamental rights and guarantees.

**Resumo—** A reincidência criminal, circunstância agravante da pena, é um dos institutos mais antigos do ordenamento jurídico brasileiro e, apesar das inúmeras reformas nas leis penais e processuais penais no decorrer da história, sofreu pouquíssimas alterações, prevalecendo a imposição automática em diversas fases do processo sob a justificativa de combate à criminalidade, sem uma análise contundente sobre o *modus operandi*, reais objetivos e fundamentos. Desta forma, o presente estudo visa a abordar a temática a partir do estudo do direito comparado a fim de demonstrar como a reincidência criminal é aplicada nos países ora selecionados, o que demonstra diversas formas de ponderar esse agravamento de pena, o



qual deve se compatibilizar com o respeito à essência democrática do processo penal, sobretudo brasileiro, pautado na prevalência dos direitos e garantias fundamentais.

## I. INTRODUÇÃO

A reincidência criminal sempre esteve presente na legislação brasileira e apresenta regras bastante peculiares, as quais ensejam discussões doutrinárias e jurisprudenciais. Tal instituto configura uma agravante obrigatória de pena, conforme artigo 61, I, do Código Penal, e acompanha a história do poder punitivo estatal produzindo diversos efeitos penais e processuais rigorosos no tratamento da pena e de seu cumprimento.

Está definido no artigo 63 da Parte Geral do Código Penal e é aplicado quando o réu comete uma nova infração penal, após a condenação definitiva por outra. Como regra geral, o legislador adotou a chamada reincidência ficta, ou seja, basta a condenação definitiva e não o cumprimento da sanção penal para caracterizá-la.

A reincidência criminal traz, sem dúvidas, consequências gravosas ao réu não só na dosimetria da pena, mas em vários momentos processuais, sendo questionado o efeito prático e se não apenas inflama uma realidade social de punição a qualquer custo. Sob a justificativa primeira da necessidade de reduzir e combater a criminalidade, com maior reprimenda àquele que se recusou em receber a ressocialização proposta pelo Estado e insistiu na prática delitiva, há décadas vem sendo aplicado esse instituto de forma automática.

Com a constitucionalidade questionada em controle difuso, em 4 de abril de 2013, no Recurso Extraordinário nº453.000/RS, em sede de repercussão geral, por unanimidade o Supremo Tribunal Federal julgou a favor da sua constitucionalidade. Vários foram os fundamentos que levaram à discussão e, ainda que considerada constitucional, os motivos que a mantêm no ordenamento jurídico são questionáveis e abrem a reflexão sobre a reformulação da forma como vem sendo aplicada.

Nesse contexto, apoia-se o presente estudo voltando-se às regras de alguns países, tratando a reincidência como um instituto internacional, o que revela que esse não possui um tratamento uniforme; em contrapartida, as altas taxas de reincidência nos mais diversos países estão em voga em quase todas as discussões doutrinárias e jurídicas. Portanto, os mais variados questionamentos em torno da reincidência não se concentram apenas em âmbito nacional, sendo de preocupação em diversos países, principalmente no que se refere aos fundamentos, aplicação e resultados práticos deste instituto.

Por meio do estudo comparado visa demonstrar como esse instrumento de controle penalsocial, que caminha ao lado do desenvolvimento da pena privativa de liberdade, por conseguinte, do fracasso da pena de prisão e sua função de tratamento ressocializador, é aplicado nos países selecionados e de que forma vem sido mantido e como foi redimensionado em alguns deles, tudo com o afim de refletir sobre o formato atual brasileiro e a compatibilização com o modelo estatal elegido.

O presente artigo é desenvolvido com base em pesquisa bibliográfica e documental, a partir do método dedutivo, e está estruturado em dois eixos principais, quais sejam, os aspectos gerais e relevância da reincidência criminal no Brasil e o *modus operandi* e algumas peculiaridades nos países selecionados. Por fim, vale mencionar que não se esgotará os temas envolvendo a reincidência, tampouco analisar-se-á esse instituto a partir do direito penal esmiuçado de cada país escolhido.

## II. A REINCIDÊNCIA CRIMINAL NO BRASIL: ASPETOS GERAIS E RELEVÂNCIA

Desde o Código Criminal de 1830, a reincidência está inserida no ordenamento jurídico pátrio como uma forma de agravar a pena. Nesse primeiro Código estava prevista no artigo 16, §3º (Ter o delinquente reincidido em delicto da mesma natureza)e, ainda, no artigo 282 do Capítulo II da Parte Quarta intitulado Sociedades Secretas com a previsão de dobro da pena no caso de reincidência.

Ao longa da história, esse instituto sofreu poucas alterações e a mais significativa foi a advinda com a Lei nº7.209/84, que reformulou a Parte Geral do Código de 1940, sendo elas: para cessar os efeitos da reincidência o período de prova do *sursis* ou do livramento condicional entrou na contagem (artigo 64, I); foi adotado o sistema vicariante, excluindo a medida de segurança ao reincidente, ou seja, imputável, rechaçando a periculosidade presumida do reincidente em crime doloso; vedou-se a suspensão condicional da pena apenas aos reincidentes em crimes dolosos.

Mesmo sendo um instituo antigo, conforme Eugenio RaúlZaffaroni (1996), é muito difícil proporcionar um conceito satisfatório de reincidência em âmbito internacional, por várias razões, tais como a centralização em torno da discussão sobre a diferença entre reincidência genérica e específica, ficta ou real, bem como a sistematização em alguns países de institutos próximos



(multirreincidência, habitualidade profissional e por tendência).

No Código Penal vigente é conceituada no artigo 63: “verifica-se a reincidência quando o agente comete novo crime, depois de transitar em julgado a sentença que, no país ou no estrangeiro, o tenha condenado por crime anterior.” Apesar desse conceito prevalecer, vale, todavia, ponderar que Salo de Carvalho (2001) observa que o Código Penal não define reincidência, apenas indica as condições pelas quais ela pode ser verificada.

Como natureza jurídica, pode ser definida como uma causa de agravante de pena, ou seja, um dado que embora não faça parte da estrutura do crime é apontado como importante para aferir a maior culpabilidade do agente.

Quanto às espécies de reincidência, a doutrina as distingue da seguinte maneira:

a) reincidência genérica, absoluta, geral ou heterogênea: quando há o cometimento de um delito, depois de ter sido o agente condenado e submetido à pena por outro delito. Em outras palavras: “[...] ocorre quando os crimes praticados pelo agente são previstos em dispositivos legais diversos, configurando natureza distinta.” Essa é a posição adotada pelo Brasil (ALMEIDA, 2012, p. 70).

b) reincidência específica, especial ou homogênea: quando exige a prática de um novo delito igual, ou da mesma categoria, daquele pelo qual sofreu anterior condenação. É o “ato de o agente perpetrar novamente crime da mesma natureza daquele pelo qual foi, anteriormente, condenado por sentença transitada em julgado. Era designada também de reincidência especial” (DINIZ, 2008, p. 135).

A dificuldade enfrentada pela doutrina estava exatamente em definir o que significava essa especificidade, ‘crimes de igual natureza’, isto é, se eram aqueles previstos no mesmo dispositivo legal ou que apresentavam *caracteres fundamentais comuns*.

Com a Reforma da Parte Geral de 1984, o conceito de reincidência específica havia sido abandonado. Antes da reforma, o artigo 47 do Código Penal determinava a aplicação da pena acima da metade da soma do mínimo com o máximo e, dentre as cominadas alternativamente, e a mais severa em caso de penas cominadas alternativamente. Desta feita, os delitos da mesma natureza eram aqueles previstos no mesmo tipo penal ou, ainda, em dispositivos diversos, contudo, com elementos comuns. Pelo fato de o termo específico ter conotação bastante ampla, gerou diversos significados.

No entanto, a reincidência específica foi novamente introduzida no ordenamento jurídico por outras legislações: I) Lei nº8.072/90 (Crimes Hediondos), que acrescentou o inciso V no artigo 83 do Código Penal para – é considerado reincidente específico aquele que pratica, nos termos já explicados, outro crime previsto na lei referida; II) Lei nº11.705/2008 que alterou a redação do artigo 296 da Lei nº9.503/97 (Código de Trânsito Brasileiro); III) Lei nº9.714/98 que alterou o artigo 44 do Código Penal passando a prever a reincidência específica ao proibir a substituição da pena privativa de liberdade por uma alternativa em caso de cometimento de mesmo crime. Entretanto, nesse caso, reincidente específico será o reincidente em crime previsto no mesmo tipo incriminador (furto e furto, lesão corporal culposa e lesão corporal culposa, etc); IV) Lei nº9.605/98 (Lei dos Crimes Ambientais); V) Lei nº11.343/2006 (Lei de Drogas).

c) Reincidência ficta ou imprópria: quando há a prática de um delito depois de ter sido condenado por outro. É, pois, a “perpetração de outro crime, pelo agente, após o trânsito em julgado da sentença que o condenou por prática de delito anterior” (DINIZ, 2008, p. 135). Nesse caso, “a denúncia, o processo, o julgamento e a condenação não deixam também de ser advertência ao criminoso, que revela pertinácia e menosprezo pela Justiça” (NORONHA, 1963, p. 326). É essa espécie a vigente no sistema jurídico-penal brasileiro, também considerada a mais rigorosa, pois basta a simples decisão condenatória definitiva, não se exigindo o cumprimento da pena (ALMEIDA, 2012).

d) reincidência real, própria ou verdadeira: consiste no cometimento de um delito depois de ter sido condenado e “sofrido pena”, por um delito anterior. Ocorre “[...] quando o réu delinque, após haver cumprido, no todo ou em parte, pena por crime anterior” (NORONHA, 1963, p. 326).

e) reincidência facultativa e obrigatória: a primeira é aplicada de acordo com o livre convencimento motivado do órgão julgador, e a segunda sempre que os requisitos legais estiverem preenchidos (ASSIS, 2016).

f) reincidência nacional: quando é cometido o novo delito após a sentença penal condenatória transitada em julgado advinda de delito cometido no território nacional brasileiro.

g) reincidência internacional: quando há sentença condenatória transitada em julgado internacional e o sujeito comete crime posterior a essa. Interessante observar que nem toda sentença estrangeira deve gerar a reincidência, pois analisa-se se a conduta também é típica no Brasil, se houve o devido processo legal e se o país da

condenação admite a reincidência. Nas lições de Eugenio Raúl Zaffaroni (2004, p. 720):

Não seria possível condenar como reincidente no Brasil uma pessoa condenada na Colômbia, porque a legislação deste país não admite a reincidência. Não seria possível condenar como reincidente uma pessoa anteriormente condenada em multa penal na Argentina, porque a legislação deste país exclui expressamente os delitos apenados com multa.

O estudo de tais espécies facilita a compreensão quando da aplicação prática desse instituto e a comparação com a forma de aplicação em alguns países, conforme proposto. Da mesma forma, importante traçar diversas peculiaridades e efeitos práticos desse instituto, destacando-se os mais relevantes para o presente estudo.

Para ser aplicada a reincidência deve haver uma sentença condenatória, nacional ou estrangeira, transitada em julgada antes do cometimento do novo crime. Alguns critérios podem ser extraídos dessa regra. Inicialmente, como o artigo 63 do Código Penal se refere ao crime, a condenação anterior por contravenção penal afasta a reincidência, mas pode gerar maus antecedentes. “De conformidade com a lei contravencional, uma anterior condenação por delito dá lugar à reincidência contravencional (artigo 7º da Lei de Contravenções Penais), mas o inverso não” (ZAFFARONI, 2004, p. 719). Nessa linha, não se pode considerar reincidente aquele que foi condenado definitivamente por contravenção no exterior, por omissão de previsão para tanto.

Em relação à condenação por crime no exterior, a decisão não precisa ser homologada pelo Superior Tribunal de Justiça para gerar a reincidência, isto por que o artigo 9º do Código Penal não inclui essa hipótese no rol dos incisos.

O delito anterior pode tanto ser culposos quanto doloso, punido ou não com pena privativa de liberdade. Também não configura reincidência quando a punibilidade do delito anterior for extinta por anistia, *abolitio criminis*, ou morte do agente.

Não induz reincidência a sentença declaratória extintiva da punibilidade de perdão judicial, conforme previsão do artigo 120 do Código Penal e Súmula 18 do Superior Tribunal de Justiça (“A sentença concessiva do perdão judicial é declaratória da extinção da

punibilidade, não subsistindo qualquer efeito condenatório”).

Não se computam para efeitos de reincidência, conforme previsão do artigo 64, II, os delitos militares próprios, ou seja, “aqueles que só um militar pode cometer, por sua própria condição” (ZAFFARONI, 2004, p. 721) e os crimes políticos, não havendo menção se todos ou apenas os próprios, por isso, entende-se que todos os delitos políticos não geram os efeitos da reincidência.

Os institutos despenalizadores da Lei nº 9.099/95, quais sejam, a transação penal, a suspensão condicional do processo e a transação penal não geram a reincidência, “pois visam evitar a abertura de um processo ou a sua continuidade” (ALMEIDA, 2012, p. 76).

No que tange à pena pecuniária, apesar de a lei não distinguir a pena para caracterizar a reincidência, entende-se que a pena de multa não a enseja, pois essa sequer é impeditiva de *sursis*. “Para ser considerado reincidente o delinquente deve preencher os critérios técnico-jurídicos do instituto” (ALMEIDA, 2012, p. 78).

Há reincidência quando o novo delito é cometido por reabilitado, isto porque a reabilitação não extingue a condenação anterior, conforme o artigo 95 do Código Penal.

Em relação ao princípio da insignificância, discute-se se seria possível aplicá-lo aos reincidentes. O princípio da insignificância exclui a tipicidade material do delito, segunda vertente da tipicidade conglobante, com a finalidade de afastar da tutela do direito penal, de *ultima ratio*, bens jurídicos inexpressivos, não havendo ofensa relevante para se valer da sanção penal.

O Supremo Tribunal Federal, no julgamento dos HC nº 123.7324, nº 123.108 e nº 123.533, a fim de uniformizar a jurisprudência do Supremo Tribunal Federal sobre a matéria, firmou o entendimento de que a aplicação ou não do princípio da insignificância deve ser analisada caso a caso pelo juiz de primeira instância<sup>1</sup>, considerando os seguintes critérios: o reconhecimento da mínima ofensividade, a inexistência de periculosidade social, o reduzidíssimo grau de reprovabilidade e a inexpressividade da lesão jurídica provocada.

No que tange aos reincidentes, as turmas do STF têm se manifestado no sentido de afastar a aplicação do princípio da insignificância (HC 97.007/SP, rel. Min. Joaquim Barbosa, Segunda Turma, DJe 31.3.2011; HC 101.998/MG, rel. Min. Dias Toffoli, Primeira Turma, DJe 22.3.2011; HC 103.359/RS, rel. Min. Cármen Lúcia, Primeira Turma, DJe 6.8.2010, e HC 112.597/PR, rel. Min. Cármen Lúcia, Segunda Turma, DJe 10.12.2012), contudo, há também o entendimento de que é possível aplicar o referido princípio de acordo com as particularidades do

caso concreto. A exemplo, no julgamento do HC 176563/SP (Rel. Min. Gilmar Mendes, j. 15.10.2019), foi aplicado o princípio da insignificância e concedida a ordem a um homem preso por roubar de um supermercado uma caixa de chocolates, um caixa de balas e uma de refresco em pó, totalizando R\$ 126,36, sendo os produtos recuperados no mesmo dia.<sup>2</sup> Diversos são os argumentos e não cabe analisá-los no presente estudo.

Outro aspecto relevante é o fato de a reincidência penal não pode ser considerada circunstância agravante e, simultaneamente, circunstância judicial, conforme entendimento sumulado do STF - Súmula 241.

Importante abordar, ainda, o sistema da temporalidade adotado pelo Código Penal com a Lei nº 6.416/77, a qual excluiu o da perpetuidade e fixou o prazo de 5 anos para depurar a reincidência. Conforme prevê o artigo 64, I, não prevalece a condenação anterior, se decorreu mais de 5 anos entre a data do cumprimento ou extinção da pena e a data da infração posterior, computando-se o período de prova da suspensão ou livramento condicional, se não houver revogação.

Denominado de período depurador, o prazo legal fixado visa eliminar a perpetuidade da reincidência, portanto, da pena, estigmatizadora na vida do condenado e, ainda, proibida pela Constituição Federal no artigo 5º, XLVII, 'b'.

Contudo, nesse aspecto, não há um consenso sobre a influência ou não da reincidência já purificada na dosimetria da pena. Há divergência jurisprudencial.

O Superior Tribunal de Justiça, em diversos julgamentos, entendeu que as condenações anteriores transitadas em julgado e já depuradas, quando da reincidência, podem ser utilizadas como maus antecedentes, permitindo a exasperação da pena-base acima do mínimo legal<sup>3</sup>. Como se vê:

Muito embora o artigo 64 do CP tenha eliminado o estado perpétuo da reincidência (que havia sido abarcado pela redação originária de 1940), esta eterna estigmatização ainda permanece na figura dos maus antecedentes. No que tange às suas consequências, esta seria, aparentemente, menos gravosa ao acusado comparativamente à reincidência, não fosse sua infundável condição (SILVA, 2014, p. 59).

Já o Supremo Tribunal Federal decidiu de forma diferente, ou seja, que a condenação anterior ao período depurador do artigo 64, I, do Código Penal não pode ser utilizada seja para fins de reincidência, seja a título de maus antecedentes e, ainda, que não se pretende induzir ao raciocínio de que a pessoa que já sofreu condenação penal terá registros criminais valorados pelo resto da vida, mas que, havendo reiteração delitiva, a depender do caso concreto, o juiz poderá avaliar essa sentença condenatória anterior.<sup>4</sup> Essa questão foi considerada de Repercussão Geral no RE593818/SC, em 2602.2009, de relatoria do Min. Joaquim Barbosa, o qual foi substituído pelo Ministro Luís Roberto Barroso, em 26.06.2013. Até o momento não há pronunciamento definitivo sobre a questão<sup>5</sup>.

Por fim, para o presente estudo é importante destacar as inúmeras restrições ou efeitos penais e processuais penais oriundos da reincidência, sempre agravando a situação do réu. A partir do momento em que o réu é considerado reincidente, o tratamento processual passa a ser mais rigoroso, da investigação criminal à execução penal, seja com agravamento da pena ou com restrições de benefícios.

Esses efeitos estão relacionados à própria finalidade e ao fundamento da reincidência como instrumento de política criminal no ordenamento jurídico pátrio. Desde a primeira concepção da reincidência no direito pátrio, sua finalidade transpareceu como uma tentativa de sancionar de forma mais rigorosa o sujeito que, uma vez recebendo a reprimenda, não trouxe o resultado antes esperado.

A reincidência, pois, é vista como uma forma de reafirmar a função punitiva do Estado em prol da segurança pública. Contudo, na aplicação deste instituto desconsidera-se se houve ou não um erro estatal quando do exercício do seu poder de punir e ressocializar, atribuindo-se, exclusivamente, ao sujeito processado toda responsabilidade pela sua reincidência. Parte-se, então, do pressuposto, de que apenas o condenado recidivo merece ser mais rigorosamente sancionado, sendo única responsabilidade do sujeito que cometera o novo delito.

Cumprido, então, elencar, não de forma exaustiva, as consequências graves da reincidência na legislação pátria. O Código Penal traz a previsão basilar da reincidência. Além do conceito, dispõe sobre regras gerais que vão refletir em todo o processo penal.

São elas:

a) impede que o regime inicial de cumprimento da pena seja o aberto ou semiaberto, salvo tratando-se de pena de detenção (artigo 33, §2º, b e c, do Código Penal)<sup>6</sup>;

b) impede a substituição da pena privativa de liberdade por uma restritiva de direitos ou multa, na hipótese de crime doloso (artigo 44, II, artigo 60, §2º do Código Penal);

c) pode provocar a conversão da pena substitutiva por uma privativa de liberdade (artigo 44, §5º, do Código Penal).

d) agrava a pena do condenado em quantidade indeterminada dentro dos limites da sanção cominada (artigo 61, I, do Código Penal);

e) é preponderante no concurso de circunstâncias agravantes (artigo 67, última parte, Código Penal), contudo, em decisão proferida pelo Superior Tribunal de Justiça no Recurso Especial nº1.341.370 – MT (2012/0180909-9) houve o entendimento de que, na segunda fase do cálculo da pena, a agravante de reincidência deve ser compensada com a confissão espontânea, uma vez que essa refere-se à personalidade do agente, sendo, portanto, igualmente preponderantes;

f) impede a concessão do *sursis*, ou suspensão condicional da pena ao reincidente doloso (artigo 77, I, do Código Penal);

g) aumenta o prazo de efetiva privação de liberdade para o livramento condicional (artigo 83, II, do Código Penal);

h) produz a revogação obrigatória da suspensão condicional da pena na hipótese de condenação por crime doloso (artigo 81, I, Código Penal);

i) faculta a revogação da suspensão condicional da pena na hipótese de crime culposos ou por contravenção penal, desde que não imposta pena privativa de liberdade (artigo 81, §1º, Código Penal);

j) proíbe a concessão de livramento condicional se a reincidência é específica em crimes hediondos e assemelhados (artigo 83, V, do Código Penal);

k) revoga obrigatoriamente o livramento condicional, sobrevivendo condenação à pena privativa de liberdade (artigo 86 do Código Penal);

l) faculta a revogação do livramento condicional, em caso de crime ou contravenção, se não imposta pena privativa de liberdade (artigo 87 do Código Penal);

m) revoga a reabilitação, quando sobrevier condenação à pena que não seja de multa (artigo 95 do Código Penal);

n) aumenta um terço o prazo prescricional da pretensão executória (*caput* do artigo 110 do CP);

o) interrompe a prescrição (artigo 117, VI, do Código Penal);

p) impede o perdão judicial e a aplicação de pena de multa no crime de apropriação indébita previdenciária (artigo 168-A, §3º, do Código Penal);

q) impede o perdão judicial e a aplicação de pena de multa no crime de sonegação de contribuição previdenciária (artigo 337-A, §2º, do Código Penal);

r) impede o reconhecimento de algumas causas de diminuição da pena, como nas hipóteses dos artigos 155, §2º (furto privilegiado); 170 e 171, §1º; 175, §2º; 180, §5º do Código Penal);

No Código de Processo Penal, a Lei 13.964/2019 trouxe regras novas, dentre elas o §2º do artigo 310 (“Se o juiz verificar que o agente é reincidente ou que integra organização criminosa armada ou milícia, ou que porta arma de fogo de uso restrito, deverá denegar a liberdade provisória, com ou sem medidas cautelares.”). A respeito, Guilherme de Souza Nucci (2020, p. 80) entende que no tocante à reincidência a medida é excessiva, pois deve ser analisado o crime que gerou a reincidência, portanto, em certas situações entende possível medidas alternativas.

O artigo 313, II, do CPP, inserido com a Lei nº12.403 de 2001, prevê que a prisão preventiva poderá ser decretada se o réu tiver sido condenado por outro crime doloso, em sentença transitada em julgado, ressalvado o disposto no inciso I do Código Penal.

“A lei não distingue se o crime posterior é apenado com detenção ou reclusão, mas o anterior necessariamente deve ser doloso”, explica Marco Antonio Marques da Silva (2012, p. 496). Importante destacar que, “reincidente em crime doloso, para os fins da disposição, é qualquer cidadão que praticar crime, sempre crime, não se cogita de contravenção penal, com pena máxima, igual ou inferior a 4 (quatro) anos” (2012, p. 496), reitera o desembargador.

Diversas legislações especiais também enaltecem a necessidade de mais rigor aos reincidentes. Destacam-se, em seguida, algumas delas para demonstrar esta afirmação.

Na Lei de Contravenções Penais (Decreto-Lei nº3.688/41), a reincidência: a) aumenta de um terço até metade a pena de contravenção penal de porte de arma se a condenação precedente for por violência contra a pessoa (artigo 19, §1º, da Lei de Contravenções Penais); b) possibilita a ocorrência da contravenção de posse não justificada de instrumento de emprego usual na prática de furto (artigo 25 da Lei de Contravenções Penais).

O artigo 76, §2º, I, da Lei nº9.099/95 impossibilita a transação penal nas infrações de menor



potencial ofensivo aos reincidentes, bem como impede a suspensão condicional do processo no artigo 89, *caput*.

O Código de Trânsito Brasileiro (Lei nº9.503/97, artigo 296) dispõe que se o réu for reincidente em crimes de trânsito, poderá ter a suspensão da permissão ou da habilitação para dirigir veículo automotor.

No artigo 90, §2º, da Lei nº9.504/97 determina que se dobre as penas pecuniárias previstas na lei em caso de reincidência.

Em relação aos crimes ambientais, a Lei nº9.605/98 prevê que a reincidência nos crimes de natureza ambiental é uma circunstância que agrava a pena, quando não constitui ou qualifica o crime (artigo 15, I).

Na Lei 10.826/2003 (Estatuto do Desarmamento) foi acrescentado também o inciso II ao artigo 20 pela Lei 13.964/2019 com a previsão de que a pena é aumentada da metade nos crimes dos artigos 14, 15, 16, 17 e 18, se o agente foi reincidente específico.

Na Lei de Execução Penal (Lei nº7.210/84), a reincidência é visualizada nos seguintes dispositivos: a) artigo 52 – constitui falta grave e sujeita o preso, ou condenado, à sanção disciplinar, sem prejuízo da sanção penal; b) artigo 118, I – ocasiona a regressão de regime de cumprimento de pena; c) artigo 112, que com as alterações inseridas pela Lei 13.964/2019, traz regras bem mais rigorosas para progressão de regime ao reincidente; d) artigo 127 – revoga até 1/3 do tempo remido.

A Lei de Drogas (Lei nº11.343/06) também traz regras específicas ao reincidente. O artigo 28, inserido no Capítulo III – Dos Crimes e das Penas – traz a previsão do portar droga para uso próprio e, apesar de as penas serem peculiares, medidas educativas, a condenação prévia por esse delito é capaz de gerar a reincidência. O §4º regulamenta que em caso de reincidência, as penas previstas nos incisos II e III do *caput* serão aplicadas por, no máximo, 10 meses, dobro da pena aplicada aos não reincidentes.

Vale mencionar, que a respeito do artigo 28 da Lei de Drogas, o Supremo Tribunal Federal, por meio do RE nº635659, está apreciando a (in)constitucionalidade desse dispositivo, já com dois votos a favor da inconstitucionalidade.

E, o artigo 44, parágrafo único, da Lei nº11.343/06 dispõe que nos crimes previstos no *caput*, o livramento condicional será dado após o cumprimento de dois terços da pena, sendo vedada a concessão ao reincidente específico. Esta é mais uma restrição decorrente da reincidência.

Após esse panorama sobre a reincidência criminal brasileira, verifica-se que no Brasil esse instituto é sempre aplicado de forma automática e no intuito de agravar a situação da pena do réu. Passa, então, a realizar

uma comparação de como a reincidência está prevista e é aplicada nos países ora selecionados a seguir.

### III. ESTUDO NO DIREITO COMPARADO E A POSSIBILIDADE DE NÃO APLICAÇÃO AUTOMÁTICA

No estudo do direito brasileiro, relevante destacar a legislação estrangeira a fim de se comparar de que modo determinado instituto vem sendo pensado e evoluído. A partir disso, é possível extrair novas ideias positivas e excluir concepções ultrapassadas.

Com essa finalidade, serão apresentadas as previsões pesquisadas sobre a reincidência em alguns países. A seleção ocorreu direcionada aos países que de alguma forma influenciaram o Brasil na previsão da reincidência ou que são mencionados pelos autores brasileiros estudados.

Esclarece-se que não é nosso objetivo esgotar todos os temas envolvendo a reincidência, tampouco analisar esse instituto a partir do direito penal esmiuçado de cada país citado. Nosso objetivo é demonstrar que a reincidência existe em outros países e é aplicada de forma diferente do previsto no Brasil.

#### 3.1 Itália

A Itália teve uma importantíssima contribuição doutrinária para a formação da reincidência como a atualmente conhecemos nos ordenamentos de herança romano-germânica.

O Código Penal Italiano é dividido em três livros (Infrações em Geral; Crimes em Particular e Dos Crimes em Particular) e cada livro é composto por diversos títulos que se subdividem em capítulos. A reincidência está inserida no Livro I – *Dei reati in generale*, no Título IV – *Del reo e della persona offesadal reato* (art. 85-131) – (Do infrator e da vítima do crime) e, finalmente, no Capítulo II: *Della recidiva, della abitudine e della professionalità nel reato e della tendenza a delinquere* – (Da reincidência, da habitualidade e profissionalismo no crime e da tendência ao crime), com previsões dos artigos 99 a 109.

Na Itália foi adotada, como no Brasil, a reincidência ficta (artigo 99)<sup>7</sup> no Código de Rocco (1930), antes da reforma de 2002, que depois foi mantida. Também é adotada a reincidência específica<sup>8</sup> e o sistema da perpetuidade, o que demonstra rigor no tratamento de recidiva:

O CP italiano, acatando o critério permanente, afirma sua independência em relação ao tempo transcorrido a partir do crime precedente. A



independência, porém, não é absoluta, uma vez que o tempo não é de todo irrelevante para a determinação da gravidade da reincidência (JESUS, 2007, p. 570).

Aplica-se a reincidência facultativa na Itália, assim como em Portugal (ASSIS, 2004). Para Guilherme de Souza Nucci, a reincidência na Itália é tratada com maior severidade, pois há três formas de reincidência:

- a) Simples: aumenta de um sexto a pena posterior se o réu pratica crime após a condenação criminal definitiva;
- b) Agravada: cometimento de um novo crime da mesma natureza ou quando cometido o crime dentro de cinco anos após a condenação anterior. E, ainda, quando é cometido novo crime no decorrer da execução da pena por delito anterior ou em período de fuga, aumenta-se, então a pena em um terço; se concorrer mais de uma dessas circunstâncias será de metade o aumento da pena (NUCCI, 2007, p. 213 e 219).
- c) Reiterada: quando o réu que cometeu o crime já era considerado reincidente, aumentando-se a pena de até metade se reincidente simples e até dois terços se agravada e, ainda de um terço a dois terços quando reincidente em período de execução de pena ou fuga, conforme artigo 99, parte final do Código Penal italiano (CHIQUEZI, 2009, p. 63)<sup>9</sup>.

### 3.2 Portugal

O Código Penal de Portugal regulamenta a reincidência trazendo regras um tanto interessantes para sua configuração, apresentando critérios mais detalhados que os brasileiros.

Presente no conjunto de 389 artigos, a reincidência é regulamentada no artigo 75, inserido na Seção II do Capítulo IV (Escolha e medida da pena) do Título III (Das consequências jurídicas do fato), tudo do

Livro I (Parte geral) – (PORTUGAL. Código Penal de Portugal. Disponível em: <<http://www.pgdlisboa.pt>>. Acesso em: 2 mar. 2020).

Adota-se a reincidência ficta, porém, para configurar a reincidência deve haver o requisito formal, ou seja, o cometimento de um crime doloso com pena efetiva superior a 6 meses, após condenação transitada em julgado também com pena de prisão efetiva superior a 6 meses.

Interessante, no entanto, é que o juiz não aplicará a reincidência de forma automática, como no Brasil. Há o requisito material e cabe ao magistrado analisar se a pena anterior não fora suficiente para evitar a prática de novos delitos pelo agente<sup>10</sup>. Aliás, esse requisito deve ser fundamentado, conforme se afere na jurisprudência portuguesa<sup>11</sup>. Não se pode deixar de citar o maior rigor nos casos de reincidência específica, tangente ao tráfico de drogas<sup>12</sup> e quando a personalidade se volta ao crime de forma reiterada<sup>13</sup>.

Há também o período depurador de 5 anos para a aplicação da reincidência, computando-se após o cumprimento da medida processual, pena ou medida de segurança privativas de liberdade, consoante pressuposto 2 do artigo 75<sup>14</sup>. É necessário comprovar nos autos a data do cometimento do crime anterior, sob pena de faltar um pressuposto formal à configuração da reincidência<sup>15</sup>.

O pressuposto 3<sup>16</sup> enumera que o crime cometido no exterior apenas servirá para a reincidência se também for crime na lei portuguesa. E o 4 menciona que “a prescrição da pena, a amnistia, o perdão genérico e o indulto, não obstam à verificação da reincidência”.

O artigo 76<sup>o</sup> dispõe que em caso de reincidência a pena será aumentada de um terço, sem alteração do limite máximo. Ademais, o aumento não pode exceder a pena mais grave aplicada nas condenações anteriores. Ainda, “as disposições respeitantes à pena relativamente indeterminada, quando aplicáveis, prevalecem sobre as regras da punição da reincidência”.

No que se refere à pena relativamente indeterminada, é uma regra inserida nos artigos 83 a 89 do Código Penal aplicável, por exemplo, àqueles que cometem crime doloso por tendência, com pena privativa superior a dois anos, após cometer anteriormente dois ou mais crimes dolosos com pena de prisão privativa superior a dois anos, com a avaliação conjunta dos fatos praticados e da personalidade do autor para tanto<sup>17</sup>.

### 3.3 Alemanha

A Alemanha, em 1986, extinguiu a reincidência (ASSIS, 2008, p. 76),<sup>18</sup> “por considerar contrária ao princípio da culpabilidade” (PUIG, 2002, p. 618 – nota de rodapé). Interessante que, quando a reincidência era prevista no ordenamento jurídico alemão, existia apenas para alguns crimes da Parte Especial e se

configurava com a exigência de duas condenações anteriores, aliada à comprovação de que as admoestações formais anteriores não foram eficientes.

Importante, contudo, notar que a reincidência, apesar de extinta na Alemanha, mantém-se viva e influencia na dosimetria da pena, pois é considerada quando da análise dos antecedentes do infrator no §46, II, em que a vida pregressa do agente deve ser considerada para a fixação da pena (DECOMAIN, 2014, p. 175), o que é questionado pela doutrina alemã, pois se o réu reitera na prática delituosa demonstrando especial periculosidade, a ele deve ser aplicada a *Sicherungsverwahrung*— Custódia de Segurança, conforme §66 StGB (ASSIS, 2014).

A esse respeito, importante destacar:

Em tema de medidas de segurança aplicáveis a pessoas inteiramente imputáveis, o CPA prevê a internação em um estabelecimento de desintoxicação, a detenção preventiva, que também poderia ser designada como internação em estabelecimento para delinquentes habituais, o acompanhamento de conduta, a supressão da licença para dirigir veículos automotores, e a proibição do exercício de profissão. Destinam-se todas a prevenir a reiteração criminosa e podem ser aplicadas juntamente com a pena criminal correspondente ao ilícito cometido. O rol das medidas de segurança consta do §61 do CPA (DECOMAIN, 2014, p. 21).

A aplicação das medidas de segurança tem prazos predefinidos pelo Código Penal, a depender da hipótese de aplicação, havendo, inclusive previsão de acompanhamento do condenado.

### 3.4 Espanha

O Código Penal Espanhol – *Ley Orgánica* 10/1995<sup>19</sup> – regulamenta a reincidência no artigo 22, 8ª, sendo uma circunstância agravante que sempre existiu no ordenamento jurídico espanhol<sup>20</sup>. Configura reincidência na Espanha quando o réu comete novo crime do mesmo título do Código Penal<sup>21</sup>, sempre da mesma natureza, após o trânsito em julgado da primeira condenação.

Observa-se, então, que vigora na Espanha a reincidência específica, havendo dificuldade de conceituá-

la. Contudo, o Tribunal Supremo espanhol já decidiu que crimes da mesma natureza são aqueles que “não só violam o mesmo bem jurídico, mas também lançam mão do mesmo modo de ataque”(ASSIS, 2014).

A Espanha adotou a reincidência ficta, já que não exige o cumprimento total ou parcial da pena da condenação anterior. E, ainda, os efeitos da reincidência não são perpétuos, visto que os antecedentes criminais cancelados, de acordo com as regras do Código Penal, não serão considerados, nem aqueles que correspondam aos delitos leves (PUIG, 2002, p. 618).

O artigo 66.1, 5ª regra, dispõe sobre a multirreincidência ou reincidência qualificada ao prever que aquele reincidente que acumule três condenações anteriores transitadas em julgado por fatos da mesma natureza e compreendidos no mesmo Título, quando da quarta condenação, o juiz poderá aplicar pena superior ao limite máximo previsto em lei, desde que justifique de acordo com a gravidade do novo delito, não se computando os antecedentes cancelados. Essa espécie de reincidência foi introduzida com a reforma penal da Lei Orgânica 11/2003, com a justificativa da necessidade de fortalecer a segurança do cidadão (VILCHES, 2015).

Para o cancelamento dos antecedentes, o Código Penal Espanhol especifica no artigo 136 que é necessário: a) a reparação do dano, salvo impossibilidade de fazê-lo, b) transcurso do seguinte tempo, sem o cometimento de novos crimes – b.1) seis meses para penas leves; b.2) dois anos para as penas que não excedam doze meses e as cominadas a crimes culposos; b.3) três anos para outras penas menos graves inferiores a três anos; b.4) cinco anos para as penas graves, igual ou superior a três anos e b.5) dez anos para as penas graves, todos com início da contagem após o dia seguinte ao da extinção da pena.

O Supremo Tribunal da Espanha decidiu em 6 de abril de 1990<sup>22</sup> que “a pena imposta ao reincidente não pode ultrapassar o marco da culpabilidade pelo fato. Assim, fixada essa medida, atendendo-se às exigências de prevenção, pode-se elevar a pena por conta da reincidência”(PUIG, 2002, p. 619 e NUCCI, 2007, p. 219)<sup>23</sup>.

A reincidência na Espanha, por fim, traz vários reflexos, pois o reincidente não tem o direito de suspensão condicional da pena, conforme previsão do artigo 80.2, regra 1ª, com exceção dos crimes culposos e dos crimes leves, revoga a liberdade condicional prevista no artigo 93 e exclui a possibilidade de indulto. E, ainda, ao reincidente pode ser aplicada medida de segurança, conforme dispõe o artigo 95 e seguintes do Código Penal.

### 3.5 França

O Código Penal Francês regulamenta a reincidência criminal na “Subsección 2: De las penas aplicables en caso de reincidencia”, artigos 132-8 a 132-16-2.

Nesses artigos é possível extrair que a França adota a reincidência ficta e genérica, com aumentos diferenciados aos reincidentes, considerando a quantidade da pena privativa de liberdade aplicada no primeiro crime e a pena máxima prevista para o segundo (CHIQUEZI, 2009).

De acordo com o artigo 132-8, se a pessoa física é condenada por sentença transitada em julgado por um crime com pena de 10 anos de prisão e comete outro crime com pena máxima de 20 e 30 anos, terá os efeitos da perpetuidade e a prisão perpétua decretada.

Ademais, quando a pessoa sentenciada por um crime com pena de dez anos de prisão, comete outro delito, no prazo de dez anos a contar do cumprimento ou da prescrição da pena deste, com a mesma pena, essa será duplicada ao máximo das penas de prisão e multa aplicáveis.

Se a pessoa for condenada a dez anos de prisão, ao cometer um novo delito, no prazo de cinco anos, o qual tenha pena superior a um ano e inferior a dez, a pena será duplicada no máximo das penas de prisão e da multa aplicável<sup>24</sup>.

### 3.6 Argentina

Na Argentina também está previsto o instituto da reincidência criminal nos artigos 50 a 53 (Título VIII do Primeiro Livro) do Código Penal<sup>25</sup>, destacando-se algumas regras que serão aqui abordadas.

O sistema adotado é o da temporariedade (JESUS, 2007, p. 569), com a regra de que não haverá reincidência após o mesmo tempo da pena executada, com o limite mínimo de cinco anos e máximo de dez anos<sup>26</sup>.

A esse respeito, ressalta-se:

O que possui limite temporal é a eficácia da condenação anterior como exigência necessária para o sujeito adquirir a qualidade de reincidente. É que se contém na Exposição de Motivos dos deputados argentinos que modificaram o Projeto de 1906, que não previa limite temporal da condenação para efeito de reincidência: “Aplicando o Projeto de 1906, condenado o delinquente uma vez, deverá estar perpetuamente submetido às

suas consequências, ainda que sua vida posterior tenha sido honesta. O direito de acusar prescreve, as penas também. Por que não há de prescrever o *antecedente* do crime, quando uma vida posterior honrada demonstrou o reajustamento do sujeito? Propomos, para que essa prescrição se opere, os mesmos prazos que regem a extinção das penas pelo transcurso do tempo (JESUS, 2007, p. 570).

Outrossim, o Código Penal Argentino adota o critério da reincidência real, já que para configurá-la o autor deve já ter cumprido, total ou parcialmente, pena privativa de liberdade em crime anterior. A pena de multa isolada não é considerada para fins de reincidência, tampouco a condenação por contravenção penal.

É admissível a reincidência internacional, desde que por força do delito praticado seja possível a extradição, segundo a lei argentina<sup>27</sup>. Não há reincidência de delitos políticos, militares próprios, anistiados e cometidos por menores de 18 anos de idade<sup>28</sup>.

O artigo 51 regulamenta o direito de registro penal, com regras sobre o resguardo de informações com a existência de processos penais, a fim de que a divulgação de certos dados prejudique a vida dos indivíduos.

O artigo 52<sup>29</sup> dispõe sobre a reclusão por tempo indeterminado em caso de reincidência múltipla ou multirreincidência, ou seja, quando o sujeito acumula reincidências. Isso ocorre quando o sujeito pratica quatro crimes em que pelo menos um tenha pena privativa de liberdade superior a três anos ou quando comete cinco crimes punidos com pena privativa de liberdade, com três anos de pena ou menos. Vale destacar que “un punto discutido es la reclusión por tiempo indeterminado, ya que vulneraría los principios de legalidad y proporcionalidad” (VILCHES, 2015, p. 22).

O parágrafo final do artigo 52 traz a possibilidade da suspensão dessa medida acessória uma única vez, e de acordo com o que dispõe o artigo 26.

O artigo 53<sup>30</sup> traz a possibilidade de o juiz conceder a liberdade condicional ao réu, depois de transcorridos cinco anos do cumprimento da reclusão acessória (pena indeterminada), sempre que o condenado tenha mantido boa conduta, demonstrando aptidão e hábito para o trabalho e as demais atitudes que revelem que ele não será um perigo à sociedade. Depois de 5 anos de liberdade condicional, o condenado poderá alcançar a

liberdade definitiva. Se violar qualquer das condições estabelecidas no artigo 13 – condições da liberdade condicional – (como por exemplo: não cometer novos delitos), terá revogado o benefício e reintegrado ao regime carcerário anterior e, apenas, após 5 anos poderá solicitar novamente a liberdade condicional.

Por fim, registra-se que a reincidência na Argentina foi objeto de análise da Corte Suprema de Justicia de la Nación decidindo esta pela constitucionalidade do instituto, com apenas o voto divergente do Ministro Zaffaroni (TEIXEIRA, 2015, p. 154 - Nota: Recurso de Hecho, causa 6457/2009, j.05-02-2013).

### 3.7 Colômbia

“Por último, existem legislações que eliminaram o conceito de reincidência, como o fez o Código da Colômbia<sup>31</sup>, de 1980” (ZAFFARONI, 2004, p. 716). Um dos argumentos que levou o país a eliminar a reincidência foi a ausência de um fundamento que não ferisse o princípio do *ne bis in idem*.

Apesar do apontamento de que a reincidência na Colômbia foi extinta, observa-se na Parte Especial do Código Penal a menção da recidiva, como, por exemplo, no crime de contrabando (artigo 319<sup>32</sup>), a qual aumenta da metade até três quartos a pena do reincidente, devendo ser específica. Mesmo assim, a reincidência não é aplicada, pois a doutrina colombiana vem afirmando que há uma nítida afronta ao princípio da legalidade inserido no artigo 6<sup>o</sup><sup>33</sup> do mesmo Código e que esse deve prevalecer sobre a regra da parte especial. Da mesma forma, mencionada interpretação está em consonância com o artigo 29-2<sup>34</sup> da Constituição da Colômbia que trata também da legalidade.

A reincidência nesse país também aparece no Código Penitenciário e Carcerário (Lei nº65/93), como um dos critérios de separação dos internos (artigo 63) – (VILCHES, 2015, p. 25).

### 3.8 Estados Unidos da América

Os Estados Unidos da América (EUA) possuem uma política criminal altamente repressiva (ALMEIDA, 2012, p. 105) e mesmo assim o índice de reincidência criminal é de 77%, de acordo com os dados estatísticos levantados pelo Departamento de Justiça que acompanhou, durante 5 anos, a vida de 404.638 ex-detentos que deixaram o sistema prisional em 2005<sup>35</sup>.

De acordo com essa pesquisa, destaca João Ozorio de Melo (2015, n.p.):

O levantamento feito para o estudo revelou que, nesse período de cinco anos, a polícia realizou cerca de 5,5 milhões de prisões de

membros dessa população de 404.638 prisioneiros, que representam 75% de todos os prisioneiros libertados no país em 2005. Muitas dessas prisões podem envolver mais de um tipo de acusação, como um crime violento e tráfico de drogas — ou delitos menores.

Para conter a criminalidade, diversos modelos de repressão foram criados nos EUA. A Teoria das Janelas Quebras (*Broken Windows Theory*), conforme LoïcWacquant (2001), criada em 1982 por James Q. Wilson (papa da criminologia conservadora nos Estados Unidos) e George Kelling, traduz o ditado popular de “quem rouba um ovo, rouba um boi”, para defender que é combatendo os pequenos delitos que se evita as grandes patologias criminais. Seguindo a mesma linha repressiva, surge na década de 1990 a política de Tolerância Zero (*Zero Tolerance*), em Nova York, elaborada por Rudolph Guiliani, prefeito da época, e por William Bratton, chefe de polícia, com a promessa de conter a criminalidade, reforçando veementemente as medidas de prevenção delitiva. Essa política alimentou uma sensação de insegurança para se justificar e apresentou reflexos sociais vultosos, como a superlotação de presídios e a sobrecarga do Poder Judiciário. Com certeza, esses movimentos desenfreadam a reincidência criminal, com a punição em demasia dos pequenos delitos.

É a *Three Strikes and You're Out*, todavia, que mais reflete na produção da reincidência criminal. Foi criada pela lei californiana *Proposition 184*, em março de 1994, após o sequestro e assassinato de Polly Hannah Klaas, de 12 anos, cometido por um reincidente, Richard Allen Davis, e teve como escopo trazer a perpetuidade da reincidência. Daniel Silva Boson (2015, p. 20) faz uma análise econômica dos efeitos da reincidência nos Estados Unidos da América. No ano de 2000 a lei sofreu alterações, pela *Proposition 36*, no sentido de trazer menos rigor aos usuários de drogas, permitindo o seu tratamento no lugar de prisão perpétua; no ano de 2011, foi permitida a possibilidade de liberdade condicional e de penas menos severas aos condenados por crimes não violentos ou graves e, no ano de 2012, limitou a prisão perpétua em razão da terceira condenação em crimes graves ou violentos. É possível aferir a preocupação com os altos custos gerados pelo sistema prisional em contrapartida a baixa efetividade.

## IV. CONSIDERAÇÕES FINAIS



Diante da pesquisa exposta, conclui-se que a reincidência criminal não é tratada de forma unívoca internacionalmente. É prevista no ordenamento jurídico de outros países, a exemplo dos destacados neste estudo, cada qual com requisitos próprios, que ora se assemelham ora se diferenciam da legislação brasileira, e em alguns países foi extinta. Assim, a discussão sobre os alcances desse instituto e os efeitos produzidos não é isolada e também repercute em decisões dos Tribunais de diversos países.

Desta forma, o estudo da reincidência criminal a partir do direito comparado demonstra que, assim como no Brasil, em outros países esse instituto também torna mais gravosa a pena àqueles que reiteram na prática delitiva, trazendo certas peculiaridades as quais foram destacadas.

Nesse contexto, foi possível observar que em algumas legislações exige-se a quantificação da pena do crime anterior, caso do Código Penal português, ou no caso americano em que há um agravamento que se alinha a teoria da tolerância, em que após o terceiro fato (*Three Strikes Laws*) a pena pode ser agravada na forma do “inimigo”. No mesmo sentido é o artigo 52 do Código argentino em que a quantificação é de quatro condenações.

O fato é que o aumento de pena tem por escopo o desestímulo a nova infração, seja a prática de novo crime ou do mesmo, contudo, não é admitido desvincular-se da aplicabilidade efetiva da pena imposta, com a promessa de reinserção social e cumprimento do “contrato social”. Mesmo com toda estrutura legal para individualização da pena e a punição mais rigorosa aos reincidentes, o encarceramento continua demonstrando sua ineficácia.

Por outro lado, não se pode considerar pessoas diferentes de formas iguais neste momento, porém a regra automática da reincidência presente em diversos dispositivos, conforme foi abordado, retira a possibilidade de analisar detidamente caso a caso, o que gera discussões doutrinárias e jurisprudências.

Toda sociedade é dinâmica, por isso mesmo, repensar o instituto, sua finalidade e aplicabilidade deve ser um desafio a ser enfrentado por juristas. Não se trata apenas da questão de constitucionalidade, mas de adequação entre a norma e sua finalidade.

Ainda que declarada constitucional, merece continuar sendo hermeneuticamente interpretada para que atenda seus fins maiores, ancorados nos direitos e garantias fundamentais dos quais não se pode declinar, pois essa é a garantia de uma sociedade democrática e um Estado, de fato, de direito.

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<sup>2</sup><https://www.conjur.com.br/dl/gilmar.pdf>

<sup>3</sup>AGRAVO REGIMENTAL NO AGRAVO EM RECURSO ESPECIAL. MOEDA FALSA. DOSIMETRIA. CONDENAÇÃO DEFINITIVA ALCANÇADA PELO PERÍODO DEPURADOR DA REINCIDÊNCIA. POSSIBILIDADE DE SER SOPESADA COMO MAUS

ANTECEDENTES. RELATIVIZAÇÃO. CASO CONCRETO. INVIABILIDADE. AGRAVO REGIMENTAL DESPROVIDO.

1. O acórdão proferido pelo Tribunal a quo está em conformidade com a posição das Turmas que compõem a Terceira Seção do Superior Tribunal de Justiça, as quais têm firme orientação de que o período depurador previsto no art. 64, inciso I, do Código Penal, afasta a configuração da agravante da reincidência, mas não constitui óbice à avaliação negativa da circunstância judicial dos antecedentes. Precedentes. 2. Na Sexta Turma, há julgados no sentido de que os maus antecedentes, quando os registros da folha de antecedentes forem muito antigos, podem sofrer relativização, admitindo-se o afastamento de sua análise desfavorável, em aplicação à teoria do direito ao esquecimento (REsp 1.707.948/RJ, Rel. Ministro ROGERIO SCHIETTI CRUZ, DJe 16/04/2018). No entanto, nem mesmo a possibilidade de relativização indicada acima pode ser aplicada no caso em tela. 3. Não é exorbitante o transcurso do prazo de pouco menos de 7 (sete) anos entre a extinção da punibilidade do crime anterior e o cometimento do novo delito. 4. In casu, não transcorreram 7 (sete) anos entre a extinção da punibilidade da condenação que gerou os maus antecedentes e o delito referente aos presentes autos. E ainda, nesse interregno, houve a prática de outro delito, o qual inclusive, deu ensejo à aplicação da agravante da reincidência. 5. Agravo regimental desprovido. (AgRg no AREsp 1483975 / SP AGRAVO REGIMENTAL NO AGRAVO EM RECURSO ESPECIAL 2019/0111843-1, Relatora: Ministra LAURITA VAZ, SEXTA TURMA, DJe 02/06/2020)

Disponível em: <<http://www.stj.jus.br>>. Acesso em: 10 jun. 2020.

PENAL E PROCESSUAL. AGRAVO REGIMENTAL NO RECURSO ESPECIAL. ROUBO. EXASPERAÇÃO DA PENA-BASE. CONDENAÇÃO ANTERIOR. DECURSO DO PRAZO PREVISTO NO ARTIGO 64, I, DO CÓDIGO PENAL. MAUS ANTECEDENTES. CONFIGURAÇÃO. 1. Segundo a jurisprudência deste Superior Tribunal, condenações anteriores transitadas em julgado, alcançadas pelo prazo depurador de 5 anos do artigo 64, I, do Código Penal, embora afastem os efeitos da reincidência, não impedem a configuração de maus antecedentes, permitindo a exasperação da pena-base acima do mínimo legal. 2. Não tendo a confissão sido considerada na formação da convicção da autoria e materialidade do delito, não caracteriza violação do artigo 65, III, "d", do Código Penal a negativa de atenuação da pena. 3. Agravo regimental a que se nega provimento. (AgRg no REsp 1500382/SP, Rel. Min. GURGEL DE FARIA, QUINTA TURMA, j.25-08-2015, DJe 11/09/2015) Disponível em: <<https://ww2.stj.jus>>. Acesso em: 8 maio 2020). AGRAVO REGIMENTAL NO RECURSO ESPECIAL. ROUBO E EXTORSÃO. ANÁLISE DAS PROVAS DOS AUTOS. NÃO OCORRÊNCIA. PENAL. DOSIMETRIA. CONDENAÇÃO ANTERIOR COM TRÂNSITO EM JULGADO. MAIS DE CINCO ANOS. PERÍODO DEPURATIVO. NÃO CARACTERIZAÇÃO DE REINCIDÊNCIA. UTILIZAÇÃO COMO MAUS ANTECEDENTES. POSSIBILIDADE. ROUBO E

EXTORSÃO. CONTINUIDADE DELITIVA. IMPOSSIBILIDADE. DELITOS DE ESPÉCIES DISTINTAS. AGRAVO REGIMENTAL A QUE SE NEGA PROVIMENTO.

1. A reavaliação dos elementos probatórios constantes da denúncia, sentença e do acórdão recorridos, não implicam revolvimento das provas dos autos, sendo admissível na via do especial para fins de fixação da interpretação da legislação federal. Precedentes. 2. "Segundo entendimento desta Corte, o período depurador de cinco anos afasta a reincidência, mas não retira os maus antecedentes" (HC 281.051/MS, minha relatoria, SEXTA TURMA, DJe 28/11/2013). Súm. 83/STJ. 3. Conforme entendimento desta Corte, não há continuidade delitiva entre os delitos de roubo e extorsão, porque de espécies diferentes. 4. Agravo regimental a que se nega provimento. (AgRg no REsp 1531323/SP AGRAVO REGIMENTAL NO RECURSO ESPECIAL 2015/0112426-5, Rel. Min. MARIA THEREZA DE ASSIS MOURA (1131), Órgão Julgador T6 – SEXTA TURMA, Data do Julgamento 16/06/2015, Data da Publicação/Fonte DJe 25/06/2015) Disponível em: <<http://www.stj.jus.br>>. Acesso em: 8 mar. 2020. PENAL. AGRAVO REGIMENTAL NO RECURSO ESPECIAL. PENA-BASE. MAUS ANTECEDENTES. CONDENAÇÃO COM TRÂNSITO EM JULGADO. PENA EXTINTA. PERÍODO DEPURADOR. MAUS ANTECEDENTES. MAJORAÇÃO DA PENA-BASE. POSSIBILIDADE. RÉU REINCIDENTE. SUBSTITUIÇÃO DA PENA. NÃO PREENCHIMENTO DOS REQUISITOS. ARTIGO 44, II E III, DO CP. AGRAVO IMPROVIDO. 1. As condenações atingidas pelo período depurador de 5 anos, previsto no artigo 64, I, do Código Penal, afastam os efeitos da reincidência, mas não impedem o reconhecimento dos maus antecedentes. 2. Não se substitui a pena privativa de liberdade por pena restritiva de direitos, quando o réu for reincidente em crime doloso ou desfavoráveis as vetoriais do artigo 59 do Código Penal, a indicar que não se mostre suficiente para a repressão do delito. 3. Agravo regimental improvido. (AgRg no REsp 1229970/SP AGRAVO REGIMENTAL NO RECURSO ESPECIAL 2010/0218753-8, Rel. Min. NEFI CORDEIRO (1159), Órgão Julgador T6 – SEXTA TURMA, j.19-11-2015, Data da Publicação/Fonte DJe 03/12/2015) Disponível em: <<http://www.stj.jus.br>>. Acesso em: 10mar. 2020.

<sup>4</sup> **Ementa:** Habeas corpus. 2. Tráfico de entorpecentes. Condenação. 3. Aumento da pena-base. Não aplicação da causa de diminuição do §4º do artigo 33, da Lei nº11.343/06. 4. Período depurador de 5 anos estabelecido pelo artigo 64, I, do CP. Maus antecedentes não caracterizados. Decorridos mais de 5 anos desde a extinção da pena da condenação anterior (CP, artigo 64, I), não é possível alargar a interpretação de modo a permitir o reconhecimento dos maus antecedentes. Aplicação do princípio da razoabilidade, proporcionalidade e dignidade da pessoa humana. 5. Direito ao esquecimento. 6. Fixação do regime prisional inicial fechado com base na vedação da Lei 8.072/90. Inconstitucionalidade. 7. Ordem concedida. "As condenações transitadas em julgado há mais de cinco anos não poderão ser caracterizadas como maus antecedentes para efeito de fixação da pena, conforme previsão do artigo 64, I, do CP "Para efeito

de reincidência: I – não prevalece a condenação anterior, se entre a data do cumprimento ou extinção da pena e a infração posterior tiver decorrido período de tempo superior a 5 (cinco) anos, computado o período de prova da suspensão ou do livramento condicional, se não ocorrer revogação”. Esse é o entendimento da Segunda Turma, que, em conclusão de julgamento e por maioria, concedeu a ordem em “habeas corpus” para restabelecer a decisão do tribunal de justiça que afastara os maus antecedentes, considerada condenação anterior ao período depurador (CP, artigo 64, I), para efeito de dosimetria da pena — v. Informativo 778. **A Turma afirmou que o período depurador de cinco anos teria a aptidão de nulificar a reincidência, de forma que não poderia mais influenciar no “quantum” de pena do réu e em nenhum de seus desdobramentos.** Observou que seria assente que a “ratio legis” consistiria em apagar da vida do indivíduo os erros do passado, já que houvera o devido cumprimento de sua punição, de modo que seria inadmissível atribuir à condenação o “status” de perpetuidade, sob pena de violação aos princípios constitucionais e legais, sobretudo o da ressocialização da pena. A Constituição vedaria expressamente, na alínea b do inciso XLVII do artigo 5º, as penas de caráter perpétuo. Esse dispositivo suscitaria questão acerca da proporcionalidade da pena e de seus efeitos para além da reprimenda corporal propriamente dita. Nessa perspectiva, por meio de cotejo das regras basilares de hermenêutica, constatar-se-ia que, se o objetivo primordial fosse o de se afastar a pena perpétua, reintegrando o apenado no seio da sociedade, com maior razão dever-se-ia aplicar esse raciocínio aos maus antecedentes. Ademais, o agravamento da pena-base com fundamento em condenações transitadas em julgado há mais de cinco anos não encontraria previsão na legislação pátria, tampouco na Constituição, mas se trataria de uma analogia “in malam partem”, método de integração vedado em nosso ordenamento. Por fim, determinou ao tribunal de origem que procedesse à nova fixação de regime prisional, sem considerar a gravidade abstrata do delito, nos termos do artigo 33, §§2º e 3º, do CP. Vencidos os Ministros Teori Zavascki e Cármen Lúcia, que concediam parcialmente a ordem, apenas quanto à fixação do regime prisional. HC 126315/SP, rel. Min. Gilmar Mendes, 15.9.2015. (HC-126315). (Disponível em: <<http://www.stf.jus.br>>. Acesso em: 8 maio 2020). **HABEAS CORPUS 119.200 PARANÁ RELATOR: MIN. DIAS TOFFOLI PACTE(S): PEDRO LEMES IMPTE(S): DEFENSORIA PÚBLICA DA UNIÃO PROC.(A/S)(ES): DEFENSOR PÚBLICO-GERAL FEDERAL COATOR(A/S)(ES): RELATOR DO RESP Nº1376390 DO SUPERIOR TRIBUNAL DE JUSTIÇA – EMENTA:** Habeas corpus. Tráfico de entorpecentes. Dosimetria. Fixação da pena-base acima do mínimo legal em decorrência de maus antecedentes. Condenações extintas há mais de cinco anos. Pretensão à aplicação do disposto no inciso I do artigo 64 do Código Penal. Admissibilidade. Precedente. Writ extinto. Ordem concedida de ofício. 1. Impetração dirigida contra decisão singular não submetida ao crivo do colegiado competente por intermédio de agravo regimental, o que configura o não exaurimento da instância antecedente, impossibilitando o conhecimento do writ. Precedentes. 2. Quando o paciente não pode ser considerado reincidente, diante do transcurso de lapso temporal superior a cinco anos, conforme previsto no artigo 64, I,

do Código Penal, a existência de condenações anteriores não caracteriza maus antecedentes. Precedentes. 3. Writ extinto. Ordem concedida de ofício. (Julgado em: 11/02/2014, PRIMEIRA TURMA, Rel. Dias Tófolli). Disponível em: <[file:///C:/Users/Prof.%20Lisandra/Downloads/texto\\_205501002%20\(1\).pdf](file:///C:/Users/Prof.%20Lisandra/Downloads/texto_205501002%20(1).pdf)>. Acesso em: 8 maio 2020).

Ementa:

HABEAS

**CORPUS. MAUS ANTECEDENTES E REINCIDÊNCIA.**

INSTITUTOS DIVERSOS. PRECEDENTES. 1. A legislação penal é muito clara em diferenciar os **maus antecedentes** da **reincidência**. O art. 64 do CP, ao afastar os efeitos da **reincidência**, o faz para fins da circunstância agravante do art. 61, I; não, para a fixação da pena-base do art. 59, que trata dos **antecedentes**. 2. Não se pretende induzir ao raciocínio de que a pessoa que já sofreu condenação penal terá registros criminais valorados pelo resto da vida, mas que, havendo reiteração delitiva, a depender do caso concreto, o juiz poderá avaliar essa sentença condenatória anterior. 3. Habeas corpus indeferido. ( [HC 157881](#). Órgão julgador: **Primeira Turma**, Relator(a): **Min. MARCO AURÉLIO**, Redator(a) do acórdão: **Min. ALEXANDRE DE MORAES**, Julgamento: **12/11/2019**, Publicação: **03/02/2020**). Disponível em:

<<https://jurisprudencia.stf.jus.br/pages/search/sjur418219/false>>, Acesso em: 10 jun. 2020.

<sup>5</sup>EMENTA: MATÉRIA PENAL. FIXAÇÃO DA PENA-BASE. CIRCUNSTÂNCIAS JUDICIAIS. MAUS ANTECEDENTES. SENTENÇA CONDENATÓRIA EXTINTA HÁ MAIS DE CINCO ANOS. PRINCÍPIO DA PRESUNÇÃO DE NÃO-CULPABILIDADE. MANIFESTAÇÃO PELO RECONHECIMENTO DO REQUISITO DE REPERCUSSÃO GERAL PARA APRECIACÃO DO RECURSO EXTRAORDINÁRIO. (BRASIL. RE 593818 RG/SC SANTA CATARINA, REPERCUSSÃO GERAL NO RECURSO EXTRAORDINÁRIO, Rel. Min. JOAQUIM BARBOSA, j.26-02-2009, Publicação DJe-064 DIVULG 02-04-2009 PUBLIC 03-04-2009. EMENT VOL-02355-06 PP-01118. Disponível em: <<http://www.stf.jus.br>>. Acesso em: 8 jun. 2020).

<sup>6</sup>Destacam-se as seguintes lições “Convém ressaltar que, se a reclusão não exceder a 4 anos serão analisadas as circunstâncias judiciais do réu a fim de verificar se o regime recomendado será o fechado ou semiaberto. [...] Neste sentido, determina a Súmula 269 do STJ que “é admissível a adoção do regime prisional semi-aberto aos reincidentes condenados a pena igual ou inferior a quatro anos se favoráveis as circunstâncias judiciais.” (ALMEIDA, Débora de Souza de. **Reincidência criminal: reflexões dogmáticas e criminológicas**. Curitiba: Juruá, 2012, p.84).

<sup>7</sup>“Artigo 99 – Recidiva – Chi, dopo esserestatocondannato per un reato, ne commetteunaltro, puèsseresottoposto a un aumento fino ad unsestodella pena da infliggere per ilnuovo reato.” Tradução livre do autor: “Artigo 99. Quem, depois de ter sido condenado por um crime, comete outro, pode ser sujeito a um

aumento de até um sexto da pena a ser imposta para o novo delito.” (Disponível em: <<http://www.brocardi.it/codice-penale/titolo-iv/libro-primo/capo-ii/>>. Acesso em: 2 jun. 2020).

<sup>8</sup> Para efeitos da lei criminal, são considerados crimes da mesma natureza, não só aqueles que violam a mesma disposição de direito, mas também aqueles que, embora esperado para ser o contrário previstas no presente código ou por leis diferentes, no entanto, para a natureza dos factos que constituinte ou dos motivos que os levaram, têm, em casos concretos caracteres básicos comuns. Disponível em: <<http://www.brocardi.it/codice-penale/libro-primo/titolo-iv/capo-ii/art101.html>>. Acesso em: 2 jun. 2020.

<sup>9</sup>CHIQUEZI, Adler. **Reincidência criminal e sua atuação como circunstância agravante**. Dissertação de mestrado. Pontifícia Universidade Católica de São Paulo, São Paulo, 2009, p.63. E vide: “Artigo 99 [...] *La pena può essere aumentata fino allametà: 1) se il nuovo reato è della stessa indole; 2) se il nuovo reato è stato commesso in cinque anni dalla condanna precedente; 3) se il nuovo reato è stato commesso durante o dopo l'esecuzione della pena, ovvero durante il tempo in cui il condannato si sottrae volontariamente all'esecuzione della pena. Qualora concorran più circostanze fra quelle indicate al secondo comma, l'aumento di pena è della metà. Se il recidivo commette un altro delitto non colposo, l'aumento della pena, nel caso dicui al primo comma, è della metà e, nei casi previsti al secondo comma, è di due terzi. Se si tratta di uno dei delitti indicati all'articolo 407, comma 2, lettera a), del codice di procedura penale, l'aumento della pena per la recidiva [è obbligatorio e], nei casi indicati al secondo comma, non può essere inferiore ad un terzo della pena da infliggere per il nuovo delitto. In nessun caso l'aumento di pena per effetto della recidiva può superare il cumulo delle pene risultanti dalle condanne precedenti alla commissione del nuovo delitto o non colposo”.* –

Tradução livre: A pena pode ser aumentada até metade: 1) se o novo crime é da mesma natureza; 2) se o novo crime culposos foi cometido nos cinco anos após a condenação anterior; 3) se o novo crime foi cometido durante ou após a execução da pena, ou durante o tempo em que o condenado se subtrai voluntariamente a execução penal. Se concorrer mais de uma circunstância daquelas indicadas no número anterior, o aumento da pena poderá ser feito até a metade. Se o reincidente cometer outro delito intencional, o aumento da penalidade, no caso referido no primeiro parágrafo, é metade e, nos casos previstos no segundo parágrafo, é de dois terços. Se for um dos crimes indicados no artigo 407, parágrafo 2, letra a) do código de processo penal, o aumento da penalidade por reincidência [é obrigatório e], nos casos indicados no segundo parágrafo, não poderá ser menos de um terço da sentença a ser imposta pelo novo crime. Em nenhum caso o aumento da punição pelo efeito de reincidência pode exceder a acumulação das penas resultantes das condenações anteriores da comissão do novo crime culposos. Disponível em <<https://www.brocardi.it/codice-penale/libro-primo/titolo-iv/capo-ii/art99.html>>, Acesso em 15 de jun. de 2020.

<sup>10</sup> “Artigo 75º Pressupostos 1 – É punido como reincidente quem, por si só ou sob qualquer forma de participação, cometer um crime doloso que deva ser punido com prisão efectiva superior a 6 meses, depois de ter sido condenado por sentença transitada em julgado em pena de prisão efectiva superior a 6 meses por outro crime doloso, se, de acordo com as circunstâncias do caso, o agente for de censurar por a condenação ou as condenações anteriores não lhe terem servido de suficiente advertência contra o crime.” (BRASIL. Código Penal de Portugal. Disponível em: <<http://www.pgdlisboa.pt>>. Acesso em: 2 mar.2020).

<sup>11</sup> “1. Ac. Tribunal da Relação de Coimbra de 30-05-2012: 1. Para efeitos de reincidência exige-se a verificação dos seguintes pressupostos: a) Formais: o cometimento de um crime doloso que deva ser punido com prisão efetiva superior a seis meses; a condenação anterior, com trânsito em julgado, de um crime doloso, em pena de prisão superior a seis meses e o não decurso de mais de 5 anos entre o crime anterior e a prática do novo crime. b) Material: que se mostre que, segundo as circunstâncias do caso, a condenação ou condenações anteriores não serviram ao agente de suficiente advertência contra o crime; 2. O preenchimento do pressuposto material tem de assentar em factos concretos, não bastando a mera menção ao certificado de registo criminal; 3. Torna-se necessário explicitar, designadamente da motivação para a prática dos factos, de ausência voluntária de hábitos de trabalho e sobre a personalidade do arguido, que permitam concluir que entre os crimes pelos quais cumpriu prisão e o crime em apreciação, existe uma íntima conexão, nomeadamente em âmbito de motivos e forma de execução, relevantes do ponto de vista da censura e da culpa, que permita concluir que a reiteração radica na personalidade do arguido, onde se enraizou um hábito de praticar crimes, e a quem a anterior condenação em prisão efetiva não serviu de suficiente advertência contra o crime, e não um simples multioccasional na prática de crimes em que intervêm causas fortuitas ou exógenas. (grifo nosso – Disponível em: <<http://www.pgdlisboa.pt>>. Acesso em: 2 mar.2020).

<sup>12</sup> “Ac. STJ de 29-02-2012: I. O artigo 75.º do CP enuncia os requisitos da condenação a título de reincidência. Assim, constituem pressupostos formais da reincidência, para além da prática de um crime, “por si só ou sob qualquer forma de participação”: – que o crime agora cometido seja doloso; – que este crime, sem a incidência da reincidência, deva ser punido com pena de prisão superior a 6 meses; – que o arguido tenha sido condenado, por decisão transitada em julgado, também em pena de prisão efectiva superior a 6 meses, por outro crime doloso; – que entre a prática do crime anterior e a do novo crime não tenham decorrido mais de 5 anos, prazo este que se suspende durante o tempo em que o arguido tenha estado privado da liberdade, em cumprimento de medida de coacção, de pena ou de medida de segurança. II. Além daqueles pressupostos formais a verificação da reincidência exige, ainda, um pressuposto material: o de que, de acordo com as circunstâncias do caso, o agente seja de censurar por a condenação ou as condenações anteriores não lhe terem servido de suficiente advertência contra o crime. III. No caso sub judice, estão preenchidos todos os pressupostos formais da reincidência. Quanto ao pressuposto de



ordem material, estando em causa uma reincidência homogênea, ou específica, é lógico o funcionamento da prova por presunção em que a premissa maior é a condenação anterior e a premissa menor a prática de novo crime do mesmo tipo do anteriormente praticado (tráfico de estupefacientes): se o arguido foi condenado anteriormente por crimes do mesmo tipo e agora volta a delinquir pela mesma prática é liminar a inferência de que foi indiferente ao sinal transmitido, não o inibindo de renovar o seu propósito de delinquir. IV. Na verdade, se o que se pretende são provas que permitam fundamentar a convicção de que a condenação anterior não teve qualquer relevância na determinação posterior do arguido, então é particularmente legítimo o apelo a uma regra de experiência comum que nos diz que a condenação anterior não produziu qualquer inflexão na opção pela prática de crimes do mesmo tipo. Se em relação a uma criminalidade heterogênea ainda se pode afirmar a possibilidade de uma descontinuidade, ou fragmentação do sinal consubstanciado na decisão anterior, pois que o contexto em que foi produzida pode ser substancialmente distinto, provocando a falência das premissas para o funcionamento da presunção, não se vislumbra onde é que a mesma afirmação se possa produzir perante crimes do mesmo tipo. V. No caso, admitindo a relevância da confissão, importa, porém, considerar a densidade da ilicitude, expressa numa actividade já com uma estrutura organizativa rudimentar com o objectivo de tráfico de droga: o arguido era o vértice, ou seja, assumia a liderança de um grupo de pessoas que, com regularidade, transportava droga em quantidades apreciáveis com o objectivo de proceder posteriormente à sua revenda. VI. Significa o exposto que o apelo aos propósitos de prevenção geral, ou especial, são condicionados pelas concretas circunstâncias de culpa e ilicitude, que se revelam com um lastro denso. Efectivamente, é toda uma actividade organizada e regular em que o arguido desempenha um papel essencial e que colide com valores fundamentais da sociedade como é a saúde física e mental dos seus cidadãos. O arguido praticava tal actividade consciente do seu significado em termos de violação da lei e queria tal resultado como forma de obter um rendimento ilícito.” (Disponível em: <<http://www.pgdlisboa.pt>>. Acesso em: 2 mar.2020).

<sup>13</sup>“ Ac. TRC de 25-02-2015: V. Tratando-se de crimes de igual natureza, a descrição dos factos respeitantes ao percurso criminoso do arguido são, inexoravelmente, reveladores de que a sucumbência revelada pela prática do novo ilícito penal é consequência de uma qualidade desvaliosa que entronca na personalidade do agente e não já fruto de causas fortuitas/acidentais, exclusiva ou predominantemente exógenas que caracterizam a pluriocasionalidade, o que conduz à afirmação de uma culpa agravada por a condenação anterior não ter servido de suficiente advertência contra o crime e, assim, à verificação da modificativa agravante geral prevista no art. 75.º do CP.

<sup>14</sup>“2 – O crime anterior por que o agente tenha sido condenado não releva para a reincidência se entre a sua prática e a do crime seguinte tiverem decorrido mais de 5 anos; neste prazo não é computado o tempo durante o qual o agente tenha cumprido medida processual, pena ou medida de segurança privativas da

liberdade.” (Disponível em: <<http://www.pgdlisboa.pt>>. Acesso em: 2 mar.2020).

<sup>15</sup>“ Ac. TRP de 25-03-2015: I. Sendo a acusação e ao acórdão omissos sobre a data em que foram praticados os crimes anteriores, falta um dos pressupostos formais da reincidência: que entre a prática do crime anterior e a do crime seguinte não tenham decorrido mais de cinco anos.” (Disponível em: <<http://www.pgdlisboa.pt>>. Acesso em: 2 mar. de 2020).

<sup>16</sup>“3 – As condenações proferidas por tribunais estrangeiros contam para a reincidência nos termos dos números anteriores, desde que o facto constitua crime segundo a lei portuguesa”. (Disponível em: <<http://www.pgdlisboa.pt>>. Acesso em: 2 mar. 2020).

<sup>17</sup>“Artigo 83º – Pressupostos e efeitos: 1 – Quem praticar crime doloso a que devesse aplicar-se concretamente prisão efectiva por mais de 2 anos e tiver cometido anteriormente dois ou mais crimes dolosos, a cada um dos quais tenha sido ou seja aplicada prisão efectiva também por mais de 2 anos, é punido com uma pena relativamente indeterminada, sempre que a avaliação conjunta dos factos praticados e da personalidade do agente revelar uma acentuada inclinação para o crime, que no momento da condenação ainda persista.” (Disponível em: <<http://www.pgdlisboa.pt>>. Acesso em: 2 mar. 2020).

<sup>18</sup>“No ano de 1986, por força da 23.ª lei de reforma de 13 de abril, BGBI. I 393, o §48, foi revogado. Entre os fundamentos para tal mudança, destacam-se, fora outros argumentos: a ausência de proporcionalidade na agravação; ausência de efeito admonitório nas condenações anteriores; falta de eficácia preventiva do instituto; indevida aplicação em crimes de bagatela e delitos sem conexão material íntima com o primeiro crime; e a presença de dúvidas quanto o aumento de culpabilidade do agente pela reincidência.” (ASSIS, Cássio Chechi de. **A solvabilidade constitucional do regime da reincidência criminal**. Dissertação de mestrado. Faculdade de Direito da Universidade de Coimbra. Out.2014. Disponível em: <<https://estudogeral.sib.uc.pt>>. Acesso em: 8 mar. 2020).

<sup>19</sup> O Código Penal espanhol está dividido em dois Livros: I. Disposições Gerais sobre os Delitos, as pessoas responsáveis, as penas, medidas de segurança e demais consequências da infração penal e II. e Dos Delitos e suas penas, os quais se subdividem em Títulos e esses em Capítulos. (Disponível em: <[file:///C:/Users/Prof.%20Lisandra/Downloads/BOE-038\\_Codigo\\_Penal\\_y\\_legislacion\\_complementaria.pdf](file:///C:/Users/Prof.%20Lisandra/Downloads/BOE-038_Codigo_Penal_y_legislacion_complementaria.pdf)>. Acesso em: 8 mar.2020).

<sup>20</sup>“Artículo 22. Son circunstancias agravantes [...] 8.ª Ser reincidente. Hay reincidenciando, al delinquir, el culpable haya sido condenado ejecutoriamente por un delito comprendido en el mismo título de este Código, siempre que sea de la misma naturaleza. A los efectos de este número no se computarán los antecedentes penales cancelados o que debieran serlo, ni los que correspondan a delitos leves. Las condenas firmes de jueces o tribunales en nuestros Estados



de la Unión Europea producirán los efectos de reincidencia salvo que el antecedente penal haya sido cancelado o pudieran serlo con arreglo al Derecho español.” (Disponível em: <file:///C:/Users/Prof.%20Lisandra/Downloads/BOE-038\_Codigo\_Penal\_y\_legislacion\_complementaria.pdf>. Acesso em: 8 mar. 2020).

<sup>21</sup> PUIG, Santiago Mir. **Derecho penal** – parte geral. 6.ed. Barcelona: Editorial Reppertor, 2002, p.620. Esclarece o autor que a relação exigida (mesmo título do Código e da mesma natureza) pretendeu ser qualitativa e assegurar uma certa semelhança entre os fatos em jogo

<sup>22</sup> Conforme Santiago Mir Puig, o STS não admitiu abertamente a inconstitucionalidade de todo agravamento da pena pela reincidência, mas apenas considerou de acordo com a Constituição quando não superar o limite da culpabilidade pelo fato, analisada sem considerar a conduta anterior do reincidente. (PUIG, Santiago Mir. Comentarios a la Jurisprudencia del Tribunal Superior – Sobre la constitucionalidad de la reincidencia en la Jurisprudencia del Tribunal Supremo y del Tribunal Constitucional. In: **Anuário de Derecho Penal y Ciencias Penales**. Madrid :Boletín Oficial del Estado, 1948-2010, t.XLVI, Fascículo III, set.-dez.1993, p.1.140.

<sup>23</sup> PUIG, Santiago Mir. **Derecho penal** – parte geral. 6.ed. Barcelona: Editorial Reppertor, 2002, p.619. Para o autor, é rechaçável que agrave a pena por uma atitude interna do sujeito, principalmente considerando uma menor capacidade de resistência frente ao delito (menor culpabilidade) de quem tenha passado pela experiência carcerária. NUCCI, Guilherme de Souza. **Individualização da pena**. 2.ed. São Paulo: RT, 2007, p.219. O autor discorda, pois a culpabilidade é determinante para considerar o crime existente e a reincidência não diz respeito ao fato, e sim ao autor. Entende ser ele mais perigoso e censurável, principalmente quando tenha cumprido pena, negando a proposta de reeducação do Estado.

<sup>24</sup> “O critério da temporariedade da reincidência é acolhido no caso de a infração posterior ter pena igual ou inferior a dez anos, visto que se transcorrido o prazo superior a dez anos entre a extinção da pena anterior e o novo crime, não haverá reincidência; esse lapso temporal será diminuído para cinco anos na hipótese de a pena do crime posterior for de um e inferior a dez anos. Nessas hipóteses, as penas de prisão máxima e de multa são duplicadas. (CHIQUEZI, Adler. **Reincidência criminal e sua atuação como circunstância agravante**. Dissertação de mestrado. Pontifícia Universidade Católica de São Paulo, São Paulo, 2009, p.61-62).

<sup>25</sup> O Código Penal argentino é organizado por dois Livros: Disposições Gerais e Dos Delitos, os quais se dividem em Títulos, compondo o total de 316 artigos. Disponível em: <http://www.infoleg.gov.ar/infolegInternet/anexos/15000-19999/16546/texact.htm>. Acesso em: 08 mar. 2020.

<sup>26</sup> CÓDIGO PENAL COMENTADO Y ANOTADO – parte general (artigo 1º ao 78). Director: Andrés José D’Alessio, Coordinador: Mauro A. Divito. Buenos Aires: La Ley, 2005. Disponível em: <http://www.ues.flakepress.com/>. Acesso em: 10 fev. 2016. “Artículo 50 – Habrá reincidencia siempre que quien hubiere cumplido, total o parcialmente, pena privativa de libertad impuesta por un tribunal del país cometiere un nuevo delito punible también con esa clase de pena. La condena anterior no se tendrá en cuenta a los efectos de considerar al reo como reincidente, cuando hubiere transcurrido otro término igual al de la condena extinguida, que nunca excederá de diez años ni será inferior a cinco”. (Disponível em: <http://www.ues.flakepress.com>. Acesso em: 10 jun. 2020).

<sup>27</sup> CÓDIGO PENAL COMENTADO Y ANOTADO – parte general (artigo 1º ao 78). Director: Andrés José D’Alessio, Coordinador: Mauro A. Divito. Buenos Aires: La Ley, 2005. Disponível em: <http://www.ues.flakepress.com/>. Acesso em: 10 fev. 2016. “ARTICULO 50 [...] “La condena sufrida en el extranjero se tendrá en cuenta para la reincidencia si ha sido pronunciada por razón de un delito que pueda, según la ley argentina, dar lugar a extradición”. (Disponível em: <http://www.ues.flakepress.com>. Acesso em: 10 fev. 2020).

<sup>28</sup> CÓDIGO PENAL COMENTADO Y ANOTADO – parte general (artigo 1º ao 78). Director: Andrés José D’Alessio, Coordinador: Mauro A. Divito. Buenos Aires: La Ley, 2005. Disponível em: <http://www.ues.flakepress.com/>. Acesso em: 10 fev. 2016. “ARTICULO 50 [...] “No dará lugar a reincidencia la pena cumplida por delitos políticos, los previstos exclusivamente en el Código de Justicia Militar, los amnistiados o los cometidos por menores de dieciocho años de edad”. (Disponível em: <http://www.ues.flakepress.com>. Acesso em: 10 fev. 2020).

<sup>29</sup> CÓDIGO PENAL COMENTADO Y ANOTADO – parte general (artigo 1º ao 78). Director: Andrés José D’Alessio, Coordinador: Mauro A. Divito. Buenos Aires: La Ley, 2005. Disponível em: <http://www.ues.flakepress.com/>. Acesso em: 10 fev. 2016. “ARTICULO 52. Se impondrá reclusión por tiempo indeterminado como accesoria de la última condena, cuando la reincidencia fuere múltiple en forma tal que mediaren las siguientes penas anteriores: 1. Cuatro penas privativas de libertad, siendo una de ellas mayor de tres años; 2. Cinco penas privativas de libertad, de tres años o menores. Los tribunales podrán, por una única vez, dejaren suspenso la aplicación de esta medida accesoria, fundando expresamente su decisión en la forma prevista en el artículo 26.” (Disponível em: <http://www.ues.flakepress.com>. Acesso em: 10 fev. 2020).

<sup>30</sup> CÓDIGO PENAL COMENTADO Y ANOTADO – parte general (artigo 1º ao 78). Director: Andrés José D’Alessio, Coordinador: Mauro A. Divito. Buenos Aires: La Ley, 2005. Disponível em: <http://www.ues.flakepress.com/>. Acesso em: 10 fev. 2016. “ARTICULO 53 – En los casos del artículo anterior, transcurridos cinco años del cumplimiento de la reclusión accesoria,

el tribunal que hubieradictadolá última condena o impuestola pena única estará facultado para otorgarlelalibertad condicional, previo informe de laautoridad penitenciaria, enlas condiciones compromisorias previstas enel artículo 13, y siempre que el condenado hubieramantenidobuenaconducta, demostrando aptitud y hábito para eltrabajo, y demásactitudes que permitan suponer verosímilmente que no constituirá unpeligro para lasociedad. Transcurridos cinco años de obtenidalalibertad condicional el condenado podrá solicitar sulibertad definitiva al tribunal que laconcedió, el que decidirá según sea el resultado obtenidoenel período de prueba y previo informe del patronato, institucióno persona digna de confianza, a cuyo cargo haya estado elcontrol de laactividaddel liberado. Los condenados conlareclusiónaccesoria por tiempo indeterminado deberáncumplirlaenestablecimientosfederales. La violación por parte del liberado de cualquiera de las condiciones establecidasenel artículo 13 podrá determinar larevocatoriadelbeneficio acordado y su reintegro al régimenencarcelario anterior. Después de transcurridos cinco años de su reintegro al régimenencarcelariopodráenlos casos de los incisos 1º, 2º, 3º y 5º del artículo 13, solicitar nuevamente su libertad condicional.” (Disponível em: <http://www.ues.flakepress.com/>. Acesso em: 10 fev.2020).

<sup>31</sup> Lei 599 de 2000, composta por dois livros – Parte Geral e Parte Especial dos Delitos em Particular, com um total de 476 artigos, divididos em títulos e capítulos. (BERNAL, José Fernando Botero (Compilador y quienactualiza). **Código Penal Colombiano** – Ley 599 de 2000. Disponível em: <<http://perso.unifr.ch>>. Acesso em: 11 mar. 2020).

<sup>32</sup> Lei 599 de 2000, composta por dois livros – Parte Geral e Parte Especial dos Delitos em Particular, com um total de 476 artigos, divididos em títulos e capítulos. (BERNAL, José Fernando Botero (Compilador y quienactualiza). **Código Penal Colombiano** – Ley 599 de 2000. Disponível em: <<http://perso.unifr.ch>>. Acesso em: 12 mar. 2020).

<sup>33</sup>“Artículo 6. Legalidad. Nadiepodrá ser juzgado sino conforme a lasleyes preexistentes al acto que se le imputa, ante eljuez o tribunal competente y conlaobservancia de laplenitud de las formas propias de cada juicio. La preexistencia de la norma también se aplica para elreenvíoenmateria de tipos penalesenblanco. La leypermisiva o favorable, aunquando sea posterior se aplicará, sinexcepción, de preferencia a larestrictiva o desfavorable. Ellotambiénrige para los condenados. La analogíasólo se aplicará enmateriaspermisivas.” (BERNAL, José Fernando Botero (Compilador y quienactualiza). **Código Penal Colombiano** – Ley 599 de 2000. Disponível em: <<http://perso.unifr.ch>>. Acesso em: 12 mar. 2020).

<sup>34</sup>Artículo 29. [...] Nadiepodrá ser juzgado sino conforme a leyes preexistentes al acto que se le imputa, ante juez o tribunal competente y conobservancia de laplenitud de las formas propias de cada juicio.” Constituição da Colômbia. (Disponível em: <<http://www.jurisciencia.com/vademecum/constituicoes-estrangeiras/a-constituicao-da-colombia-constitucion-de-colombia/582/>>. Acessoem: 12 fev.2020).

<sup>35</sup> DUROSE, Matthew R; SNYDER, Howard N., Ph.D., and Alexia D. Cooper, Ph.D., BJS Statisticians. **Multistate Criminal History Patterns of Prisoners Released in 30 States**. U.S. Department of Justice Office of Justice Programs Bureau of Justice Statistics. SpecialReport, september 2015, NCJ 248942. Disponível em: <<http://www.bjs.gov/content/pub/pdf/mschpprts05.pdf>>. Acesso em: 09 jun.2020.

# Detection of SARS-CoV-2 on surfaces of an Intensive Care Unit

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**Keywords** — *Disinfection; Surfaces; RT-PCR; COVID-19; SARS-CoV-2.*

**Abstract**— *The study aimed to evaluate the presence of SARS-CoV-2 on surfaces in an Intensive Care Unit and to identify the role these surfaces may play in the transmission of this virus. The research was exploratory, descriptive, prospective, experimental research, with quantitative approach, conducted in the second half of 2020 in a public hospital of reference in the care for critically ill patients with COVID-19 in Santarém-Pará. It comprised 45 samples of surfaces of the most touched areas in the adult ITU of patients diagnosed with COVID-19 through RT-PCR: corresponding to 9 (nine) samples for each of the surfaces (on the mattress; side rails and bed control panel; mechanical ventilator circuit; bedside table and infusion pump). The samples were collected during the day in an occupied bed, using a swab on the extension of the surface. In the sequence they were submitted to the extraction process of genetic material, Ribonucleic Acid (RNA), of the SARS-CoV-2 virus, and later submitted to the amplification of the genetic material. According to the data obtained, all the surface samples analyzed in the present study tested negative for SARS-CoV-2, considering that the analysis was performed in ITU, in the period when inpatients were infected with SARS-CoV-2 and in transmissibility phase. These results suggest that the risk of exposure to a contaminated surface within an ITU is low, provided that preventive measures and sanitization routines are maintained. Cleaning and disinfection of care surfaces, using the standard protocol recommended by the National Health Surveillance Agency - Anvisa, are considered effective measures in containing SARS-CoV-2 transmission and infectivity.*

## I. INTRODUCTION

The pandemic caused by the new coronavirus SARS-CoV-2 has been growing exponentially in the world and has reinforced the interest for the *Coronaviridae* family, more specifically the human coronaviruses (HCoV), historically known for causing respiratory tract infections,

requiring admission to Intensive Care Units (ICU) for more severe respiratory problems, motivating several institutions to carry out research and monitoring of COVID-19. [1,2]

In this sense, human-to-human transmission occurs in the incubation period between 02 to 14 days, facilitating its spread by droplets, hands or contaminated surfaces of

therapy units. [3] These units are inevitably a large reservoir of opportunistic pathogens, so that healthcare-associated infections (HAIs) can be acquired not only by patients who present higher susceptibility, but also by visitors and employees of the hospital itself. [4] Moreover, these viruses show an environmental resistance that increases the possibility of transference between contaminated hosts, through surfaces, hands, among others. This resistance has led to the need to develop efficient prevention measures in order to reduce the viral load. As there are still no treatments, and the possibility of genetic mutation of the virus that could reduce the effectiveness of currently available vaccines cannot be ruled out, it is necessary to use other approaches to manage the infection and especially its prevention.[5-7]

The control of pathogen spread in the hospital environment is a practice based on cleaning and disinfection of contaminated surfaces, which are mandatory requirements for managers and healthcare workers. Commonly to this, chemicals traditionally, such as sodium hypochlorite at 0.1%, alcohol at 62 to 71% and hydrogen peroxide 0.5% have been used for surface disinfection in terminal or concurrent cleaning in hospital settings. [8,9]

Due to the significant increase in cases and the occupation of almost all available beds in both the public and private network, the need to verify the environment in which patients are receiving care has arisen. From this perspective, the objective of this study was to evaluate the presence of SARS-CoV-2 viral RNA on frequently manipulated surfaces in an ICU of a public hospital of medium and high complexity in the interior of the Amazon, and to identify the role that these surfaces can play in the transmission of this virus.

## II. METHODS

### 1.1 Design, study site and period

Exploratory, descriptive, prospective, experimental research, with a quantitative approach, carried out at the Regional Hospital of Baixo Amazonas (HRBA), a public health unit of medium and high complexity that serves users of the Unified Health System (SUS). It is currently run by the Social Organization Pró-Saúde Associação Beneficente de Assistência Social e Hospitalar. This hospital is part of the flow of care for severe patients with COVID-19 in Santarém-Pará.

### 1.2 Sample acquisition and conditioning protocol

The sample composition was chosen according to the high frequency in which the surfaces are manipulated during the care and stay of the infected patient, obtained before and after concurrent disinfection, as described below: 70% alcohol was sprayed on the areas of interest (mattress; lateral grid and bed control panel; mechanical ventilator circuit; bedside table and infusion pump) and

removed after sixty seconds of contact with the surface, using disposable multi-purpose wipes (Perfex®).

The samples were identified with codes A1 to A5 (Fig. 1-5). A region of interest was defined on each surface, depending on the manipulation site. Each sample was collected in triplicate, generating subcodes that corresponded to the collection of the same surface within the same group. The information regarding each code, such as collection day, time, bed, surface, tested region, and sample number was catalogued and stored for later correlation.

To standardize the samples, the collection period between the fifth and seventh day of the appearance of the first symptoms of the flu syndrome was eligible, in individuals with positive PCR (Polymerase Chain Reaction) results for Covid-19.



Fig.1. samplecollection sites - (A1) side rails and bed panel.



Fig.2. (A2) bed.





Fig.3. (A3) infusion pump.



Fig.4. (A4) bedside table.



Fig.5. (A5) mechanical ventilator circuit.

The data collection procedure comprised 45 samples in total and was carried out in two phases: a) obtaining samples from the most manipulated areas of the care units in the ICU of the HRBA (mattress; lateral grid and bed control panel; mechanical ventilator circuit; bedside table, and infusion pump) and b) testing the samples for the presence of viral RNA in the Center for Diagnostic Medicine - CDM1.

The samples were collected by zig-zag swabbing the surface with a sterile Rayon swab, from left to right, at 5 mm intervals, diagonally, to standardize the material quantification process. The collection area was delimited at 100 cm<sup>2</sup> (approximate area 10x10 cm).

Each swab was placed in a collection tube containing 0.9% NaCl, labeled and stored at -20°C.

Subsequently, the samples were placed in a thermal box with reusable ice at a temperature between 2°C and 8°C, on a support wrapped with cotton and absorbent blanket for greater security and stability in transport to the analysis laboratory, where molecular analysis of the samples was performed.

The samples of the surfaces were collected after the concurrent cleaning, which was performed with the disinfectant agent 70% alcohol, [10] sprayed all over the surfaces (mattress; lateral grid and bed control panel; mechanical ventilator circuit; bedside table and infusion pump) and removed by mechanical friction after sixty seconds of contact with the surface, using disposable multi-purpose cloths (Perfex ®), a procedure performed by a nursing technician with exclusive function of concurrent cleaning at each shift and/or need.

In cases of spillage of organic matter, which may prevent direct contact with the disinfectant on the surface and inactivate its germicidal properties, [11] the technique used continued to be removal of the excess with a paper towel, then sprayed the solution of VIREX® (Sodium Hypochlorite 1%) on the site, after 5 minutes it is removed with the help of disposable multi-purpose wipes (Perfex ®), according to the Work Instruction (IT) of the HRBA.

It is noteworthy that the processes of cleaning and disinfection of surfaces of the care units of the adult ICU of the HRBA, underwent several changes according to the legislation in force at the time (ANVISA, 2020). [12]

### 1.3 Detection and analysis of SARS-CoV-2 by means of RT-PCR

In an accredited laboratory for molecular analysis, the samples were submitted to the process of extraction of genetic material, Ribonucleic Acid (RNA), from the SARS-CoV-2 virus. For viral RNA extraction, 200µL of an aliquot from each sample was used and extracted according to the protocol defined by the supplier of the BIOPUR Kit Mini Spin Virus DNA/RNA 2.0 kit from Mobius Life Science, adapted with the addition of the ethanol drying step for 30 seconds at 15,000 RPM (Rotation Per Minute) before the dilution step.

After extraction, the samples were subjected to amplification of the SARS-CoV-2 virus genetic material. Cycling, mix preparation, detection markers, and extraction quality control protocols were followed according to the guidelines in the Mobius Life Science XGEN Master COVID-19 kit. RT-qPCR (Reverse Transcription Followed by Real-Time Polymerase Chain Reaction) reactions were performed on the QIAGEN Rotor Gene 5plex HRM equipment. The threshold value for all virus detection markers (N and ORF1ab genes) and extraction quality control was considered to be in the range of 0.03 to 0.3.

For the validation of the assay parameters the amplification value Ct (Cycle Threshold) of the positive



control and null for the extraction quality control was considered valid. For the virus detection markers, it was considered  $\geq 18 \leq 38$ , while for the negative control the

amplification signal in the extraction quality control and the Ct value was null or  $> 38$  in the virus detection markers (Gene N and Gene ORF 1ab) (Table 1).

Table 1. Parameters for assay validation.

	Valid Assay		Non-valid Assay	
	Positive Control	Negative Control	Positive Control	Negative Control
	Ct Value	Ct Value	Ct Value	Ct Value
Extraction quality control	Null	Presence of amplification signal	Presence of amplification signal	Null
Gene N	$\geq 18 \leq 38$	Null or $> 38$	Null or $> 38$	$\geq 18 \leq 38$
Gene ORF1ab	$\geq 18 \leq 38$	Null or $> 38$	Null or $> 38$	$\geq 18 \leq 38$

CT - amplification value.

### III. RESULTS

The sampling comprised 45 surface samples from most touched areas in the adult ICU of patients diagnosed with COVID-19 through RT-PCR. All analyzed samples tested negative for COVID-19 RNA (Table 2), it should be noted that the samples were collected from ICU beds with

patients who were infected and in the transmissibility phase. These results suggest that the risk of exposure to a contaminated surface within an ICU is low, provided that preventive measures and sanitization routines are maintained.

Table 2. Collections obtained by RT-PCR for screening of SARS-CoV-2 RNA.

Surface Places	No. of tests	Result
A1	09	Not detected
A2	09	Not detected
A3	09	Not detected
A4	09	Not detected
A5	09	Not detected
<b>TOTAL</b>	<b>45 tests</b>	

### IV. DISCUSSION

The absence of detection of SARS-CoV-2 by RT-PCR in the surfaces of the adult ICU of the HRBA suggests that disinfection of surfaces is a clearly indicated and effective practice in the prevention and transmission of this pathogen because it is a single-stranded enveloped virus, i.e., it has a lipoprotein structure around the genomic RNA, facilitating its inactivation by several sanitizing products. In this sense, the survival of this microorganism in inanimate places has become a challenge for effective cleaning of healthcare environments, hence the urgent need to develop means to make the environment safe, not only for patients but also for professionals working in nosocomial environments. [13] On the other hand, because it is an

extremely infectious virus, it requires surface disinfection methods that use effective products. Among the various sanitizers used in surface disinfection, with potential inactivation potential of SARSCoV-2, we highlight alcohol 70%, quaternary ammonium salts, hydrogen peroxide and sodium hypochlorite.

Considering the ability of SARS-CoV-2 to survive on inanimate surfaces, and focusing on the confrontation of the new pandemic, the prevention of further spread becomes decisive for the success in reducing the ongoing outbreak, which has victimized about 22.1 million infected people in Brazil, 616 thousand dead, computing a mortality rate of 3.0%. In Santarém-Pará, until this last balance sheet there

were 611 thousand confirmed cases and 16,942 thousand deaths. [3,14]

The mode of Covid-19 transmission occurs mainly via respiratory droplets after coughing or sneezing from persons infected with SARS-CoV-2. [15] There is also the likelihood of autoinoculation of the virus after contact with contaminated surfaces. Thus, the ability of SARS-CoV2 to infect, as well as the extent and speed of its viral spread, depend on the characteristics of both the virus and the surfaces on which it is found. [9,15,17]

A study conducted in the Republic of Korea, by Lee and collaborators(2020), corroborates with our findings, where RT-PCR was used for viral identification, 68 samples of surfaces from six hospitals, which had been cleaned and disinfected, there was no detection of SARS-CoV-2. However, two samples of the 12 that were collected at a rehabilitation center confirmed positive results for the presence of RNA polymerase and envelope genes of SARS-CoV-2,[16] indicating that cleaning procedures are effective in controlling SARS-CoV-2 infections.

The study by Chia and collaborators (2020) in Singapore evaluated 245 samples from the surfaces of 15 patients infected with COVID-19 in different stages of the disease, where high contamination was found in 66.7% of the patients evaluated in the first week of infection and 20% after the second week, with the highest rate of contamination on the floor (65%), the exhaust fan (60%), the bed rail (59%), and the bedside cabinet (47%), respectively, [18] results that refute our findings.

Added to the above, RT-PCR is considered a variable method among different biological samples to identify SARS-CoV-2. However, the diagnostic efficiency of several commercialized real-time RT-PCR kits for SARS-CoV-2 may be lower than ideal, i.e., <100%. [19] A study in China, for example, concluded that 41% of false negative RT-PCR test results remained false negative for a two-week period.[20] This fact is detrimental to the containment of the pandemic, since these individuals continue to transmit the disease because they are unaware of it.

It is important to point out that 45 samples were collected from 5 areas, corresponding to 100 cm<sup>2</sup> for each collection, at an ambient temperature that ranged from 18°C to 23°C, and an average relative humidity of 51%. In this sense, the survival of SARS-CoV-2 on surfaces may be influenced by environmental temperature, air humidity, and also by the viral load of the disease. [3,9] Despite all controversy regarding the survival time of CoVs on surfaces, it has been estimated that temperatures above 30 °C may reduce virus survival. [21,22]

Moreover, another point to be considered, are the high standards of hygiene and disinfection adopted by managers and hospital infection control service in the

researched institution, which was recognized as one of the ten best public hospitals in Brazil in 2019 and qualified with the highest national certification, accredited with Excellence, granted by the National Accreditation Organization (ONA) which, since then advances in care quality.

## V. CONCLUSION

The coronavirus pandemic brought to the scientific community, as well as to the patients, health team and laboratories, the challenge of facing an invisible and extremely powerful adversary, leading us to review some cares related to sanitation in care environments.

The absence of SARS-CoV-2 viral RNA on surfaces in the intensive care unit of the HRBA, suggests that surface disinfection is considered effective in containing transmission, infectivity of COVID-19, and maintaining a safe nosocomial environment.

It is noteworthy that the protocols for sanitization of the environment of the care units practiced by the HRBA are in line with the resolutions and determinations of the National Health Surveillance Agency (ANVISA) and the World Health Organization (WHO), which support good practices in health services. Finally, concurrent cleaning and disinfection of surfaces are considered essential elements for the control of healthcare-associated infections by ensuring an environment with clean surfaces, which may justify the absence of Covid-19 RNA detection on the surfaces evaluated.

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# Artificial Intelligence approaches for IoT Security: State of Art

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**Keywords—** *IoT, Machine Learning, Deep Learning, Security, Blockchain.*

**Abstract—** With an estimation of more than 35 billion interconnected smart devices by the end of 2021, Internet of Things (IoT) is one of the most rapidly growing technologies in the last decade. However, the complexity nature of IoT systems and the exponential amount of data collected and exchanged between Things relieve a big challenge in terms of security and privacy. Implementing classical security measures, such as encryption, authentication, access control, network and application security for IoT devices is no more effective against sophisticated Cyber-attacks. Artificial intelligence (AI) approaches such as Machine Learning (ML), Deep Learning (DL) and Blockchain can be leveraged to enhance the security of IoT and deal with its various problems. In this paper, we will describe the IoT technology and its domain of application, the protocols used to communicate between smart devices, security issues and existing AI solution.

## I. INTRODUCTION

Internet of Things (IoT) is a network of smart devices with the capability of communicating and sharing information over the internet. These smart things can be deployed in many different environments to collect data. The applications domains of IoT are various like smart home, smart city, healthcare, smart transportation system, agriculture and smart grid system. As estimated, there will be more than 35 billion IoT devices connected by the end of 2021. IoT devices can generate exponential data, which make it very difficult in term of processing and storing. Three layers constitute the pillars of IoT architecture. Physical, network, and application layer.

Devices in the physical layer, are embedded with sensors that can detect and interact with the environment. For example, in smart homes, devices like thermostat can help control the home's temperature with no human interaction and it can be adapted according to the user's activity or the temperature outside the house. In a smart hospital, IoT

devices can help monitoring hygiene by preventing patients from being infected. IoT technology comes with lots of challenges.

Data storage, standardization, processing, inter-operability, trust management, identity, availability, confidentiality, integrity, security, and privacy are some of the open challenges in various IoT applications [1]. In section 1 of this paper work we will try to describe the IoT technology, its infrastructure and protocols, the vulnerabilities and the different known attacks. Section 2 is where we will give an overview of different known Artificial Intelligence approaches to help enhancing the security of IoT technology.

## II. INTERNET OF THINGS (IOT) INFRASTRUCTURE, PROTOCOLS AND APPLICATION

Real time applications can benefit a lot from Internet of Things (IoT). To build an intelligent system IoT need to

integrates radio frequency identification (RFID), sensors, smart devices, and interconnection between these Things. The IoT has different types of a network like a distributed, ubiquitous, grid, and vehicular. The applications of IoT made a huge impact in day to day life like sensors deploy in the patient body to monitoring in critical condition, monitoring gas leakage in smart kitchen, agriculture field, smart car parking, smart transportation, tracking goods details in supply chain system using sensors in the vehicle. The sensors are resource constraint devices connected through wired or wirelessly across heterogeneous networks. The IoT networks are possessed different security, privacy, and vulnerable to the attacker.

### 1.1. IoT infrastructure

IoT application consists of different smart things that collect, process, compute and communicate with other smart things. IoT has three layers physical, network, and application layer. Recently industries are developed many things which are embedded with intelligent things. As shown in Fig. 1 IoT infrastructure consists of not only sensors, but it also integrates with some emerging technology. The IoT application is based on either IoT-Cloud or IoT-Fog-Cloud.

The security issue like data privacy [13], machine to machine communication [14], real-time monitoring [15] and IoT testbed [16] needs to be addressed for efficient IoT applications. IoT architecture may be centralized, decentralized and distributed structure. IoT applications can face many challenges issues in term of processing and computing in real-time. Cloud computing has emerged as a key technology to provides more storage and data processing and assures security. But as the technology continue to grow, IoT applications start to demand processing and computing in the edge of the network in most of the real-time monitoring. So that quick action can be taken like monitoring the health condition of the serious patient, fire detection. When processing and computing are done on the edge of the network using fog devices, it becomes more vulnerable to the attacker as their devices are lightweight device traditional security is not applicable. During analytic data, a technique like a machine learning is recently used to make the IoT system more intelligent and independent to make a decision. The different smart devices are connected to make an application using some standard protocols. The security issue exists in IoT infrastructure, which needs to be addressed to build trust among end-users and make the system temper-proof. The data interoperability [17] in the IoT system works using an intelligent algorithm.

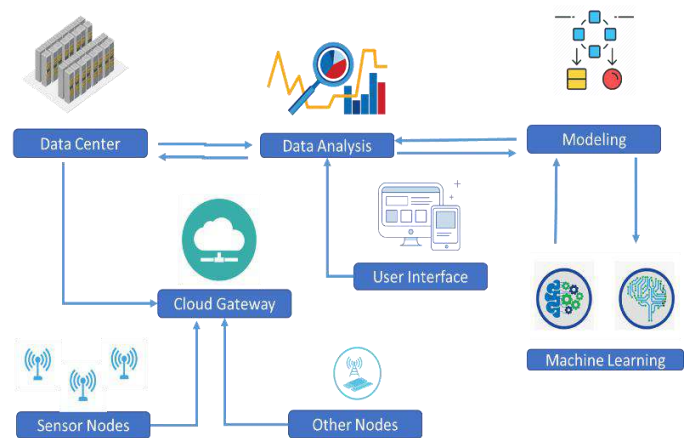


Figure 1. IoT Infrastructure

### 1.2. IoT Protocols

IoT protocols are the essential characteristics that make interaction and communication possible between things (devices, sensors, servers...). Here some main classic and mostly used IoT protocols:

#### 1.2.1. CoAP

As defined in RFC 7252, Constrained Application Protocol (CoAP), is a specialized Internet Application Protocol for constrained devices. It allows those devices called "nodes" to use similar protocols to communicate with the wider Internet. CoAP is designed to be used between devices on the same restricted network.

#### 1.2.2. TCP

Transmission Control Protocol (TCP) is a connection-oriented communications protocol that provides the facility to exchange messages in a network between computer devices.

#### 1.2.3. MQTT

MQTT (MQ Telemetry). It is a lightweight, straightforward publish-subscribe network-messaging protocol for devices with low bandwidth and high latency. It usually uses TCP/IP but also can be supported by network protocols that provide ordered, bi-directional and lossless connections. The main goal of the protocol is to reduce the consumption of network bandwidth and resources without degradation of delivery assurance and reliability.

#### 1.2.4. AMQP

An open standard for transferring business messages between applications or organizations is the Advanced Message Queuing Protocol (AMQP). It connects systems, feeds business processes with the information they need, and transmits the instructions that achieve their goals reliably forward.



#### 1.2.5. UDP

A Transport Layer protocol is the User Datagram Protocol (UDP). UDP is part of the Internet Protocol suite, known as UDP / IP. Like TCP, this protocol is unstable and unconnected. There is thus no need to create a link before transferring data.

#### 1.2.6. REST

REST (State Transfer Member) is a software architectural style based on web standards that was created to guide the design and development of the architecture for the World Wide Web. It turns around resources where each element is a resource, and a resource is accessed using standard HTTP methods through a specific interface. Roy Fielding introduced REST in 2000. A REST server offers access to resources in REST architecture, and REST user accesses and modifies resources. Here, URIs / global IDs classify each asset. REST uses a variety of representations to describe a resource such as text, JSON, XML.

#### 1.2.7. DCCP

DCCP provides a way for congestion-control mechanisms to be accessed without having to implement them at the application layer. It allows flow-based semiconducting, as in the Transmission Control Protocol (TCP), but does not provide reliable delivery on-order. Sequenced transmission across multiple streams is not possible in DCCP, as in the Stream Control Transmission Protocol (SCTP). A DCCP link requires both the network acknowledgment and data traffic. Acknowledgments notify a sender that their packets have arrived and whether they have been labeled with an Explicit Notification of Congestion (ECN).

#### 1.2.8. RSVP

The Resource Reservation Protocol (RSVP) is a transport layer [1] protocol designed to use the distributed infrastructure model to reserve resources across a network. RSVP works over an IPv4 or IPv6 and sets up resource reservations for multi-cast or unicast data flows, initiated by the recipient. It does not transmit data from applications but is similar to a control protocol, such as the Internet Control Message Protocol (ICMP) or the Internet Group Management Protocol (IGMP). RSVP is set out in RFC 2205.

#### 1.2.9. SCTP

The Stream Control Transmission Protocol (SCTP) is a computer networking communication protocol that operates at the transportation layer and serves a similar role to the popular TCP and UDP protocols. It is defined in RFC 4960 by IETF. SCTP incorporates some of the features of both UDP and TCP: it is message-oriented like UDP and ensures secure, in-sequence congestion-controlled transmission of messages like TCP. It differs

from those protocols by providing multi-homing and redundant paths to increase resilience and reliability.

#### 1.2.10. CLNS

Connectionless mode Network Service (CLNS) or simply Connectionless Network Service is an OSI Network Layer data-gram service that does not require a circuit to be set up before data is transmitted, and routes messages to their destinations independently of any other messages. CLNS is not an Internet service but offers features similar to those offered by the Internet Protocol (IP) and User Datagram Protocol (UDP) in an OSI Network environment.

#### 1.2.11. ICMP

Connectionless-mode Network Service (CLNS) or simply Connectionless Network Service is an OSI Network Layer data-gram service that does not allow a circuit to be set up before data is transmitted and routes messages to their destinations independently of any other messages. As such, it is a best-effort rather than a "reliable" delivery service. CLNS is not an Internet service but offers features similar to those offered by the Internet Protocol (IP) and User Datagram Protocol (UDP) in an OSI Network environment.

#### 1.2.12. ISDN

Integrated Services Digital Network (ISDN) is a set of communication standards for simultaneous digital transmission of voice, video, data, and other network services over the traditional circuits of the public switched telephone network. The key feature of ISDN is that it integrates speech and data on the same lines, adding features that were not available in the classic telephone system. In the emergency mode of IoT devices, the ISDN facility can be useful.

### 1.3. Application Domain

IoT applications are nowadays developed in many fields. The development of many open-source platforms like Azure IoT Suite, IBM Watson, Amazon Web Services (AWS), Oracle IoT, Kaa, Bevywise IoT platform used for industrial IoT, IoTIFY cloud-based platform used to build scalable IoT applications. Most of the opensource platform is enabled with AI and ML technology for intelligent processing and computing the information. The manufacture of smart devices that can read, process, and computing the things makes the IoT as one of the emerging fields. There are many application areas where IoT is used. IoT has already made an impact on enhancing and increasing the efficiency of the system.

#### 1.3.1. Smart home

The IoT makes the traditional home system into an intelligent one. The refrigerator, smart television, security camera, gas sensors, temperature sensor, light system all

can sense the home environment, communicate and connect to the internet through wired or wireless. Even the refrigerator can place an order to the registered retail shop and give notification to the user. Due to the development of smart things, the living standard becomes more comfortable. In paper [18], authors design a smart home system based on IoT technology. Using technology like IoT and Fog computing home converted into an intelligent home system where monitoring of the home can be done remotely as well as processing can be done instantly. The authentication of devices is essential to prevent unwanted access to the IoT network. The authors in Satapathy et al. [19] and Panda et al. [20] proposed different authentication schemes for a smart home network. Still, some security issues [21], are exist in IoT based smart home systems.

#### 1.3.2. Smart hospital

Since the development of IoT patient monitoring in real-time is possible with the use of sensors and fog/edge computing, the paper [22], authors have proposed an IoT-cloud based framework for data collection in the healthcare system. Similarly, in Moosavi et al. [23], authors performed the authentication and authorization of the smart devices in the healthcare system. In the healthcare system, privacy is one of the main issues, so proper security and privacy protocol need to be developed to secure the system.

#### 1.3.3. Smart city

The ever-growing city has lots of problems like traffic management, waste management, waste management, and environmental management. The city needs a solution to monitor and control the problem exist. In papers [24,25], authors explained the challenges that exist in implementing smart cities and done a survey in detail about how IoT can solve an existing problem. Using IoT and associated technology, a smart city can be developed to enhance the living standard of the city, maintaining the security and privacy issue of the citizen.

#### 1.3.4. Smart transportation

In recent times traffic is one of the major problems in a city. The intelligent transportation system is the need of the hour. The IoT enables vehicles can collect information from the roadside unit and process to get the details about journey path, time, and traffic details. Some of the research work [26,27] addressed the smart transportation issue using IoT. In paper [28], the authors proposed the IoT-ITS system for the transportation system. The authors in Dey et al. [29] proposed a "Magtrack" to detect condition of the road surface using in-build mobile sensors and machine learning concepts.

#### 1.3.5. Smart grid

The smart grid is one of the application areas of IoT, where a grid system can be made automation using IoT. The electric power generation and distribution among consumers can be monitor in real-time. The cybersecurity solution approach [30] is explained in detail. The architecture of the IoT-Cloud based system proposed by the authors in paper [31]. The efficient, economical and distribution can be improved using the IoT technology in the smart grid system.

#### 1.3.6. Supply chain system

The IoT smart devices, once used in a supply chain management system, can fundamentally change the traditional way to monitor the transport system. By using the IoT technique, the material is easily located, their current condition, packing details, and it is easy to track how goods are a move through the supply chain. It increases to maintain the demand-supply of good, easy to monitor the material movement, real-time tracking, efficient storage, energy efficient, and distribution. The authors in Li et al. [33], explained how tracking and tracing could be done in real-time using the IoT system. Similarly, in paper [34,35] authors, discussed the IoT based architecture and risk management in the supply chain system. In paper [34], authors have proposed artificial intelligent integration with IoT for the retail shop supply chain system.

#### 1.3.7. Smart retails

The retail sector also using IoT services along with artificial intelligent [36] to enhance productivity, improve store operation, and to take the decision in real-time to manage the inventory system.

#### 1.3.8. Agriculture

Agriculture is one of the promising application areas in IoT. In a smart agriculture system by deploying the sensors to monitor the soil quality, water management, crop growing condition, etc. which improve the farming efficiency by reducing time and cost. In real-time, a user can monitor all details from the remote locations. In paper [37,38] authors proposed smart irrigation using machine learning and IoT to enhance farming. similarly, in paper [39,40], smart water management and weather conditions in the agriculture system are explained in detail. Likewise, in paper [41,42], smart agriculture system integration with IoT technologies is explained in detail. As some of the work already done in the field of agriculture, still some security issues exist like mobility, infrastructure, and secure processing of the collected data.

#### 1.4. Security attacks in internet of things

##### Jamming attack

Jamming attack is a subset of DoS attacks where the attacker tries to affect the communication channel in paper [43] authors also explained the details about the jamming attacks.

##### Dos attack

Dos attack is one of the common attacks used in IoT applications. Most of the IoT devices are a low-end device which is vulnerable to the attacker. The attacker gets under the data traffic stream through device connection or infrastructure.

##### Denial of service (DoS)

Denial of service (DoS) attacks, consists of a huge volume of network packets, targeting the node present in the application causes service interrupt in real-time.

##### IDS Attack

Intrusion detection system (IDS) is the process in which network traffic is control by the attacker. There are some types of IDS attacks, like misuse detection, anomaly detection, Host-based IDS, and Network-based IDS. The authors in paper [45] described the IDS attacks in IoT network. Malicious node attack is possible in a distributed IoT network due to the heterogeneous nature of the smart devices. The identify the genius node or fake node in the network is a challenging one. In paper [46] authors proposed a perception and K-mean to build the trust among the node and detect the malicious node.

##### Malicious node attack

Malicious node attack is possible in a distributed IoT network due to the heterogeneous nature of the smart devices. The identify the genius node or fake node in the network is a challenging one. In paper [46] authors proposed a perception and K-mean to build the trust among the node and detect the malicious node.

##### Power analysis attack

Power analysis attack and its corresponding solution approach are explained in papers [47,48]. This attack is mainly made to gain the computational power of the nodes so that the basic cryptographic algorithm is not possible to execute. In an IoT network, privacy also needs to be maintained to build trust among the node. Internal attack in paper [49] and Access control attack in paper [50] are discussed in details.

##### Wormhole attack

Wormhole attack is taken place at the 6LoWPAN layer, where the attacker makes a tunnel between two nodes that are connected [51].

##### The Side channel security attack

The Side channel security attack in cloud-based IoT application along with the security challenges are explained in paper [52]. Similarly, Distributed Dos attack is the process where the server is unreachable so that smart nodes in the network cannot get the services it desires to get [53].

##### Man-in-the-middle attack

Man-in-the-middle attack, where the attacker relays the message or change the message during the transmission in the insecure channel, explained in Li et al. [54] IoT-Fog network.

##### Active attacks

Active attacks is explained in Zhang et al. [55] and its corresponding solution in the physical layer of the IoT network. There are different types of active attacks possible in IoT, where attackers make changes in the target node. The authors in Raoof et al. [56] explained the Routing attacks in routing protocol lossy network based on IoT application. The Sybil attack is one most common types of attack in IoT. The authors in Zhang et al. [57] and Mishra et al. [58] study the phases of Sybil attacks and their countermeasures in the internet of things. The Deceptive attack in La et al. [59] and Spoofing attack in Zhang et al. [60] authors have addressed the corresponding attacks and their security analysis in the internet of things applications.

##### The Buffer overflow attacks

The Buffer overflow attacks is the process of writing the program in a block of memory where the memory space is insufficient. The A IoT network, when nodes execute the different programs in the devices for processing or computation purpose attackers, can capture that and perform memory overflow attack. The detecting buffer overflow attack and providing appropriate security design in explained in Xu et al. [61]. In a large IoT network where heterogeneous devices are connected and communicate with each other. The trust is one of the major issues in the network. The Impersonation attacks where a fake node behaves like a genius node in the network and tries to gain the information from other nodes. This is one of the most challenging issues in IoT applications where smart devices are heterogeneous and low-end devices.

### III. ARTIFICIAL INTELLIGENCE FOR CYBER SECURITY

Information and communication technology researchers agree that information security (InSec) is of primary importance [44]. Consequently, a number of studies have

attempted to address this by adopting improved techniques and technological artefacts; including the use of malware detectors, intrusion detection and prevention systems (IDPS), sophisticated firewall setups and data encryption algorithms. Although some studies have argued that InSec issues can be effectively managed by focusing on human behaviour [44], others have argued that focusing on human behaviour alone is not sufficient [51]. For example, the quantum of information handled by most organizations necessitates considerable automation [12]. Hence, there is the need for an appropriate balance between humans, technology and policy management in organizational security activities.

Conventional CyberSec prevention technologies use fix algorithms and physical devices (such as sensors and detectors), thus they are ineffective at containing new cyberspace threats [44]. For instance, the first generation of antivirus systems were designed to identify viruses by scanning its bit signature. The fundamental assumption of this concept is that a virus has the same structure and bit pattern in all instances. These signatures and algorithms are therefore fixed. Although the catalog of signatures is updated on a daily basis (or whenever the device is connected to the Internet), the sophistication and regular release of vast malware make this approach ineffective. However, the introduction of signature-less approaches that are capable of detecting and mitigating malware attacks using newer methods such as behavioural detections and AIs have been argued to be more effective [62].

This suggests that advancement in AI applications have made it possible to design relatively effective and efficient systems that automatically identify and prevent malicious activities within cyberspaces [51]. They have been adopted to support existing technological methods as they provide effective standards and mechanisms to better control and prevent cyber-attacks. Despite all the benefits AI provides, the rapid evolution of approaches makes it extremely difficult for researchers to identify the most efficient technique and its impact on cyberspace security. There is no ambiguity that the general perception amongst InSec and CyberSec researchers and practitioners suggest that AI has improved organizational information security, yet to the best of our knowledge, these claims are speculative and have not been empirically substantiated. Most existing studies have either demonstrated how their innovation outperform a selection of existing methods or surveyed a sample of systems and assess their performance in comparison to theirs. In all cases, the level of selection biases is relatively high. Accordingly, there is the need for an aggregated literature that provide summaries on issues,

challenges and future research directions within the domain.

Power analysis attack and its corresponding solution approach are explained in papers [47,48]. This attack is mainly made to gain the computational power of the nodes so that the basic cryptographic algorithm is not possible to execute. In an IoT network, privacy also needs to be maintained to build trust among the node. Internal attack in paper [49] and Access control attack in paper [50] are discussed in details. Wormhole attack is taken place at the 6LoWPAN layer, where the attacker makes a tunnel between two nodes that are connected [51]. The Side channel security attack in cloud-based IoT application along with the security challenges are explained in paper [52]. Similarly, Distributed Dos attack is the process where the server is unreachable so that smart nodes in the network cannot get the services it desires to get [53]. Man-in-the-middle attack, where the attacker relays the message or change the message during the transmission in the insecure channel, explained in Li et al. [54] IoT-Fog network. Active attacks are explained in Zhang et al. [55] and its corresponding solution in the physical layer of the IoT network. There are different types of active attacks possible in IoT, where attackers make changes in the target node. The authors in Raoof et al. [56] explained the Routing attacks in routing protocol lossy network based on IoT application. The Sybil attack is one most common types of attack in IoT. The authors in Zhang et al. [57] and Mishra et al. [58] study the phases of Sybil attacks and their countermeasures in the internet of things. The Deceptive attack in La et al. [59] and Spoofing attack in Zhang et al. [60] authors have addressed the corresponding attacks and their security analysis in the internet of things applications. The Buffer overflow attacks is the process of writing the program in a block of memory where the memory space is insufficient. The A IoT network, when nodes execute the different programs in the devices for processing or computation purpose attackers, can capture that and perform memory overflow attack. The detecting buffer overflow attack and providing appropriate security design in explained in Xu et al. [61]. In a large IoT network where heterogeneous devices are connected and communicate with each other. The trust is one of the major issues in the network. The Impersonation [62] attacks where a fake node behaves like a genius node in the network and tries to gain the information from other nodes. This is one of the most challenging issues in IoT applications where smart devices are heterogeneous and low-end devices.

Learning methods for IoT security have been grouped into ML, DL and RL methods. ML methods consist of supervised and unsupervised approaches. The supervised



approaches are further categorised into DT, SVM, NB, KNN, RF, AR and EL. Moreover, the unsupervised method only consists of two methods, which are K-means and PCA. DL methods are also grouped into supervised, unsupervised and hybrid approaches. Supervised approaches consist of CNN and RNN methods. Unsupervised approaches also consist of AE, RBMs and DBNs methods. Lastly, hybrid approaches consist of GAN and EDLNs methods. No further categorisation was found under RL methods.

### 1.5. Machine Learning

Machine learning (ML) refers to intelligent methods used to optimize performance criteria using example data or past experience(s) through learning. More precisely, ML algorithms build models of behaviours using mathematical techniques on huge data sets. ML also enables the ability to learn without being explicitly programmed. These models are used as a basis for making future predictions based on the newly input data. ML is interdisciplinary in nature and inherits its roots from many disciplines of science and engineering that include artificial intelligence, optimization theory, information theory, and cognitive science [54]. Machine learning is utilized when human expertise either do not exist or cannot be used such as navigating a hostile place where humans are unable to use their expertise, for instance robotics, speech recognition etc. It is also applied in situations where solution to some specific problem changes in time (routing in a computer network or finding malicious code in a software or application). Furthermore, it is used in practical smart systems, for instance Google uses ML to analyse threats against mobile endpoints and applications running on Android.

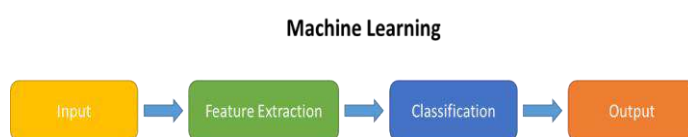


Fig.2. Machine Learning process

It is also used for identifying and removing malware from infected handsets. Likewise, Amazon has launched a service Macie that uses ML to sort and classify data stored in its cloud storage service. Although ML techniques perform well in many areas; however, there is a chance of false positives and true negatives. Therefore, ML techniques need guidance and modification to the model if inaccurate prediction is made. On the contrary, in Deep Learning (DL), a new breed of ML, the model can determine the accuracy of prediction by itself. Due to self-service nature of DL models, it is rendered as more suitable for classification and prediction tasks in

innovative IoT applications with contextual and personalized assistance. Although traditional approaches are widely used for different aspects of IoT (e.g. applications, services, architectures, protocols, data aggregation, resource allocation, clustering, analytics) including security, the massive scale deployment of IoT however, advocates for intelligent, robust, and reliable techniques. To this end, ML and DL are promising techniques for IoT networks due to several reasons, e.g. IoT networks produce a sheer amount of data which is required by ML and DL approaches to bring intelligence to the systems. Furthermore, the data generated by the IoT is better utilized with the ML and DL techniques which enable the IoT systems to make informed and intelligent decisions. ML and DL are largely used for security, privacy, attack detection, and malware analysis. DL techniques can also be used in IoT devices to perform complex sensing and recognition tasks to enable the realization of new applications and services considering real-time interactions among humans, smart devices and physical surroundings.

Using ML and DL techniques in IoT applications on the other hand bring multi-faceted challenges. For instance, it is challenging to develop a suitable model to process data from diverse IoT applications. Similarly, labelling input data effectively is also a cumbersome task. Another challenge is using minimum labelled data in the learning process. Other challenges stem from the deployment of these models on resource-constrained IoT devices where it is essential to reduce the processing and storage overhead [55]. Similarly, critical infrastructure and real-time applications cannot withstand the anomalies created because of ML or DL algorithms. In the above context, it is imperative to systematically review the security solutions of IoT that leverage ML and DL techniques.

### 1.6. Deep Learning

Deep Learning (DL) is a subset of machine learning techniques, based on artificial neural networks, mirroring the information processing of real biological nervous systems, made of various perceptrons layers. Artificial neural networks have been devised in the past century, but they have recently come back to the limelight thanks to the developments in the computational power of computers, fostering the adoption of DL architectures, made of several related layers, each one composed, in turn, of hundreds or thousands of neurons. More precisely, each layer receives input data and abstracts and organizes them into a sort of hierarchy, useful to learn features as well as to classify different patterns. Compared to traditional machine learning techniques, DL algorithms are considered much more suitable in contexts featuring a high level of complexity, i.e., having several features and a huge



number of data, and being capable of achieving very high performance. The training phase of a deep neural network training has a particular feature: it can be split into two main steps, namely the forward and the backward propagation. In the former, the activation of the internal nodes, representing neurons or perceptrons, is performed according to a certain activation function, layer after layer, from the network input to its output [52]. Conversely, the latter allows for the refinement of the network performance by means of updated weights and bias values to be assigned, if necessary, to the single nodes.

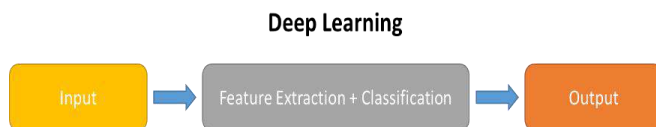


Fig.3. Deep Learning process

There exist various types of deep neural networks, each one with its own main characteristics in terms of number of layers, types of operations performed in the layers, connections across the layers, etc. However, a first rough classification can pertain to the deep supervised, unsupervised, hybrid, and reinforcement learning approaches.

The supervised DL approaches ground their own predictions or classifications on the basis of a particular learned mapping between an instance and a certain label or class generating a discriminative model [53]. In other words, these methods are able to relate the input parameters (features) and the required output (the class) thanks to a priori knowledge of the label of a certain instance. The initial stage of supervised approaches provides that learning examples train the algorithms, then used to predict or classify a novel unlabelled input instance [54]. These approaches usually encompass Convolutional Neural Networks (CNN) as well as Recurrent Neural Networks (RNN). On the other hand, the unsupervised DL approaches can learn important representations of the input without the necessity of pre-labelled training data [55], creating a so-called generative model. These approaches generally intend to: (i) analyse unlabelled data to find previously unknown similarity relationships within the training instances and then (ii) to categorize new unlabelled instances into distinctive groups by exploiting the similarities found in the training set. Some representative members of these approaches are deep Auto Encoders (AE), Restricted Boltzmann Machines (RBM), and Deep Belief Networks (DBN). The hybrid DL approaches are a combination of the aforementioned, combining both discriminative and generative models. Examples of such DL approaches can be seen in

Generative Adversarial Networks (GAN) and Ensembles of Deep Learning Networks (EDLN). Finally, deep reinforcement learning provides entities that learn according to a trial-and-error procedure, involving how their actions can affect the surrounding context. A certain reward is estimated after each action, which moves the whole learning system towards a new state accordingly. Entities will get rewarded for good actions and penalized for bad actions [56]. An example of this category is surely Deep Q-learning (QL). In the following subsections, we will summarize the main types of deep neural networks, that we found in performing the systematic review we carried out.

### 1.6.1. Supervised deep neural networks DNN

#### 1.6.1.1. CNN

A first type of supervised DNN is the CNN, which has been originally devised to shrink the number of parameters in image recognition tasks, replacing traditional artificial neural networks. The reduction of the parameters, by means of sparse interaction, parameter sharing and equivariant representation [9], allows the simultaneous cutting down of the connections between layers, thus augmenting the scalability as well as improving the overall training time complexity. Basically, a CNN is made of two types of layers, which are usually interchanged, namely, convolutional layers and pooling layers. The former are in charge of convoluting data parameters using multiple equal-sized filters [57]. The latter reduce the sizes of the following layers by means of max pooling (division into non-overlapping clusters and selection of the maximum value per cluster) or average pooling operations, which act as a sort of down-sampling. The reduction of the parameters can be seen when a CNN is extensively applied to the training set, thus permitting the automatic learning of features from raw data with high performance. Notwithstanding, the disadvantage of a CNN is the high computational cost; thus, its implementation on resource-constrained devices, such as those present in an IoT environment, is challenging and often requires the help of edge computing devices.

#### 1.6.1.2. RNN

Another type of supervised DNN is the RNN, which has been introduced to manage sequential input data, e.g., speech, text, sensor data, etc., thus considering, in the prediction about the current sample, the associations of several previous samples as well. In summary, the output of an RNN depends both on present and past inputs; therefore, the traditional feed-forward scheme is not suitable in this context, whereas the back-propagation technique fits perfectly [58]. The main feature of an RNN is a temporal layer, getting sequential input data and learning multifaceted variations thereof. This is performed

by using hidden units of a recurrent cell [59], which elaborate the current state of the network by means of an estimation of the following state as an activation of the previous state. However, the main disadvantage of an RNN is the so-called vanishing or exploding gradient [60], which prevents the weights of the network from being correctly updated. RNNs can be used for IoT security by analysing the great quantity of sequential data produced by IoT smart objects, namely by detecting time series-based threats.

#### 1.6.2. Unsupervised deep neural networks

A first type of unsupervised DNN is made of an AE, which, as the name may suggest, aims to reproduce the input into the output. Usually, AE have only one hidden layer joining its two main parts: an encoding function  $h = f(x)$ , abstracting the input into a so-called code, and a decoding function  $r = g(h)$ , which tries to replicate the input with minimum reconstruction error [9,61]. One of the advantages is that an AE can give priority to some input feature in the copying process; thereby, it is normally very effective in extracting a reduced set of useful characteristics out of the input data. A disadvantage may be the fact that an AE cannot reconstruct the input perfectly, as it only reproduces an approximation thereof, by simply copying the inputs being similar to the training data having already been processed. Moreover, an AE requires a high computational time and it could only make the learning process more complicated in case the considered training dataset has no significant relationships with the testing dataset. Other types of unsupervised DNN are deep generative models such as RBMs, wherein no links between any two nodes belonging to the same layer are present.

An RBM is made of two main types of layers, namely the visible and hidden layers, in order to understand hierarchically features from the input data themselves. The former encompass known inputs, while the latter entail latent variables, i.e., the features captures in the initial visible layer, spread into further multiple layers. The main issues with RBMs concern the accurate follow-up of the evolution of the training data over time, as well as the limited capability to represent features. However, RBMs can be improved by stacking two or more of them in order to create another type of generative DNNs, i.e., a DBN [55]. The stacked RBMs perform greedy layer-wise unsupervised training in order to enhance the robustness and the performance of the whole training procedure. This objective is achieved by training each RBM layer, one layer after the other, executing the operations of each layer on top of the formerly trained layer and applying a SoftMax layer during the fine-tuning phase of the features with respect to the labeled samples [63]. Indeed, after the

pre-training phase, a DBN turns out to be a feedforward network that fine-tunes the weights with contrastive convergence [59]. Moreover, although contrastive convergence may lower computational time, these types of DNN are still not very much applicable to resource-constrained devices.

#### 1.7. Blockchain

A Blockchain is a distributed public database that keeps a permanent record of digital transactions. The distributed ledger records the transactions of Blockchain blocks, and every block is related with a hash function to preserve the chain with its previous block [14]. The network elements/nodes will receive a pair of the public key and private key upon registering to the network. Public key works as a unique identifier for each element. Private key also helps to sign transactions in the network and is used for encryption and decryption. The transactions are received by all the nodes and are validated. They are grouped into a timestamped block by few nodes designated as miners [14]. Blockchain is a “No Central Authority,” consensus algorithm used to select a block, among the number of blocks created by the miners, added to the Blockchain network. For making any changes to the existing block of data, all the nodes present in the network run algorithms to evaluate, verify, and match the transaction information with Blockchain history. If the majority of the nodes agree in favour of the transaction, then it is approved, and a new block gets added to the existing chain. Implementing Blockchain comes with benefits such as securing data, reducing errors, ensure reliability, and improve integrity and effectiveness

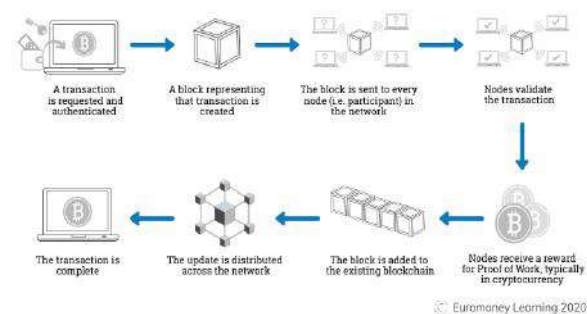


Fig.4. Blockchain Process

## IV. CONCLUSION

In this paper, we tried to give an overview of IoT technology and its application domains study various security challenges that can be faced by IoT applications then we have described some existing AI approaches that can enhance IoT security. From the survey, it was found that some research has already been done in various technology like Machine learning, Artificial intelligence,

and Blockchain technology, which are capable of addressing the existing security issue. So, in detail study has been made in three technology machine learning, artificial intelligence and Blockchain technology, and their integration with IoT. Security is an important issue that needs to address. In this survey, we have focused on the emerging Artificial intelligence technologies like DL, ML, and Blockchain and their integration with IoT to make the system more secure.

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# Sustainability of Passenger Waterway Transportation under Demand and Service Level Constraints: A case study in Belém, Brazil

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**Keywords—** sustainability, waterway transportation, cost model, activity-based costing, linear programming.

**Abstract—** Waterway transportation is a very ancient mobility solution. Amazon region represents a good case study, where waterway transport played and is still playing a very important role. Nevertheless, passenger waterway transportation lacks economic models that help in designing and implementing strategies towards sustainability. In this work, a cost model of passenger waterway transportation was developed based on the assumptions of activity-based costing and used linear programming for cost optimization under demand and service level restrictions, with an objective-function of profit maximization of service. The model was applied in a passenger waterway transportation company to three crossings in Belém city - Brazil, for passengers and cargo, and vehicle transportation, operating on trips between Belém and Marajó Island. Different simulations in order to explore the opportunities and conditions of operational cost reductions were made. The search was for the best relation between cost and profit, i. e., model parameters include variable cost, profit and maximum number of possible trips. On results, cost reduction alternatives were established in order to reach the maximum profit and number of trips. The model proved to be useful for the design of sustainable waterway transportation services through the analysis of feasible and effective cost reduction strategies.

## I. INTRODUCTION

Waterway transportation services have been using notably seas and rivers, lakes and canals to transport people where the natural conditions are favorable or where no other alternatives are feasible or represent a better economic solution. Using the water to travel and to

transport was the first type of transportation to employ an energy source other than human or animal power; i.e., wind [1]. More recently, the development of the steam engine revolutionized water transportation because the energy source resulted more constant and reliable. In certain regions, waterway transportation systems are still

fundamental but face many challenges to be sustainable from several perspectives.

In general, a waterway transportation system is composed of a navigable channel, navigation equipment and an operational plan. Depending on the demand and planning and control restrictions, to which the service is subject, there is a defined operational arrangement, whether for passengers or cargo, and a specific price. Among its main characteristics and advantages, it is seen as a lower cost and less polluting alternative to other transportation systems, with the possibility of wide use in places of water potential. In addition, water has become a vector of penetration and occupation of regions, defining flows by settlement locations and influencing the supply and distribution of cargo, as well as passengers.

Worldwide, cases of waterway transport are notable from various perspectives. In Asia, several studies show the social and economic importance of waterway transportation for the regional development highlighting also operational and service level difficulties. Such studies, typically, focus on descriptive analysis of historical data series [2]-[4]. In Europe, despite the existence of research on waterway passenger transport, approaching particularly modal integration and intermodality in metropolitan areas, studies are more comprehensive in the case of waterway cargo transport, exploring port infrastructure and operational issues. Likewise, the role of public policies and governments is strongly discussed, focusing on sustainable transport development.

Methodologically, analytical methods are among the most used, as well as techniques of data analysis and simulation, which complement econometric methods and economic evaluation approaches [5]-[7]. In North America, characterized by great seaworthy rivers, several surveys studied waterway transportation of passengers and freight, with predominance in terms of modal integration and logistics analysis. Some studies use operational research techniques and descriptive data analysis, and also econometric models and investment appraisal approaches [8]-[10].

Passenger waterway transportation should be understood considering economic but also political, environmental and social perspectives. Brazil can be viewed as a good case study. Indeed, all these perspectives should be considered to have a full understanding of this phenomenon. There are companies of passenger waterway transportation that operate under the regime of public concessions having, in the interstate and international sphere, activities and sales prices regulated by the National Agency of Water Transportation and, in the state sphere, by the Service Regulation Agencies of each State.

Considering that, companies of this type can have little influence on the fares and the demand (number of passengers) that make up their passenger billing, due to the regulation, and excluding from this situation the revenues earned from the transport of parcels. Furthermore, due to requirements from the Brazilian Navy, they also have crew scale restrictions, which affect the desired results, and business sustainability.

Particularly, in the Amazon region, companies of passenger waterway transportation performing their activities through public concessions present some economic difficulties. This fact can be verified through the existing competition between the activity of passenger waterway transportation and other modes, such as air transportation for longer distances, which is practicing prices closer and closer to the fares charged in such waterway transportation systems. In other cases, waterway transportation needs to compete also with road connections and the use of private vehicles, particularly in short journeys [11].

Political aspects and options of public policy are also important to understand the context of waterway transportation services. Similarly, to what happened in other towns of the Amazonia region in the middle of the 20<sup>th</sup> century, the Metropolitan Region of Belém was populated in order to guarantee the political control of the region and waterway transport played a very important role in the social and economic development of the region. However, its importance has declined since the middle of the 20<sup>th</sup> century due to the advent of road transport, which is the current prevailing mode of transport in the region. As a result, the territorial occupation patterns in the region have changed as well.

Furthermore, the environmental impacts of waterway transport systems might be felt at local level in three dimensions – physical, biological and human. These impacts can have short, medium- or long-term lasting effects that might start right after the new transport system is put into operation. Namely, it might contribute to ease heavy traffic congestion of road transport system and to intensify the socioeconomic activities that are dependent on urban waterway transport. Other benefits include opening of new markets, increased mobility of the islanders because of improved access to transport services, and changes in land use and occupation patterns in the planning areas.

Nevertheless, passenger waterway transportation lacks economic models that help in designing and implementing strategies towards sustainability from both a financial and an economic perspective, i.e., considering both the investors and the society. All economic, social and

environmental issues should be taken into account, but such sustainability must begin to be financial, because without viable companies there is no service in free market conditions, public concessions or state-owned industries. Passenger waterway transportation is characterized by restrictions imposed by the market and by law, i.e., from one hand, intermodal competition and market demand in terms of service level; from the other hand, by the existence of a regulatory environment of public concession and institutional restrictions.

In this context, a proper management of costs is of particular importance. However, traditionally, cost models and cost management practices have been focused only on reducing operations costs, in order to keep low prices and gain market competitiveness. Thus, strategic cost management emerges as one of the instruments that can be used to obtain, analyze and optimize the company's costs in accordance with its strategy, the optimized use of resources and the efficiency of activities performed [12]. Traditional costing systems also do not adequately translate the value creation process that relates resources consumed, activities developed and products or services produced for different categories of customers. This reality has motivated the emergence of new costing models, focused on the analysis of the activities that support businesses processes, e.g., such as Activity Based Costing – ABC [13].

Therefore, in this research project, a cost model was developed based on ABC principles namely; assigning resources to the activities and the later to the services provided using proper cost drivers. In an industry were revenues drivers (both number of passengers and price) are conditioned by laws, rules and regulations controlled by several agencies, a good cost management plays a very important role in the sustainability of the business.

Indeed, facing demand and service levels restrictions, cost optimization is indispensable for the sustainability of the service. Such optimization can be supported on simulation models, cost optimization techniques, sensitiveness analyses and searching minimum costs. Different approaches can be undertaken, both deterministic and stochastic. In this exploratory work, a deterministic approach was followed, considering a stability in the system, highly regulated in terms of fares and passenger capacity per trip. The system objective is to maximize the profit and the sustainability of the service provided.

Thus, a linear programming model [14] was developed where the objective-function maximizes the profitability of the waterway transportation services under revenues and cost restrictions, service level conditions and return on investment expectations. The optimization model relies on

a cost model that relates resources-activities-services, i.e., resources are consumed by the activities and of later support the different crossings. The mathematical relationships established between these elements through appropriate cost drivers turn the model much more reliable and useful, particularly, for optimization purposes.

This model can help companies and public agencies, in the analysis of the internal cost structure of waterway transportation, towards the design of effective cost reduction strategies, the analysis of potential new markets or new services, to establish new partnerships, to support investment decisions, or to recommend public policies.

The model was applied considering the cost structure of a typical passenger transportation company located in the Amazon River in Belém, State of Pará, Brazil, and three different crossings. From this case study, it was possible to understand the cost structure that support the waterway transportation, namely, the costs of the main activities and of the most relevant cost objects. In order to compute profitability margins, identify cost reduction opportunities and the conditions of competitive advantage related to the different strategic options that can be pursued namely, cost leadership, differentiation or segmentation [15].

The paper is structured as follows. Section 2 presents and discusses the main concepts that supported the development of the cost model and the optimization approach. The case study is presented in Section 3 and the results are presented and discussed in Section 4. The main conclusions, final remarks and opportunities for further research are presented in the last section

## II. MATERIAL AND METHODS

The current business environment, which is based on information, requires adequate management tools to manage and measure accurately costs, revenues and performance. In this context, strategic cost management is fundamental to obtain, analyze and optimize the company's costs in accordance with its strategy, the optimized use of resources and the efficiency of activities performed [16]. Strategic cost management consists of the use of cost information to develop and identify superior strategies that will produce a competitive advantage [17].

The use of cost models based on activities proved to be more useful than traditional costing models for the understanding of cause-effect relationships that explain the costs of products and services. The Activity-Based Costing (ABC) method considers that to produce a product or service it is necessary to perform certain activities that, in turn, consume resources. Thus, in an ABC costing system

resource costs are assigned to activities, firstly, and such costs are allocated to cost objects using appropriate cost drivers [18].

Cost drivers are fundamental in this approach because they represent the cause-effect relationship between resource use, activity performance and cost objects [19]. The information extracted from the ABC model allows us to identify activities that add value and those that do not the latter could be reduced or eliminated; without compromising, the value created from the customer perspective [20].

The ABC method seeks to answer which activities are being executed by the organization; how much does it costs to be executed; and, how much of each activity is necessary for the products and services, considered as cost objects. In short, in ABC, the cost of a product or service results from the sum of the direct costs and the cost of all the activities necessary to produce the product or service [21]. The ABC is applied through two main steps: the first, in which the costs of resources consumed are allocated to the various activities of the organization.

In this step, resource drivers are used to distribute the costs consumed over more than one activity. Second, the costs of the activities are allocated to the cost objects based on their consumption of the activities. This allocation is done using activity cost drivers. Finally, direct costs are added to the cost objects in order to compute the total cost of the product or service. The use of ABC provides relevant information for both operational and strategic cost analysis, identifying what generate costs, and helping in the design of plans towards reducing total costs in a sustainable manner.

There are just a few works on cost and economic models and economic analysis in waterway transportation, and some a literature review on waterway transportation modelling through case studies [22]. In some studies, environmental, social, economic, financial, operational and technical aspects were considered. Waterway transportation has been analyzed using the cost-benefit analysis method and the Analytic Hierarchy Process [23]-[24], and Monte Carlo simulation, using dynamic and linear programming [25].

Some studies made the evaluation of investments considering the cash flow and sensitivity analysis [26]-[27]. The use of these different methods depends on the reliability of the data available and of the independent and dependent variables used. In this work, the passenger waterway service cost model was structured as it is presented in TABLE 1.

*Table.1: Key-elements of the activity-based costing model*

	Cost accounting information was obtained from a typical waterway company for the years 2017, 2018 and 2019, in a monthly basis; namely, equipment depreciation, salaries, cleaning and security, electricity, fuel, maintenance, etc.; some resources were assigned directly to the respective activity and other were allocated to several activities, according to the consumption relationship resource-activity, having as main resource cost driver the fuel consumption, because this one is highly correlated to the number of journeys, nautical miles traveled, maintenance expenses, etc.
Resources	
Activities	Activities were classified as primary, directly assigned to the cost objects and secondary or support activities, which were allocated to the other activities. Activities' costs were allocated to the crossings considering the number of journeys made.
Cost objects	Documents analysis, on-site observations and interviews allowed to identify the most relevant costs and respective cost drivers; only the crossings were considered cost objects; direct resources (e.g., fuel consumption was allocated directly to the cost objects) and indirect costs were allocated through the activities.

Source: authors (collected from the company).

Thus, the cost model us built on the principles of ABC turning it more sophisticated, accurate and relevant for decision making, than previous models used in this context. The deterministic use of the cost model allowed us to compute the costs and margins by cost object, overall profitability, return on investment and to analyze the cost structure and value creation process relating resources, activities and cost objects. An optimization model can be used for cost optimization purposes and profit maximization through the analysis of cost reduction opportunities and potential strategies as well as the global impact of such changes in the service under certain constraints. The use of ABC allows an effective strategic cost analysis of the business processes, identifying the relevant cost drivers and the cause-effect relationships, which help decision makers to know where and how much can be reduced in total costs in a sustainable manner.



On the other hand, Linear Programming (LP) provides the simulation of scenarios under certain restrictions, in order to seek the best use of resources. Some studies on transportation were found using Linear Programming (LP): to optimize operational arrangements of transport system components [28]; in multi-objective routing problems of vehicles [29] and in the analysis of performance improvement opportunities [30]. Recently, in urban transport networks studies [31] and for exploring challenges and opportunities of sustainable development of logistics networks [32].

Linear programming model belongs to the mathematical programming field that supports the optimization (maximization or minimization) of one or multiple objectives, which can be linear or non-linear [33]-[35]. Linear programming, in general, is the simplest case to solve in mathematical programming. A linear programming problem is described by linear functions of decision variables. Nonlinear programming is very common in practical cases, being composed of an objective function, general restrictions and variables, where at least one function is nonlinear, which can be the objective function or one of the restrictions.

$$\begin{aligned} \text{Max } z &= c^T x \\ \text{s.t. } Ax &= b \\ x &\geq 0 \end{aligned} \quad (1)$$

Where  $A$  is a matrix  $m \times n$ , (all linearly independent lines). We can decompose vector  $c$  into its basic and non-basic components,  $c = (c_B, c_R)$ , assuming that the existing viable basic solution is represented by a vector  $\bar{x} = \begin{pmatrix} B^{-1} \\ 0 \end{pmatrix}$ , whose associated value is given by the:

$$z_0 = c \begin{pmatrix} B^{-1} \\ 0 \end{pmatrix} = (c_B, c_R) \begin{pmatrix} B^{-1}b \\ 0 \end{pmatrix} = c_B B^{-1}b. \quad (2)$$

We can present the vector  $x$ , depending on the basic and non-basic variables, as follows:

$$\bar{x} = \begin{pmatrix} x_B \\ x_R \end{pmatrix} \text{ e } b = Ax = Bx_B + Rx_R \quad (3)$$

Multiplying by  $B^{-1}$  the expression of  $z_0$  is given by

$$\begin{aligned} x_B &= B^{-1}b - B^{-1}Rx_R \\ &= B^{-1}b - \sum_{j \in J} B^{-1}a_j x_j \end{aligned} \quad (4)$$

In this way, we can rewrite the expression.  $z = cx$ , as follows:

$$\begin{aligned} z &= cx \\ &= c_B x_B + c_R x_R \\ &= c_B (B^{-1}b - \sum_{j \in J} B^{-1}a_j x_j) + \sum_{j \in J} c_j x_j \end{aligned}$$

$$= z_0 - \sum_{j \in J} (z_j - c_j) x_j \quad (5)$$

Where  $z = c_B B^{-1}a_j$  for each non-basic variable.

The convergence criterion considered for the model is:

$$z - \hat{z} = (c_R^T - c_B^T B^{-1}) x_R > 0 \quad (6)$$

$$\bar{R}_k = B^{-1}R_k \text{ e } x_{R,k} = \min \left\{ \frac{\hat{x}_{B,i}}{\bar{R}_{k,j}}, \bar{R}_{k,j} > 0 \right\} \quad (7)$$

### III. CASE STUDY

The case study was developed in a company with three crossing services by waterway transportation in the Metropolitan Region of Belém, for passengers and cargo, and vehicle transportation. The services are the following:

1. Belém-Camará crossing: daily frequency passengers' service, authorized by state entity. The crossing is of 30 nautical miles long and it can be used two different equipment: a ship for 600 passengers and a boat for 137 passengers. There is a competitor company with similar equipment and, another one, which operates in this crossing with a ferryboat.
2. Belém-Arapari crossing: daily frequency, transport of passengers' vehicles and cargo, authorized by state entity. The journey begins in the south bank terminal of Belem and ends at the Arapari terminal, in the southeast of the State of Pará. The crossing is 10 nautical miles long and it can be done using two types of equipment: a pusher and a ferry, which adds up to an average of 50 standard capacity vehicles. There are three companies competing in this crossing.
3. Belém-Cotijuba crossing: daily frequency, for the transportation of both passengers and cargo, through a concession contract with the Belém City Hall. The crossing is 10 nautical miles long with one equipment: a ship for 350 passengers.

The company also has a replacement equipment, a ship for 238 passengers and, shares a ferryboat as replacement equipment with three other companies that operate in the Belém-Arapari crossing. The three crossings have some specific resources and share some operational and administrative resources, too. The mission of the company is to meet the needs of the demand efficiently, at the lowest possible cost. Fig. 1 shows the different crossings.

The empirical study was made in three different phases. A documental analysis phase was carried out for the general characterization of the company and the services offered, and data about the cost structure was obtained to identify the value chain of the service and the resources employed. At this stage, empirical observations of the service were made, notes were taken of the activities



developed in the various sectors and several interviews were conducted at the company. It was also possible to identify the drivers of the activities and the structure of the value chain. A reasonable level of aggregation was also sought, considering the difficulties that defining each activity would bring to the information system.

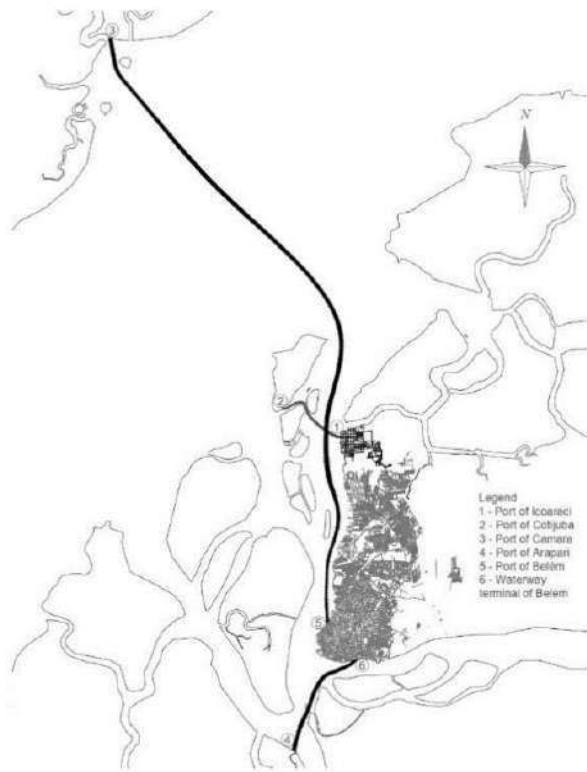


Fig. 1 Caption: map of Belém metropolitan region and Marajó Island, both in Brazil, at the mouth of Amazon River with the Atlantic Ocean. The legend identifies six ports: number 1 – Port of Icoaraci; number 2 - Port of Cotijuba; number 3 - Port of Camará; number 4 - Port of Arapari; number 5 - Port of Belém and; number 6 - Belém waterway terminal. The figure shows the waterway transport routes from Belém (from port number 1) to the Port of Camará at Marajó Island (port number 3), with interconnection with another waterway transport route from the Port of Cotijuba, number 2. It also depicts the waterway transport route connecting number 4 and 5 ports.

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identify the drivers of the activities and the structure of the value chain. A reasonable level of aggregation was also sought, considering the difficulties that defining each activity would bring to the information system.

In sequence, there was a second phase, composed by interviews conducted with the company's employees, since the experience acquired can provide reasonable estimates of the consumption of resources by the different activities, as well as to establish the cause-effect relationship between the consumption of resources and their activities. Finally, defined the activities, the resources that each activity consumed were allocated to them.

In an interview with the company's board of directors, the following main challenges were identified:

- The out-of-date tariff for the Belém-Camará and Belém-Arapari crossings, in the last 20 years, and without any perspective of adjustment by the regulatory agency;
- The high rate of seasonality of the service, where only in two months of the year it is possible to have the capacity filled;
- The large number of equipment of competitors in the Belem-Camará and Belém-Arapari crossings and, in the Belem-Cotijuba crossing, and the competition from informal transport;
- Shortage of skilled labor;
- Conflicts of operational nature and financial adjustment with competing companies;
- Inefficiencies resulting from predominantly family-based management models without professional management.

Indeed, it is challenging for companies operating in this context. There is a revenue growth restriction, because the government regulates the tariff and, costs are committed by the seasonality of the demand – the company in only two months of the year operates at full capacity. Cost drivers are miles travelled and the type of equipment used, both impact in the fuel consumption, the main variable cost. Labor costs are also important but are mainly fixed costs.

The optimization of both fixed and variable costs asks for continuous improvement, conversion of some fixed costs in variable ones, and expense reduction; as well as, optimization of the number of journeys and the reduction of idle capacity, sharing resources or using such available capacity (e.g., in terms of maintenance) to perform other activities that can result in additional revenues. The restrictions in terms of demand (both quantity and price) does not allows increasing revenues, thus profit maximization implies a cost optimization approach.

#### IV. RESULTS AND DISCUSSION

The analysis of the case study was initially done by modeling the cost structure, following the principles of ABC. Subsequently, a cost optimization analysis was made using a linear programming model. A sensitivity analysis and several simulations were carried out for the three crossings. There are two companies operating in the Camará crossing, four companies in the Arapari crossing and only one company operates the Cotijuba crossing.

##### 4.1 Cost model

Considering the passenger waterway transportation cost structure presented in Section 2, it was collected information on the costs of the resources that support the crossings, as well as, the cost drivers for each activity. Finally, once the costs of the activities were computed, they were allocated to the cost objects (i.e., the three crossings), for the years 2017, 2018 and 2019. The activity costs, which were assigned to the crossings, were computed in a monthly basis and on average per year, as shown in TABLE 1. TABLE 2 shows that fleet maintenance and equipment operation activities are the main primary activities and, the maintenance of the company headquarters the secondary activity that consumes more resources. Fleet maintenance and the maintenance of the company headquarters are activities explained mainly by labor costs and costs related to the equipment operation, being fuel consumption costs the most significant one. Camará crossing has higher costs in all activities as shown in TABLE 3.

It is important to point out that transportation services ask for a considerable amount of resources and direct costs, particularly fuel and labor, and the main cost driver for these activities is nautical miles. Likewise, maximum revenues were obtained considering the number of journeys established by the State Regulation Agency, which regulates the service. Furthermore, demand seasonality turned possible to calculate the revenues per month. TABLE 4 shows the *status quo*, highlighting the average monthly profit. Notice that Camará crossing presents a negative profit. This situation leads the company to have losses of US\$ 508,30 per month. Since revenues cannot be increased and the number of journeys cannot be reduced significantly, there is a need to reduce costs and increase the profit margin to achieve the desirable return on investment, which is considered in the industry to be around 10% of the revenues. This situation leads to an optimization model of profit maximization through cost reduction strategies.

##### 4.2 Optimization model

A scenario of 10% overall and by journey profitability over the total revenues was set up and the maximum allowed average costs for each crossing was established. Fuel costs, which are variable and dependent on the number of journeys, were also considered. The results are presented in TABLE 5. Camará and Arapari crossings have similar costs, excepting depreciation costs, since the company operates with ships in the Camará crossing and with a ferryboat in the Arapari crossing.

Table 2: Activities costs per crossing on average per month (values in US\$)

		Primary Activities Costs		
		(1)	(2)	(3)
Operational				
1	Administrative support at the port	4,904.42	3,433.10	1,471.33
2	Ticket Sales (ticket manufacture/refund/distribution and card costs)	5,005.99	5,074.76	3,113.41
3	Release of the fleet and crew (equipment preparation and crew scale)	1,337.72	192.67	79.89
4	Fleet maintenance (personnel/storage and equipment)	7,374.20	6,052.13	2,669.43
5	Equipment operation (inputs and crew)	45,555.70	24,501.62	10,093.89
6	Equipment operation (depreciation)	4,468.20	3,025.79	745.03
Non-operational				
1	Advertising and marketing	269.01	63.32	40.47
		Secondary Activities Costs		
1	Maintenance of the company headquarters	6,022.59	4,618.17	2,176.50
2	Administrative Activities	3,351.18	2,345.83	1,001.28
3	Accounting and Finance Services	103.85	103.85	103.85
4	Other Activities*	7,480.72	4,815.02	2,202.63

\*Other Activities: pro-labore board, company advertising, bank/loan charges/employer's union monthly fee.

Crossing (1) – Belém – Camará; Crossing (2) – Belém – Arapari; Crossing (3) – Belém – Cotijuba.

Source: authors (collected from the Company).

Table 3: Current scenario - monthly financial results (values in US\$)

Crossings	(average by month)			
	Revenues	Journeys	Costs	Profit
Camará	71,258.14	112	85,873.59	14,615.45
Arapari	67,891.36	231	54,226.25	13,665.11
Cotijuba	24,139.74	123	23,697.70	442,04
Total	163,289.25		163,797.50	-508,30

Source: authors (collected from the Company).

Table 4: 10% Profit scenario (values in US\$)

Operational		Primary Activities Costs (on average per month)			
		(1)	(2)	(3)	Resource Costs
1	Administrative support at the port	14,84	11,96	43,72	9,808.85
2	Ticket Sales (ticket manufacture/refund/distribution)	21,94	25,32	44,63	13,194.16
3	Release of the fleet and crew (equipment preparation)	0,83	0,65	11,92	1,610.28
4	Fleet maintenance (personnel/storage and equipment)	26,16	21,71	65,74	16,095.76
5	Equipment operation (inputs and crew)	43,05	60,81	137,54	32,865.50
6	Equipment operation (depreciation)	13,08	6,06	39,83	8,239.02
Non-operational					
1	Advertising and marketing	0,27	0,33	2,40	372,80
Secondary Activities Costs (on average per month)					
1	Maintenance of the company headquarters	19,96	17,70	53,69	12,817.27
2	Administrative Activities	10,14	8,14	29,88	6,698.29
3	Accounting and Finance Services	0,45	0,84	0,93	311,56
4	Other Activities	20,81	17,91	66,69	14,498.37
Maximum Cost		234,41	192,71	765,59	146,960.32
Fuel		62,86	21,27	268,60	47,285.71

Crossing (1) – Belém – Camará; Crossing (2) – Belém – Arapari; Crossing (3) – Belém – Cotijuba

Source: Authors (collected from Company under study).

Table 5: Optimization scenarios, maximum profit and number of journeys

Simulations	Constraints	Maximum Profit (US\$)	Journeys		
			Camara	Arapari	Cotijuba
1	With 10% profit, considering information presented in Table 4 data and the PL model.	14,931.77	90	231	120
2	Considering the sensitiveness analysis made in the first simulation, and a cost reduction in Camara crossing,	16,269.41	110	231	120
3	Cost reductions in all crossings, proportional to the weight of activity costs in each crossing.	16,161.44	110	231	123
4	No cost reductions, sharing the costs of Administrative support at the port and Fleet maintenance in the Camara	16,008.62	107	231	120
5	Cost reductions in the Camara Crossing and sharing the costs of Administrative support at the port and Fleet maintenance in the Camara crossing (with two	16,266.66	111	231	123

Cotijuba crossing, with the highest monthly costs, is made with only one ship, having a low frequency of journeys (only two journeys per day). The service is still subsidized and operated by just one company.

The LP model used in this work was defined as follows: the objective-function ( $z$ ) considers the maximization of the profit of the company; the decision variables  $x_1, x_2$  and  $x_3$  are the number of journeys of the three crossings: Camará, Cotijuba and Arapari, respectively. The restrictions consider the costs of the different activities and direct costs (i.e., fuel consumption);  $c_i$  represents the profit coefficients vector for each journey;  $a_{ij}$  the coefficients' matrix and  $b_i$  the vector of the coefficients available for each restriction. The resources available for each activity are presented in the last column. From these results, it was developed a linear programming model presented in Eq. (8).

$$\begin{aligned} \text{Max } z &= 63,53x_1 + 19,3x_2 + 19,63x_3 & (8) \\ \text{s. t. } 43,72x_1 + 14,84x_2 + 11,96x_3 &\leq 9,808.85 \\ 44,63x_1 + 21,94x_2 + 25,32x_3 &\leq 13,194.16 \\ 11,93x_1 + 0,83x_2 + 0,65x_3 &\leq 1,610.28 \\ 65,74x_1 + 26,16x_2 + 21,71x_3 &\leq 16,095.76 \\ 137,54x_1 + 43,05x_2 + 60,81x_3 &\leq 32,865.50 \\ 39,83x_1 + 13,08x_2 + 6,06x_3 &\leq 8,239.02 \\ 2,40x_1 + 0,27x_2 + 0,33x_3 &\leq 372,80 \end{aligned}$$

$$\begin{aligned} 53,69x_1 + 19,96x_2 + 17,70x_3 &\leq 12,817.27 \\ 29,88x_1 + 10,14x_2 + 8,14x_3 &\leq 6,698.29 \\ 0,93x_1 + 0,45x_2 + 0,84x_3 &\leq 311,55 \\ 66,69x_1 + 20,81x_2 + 17,90x_3 &\leq 14,498.37 \\ 756,59x_1 + 234,41x_2 + 192,71x_3 &\leq 146,960.32 \\ 268,60x_1 + 62,86x_2 + 21,27x_3 &\leq 47,285,71 \\ x_1 &\leq 112 \\ x_2 &\leq 231 \end{aligned}$$

After this initial round of cost optimization, five optimization scenarios were simulated (TABLE 6). In order to find these reductions, several simulations were made seeking the best relationship between cost and profit.

Parameters include variable costs, profit and maximum number of possible trips. The simulations 2, 3 and 5 resulted in the best relations between the maximum profit and the largest number of trips. It was possible to establish cost reduction alternatives, keeping values very close to the maximum profit and the number of trips, so that the company could assess which of these would be better, or easier to be carried out. Since Camará crossing is the one that presents the highest costs, it received most of the attention of the cost reduction analysis. From Table 6, we can observe that Simulation 5 is the one that fits better the required level of service, defined by the Regulatory Agency. It also offers the best level of profitability.

Table 6: Reduced cost per activity for Camará, Arapari and Cotijuba crossings (in %)

Operational		Primary Activities				
		Simulation 2	Simulation 3		Simulation 5	
			(1)	(2)	(3)	
1	Administrative support at the port	9 %	14 %	9 %	4 %	4 %
2	Ticket Sales (ticket manufacture/refund/distribution)	8 %	8 %	8 %	5 %	4 %
3	Release of the fleet and crew (equipment preparation)	35 %	38 %	6 %	2 %	9 %
4	Fleet maintenance (personnel/storage and equipment)	22 %	12 %	9 %	4 %	4 %
5	Equipment operation (inputs and crew)	20 %	11 %	8 %	5 %	4 %
6	Equipment operation (depreciation)	1 %	17 %	12 %	2 %	4 %
		Secondary Activities				
1	Maintenance of the company headquarters	21 %	12 %	9 %	5 %	4 %
2	Administrative Activities	25 %	14 %	9 %	3 %	4 %
3	Accounting and Finance Services	17 %	6 %	6 %	6 %	3 %
4	Other Activities	25 %	5 %	9 %	5 %	4 %

Crossing (1) – Belém – Camará; Crossing (2) – Belém – Arapari; Crossing (3) – Belém – Cotijuba

Cost reductions can be reached by sharing some activities with other companies eventually, competitors. Cost reduction strategies should do not compromise the service level as well as maximizes the profit and the company's return on the investment, globally and by crossing.

## V. CONCLUSION

In Amazon region, passenger of waterway transportation companies working under public concessions present some economic difficulties, as the case study presented here. The transportation system is regulated by the government (e.g., tariff and service level in terms of number of passengers per crossing) and the Navy sets some significant costs, such as salaries. Thus, profit maximization is constrained in terms of revenues, what implies a strong optimization of the resources used. Such optimization asks first for an accurate allocation of the costs to the activities because are these which can be optimized through efficient strategies such as, for example, sharing equipment and infrastructure.

The cost structure of the service, namely the relevant activities and resources, and respective cost drivers was analyzed considering three years of operation. Fuel and labour are the most significant resources and nautical miles the cost drivers of most activities. There is a cross-subsidy between crossings. However, some facts interfere in this regularity; whether punctual or derived from demand characteristics. For example, due to the seasonality of demand, which only peaks in two months of the year (July and December), implying that equipment are fully used in only two months of the year.

The seasonality of the service is a problem that might be mitigated with more passengers in high season periods, in order to cover the low season. In addition to seasonality, the company faces competition, which further contributes to an over-supply of the service, and to the existence of an operational deficit. In addition, this deficit is also due to the tariff gap, because fares have not been updated in the last years.

In order to explore the opportunities and conditions of operational cost reductions, simulations were made. It was applied a linear programming model followed the premise of a deterministic approach, considering the stability of the system, highly regulated in terms of fares and passenger capacity per trip. Some aspects can be highlighted: the current business model can be optimized through effective and sustainable cost reductions such as partnerships and collaboration among competing companies, e.g., sharing costs of some activities. Indeed, several costs can be reduced if the infrastructure and land labor (port and

maintenance) are shared. Furthermore, there are economies of scale to be explored in the acquisition of resources, particularly, fuel; in which supports Scenario 5.

Finally, there are some research opportunities, which could be explored, e.g., the model and optimization approach developed can be replicated in other similar waterway transportation companies. Further studies could be developed to extend this research, including the impact of seasonality, risk and uncertainty, or assuming demand seasonality and the analysis of the breakeven point. Operational characteristics as speed and capacity of the boats, which can reduce significantly fuel consumption. Furthermore, it is imperative to study the design of tariff models, which, for example, include the impact of services free-of-charge granted for seniors and students.

The model and approach proposed here extends the previous literature on cost and economic models and economic analysis in waterway transportation and offers a basis for further developments with practical and theoretical relevance. In addition to unveiling a reality present in the Amazon region and other regions worldwide where waterway transportation is important.

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# Importance of Regulation in the Brazilian Intellectual Property Legal System and the Consequences of the Delay for the Development of the Country

## Importância da Regulamentação no Sistema Jurídico Brasileiro da Propriedade Intelectual e as Consequências do Atraso Para o Desenvolvimento do País

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**Palavras-Chave—** Inovação, TRIPS, Proteção do  
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**Abstract—** Intellectual property rights have their roots in the Paris Conventions (1883) and Bern (1883) and will materialize in contemporary society through TRIPS. Brazil, as a signatory country to these international agreements, sought to adapt its domestic System of knowledge protection. However, it was a relatively tardy measure, considering that implementation took place, in the late 1970s, through the Industrial Property Law (Law nº 9279/1996), which had a high cost to the country in terms of development. As if the time delay were not enough, the protection of knowledge in Brazil was born out of date, considering the advance of patent rights on biotechnology. By denying patents on genetic and modified material, the country opened its borders to patent applications requirements from developed nations, based on TRIPS. Thus, from the dialectical method combined with the hypothetical-deductive method, this work seeks to investigate the intellectual property rights of Brazil, having international treaties and national legislation as references. The results show that the country paid dearly for the negligence in protecting its knowledge, which placed it in the rear of scientific and technological development, and resulting in the expansion of the technological domain of developed nations in Brazilian territory.

**Resumo—** Os direitos de propriedade intelectual têm sua origem nas Convenções de Paris (1883) e Berna (1883) e vão se concretizar na sociedade contemporânea pelo TRIPS. O Brasil, como país signatário desses acordos internacionais procurou adequar seu Sistema doméstico de proteção do conhecimento. Entretanto, o viés temporal foi relativamente tardio, considerando que a

*implementação se deu tardiamente, na década de 1970, por meio da Lei de Propriedade Industrial (Lei nº 9.279/1996), o que custou caro ao País em termos de desenvolvimento. Como se não bastasse o atraso temporal, a proteção do conhecimento no Brasil já nasceu desatualizada, considerando-se o avanço dos direitos de patentes sobre a biotecnologia. Ao negar as patentes sobre o material genético e modificado, o País abriu suas fronteiras aos pedidos de patentes das nações desenvolvidas, com base no TRIPS. Deste modo, a partir do método dialético combinado com o hipotético-dedutivo, busca-se neste trabalho investigar os direitos de propriedade intelectual do Brasil, tendo como referenciais os tratados internacionais e a legislação nacional. Os resultados apontam que o País pagou caro pela negligência na proteção do seu conhecimento, o que o colocou na retaguarda do desenvolvimento científico e tecnológico, e que resultou na ampliação do domínio tecnológico das nações desenvolvidas em território brasileiro.*

## I. INTRODUCTION

This article aims to present the knowledge protection superstructure in Brazil. The country took a long time to define its Intellectual Property Policy, doing so only in the 1970s. Previous rules were specific, such as the Medeiros and Albuquerque Law, which dealt with copyright. It was only in 1996 that a law regulating patent rights was enacted, a matter regulated by the Brazilian Industrial Property Law (Law No. 9.279/1996), and, later, the Copyright and Related Rights Law (Law No. 9.610/98), even though the country adhered to the Paris Convention in 1884, and it was ratified in 1975.

On the other hand, by guaranteeing the legal security of protection of intellectual property rights, it did not prioritize domestic patents, not imposing an innovative attitude on Education and Research Institutions in Brazil. Teaching prevailed and the intellectual property only became a strategic issue in the 2000s, with the enactment of Law No. 13.243/16, for the consolidation of innovation in the scope of national Research and Development (BRASIL, 2016b).

To achieve the proposed objectives, the Dialectical Method of Aristotle, Socrates (399 BC) and Plato (427-347 BC) was adopted, combined with the Hypothetical-Deductive Method (Karl Popper, 1935), involving propositions from the areas of Legal and Economic Sciences. The investigative technique was based on national and international legislation and doctrine, mainly within the scope of the World Trade Organization (WTO), via Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS).

For better understanding, this work has been divided into Sections and subsections. Section 1 is conceptual, addressing aspects of knowledge protection and

its insertion in the legal system (Section 1); the direct relationship that exists between private property and intellectual property (Section 2); intellectual property as a right (Section 3); and, intellectual property and access to genetic heritage (Section 4).

Section 2 is more pragmatic, as it presents the legal definitions and patenting processes adopted by the National Institute of Intellectual Property (INPI) on invention patents (Section 1); Utility Model patents (Section 2); Industrial Design patents (Section 3); and, Entitlement and Licensing (Section 4).

Thus, it is believed that this work can be important in the activities of the professor/researcher in the identification and patenting of the inventive activities developed within the scope of their actions, as well as for society in general.

## II. MAIN INTERNATIONAL KNOWLEDGE PROTECTION AGREEMENTS TO WHICH BRAZIL IS A SIGNATORY

The main international agreements for the protection of knowledge that regulate intellectual property to which Brazil is a signatory, are: Berne Convention (Copyright), 1886; Paris Convention (Industrial Property), 1883; Rome Convention (Rights of Interpreters), 1961, and the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), 1994. These agreements guide the formation of internal legislation in signatory countries, such as Brazil (TAFFOREAU, MONNERIE, AND KPOLO, 2015).

The management instance on a global level is the World Intellectual Property Organization (WIPO, 2019), which deals with administrative issues, and the WTO,

responsible for applying sanctions in case of non-compliance. In Brazil, the governmental body for protecting knowledge is the Ministry of Industry, Foreign Trade and Services, and the management body is the INPI. It is the Ministry's responsibility to receive the patent deposit and manage the search services for precedence, anteriority. In this scope, the consequences of these multilateral agreements in the Brazilian legal system will be verified, as well as their particularities.

### III. PROTECTION OF KNOWLEDGE IN THE BRAZILIAN LEGAL SYSTEM

In Brazil and in countries governed by the Principle of the Democratic Rule of Law, the protection of knowledge is an area of law that protects intellectual creations, providing their holders with economic rights. Therefore, it is a matter of the Economic Law sector, here understood by Souza (1977), apud Del Masso (2013, p. 28) as being:

[...] the branch of law that has as its object the regulation of economic policy and as subject the agent who participates in it. As such, it is a set of economic norms that ensure the defense and harmony of individual and collective interests, in accordance with the ideology adopted in the legal order. For that, it uses the principle of economy.

Economy, taken as a principle here, refers to the legal valuation of the economic. Its function is to enable applicators of Economic Law "stop reasoning only legally to achieve the effects of a rule created or applied to comply with the precepts of the economic order" (SOUZA, 1977, apud DEL MASSO, 2013, p. 28).

When dealing with the matter, Bagnoli (2009) understands that Economic Law came to consolidate economic power, understood by him as:

[...] the manifestation of power conditioned to the economic factor that subordinates those who do not hold the economic element. The manifestation of economic power is a difficult one to have its domination

perceived, in which the dominant and the dominated are related forming something unique, while remaining distinct, each one having one face of the same coin. (BAGNOLI, 2009, p. 28).

For the author, this "coin" maintains its balance thanks to the action of the State, which regulates and distributes justice (BOBBIO, 1987) in a balanced way.

The absence of the State in the economic domain to inspect and regulate the free initiative of economic agents in defense of competition, or the relationship established between public and private power, imply the increase of capitalist monopolies, 'conquered in the market by virtue of power of property'. The relationship between economic power and law leads legal scholars to think of ways to control economic power. Therefore, it is necessary to understand the factors that transformed society and the States and the relationship between Law and Economy (BAGNOLI, 2009, p. 35; no emphasis in the original).

According to the author, both Law and Economics have a profound "imbrication" with Social Sciences, which is why the complexity of these relationships that involve Law and Power should be considered, and understanding them is one of the great challenges of legal-political reflection. From the emergence of the Modern State, the role of Law underwent profound transformations, ceased to be a political reference to be consolidated in a positive 'way, with the guarantee of legal security consolidated by Napoleon's Civil Code of 1808 (BORGES, 2008). In the Modern Era, this relationship between the Modern State and the relationship between Law and Economics became mediated. The Law came to figure as an "instrument of government" (BAGNOLI, 2009).

From the perspective of a Law as an *instrument of government*, the greatest good to be protected is *free*

<sup>1</sup> Positive Law is embodied in the rules and principles that regulate people's behavior through coercion" (MORAES,

G.P. Course of Constitutional Law. 6. ed. São Paulo: Atlas, 2014. p. 4).



*enterprise*, which was the genesis of the French Revolution. In Borges' (2008) understanding, this freedom was only possible due to the "positivization" of rights, notably the 19th century Civil Code, which guaranteed the much-desired legal security of relationships between peers, giving rise to the economic gains that sedimented the society of the Modern Era and its developments remain until contemporaneity.

As can be seen, the struggle of modern Law was to guarantee private property, understood in it: land, things that are on the land and under it, among them improvements and natural resources that may exist such as: water, mineral resources, forests, wild animals, among others.

From this legal framework, Law underwent a bifurcation to make room for Private Law. So, from the Modern Era, there is a classic division of Public Law and Private Law. The Absolutist (Public) State was taken away by the Liberal (Private) State. It was up to the State to establish the general rules of Public Law so that society could develop through free initiative. The norms of this development were contained in the Modern Constitution and the Civil Code of Napoleon. State guarantees plus the strength of capitalism produced the world that exists until today (BORGES, 2008).

From this new scenario of freedoms and opportunities, there was a need to establish rules that could govern economic growth, inflation, unemployment. From this social melting pot emerges Economic Science and the concept of *market*, defined as "a group of buyers and suppliers of a product or service and the institution or arrangement through which they meet to carry out the transaction" (HUBBARD & O'BRIEN, 2010, p. 106).

In this group is the figure of the *entrepreneur*, understood here as "someone who operates a business, bringing together the factors of production – labor, capital and natural resources – to produce goods and services". A large part of the responsibility of a country's Economic System is entrusted to the entrepreneur. It is up to him to decide what to produce, based on the *belief* that there is a *market* (consumers) that is willing to purchase the products that are produced by him (HUBBARD & O'BRIEN, 2010, p. 108-110).

According to HUBBARD & O'BRIEN (2010), the entire Economic System is structured on private rights, which must be guaranteed by the State, namely: the right to private property and the right to the protection of private property.

#### IV. PRIVATE PROPERTY AS AN INDUCTOR OF INTELLECTUAL PROPERTY IN BRAZIL

In a *economy of market*, "the government does not restrict how companies produce or supply products and services or how they employ the factors of production, but the absence of government intervention is not enough for a market system to work properly". The government must secure *property rights* for the Market System to function. Furthermore, it is the role of the state to solve the conflicts that arise from this System, offering a Judiciary System that can guarantee the fulfillment of contractual agreements, thus enabling the harmony of the society under the law. This relationship is called the *legal environment* (HUBBARD & O'BRIEN, 2010, p. 110).

In the Brazilian Legal System, the right to private property was guaranteed since the Constitutional Charter of 1824, in article 179, XXII (BRASIL, 2017). It remained in the constitutions of 1891, 1934, 1937, 1946, 1967 and 1988. In the Federal Constitution of 1988 it is guaranteed in article 5th, *caput* and item. XXII; the right to hereditary property, in items XXX and XXXI, of article 5th; and intellectual property rights, which include copyright and industrial property rights, provided for in items XXVII and XXIX, of the same article 5th (MORAES, 2014).

Private property also finds legal protection in the Brazilian Civil Code (Law No. 10.406, of January 10, 2002), by establishing in article 1228 that "the owner has the right to use, enjoy and dispose of the thing, and the right to repossess it from the someone that unfairly possesses or detains it" (BRASIL, 2017). In the United States of America, private property is protected by the 5th Amendment (Federal Government) and the 14th Amendment (State governments). Under the 5th Amendment, the US Federal Government guarantees not to dispose of life, liberty, or property without due process. The 14th Amendment extends the same rights to the state level (HUBBARD & O'BRIEN, 2010).

It can be inferred that *private property*, legally, is understood "as the right to use, enjoy and dispose of tangible property, being na object or real state, and claim it from someone that unfairly own it or hold it" (ARIMATÉIA, 2003, apud MORAES, 2014, p. 581). According to the author, this understanding unfolds in two dimensions: the economic (or internal) and the legal (or external). The economic (or internal) dimension comprises the "right to use the thing according to its economic destination (use), to obtain its fruits from it (enjoyment) and to alienate, transform or destroy it (disposition)". As for the legal (or external) dimension, it safeguards "the right to remove another person from the sphere of ownership of the

owner (exclusion) and to pursue the thing wherever it is found, being able to recover it from the hands of those who unfairly possess it or detain (sequestration)" (PEREIRA, 1951, apud MORAES, 2014, p. 581)).

## V. RIGHT TO INTELLECTUAL PROPERTY IN BRAZIL

Intellectual property is formed by a set of rights that people or companies hold and guarantee the "exclusive use of their properties, including the right to buy or sell them". It is important to clarify that this property can be tangible or intangible, such as a process or an idea (books, films, software, etc.), in addition to innovative production methods. In contemporary democratic countries, intellectual property rights are very important for several reasons, such as: national sovereignty, wealth generation, food production, among many others. One of the legal instruments to protect **intellectual property rights** is the *patent*. Through it, the Federal Government guarantees the exclusive right of one to get the profits that come from one's idea. (HUBBARD & O'BRIEN, 2010; not highlighted in the original).

Legally, intellectual property is "delimited as rights resulting from human intelligence, containing the copyright as well as the industrial property right". The copyright "is verified by the use, publication and reproduction of works of literary, artistic or scientific nature, over which the author has moral and patrimonial rights". Therefore, "they carry the right to claim, at any time, the authorship of the work, to have their name, pseudonym or sign indicated or advertised, as being the author..." (ASCENÇÃO, 1980, apud MORAES, 2014, p. 582-583).

On a global level, intellectual property is governed by the Convention Establishing the World Intellectual Property Organization. In the document there is no exact definition of the term, but it points out what its applications are:

Literary artistic and scientific works; performances of performing artists, phonograms, and broadcasts; inventions in all fields of human endeavor; scientific discoveries; industrial designs; trademarks, service marks, and commercial names and designations; protection against unfair competition; and "all other rights resulting from intellectual activity in the

industrial, scientific, literary or artistic fields. (CONVENTION ESTABLISHING THE WORLD INTELLECTUAL PROPERTY ORGANIZATION, Article 2, § viii, 1967)

The World Intellectual Property Organization (WIPO) is the administrator, since 1967, of the Berne Convention (WIPO, 1967). This Convention, signed in 1886 (WIPO, 1886), in the city of Bern (Germany) was the first international agreement between sovereign nations that protected copyright. Later, in 1896, the agreement was revised in Paris, and in Berlin, in 1908. In 1914, again in Bern, there was a complement to the agreement. In 1928, the agreement was revised in Rome, then in Brussels (1948), in Stockholm (1967) and, in 1971, again in Paris. Almost all signatory countries are members of the WTO, which regulates aspects of intellectual property that must be complied with, including by countries that are not members of the Organization. In Brazil, the convention became effective May 6, 1975, through Decree No. 75.699.

In Brazilian territory, the INPI is the federal agency, linked to the Ministry of Industry, Foreign Trade and Services, created in 1970, responsible for the Brazilian System of Concession and Guarantee of Intellectual Property Rights for Industry. Among the services provided by this institution are: the registration of trademarks, industrial designs, geographical indications, computer programs and topographies, geographical indications, computer programs and circuit topographies, the granting of patents and the registration of contracts of franchise and the different modalities of technology transfer (INPI, 2021).

In relation to industrial property rights, they envision the protection of production in the industrial domain, as well as the fairness of commercial competition (CERQUEIRA, apud MORAES, 2014; WIPO, 2021). Its protection "is effective by the granting of patents for inventions or utility models and registrations of industrial designs and trademarks, notwithstanding the prevention and repression of false indications of origin...". Legal support is Law No. 9,279/1996, articles 2nd, 6th, 94th, 122nd, 176th and 191st (STF, apud MORAES, 2014).

## VI. INTELLECTUAL PROPERTY AND ACCESS TO BRAZILIAN GENETIC HERITAGE

The main definitions and procedures regarding access to knowledge from Brazilian biodiversity, which is regulated by Decree No. 8772/2016, are presented below.

This Decree considers as part of the genetic heritage existing in the national territory, for legal purposes, the microorganism that has been isolated from substrates of the national territory, the territorial sea, the exclusive economic zone or the continental shelf (art. 1st, §1st of Decree No. 8772/2016) and article 20th of the Federal Constitution of 1988.

Decree 8.772/2016, art. 3rd, § 2nd regulates, firstly, the steps of proof of access to knowledge. In the case of **scientific research**, proof must be provided by the following means: publication of an article in a scientific journal; communication at scientific events; filing a patent application; research conclusion report with a public development agency or entity - Genetic Heritage Management Council (CGEN); or, publication of course conclusion papers, master's degree thesis, doctoral degree thesis. In the case of **technological development**, proof of access to genetic heritage must be through: filing a patent application; record of a new seedling ready to be harvested; product registration with public agencies; or, proof of product marketing (BRASIL, 2016a).

Regarding access to indigenous knowledge, traditional communities and farmers, article 16th of Decree No. 8772/16 establishes the following procedures: first, clarify the indigenous population, traditional community or traditional farmer on: a) the social, cultural and environmental impacts that come from the execution of the activity involving access to associated traditional knowledge; b) the rights and responsibilities of each of the parties in carrying out the activity and its results; and, c) the right of the indigenous population, traditional community and traditional farmer to **refuse** access to associated traditional knowledge. This "refusal" is embodied in the Principle of Legality, provided for in article 5th of the Federal Constitution of 1988, which guarantees that "No one will be obliged to do anything, except by force of law" (BRASIL, 2016a)

To manage access to genetic heritage, the CGEN was created, with a deliberative, normative, consulting and appealing character, operating through a Plenary, Thematic Chambers, Sectorial Chambers and Executive Secretariat. It is competent to: coordinate the design and implementation of policies for managing access to genetic heritage and associated traditional knowledge and benefit-sharing; establish technical standards; guidelines and criteria for drawing up and complying with the benefit-sharing agreement, among others (Articles 4th and 6th of Law No. 8772/2016).

Regarding the sharing of benefits, the law established the following: for indigenous populations, traditional communities and traditional farmers, an

agreement must be signed between the parties (Article 24th of Law No. 13.123/2015 and Article 48th of Decree 8.772/16); and, for the National Fund for Benefit Sharing (FNRB), the percentage is 1% of the net revenue from the sale of the product resulting from access to genetic heritage (Article 48th of Decree 8772/16) (BRASIL, 2016a).

The commercialization of products built on the Brazilian genetic heritage generates billions of profits for the industry, almost always from foreign capital. Sharing the profits with the local populations and communities that paved the way for this economic wealth is the least that can be done. However, the percentage of 1% is considered little in relation to the economic potential of the sector. Regarding the authorization of free negotiation between the parties for access to genetic heritage, it is still early for an analysis, but judging by the economic power of the pharmaceutical and cosmetic industry, this negotiation will very likely consolidate what has always been there: exploitation of the most poor, whether people or countries (SACCARO JÚNIOR, 2011).

According to Antunes (2012, p. 446) "the main international document to establish legal frameworks for the development of economic activities related to biological diversity is the Convention on Biological Diversity (CBD)". It was signed, including by Brazil, during the United Nations Conference on Environment and Development (UNCED), which took place in Rio de Janeiro in 1992. Approval was made via the National Congress, through Legislative Decree No. 2, of 3 of 3 February 1994; and, the enactment was given by Decree No. 2.159, of March 16, 1998.

For the author, it is a *key document* to guarantee the protection of ecosystems and promote sustainable development. He points out that the CBD has been little studied by Brazilian researchers. International scientific production on the subject is significantly greater, demonstrating that Brazilian scholars have devoted little time to investigating this agreement, which is of fundamental importance for Brazilian biological diversity. The explanation, according to him, lies in the preservationist approach that is given when it comes to Brazilian biodiversity. The spirit of the CBD is conservationist, not preservationist, he emphasizes (BRASIL, 1994).

Also, for Antunes (2012, p. 447), the problematic point of the CBD is linked to access to traditional knowledge associated with Brazilian biological biodiversity. The theme has drawn the attention of international organizations such as WIPO and the WTO, mainly in relation to the conflicts between the United States of America (USA) and Brazil, in relation to the Agreement

on Trade Related Aspects of Intellectual Property Rights (TRIPS) about this access to knowledge (INPI, 2021).

The main conflict refers to articles 27th and 28th of the TRIPS Agreement, which recognizes the patenting of any invention, product or process, in all technological sectors in Brazilian territory. However, the Intellectual Property Law (Law No. 9,279/96 authorizes the “compulsory license” in cases of national emergency or public interest. The US accuses Brazil of non-compliance with the TRIPS Agreement, to which both are signatories. The Brazilian government withdraws from Law No. 9,279/96 the authorization of the “compulsory license.” The conflict ended up at the WTO, and later, in 2001, Brazil and the USA signed an agreement ending the conflict. In this agreement, Brazil agrees to announce in advance its intention to adopt patent infringement via a “compulsory license” in cases of national emergency or public interest (WIPO, 2017).

This was just one specific conflict between Brazil and the USA. Other points, on a global level, demand attention. The tensions about biological diversity and intellectual property are situated in a twofold aspect: “the loss of flora and fauna diversity (i); and, the loss of cultural diversity” (ii) (ANTUNES, 2012, p. 440). To get an idea of this cultural impact, the different indigenous peoples and their language can be mentioned. There are currently about 217 Brazilian ethnic groups and 170 languages. This entire linguistic culture has been gradually compromised by the possibility of scarcity of biodiversity, the result of constant deforestation and occupation of the natural *habitats* of these peoples.

Other critical points regarding intellectual property on biological diversity have been highlighted by scientists such as Vandana Shiva, Indian scientist. For her, genetic patenting has formed new colonies. Natural elements such as land, forests, rivers, oceans and atmosphere have been colonized by those rich countries that have scientific knowledge. The result of this colonization process is the pollution and depletion of developing countries that are home to this mega biological diversity. The same concern has been the subject of studies by the American scientist Jeremy Rifkin. According to him, the theme is one of the greatest challenges facing humanity, as it leads to questioning the values of biodiversity: intrinsic or utilitarian (RIFKIN, 1999, apud ANTUNES, 2012).

The legal basis that deals with Genetically Modified Organisms (GMOs) is in the Federal Constitution of 1988, article 225th, paragraph 1, II and V, which delegates to the Government the responsibility for the conservation of the country's diversity and genetic heritage and the inspection of research and manipulation of genetic

material (FIORILLO, 2021). The infra-constitutional legislation unfolds into: Law n° 8.974, of January 5, 1995 (Biosafety Law); Law No. 9,456, of April 28, 1997 (Protection of New Seedlings); Law No. 11.105, of March 24, 2005; (Biosafety Standards); and, Law No. 11.794, of October 8, 2008 (Regulates the scientific use of animals in national territory) (ANTUNES, 2012).

According to Fiorillo (2021, p. 499-500), the genetic heritage, seen here from the legal perspective, is “the information of genetic origin contained in samples of the whole or part of a plant, fungal, microbial or animal specimen, in the form of molecules and substances derived from the metabolism of these living beings and extracts obtained from these living or dead organisms”. The research and manipulation of genetic material has become a legal reality in Brazil since the Federal Constitution of 1988, when it establishes in its article 218th, § 2nd that “technological research will be predominantly focused on solving Brazilian problems and the development of the national and regional productive system” (BRASIL, 2012).

However, this scientific and technological development has not yet been consolidated in Brazil. This is due to the complex global protection system that interferes with the national system, due to the TRIPS Agreement. Although the country is one of the greatest holders of global biodiversity as it is home to two important biomes, Pantanal and Amazon (among others), the fragile scientific and technological base makes it hostage to foreign knowledge, which reflects on patent indicators, mainly in the areas of biotechnology and pharmaceuticals, as shown in table 1.

*Table 1 – Patents filed by the United States of America and Brazil, by area of knowledge, in the period 2011-2015, in percentages (%).*

KNOWLEDGE AREA	PERCENTAGENS (%)	
	USA	BRAZIL
Biotechnology	3,92	----
Pharmaceuticals	6,21	4,27
Medical technology	8,15	5,71

Source: WIPO (2020).

As one can see, even though Brazil is a mega-diverse country, the scientific and technological domain in biologically-based areas still belongs to the United States of America (USA), a country with few biological resources. It is clear that it is not enough just to harbor natural resources to have control over them. It is of fundamental importance to master technology for the development of products based on natural resources.



This delay in biotechnology and pharmaceutical research is due not only to the lack of basic research infrastructure in Brazilian Universities and Research Centers, but also to the archaic knowledge protection system, as Article 10th of the Industrial Property Law, Law No. 9,279/96 expressly prohibits the patenting of biological materials found in nature (BRASIL, 1996). However, under the TRIPS Agreement, Brazil is forced to accept the deposit of patents from the foreign industry, even for genetically modified organisms. This national legislative barrier makes the country hostage to the international technological domain.

## VII. TYPES OF PATENTS OF THE BRAZILIAN LEGAL ORDINANCE

Brazilian legislation allows entrepreneurs to protect industrial property in three ways: patents for inventions, based on the originality of the inventive step; utility model patents, resulting from the functional improvement of the object; and the industrial design patent, based on the functional and aesthetic improvement of the object. The most traditional ways of protecting knowledge in Brazil and its process flows are presented here, in accordance with Law No. 9,279/96 (Industrial Property Law).

### 7.1 INVENTION PATENTS

An Invention Patent is a title of privilege granted in relation to an invention (product or process) that meets the requirements of novelty, inventive activity and industrial application. A patent represents a technical solution (invention) to a problem, which the inventor requires exclusivity, as a result of his efforts (intelligence, time and money). This invention can be a new industrial product (compound, composition, object, device, device, etc.) and/or a new industrial activity (process, method, etc.)

In order to be able to exclude third parties from the commercial exploitation of his invention, the inventor reveals the proposed solution to society, by means of filing the patente application with the INPI. From the deposito f the application, at the end of an analysis process, the inventor receives a temporary title (Patent Letter), which is valid for 20 years from the date of deposit. After this period, the knowledge becomes public domain. The patent is governed by the principle of territoriality, that is, it only has value in the countries where it is granted. For example, if an inventor files his application with the INPI, in Brazil, it will only be valid in Brazilian territory. However, if he filed with the Japan Patent Office, the range would extend to Japan and so on.



Fig.1. 3B Scientific Scissors Utility Model Patent for Kinesiotherapy.

Source: <https://www.3bscientific.com.br>



## 7.2 UTILITY MODEL PATENTS

Utility Models (UM) patents protect the inventive act that results in the functional improvement of an object of practical use, or part of it, that is susceptible to industrial application. In this modality, the protection is of 15 years, counting from the date of deposit. The object must be three-dimensional (instrument, utensil and tool) and possible for industrial application. In this way, the processes are excluded from protection via the Utility Model patent.

It is of fundamental importance to differentiate the Invention patent from the Utility Model patent. As with the Invention, the Utility Model patent is also the result of the author's effort, however, the object already exists and the effort was only to improve it, such as a square-handled tool, it can be improved by developing it with a round handle. The improvement will be functional, as the tool already existed, however, it will be more comfortable to handle it or, even defining other functions for the same object, such as gardening, medicine, as shown in the Picture 1.

Kinesiotherapy is a technique that uses bandages to treat muscle injuries, especially in high-performance athletes. Common scissors were used to cut the bandage tapes used in the treatment. However, they were not effective for cutting the numerous ribbons, as the ribbons contain glue that accumulated on the blades, compromising the work of professionals in this area. So 3B Scientific's engineering department developed scissors made of stainless carbon steel, coated with black carbon fluorine resin, which prevents the scissors from retaining the gum on the tape.

In this case, the patent was for Utility Model and also for Industrial Design, because, in addition to improving the object's performance, an ergonomic handle was developed that improves its functionality, providing more comfort in its handling. It is evident that a patent for invention does not fit here, as the object scissors was invented a long time ago..

## 7.3 INDUSTRIAL DESIGN PATENT

Another patent, still in the field of Industrial Property, is Industrial Design, whose purpose is to protect the ornamental and aesthetic aspect of the product. The term of protection is 10 years, which can be renewed for three more periods of five years. The total protection can reach 25 years. Process flow is more simplified.

## 7.4 PATENT OWNERSHIP AND LICENSING

According to article 6th of the LPI, the author is guaranteed the right to patent an invention or utility model, which may be requested in his own name, by their heirs or successors, by the assignee, or by anyone to whom the law

or the employment contract or provision of services to determine that it belongs to the ownership (§ 6th).

In the case of an invention or utility model developed jointly by two or more people, the patent may be applied for by all or any of them, by means of a power of attorney from the others. If two or more authors independently carry out the same invention or utility model, the right to obtain a patent will be assured to the one who proves the earliest deposit, regardless of the dates of invention or creation.

In the case of an employee, according to article 88th of the LPI, the rights belong exclusively to the employer, when arising from the nature of the services for which the employee was hired.

Exceptions are provided for in articles 90th and 91st of the LPI. According to article 90th, if the employee is not hired for research and development and does not use the employer's resources, such as means, equipment, facilities, etc., the patent belongs exclusively to him. However, if the employee is not hired for research and development, but used the employer's resources to carry out the invention or utility model, the division must be equal parts. However, the employer has exclusive rights to an exploration license, subject to fair remuneration to the employee.

As for licensing, it is an authorization granted by the patent holder to one or more companies to manufacture and sell the product protected by the patent. The instrument is the contract between the parties. It stipulates terms, conditions, fines and royalties (between 1% to 5% of net sales related to the sale of the product).

It is important that universities that carry out research are aligned with the commercial objectives of companies, as this synergy leverages economic and financial resources for both parties. It is important to remember that the joint ownership of a company with a university allows the preference of that company in the commercial exploitation of research results, thus preventing the university from having to seek partnerships in an unknown universe of companies. This strategy is good for both parties as it saves time and resources.

There are four types of licenses: Non-Exclusive License, Exclusive License, Patent License and Cross License.

**Non-Exclusive License:** is the most common of them. It happens when the rights assigned to the license can be assigned to others and not just one person or company. Example: software.

**Exclusive License:** it happens when the applicant for the license is a single entity, holder of the license rights. For

example: a soft drink company holds the exclusive right to market its products on a certain beach, or pedestrian party, or event, excluding other competitors in that specific geographic market.

**Patent License:** is a licensing agreement, signed by the author/inventor/innovator and a natural or legal person, granting rights to commercially exploit a patent. The contract is intermediated by INPI.

**Cross License:** it is characterized by the crossing of two licenses in an agreement. It is applied when each of the parties to the agreement wishes to obtain certain rights relating to the other party's property. A simple example for better understanding: a cell phone company and a software company. Both depend on each other to expand their markets. The benefit is mutual between them.

However, for this complex system of protection to result in economic assets for national companies and for the country, national technological mastery (domestic patents) is necessary, which must be greater than foreign knowledge (foreign patents) and, still, knowledge spillover, that is, the export of knowledge. This strategy is what makes a country

really sovereign and economically independent (BRASIL, 1996).

Brazil presents a certain leadership among other developing countries, such as Argentina and Mexico, as shown in table 2. This leadership can be identified by the number of domestic and foreign patents and by the spillover of knowledge, in the period from 2010 to 2019. Brazil presented a growing picture of domestic patents in relation to the other countries analyzed (Argentina and Mexico). In 2010, there were 314 domestic patents in Brazil and in 2019 there was a jump to 906, while Argentina had only 211 in 2010 and ended 2019 with 165. Mexico had 229 in 2010, ending 2019 with 438 domestic patents. However, foreign domain is greater in the three countries analyzed. Although Brazil closed 2019 with 906 domestic patents, it held 10,041 foreign patents in the same year. Argentina and Mexico have similar numbers of foreign knowledge domain in national territory. When analyzing the knowledge spillover, the three countries had lower numbers than foreign patents (Table 2).

Table 2 – Number of domestic, foreign and patents exported by Brazil, Argentina and Mexico, in the period 2010 to 2019.

YEAR	DOMESTIC PATENTS			FOREIGN PATENTS			PATENTS EXPORTED		
	BRA	AR	MEX	BRA	AR	MEX	BRA	AR	MEX
2010	314	211	229	2,937	1.155	9,170	492	104	195
2011	380	224	245	3.059	1,067	11.240	567	112	233
2012	365	208	290	2,465	724	12.068	662	146	381
2013	385	228	312	2,587	1.069	10,056	856	182	514
2014	374	265	305	2.375	1,095	9.514	940	142	478
2015	460	214	410	2,951	1.345	8,928	924	161	487
2016	533	201	423	3.662	1,678	8.229	932	176	527
2017	714	176	407	4,736	2.126	8,103	914	178	689
2018	1.066	129	457	8,900	1.396	8,464	910	161	712
2019	906	165	438	10.041	2,012	8.264	947	203	707

Source: WIPO (2019)

On the other hand, the developed countries analyzed, USA, Germany and France, present a totally different picture, demonstrating the refinement of their protection system, as well as their scientific and technological superiority in terms of domain and

predominance of domestic patents over external knowledge (patents foreign companies). This solid knowledge base enables economic gains through knowledge spillover, as shown in table 3.

Table 3 – Number of domestic, foreign and exported patents from the USA, Germany and France, in the period 2010 to 2019.

YEAR	DOMESTIC PATENTS			FOREIGN PATENTS			PATENTS EXPORTED		
	USA	GER	FRA	USA	GER	FRA	USA	ALE	FRA
2010	107,792	74,401	24,278	111.822	12,198	1,832	83,083	99,425	41,527
2011	108.626	73,216	24,287	115,879	12,458	2,099	93.443	102,579	42,985
2012	121,026	73,905	24,442	132.129	14,720	2,092	108,091	109,761	45,855
2013	133.593	73,929	24,538	144,242	15,814	2,196	110.569	110,686	46,633
2014	144,621	73,826	25,116	156.057	17,811	2,033	110,033	105,817	47,288
2015	140.969	72,217	25,085	157,438	19,509	1,994	116.100	103,342	47,567
2016	143,723	73,574	24,714	159.326	19,419	2,012	133,367	103,753	46,914
2017	150.949	73,345	25,040	167,880	19,927	1,832	134.808	103,061	46,044
2018	144,413	73,333	24,741	163.346	21,281	1,919	144,667	106,758	44,404
2019	167,115	73,448	24,334	187,315	20,802	1,766	142.529	104,911	43,055

Fonte: WIPO (2019)

Analyzing table 3, one can see a technological superiority of the analyzed countries (USA, Germany and France) in relation to developing countries (table 2). Although Brazil leads the countries in table 2, with 906 domestic patents in 2019, the US ended the year with 167,115 patents, Germany with 73,448 and France with 24,334. These three countries still demonstrate technological superiority in relation to the number of foreign patents they harbor in their territories. Germany, in 2019, had 73,448 domestic patents and only 20,802 foreign patents in its territory, and exported 104,911 patents to other countries. France held in the same year, 24,334 domestic patents and only 1,766 foreign patents, exporting 43,055 patents to other countries. This technological superiority results in an increase in GDP and, consequently, more investments in development, thus forming a constant cycle of scientific, technological and economic development.

## VIII. CONCLUSION

Intellectual property rights enable the economic development of a country. Brazil, despite having adhered to the global system of protection, via the Paris, Berne Convention and the TRIPS Agreement, took a long time to consolidate its domestic system of protection and, when it did, it was still very traditional, legitimizing an archaic system of protection. While the world develops its scientific and technological potential, through investments in infrastructure of qualified personnel, solid research base in public and private universities, as well as a more adherent legislative system, Brazil is still slipping on a traditional path that does not allow the full development of biotechnology. Even housing two of the biomes that reflect

the Nation's biological wealth, such as the Pantanal and the Amazon, the country is still hostage to foreign knowledge, resulting in a delay in economic development.

Bringing the Brazilian nation to a rich and powerful place, necessarily entails expanding and reforming its investment system in research, development and its legislation to which it could translate what is most significant in these areas in the world and that could be as a mirror for national development. This involves patents.

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# Screening for cross-cultural adaptations of the Patient's Dignity Inventory

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**Keywords—** Patient Dignity Inventory, Validation, Cross Cultural, Psychometric, Integrative Review.

**Abstract—** Cross-cultural adaptation is a process that involves the transfer of knowledge between different cultures. Therefore, for a psychological instrument to be used in another country, for example, it is necessary to follow methodological rigors for an effective final model. In the field of oncology, research on the concept of dignity is incipient in most of the countries and one of the precursors of this concept was the Canadian psychiatrist, Harvey Chochinov. A model called the Dignity Model was developed and resulted in an inventory (Patient Dignity Inventory). The objective of this research is to carry out a screening on the cross-cultural adaptation studies of the Patient's Dignity Inventory. It is an integrative literature review to verify the main studies published databases about validation of the Patient Dignity Inventory. MEDLINE, LILACS, Scielo and Google Scholar databases were used to track adaptation studies. The keywords "Patient Dignity Inventory" AND "Validation" OR "Cross Cultural" were used for the collection of articles. In the initial results, 121 articles were found. After applying all filters, 19 articles were found within the criteria selected for review. It was noticed that most of the studies used rigorous methods, resulting in inventories with satisfactory psychometric properties for use in another culture.

## I. INTRODUCTION

The applicability of instruments produced in different origins is a challenge that has become increasingly common for the scientific community. Globalization has boosted psychological assessment processes in an accelerated way, since through access to information means, it is possible to discover new

constructs or even means of assessment that had not been thought of before.

The realities between countries can be quite different, whether from a social, economic, linguistic, cultural point of view, or even in terms of evaluation that make sense for that population. That said, when we are faced with the process of adapting an assessment instrument to another different context, we need to



consider all these interferences that influence in the construction of the new guise that this instrument acquires when entering a new reality.

Thus, when tracing the scientific literature on conceptualizations and guiding ourselves on this theme, Arruda-Colli et al (2021) points out that this process of adapting an instrument basically follows - in a synthetic way - three steps, which would be: 1 - Perform an assessment of the realistic capabilities of a given instrument to measure the same construct in a different culture and language; 2 - Strictly follow the translation steps (and all others that involve this linguistic aspect); and, 3- Check the equivalence of the version being adapted (putting what has been developed so far to the test). Thus, it is important to note that it is a process with steps that necessarily follow an order to obtain a satisfactory result.

The health context is a multifaceted space in which it relates to different types and areas of knowledge, but still with an emphasis on a curative and biomedical health logic. In this way, studying a perspective that promotes humanization and reflection of the care that is focused on the patient is a challenge. For this, it is necessary to understand that when dealing with humans, we need to turn to the needs of the other, with a look at the psychological, physical, social, spiritual, and cultural aspects. It is no longer possible to conceive of the idea of studying the individual without considering all these aspects.

In contexts specialized in patient care who have a progressive disease, sometimes incurable or terminal, it is essential to understand the different facets that permeate this individual. Thompson and Chochinov (2010) point out that changes occur increasingly and seem to take over various domains of life, whether in the social, cultural, individual experiences or even personality fields. Thus, these authors also add that the perception and recognition of dignity in a social way directly influence the care provided by the professionals involved in the process, as well as the perception of those who receive this care, whether the sick individual and/or their family members.

Therefore, it is through these theoretical vs. practices that are built models that allow dialogue with the concepts of dignity with professional activity and care aimed at patients. There are several theoretical models that try to study this topic. But before we elucidate ourselves on some of these models that will not be studied (except for the Model of Dignity by Chochinov and collaborators - which will serve as a theoretical-empirical model for the development of this research project), we must first proceed with a study of the latent and prominent meanings when we talk about dignity. Notions of dignity can also

help health professionals in their actions in the act of caring for those facing a life-threatening illness (Chochinov, 2002).

Canadian psychiatrist Harvey Max Chochinov developed a model that promoted the evidence of patients' desires in conditions of illness without therapeutic possibilities. This practice has spread worldwide due to its applicability and effectiveness in promoting and maintaining dignity. Thus, through speeches and experiences with patients in centers whose main driver was dignity, Chochinov developed a model of care that aims to preserve dignity. This model is divided into three areas: 1- Concerns related to illness; 2- Repertoire for the conservation of dignity; 3- Inventory of social dignity. Based on the model described above, an instrument was developed to measure the sources of concerns/stressors related to dignity. Thus, it is a way of evaluating how the patient perceives himself in the face of illness and the suffering associated with it.

Then, the inventory called The Patient Dignity Inventory (PDI) was developed, consisting of 25 items, covering the sense of dignity of the individuals tested. It is considered a self-report instrument and the items are scored within a *likert scale* from 0 to 5 points, thus, the higher the score, the greater the individual's suffering. It is also proposed in addition that if individuals assemble from 3 points on any item, interventions should be carried out following the dignity model clinic proposed by the author. The 25 items that make up the inventory are divided into five factors: 1- Concern about symptoms (related to sources of physical and psychological suffering); 2- Existential Anguish; 3- Dependency; 4- Peace of Mind; 5- Social Support.

This work intends to search in the main databases, for research that validated the PDI for their cultural contexts. Using inclusion and exclusion criteria to bring together the most accurate findings of open access articles available.

## II. METHOD

The present study is an integrative literature review with national and international scope, whose purpose was to present the scientific productions regarding the cross-cultural adaptations of the patient's dignity inventory in different countries. The integrative literature review model aims to infer generalizations on a given topic, based on publications related to the subject of interest (Cecílio & Oliveira, 2017).

The study was developed from research carried out in the following databases: a) SciELO - Scientific

Electronic Library Online, is a virtual library that displays a collection of scientific journals from the following countries: Brazil, Argentina, Chile, Colombia, Cuba, Spain, Mexico, Portugal and Venezuela; b) LILACS - Latin American and Caribbean Literature in Health Sciences, is a bibliographic index of records in the technical scientific literature on health, produced by Latin American and Caribbean authors; c) Medline- Medical Literature Analysis and Retrieval System Online, an international database that gathers bibliographic references and abstracts from biomedical journals. d) Google Scholar – Freely web search with full text databases with an enormous variety of scientific articles.

The period between the year 2008 and June 2022 was adopted as a criterion for temporal division. Since the first article about the inventory was published only in 2008. As a search strategy, the crossing of the keywords was used: Patient Dignity Inventory AND Validation OR Cross Cultural, to provide scope for the research. To proceed, the following research question was used: what are the main studies and research carried out on the validation processes of the patient's dignity inventory described in the world scientific literature?

Regarding the inclusion criteria, the following were stipulated: a) scientific articles available in full and with free access in electronic support; b) studies available in English, Spanish and Portuguese, which followed the specified time frame and contained the key words in the title, abstract or subject; c) studies that contemplated the theme of the validation processes of the specific instrument (PDI).

Regarding the exclusion criteria, the following were considered: studies that diverged from the proposed objective, studies that referred to the application of the inventory in previously adapted contexts, that brought another instrument or that promoted the evaluation of the Patient Dignity Model.

The search for publications was carried out independently and blindly by two researchers. In the initial bibliographic survey, before placing the filters, 121 articles were retrieved. After placing the filters, 25 articles were pre-selected. Following the analysis and consideration of the inclusion and exclusion criteria, as well as seeking the focus of the theme, a total of 19 articles for literature review were obtained. It is important to point out that there were no articles written in Spanish, in this sense, it was only possible to analyze the articles in English and Portuguese. In relation to articles that appeared in two or more databases, the one found in the first searched database was used.

For greater understanding, follow the flowchart for refining the selection (Figure 1).

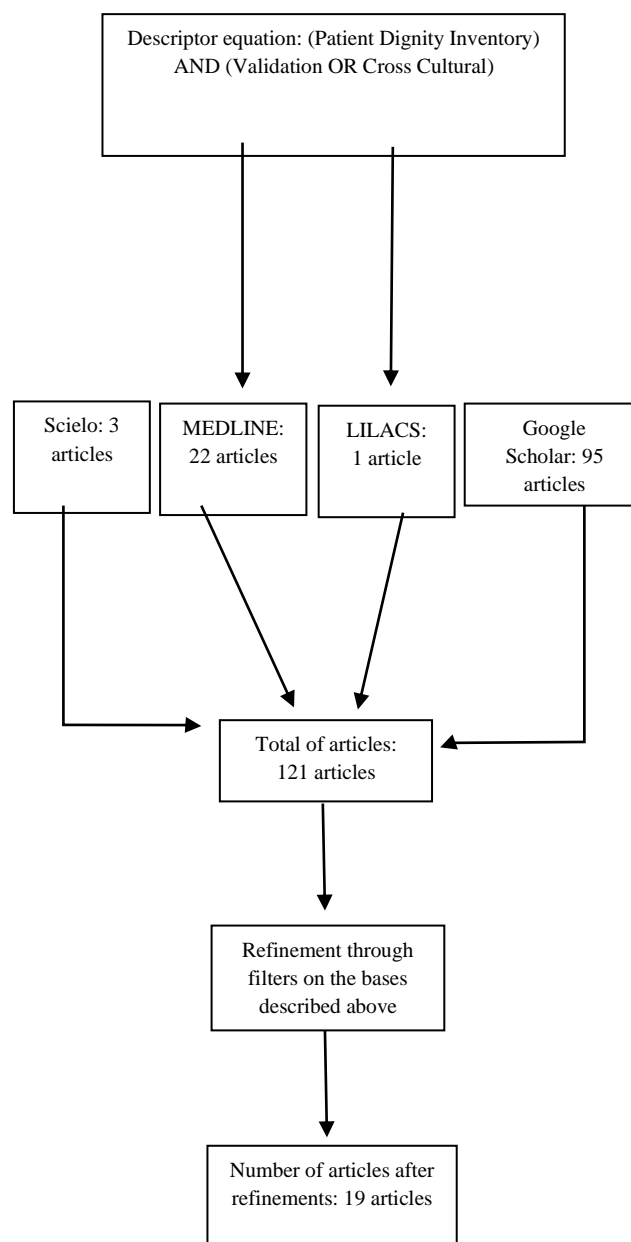


Fig. 1: Flowchart – articles PDI

For the analysis process, after reading the titles, abstracts and, when necessary, reading the full text, an evaluation of the selected articles was elaborated, through methodological procedures aimed at structuring and organization. For this purpose, an Excel table for Windows was created, which included information regarding: the database in which the article was found, the title, the year, authors, the journal, abstract and conclusions. Incorporated into this, the thematic content analysis technique was used through the reading and rereading of the articles, seeking to identify the main aspects that stood out or were

reproduced in the studies. Finally, relevant topics for discussion were established.

### III. RESULTS AND DISCUSSION

Regarding the scientific production focused on studies that carried out cross-cultural adaptations of the PDI in the most diverse countries, there is a great focus on the target audience of cancer patients. Of the 121 pre-selected articles with filter, after removing duplicates,

reading the abstracts, and full reading in cases where the appreciation of the abstract was not enlightening, the result of 19 articles, in Portuguese and English, was considered. It is noteworthy that, despite the Spanish language being considered in the initial search, after the methodological course explained, no articles were found in this language. We can show these results through Table 1.

*Table.1: Information about the studies*

N	Título	Ano	Autor	Periódico	Conclusões
1	Assessment of patients' dignity in cancer care: preliminary psychometrics of the German version of the Patient Dignity Inventory (PDI-G)	2014	Leon P.Sautier, Sigrun Vehling, Anja Mehnert	Journal of Pain and Symptom Management	We conclude that PDI-G is a psychometrically sound instrument assessing a broad range of dignity-related distress issues in patients with cancer.
2	Cross-Cultural Adaptation to Portuguese of the Patient Dignity Inventory Instrument	2019	Alessandra do Nascimento Cavalcanti, Karina Danielly Cavalcanti Pinto, Eulália Maria Chaves Maia	Revista de Enfermagem da UFPE	It is expected, through the results obtained, that the inventory be adapted according to the scientific parameters of the literature, reaching confidence coefficients above 0.8, characterizing in an instrument of high efficacy that one intends to measure.
3	Translating the Patient Dignity Inventory	2019	Karin Blomberg, Olav Lindqvist, Carina Werkander Harstade, Annika Söderman, Ulrika Östlund	International Journal of Palliative Nursing	The process of translation and adaptation added clarity and consistency. The Swedish version of the PDI can be used in assessing dignity-related distress. The next step will be to test this Swedish version for psychometric properties in a larger group of patients with palliative care needs before use in research.
4	Spanish version of the patient dignity inventory: translation and validation in patients with advanced cancer	2015	María Rullán, Ana Carvajal, Jorge M.Núñez-Córdoba, Marina Martínez, José Miguel Carrasco, Irene García, María Arantzamendi, Alazne Belar, Carlos Centeno	Journal of Pain and Symptom Management	The Spanish version of the PDI showed adequate psychometric properties when tested with advanced cancer patients.

5	Czech version of the patient dignity inventory: translation and validation in incurable patients	2018	Helena Kisvetrová, David Školoudík, Libuše Danielová, Kateřina Langová, Renáta Váverková, Milena Bretšnajdrová, Yukari Yamada	Journal of Pain and Symptom Management	The results from the study support the reliability of the PDI-CZ and its future use in patients with incurable cancer and noncancer patients.
6	Validity and reliability of the Brazilian version of the Patient Dignity Inventory (PDI – Br)	2021	Donato, Suzana Cristina Teixeira ; Chiba, Toshio ; Carvalho, Ricardo Tavares de ; Salvetti, Marina de Góes	Revista Latino-Americana de Enfermagem	Composed of three domains and 25 items, the PDI - Br instrument presented satisfactory psychometric properties for its use in our environment, through the evidence of validity and reliability.
7	The Patient Dignity Inventory and Dignity-Related Distress among the Critically Ill.	2022	Mergler, Blake D; Goldshore, Matthew A; Shea, Judy A; Lane-Fall, Meghan B; Hadler, Rachel A.	Journal of Pain and Symptom Management	This study demonstrates that the inventory can be used to assess patient distress in critical care settings. Further research may elucidate the role of dignity-based interventions in treating and preventing post-intensive care psychological symptoms.
8	Validity and reliability of the Turkish version of the Patient Dignity Inventory.	2021	Eskigülek, Yasemin; Kav, Sultan	Palliat Support Care	PDI-TR was found to be a valid and reliable tool in palliative care patients in Turkish society.
9	Validation of the Patient Dignity Inventory in Mexican Cancer Patients.	2021	Rodríguez-Mayoral, Oscar; Galindo-Vázquez, Oscar; Allende-Pérez, Silvia; Arzate-Mireles, Cinthya; Peña-Nieves, Adriana; Cantú-Quintanilla, Guillermo; Lerma, Abel; Chochinov, Harvey Max	J Palliat Med	The Mexican version of the PDI shows adequate psychometric properties in patients with cancer. We suggest the use of PDI-Mx in clinical care and research.

10	Korean Version of the Patient Dignity Inventory: Translation and Validation in Patients With Advanced Cancer.	2021	Oh, Si Nae; Yun, Young Ho; Keam, Bhumsuk; Kim, Young Sung; Koh, Su-Jin; Kim, Yu Jung; Kang, Jung Hun; Lee, Kangkook; Hwang, In Cheol; Oh, Ho-Suk; Song, Eun-Kee; Shim, Jae Yong.	Journal of Pain and Symptom Management	Our findings indicate that the PDI-K is a valid and reliable instrument to measure dignity-related distress in patients with advanced cancer. This tool provides a four-factor Korean language alternative to the PDI
11	Validity and reliability of the Mandarin version of Patient Dignity Inventory (PDI-MV) in cancer patients.	2018	Li, Yu-Chi; Wang, Hsiu-Hung; Ho, Chung-Han	PLoS One	The PDI-MV is a psychometrically sound instrument assessing a broad range of dignity-related distress issues in cancer patients.
12	Psychometric properties of the Patient Dignity Inventory in an acute psychiatric ward: an extension study of the preliminary validation.	2018	Di Lorenzo, Rosaria; Ferri, Paola; Biffarella, Carlotta; Cabri, Giulio; Carretti, Eleonora; Pollutri, Gabriella; Spattini, Ludovica; Del Giovane, Cinzia; Chochinov, Harvey Max	Neuropsychiatr Dis Treat	The PDI can be a reliable tool to assess patients' dignity perception in a psychiatric setting, which suggests that both social and clinical severe conditions are closely related to dignity loss.
13	Psychometric Properties of the Greek Version of the Patient Dignity Inventory in Advanced Cancer Patients.	2017	Parpa, Efi; Kostopoulou, Sotiria; Tsilika, Eleni; Galanos, Antonis; Katsaragakis, Stylianos; Mystakidou, Kyriaki	Journal of Pain and Symptom Management	The Greek version of the PDI showed good psychometric properties in advanced cancer patients, supported the usefulness of the instrument assessing the sense of dignity distressing aspects of the terminally ill cancer patients.



14	Dignity and Psychosocial-Related Variables in Advanced and Nonadvanced Cancer Patients by Using the Patient Dignity Inventory-Italian Version.	2017	Grassi, Luigi; Costantini, Anna; Caruso, Rosangela; Brunetti, Serena; Marchetti, Paolo; Sabato, Silvana; Nanni, Maria Giulia	Journal of Pain and Symptom Management	The study confirmed that the PDI-IT is a valid instrument to be applied in oncology and measuring three factors, namely existential, psychological, and physical distress, as core dimensions of dignity, to be monitored and treated in clinical settings.
15	Patient dignity inventory (PDI) questionnaire: the validation study in Italian patients with solid and hematological cancers on active oncological treatments.	2012	Ripamonti, Carla Ida; Buonaccorso, Loredana; Maruelli, Alice; Bandieri, Elena; Pessi, M Adelaide; Boldini, Stefania; Primi, Caterina; Miccinesi, Guido	Tumori	The Italian version of PDI is a valid and reliable tool to evaluate the dignity related-distress in out-patients with either solid and haematological cancers, on active oncological treatments, in non-advanced stage of the disease.
16	Analysis of the construct of dignity and content validity of the patient dignity inventory.	2011	Albers, Gwenda; Pasman, H Roeline W; Rurup, Mette L; de Vet, Henrica C W; Onwuteaka-Philipsen, Bregje D	Health Qual Life Outcomes	This study demonstrated that the PDI items were relevant for people with an advance directive in the Netherlands. The comprehensiveness of the items can be improved by including items concerning communication and care.
17	Estrutura fatorial da escala de dignidade em doentes com necessidades de cuidados paliativos	2017	Cunha, M., Loureiro, N., Duarte, J., & Carvalho, F.	Millenium - Journal of Education, Technologies, and Health	This research constitutes a further step, in the study of the psychometric properties of the Patient Dignity Inventory, in a sample of the Portuguese population. The comparative study of the present research, with the results obtained by Chochinov et al. (2008) revealed, that in the present study, the values of internal consistency in the various factors and the overall score are more robust. The results suggest that the identification of dignity predictive factors, in people with palliative needs, can develop and implement clinical strategies for their promotion, which can be an important contribution to future research and clinical practice.

18	Patient Dignity in Coronary Care: Psychometrics of the Persian Version of the Patient Dignity Inventory	2015	Abbas Abbaszadeh, Fariba Borhani, Roghayeh Mehdipour Rabori	Br J Med Med Res.	This tool can be useful in measuring coronary patients' dignity and the distress associated with dignity that these patients comprehend, and it can be used in Persian-speaking countries.
19	The patient dignity inventory: a novel way of measuring dignity-related distress in palliative care.	2008	Chochinov, Harvey Max; Hassard, Thomas; McClement, Susan; Hack, Thomas; Kristjanson, Linda J; Harlos, Mike; Sinclair, Shane; Murray, Alison.	Journal of Pain and Symptom Management	The PDI is a valid and reliable new instrument, which could assist clinicians to routinely detect end-of-life dignity-related distress. Identifying these sources of distress is a critical step toward understanding human suffering and should help clinicians deliver quality, dignity-conserving end-of-life care.

It was found that the largest number of articles published considering the proposed theme occurred in 2021 with 04 publications, with a dispersion of publications over the years from 2008 to 2022. Over the years, there has been a greater publication of studies on adaptation processes.

An important information that deserves attention in the results of the articles was in relation to the journals in which the research was published, and it is possible to evidence the more frequency of publication in the "Journal of Pain and Symptom Management". Of the 19 articles found, including the article from the original study, 8 of them were published in this journal, corresponding to 42.1% of the research carried out. Thus, in addition to the journal's qualis (A2) and impact factor (3.92), it can be thought that the journal has great acceptability for the theme, thus contributing to the choice of authors.

Regarding the databases in which the articles were found, it was possible to perceive that most of the searches were concentrated in MEDLINE (63.2%), followed by Google Scholar (26.3%) and finally, Scielo (10, 5%). This is an expected result considering that MEDLINE concentrates a greater collection of highly relevant international journals and that ended up being the profile of research carried out on this topic.

Furthermore, it is important to point out some more statistical aspects that the articles brought that refer directly to the processes of psychometric properties of the instrument. The construction of criteria that aim to evaluate the statistical and psychological testing properties of a given instrument are of paramount importance for the

guiding definition and for the quality of that measurement, regardless of the construct being evaluated. The need for an in-depth assessment of the properties that are proposed to measure certain characteristics in a questionnaire is unique. Thus, even before becoming apt for wide use, the instruments must offer accurate, interpretable, and valid data for the evaluation of the population, with measures that have scientific robustness. Thus, the performance about the results of the measurements is due - for the most part - to the reliability and validity of the instruments, being considered as the main measurement properties.

In the studies of this review, it was observed that the PDI is adapted and validated for 17 different countries and one of the ways to measure the reliability of these studies is through a coefficient called Cronbach's Alpha. Thus, Cronbach's alpha coefficients for the original version of the instrument in Canada (2008) was 0.93, in the Iran study (2015) it was 0.85, the Italian version (2012) was 0.96, the Spanish (2015) was 0.89, German (2014) version was 0.96, Chinese (2018) version was 0.95, Czech (2018) version was 0.92, Greek (2017) version was 0.70, the Brazilian version of São Paulo (2021) was 0.90, the Brazilian version of Natal (2019) was 0.93, the Portuguese version (2017) was 0.96, the Turkish version (2021) was 0.94, the Mexico version (2021) was 0.95, the South Korean version (2021) was 0.96. The Swedish version (2019) and the Netherlands version (2011) did not reveal these values in their available articles.

Still as a relevant part of the data found regarding the behavior of the inventory in different cultures, it can be mentioned that the number of PDI factors occurred as follows in different countries:

- 5 factors: Canada (original instrument), Brazil (Cancer patients), Turkish, Greece, Portugal
- 4 factors: Germany, Czech Republic, United States, Mexico, South Korea, China, Iran
- 3 factors: Spain, Brazil (patients in palliative care), Italy (psychiatric patients), Italy (cancer and non-cancer patients)
- 1 factor: Italy (cancer patients)

These results demonstrate similarities that the studies may have among themselves, whether related to pathology, as well as in similar institutional contexts, as well as the way a certain population reacts to challenging situations. These data were obtained through an extensive statistical analysis that reproduced a model that provided us with the behavior of the inventory. The Swedish version and Netherlands version did not reveal this information about how many factors the inventory in these realities have.

In this way, cultural adaptation, while it is a process that involves elements of psychometrics, ends up involving other areas that, if not considered, directly reflect on the results. Considering culture, context, language, and nuances are all part of successful cross-cultural adaptation.

#### IV. CONCLUSION

It is of fundamental importance to encourage and expand discussions for how the researchers of the field are directing their efforts to ensure that the methodological steps are visible, in compliance with the international guidelines recommended for the processes of elaboration and cross-cultural adaptation of instruments. These precautions make it possible to highlight the various methodological possibilities, with their scope and limitations.

In addition, understanding the most diverse facets to better assess the processes that involve the dignity of the patient who finds himself in challenging pathological situations is of paramount importance. That's why the incentive for scientific research in this area, which is still so incipient of results, is to bring out a higher quality assistance for those who really needs this kind of care.

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# Systematic Literature Review (SLR) Development of the IoT Industry in the South America Region

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Systematic Literature Review, South  
America.*

**Abstract** — *In the 2022 and later we know that the technology will have a key participation to help us in all kind of tasks mainly using internet connection, due the new normality. Industry 4.0 has been one of the most relevant field. IoT as part of it. This Systematic Literature Review (SLR) we will cover the South America countries and their development status, addressing the development categories and the Hardware that has been cited on papers on the last 5 years.*

## I. INTRODUCTION

IoT (Internet Of Things) is been bigger them ever according to the World Economic Forum's State of the Connected World report, there are more connected devices than people in the world and 41.6 billion devices are expected by 2025, with the impact of COVID-19 the demand of IoT market estimates and expectations for its current and future growth [Amon et al.].

The main purpose of this paper is to carry out a systematic literature review in order to assess the current scenario of *IoT* development in South American countries, analyzing which countries are most engaged in the development of new *IoT* solutions, what types of hardware are used by their works and what are the main topics

addressed by these works. For this, we analyzed about 1400 articles that were obtained from sources such as *IEEE (Institute of Electrical and Electronic Engineers)* and *ACM (Association for Computing Machinery)*.

This paper consists of five sections. Section I contains a brief introduction and explains the structure of this paper. Section II explains the methodological stages of a systematic literature review (SLR), namely: Planning to Conducting. Section III includes findings from the review literature. Section IV contains conclusions on the reviews and findings obtained, supported by the Future Works Section, which illustrates the potential for further research that can be done sourced from this research.



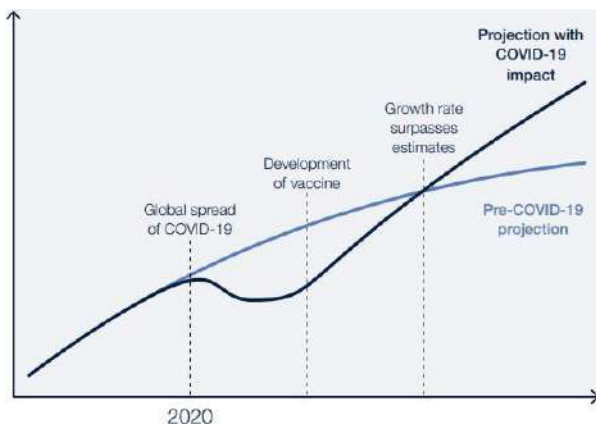


Fig. 1: IoT connections growth rate

## II. RESEARCH METHODOLOGY

The systematic literature review (SLR) will be used for this study. Based on search results of papers published on journals.

The countries in the research are Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay and Venezuela all from South America [Yaseen et al.] [Khan et al.]

### 2.1 Planning

#### 2.1.1 Research question

The main objective in this SLR, is to have an overview in the development of the IoT industry in countries of South America. In order to get that goal we have consider some questions:

- What is the current state of IoT industry development in the South America Regioncountries?
- What are the Development Categories on IoT industry for the contries in the SouthAmerica Region?
- What are the IoT hardware platforms used for development in the South America Region?

#### 2.1.2 Data source

Sources that have all topics related to technology and innovation, and have listed journals that contains information of electronics and computer science: IEEE and ACM Digital Libraries.

#### 2.1.3 Search string

A search string is composed using Boolean connectors AND, OR based in the main words related of our research questions and its population. Such string will give the output in an advanced search from the different sources used.

("Argentina" OR "Bolivia" OR "Brazil" OR "Chile" OR "Colombia" OR "Ecuador" OR "Guyana" OR "Paraguay" OR "Peru" OR "South America" OR

"Suri name" OR "Uruguay" OR "Venezuela") AND ("Internet of things" OR "Industrial Inter net of Things" OR "IIOT" OR "IOT" OR "Smart devices" OR "Web of Things") AND ("Software" OR "Hardware")

### 2.1.4 Inclusion and exclusion criteria

As inclusion criteria we have stated three items to check using them to accept the article to be pass to next phase that is quality criteria selection.

#### 2.1.4.1 Inclusion

The selected research must be written in English; related to South America; the solution developed must be aimed to solve problems on IoT industry.

#### 2.1.4.2 Exclusion

Articles not published in the English language; before 2016; duplicated; not related to South America; the solution developed is not aimed to solve problems on IoT platform.

### 2.1.5 Quality criteria for study selection

To evaluate quality of the articles to be selected we have taken the following considerations:

- What is the main topic related with IoT development;
- There is a discussion in IoT industry;
- There is used a hardware or software involved in the IoT industry;
- Is it a research proposed from an university or another organization.

The selections was based in take topics and subtopics, classify article by one article and list them into columns to have categorical information.

## 2.2. Conducting

### 2.2.1. Primary study selection

The sources listed is filtered using Tollgate Approach following the phases.

Phase 1: do a search using the search string. In this phase we found 1390 articles in Phase one with the string on IEEE and ACM as per Table 1;

Phase 2: remove duplicated articles. We could find 570 duplication's;

Phase 3: Based on the Inclusion and Exclusion Criteria, accept or reject articles by reading titles and abstract;

Phase 4: Based on the Quality Criteria, accept or reject articles by reading the full article.

Table 1. Search results

Database	Search result
IEEE	556 articles
ACM	834 articles
Total	1390 articles

### 2.2.2 Data extraction and synthesis

Classification of papers due to the country.

Table 2. Country distribution data

Country	Total	Percentage
Argentina <sup>1</sup>	6	3.73%
Bolivia	0	0%
Brazil <sup>2</sup>	126	78.26%
Chile <sup>3</sup>	2	1.24%

<sup>1</sup> [Tsiganos et al. 2019] [Bor et al. 2016] [Lobo et al. 2017] [Tsiganos et al. 2020] [Chesnevar et al. 2020] [noa]

<sup>2</sup> [Antunes et al.] [Azevedo et al.] [Delabrida et al. b] [Farias et al. a] [Fernandes et al. b] [Kon et al.] [Magrani] [Motta a] [Sant'Anna et al.] [Vasconcelos et al.] [Almeida et al.] [Andrade et al. a] [Andrade et al. c] [Andrade et al. b] [Bachiega et al. ] [Bao et al.] [Barros et al. b] [Barros et al. a] [Batista et al. ] [Bezerra and Souza a] [Bezerra and Souza b] [Bischoff and Farias] [Borba et al.] [Braga et al. ] [Branco et al.] [Brandao] [Campos et al.] [Carrero et al.] [Carvalho et al. a] ~ [Carvalho et al. b] [Chagas et al.] [Chauhan et al.] [Cortes et al.] [Costa et al. b] [Costa] [Costa et al. a] [Costa and Teixeira] [Cunha et al.] [Dantas et al.] [Delabrida et al. a] [Dias et al.] [Domenech et al.] [Duarte and Prestes] [Farias et al. b] [Feio et al.] [Fernandes et al. a] [Ferreira et al.] [Filho et al. a] [Filho et al. b] [Fonseca et al. b] [Fonseca et al. a] [Gama et al.] [Garcia and Lara] [Gonçalves et al.] [Junior and Gama ] [Kassab et al.] [Lopes et al.] [Lunardi et al.] [Luz et al.] [Maie et al.] [Makara et al. ] [Martini et al. ] [Martins et al. a] [Martins et al. c] [Martins et al. b] [Mauro et al.] [Moraes and Martins ] [Moratelli et al.] [Moreira et al.] [Motta et al. b] [Motta et al. a] [Motta b] [Motta et al. c] [Moura et al. a] [Moura et al. b] [Muck et al.] [Nepomuceno et al.] [Neto et al. a] [Neto et al. b] [Neu et al. ] [Oliveira et al. b] [Oliveira and Lopes] [Oliveira et al. a] [Paldes et al.] [Perdomo et al.] [Ponciano et al.] [Potter and Sztajnberg] [Rangel et al.] [Reis et al. b] [Reis et al. a] ~ [Rodrigues et al.] [Rodriguez et al.] [Rodriguez and Batista] [Roriz et al.] [Salgado et al.] [Santana et al. c] [Santana et al. b] [Santana et al. a] [Santo et al.] [Santos et al. b] [Santos et al. c] [Santos et al. a] [Savoine et al.] [Sepulveda et al.] [Silva and Braga] [Silva and Baranauskas] [Silva et al. b] [Silva et al. c] [Silva et al. a] [Sousa et al. c] [Sousa et al. a] [Sousa et al. b] [Souza et al. d] [Souza et al. b] [Souza et al. a] [Souza et al. c] [Tsuchiya et al.] [Valle et al.] [Veiga et al.] [11] [Nascimento] [Pico-Valencia et al.] [Frohlich and Resner] [Farahmandpour et al.] [L. et al.] [Courtais et al.]

<sup>3</sup> [Ko et al. 2016] [Villegas et al. 2019]

Colombia <sup>4</sup>	11	6.83%
Ecuador <sup>5</sup>	9	5.59%
Guyana	0	0%
Paraguay	0	0%
Peru <sup>6</sup>	9	5.59%
Suriname	0	0%
Uruguay	0	0%
Venezuela	0	0%

From a brief analysis of Table 2, we were able to identify that Brazil is much more relevant in IoT considering papers than the other countries in South America, being followed by far from Colombia, Ecuador and Peru.

Table 3. Topics distribution

Topic	Total	Percentage
Agriculture	5	3.03%
Health	12	7.27%
Environment	29	17.57%
Industry	1	0.06%
Framework	15	9.09%
Other	103	62.42%

As we can see on Table 3, there are a widely distribution of the topics and we were able to identify that Environment, Framework and Health are the main topics areas and most the papers are distributed over other that shows the multidisciplinary use of IoT and not able to find any high development in a specific topic.

Other relevant information that we could extract from the SLR is that 31.5% of the papers were not related to software or hardware implementations. They were studies or literature reviews.

<sup>4</sup> Gomez et al. 2017] [Cabrero et al. 2017] [Velasquez et al. 2017] [Rodriguez et al. 2017] [Wynn et al. 2017] [Arevalo-Gómez et al. 2018] [Cano et al. 2019] [Rivera et al. 2020] [Osorio et al. 2020] [Sepulveda et al. 2017] [Ahmed et al. 2018]

<sup>5</sup> [Nugra et al. 2016] [Yanez et al. 2016] [Chilcañán et al. 2018] [Avila-Campos et al. 2019] [Placencia et al. 2019] [Chilcanan et al. 2019] [Abril et al. 2019] [Campana and Dominguez 2020] [Flor et al. 2021]

<sup>6</sup> [Guerra and Perez 2016] [Guerra and Perez 2017] [Burd et al. 2017] [Burd et al. 2018a] [Burd et al. 2018b] [Benites et al. 2019] [Perez et al. 2020] [Chavez et al. 2020] [Kon et al. 2020]

### 2.2.3 Supporting data from government reports

When getting data from government we selected the three biggest economies in south America and looked into their official government website to retrieve data related to IoT and how the country is expecting that to near future. Based on that premise with support data acquired on the world bank we have Brazil, Argentina and Colombia and the biggest economy in South America [dat].

Based on Brazilian Ministry of Science, Technology and Innovations "IoT.BR National Plan seeks to carry out actions to improve the quality of life of citizens, to increase the country's competitiveness and productivity, as well as to strengthen the production chains of the various economic sectors.

In this context, the National IoT Plan - IoT.BR was launched, through the publication of Decree 9854, of June 25, 2019, whose aspiration is to make the Internet of Things an instrument of sustainable development for Brazilian society, capable of increasing competitiveness of the economy, strengthen national production chains and promote better quality of life. Based on this objective, four application environments were prioritized: Smart Cities, Health 4.0, Agro 4.0 and Industry 4.0" [min] Based on Argentina chief of cabinet of Ministers of public innovation "The development of the Internet of Things requires a multidimensional approach, which includes different actors from the public, private, academic and civil society sectors. Under this framework, we seek to accelerate the deployment of IoT and chart a path to boost the economic and social development of Argentina, leveraged on this technology. To do this, we are working on a National Plan for the Internet of Things from the interaction of different areas of Government, with the inclusion of actors from the public, private, academic and civil society sectors.

The articulation of the State with private actors is a key instance for the integration of global supply chains, caring for the environment, the formation of digital cities, the advancement of industry 4.0, the growth of IoT in agricultural production, as well as in sectors related to mining, oil and electricity, home automation, to name a few.". [Arg 2018] In the Colombia official web site we were no able to find any relevant information related to IoT.

## III. FINDINGS

### 3.1 The IoT industry distribution in South America on research studies

The distribution of the Internet of Things industry in South America countries was obtained from the research publications on IEEE and ACM Digital Library as per Table 2. We were able to find the distributions of the

countries with top three Brazil (78.26%), Colombia (6.83%) and Ecuador (5.59%) as it has been pointed out on Table 2. We were no able to find any research publications on the six countries namely Bolivia, Guyana, Paraguay, Suriname, Uruguay, Venezuela.

### 3.2. Classification of research fields

After the study we could identify, based on Table 3, that the South America focus the studies in Environment, Framework and Health but the majority of papers was distributed in several different areas.

### 3.3. Paper's hardware distribution

This SLR has reveled to us that the most used by researchers in South America is the Arduino and Mobile platforms, as shown in Figure 2.

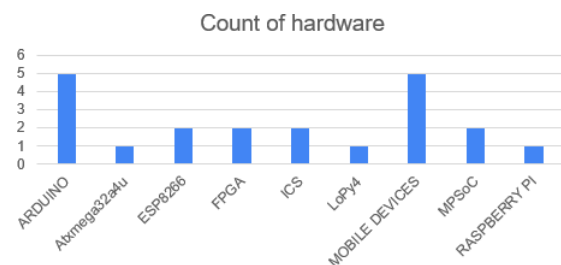


Fig. 2: Hardware for IoT

### 3.4 Paper's annual distribution

Looking for the papers distribution over the last 5 year we were no able to identify any pattern but we can see the data on the Figure 3.

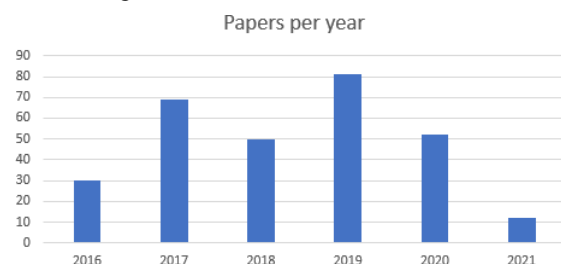


Fig. 3: Papers published per year

## IV. CONCLUSION

Using the scientific sources of publications we filtered 1390, to know that Brazil is the main researcher country and there are 6 of 12 countries that are not publishing in areas related to IoT and it represent an opportunity to get involved in such area, given that in South America there are many applications in topics like agriculture that has only 5% of presence in all the studies reviewed.

As shown in the Findings section and the Table 3, we discovered that the main areas addressed by the publications analyzed by this work were Environment, Framework and Health but the most works were distributed over other topics showing us the multidisciplinary use of IoT.

We identified by the Figure 1 that the hardware most used on the publications were Arduino and Mobile devices, showing how important is a low cost device as Arduino and how IoT could be applied to mobile devices due to its small size and low energy consumption.

We also noticed that in the year 2021 there were fewer publications than in the last five years, as we can see on the Figure 2. We attribute the lack of publications is related to the COVID-19 pandemic that has been restricting the number of research studies.

## V. FUTURE WORKS

This topic will cover similar studies that can be done next to this SLR. The same study can be done in the future to understand how that technology is growing over the years in IoT field in South America. Similar study can be done in other regions to understand its maturity and compare with that study to get a broader view of the IoT in the world. Going forward with industry 4.0 similar studies can be done with different technologies i.e. (Smart manufacture, Smart factories, Cloud computing, Cognitive computing, Artificial intelligence) that will help to identify which region or country is growing more in a specific area. With all that studies done together we will have a broad view of the development of industry 4.0 that will support humanity over the next years ahead.

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# A computerized solution for controlled distancing in a municipality in the state of Rio Grande do Sul/Brazil

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**Keywords—** Computing, statistics & numerical data, Epidemiological surveillance, Health Management and Planning, Health policies.

**Abstract—** The World Health Organization pronounced prevention, control, and management measures necessary from the state of a pandemic by coronavirus (SARS-Cov-2). Planning in situations of uncertainty is a task that aims to discover, evaluate, and face this circumstance. Objective: to describe a computerized solution for the distance control in establishments authorized to operate in the municipality of Gravataí (State of Rio Grande do Sul, Brazil), from May 1 to August 19, 2020. Results: The legal responsible for the establishment had to declare the customer service total area, administrative/production sector, and the total number of workers. The rule applied was the distance of at least 2 m<sup>2</sup> among people. A matrix determined by the system of colored flags was used to place a set of deliberations aimed to prevent and confront the COVID-19 epidemic, following mandatory protocols and specific criteria related to economic activities. Conclusion: The automated computerized solution to control distancing was useful for management in terms of inspection and quick decision-making, as it provided the necessary information regarding compliance with municipal and state decrees regarding the prevention of the new coronavirus.

## I. INTRODUCTION

In December 2019, a new betacoronavirus subtype was reported in Wuhan province. Known as SARS-Cov-2, this virus is associated with respiratory conditions hitherto of unknown origin, relating both to mild and severe forms of the disease<sup>1</sup>. Due to its high transmissibility, the virus has spread with such swiftly and in an overwhelming manner. Consequently, on March 11th, 2020, The World Health

Organization (WHO) has declared a pandemic status for the new coronavirus<sup>2</sup>.

Thus, planning in situations of uncertainty is a fundamental task that aims to discover, evaluate and face this circumstance. In this context of uncertainties, robust risks and actors with different interests, a non-deterministic planning looks to order human conduct. In view of this, it tries differently from the rationality of

traditional planning, which is based on setting up objects relating them to resources and deadlines<sup>3</sup>.

The COVID-19 pandemic sets a scenario that keeps many goals inarticulate and unknown means to achieve them. The pandemic illustrates the uncertainties about the means and ends, that is, a true chaos. In this arrangement, government action is expected to aim to institute order.

In the midst of a context of crisis and the need to guarantee governance, as alternative to traditional planning models there is the Strategic Planning Situational (SPS) by Carlos Matus, which aims to integrate ways of thinking and actions of technicians and politicians in the search for answers to the problems that afflict social groups and society as a whole. This model is based on knowledge formed not only by the heterogeneities of the human and social sciences, but also by political and administrative sciences, enabling an analysis entwined with the problems of society, with the prediction of interventions within a scale of urgency and priorities<sup>5</sup>.

Based on the guidelines of the Epidemiological Surveillance Guide of the Public Health Emergency of National Importance due to Coronavirus Disease 2019, the Federated Units defined their surveillance and control strategies for disease. The state of Rio Grande do Sul, through Decree No. 55,240, of May 10, 2020, instituted the "Controlled Distance System for prevention and dealing with the pandemic caused by the new coronavirus" (COVID-19)<sup>6</sup>.

The System allows monitoring the evolution of the coronavirus epidemic, and health, social and economic effects. Based on scientific evidence and the strategic analysis of information, this model establish a set of measures aimed at preventing and dealing with the pandemic, observing the regional segmentations of the health system and sectoral divisions of economic activities according to the National Classification of Economic Activities (NCEA)<sup>6</sup>.

In the Controlled Distancing System, the territory of the state of Rio Grande do Sul was divided into seven macro-regions. Each of them are composed of the corresponding municipalities of the 21 Regions, that aggregate 30 Health Regions<sup>7</sup>. The pandemic situation in the Regions is checked through the evaluation of 11 indicators determined to measure the spread of the virus and the possibility of response by the health care system<sup>8</sup>.

Considering the 21 Regions and according to the pre-established scores of the indicators, a system of flags was created. The colors yellow, orange, red and black are used, respectively, for the gradual and proportional application of a set of measures aimed at prevention and

coping with the COVID-19 epidemic. The banners were structured according to mandatory protocols and specific criteria to be followed by the different sectors of the economy. They used as a basis a weighted average of the indicators, classifying each Region in a colored flag weekly<sup>8</sup>.

In this perspective, there are operating criteria that vary according to the color of the flag. The operating ceiling for each activity is highlighted, which decides the maximum number of workers present, simultaneously, in the work environment. Also, the operating ceiling must meet the occupancy ceiling of an environment, which means that the activity cannot run with a number of workers or public greater than the maximum number of individuals authorized for the free physical space, respecting the minimum mandatory distance. The mode of operation, on the other hand, indicates the way in which an activity is carried out when it is in operation. The activities can be carried out in person, however with restrictions applied through protocols and/or alternative ways to keep it in operation (e.g.: teleworking, delivery, pick up and take away, drive-thru, individualized service, among others).

The county of Gravataí is part of Region 10 of the Controlled Distancing System in the state of Rio Grande do Sul. The region is named after the capital of the state of Rio Grande do Sul, which is part of it: Porto Alegre. As this is the most populous municipality, Porto Alegre developed a web platform capable of applying the various Municipal Decrees and regulations from the State Controlled Distance System.

To develop and implement computerization, it was necessary professionals who develop/operate information systems and technical professionals of the health sector. All civil servants that taken part in the development process of the system were statutory and assigned to the Municipal Health Department (MHD) of Gravataí. Hardware resources, physical devices, and equipment used for information processing (machines and media) were fundamental in this process. These resources were working tools of the civil servants of the Hall city, whose acquisition took place before the COVID-19 pandemic. Also, a software was used to control the hardware and to process the information.

The present study aims to describe an automated computerization solution for the controlled distancing from establishments authorized to work in the municipality de Gravataí, from May 1st to August 19th of 2020.

## II. METHODS

On May 1st, 2020, the Term of Health Responsibility<sup>9</sup>, generated through an electronic address (<http://saude.gravat.ai.rs.gov.br/termo>) was instituted. Based on information about the administrative/production and customer service areas, self-declared by the entrepreneurs, the system calculated the maximum number of people in the service area to the customer (occupancy ceiling) and in the administrative/production area (operation ceiling).

That computerization was implemented prior to the controlled distancing from the state of Rio Grande do Sul. At first, the person responsible for the establishment self-declares the total number of areas intended for customer service and administration/production, and the total number of workers. The rule to be applied was the distance of at least 2 meters between people. The following formulas were used for this calculation:

Administrative/production area (AA) = sum of free areas for circulation and length of stay ( $m^2$ ) of workers (At) per  $m^2$ .

[Customer area (AC) = sum of free areas for circulation and stay ( $m^2$ ) for customers (Al) for  $m^2$ ]

The  $m^2$  in the denominator refers to the area of the circle that each individual occupied considering the interpersonal distance of 2m, being the radius equal to 1 (one). Subsequently, the Term of Sanitary Responsibility was based on the matrix determined by the colored flag system<sup>8</sup>.

Following the protocols of the Controlled Distancing System, in the Term of Sanitary Responsibility, the occupancy ceiling indicated the number of persons present, simultaneously in the establishment, obeying the Norms of Fire Prevention and Protection<sup>10</sup> and observing the mandatory distancing of 2 meters between individuals. In this way, to measure the occupancy ceiling of establishments released for operation, the following general formula was used:

[Occupancy Ceiling (TOc) = sum of free areas for circulation and permanence ( $m^2$ ) of the client (Al) by the rule of the controlled distancing system (0.25) by the Municipal Reduction Coefficient (CRm) and Coefficient Public normative (CNp)], i.e.,  $[TOc = A \times 0.25 \times (1 - CRm) \times CNp]$ .

To establish the occupancy ceilings, the calculation involved the parameter of one person wearing a mask for every  $2m^2$  of free area or one person without a mask for every  $5.5m^2$  of free area. Therefore, the rule of the municipal controlled distancing system defined the

occupation as one person for every  $4m^2$  of area, regardless of the use of a mask.

The Municipal Reduction Coefficient (CRm) was applied in the self-declared area, both for the calculation of the occupancy ceiling and for the operating ceiling, considering that the establishments would refer to the total area and not to the free area in line with the municipal decree. Therefore, in the orange flag, period from May 2 to June 22, 2020, when the area was up to  $100m^2$ , it was reduced by 20%; 101 to  $200m^2$ , 30%; from 201 to  $400m^2$ , 40%; and if greater than  $400m^2$  the reduction was 50%. In the red flag, in force between June 23 and August 19, 2020, the reducers applied in the areas self-declared were: 40% in those smaller than or equal to  $100m^2$ , 45% in areas between 101 and  $200m^2$ , 50% when between 201 and  $400m^2$ , and 60% for those above  $401m^2$ .

The public normative coefficient refers to the percentage of capacity allowed by economic activity as expressed in municipal decrees based on the Controlled Distance System of the State of Rio Grande do Sul. As for the operating ceiling, whose concept was mentioned above, it was established according to the flag color and the economic activity, and its value could not exceed that of the occupancy ceiling. Also, when the administrative/production area is less than  $4m^2$ , the operating ceiling is equal to one (=1).

To calculate the operating ceiling, the following two formulas were applied, prevailing the most restrictive value when compared.

[Operation Ceiling (TOp): Worker Normative Coefficient (CNt) x No. workers per shift (T), i.e.,  $TOp = CNt \times T$ ]

Or

[Operation Ceiling (TOp): sum of free areas for circulation and permanence ( $m^2$ ) of the worker (At) by the rule of the municipal Controlled Distance System (0.25) by the municipal Reduction Coefficient (CRm), i.e.,  $TOp = A \times 0.25 \times (1 - CRm)$ .]

The worker normative coefficient refers to the percentage of workers allowed by economic activity considering municipal decrees.

## III. RESULTS

The legal responsible for the establishment accessed the computerization tool through the link <http://saude.gravat.ai.rs.gov.br/termo/>, and fill in the branch of activity. The system only allow proceeding if the activity was authorized to operate.

On the next screen, a window appear with the current municipal decree regarding the controlled distancing regime, and a field for the applicant to fill in with the number of the National Registry of Legal Entities or Individuals of the Federal Revenue.

Subsequently, a form was presented with indispensable variables for identification of the establishment, in particular, the self-declared areas for calculating the occupancy and operating ceiling, and number of workers (Figure II, quadrant bottom).

When clicking on “generate term”, the following screen displayed the verification of the data of the legal person responsible for the establishment. After confirmation, the Term of Responsibility is generated and saved in the database of the controlled distancing management tool, for use by the municipal agents.

This computerization tool had a control panel for the establishments, presenting the area and population variables from the Terms of Sanitary Responsibility (Table 1) generated by establishments authorized to work.

It was possible to observe three scenarios, the first being prior to the Controlled Distance System in the state of Rio Grande do Sul, and the other two referring to the colors of the deliberated flags for Region 10, where Gravataí is inserted (Table1).

The first scenario took place from May 1st to 12th 2020<sup>9</sup>; the second, due to the orange flag, it was from May 13th to June 22nd, 2020, <sup>11,12</sup>; and the third, under the red flag took place between June 23rd and August 19th, 2020 <sup>12,13</sup>. At table 1, it can be seen that, even with the progression of the severity of the scenarios, there was an increase in registered entrepreneurs and, consequently, an increase in the number of workers and clients released in specific economic areas.

To exemplify the difference in the occupancy ceilings values (the number of persons present, simultaneously, in the establishment) and of operation (the maximum number of workers present at the same time in the work environment) according to the scenarios (Table 2), it used the activity of restaurant – dish done. For this, the following fields were filled in: total number of workers = 10; administrative/production area = 20; free area for customer movement = 100.

The worker normative coefficient of scenario 2 is from the Decree 17.934, of May 13, 2020, and scenario 3 was present in the Decree 18.014, of June 23, 2020. In other words, the computer tool was always in line with its legal counterpart.

#### IV. CONCLUSION

The pandemic caused by the new coronavirus (SARS-Cov-2) corroborated the need for measures to prevent, control and manage the disease in a marked way. Planning in this context of uncertainty configures a fundamental task to discover, evaluate and face it. Thus, the state of Rio Grande do Sul/RS instituted the Controlled Distancing System, holding general and specific rules according to economic activity. Thus, in the government exercise, the Municipality of Gravataí/RS, aiming to prove the order, created a computerized solution to control compliance with the rules prescribed by the state model.

This tool is an innovative and useful resource for management in terms of inspection and quick decision-making since it has the fundamental information to follow municipal and state decrees regarding the prevention of SARS-Cov-2. It is understood that the present work will contribute to the improvement and expansion of the use of technologies of this nature by other municipalities at this time of pandemic by the new coronavirus.

*Table 1 - Total population (administrative/production and customers) according to area of establishments by scenario*

Registered Entrepreneurs		Scenario 1 (May 1st to 12th, 2020)	Scenario 2 orange flag	Scenario 3 Red flag
		4.841	7.130	7.904
Áreas (m2)	Management or Productions	601.393	41.201	153.031
	Clients	969.894	168.211	40.793
	Total	1.571.287	209.412	193.824
Population	Management or Productions	191.849	11.093.928	1.576.888
Population (people)	Clients	308.967	1.172.776	1.354.193
	Total	500.816	12.266.704	2.931.081

*Source: Municipal Health Department of Gravataí/RS (2020)*



Table 2 – Scenarios based on the branch of activity à la carte restaurant – prepared dish

	Scenario 1 (May 1st to 12th, 2020)	Scenario 2 orange flag	Scenario 3 Red flag
Municipal Reduction Coefficient	-	0,8	0,6
Public normative coefficient	-	-	-
worker normative coefficient	-	0,5	0,5
Administrative or production area/Operation Ceiling	05	04	03
Client Area/Occupancy Ceiling	32	20	15

Source: Municipal Health Department of Gravataí/RS (2020)

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## The Management of Solid Waste in the Rodolfo Aureliano Forum - Case Study

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**Keywords—** Collectors. Cooperatives. Court  
of justice. Solid Waste.

**Palavras-chave—** Catadores. Resíduos  
Sólidos. Cooperativas. Tribunal de Justiça.

**Abstract** — The relevance of the work of cooperatives and associations of recyclable material collectors was recognized by Law 12,305/10, which also encouraged solid waste collectors to meet in cooperatives and associations. In this scenario, the National Council of Justice (CNJ) determined that it was mandatory for all Brazilian courts to adopt measures of public sustainability policies, as well as the implementation of the Sustainable Logistics Plan of the Judiciary (PLS-PJ). The research carried out a qualitative approach, conducting interviews with the cooperative members of the Work Cooperative of Recyclable Solid Waste Collectors (COOPAGRES) that has a partnership with the Forum Judge Rodolfo Aureliano, located in the city of Recife-PE. The research results identified that it is necessary to remedy the communication deficiency between the Forum and the Cooperative, as well as to include the participation of the association and its associates in the construction of the plan (PGRS) of the Forum and in its execution, so that the practices are adopted in an ecologically correct manner. This is the search for social and economic inclusion and recognition of solid waste collectors.

**Resumo** — A relevância do trabalho das cooperativas e associações de catadores de materiais recicláveis foi reconhecida pela Lei 12.305/10, que também incentivou que os catadores de resíduos sólidos se reunissem em cooperativas e associações. Nesse cenário, o Conselho Nacional de Justiça (CNJ) determinou que era obrigatório que todos os tribunais brasileiros adotassem medidas de políticas públicas de sustentabilidade, bem como a implantação do Plano de Logística Sustentável do Poder Judiciário (PLS-PJ). A pesquisa realizou uma abordagem qualitativa, realizando entrevistas com os cooperados da Cooperativa de trabalho de catadores de resíduos sólidos

*recicláveis (COOPAGRES) que possui uma parceria com o Fórum Desembargador Rodolfo Aureliano, localizado na cidade de Recife-PE. Os resultados da pesquisa identificaram que é necessário sanar a deficiência de comunicação entre o Fórum e a Cooperativa, bem como que seja incluída a participação da associação e de seus associados na construção do plano (PGRS) do Fórum e na execução deste, para que as práticas sejam adotadas de forma ecologicamente correta. Esta é a busca pela inclusão e reconhecimento social e econômico dos catadores de resíduos sólidos.*

## I. INTRODUCTION

Consumption and the activity of consuming aim at meeting basic or superfluous needs and, with population growth and economic development, the so-called consumer society emerges that tends to consume excessively, factors that led to environmental degradation on a larger scale (CAVALCANTI, 2018).

Over the years, the development model that the world has been experiencing, especially after World War II, has become unsustainable, providing negative and harmful results for the environment, according to Cavalcanti (2018). For Besen (2019), soil contamination of groundwater, rivers and seas by solid waste puts the entire ecosystem at risk, including the existence of life on Earth.

Historically, consumerism began in the mid-twentieth century and, as a consequence of the expansion of production, there was an increase in the concentrations of carbon dioxide (CO<sub>2</sub>) in the atmosphere, due to the consumerism of the population, which is primarily responsible for the accumulation of municipal solid waste, many of which could be reduced, reused and recycled, reducing the impact of waste on nature (ALMEIDA, 2019).

In this context, there is a need to implement a sustainable growth development model that does not harm nature and the environment (ALMEIDA, 2019). One of the solutions identified was the creation and implementation of the waste recycling process, seeking the reintroduction of part of the matter that would become garbage is one of the means to ensure sustainability for future generations (ARAÚJO; FURTADO; SANTOS, 2018). Also, because human development, long ago, was based on the exploration of human resources, which, because it was carried out without any care, had as a consequence the degradation of the environment (ARAÚJO; FURTADO; SANTOS, 2018).

In this scenario, the figure of the solid waste picker appears, professionals who perform their labor in precarious conditions in the collection, being exposed to contaminated chemical and biological agents. In addition to the lack of quality in the environment that the waste

picker carries out his work, these professionals still face social exclusion due to the prejudice of part of society with this profession, according to Lima (2018).

Lima (2018) points out that it was in the informality of the work of the solid waste picker that these workers identified in the constitution of cooperatives of solid waste pickers one of the alternatives for the organization of labor. In Brazil, the formal model of CSU waste pickers' cooperatives had its emergence in the 1990s, being limited to the most profitable materials (LIMA, 2018). The importance of these cooperatives is highlighted, as they represent, organize, and train these recycling professionals and, not only for this, but, and mainly, for the importance they have for the environment, due to their role of sustainability (ABRELPE, 2021).

Brazilian legislation also encourages these cooperatives, as can be identified in the Brazilian Constitution of 1988 that in its article 5, item XVII, grants license for the formation of cooperatives and associations without the need for prior authorization, as well as grants differentiated tax treatment to cooperatives, in accordance with the provisions of Art. 146, III, point (BRASIL, 1998).

Also in the Brazilian legal system, in 2010, the National Solid Waste Policy (PNRS) was elaborated, created by Law No. 12,305 of August 2, 2010 and regulated by Federal Decree No. 7,404 of December 21, 2010, which deals with the principles, objectives and instruments necessary to make it possible to make the country's progress possible in addressing the main environmental problems, resulting from inadequate management of waste (BRASIL, 2010).

The PNRS legislation includes "[...] guidelines on integrated management and management of solid waste, including hazardous ones, the responsibilities of generators and public authorities and the applicable economic instruments" (BRASIL, 2010). It should be noted that in Article 7 of Law No. 12,305/2010 the following objectives are established: the non-generation of waste; the protection of public health and environmental quality; and the valorization of the waste picker – which summarize, in general terms, the specifications brought in

the bulge of legislation (BRASIL, 2010).

Solid waste management plans include the possibility of providing for the participation of associations or cooperatives of waste pickers in the management of recyclable or reusable solid waste. This demonstrates how worrying solid waste is for society and governments, and how necessary recyclable solid waste pickers and their cooperatives are needed.

Despite the legislative progress, in practice, there are still growing problems involving the disposal of waste, especially those of household origin, due to the lack of specialized areas that make up the final disposal of production (ARAÚJO; FURTADO; SANTOS, 2018). According to data from the Plastic Chain Incentive Plan, Abiplast - Brazilian Association of the Plastic industry and plastics company Braskem, "in 2020, 23.1% of the plastic packaging we use at home was recycled. They were transformed into bottles, bottles, buckets, bowls and dumpsters, reducing garbage in the environment" (VITOR, 2021, s/p). Even with this percentage, "the amount of material that is not reused is still quite considerable because, according to Abiplast, in 2020 Brazil did not reuse 169,000 tons of material" (VITOR, 2021, s/p).

Several studies have already been conducted addressing the theme of solid waste management, and it is identified that "the adequate final disposal of solid waste still remains one of the biggest problems faced by the public administration, because most municipalities in the country dump their waste in open dumps with no treatment" (GONÇALVES; CRAMER; SOARES, 2019, p. 25). In this scenario, the issue of solid waste management in the State of Pernambuco is carried out by the State Department of Environment and Sustainability of Pernambuco (Semas-PE) which has as main objective to zero the dumps of the entire state by the year 2022. According to data from Semas - PE, "currently 5,500 tons/day are disposed of in landfill. In percentage terms, 60% go to landfill and 40% go to the dump" (CRISPIM, 2020, s/p).

In the Brazilian judicial system, the National Council of Justice (CNJ) through Resolution CNJ No. 201/2015 (CNJ, 2015) determined that it was mandatory for all Brazilian courts to adopt measures of public sustainability policies, as well as the implementation of the Sustainable Logistics Plan of the Judiciary (PLS-PJ). In compliance with the determination, the Court of Justice of the State of Pernambuco (TJPE), located in the city of Recife, capital of the State of Pernambuco, implemented the Sustainability Center of the TJPE to promote several campaigns for social and environmental transformation

through the conscious and selective collection of waste from this body (MARQUES, 2018).

Based on the data available, this research was proposed to investigate the measures of public sustainability policies of the Forum Judge Rodolfo Aureliano, which is the TJPE Forum that most processes in the State of Pernambuco according to statistical data from the TJPE (TJPE STATISTICS, 2021). To identify the evaluation of solid waste management at the Rodolfo Aureliano Forum, the following question arose: what are the measures adopted by the Rodolfo Aureliano Judge's Forum? Are these measures taken in conjunction with recyclable solid waste pickers' cooperatives?

Thus, the study contributes to the area of environmental management and social interaction, at a time when it seeks to identify how the local judiciary can direct waste pickers in the region in their actions, pointing out the influence of the partnership between the Judiciary Body and the waste pickers' cooperative, as well as identifying the social impact of this partnership.

## II. MATERIALS AND METHODS

### PLACE OF STUDY

The research was carried out at the Forum Judge Rodolfo Aureliano, which is a reference in the Judiciary of Pernambuco and is located on Avenida Desembargador Guerra Barreto, s/n, Ilha Joana Bezerra, in the city of Recife, State of Pernambuco, where the largest number of cases in the State Court is being handled. In February 2018 the Forum Judge Rodolfo Aureliano, also known as the Recife Forum, implemented the selective collection project through the Sustainability Center of the TJPE, and 80 selective collectors were made available in the corridors of the Recife Forum (MARQUES, 2018).

In the year prior to this implementation, "the Urban Maintenance and Cleaning company (Emlurb) promoted a training on selective collection with outsourced employees of the Recife Forum, and a meeting was held with the heads of secretary to present the project" (MARQUES, 2018).

To achieve the objectives of this project, the Court entered a contract with the Cooperative of Work of Recyclable Solid Waste Pickers (COOPAGRES), established at Travessa do Gusmão, no. 178, São José neighborhood, Recife/PE, registered with CNPJ 05.093.501/0001-83, having started its activities on May 29, 2002. Coopagres's main activity is the wholesale trade in paper and cardboard waste.

In the contract it was stipulated that the waste pickers of coopagres cooperative would collect recyclable



solid waste, such as paper, plastics, glass, metals and other materials that the Administration of the building understands to be legally possible to allocate and be the object of interest of the Cooperative, as stipulated in Contract no. 002/2018. Also, according to the concluded, waste should be destined environmentally for recycling and reuse, where the selective collection of solid waste began in Rodolfo Aureliano in 2018.

## RESEARCH DESIGN

Given the general objective, which is to examine the management of public sustainability policy measures of the Rodolfo Aureliano Forum and its structuring with a local waste pickers' cooperative, the research was developed with the researchers' field trip, addressing the intended target audience, and making the records in the data collection journal.

On the qualitative approach, it fits this way, because the work seeks to relate the objective world with the subjective subject. Another characteristic of the qualitative approach of the study can be verified in the search for particular identities of each interviewee and, from the collected stories, it is possible to respond to the specific objectives to which the study is proposed (GIL, 2022).

This research has a descriptive approach, because it aims to describe the facts and phenomena, according to Triviños (2012). Furthermore, descriptive investigation is "structured to measure characteristics in a research question, the cross-sectional of which occurs by collecting data at a point of time and synthesized statistically" (SCHARF; Padilha; SANCHES, 2016, p. 64). Therefore, this research is characterized as qualitative in view of its purpose, both exploratory and descriptive (GIL, 2022).

Initially, the theoretical model of the research was constructed based on previous studies on the subject. The second stage consisted of field research, with the application of interviews, with the objective of examining the objectives of the research. At this stage, the researcher went to COOPAGRES to conduct interviews with the waste pickers of the cooperative. He started reporting on the importance of the research, as well as stating that the interviewees' identity will be preserved, and the answers will be used as an integral part of the research to analyze the objectives.

Subsequently, 8 personal questions were asked, and the first question was to know the age, later marital status, soon after the number of children, then school education, sought to identify the average family income, as well as questioned whether they received benefit from any social program. Soon after, he was asked how long they worked in the investigated cooperative and whether they

had worked in another. And finally, they were asked at what age he began working as waste pickers for recyclable materials. Subsequently, 10 questions were asked to meet the research objectives.

The answers were transcribed at the time of the interviews, and no information was provided, nor corrected any errors of Portuguese language that may exist, in order to demonstrate the reality of the fact narrated by the interviewee at the time of the interview.

## POPULATION AND SAMPLE

The research universe is composed of all solid waste pickers who are co-opted by COOPAGRES, which is a cooperative company working for recyclable solid waste pickers located at Rua Travessa do Gusmão, 178, São José neighborhood, Recife/PE - CEP 50090-580, and which has 24 cooperative members.

The researcher approached all the members who were at the research site, seeking to develop a relationship with the waste pickers, so that they could answer the questions of the questionnaire. The interviews were conducted with the subjects until saturation, that is, until the moment when the researcher identified that the answers were similar to each other. According to Nascimento *et al.* (2019, p. 244) "the theoretical saturation of the data is also found in the scientific literature as external validation, since it is related to the results of the research".

## DATA ANALYSIS PROCEDURE

Discourse analysis was the methodological technique applied to the interpretation of the collected information, having been developed based on historicity, interdiscursivity and systematicity, seeking to understand the real meaning of the message transmitted by the catadores interviewed (GIL, 2022).

The specific objectives of the research were also explored through discourse analysis, contextualizing verbalization to obtain responses to the behavioral condition of recyclable solid waste pickers in relation to the work developed in the Cooperative and Rodolfo Aureliano Judge's Forum.

With the application of discourse analysis, a technique that proved to be more appropriate for the present work, understandings were established on the management of public sustainability policy measures of the Rodolfo Aureliano Forum and its structuring with COOPAGRES, which is a local waste pickers' cooperative.

## INSTRUMENT AND DATA COLLECTION

Data collection was performed through interviews, whose proposed script is in Appendix A. They



were carried out with recyclable solid waste pickers who are cooperated according to their experience in the management of public sustainability policies of the Rodolfo Aureliano Forum, providing the researcher with the possibility of analyzing not only the interviewees, but also the environment in which it is inserted and, thus, identify the demographic, psychographic and behavioral condition of the cooperative waste pickers.

The knowledge departing from the theme studied in the bibliographical research generated a framework for the production of the script of the semi-structured interview, used in the second stage, and the answers were fully transcribed, without any grammatical correction or omission of what was said, for the proper analysis of the discourse.

### III. RESULTS AND DISCUSSION

In this chapter, the results obtained in the interviews conducted with the cooperative recyclable solid waste pickers of COOPAGRES located about São José, in the city of Recife/PE and contracted by the Rodolfo Aureliano Court, are presented. The interview began with 8 personal questions, and the first question was to know the age, later the marital status, soon after the number of children, then school education, sought to identify the average family income, as well as questioned whether they received benefit from any social program. Soon after, he was asked how long they worked in the investigated cooperative and whether they had worked in another. And finally, they were asked at what age he began working as waste pickers for recyclable materials. Subsequently, 10 questions were asked to meet the research objectives.

For this, interviews were conducted with the subjects until saturation, that is, until the moment when the researcher identified that the answers were like each other (NASCIMENTO et al., 2018). The researcher attended COOPAGRES, on alternate days and times, having interviewed a total of 6 members, with an average duration of 30 minutes.

During the interviews, the answers were transcribed according to the interviewees' original speech, without suitability for the cultured language, to properly interpret the meaning of what was said at the time. This decision showed, in some cases, that colloquial language is common, with cacoethes and grammatical errors. None of these deviations, however, makes the results impossible. On the contrary, when the analysis is well performed, it brings value to the study, because it kept the interviewees' discourse as it was captured.

The research instrument met the objectives of the

study as follows:

*Table 1 - Attendance to the objectives from the research instrument.*

OBJECTIVE	QUESTIONS THAT MEET THE OBJECTIVE
Discuss the management of public sustainability policy measures of the Forum Judge Rodolfo Aureliano and its structuring with a local waste pickers' cooperative (General).	10, 11, 12
Evaluate the collaboration of cooperatives/associations of waste pickers in the management of selective collection in the Forum Judge Rodolfo Aureliano (specific 3).	16, 17
Evaluate the management model of the one adopted by the Rodolfo Aureliano Judge Forum for selective collection, evaluating based on economic, social and environmental dimensions (specific 1).	9, 18
Describe the sociocultural and economic profile of the cooperatives/associations of waste pickers who work in the Forum Judge Rodolfo Aureliano (specific 2).	13, 14, 15

Source: The authors (2022).

During the interviews, the answers were transcribed according to the interviewees' original speech, without suitability for the cultured language, to properly interpret the meaning of what was said at the time. This decision showed, in some cases, that colloquial language is absolutely common, with cacoethes and grammatical errors. None of these deviations, however, makes the results impossible. On the contrary, when the analysis is well performed, it brings value to the study, because it kept the interviewees' discourse as it was captured.

#### MANAGEMENT MODEL FOR SELECTIVE COLLECTION

To meet the first specific objective, to evaluate the management model adopted by the Rodolfo Aureliano Forum for selective collection, evaluating based on the economic, social and environmental dimensions, 2 questions were applied to the participants. The questions sought to identify whether the respondents had knowledge about how the management of the public sustainability policies of the Public Sustainability Forum of the Forum of the Forum judge Rodolfo Aureliano works and, to do so, the interviewee was asked to issue his/her opinion on the subject addressed.

Thus, the first question questioned whether the interviewees were aware of how the management of the public sustainability policies of the Forum of the Forum judge Rodolfo Aureliano works. Interviewee E1 commented: "They leave material very scattered, then have to do the cleaning". The interviewee E3 stated that "no", that is, he was not aware of how the management of public policies worked. The interviewee E5 states that "I do not have access, they give good quality material". It should be highlighted that most of the interviewees answered that they do not have a knowledge capable of answering the question directed to the specific objective 1 of this

research.

On the subject, several authors (SOUZA, 2018; ALMEIDA, 2019; LIMA, 2020) recognize the need to continuously improve the waste management process, as well as indicate that environmental adequacy practices should be developed.

The second question wanted to know about the interviewee's view on the collaboration of cooperatives/associations of waste pickers in the management of selective collection in the Forum Judge Rodolfo Aureliano. Interviewee E2 answered that: "nothing to say", and this statement was corroborated by interviewee E3: "important, can not say". The understanding that the interviewees have about the waste pickers in the management of selective collection is not in harmony with what the literature brings about the importance of building a support network to support strategies and articulations for selective collection (SANTIAGO; SECCO-OLIVEIRA; SAINTS; ZANIN, ZANIN, TEIXEIRA, 2021).

However, two interviewees who reason differently, knowing how to indicate collaboration, and interviewee E1 commented that the collaboration would be: "quickness to pick up the material", followed by E4 stated that: "there could be an agreement with PCR to receive a monthly budget, as some cooperatives already receive". The interviewee E5 states that the collaboration is: "economy of the forum, we do a job that they do not need to pay another company".

In this sense, the interviewees demonstrated that it is necessary a greater interaction between the cooperative and the Forum in order to jointly build a network of interaction and articulation for the development of the selective collection program. Moreover, with the approximation of the cooperative with the organization besides being a means of network formation (co-operations and public policies), it is also one of the attributes for their competitive advantage in the market (ARAÚJO; FURTADO; SANTOS, 2018).

#### SOCIOCULTURAL AND ECONOMIC PROFILE OF COOPERATIVES/ASSOCIATIONS OF WASTE PICKERS

To meet the second specific objective, which is to analyze the sociocultural and economic profile of waste pickers' cooperatives, 3 questions were asked for the cooperative members, seeking to identify whether the waste picker's profession is valued, the difficulties faced in the profession and whether it is unhealthy or excluding.

Thus, the first question tried to verify, together with the interviewees, whether they thought that the

profession of waste picker of recyclable materials is valued. In total, 4 respondents answered that the profession was not valued and 2 respondents stated that it was valued. Respondent E1 pointed out that: "no, they do not give due value". In addition, respondent E3 pointed out that "no, they humiliate a lot".

With a different thought from the previous ones, respondent E2 stressed that he feels that his profession is valued because "(...) that's where my income comes from, bread." Respondent E6 stated that the profession is valued: "yes, people see the disposal of garbage".

Basically, the answers corroborate the struggle that waste pickers carry out seeking their inclusion and social recognition. According to Araújo, Furtado and Santos (2018, p. 165), "recycling cooperatives represent a means of social inclusion, economic rise and minimization of environmental problems arising from garbage, presenting effects on the three basic dimensions of sustainability, namely: economic, social and environmental".

The second question wanted to know the difficulties to practice the profession of waste picker, obtaining as an answer that the difficulties are normal, excessive heat, prejudice, lack of help from the state and, finally, one of the interviewees stated that he had no difficulty. The garbage collector historically exercises a profession that is "invisible" to society and the public authorities, a factor that determined that this population had little access to public services, as well as did not provide means of economic and social ascension, resulting in a poor population (ARAÚJO; FURTADO; SANTOS, 2018).

The third question dealt with the presence of unhealthiness and questioned whether the interviewees felt they were excluded from society because of their profession. Regarding this question, all respondents stated that it is unhealthy and that they feel excluded from society. Respondent E6 pointed out that: "if you don't work with PPE, yes". In this sense, it is noticeable that "the collection of "garbage" continues to be considered as something excluding, even if it constitutes a possibility of social inclusion of a portion of workers" (LIMA; TRINDADE, 2018, p. 37).

From the answers given in the interviews, the feeling of social exclusion and exposure to the unhealthy environment is due to the history of the profession itself, but that, despite legislative advances, they have not yet been able to guarantee that workers exercise their work in a healthy environment and that they would provide a social and economic ascent.

## THE COLLABORATION OF COOPERATIVES/ASSOCIATIONS OF WASTE PICKERS IN THE MANAGEMENT OF SELECTIVE COLLECTION

In the attendance to the third specific objective, to describe the collaboration of cooperatives/associations of waste pickers in the management of selective collection, 2 questions were applied to the respondents.

The first asked about whether the respondent thinks important the work of cooperatives and whether he thinks that his work is important to the judiciary. He was unanimous in the responses, stating that the work of cooperatives is important. Respondent E6 also pointed out that "(...) cooperatives must come together." Respondent E5 stated that the importance is related to "(...) income and the environment." On this question, Law 12.305/2010 itself recognizes the importance of reusable and recyclable solid waste as an economic good and social value, generating work and income (BRASIL, 2010). It occurs that, despite the legislative recognition, in the day-to-day "the occupation of waste picker is in the so-called "marginal economy", characterized by precarious working conditions, with little or no recognition of society for the possible benefits it can bring to public cleaning and the environment, in general" (LIMA; TRINDADE, 2018, p. 34).

The second question asked what was your expectation of the Forum with the waste pickers? Respondent E5 reported that the expectation is to "increase the amount of material and help in transport". The respondent E6 highlighted an important point in stating that his expectation is that the Forum "will approach, hold meetings". The Respondent E4 expects the Court to make "PPE donations". In this sense, it is perceived that the interviewees' expectations are that there is a greater approximation between the cooperative and the Court. Peroni (2020) points out that for the government and the population to recognize the importance of waste pickers it is necessary that "a large campaign of information and mobilization of society for the separation and disposal of waste in an appropriate way" and further adds that "people need to know that the proper separation and disposal of their waste, in addition to collaborating for the preservation of the planet, it also represents the generation of work and income for thousands of waste pickers."

There was also emphasis on the feelings that respondents have when comments are made about the importance of the cooperative's work. This importance was highlighted by Peroni (2020) when he stressed that "recycling is one of the instruments of the circular economy and in countries with the profile of Brazil has

great importance, because it moves a gigantic economy and ensures the survival of thousands of people".

## MANAGEMENT OF THE MEASURES OF PUBLIC POLICIES OF SUSTAINABILITY OF THE FORUM DESEMBARGADOR RODOLFO AURELIANO AND ITS STRUCTURING WITH A COOPERATIVE OF LOCAL WASTE PICKERS

To achieve the general objective, it is to discuss the management of public sustainability policy measures of the Forum Judge Rodolfo Aureliano and its structuring with a cooperative of local waste pickers three issues were applied to the participants. Specifically in this case, it is important to highlight that the understanding of the values discussed above will be part of the fulfillment of this objective, in addition to the questions dedicated. Thus, both the following questions and the analyses of the previous items are part of the discussion about management. It is, in practice, a closing of Chapter 4 - Results and Discussion, to meet the general objective of the dissertation.

The first question questioned whether the interviewee has already participated in any training course to work in the Forum Judge Rodolfo Aureliano and requested the indication of which courses, only 1 respondent claimed to have taken a training course. Thus, respondent E1 replied that: "yes, by the cooperative". The other respondents stated that they had not taken any course to act in the Forum. Training is very important to consolidate popular recycling, as well as to stimulate the formation of cooperatives.

The second question dealt with the interviewee's experience in another body of the Judiciary. When questioned, only 1 respondent stated that they had experience in another body and the others do not have experiences in other bodies, with the Recife Forum being the first to act.

On the experiences, these tend to assist in the management and "consolidation of the notion of popular recycling and led to the perception that to enable such a project, financial resources would be needed for working capital, for investment in structure and equipment, training courses, technical advice to workers, among other things" (SILVA, 2020, p. 110).

The third question asked the interviewees what the difference is between working in the Forum and in the other Bodies, as well as asasing that examples of places that the interviewee has already worked for be cited. The interviewee E1 pointed out that he only has experience in the Forum and in the "street", stating that "in the cooperative is much better. Danger with glass." The interviewee E4 highlighted that "need to adjust the

separation of the material, everything is scattered making the work difficult". The interviewees E2, E3, E5 and E6 could not answer the question.

In this sense, it is identified, with the answers obtained, that despite the advances, it is still necessary that these professionals have a greater participation in the decision-making in relation to the management of solid waste, as well as that training courses be provided for a better development and execution of this activity. Another point identified is in relation to the embryonic recognition of this profession, and recognition should be stimulated, including the fact that these professionals are necessary for the management of solid waste in accordance with Law 12.305/10.

In line with the other analyses (management model, sociocultural profile, collaboration), a positive relationship was evidenced with the feeling of being satisfied with their professional performance, as well as are aware of the responsibility and importance of the professional. The set of responses pointed out that there are still many changes that must be made, especially in the communication and integration between the cooperative and the Court, so that together they plan and execute solid waste management in the best way.

#### IV. FINAL CONSIDERATIONS

The general objective of this work was to examine the management of public sustainability policy measures of the Rodolfo Aureliano Forum and its structuring with a local waste pickers' cooperative, which was the basis of this study.

An important contribution of the study was to identify that, according to the information provided by the interviewees, there is no interaction between the Forum with solid waste pickers, since the interviewees indicated that they did not have access to information about public policies adopted by the Forum, as well as most of the interviewees did not take any improvement course to work with the Forum.

In view of this fact, the present research identified that it is necessary to re-apt the deficiency of communication between the Forum and the cooperative, as well as that the participation of the association and its associates in the construction of the plan (PGRS) and in the implementation of the plan, is included, so that the practices are adopted in an ecologically correct manner.

It is important to highlight that the inclusion of cooperatives and their cooperative members in decision-making is fundamental for the strengthening and development of the cooperative, as well as stimulates the

process of social inclusion of waste pickers, a factor that should be developed by the Forum Judge Rodolfo Aureliano.

Another contribution was to identify the gaps in the collaboration network of the Rodolfo Aureliano Forum, highlighting the lack of dialogue and the lack of training of solid waste pickers to act and comply with the PGRS, in breach of the national solid waste policy.

The third contribution refers to bringing to academia and society the discussion about the essentiality of public policies aimed at waste pickers of recyclable materials, considering that working conditions must be guaranteed by public agencies, as well as the importance of the work of these professionals, ensuring them a dignified life.

The debate on the transformation of garbage and its return to the productive sector is important because this work is responsible for reducing the waste of raw materials and energy, essential factors for the economy and society. But all this transformation could not be accomplished if it were not for the actions of waste pickers and, despite all the legislative advances, still do not have the social and financial recognition they deserve, much less have an incentive to education and specialization, this being a factor that can limit both associations and the very execution of the profession.

As managerial possibilities, the Forum Judge Rodolfo Aureliano and the other organs of the Judiciary can be more adequately used for what is established in the National Solid Waste Policy, especially in the construction of an inclusive policy of associations and their associates in the preparation and execution of the PGRS, which proved to be nonexistent in this research.

The academic possibilities for further studies should be developed in the light of the analysis of the management of the organs of the judiciary, seeking to identify the reasons that trigger the lack of communication between them and the waste pickers' cooperatives in the management of solid waste. Researchers will be able, if they do so, to bring out important results to better understand how it is possible to perform integrative management.

The limitations refer to the interviewees and their area of housing and work, since they are in a specific point/region of the country, which can lead to different results if the collection of the research data in other Brazilian states is made.



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# Gamma Radiation ( $^{137}\text{Cs}$ ) for the Treatment Against Resistant Fungi in Two Brazilian Libraries

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**Keywords—** Gamma irradiation, Fungi, Cesium, Molecular Biology, Libraries.

**Abstract—** The present work showed that a wide diversity of fungi was found in the environment where the Collection Academia Brasileira de Ciências is stored, in the Henrique Morize Library, being this diversity quite common in spaces storing this kind of cellulosic material. Fungal genera such as *Aspergillus*, *Cladosporium*, *Rhizopus* and *Trichoderma* were identified through modern Molecular Biology techniques. The presence of these fungal genera is probably associated to climatization and humidity control, which prevent the occurrence of a wider diversity of microbes. However, two fungal genera, *Trichoderma* and *Rhizopus*, resisted  $^{137}\text{Cs}$  irradiation doses with up to 19 kGy, considered high for the elimination of fungi. On the other hand, in the National Library, particularly in some sectors, an even higher diversity of fungal species/genera was observed, a fact that seems to be compatible with the size of the library, with a much higher circulation of people. This higher microbial diversity indicated the occurrence of fungal species absolutely uncommon for in libraries and archives, such as: *Diaphorina*, *Trametes*, *Arxotrichum*, *Grammothele*, *Pessiophora*, *Phebia* and *Talaromyces*. Just successive samplings in the same areas will allow a confirmation if these fungal genera are permanent or occasional, due to some oscillation in the operation of circulation systems or a possible transport of these species from the outside to the library, which allows those species to remain latent in relation to growth. All microbial samples from the National Library, survived irradiation up to 16kGy.

## I. INTRODUCTION

The problem of microbial contamination in air-conditioned artificially controlled spaces is being focused by several researchers [1-4].

Fungal diversity in these spaces becomes critical due to the possibility of recirculation of suspended particles into the interior of those spaces. Climatization equipments are usually associated to relative humidity control systems, which, may contribute to the concentration of microbial species from the air, if not properly operated.

This problem becomes even more severe, if climatized spaces constitute spaces for the safeguard of cellulosic materials, that may contribute for the proliferation of fungi and bacterial cells.

Libraries and archives constitute suitable spaces for these types of microbial proliferation, a fact that can compromise the quality of atmospheric air for users and workers, as well as a decrease in the permanence index of books, historical documents, personal archives, photographs, parchments, all of them from lignocellulosic nature.

What is usually observed is the search for local solutions, almost never reproducible for other spaces, even with similar characteristics, due to local specificities, distinction in the occurrence of fungal species and availability of techniques for microbiological monitoring and technological solutions.

Microbiological monitoring of climatized environments has become a common practice all over the world, in particular when it is related to deteriorating processes of specific substrates. It is known that microorganisms of the most diverse types are present in environments, often associated with suspended particles resulting from inadequate preventive maintenance of air circulation devices or air humidity controllers in bad operating conditions. Literature reports several methodologies for monitoring air-conditioned environments, with regard to the quantification of microorganisms. These are adapted or targeted to the environmental characteristics of the monitored area, and the likely occurrence of microbial genera.

Pasanena et al. [5] studied fungal growth and viability in building materials under controlled humidity conditions. The materials were submitted to various environmental conditions with variable water absorption and relative air humidity, and, after appropriate treatments, fungi and actinomycetes were cultivated after two weeks of incubation. The results showed that when water was absorbed by capillary action, fungal growth started more quickly in wood-based materials, under humidity in the order of 20% (m/v). Condensation under variable conditions of relative humidity and temperature caused differentiated growth of fungal populations, followed by rapid growth, particularly at high relative humidity. It is noteworthy that the fungal species were particularly tolerant to fluctuations in temperature and relative humidity conditions, with very few effects that compromised fungal viability. In a recent literature review, Pinheiro and Sequeira [6] wrote an extensive review focusing on the action of fungi in cultural heritage collections, including paper-based documents,

photographs, films, presenting current techniques for prevention, treatment and more appropriate strategies for studies in the area of biodeterioration. Shirakawaa et al. [7] verified the susceptibility of fungal attack to phosphogypsum. Procedures described by ASTM were used, which suggest a combination of three fungal species for biodegradation studies. Furthermore, the authors chose to use a strain of *Cladosporium* sp. isolated from the material itself. It was verified in the study that the species introduced in the tests did not present growth on phosphogypsum, a fact that was not observed for the genus *Cladosporium*. In order to inhibit fungal growth, the authors tested phosphogypsum heated to 600 °C as a substrate for development of *Cladosporium*, *Aspergillus niger* and *Trichoderma* strains, previously isolated from the environment and stored for two years. All showed development in media containing phosphogypsum as a substrate, although *Fusarium* and *Rhizopus* strains showed different behavior, not causing discoloration of the phosphogypsum contained in the media on Petri dishes. Nielsen et al. [8] studied the influence of relative humidity and temperature on the growth and metabolism of fungal species in various types of building materials. The authors, in order to evaluate the metabolic diversity, incubated several samples of building materials based on wood, starch and composite materials, at temperatures ranging from 5 to 25 °C, under conditions of relative humidity of 69 to 95% and for a period of up to seven months. From these tests, authors were able to conclude about the diversity of species acting on the materials, most of them belonging to the genera *Penicillium*, *Aspergillus* and *Eurotium*, all of them able to produce secondary metabolites and mycotoxins.

Giannantonio et al. [9] observed the formation of surface incrustations on concrete, under controlled conditions as well as with the supplementation of compounds to the concrete. Authors verified that fungal strains of *Alternaria*, *Cladosporium*, *Epicoccum*, *Fusarium*, *Mucor*, *Penicillium*, *Pestalotiopsis* and *Trichoderma* colonized directly on the concrete.

Hoang et al. [10] evaluated the susceptibility of green building materials to biodeterioration by *Aspergillus niger*, as a reference fungus. The detection of spores and the presence of nutrients contributed to the growth of *Aspergillus niger* on plastic-based walls and ceilings. The authors observed a strong correlation between the content of the mixture and the organic materials, observing the time in which the coating of 50% of the surface area by fungi took place. The results suggest that the presence of organic matter in a given material seems to be a key factor for the diagnosis of fungal susceptibility with consequent biodeterioration. Not only the materials are responsible for



the spread of fungal and bacterial spores, but also the climatic conditions of the environment.

Picco and Rodolfi [11] studied the dissemination of fungal species in the Milan metro, identifying species typical of the external environment and their correlation with the internal environment. They identified the presence of *Cladosporium*, *Penicillium*, *Epicoccum* and *Alternaria* in the external environment, and, internally, the possibilities of spore diffusion of these same species, led to the development of the same genera.

Milanesia et al. [12] identified signs of deterioration in three regions of an 18th-century fresco in the Santissima Annunziata Church in Siena, Italy. In addition to identifying the composition of the fragments of the fresco by scanning electron microscopy, part of the fragments was incubated in suitable culture media for the growth of heterotrophic aerobic microorganisms, identifying, after incubation, strains of *Kocuria erythromyxa* and *Sphingomonas echinoides*, by sequencing of DNA. These microorganisms grew rapidly in a mineral medium free from a carbon source, with visible biofilm formation of a deteriorating nature.

Portugal et al. [13] used molecular biology techniques to elucidate fungal morphology in order to assess the infection of historical documents. The researchers identified a wide diversity of fungi on all types of papers. Fourteen fungal genera were identified, the most frequent being *Cladosporium*, *Penicillium* and *Aspergillus*, and the least abundant of the genera *Alternaria*, *Botrytis*, *Chaetomium*, *Chromelosporium*, *Epicoccum*, *Phlebiopsis* and *Toxicocladosporium*. The authors emphasize that, among the genera found, in all types of papers there was the presence of *Cladosporium cladosporioides* and *Penicillium chrysogenum* as the most representative.

Abe [14] identified the occurrence of fungal contamination in materials stored in an art museum, which was monitored using a biological index related to climatic parameters, which gives an indication of the environmental capacity of the fungus to proliferate in that region. In order to determine this index, fungal spores were encapsulated at the site and spore germination, measured by the extent of fungal hyphae, was measured. The predominant *Aspergillus penicillioides* and *Eurotium herbariorum*, are most likely species in that environment.

The main modes of action of microbial species typical of paper collections can be found in Tables 1 and 2.

A series of other microbial populations are reported in the published literature, and in each of them specific microbial groups are identified that are related to the characteristics of the materials where populations grow, as well as to environmental factors that regulate the

proliferation of these populations.. All these works allow us to conclude that microorganisms that colonize building materials or are found in aerial microenvironments are the same that colonize surfaces, including those made up of ligno-cellulosic materials that are part of documents in collections. Thus, for transferring files and book collections between areas under different climate conditions, attention must be paid to the fact that the maintenance of microbiological activity must be carefully evaluated.

Table 1 – Bacteria in archives and libraries

Bacteria	Source	Enzyme/Product	Effect
<i>Acinetobacter</i>	Paper	Protease	Support degradation
	Air	Amilase	
<i>Bacillus</i>	Organic material	Cellulase	Acidification Fiber degradation
	Air	Organic acids	
<i>Cellvibrio</i>	Paper	Cellulase	Acidification
	Textiles	Acetic acid	
<i>Lactobacillus</i>	Organic material	Cellulase	Acidification
		Lactic acid	
<i>Micrococcus</i>	Organic material	Cellulase	Acidification
	Air	Organic acids	
<i>Pseudomonas</i>	Organic material	Protease	Decoloration
		Organic acids	
<i>Staphylococcus</i>	Paper	Lactic and acetic acids	Acidification
	Textiles		
<i>Streptococcus</i>	Paper	Lactic and acetic acids	Acidification
	Textiles		

Based on these information, the present article aims to identify fungal populations present in two different libraries, evaluating atmospheric contamination and also in selected pieces from special collections. Once the



populations present in both cases are known, the use of the gamma irradiation will be used, aiming to evaluate the minimum concentration of radiation capable of preventing the proliferation of fungi in each case.

Table 2 – Fungi in archives and libraries

Fungus	Source	Enzyme/Product	Effect
<i>Alternaria</i>	Organic material Air	Protease Amilase	Decoloration
<i>Aspergillus</i>	Organic material Air	Organic acids	Acidification
<i>Chaetomium</i>	Papel, Cartão	Celullase Organic acids	Decoloration
<i>Cladosporium</i>	Organic material Air	Protease Latic acid	Decoloration Acidification
<i>Fusarium</i>	Organic material Air	Celullase Organic acids	Fiber damage
<i>Mucor</i>	Organic material Air	Protease Organic acids	Decoloration Acidification
<i>Penicillium</i>	Organic material Air	Enzymes Organic acids	Decoloration Acidification
<i>Rhizopus</i>	Organic material Air	Enzymes Organic acids	Decoloration Acidification

<i>Sporotrichum</i>	Paper Air	Cellulase Ligninase	Decoloration Acidification
<i>Trichoderma</i>	Paper Wood	Celulase e ác. Orgânicos	Decoloration Acidification
<i>Verticillium</i>	Paper Textile s	Celulase e ác. Orgânicos	Decoloration Acidification

## II. MATERIALS AND METHODS

### 2.1 Samples collection

The locations selected were: (1) Henrique Morize Library of the Museum of Astronomy and Related Sciences (MAST) and the National Library (BN), both located in the city of Rio de Janeiro, Brazil.

### 2.2 Culture media

The culture medium used for the growth of total fungi was Sabouraud Dextrose with chloramphenicol, an agar recommended for the cultivation of fungi.

The culture medium, as specified above, is a preferential medium for the isolation of fungi and yeasts, since it has satisfactory sources of nitrogen, in addition to a mixture of amino acids due to the presence of meat peptones and casein. The high concentration of dextrose and the acidic pH resulting from the composition of the medium mean that this medium tends to inhibit bacterial growth, in addition to the inhibitory effect chloramphenicol.

The culture medium was dissolved in distilled water at a concentration of 65.0 g/L, autoclaved at 121°C for 20 minutes in a vertical autoclave, and distributed in sterile Petri dishes, in a laminar flow chamber, waiting for solidification after cooling, around 30 minutes. The medium thus prepared and distributed in Petri dishes was stored for a maximum time of 48 hours, proceeding to the collection of samples to evaluate the fungal growth.

### 2.3 Environmental and surface procedures

This phase of the work describes the procedures used to collect environmental and selected books/documents from the two libraries. Two strategies were adopted: (1) Environmental collections: In this case, Petri dishes containing Sabouraud medium were opened and placed in several spaces and the particles were allowed to settle for 1 hour. In this case, it is expected to have an estimate of

aerial fungal populations, potentially contaminating the books; (2) Surface collections (Figure 1). In this case, selected works (in the same spaces where environmental collections were carried out), were separated and subjected to a brief surface “scraping”, to evaluate the possible contamination on the surface of the work(s) resulting from environmental deposition. In this case, after swabbing, the swabs were again swabbed on the surface of Petri dishes containing Sabouraud medium.



Fig. 1: Procedure for surface collection

Samples collected, both in the environment and on the surfaces, were incubated for 7 days at 23 °C. After this period, a photographic record of each plate was carried out, for further identification by Molecular Biology.

### 2.3.1 Henrique Morize Library (MAST)

The collection at the Henrique Morize Library was carried out at the end of 2018, comprising a total of 120 Petri dishes containing Sabouraud medium, distributed as follows: 60 for the general environment, including the Library's sliding shelves, 25 for evaluation of the books in the Collection from the Brazilian Academy of Sciences processed by the MAST team and 35 for books from the same collection not processed by the MAST team.

The purpose of this distribution may indicate the effectiveness of the cleaning process of the works (processing) and also, to verify if samples from the environment have somehow contaminated the works of the collection. Collection points were determined jointly with the Henrique Morize Library team and based mainly on the recent acquisition of the collection of the Brazilian Academy of Sciences by MAST. This collection showed particular interest in the development of the present work, due to the fact that it is a large collection, with a wide documental diversity and because it contains processed (sanitized) and unprocessed books/documents, which could indicate interesting results about the possible fungal contamination. Simultaneously, documents/books from the ABC Collection were selected, to assess if the documents/books of the Collection could bring some

external contamination to the MAST collections, since there was no precise information about its previous condition of storage. Thus, we sought to have a wide range of documents and books so that we could have an accurate diagnosis of previous contamination (Table 3). Table 3 therefore indicates the number and diversity of books and documents that were individually evaluated by surface rubbing with sterile swabs, as previously described.

Table 3: Documents/books selected for surface collection of samples from the ABC Collection

Number of pieces	Type
5 (B1 a B5)*	Reference books
5 (B6 a B10)	Leaflets
5 (B11 a B15)	Thesis
5 (B16 a B20)	History books
5 (B21 a B25)	Regular books
5 (B26 a B30)	Books – Good conservation state
5 (B31 a B35)	Books – Bad conservation state
5 (B36 a B40)	Common books – Good conservation state
5 (B41 a B45)	Common books – Bad conservation state
5 (B46 a B50)	Books – Unconventional languages
5 (B51 a B55)	Periodicals
5 (B56 a B60)	Annals of Congresses

\* Shadowed cells indicate processed (cleaned) books/documents.

### 2.3.2. National Library

Similarly, we tried to use the same methods carried out in the Henrique Morize Library, collecting samples in the environment and in specific works of the National Library. Although the characteristics of location, size, light incidence, among other factors, do not allow a direct comparison between the two libraries, we tried to adopt the same methodology.

The collection at the National Library, carried out in early 2020, is specified in Tables 4 and 5.

Environmental collections were carried out in the area where Common Books and Periodicals were located and also in copies selected by the staff of the National Library. The location of each work is specified and can be easily located in the National Library.

Similarly, samples collected were incubated for fungal growth, isolated and identified.

Table 4: Sampling – Common Books

Common Books – 6 <sup>th</sup> . Floor	
Environment	
1	Bookcase 453 – 1 <sup>st</sup> . Shelf
2	Bookcase 450 - 1 <sup>st</sup> . Shelf
3	Bookcase 446 - 1 <sup>st</sup> . Shelf
4	Bookcase 443 - 1 <sup>st</sup> . Shelf
5	Bookcase 441 – Bookcase (Low)
6	Bookcase 472 - 1 <sup>st</sup> . Bookcase (Up)
7	Bookcase 221 – 2 <sup>nd</sup> . Shelf
8	Bookcase 240 – 3 <sup>rd</sup> . Shelf
9	Bookcase 246 – 3 <sup>rd</sup> . Shelf
10	Bookcase 265 – Bookcase (Low)
11	Bookcase 269 – 2 <sup>nd</sup> . Shelf
12	Bookcase 289 – 1 <sup>st</sup> . Shelf
13	Bookcase 289 – 5 <sup>th</sup> . Shelf
14	Bookcase 302 – 2 <sup>nd</sup> . Shelf
15	Bookcase 297 – 3 <sup>rd</sup> . Shelf
16	Bookcase 313 – 7 <sup>th</sup> . Shelf
17	Bookcases 305 and 316 – Floor
18	Cabinet VI
19	Bookcase 409 – 4 <sup>th</sup> . Shelf
Surface of books/documents	
A	Loc: VI - 289, 5, 17 / Low
B	Loc: VI - 289, 1, 15 / Low
C	Loc: VI - 289, 3, 36 / Up
D	Loc: VI - 302, 2, 85 / Back
E	Loc: VI - 302, 2, 82 / Low

### 2.3.3. Molecular Biology

The extraction of DNA from isolated colonies was done with Quick DNA Fungal/Bacterial Miniprep kit, from ZymoResearch. The polymerase chain reaction was performed to amplify the specific region of DNA (ITS), which is unique to fungi. PCR (polymerase chain reaction) results were obtained by gel electrophoresis and the samples were then evaluated for their sequences. From the results it was possible to identify most of the fungi.

This procedure was adopted for all species isolated in both libraries. Photographic records (macroscopic and microscopic) were only possible for the fungi isolated in the Henrique Morize Library, due to operational reasons. However, this did not prevent the complete identification of fungi from both libraries.

Table 5: Sampling - Periodicals

Periodicals - 4 <sup>th</sup> . Floor	
Environment	
1	Bookcase 19 – 2 <sup>nd</sup> . Shelf
2	Bookcase 21 – 3 <sup>rd</sup> . Shelf
3	Bookcase 48 - 2 <sup>nd</sup> . Shelf
4	Bookcase 46 - 2 <sup>nd</sup> . Shelf
5	Bookcase 98 - 2 <sup>nd</sup> . Shelf
6	Bookcase 92 - 3 <sup>rd</sup> . Shelf
7	Bookcase 150 – 5 <sup>th</sup> . Shelf
8	Bookcase 145 - 3 <sup>rd</sup> . Shelf
9	Bookcase 193 - 2 <sup>nd</sup> . Shelf
10	Bookcase 198 - 3 <sup>rd</sup> . Shelf
11	Bookcase 482 – 1 <sup>st</sup> . Shelf
12	Bookcase 203 – 4 <sup>th</sup> . Shelf
13	Bookcase 211 – 5 <sup>th</sup> . Shelf
14	Bookcase 277 - 2 <sup>nd</sup> . Shelf
15	Bookcase 270 – 4 <sup>th</sup> . Shelf
16	Bookcase 300 - 3 <sup>rd</sup> . Shelf
17	Bookcase 307 - 3 <sup>rd</sup> . Shelf
18	Bookcase 334 - 2 <sup>nd</sup> . Shelf
19	Bookcase 346 - 3 <sup>rd</sup> . Shelf
20	Bookcase 359 – 4 <sup>th</sup> . Shelf
Surface of books/documents	
A	Loc: 4, 019, 03, 14 / Cover – Front
B	Loc: 4, 019, 03, 05 / Cover – Front
C	Loc: 4, 020, 03, 01 / Cover - Back
D	Loc: 4, 020, 03, 15 / Cover – Front
E	Loc: 4, 020, 03, 05 / Cover - Back

### 2.3.4. Irradiation with <sup>137</sup>Cs

Fungi were irradiated in increasing doses, aiming to identify the ideal dose to eliminate the overgrown fungi. Thus, although the procedure was carried out directly on

the Petri dishes where the fungi grew, the same procedure could be applied to the fungi on the surface of the works.

The equipment used was a 19-ton cavity research irradiator (Figure 2). Currently, its sources of  $^{137}\text{Cs}$  with activity of 43.2 KCi provide a maximum dose rate of 1.45  $\text{KGy.h}^{-1}$  inside two rectangular irradiation chambers 68 cm wide, 137 cm long and 20 cm high positioned above and below the plane of the gamma source. The gamma source consists of 28 parallel spaced, double-encapsulated plates containing cesium-137 (Figure 3). A pneumatic system allows not only the access door to be moved, but also the sources, through a control panel. IDQBRN adopts gamma irradiation as a multipurpose technique, with a qualified team dedicated to the application of ionizing radiation in industrial processes, as well as in environmental preservation.



Fig 2: Front view of IDQBRN gamma irradiator

An ascending irradiation time was adopted in the assessment of the threshold concentration for each fungal species. The irradiations were carried out after an incubation period of 14 days and the tests were carried out at the Research and Development Institute of the Army Technological Center (IPD / CTEX), in Guaratiba, Rio de Janeiro.

Petri dishes were placed in groups in the irradiation chamber, occupying the central section of the shelf, with a predefined threshold height of 7 cm, in order to achieve the lowest dose uncertainty. Next, the samples were irradiated with a source of  $^{137}\text{Cs}$  for specific periods of time, as shown in Figure 3.

In order to prevent uncertainty, exposure times were calculated using a computer software developed specifically for this purpose, based on the latest dosimetric charts from the irradiator. The dose range was: 1, 2, 3, 5, 6, 9, 12, 16, 19, 22 and 25  $\text{KGy}$ , with an average uncertainty of  $\pm 5\%$  [15].



Fig. 3: Petri dishes inside the chambre of the irradiator

Immediately after the irradiation sessions, samples were moved to boxes and submitted to analytical tests in the laboratory, in order to monitor the post-radiation fungi viability. This means that after the irradiation procedure, the same samples in a Petri dish were taken back to the laboratory and new transfers were made to freshly prepared culture medium in order to verify the fungal viability after the procedure. This would allow to assess the fungal resistance to the treatment. The post-incubation methodology, after irradiation, was the same as presented previously.

### III. RESULTS AND DISCUSSION

#### 3.1 Fungal growth – Henrique Morize Library

All Petri dishes were placed in a controlled chamber at  $25^{\circ}\text{C}$  for 14 days. The number of Petri dishes with fungi in the collection and in bookcases were substantially large (Figure 4).

Figure 4 shows the most characteristic fungi isolated from environmental collections and selected pieces from the Henrique Morize Library. From Figure 4 it can be seen the occurrence of approximately ten morphological types, regardless of the collection location. This is in accordance to what was intended to be proved: the fact that potential fungal contamination could indicate a cross-contamination of the space on the ABC Collection or vice versa. This isolation also allowed the evaluation of fungal resistance to irradiation, showing a possible variability among the species found.





Fig. 4: Samples from Henrique Morize Library (fungi already isolated)

It is worth mentioning, in this phase of the work, that the selection and isolation of the species was made only by morphological characteristics of the types grown in Petri dishes. There was still no exact information about who these species would be.

Table 6 shows the fungal species identified after isolation and their post-growth macroscopic and microscopic images on Sabouraud Dextrose medium, now based on Molecular Biology techniques.

The identification procedure by Molecular Biology, was carried out in cooperation with the National Institute of Technology (INT) and the main fungi identified are described in Table 7.

Since the samples collected were grouped into morphological groups; the identification presented in Table 7 showed the average occurrence of 15 fungal species, restricted to 9 fungal genera (*Cladosporium*, *Pestalotiopsis*, *Hamigera*, *Pleospora*, *Aspergillus*, *Rhizopus*, *Pleosporales*, *Trichoderma* and *Hypocrea*). These are cosmopolitan fungi, originating from the atmosphere and common in libraries and archives.

Bensch et al. [16] carried out a large study showing the universal occurrence of fungi of the genus *Cladosporium* in climate-controlled environments, showing that in samples collected in Europe, North America, South Africa,

New Zealand and China, the *Cladosporium* genus presents worldwide dissemination. The authors showed the occurrence of 46 species belonging to this genus, all of them documented, 16 of which are new species. The study, however, does not present data about the occurrence of this genus in samples collected in South America, although it is known that its occurrence is also common, for example, in Brazil.

Table 6: Fungi identified in the ABC Collection (MAST)

Classification	Microscopy	Macroscopy
<i>Cladosporium cladosporioides</i>		
<i>Pestalotiopsis sp.</i>		
<i>Hamigera paravellanea</i>		
<i>Rhizopus oryzae</i>		
<i>Aspergillus niger</i>		
<i>Periconia sp.</i>		
<i>Trichoderma longibrachiatum</i>		
<i>Trichoderma viride</i>		
<i>Hypocrea viride</i>		
<i>Hypocrea lixii</i>		

Table 7: Fungi from Henrique Morize Library



Sample	Classification
1	<i>Cladosporium cladosporioides</i>
2	<i>Pestalotiopsis sp.</i>
3	<i>Hamigera paravellanea</i>
4	<i>Pleospora sp.</i>
5	<i>Aspergillus niger</i>
6	<i>Rhizopus oryzae</i>
7	<i>Aspergillus sp.</i>
8	<i>Pleosporeles sp.</i>
9	<i>Aspergillus flavus</i>
10	<i>Trichoderma viride</i>
11	<i>Hypocrea viride</i>
13	<i>Hypocrea lixii</i>
14	<i>Periconia sp.</i>
15	<i>Trichoderma longibrachiatum</i>

Hassan et al. [17] also attest the occurrence of *Cladosporium* in public libraries, comparing the results with the microbial occurrence in internal and external environments of libraries. The authors conclude that the external environment becomes the main source of contamination in libraries, with bacteria resulting from human activities, usually inappropriate handling of pieces. Fungi of the genera *Penicillium*, *Cladosporium* and *Aspergillus* are, respectively, the major contaminants. It is observed that two of the three genera mentioned by the authors were found in the Henrique Morize Library (or in selected pieces from the ABC Collection), confirming the authors' indication.

The *Pestalotiopsis* fungus is normally associated with the degradation of petroleum, and there are no references that indicate its relationship with the degradation of cellulose or its usual atmospheric occurrence. However, recently, Vieto et al. [18] showed its occurrence and cellulolytic activity in a 19th century work of art, thus showing the importance of further studies that can understand the combined effect of fungal consortia in biodeterioration processes.

The same applies to the genera *Hamigera*, *Pleospora* and *Pleosporeles* where no references were found that could explain their occurrence in libraries or archives. It should be noted that it is not always possible to explain or correlate the occurrence of microbial species in certain environments, which may be due to external factors that cannot always be explained or detected.

Zyska [19] proved the wide occurrence of microorganisms in library spaces, exemplifying the wide diversity found. The author reports the presence of 84 fungal genera isolated in a period of 60 years from materials from libraries and archives (books, articles, papyrus, glues, paints, magnetic tapes, wood, etc.). The author reports that 43 genera of fungi were isolated from the air, and each fungus occurred at least 3 times. It should be noted that the scope of the research included surveys carried out for more than 60 years. In the limited space of time for the development of this present work, it was not possible to collect samples to confirm the occurrence of the species, which may be momentarily in the environment, not being characteristic species of that space.

Literature presents several articles that correlate the occurrence of the *Rhizopus* genus with the biodegradation of cultural heritage, particularly those made of cellulosic materials. Cappitelli et al. [20] carried out an extensive study on the biodeterioration of synthetic polymers by microorganisms of the genus *Rhizopus*, concluding that most synthetic polymers are susceptible to fungal attack, alerting to the need to fill a gap in the study of this type of biodeterioration. Pinheiro and Sequeira [21] also studied biodeterioration of cultural heritage by microorganisms of this fungal genus.

Beata [22] also reports the occurrence of the *Rhizopus* related to the biodeterioration of cultural heritage, particularly due to its cellulolytic characteristic, with emphasis on advanced proteomics techniques for identification.

The same observation was made for *Trichoderma* genus, a fungus with wide occurrence, particularly in archives and libraries. Jia et al. [23] suggest antifungal substances for the preservation of cellulosic materials against the action of fungi of the genus *Trichoderma*. Zhang et al. [24] report the biodegradation of leather (eg, book covers) and papyrus by microorganisms of this genus.

Finally, the genus *Hypocrea* is reported in the literature as being responsible for the degradation of photographic materials and also as producers of pigments during colonization on papers [25-26].

Considering now the results from the ABC Collection books, the Henrique Morize library (MAST) showed the presence of fungal growth until 16 kGy for the genera *Rhizopus*, *Periconia* and *Trichoderma*, thus showing that these three genera are the most resistant to treatment with gamma radiation. Additional fungal growth in the same samples was not observed at 19 kGy, and radiation-induced fungal inactivation was therefore assumed. The

irradiation curve for the samples most resistant to gamma radiation treatment can be found in Figure 5.

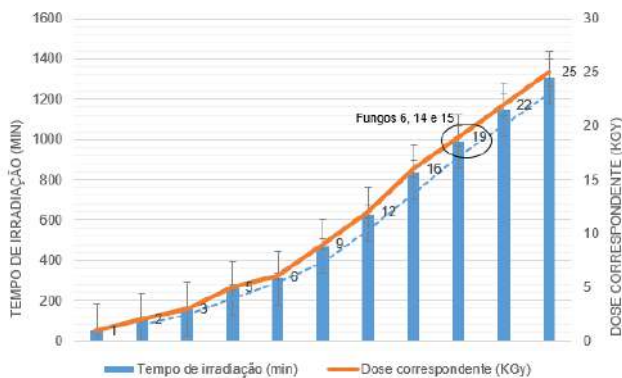


Fig. 5: Irradiation up to 16 kGy

In the work by Kalawate and Mehetre [27], the authors studied fungal resistance to gamma radiation on wood. Doses up to 10 kGy were efficient in eliminating fungi, although they studied doses up to 50 kGy. An important fact reported by the authors is that dosages up to 10 kGy did not compromise the cellulosic structure, a fact confirmed by scanning electron microscopy.

Maity et al. [28] studied the effect of gamma radiation on fungi of *Trichoderma* and *Aspergillus* genera, both also found in the present study. They found that small doses of Cobalt inhibited fungal germination, with the elimination of species at 2.5 kGy. The authors, however, worked with fungi present in seeds, a matrix quite different from the one studied in the present work.

Linh et al. [29] studied the effect of gamma radiation on fungi that colonize Japanese paper. The objective of that work was to evaluate the effect of gamma radiation on fungi of the genera *Aspergillus*, *Penicillium* and *Cladosporium*, also evaluating the effect of radiation on the mechanical structure of the paper. In order to achieve this goal, Japanese paper samples were moistened and contaminated with the aforementioned fungi. The effects of gamma treatment were measured at different stages of fungal growth. It was observed that doses around 10 kGy already affected the structure of the paper, as well as its color.

### 3.2 Fungal growth – National Library

Observing the results obtained from the samples from the National Library, with the morphological types found in the Henrique Morize Library, it can be predicted that, at least macroscopically, the morphological types seem distinct (Figure 6). This is a relevant fact, since it is to be expected that, due to the characteristics of location, ventilation, temperature control and relative air humidity,

among others, different morphological types can occur in different spaces.



Fig. 6: Samples from National Library

Culturable fungi isolated were identified using Molecular Biology techniques and the list of fungi is shown below (Table 8).

Since these fungi were isolated from another space, from another library, it is possible to observe the variability of genera/species in relation to those previously identified in the Henrique Morize Library. The classic environmental contaminants, present almost universally, were also found here: *Penicillium*, *Aspergillus* and *Fusarium*.

What draws attention in Table 8 is the presence of unusual species, probably due to factors such as: incidence of light, chemical contamination due to the central location of the library and intense movement of personnel that can contribute to the movement of exogenous organisms to the internal space. For example, about the species *Diaphorte paranensis*, no mention was found in the published literature. Another example is the fungus *Trametes*, associated with white rot.

Table 8: Culturable fungi from National Library

Classification
<i>Penicillium citrinum</i>
<i>Simplicillium obclavatum</i>
<i>Aspergillus versicolor</i>
<i>Fusarium lichenicola</i>
<i>Diaphorte paranensis</i>

<i>Trametes vilosa</i>
<i>Arxotrichum</i> sp.
<i>Aspergillus calidoutus</i>
<i>Eutypella scoparia</i>
<i>Grammothele subargentea</i>
<i>Peniophora albobadia</i>
<i>Phebia floridensis</i>
<i>Talaromyces amestokiae</i>
<i>Penicillium resedanum</i>

Fungi of the *Arxotrichum* genus are usually endophytic, associated with the inner parts of certain plants [30]. Fungi of the genus *Eutypella* are usually associated with sediments and in high depth environments [31].

Unusual occurrences, such as *Grammothele*, *Peniophora*, *Phebia* and *Talaromyces* were found. This fact does not invalidate the procedures adopted in the present work, since this diversity of species can indicate the need for a continuous monitoring, since a seasonal change can alter the environmental microflora.

Table 9 presents the distribution of fungi. Given the presence of so many isolated species, some repeated at various points, the use of gamma radiation was used to eliminate them.

All fungi showed viability up to 16 kGy, a result different from that observed for the Henrique Morize Library, where 3 fungal species were resistant up to 19 kGy radiation.

It is known that gamma radiation destroys the DNA structure of cells inhibiting the growth of fungi completely once they lose their functions. Incomplete inhibition can cause only minor damage to cells. High-energy irradiation directly impacts the DNA of living organisms, inducing cross-links and other changes that render the organism unable to grow or reproduce. When these rays interact with water molecules in an organism, they generate transient free radicals that can cause DNA damage.

These results corroborate what was previously reported: the variability of species, their origins, growth cycles and environmental conditions can contribute to a large amount of fungi capable of resisting even to high doses of radiation.

Table 9: Fungal viability after gamma irradiation

Fungi <sup>1</sup>	1 to 16kGy	19kGy	22kGy	25kGy
<i>Penicillium citrinum</i>	✓	X	X	X
<i>Simplicillium obclavatum</i>	✓	X	X	X
<i>Aspergillus versicolor</i>	✓	X	X	X
<i>Fusarium lichenicola</i>	✓	X	X	X
<i>Diaphorte paranensis</i>	✓	X	X	X
<i>Trametes vilosa</i>	✓	X	X	X
<i>Arxotrichum</i> sp.	✓	X	X	X
<i>Aspergillus calidoutus</i>	✓	X	X	X
<i>Eutypella scoparia</i>	✓	X	X	X
<i>Grammothele subargentea</i>	✓	X	X	X
<i>Peniophora albobadia</i>	✓	X	X	X
<i>Phebia floridensis</i>	✓	X	X	X
<i>Talaromyces amestokiae</i>	✓	X	X	X
<i>Penicillium resedanum</i>	✓	X	X	X

✓ Viable cells; X: Inactivated cells

#### IV. CONCLUSIONS

- Procedures adopted made it possible to identify the fungi present in the environment and in selected works from the Collection of the Brazilian Academy of Sciences. A diversity of fungi was observed, apparently compatible with the size of the library, with the occurrence of cosmopolitan fungi.

- In the National Library, where the Common Books and Periodicals are located, the fungal diversity was much greater than that found in the Henrique Morize Library, showing consistency with the size of the spaces.

- Many identified species are not common in archives and libraries, requiring periodic sampling in the same spaces in order to verify the prevalence of the species.

- It cannot be said that one library is more contaminated than the other; it can be said that the levels of fungal occurrence are compatible with the dimensions of the spaces and with the existence of air conditioning and relative humidity control systems present in the spaces.

- Molecular Biology techniques employed allowed the identification of unusual fungal species, which may not have relevance in the processes of microbiological degradation of cellulosic materials.

- Three fungal species isolated from the Henrique Morize Library (ABC Collection) were resistant to treatment with  $^{137}\text{Cs}$  up to a dose of 19 kGy, a value that, according to the literature, already compromises the cellulose structure. Only doses above 19kGy were effective.

- Despite the greater diversity of species found in the spaces of the National Library, all were sensitive to treatment with  $^{137}\text{Cs}$  up to a dose of 16 kGy.

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# Digital Exclusion: Nuances of a phenomenon which causes inequalities and compromises civic engagement in information society

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**Keywords** — Digital divide, digital exclusion,  
digital inclusion, network society

**Abstract** — Digital exclusion is a phenomenon which nearly impacts all sectors of society, causes inequalities, compromises civic engagement networks and that may lead to social exclusion. This work proposes a debate about the research conducted by Celestino & Valente (2022) on digital exclusion, and aims to identify its nuances within a time period of two decades (2000-2021), as well as its involvements in social, cultural and democratic issues. The phenomenon of digital exclusion has been researched in an holistic approach and geared towards certain groups and specific contexts, but the infrastructural issue is still a major factor in the development of policies and projects for digital inclusion.

## I. INTRODUCTION

The concept of digital exclusion has developed mainly due to some publications issued from the 2000's onwards, when awareness and inclusion of variables related to technological, social and economic contexts as well as spatial aspects and individual factors led to a cycle of cause and effect which directly impacted this problem and vice versa. A synthesis of concepts points that around the 2000's, one had already realized that digital exclusion was not necessarily connected to the sole factor of having digital equipments, but rather to the equity that should have been sought after in new production models and network economy (Schwartz, 2000, quoted by Lucas, 2002).

Currently, the concept of digital exclusion indicates the impossibility for an individual to make use of the ways of social interaction of the new world (Da Silva, 2021), since a number of daily activities have migrated to the virtual environment, mainly during the pandemic of Covid-19, as

we saw on the fields of Education (Coleman, 2020) and Work (Kuc-Czarnecka, 2020).

It's essential to quote Lévy (2010), for whom digital exclusion is a supplementary factor of inequalities among individuals and communities, both locally and globally. This came as a result of people realizing after some time that digital exclusion might be related to: socioeconomic differences (Lucas, 2002); lack of access to Information and Communication Technologies (ICT's) and its benefits (Pires, 2002; De Almeida et al., 2005; Grossi et al., 2013); the impossibility of cultural expression and individual identity (Rosa, 2017; Fadanelli & Porto, 2020); inequality of resources and structural issues (Knop, 2017); geographical issues (Coral, 2015); and, mainly, social exclusion (Dos Santos, 2003; Bernardes, 2010; Ragnedda & Ruiu, 2016; Helsper, 2017; Fadanelli & Porto, 2020).

In a sense, one can consider digital exclusion as a phenomenon which impacts nearly all sectors of life, bringing about more inequality and also leading to social exclusion. Bearing this in mind, it's necessary that the use

of digital technologies and networks provides a channel to express the rights of digital citizenship, as assumed by Tavares & De Souza Vieira (2020).

According to De Souza (2010, p. 271), In the beginning of the 21st century, some technology enthusiasts, like Strover (2003) and Compaine (2001), have declared digital exclusion as outdated, or at least, nearly extinct. Around 20 years after those statements from the authors, the actual scientific literature and context prove that such a phenomenon has acquired a chronic behavior, but it can (and should) be treated, specially in minor spheres, by actions able to reach multiple directions, causes and tendencies involved on this subject, mostly the ones related to Education, Employment and Social Inequality.

This research is inside a context of accelerated process of Digital Transformation and Innovation, in which there are plenty of services, governmental included, that have been offered in the digital format. Such an act has been favored by social isolation resulting from the pandemic of the new Coronavirus (SARS-CoV-2), which causes the disease of Covid-19. As an example, distance learning has spread and been accepted as well as home office and migration of social life to the context of a network society, as previewed by Castells (1999), Jan Van Dijk (2006) and Mance (2012).

Van Dijk (2006, p. 02) states that networks are considered the “nervous system” of the present society. The reason for such is that connections surpass geographical barriers and interconnectivity achieves a potential higher than of traditional media. Within this context, there exists a better distribution of knowledge and information in both synchronous and asynchronous ways, but at the same time the access comes from an unequal engagement of society.

Given the possibility of multilateral communication, interpersonal relations have known an increase both in quality and quantity. Therefore, these same relations have been virtualized, according to the statement of Hjarvard (2012), for whom the media can't be separated from a vast array of institutions. For Hjarvard (2012), mediatization is equivalent to virtualization of social interactions, which are no longer real as soon as they migrate to digital and social media. As a consequence, in contemporary society, media can't be regarded as separate from culture. On the contrary, they mingle and become one thing, as an integral part of a number of diverse institutions.

This is what has been observed with the tendency of migration from communication face to face to, as an instance, communication done through instant messages applications such as WhatsApp; as well as from presential

videoconferences to platforms like Zoom; from physical stores shopping to virtual apps like iFood, where you can buy since food to pharmacy and pet products; or even from CV's given in hands to LinkedIn, where one can show his/her talent, build a network, find courses or even get a job. Doing this, it's possible to perceive that virtual relations have brought agility and amplified the possibilities of social growth, becoming part of our actual culture, which was called by Lévy (2010) Cyberculture. As assumed by Tavares and De Souza Vieira (2021, p. 296):

This new format of network society, although interconnects all people, either directly or indirectly, did not bring about a solution to social exclusion (something it can't really resolve given the complexity of the causes involved on this exclusion), but brought about visibility to another form of exclusion, the digital one, that has to be confronted by State and society. To overcome digital exclusion is crucial for the use of the expansion of digital citizenship, also known as Cybercitizenship, as an instrument for the strengthening and increase of political engagement, specially in the field of civic engagement.

Therefore, as widely seen in the scientific literature, an individual who does not have access to mediated or mediatized relations, whether due to availability or lack of resources to acquire digital technologies (Lucas, 2002; Knop, 2017), access to the Internet (Pires, 2002; De Almeida et al., 2005; Grossi et al., 2013), or even the skills, competencies or limiting factors to use such technologies (Padilla-Góngora et al., 2017; Kalenda & Kowaliková, 2020; Kwiatkowska & Slórzewska-Amberg, 2020), experiences the process of digital exclusion.

The fragility of network participation may perpetuate the feeling of a group subduing another one, causing a socio-digital stratification. At this point, Bernardes (2010), in a reading of Martins (1997) and Demo (1998), agrees with the authors when they state that there is no absolute social exclusion, but rather a weakness in the participation of the poorest strata, due to the weakening of social bonds. In addition, the excluded individual loses his/her visibility which is, according to Thompson (2008, 2018), one of the main factors resulting from mediation of reality.

As a result, the lack of participation in networks can express a certain predominance of one group over another, impacting, generically and comprehensively, democratic aspects in the digital sphere and, consequently, real. In this sense, it is essential to study the impacts that digital exclusion may have on society as a whole, since digital inequalities reflect social inequality and marginalization (Knop, 2017).

The main objective of this work was to expand the research of Celestino & Valente (2022) regarding digital exclusion. We also proposed an analysis and discussion of the authors' conclusions, so that we identify the nuances of digital exclusion within the proposed time period, thus establishing the understanding of the problem over time, as well as its correlation with different social issues.

As guidelines for this research, we have raised three questions: 1) How has the concept of digital exclusion evolved or adapted since the year 2000? 2nd) What can be said of the relation between digital exclusion and social problems? 3rd) What are the possible negative impacts suffered by digitally excluded citizens nowadays?

The work by Celestino & Valente (2022) consists in an integrative literature review, which is a methodology that allows the careful and correlated grouping of works from different areas, as described by Cooper & Hedges (2009) and Greenhalg et al., (2005). The initial research by Celestino & Valente (2022) was restricted only to articles, published in Portuguese, English or Spanish in the period from 2000 to 2021, being excluded, at this stage, duplicated materials in databases or in other formats, such as: books, book chapters, simple or expanded abstracts, slides, posters and texts without indication of the place of publication.

Initially, the selected databases were: SciELO, DOAJ, REDIB, DIALNET and SCOPUS. It was considered that, despite being works originating from indexed databases, the sample could be small and limit the understanding of the topic, so the search was expanded to Google Scholar. There were selected articles from indexed journals with at least one area evaluated with Qualis/CAPES A1 to B2, or whose methodological procedures had been clear and defined resulting in a sample of 19 articles.

In order to broaden the discussion and corroborate the findings of the sample, we carried out an exploratory research. The analysis of the texts sought to cover aspects such as: a topic of intersection with the digital exclusion theme; present time technological and social contexts; objective and perspective of the work.

The sample of works, data and evidence presented by Celestino & Valente (2022), comprises the following authors: Mattos (2003), Cysne et al., (2005), Sorj & Guedes (2005), Sorj & Remold (2005), Bernardes (2010), De Souza (2010), Ehlerst & Bassani (2013), Grossi et al., (2013), Cruz-Cunha et al., (2014), Marques (2014), De Campos Pinheiro (2014), Godoi e Silva et al., (2017), Knop (2017), Greer et al., (2019), Kwiatkowska & Skórzewska-Amberg (2019), Faure et al., (2020), Kalenda & Kowalikowá (2020), Dos Santos et al., (2020) and Tavares & De Souza Vieira (2020).

## II. COMPLEMENTARY RESEARCH

In order to “analyze and compare Internet users on a global scale, the Internet World Stats (IWS) takes a broad definition as a reference and defines an Internet user as anyone currently able to use the Internet” (IWS, 2022). From this standpoint, according to the system, there were 160,010,801 Internet users in Brazil in May 2021, which corresponds to a rate of 74.8% active users, according to IWS; approximately 257,814,274 mobile phone subscriptions as of December 15, and about 151,300,000 Facebook users as of March 2021, representing 70.7% of users.

In 2003, The Committee for the Democratization of Information Technology (CDI) launched the Digital Exclusion Map (of Brazil), prepared by the Social Policies Center (CPS) of the Fundação Getúlio Vargas (FGV), under the coordination of Neri (2003). The objective of the project was to analyze public and private digital inclusion actions, tracing a relationship between social profile and ICT's, afterwards comparing it with the hunger map in Brazil. Besides that other aspects were taken into account such as education, employment and business.

The composition of the data shown on the map was composed based on sources such as: National Household Sample Survey (PNAD/IBGE), Living Standards Survey (PPV/IBGE) and Living Conditions Survey (PCV/SEADE), among others. Also, on administrative records and research conducted in establishments, such as the Ministry of Labor and Employment (RAIS and CAGED), Industrial Research of Technological Innovation (PINTEC/IBGE) and the United Nations (UN).

In the Map of Digital Exclusion (Neri, 2003), exclusive social groups were delimited, with emphasis on racial and gender characteristics and incidence of disabilities, among others, and the government, school, employment, business and households were identified as channels of inclusion. The relationship between income and digital inclusion can be seen in the following statements of the project: Poor people need, above all, opportunity. Opportunities today are represented by the possession of assets linked to information technology” and the long-term impact of income transfers as insurance and social leverage is comparable to that of asset transfers. Digital Inclusion leverages the effects of these policies (Neri, 2003, p.15).

This multifaceted view of digital exclusion was dismembered by the scientific literature of the following years, which reinforced the channels of digital inclusion as valid and important for people with low economic status and social vulnerability (Grossi et al., 2013). Some data from the Continuous National Household Sample Survey

(PNAD Contínua), in the fourth half of 2019, carried out by the Automatic Recovery System (SIDRA), of the Brazilian Institute of Geostatistics (IBGE, 2022), on a total of 71,127 Brazilian households, pointed out that: 1) on the existence of a PC or Tablet in the household: PC's in 41.4% of households; Tablets, in 11.6%; and both PC and Tablet in 9.3%; 2) on the existence of a mobile phone at home: 94.4% had a mobile phone, of which 96% were in urban areas and 84.3% in rural areas; in addition, in 4% of the urban region there was no mobile phone, as well as in 15.7% of the rural region; 3) on internet use: there was internet access in 87.4% of households – 91.6% in urban areas and 61.6% in rural areas; in addition, there was no use of the internet in 12.6% of the households, among which 8.4% were in the urban area and 38.4% in the rural area; 4) on the equipment used to access the internet – PC: 45.1%, 47.9% in urban areas and 19% in rural areas; mobile phone: 99.6%, this total being from both urban and rural areas; television – 32.7%, 34.9% in urban areas and 12.9% in rural areas.

The Executive Summary ICT Households, prepared by CETIC.BR, for the year 2020, which analyzed digital environments during the first year of the pandemic, showed that the migration of activities to the digital environment caused the demand for broadband internet at home. According to survey data, in 2020 home internet access reached 83%, representing an increase of 12 points over the previous year. As for the use of the internet, 81% of the Brazilian population had access, with an increase of 7% compared to the previous year. According to the report, individuals aged 10 and over were considered, and the factor that most prevented access to internet services was cost (Pesquisa..., 2020).

Also according to the report (Pesquisa..., 2020, p. 05), it was identified 28.8 million households with Internet and without a computer; 676 thousand households with a computer and without Internet; 33 million households with computers and Internet; and 11.8 million households without computers and without Internet. Regarding the intention of use, the report points out that the search for websites with government services increased from 28% to 42%; 45% of usage was for school purposes, increased online course offerings and increased self-study.

At this point, it is worth mentioning what Sorj & Guedes (2005, p. 103) state, for whom studies concerning digital exclusion must overcome the simple and structural barrier of having equipment able to access the internet. On the other hand, Wang et al. (2021) have shown that urbanization based on ICT's, intrinsically related to infrastructural issues, is of great importance for the reduction of digital exclusion.

In light of all the above, due to the relationship between digital exclusion and a number of social issues, it is important to quote the "Sustainable Development Goals in Brazil" proposed for the 2030 Agenda of the United Nations Brazil (Nações Unidas Brasil, 2022) and addressed in Celestino & Valente (2022), highlighting, among them: 3) health and well-being, in guaranteeing access and quality for all ages; 4) education and quality, in the guarantee of inclusive and equitable education, with lifelong opportunities; 5) gender equality, with an emphasis on women's empowerment; 8) decent work and economic growth, through inclusive and sustainable growth; 9) industry, innovation and infrastructure, with increased access to ICT's and universal internet provision at affordable prices; and 10) reduction of inequalities, with the promotion of social, economic and political inclusion for all.

In relation to education, the Federal Constitution, in its art. 205 (Senado Federal, 1998), states that education is a right for all people and a duty of the State and the family, [which] will be promoted and encouraged with the collaboration of society, aiming at the full development of the person, their preparation for the exercise of citizenship and their qualification for work. Digital networks and media can act as means for the development of this collaborative integration of society, due to their potential to mediate interactions between/for all.

From the perspective that individual issues are related to social and temporal contexts, there may be an advance in research on digital exclusion if we consider that objective inequalities lead to relative exclusion and that digitally excluded individuals are aware of levels of engagement and the value of connecting with family and relatives, as well as interest groups (Heslper, 2017). In this regard, Heslper (2017) indicates the need to look at social inequalities beyond digital ones, since the axis of the issue of digital inequality lies in other adjacent factors. An in-depth look at inequalities can be seen in Da Costa (2012), where he covers a number of theoretical aspects of global and objective inequalities, among others.

Berrío-Zapata et al. (2020) has identified that digital exclusion linked to gender has not been researched in Latin America and claimed that the exclusion of women is probably linked to the model of patriarchal society that has dragged on over the years, creating a disadvantage for them in face of men in different sectors of society. In Cysne et al. (2007), the probability of a male individual accessing the internet was 32.1% higher than a woman. The United Nations University report (Sey & Hafkin, 2019) presented a study around the world to identify the gaps in internet access and digital technologies between men and women and, among the various results, it is



possible to identify that, in countries like Brazil, Costa Rica, Colombia, Jamaica and Paraguay, women use cell phones more than men.

### III. CATEGORIES IMPACTED BY DIGITAL EXCLUSION

#### Infrastructural aspects

In relation to one of the first works analyzed - Cysne et al. (2005) -, we realized a development on the approach of the subject, which has unfolded from the inferences of structural causes within a holistic view, considering aspects such as age (Padilla-Góngora et al., 2017; Faure et al., 2020), gender (Berrío-Zapata et al., 2020), mental capacity (Greer et al., 2019), inequalities (Helsper, 2017) and network relationships and interactions that occur in the construction of Cyberculture (Lévy, 2010).

The look at digital exclusion from the infrastructural point of view, taking into account the possession of electronic equipment or internet access, may be primitive, according to Sorj & Guedes (2005), however, it should not be underestimated. The structure is the basis for the development of digital inclusion projects and policies, such as the implementation of telecenters, as seen in the works of Sorj & Remodl (2005) and Grossi et al. (2013). As seen further in Wang et al. (2021), infrastructure needs to be considered as an aspect of urban development, and should be the responsibility of the government, due to its importance and relevance in promoting digital inclusion.

Considering that there was an increase in the demand for broadband internet during the pandemic and that people with fewer resources found barriers to adapt to this reality and that mediated or mediated interactions and relationships strengthen during periods of isolation and social distancing, it is possible to infer that those individuals who did not obtain access to internet in order to remain engaged faced a triple exclusion, which includes: the social sphere, compromised at some point by the lack of communication; the technological sphere, given the social inequality; and the interactionist, mediated by the media or digital networks.

As interactions took place, for the most part, by digital means, it is considered that the cell phone has been the great ally of users to stay connected to digital life, primarily because, according to data already presented by IBGE (2022), only 4% of the households did not have a cell phone and, secondly, because the mobile phone (94.4%) exceeded the number of computers (41.4%) in the household. In addition, in 99.6% of households, internet access was via cell phones.

In this regard, we corroborate the idea of Wang et al. (2021), that mobile phones are an essential tool in the development of policies and projects to reduce digital exclusion, and we would like to mention the work of Banks (2013), in which the cell phone was used in an action to fight poverty in a community in Africa that did not have internet.

#### Demography

In the first works of the sample selected by Celestino & Valente (2022) (19 articles), we highlight Mattos (2003) and Cysne et al. (2005), in which the impacts of ICT on economic, social and cultural issues were observed at the global level. The digital favoring of urban centers and groups of White, Asian or people with consolidated work was evident. This, in itself, indicates the beginning of a succession of egalitarian problems and events that were built, dragged and perpetuated over the analyzed time frame. On the other hand, an optimistic result was shown in the Survey on the use of Information and Communication Technologies in Brazilian households (Pesquisa..., 2020), in which 67% of users with internet access through smartphones were black women, which indicates that changes are possible and may shed light on the discussions by Berrío-Zapata et al. (2020) on the digital exclusion by gender.

Furthermore, if we compare the results of Sorj & Guedes (2005) with the United Nations University report (Sey & Hafkin, 2019), in which there are countries where women have accessed the internet more than men — and that, as suggested by Lévy (2010), this is a trend analysis, which indicates a change in social-technical behavior — we will have a clear perception that it is possible to narrow the issues of digital exclusion, unless with regard to issues concerning access.

For Berrío-Zapata et al. (2020), gender inequality is not a factor of interest in research on digital exclusion, and the authors' point of view requires attention. A publication on the social media LinkedIn, the most popular in terms of professional careers, pointed out that it still prevails over jobs that are on the rise (LinkedIn, 2022), which certainly indicates that the topic should be researched and discussed with more interest by companies and for all of society. For Sorj & Guedes (2005), digital exclusion is proportional to age.

This is an issue, however, that needs to be analyzed according to the characteristics of each group. If, on the one hand, children are the most excluded (Sorj & Guedes, 2005), on the other hand, the elderly are also excluded (Padilla-Góngora et al., 2017; Faure et al., 2020), given the lack skills or even age limitations. On the other hand,



Vitorino et al. (2019) demonstrated that it is possible to have good results with the use of digital technologies with the elderly, and also, according to Grishchenko (2020), they have become increasingly common to this profile of people.

It is worth mentioning that, despite being grouped in the “age” variable, the elderly can be considered more digitally excluded for reasons related to other factors, such as loss of cognitive capacity or neurodegenerative diseases, and children, due to lack of digital literacy or literacy, in addition to other factors, which, for us, leads to the need to subdivide the categories for a more detailed study.

### **Education, information skills and competences appropriation**

With the beginning of the pandemic, education migrated to the digital context with remote teaching strategies, which increased digital exclusion, due to structural issues, as many students used the internet in schools. The literature has shown that the internet is used as a research source by many students (De Campos Pinheiro, 2014), greatly influencing their school averages. It was also evident the need and importance of teacher training for the use of ICT's (Ehlert & Bassani, 2013) and that teacher's digital exclusion may occur due to lack of mandatory use of digital technologies and excessive bureaucratization (Godoi e Silva et al., 2017).

The discussion is valid that having a device with internet access, but without a basic education, which has developed the minimum of informational skills, with the direction for the appropriate and effective use of digital technologies, can result in precarious inclusion, given that in Bernardes (2010) or it may still not be enough to solve the problem of digital inclusion, considering the skills and abilities necessary to exploit its resources.

It was also evident the relationship between education and the development of digital skills and abilities for the placement of the individual in the job market, increasing the possibilities of individual and collective growth, mainly associated with the impacts of digital exclusion in a socio-ecological model of sustainability (Eizenberg & Jabareen, 2017; Kalenda and Kowalikow , 2020).

When it comes to competence in the use of information technologies, much more is expected than simply knowing how to browse Internet pages or exchange messages. Belluzzo (2014, 2017) expands and explores the concept of competencies with the use of the word ‘CoInfo’, which relates to the applicability of information in real life in different contexts. For the author (2017, p. 62), CoInfo is

the one that enables people to deal with all sources of information, in the sense of organizing, filtering and selecting what is really important for decision-making in the organizational environment.

Thus, it is understood and expected that the individual can use digital technologies to access content such as training courses, curriculum banks, to apply for a vacancy, as well as to develop culturally by reading ebooks, articles and texts. And, here, it is worth mentioning that it is important that he knows how to choose quality sources, find out about the cultural program of his city, the news, as well as develop a social cycle.

The construction of competences is largely linked to education, and occurs throughout life (Belluzzo, 2017). The studies by Faure et al. (2020) on autonomy throughout life pointed out that learning can change its path and have different impacts and that individuals need access and skills to use technological tools. In this regard, Belluzzo (2014) states that learning must include the development of social and creative skills, in addition to equal opportunities for the inclusion of individuals.

The individual who does not have access to networks has their citizenship participation compromised (Tavares & De Souza Vieira, 2020), by losing the opportunity to actively participate in the new forms of interaction in the current world (Da Silva, 2021). It can be inferred that the digital exclusion poses a challenge to the development of society as a whole, especially when it comes to the view of the socioecological model, whose individual role affects the whole (Eizenberg & Jabareen, 2017; Kalenda & Kowalikow , 2020).

In the context of Education, the study by Marcial (1999) points out that competences are developed according to the technological context and that students in the digital age have appropriated the tools and their use for communication and the selection of relevant information. For the author, competencies go through a process that involves understanding and the difference between the structure of information and knowledge. Therefore, it is necessary to ask a quality question, in order to define a good search strategy; know what you are looking for, identify the best sources and locate different resources; know how to understand, interpret and communicate their findings clearly, among others. In the current context, this is extremely important and relevant, given the exorbitant amount of information available on the internet.

### **Spatial and geographic**

Regarding the spatial issue, the digital exclusion can occur anywhere (Bernardes, 2010), especially in isolated

areas, such as rural areas. This points out that, despite several variables that permeate the theme of digital exclusion, infrastructure is a key factor for all other variables to be measured. In line with this, the 2019 data from the IBGE (IBGE, 2022) reinforced the disadvantaged position of rural areas, in which, among the 87.4% of households with internet availability, 61.6% were from the rural area, while 91.6% were from urban areas; and among the 12.6% who did not have access to the Internet, 8.4% were from urban areas and 38.4% from rural areas.

For Saleminck (2016), the concept that social exclusion leads to immediate digital exclusion needs to be revised, as it is possible to only partially agree with this idea, since individuals who inhabit a certain community, as in the case of gypsy-travelers, can be, on the one hand, excluded from the society that surrounds them, but, at the same time, they are not necessarily digitally excluded. The author carried out a study in which he involved interviews and observations of Roma groups in the Netherlands, and in it he identified that Roma (gypsy-travelers) are digitally engaged, despite their social exclusion and marginalization and low digital literacy.

Saleminck (2016) pointed out that the fact that gypsy-travelers often have nomadic habits and are in different places did not hinder the digital engagement of this group of individuals. Thus, it is inferred that the spatial and geographic issue needs an analysis related to the social group in question. In this sense, one can also cite the studies by Sorj & Guedes (2005) and Sorj & Remold (2005) on digital technologies in the favelas of Rio de Janeiro, which, despite being, in a way, 'excluded' from society, they are not necessarily digitally excluded areas — they may suffer a certain aggravation of the digital exclusion due to local factors, mainly related to economic power, but not necessarily because they are close to or inserted in urban centers.

### **Intrapersonal characteristics**

In recent literature, a concern has been identified that goes beyond infrastructural issues, and it has sought to establish a correlation between the digital exclusion and more quantitative and qualitative aspects, as suggested by Sorj & Remold (2005), such as disabilities and dependence of the elderly (Cruz -Cunha et al., 2014; Kwiatkowska and Skórzewska-Amberg, 2019), individuals with mental health problems (Greer et al., 2019) and the digital exclusion influenced by lifelong changes (Faure et al., 2020).

Regarding the elderly, such limitations are usually caused by factors linked to age, such as memory loss, motor coordination or loss of visual acuity, in addition to low literacy in digital technologies, considering that these

are more common in recent generations. The lack of skills to use digital technologies leads to dependence on a third person to use them, as seen in Cruz-Cunha et al. (2014), in a municipality in northern Portugal, and Kwiatkowska and Skórzewska-Amberg (2019), in Poland.

On the other hand, the work of Vitorino Righetti & Packer (2019) shows that it is possible to work with assistive technologies to promote the inclusion of the elderly, despite the various limitations of this group of individuals. The study by Grishchenko (2020), carried out in Russia, pointed out that there is a reduction in the digital exclusion, especially for the elderly, for whom digital technologies have been increasingly common, in addition to a matter of cost reduction of digital technology equipment, access to which is related to factors such as health and employability.

This, in a way, resolves one of the structural issues and opens the way for a qualitative treatment of the issue, thus proving the thinking of Lévy (2010), for whom there was a tendency to reduce the digital exclusion, because the cost will tend to increase less and less. In any case, the 'resolution' of the issue does not occur in a homogeneous way, but in specific groups.

It is worth reflecting here on Lévy's (2010) ideas about Cyberculture. For him, the sum of different projects carried out in different places and with specific objectives, may come to be aggregated by the convergence of the media, so that the development of collective intelligence in individual appropriation reduces the effects of exclusion caused by the technosocial movement.

The study by Padilla-Góngora et al. (2017) with people aged 65 and over identified that 57.40% were women and most of them do not have the necessary skills and competences to use ICTs, such as turning a computer on and off; use tools and programs or use basic smartphone features, such as sending messages or connecting to the internet. Here, we can see the intersection of two variables: age and sex. In addition to possible difficulties arising from age, the issue of stigma against women should also be considered (Berrío-Zapata et al., 2020), which indicates the need to analyze the issue in a multivariate or multimodal way (Cysne et al., 2007; De Queiroz Ribeiro et al., 2013), as well as relative exclusion, as seen in Heslper (2017).

Another group of people who have been of interest in research in the context of digital inclusion and exclusion are individuals with mental health problems and socialization difficulties. A WHO survey (2020) applied in 130 countries pointed out that the pandemic worsened mental health problems and that there was an increase in demand for services in this area. The data were presented

at The Big Event for Mental Health (IAAP, 2020), where there was a discussion about suicide rates among young people and investment in mental health. This corroborates the work of Greer et al. (2019), in which it can be seen that the pandemic has certainly worsened this situation, especially for those who, in addition to comorbidity(ies), may have other problems, of a socioeconomic or geographic nature.

#### **Network participation and social inclusion: citizenship, democracy and digital culture**

Ragnedda & Ruiu (2016), based on Van Dijk (2005), identified participation and social inclusion as the most important factors in combating digital inequality. According to the authors, the areas in which the digital exclusion is most noticeable are: economy, training, society, spatiality, politics and in the institutional area.

Digital technologies have brought a new form of exclusion, as the impossibility of individuals to participate in the network can mean the loss of the benefit of exercising their citizenship (Tavares & De Souza Vieira, 2020). This is perhaps one of the biggest challenges and the most worrying, since equity, voice, participation, integration are also lost, with this the individual practically does not exist in the digital realm.

Marques (2014) identified that the digital exclusion is treated along two main lines: 1st) that it is a governmental and State problem; 2nd) that it is a problem that will normalize over time. For the author, the digital exclusion depends on the context and will not be resolved only with public policies. In this regard, Sousa (2017) believes that the digital exclusion can only be eradicated through the collaboration of all people.

According to Belluzo (2014, p. 50), the contemporary currents of the knowledge society derive from two great forces: greater intercultural interaction made possible by global electronic networks and an economic system in which the functions of knowledge are related to the concept of commodity. This was widely discussed and pointed out the importance of digital inclusion in issues of participatory, socio-interactionist and socio-economic citizenship.

Although all the literature has shown the need for ICT skills, Lévy (2010) indicates that fewer and fewer skills will be needed to use information environments, whose interfaces will tend to be increasingly friendly. This can be seen in the similarity between applications, when we assimilate buttons with similar functions in different interfaces. This issue is present in the development of interfaces and reflects a concern with usability on the part

of the user, as can be seen in Lowdermilk (2013) and Neil (2012).

#### **IV. CONCLUSION**

Through the analysis of the sample of articles selected by Celestino & Valente (2022), it is concluded that in general terms, the digital exclusion can be researched from the following perspectives: a) infrastructural; b) education, information skills and competences in content appropriation; c) demography; d) spatial and geographic; e) intrapersonal characteristics; f) network participation and social inclusion: citizenship, democracy and digital culture.

It is possible to verify that the digital exclusion is a cyclical and redundant phenomenon between cause and consequence, directly related to the technological structure of the moment, space and access to the internet in a ubiquitous way and that requires intrapersonal capacity, personal motivation and skills to appropriate the benefits of information and network services, being one of the edges that can contribute both to social exclusion and to the reduction of inequalities.

The same research problems reported in the older works in the sample, such as the issue of infrastructure and ICT skills, are still identified in more recent works, indicating that the problems that give rise to the digital exclusion have not yet been definitively resolved. Despite this, discussions have matured to the point of looking at digitally excluded individuals from a qualitative perspective.

Regarding the digital technologies used to access the internet, the cell phone is consolidated as a device with great potential to contribute to various digital inclusion policies, due to its low cost compared to a microcomputer, as well as its mobility, ubiquity and integration with different social media and apps.

Regarding the initial questions, it is concluded:

1st) the concept of digital exclusion evolved from the strict perspective that digital inclusion would be linked only to infrastructural issues to a level that considers qualitative, intrapersonal and socio-interactionist aspects, corroborating the perception of Helsper (2017) and being necessary, still, the articulation of the theme with theories of global and social inequalities, as seen in Da Costa (2012);

2nd) the correlation of digital exclusion with social problems is based on notes that indicate that the lack of access to education through the media can influence employability; that there is a strong relationship between the digital exclusion and gender issues with employability;

that individuals with little autonomy, due to their characteristics or limiting factors, no longer have access to the equitable purposes of the network society; and that there may be a lack of equity in the exercise of citizenship;

3rd) it can be said that a digitally excluded individual simply 'does not exist' in the context of digital networks, which will deprive him of all possible benefits, including: access to education, access to employment opportunities, access to telehealth, access to government services, lack of participation in a social context. Such factors can compromise their social and egalitarian development.

It is concluded that the problem of digital exclusion can be addressed by two general lines: 1st) the group that does not have minimum structural conditions, such as conditions for acquiring devices and access to networks, also related to basic issues, such as housing and access to basic services such as energy and internet. After all, what good is having a computer or a smartphone with internet access if there is no electricity? The structural problem has been dragging on for (much) more than 20 years, and it is possible to consider it, in this sense, the first and main factor that results in the digital exclusion. With the advent of new technologies and new forms of network access, it is worth considering, according to Wang et al. (2021, p. 02) the "[...] 5G base stations, the industrial Internet of Things, artificial intelligence (AI) and data centers [...] in the development of the so-called 'new infrastructure' of urban centers, in order to boost economic and social development and, in a way, reduce the digital exclusion";

2nd) of the group that has the structure and minimum conditions to access the internet, which requires identifying needs by grouping and developing policies for specific groups, as in the case of the elderly, people with health problems (physical or mental), people with disabilities (PD), people of different races, from remote communities, with the intention of solving specific problems that impact the whole.

From this first classification into two large groups, it is considered that studies should not be developed under just one variable, but based on the correlation between them, and should be aggregated according to each specific context, given the complexity of the subject. For example, women have a certain percentage of digital exclusion, but this number changes and varies if other variables or covariates are considered. In this way, a black woman with mental health problems and resident of an isolated area, compared to an elderly black woman, resident of a large metropolis, would statistically be part of other simultaneous groups of digital exclusion, which can lead to the production of erroneous and inaccurate data.

It is also concluded that the digital exclusion may negatively impact several Sustainable Development Goals in Brazil for the UN 2030 Agenda (Nações Unidas Brasil, 2022), with the need, therefore, for research, development and application of strategies and policies to try to mitigate the impacts on the lives of people who cannot be inserted in a digital context, failing to enjoy its benefits, to express themselves culturally and in a citizen and, often, democratic way.

### Study limitations

As this is a restricted scope by the inclusion of works on the term "digital exclusion", works with keywords or related terms were not searched, such as "digital divide", "digital apartheid", "brecha digital", among others, which could (may) broaden the perspective on the topic. This is because some authors bring these terms as a synonyms and others bring it as an individual meaning. In addition, the selection and analysis of data did not consider the divisions of second and third levels of the digital exclusion, found in the literature, because it is an initial contact with the theme.

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## Process of humanization of childbirth: Historical evolution and perspectives

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**Keywords—** Humanized Childbirth, Humanization of Assistance, Obstetrics.

**Abstract—** The study aimed to investigate, through the literature, the historical evolution and perspectives of the humanization process of care during childbirth. This is a bibliographic research, in which two databases were searched, namely: SciELO and LILACS, with national publications in the last 10 years. Fourteen scientific articles were analyzed using articles published in Portuguese as inclusion criteria; full articles and articles published and indexed in the aforementioned databases in the period from 2012 to 2022. As a result, it became evident that the humanization of childbirth is very current and still occurs as a reaction to several procedures performed without indication, requiring efforts to all the subjects involved, seeking to guarantee the woman quality and comprehensive care, which requires from all the actors involved with health care efforts to abolish aggressive behavior. It was

*concluded that the movement for the humanization of childbirth shows that the issue of birth is also the responsibility of the government and, given the current problems such as those related to the infrastructure weaknesses of the health network in Brazil, it is also configured as a health issue public.*

## I. INTRODUCTION

Over time, midwifery has undergone numerous changes. In the 19th century, women gave birth to their children with the help of midwives, in their own home [1]. The obstetrician was requested only if there were complications at the time of delivery.

However, the increase in interventions in the pregnancy-puerperal cycle and the excessive medicalization contributed to a new scenario of parturition, in which women began to undergo procedures often without indication and their autonomy was no longer respected [2]. Health professionals, consequently, began to gain prominence when performing these procedures and became the main protagonists of this event.

Today, the importance of making the woman the protagonist of her own childbirth is perceived, guaranteeing the rights to quality care in this period of pre, trans and postpartum.

In this perspective, in view of the explanations made, the question was: How did the historical evolution happen and what are the perspectives of the process of humanization of childbirth?

The study aimed to investigate, through the literature, the historical evolution and perspectives of the humanization process of care during childbirth.

## II. METHODOLOGY

This is bibliographic research considering that this is a research alternative that proposes to search and analyze the published knowledge regarding a certain theme. A search was carried out in two databases, namely: SciELO (Scientific Electronic Library Online) and LILACS (Latin American and Caribbean Literature in Health Sciences), with national publications in the last 10 years.

As a criterion for the inclusion of the sample, a search was carried out in the bases mentioned above with the Descriptors in Health Sciences (DeCS): humanized childbirth, humanization of care and obstetrics. The inclusion criteria defined for the selection of articles were: articles published in Portuguese; full articles and articles published and indexed in the aforementioned databases in the period from 2012 to 2022. Subsequently, a pre-analysis of all articles found was carried out, through the initial

reading of titles and abstracts and articles that were not related to the theme. Articles published in journals were considered as analysis documents.

The review in the databases resulted in twenty-five publications. Considering the inclusion and exclusion criteria, eleven were excluded from the study, as they did not specifically address the subject studied. Therefore, fourteen publications were analyzed in full, which were suitable for the purpose of this review.

The presentation of the results and discussion of the data obtained was elaborated in a descriptive way, allowing the reader to evaluate the applicability of the elaborated review, in order to achieve the objective of this method, that is, to positively impact the performance of the nursing team, providing subsidies to the nurses in their daily decision-making.

## III. RESULTS AND DISCUSSION

Considering the history of obstetrics, it is known that traditionally care during the birthing process was performed by midwives, in the comfort of their homes and under the eyes of their families.

Midwives who had empirical knowledge were trusted by women, often being part of popular classes [1]. There was still no interest on the part of the medical profession in providing care to parturient women, as they considered it a devalued health service and the responsibility of women.

The beginning of the use of obstetric forceps indicated the beginning of the modern period of obstetrics, which interfered in the performance of midwives, in which their work was devalued. This period occurred with the emergence of surgery, highlighting the pathophysiological aspects to the detriment of the psychic and cultural dimensions of women in the pre, trans and postpartum context. As a result, care for childbirth has changed, and pregnancy and childbirth, which are natural and physiological phenomena, were considered pathological and medicalized processes, changing their original essence from an existential event for mother and child into a social event [3, 4]. In this sense, the moment of delivery was institutionalized, making the presence of a doctor necessary for its performance.

In the period between 1780 and 1835, the morphological and functional bases of the female genital system were discovered and this led to the perception of childbirth as a health hazard, thus causing definitive changes in childbirth care, in which the woman as a pregnant woman was considered a woman. sick, it was when the midwives were denied intervention in this process, as pregnancy came to be considered a medical situation that requires treatment from a true medical professional [5]. In this sense, childbirth emerged as a surgical procedure that must be performed in a hospital environment [3].

During the 19th century, the fight against quackery began, a movement that blamed midwives for the high rates of maternal mortality. In this context, it was not considered that the women who were assisted were already vulnerable, living in precarious conditions, which facilitated maternal deaths. Thus, the performance of midwives suffered a sharp decline, with emphasis on childbirth performed in the hospital environment with the presence of the doctor [4].

In Brazil, in 1970, the current health model began to receive much criticism from feminist movements and other sectors of society [6]. The obstetric care model began to be questioned, predominantly characterized, among other aspects, by the institutionalization of childbirth centered on medical acts and on the use of procedures and practices considered interventionist without indication.

As early as 1980, estimates suggested that approximately 500,000 women died each year from preventable causes related to pregnancy. Hemorrhages, hypertensive diseases, sepsis, illegal abortion were considered the main causes of maternal deaths [7]. In later years, greater attention was paid to obstetric complications and some efforts were made to prevent and detect problems. Thus, greater emphasis was given to coping with obstetric complications. Therefore, in 1985, many advances were observed, but there was no significant drop in the number of maternal deaths worldwide [7].

In the 1990s, it came to be understood that women are inserted within a broader context of reproductive health and sexual rights, emphasizing the role of other factors in women's health-disease relationship, such as education, income, place of birth and degree of oppression to which women are subjected in society. Thus, these indicators would be related to maternal mortality [8]. Thus, the reduction of maternal mortality was included as one of the goals to be achieved within the Millennium Development Goals (MDGs). It is pointed out that between 2000 and 2015 more than 1.5 million deaths were avoided [9, 10].

However, unequal access to health services, care in the face of complications and inadequately provided assistance

during pregnancy, childbirth and the puerperium are still major obstacles to the survival of women in the world [7].

The World Health Organization (WHO) developed a set of recommendations with the objective of clarifying the "good practices" in normal birth care, seeking to make it as physiological as possible. These recommendations were classified into four categories: Category A – useful practices that should be encouraged; Category B – practices that are demonstrably ineffective and should be eliminated; Category C – practices for which there is insufficient evidence to support a clear recommendation and which should be used with caution; Category D - practices frequently used inappropriately, disclosed in the document called Assistance to Normal Childbirth: A Practical Guide [11].

The quality of care for women at the time of childbirth is considered very important to be discussed. In this context, the Conference on Appropriate Technology for Childbirth took place. From this event, some recommendations were suggested, such as a review of the practices adopted during childbirth, excluding interventions without indication. In addition to the adoption of strategies that allow women's autonomy at the time of childbirth [6].

From this perspective, and with the intention of encouraging natural childbirth, the Ministry of Health instituted Ordinance No. dystocia performed by an obstetrician nurse" (Ordinance No. 2815/1998) [12].

In addition, Ordinance 466/2000, considering the ordinances GM/MS n° 2.816, of May 29, 1998, and GM/MS n° 865, of July 3, 1999, established as competence of the states and the Federal District the definition of limit, per hospital, of the maximum percentage of cesarean sections in relation to the total number of deliveries performed and also the definition of other strategies to obtain a reduction of these procedures within the state [13]. In addition, in 2000, the Program for Humanization in Prenatal and Birth was launched, drawing attention to the reorganization of care through the linking of prenatal care to childbirth and the puerperium (As Ordinances MS/GM 569/2000) [14].

In the current Brazilian reality, it is observed that the proportion of cesarean deliveries is one of the highest in the world, much higher than the limit of 15% recommended by the World Health Organization (WHO) to guarantee quality maternal-fetal care [9, 17]. The percentage of cesarean deliveries had relative growth in all regions of the country, from 15% in 1970 to 48.8% in 2008 [9], and in 2009 it surpassed, for the first time, that of vaginal deliveries [16]. In 2010, while the large national regions Northeast and North had proportions of cesarean deliveries of 41% and 44%, respectively, the South and Southeast had higher proportions, of 58.1% and 58.2%, respectively [17].



When there is an adequate clinical indication, cesarean section is an effective intervention to reduce maternal and neonatal morbidity and mortality. However, several non-clinical factors are related to the high number of cesarean sections, such as the association between purchasing power and access to health services for the surgical procedure, among other factors [15]. In this sense, the WHO defends that care at birth should provide the least possible intervention, prioritizing normal delivery, with safety, in order to obtain a healthy mother and child. Its recommendations for childbirth care consist of a paradigm shift, among which are: the rescue of the appreciation of the physiology of childbirth, the encouragement of a harmonious relationship between technological advances and the quality of human relationships; in addition to respecting citizenship rights [18].

Furthermore, it is known that maternal mortality remains high with around 280,000 maternal deaths worldwide each year [9], at around 210 deaths per 100,000 live births, the reduction of inequalities and the increase in of the quality of obstetric care are fundamental points for the reduction of maternal mortality [19].

Among the current health policies, the creation of Federal Law No. 11,108, which guarantees women the choice of a companion in the pre, trans and postpartum period [20], as well as the creation of Rede Cegonha, in 2011, are examples of policies positive aspects for achieving quality and humanized care. The creation of normal birth centers, within the Rede Cegonha Program, enables the active participation of obstetrician nurses in a more intense way, for the qualification of care involved in processes of autonomy of parturients, which mainly considers their active participation at the moment. of childbirth and respect for their therapeutic choices [6].

In this way, it is clear that the humanization of care during childbirth is very current, and requires efforts from all the subjects involved, seeking to guarantee women with quality and comprehensive care, which requires all actors involved with health care. efforts to abolish aggressive behavior.

#### IV. CONCLUSION

It was concluded that the discussion about the humanization of childbirth is current and still happens as a reaction to several issues such as: routine cesarean section and use of enema, shaving, amniotomy, intravenous oxytocin, episiotomy without indication, as well as the need for attention adequate and quality by the professionals.

In this way, the practice of humanization arises from an attempt to direct a different look at the role of women at the

moment of childbirth, considering their anxieties, desires, beliefs and life context.

The movement for the humanization of childbirth shows that the issue of birth is also the responsibility of the government and, given current problems such as those related to the infrastructure weaknesses of the health network in Brazil, it is also a public health issue. From this perspective, public policies must have guiding directions for the realization of these points and guarantee quality care.

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# Preclinical Toxicological Evaluation of the Consumption of Fish from the Cachoeira River Hydrographic Basin in Rats

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**Keywords** — diet, food and nutrition,  
sustainable development, environmental  
monitoring, fish, food safety, toxicology.

**Abstract**— Fish is one of the healthiest food sources once it has proteins, vitamins, minerals and the omega-3 polyunsaturated lipids. Nevertheless, to be healthy, the protein in fish meat must not have contaminants further than allowed. This study aimed to investigate the preclinical toxicologic effects of consumption of fish meat from Cachoeira river (Joinville, Santa Catarina, Brazil). Groups of rats were divided and received for a month: standard ration, farmed fish meat and fish meat from Cachoeira river twice a week. One day after the last exposition, animals were euthanized and blood, spleen, heart, liver, kidney, cerebellum, and cerebral cortex were collected to measure oxidative stress, biochemical and hematological parameters. Metals levels were also analyzed in fish meat by atomic emission spectrometry. Significant elevation of carbonylated proteins were observed in heart and liver and thiobarbituric acid reactive substances in liver, plasma and cerebellum were observed. Total

*sulphydryl content decreased significantly in cerebellum, liver and heart, and decreased catalase activity in the liver and superoxide dismutase activity in the kidneys were also present among rats who consumed fish meat from Cachoeira river. No modification of hematological parameters was observed, and only significant decrease of HDL occurred among biochemical parameters. Analysis of metals in river fish meat showed a fivefold increase in zinc and aluminum compared to farmed fish meat. Short-term exposure to fish meat from the Cachoeira River resulted in increased oxidative stress, liable to be transferred through the food chain, possibly associated with the increased presence of heavy metals.*

## I. INTRODUCTION

Food is a basic need to ensure survival and to improve the quality of life of the human being, as long as adequate nutrients are consumed for the maintenance of health. The nutrients are divided according to their function in the body into macro and micronutrients and the quantity consumed is defined according to the energy needs of each person and in each phase of life (Ribeiro et al., 2017).

Proteins can be divided into vegetable and animal (from meat, eggs, and fish). Proteins from fish meat are extremely important for health and must be part of routine meals, and its consumption is recommended at least twice a week. Furthermore, fish meat provides vitamins A, E, D, B1, B2, B5, B6, B9, in addition to the minerals calcium and phosphorus, sodium, potassium, manganese, copper and cobalt, zinc, iron and iodine, and also contains all essential amino acids in balance (Food and Agriculture Organization – FAO - 2014). Fish meat is also a source of omega 3, a polyunsaturated lipid with direct action in the prevention of cardiovascular diseases, non-transmissible chronic diseases, and takes part in the neurological development of the fetus and in early childhood (Santos et al., 2013).

To ensure that fish meat is offered and consumed within food safety standards, the place where fish grow and reproduce must be free of contaminations, since they can be transferred to the human body after ingestion in varied degrees, depending on the quantity, length of consumption and level of contamination of the food, and can cause serious health problems, such as predisposition to cancer, cardiovascular diseases and neurotoxicity (Silva & Santos, 2016). The determinant for ensuring the integrity of this source of protein depends on where these fish come from and how this water resource is constituted and whether there is eutrophication that will modify its characteristics (Macedo & Sipaúba-Tavares, 2018).

The problem faced in Brazil and in developing countries is related to most of the raw sewage released without any prior treatment in water courses, containing various types of contaminants, which negatively affect the

aquatic environment, which reflects directly on people's health, becoming increasingly necessary the adoption of a practice focused on sustainable development aiming to maintain and preserve natural resources (Campos & Kuhn, 2021; Vincze et al., 2015).

Hence, fish coming from a river with contaminated water can cause damage to the health of the consumers in the long term, due to the exposure to contaminants such as: domestic and industrial effluents, chemical substances from pesticides and fungicides used in agriculture, and heavy metals deposited in the water and which can concentrate in the fish muscle: cadmium ( $\text{Cd}^{+2}$ ), lead ( $\text{Pb}^{+2}$ ), chromium ( $\text{Cr}^{+6}$ ) and mercury ( $\text{Hg}^{+2}$ ) (Lima et al., 2015). The hydrographic basin of the Cachoeira river is located in the central region of the city of Joinville, covers 83.12  $\text{Km}^2$  in area and represents 7.3% of the city area. Its 100 source is located in the Costa e Silva neighborhood, 40 meters above sea level and its mouth is characterized by an estuary under the influence of tides and where areas with mangrove remnants can be found (Ribeiro & Oliveira, 2014).

In view of the perception of the local social reality of consumption of fish meat from the Cachoeira river, which receives effluents from several origins, including chemical industry, the concern with the long-term exposure of the population to possible contaminants received by the river that may be bioaccumulated in the fish meat arose. Hence, the present study aims to investigate the pre-clinical toxicological effects in rats exposed to the consumption of fish meat from the Cachoeira river basin, which may pose health risks to consumers due to the routing of residential and industrial sewage causing pollution of the river, confirmed by the spatial and temporal variation of water quality index (Oliveira et al., 2013).

## II. METHODS

Pre-clinical experimental study, carried out at the University of Joinville Region (UNIVILLE), conducted in the sectorial bioterium and in the laboratories of

pharmaceutical practices and instrumental analysis. The experiments were conducted after approval of the research project by the UNIVILLE's Ethics and Research Committee on Animal Use (Opinion 01/2019).

## 2.1. Experimental Protocol in vivo

Wistar female albino *Rattus norvegicus*, with an average initial weight of 80-100g, 122 from the Bioterium of the Blumenau Regional University Foundation were used (FURB 123 – SC – Brazil). The animals were received at the age of 21 days, housed (4 per cage) and acclimated for 7 days in the sectorial bioterium of the University of the Joinville Region for adaptation. The animal holding rooms were kept on a 12-h light/dark cycle (lights on at 7:00 am and off at 7:00 pm), temperature between  $22 \pm 2$  °C and humidity between  $50 \pm 5\%$ , with an air exhaust system. The animals had free access to feed and water. The 128 experiments were carried out according to the provisions of Law No. 11,794 (Brasil, 2008), and other regulations applicable to the use of animals in teaching and/or research, especially the Normative Resolutions of the National Council for the Control of Animal Experimentation (Marques et al., 2009) and the recommendations required by "Guide for the Care and Use of Laboratory Animals (Clark et al., 1996)". After acclimatization, the animals were divided into groups that were exposed for one month to fish meat from farmed fish or from the Cachoeira River, as shown in Table 1:

Table 1. Division of the experimental groups for 1 month exposition to standard ration, farmed fish and Cachoeira river fish meat.

Day of the week	Control group	Farmed fish group	Cachoeira river fish group	Animals per group
Monday	Feed	Feed	Feed	8
Tuesday	8h fasting	8h fasting	8h fasting	8
Wednesday	Feed	Fish	Fish	8
Thursday	Feed	Feed	Feed	8
Friday	8h fasting	8h fasting	8h fasting	8
Saturday	Feed	Fish	Fish	8
Sunday	Feed	Feed	Feed	8

Source: the authors (2022).

The animals in the control group received standard feed (Nuvilab®) and the 139 animals in the experimental groups received 2 servings per week of fish meat. Eight hours before the supply of fish meat, the feed was removed

from the boxes of all groups, including the control group. The animals were exposed to fish meat for a period of one month. In order to define the serving of fish offered to each rat, we used the World Health Organization (WHO) recommendation (2014) of consumption of 12 kg of fish per year for an adult of 70 kg (a serving of 125 g/70 kg twice a week).

This proportion was converted according to the body mass of each animal, which was weighed fortnightly, resulting in the following calculation for how much fish would be offered to each animal:  $125 \text{ g} / 70 \text{ Kg} = 0,001785 \text{ µg}$   $149 \therefore 0,00178 \text{ µg} \times \text{body mass of each rat (g)} = \text{amount of fish meat offered}$ . One day after the end of each exposure period, the animals were euthanized by decapitation for collection of whole blood, and the spleen, heart, liver, right kidney, heart, cerebral cortex, and cerebellum were excised.

## 2.2. Sample preparation

### 2.2.1. Blood

Whole blood for the analysis of hematological parameters was obtained from blood of the rats by decapitation and conditioned in tubes with and without ethylenediaminetetraacetic acid tripotassium (EDTA K3). The blood was centrifuged at  $1000 \times g$  for 10 minutes to separate plasma and serum, which were kept in a freezer. The freshly collected blood was used for analysis of hematological parameters and preparation of a slide for differential blood cell count.

Red cells were washed 3 times with ice-cold saline solution (0.153 mol/L sodium chloride) and lysates were prepared by adding 1 mL of distilled water to 100 µL of washed and frozen red cells. For determination of antioxidant enzyme activity, the red cells were frozen and thawed 3 times and centrifuged at  $13,500 \times g$  for 10 min. The supernatant was diluted to contain approximately 0.5 mg/mL protein.

### 2.2.2. Tissue preparation

Liver, kidney, heart, spleen, and brain structures (cortex and cerebellum) were removed, decapsulated and kept on ice in saline buffer (154 mM NaCl, 5 mM Tris-HEPES, pH 7.5). The homogenate (15%) (w/v) was prepared in appropriate buffer 175 according to the methodology to be employed, using Potter-Elvehjem homogenizer (5 pulses). The homogenate was centrifuged at  $\times 3,000 \text{ g}$  at 4 °C for 15 minutes to remove cellular debris and the supernatant was stored in aliquots and stored at -80 °C for later determination of the activity of the antioxidant enzymes catalase (CAT), superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) and oxidative stress: thiobarbituric acid reactive substances



(TBARS), total sulfhydryl (SH) and carbonylated 181 protein (CP) content.

### 2.3. Measurement of oxidative stress parameters

#### 2.3.1. TBARS

TBARS were determined according to the method described by Ohkawa et al. (1979). The TBARS methodology measures malondialdehyde (MDA), a product of lipoperoxidation, caused mainly by hydroxyl free radicals. Homogenized tissues and plasma were mixed with 20% trichloroacetic acid and 0.8% thiobarbituric acid and heated in a boiling water bath for 60 min. TBARS were determined by absorbance at 535 nm. A calibration curve was obtained using 1,1,3,3-tetramethoxypropane as the precursor of MDA and each point of the curve was subjected to the same treatment as that of the supernatants. The results are expressed as nmol of MDA per mg of protein.

#### 2.3.2. Total SH content

Total sulfhydryl content was determined according to the method described by Aksenov & Markesbery (2001), which is based on the reduction of dithionitrobenzoic acid (DTNB) by thiols, generating a yellow derivative, thionitrobenzoic acid (TNB), which is measured spectrophotometrically at 412nm. Briefly, 50µL of homogenate was added to 1 mL of buffer (PBS) pH 7.4 containing 1mM EDTA. The reaction was started by adding 30µL of 10.0mM DTNB and incubated for 30 minutes at room temperature in a dark place. The results are expressed as nmol TNB/mg protein.

#### 2.3.3. CP Content

Carbonyl content was measured using the method described by Reznick & Packer (1994), based on the reaction of protein carbonylation with dinitrophenylhydrazine forming dinitrophenylhydrazone, a yellow compound, measured spectrophotometrically at 370 nm. Briefly, 200 µL of homogenate or plasma were added to plastic tubes containing 400 µL of 10 mM dinitrophenylhydrazine (prepared in 2 M HCl). The samples were kept in the dark for 1 h and vortexed every 15 min. Subsequently, 500 µL of trichloroacetic acid 20% will be added to each tube. The mixture was vortexed and centrifuged at 14,000 x g for 3 min and the supernatant obtained was discarded. The sediment was washed with 1 mL ethanol / ethyl acetate (1: 1 v/v), shaken and centrifuged at 14000 x g for 3 min. The supernatant was discarded and the sediment resuspended in 600µL of 6M guanidine (prepared in a 20 mM potassium phosphate solution, pH 2.3), before vortexing and incubation at 60 °C for 15 min. The samples were then centrifuged at 14,000 x g for 3 min and the supernatant used to measure

absorbance at 370 nm (UV) in a quartz cuvette. The results were reported as total carbonyl content (nmol / mg protein).

#### 2.3.4. CAT activity

This parameter was measured by the method of Aebi (1984) using a Shimadzu UV-visible spectrophotometer. The method used is based on the disappearance of H<sub>2</sub>O<sub>2</sub> at 240 nm in a reaction medium containing 25 µL of sample and 600 µL of 10 mM potassium phosphate buffer, pH 7.0, containing 20 mM H<sub>2</sub>O<sub>2</sub>. The absorbance was measured every 10 seconds for 1 minute 40 seconds. One unit is defined as 1µmol of H<sub>2</sub>O<sub>2</sub> consumed per minute and the specific activity is calculated as units of CAT / mg protein.

#### 2.3.5. SOD activity

This parameter was determined by the pyrogallol auto-oxidation method as described by Marklund (1985), a highly superoxide (O<sub>2</sub>•)-dependent process, which is a substrate for SOD. Briefly, 15 µL of each sample were added to 215µL of a mixture containing 50 µM of Tris buffer, 1 µM of EDTA, pH 8.2, and 30 µM of CAT. Thereafter, 20 µL of pyrogallol were added and the absorbance was recorded immediately every 30 seconds for 3 minutes at 420 nm using a Shimadzu UV-visible spectrophotometer. The inhibition of pyrogallol autoxidation occurs in the presence of SOD, whose activity can be indirectly tested spectrophotometrically. A calibration curve was performed with purified SOD as reference, to calculate the activity of SOD present in the samples. One SOD unit is defined as the amount of SOD required to inhibit 50% of the pyrogallol autoxidation and the specific activity is reported as units/mg of SOD protein.

#### 2.3.6. GSH-Px activity

The measurement of this parameter was performed by the Wendel method (1981), using tert-butyl hydroperoxide as substrate. The decomposition of NADPH was monitored in a spectrophotometer at 340 nm for 3 minutes and 30 seconds (Shimadzu UV-visible spectrophotometer). The medium contains 90 µL of the sample and 800 µL of 10 mM potassium phosphate buffer, pH 7.4; 20 µL of 2 mM GSH, 30 µL of 0.15 U/mL GSH reductase, 10 µL of 0.4 mM azide, and 10 µL of 0.1 mM NADPH. The absorbance was measured every 10 seconds for 1 minute and 30 seconds. Then, 50 µL of 0.5 mM tertbutyl hydroperoxide was added and the absorbance read for another 2 minutes. One unit of GSH-Px is defined as 1µmol of NADPH consumed per minute and the specific activity is presented as GSH-Px units / mg of protein.

#### 2.3.7. Protein dosage



The determination of proteins was performed by the Lowry method (1951), using bovine serum albumin as standard.

#### 2.4. Measurement of biochemical parameters

The biochemical parameters glutamic oxalacetic transaminase (GOT) and glutamic pyruvic transaminase (GPT), thyroid-stimulating hormone (TSH), free thyroxine (FT4) and triiodothyronine (T3) and creatinine were measured by an automatic process in the Siemens Advia Centaur Immunassay System (Santa Helena Laboratory in Jaraguá do Sul – SC - Brazil). The measurement of total protein, albumin, uric acid, urea, total cholesterol (TC), HDL cholesterol and triglycerides (TG) were measured by spectrophotometry in the laboratory of Pharmaceutical Practices at UNIVILLE using Labtest kits. Blood levels of VLDL and LDL cholesterol were deduced using the Friedewald equation.

#### 2.5. Measurement of hematological parameters

The hematological parameters were measured by an automatic process of light absorption and electrical impedance reading through automation with the Horiba ABX Pentra 60 analyzer. The parameters of the red series (hemogram) were evaluated: hemoglobin, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), cellular hemoglobin concentration mean (CHCM), erythrocyte count, RDW (Red Cell Distribution Width), indexes related to hemoglobin concentration and microscopic analysis of the blood smear to observe changes in shape and color of the erythrocytes. The leukogram (total number of leukocytes, neutrophils, eosinophils, lymphocytes, monocytes, and basophils) and the total number of platelets were also evaluated.

#### 2.6. Collecting the fish

Tilapia was selected for this study because it is a widely consumed fish among Brazilians, has a great cost-benefit relation for consumers, and its meat is considered a protein of high biological value and firm texture. This fish can also grow in adverse environments, has omnivorous feeding habits, and feeds on all kinds of organic material available in the water, mollusks, seeds, vegetables of any species, crustaceans, among others (Bemvenuti, Fischer, 2010).

The farmed fish selected were *Oreochromis Nile* tilapia from a monoculture of tilapia in an excavated and breeding farm located on Quiriri Road in the city of Joinville (SC). The place of culture is regularly attended by the team of the fish farming sector of the rural development unit of the Secretary of Agriculture and Environment, which regularly analyzes the culture water and confirmed that the discriminated culture parameters

are within the ideal for tilapiculture. The feed offered to the omnivorous fish has 30% crude protein (Nicoluzzi brand).

The fish were captured with nets, stored in thermal boxes, and immediately delivered to the researcher for cleaning and freezing until the moment of preparation. The fish from the Cachoeira River were collected following the methodology of Lima et al. (2015), with nets, and 3 fish of the same species were captured, stored in Styrofoam boxes with ice until arrival at the UNIVILLE toxicology laboratory, where they were measured and weighed. The fish were collected at most every 3 months, a safe period for storage and maintenance of the quality of the meat for consumption. New collections of fish from the Cachoeira river always occurred 15 days before all available frozen servings were consumed, thus maintaining the collection and consumption period within the 3-month period. The collection of fish was performed during the day, always considering the condition of no rainfall for at least two days before the collections and taking into account the ease of access and the presence of the target species (Pinheiro et al., 2015). The tilapia was collected in the same stretch of the Cachoeira River (coordinates 26°16'084"S 48°51'880" W), in the Costa e Silva neighborhood, in Joinville (SC). The fish were collected using 4-cm mesh cast nets and 8-meter long 1-meter wide 6-cm mesh gillnets.

After being captured, the individuals were identified to the lowest taxonomic level possible to confirm that it was the target species, placed in plastic bags, weighed, labeled, sealed, and stored in a thermal box with ice. Nineteen individuals were collected, totaling 5100 g of tilapia. The collection procedures were conducted after permission from the Biodiversity Authorization and Information System (SISBIO) No. 10476-3 by the biologists Diogo Augusto Moreira (Regional Council of Biology - CrBio - 81154) and Johnatas Adelir-Alves (Regional Council of Biology - CrBio - 053967).

#### 2.7. Preparation of the fish meat

The selection and preparation of the fish meat for consumption by the rats followed the food safety standards of the Collegiate Directorate Resolution (CDR) No. 216, of September 15, 2004, which provides on the Technical Regulation of Good Practices for Food Services (Agência Nacional de Vigilância Sanitária – ANVISA - 2004). Soon after the fish was caught, it was cleaned, gutted, and its scales and head were removed. The flesh of the farmed fish and of the Cachoeira river was separated from the bones and only the raw, filleted meat was packed individually or a maximum of two fillets in transparent

plastic bags selected according to CDR standard No. 259/2002 (Brasil, 2002), kept at a temperature between 0°C and -2°C until the moment of thawing and cooking of the meat. The thawing of the meat occurred under refrigeration conditions at a temperature below 5 °C, to prevent the surface areas of this food from remaining in conditions favorable for microbial multiplication.

The cooking was carried out in a glass container, only in drinking water without any added seasoning, at a temperature of 150 °C for 10 minutes (Brasil, 2004). After cooking, the fish meat was cooled, separated into servings and then frozen at -5 °C, packed in plastic bags according to the CDR No. 259/2002 to ensure the nutritional safety of this food and minimize the risk of cross contamination. The meat was thawed in a microwave oven for 2 minutes before being offered to each animal. Next, it was packaged in a thermal bag for transport to the bioterium, where each serving was weighed on precision scales (Brasil, 2018; Cribb et al., 2018). The fish meat was offered to the animals twice a week, after an 8-hour fasting period. Each animal was placed individually in a cage to ensure that each one consumed its serving, and after verification of total consumption of the serving, they were placed back in the larger box together with the other animals in their group and unlimited feed was made available again. Leftovers of the thawed fish meat after consumption by the rats were not reused.

## 2.8. Heavy metals in fish meat quantification

The analyses of heavy metals concentration in fish meat were conducted in triplicate by inductively coupled plasma atomic emission spectroscopy (ICP-OES) in an Avio 200-Perkin Elmer instrument, adapted from the methodologies of Sanches Filho et al. (2013) and Uysal et al. (2008). 5 g of each sample of farmed fish meat and from the Cachoeira River were weighed and placed in a lyophilizer for 24 hours. After drying, 3.40 g of the farmed fish meat sample and 3.22 g of the fish meat sample from the Cachoeira river were left. To each sample 10 mL HCl (20%) + 4mL HNO<sub>3</sub> (50%) were added, and they were placed on the heater plate at 90°C and left for 30 minutes in reflux. The samples were then filtered into a 100 mL flask and volumized with Milli-Q water. All the material used in the sample preparation was washed with a solution of Extran and water and then placed in 10% (v/v) nitric acid for at least 24 hours. After immersion in the acid, the material was washed seven times in Milli-Q water. The results of the metal analysis are expressed in ppm.

## 2.9. Statistical Analysis

Results are presented as mean  $\pm$  standard deviation (metal level measurement) or mean  $\pm$  standard error (oxidative stress, biochemical and hematological

parameters), were tabulated and analyzed using GraphPad Prism 6.0 software. Analysis of variance (ANOVA), followed by Kruskal-Wallis post-test (non-parametric data) or Tukey's test (parametric data), for comparison among groups was conducted, with values of  $p < 0.05$  considered significant.

## III. RESULTS

No statistically significant differences were observed for oxidative stress parameters and antioxidant enzymes in the spleen and cerebral cortex among the groups (Table 2) and there were no relevant differences between animals fed with feed and farmed fish. In the cerebellum a significant elevation of TBARS (24.0%) and a relevant decrease of SH (30.8%) were observed in the animals fed with the fish from the polluted river, and although there was a decrease in GSH-Px activity, no statistical relevance was reached ( $p = 0.104$ ) and no changes in the activity of the other antioxidant enzymes were found. In the heart, there was a significant decrease of SH (15.9%) and a relevant increase of the total content of CP (56.2%), but there were no relevant changes in the activity of antioxidant enzymes and lipid peroxidation in this organ. A significant elevation of TBARS (15.9%) and CP (50.0%) was observed in the liver, as well as a relevant reduction of SH (14.8%) in animals that received fish from the Cachoeira River.

Moreover, the enzymatic activity of SOD suffered statistically significant reduction in the liver (11.0%) of the animals that received the fish meat from the polluted river. In the kidney, the elevation in total CP content did not reach statistical relevance ( $p = 0.07$ ), however it is not insignificant considering that it is only one month of exposure to the food. Among the antioxidant enzymes, a significant reduction (25.5%) in CAT activity was found in this organ in the animals fed with the fish meat from the polluted river. In plasma, a 79.4% elevation of TBARS was found in the group of animals that consumed the fish meat from the polluted river compared to the other groups. There was no significant modification of the other parameters or in the activity of antioxidant enzymes in erythrocytes (Table 3).

*Table 2 - Oxidative stress parameters after one month of exposure to standard ration, farmed fish, and fish meat from the Cachoeira river.*

Organ (Group)	TBARS (nmol/mg of protein)	SH (nmol/mg of protein)	CP (nmol/mg of protein)
Spleen (Feed)	3.1 $\pm$ 0.1	33.2 $\pm$ 1.5	7.2 $\pm$ 0.1

Spleen (Farmed)	3.1 ± 0.1	34.4 ± 1.3	6.7 ± 0.2
Spleen (Cachoeira)	3.1 ± 0.1	31.1 ± 1.9	7.3 ± 0.2
Cerebellum (Feed)	4.3 ± 0.1	25.1 ± 1.6	5.2 ± 0.1
Cerebellum (Farmed)	4.2 ± 0.2	22.2 ± 1.3	5.1 ± 0.1
Cerebellum (Cachoeira)	<b>5.42 ± 0.3*</b>	<b>17.39 ± 1.1*</b>	5.27 ± 0.1
Cortex (Feed)	3.1 ± 0.2	22.2 ± 0.7	5.1 ± 0.1
Cortex (Farmed)	2.8 ± 0.1	22.5 ± 0.6	5.1 ± 0.1
Cortex (Cachoeira)	3.2 ± 0.2	21.8 ± 0.7	5.2 ± 0.1
Heart (Feed)	4.0 ± 0.1	36.3 ± 1.8	5.5 ± 0.1
Heart (Farmed)	4.1 ± 0.1	35.3 ± 1.2	5.26 ± 0.2
Heart (Cachoeira)	4.2 ± 0.1	<b>30.5 ± 1.3*</b>	<b>8.61 ± 0.2***</b>
Liver (Feed)	2.5 ± 0.1	89.6 ± 5.2	4.1 ± 0.2
Liver (Farmed)	2.5 ± 0.1	97.4 ± 2.5	4.6 ± 0.1
Liver (Cachoeira)	<b>2.9 ± 0.1*</b>	<b>76.2 ± 3.9**</b>	<b>6.1 ± 0.2***</b>
Kidney (Feed)	2.5 ± 0.1	31.7 ± 1.4	3.4 ± 0.2
Kidney (Farmed)	2.6 ± 0.1	30.3 ± 1.0	3.3 ± 0.2
Kidney (Cachoeira)	2.6 ± 0.1	31.4 ± 0.6	4.0 ± 0.1
Plasma (Feed)	3.48 ± 0.21	31.04 ± 0.98	Not measured
Plasma (Farmed)	3.43 ± 0.16	29.20 ± 1.06	Not measured

Plasma (Cachoeira)	<b>6.10 ± 0.26***</b>	28.62 ± 0.71	Not measured
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Source - the authors (2022).

\* Statistically significant difference between feed and farmed fish groups ( $p < 0.05$ ).

\*\* Statistically significant difference between feed and farmed fish groups ( $p < 0.01$ ).

\*\*\* Statistically significant difference between feed and farmed fish groups ( $p < 0.001$ ).

*Table 3 – Antioxidant enzymes activity after one month of exposure to standard ration, farmed fish, and fish meat from the Cachoeira river.*

Organ (Group)	CAT (U/mg of protein)	SOD (U/mg of protein)	GSH-Px (U/mg of protein)
Spleen (Feed)	10.2 ± 0.8	9.8 ± 0.2	37.7 ± 1.6
Spleen (Farmed)	9.9 ± 0.6	9.7 ± 0.2	37.5 ± 1.6
Spleen (Cachoeira)	12.0 ± 0.7	9.5 ± 0.1	36.0 ± 1.9
Cerebellum (Feed)	6.8 ± 0.1	5.1 ± 0.1	26.4 ± 0.7
Cerebellum (Farmed)	6.95 ± 0.1	4.72 ± 0.1	29.4 ± 2.0
Cerebellum (Cachoeira)	7.09 ± 0.1	4.69 ± 0.1	25.0 ± 1.8
Cortex (Feed)	7.0 ± 0.1	6.4 ± 0.3	28.8 ± 1.8
Cortex (Farmed)	6.9 ± 0.2	6.4 ± 0.3	28.0 ± 1.3
Cortex (Cachoeira)	7.0 ± 0.1	7.3 ± 0.4	29.6 ± 1.3
Heart (Feed)	9.3 ± 0.5	5.7 ± 0.1	60.3 ± 3.1
Heart (Farmed)	9.1 ± 0.3	5.8 ± 0.1	61.7 ± 2.0
Heart (Cachoeira)	8.4 ± 0.3	5.7 ± 0.1	60.5 ± 1.1
Liver (Feed)	15.2 ± 0.6	6.3 ± 0.2	64.5 ± 2.4
Liver (Farmed)	15.1 ± 0.5	6.0 ± 0.1	59.0 ± 1.5

Liver (Cachoeira)	15.5 ± 0.5	<b>5.6 ± 0.1*</b>	58.5 ± 3.5
Kidney (Feed)	15.4 ± 0.6	6.3 ± 0.1	32.6 ± 1.3
Kidney (Farmed)	15.6 ± 0.5	6.4 ± 0.1	32.4 ± 1.8
Kidney (Cachoeira)	<b>11.5 ± 0.5*</b>	6.8 ± 0.1	33.8 ± 1.6
Erythrocytes (Feed)	2.75 ± 0.16	5.93 ± 0.08	25.10 ± 1.29
Erythrocytes (Farmed)	2.70 ± 0.10	6.30 ± 0.12	25.40 ± 1.52
Erythrocytes (Cachoeira)	2.62 ± 0.08	5.98 ± 0.16	23.76 ± 1.27

Source - the authors (2022).

\* Statistically significant difference between feed and farmed fish groups ( $p < 0.05$ ).

The thyroid and kidney functions of the animals were not significantly modified in any of the groups (Table 4). The lipidogram showed a significant reduction in HDL cholesterol for the consumption of both farmed fish and fish from the polluted river. There was a tendency of alteration in the hepatic function, verified through the increase of GTP, but it did not reach statistical significance ( $p = 0.07$ ).

Table 4 – Biochemical parameters after one month of exposure to standard ration, farmed fish, and fish meat from the Cachoeira river.

Parameter	Feed (n = 8)	Farmed Fish (n = 8)	Fish from Cachoeira (n = 8)
TSH ( $\mu$ U/mL)	0.012 ± 0.002	0.013 ± 0.002	0.012 ± 0.001
FT4 (ng/dL)	1.442 ± 0.032	1.548 ± 0.007	1.538 ± 0.005
T3 (ng/mL)	0.462 ± 0.011	0.491 ± 0.003	0.500 ± 0.002
GOT (U/L)	245.40 ± 26.76	280.25 ± 28.01	237.00 ± 30.75
GPT (U/L)	67.00 ± 16.04	80.50 ± 15.66	102.66 ± 9.22
Total Proteins (g/dL)	5.91 ± 0.07	5.71 ± 0.19	6.04 ± 0.19

Albumin (g/dL)	2.31 ± 0.19	2.68 ± 0.09	2.64 ± 0.03
Urea (mg/dL)	49.87 ± 4.86	55.84 ± 4.56	53.87 ± 3.22
Creatinine (mg/dL)	0.73 ± 0.03	0.67 ± 0.02	0.68 ± 0.01
Uric acid (mg/dL)	1.62 ± 0.24	2.08 ± 0.26	2.00 ± 0.31
Total Cholesterol (mg/dL)	222.20 ± 12.89	207.80 ± 7.59	183.30 ± 7.01
C-HDL (mg/dL)	55.00 ± 5.99	<b>31.60 ± 2.11*</b>	<b>26.83 ± 0.70*</b>
TG (mg/dL)	171.60 ± 7.43	188.80 ± 5.11	189.40 ± 8.75
C-LDL	132.90 ± 15.89	136.00 ± 7.72	115.50 ± 7.26
C-VLDL	34.32 ± 1.48	37.77 ± 1.02	37.89 ± 1.75

Source - the authors (2022).

\* Statistically significant difference compared to the feed group ( $p < 0.05$ ).

No statistically significant differences were found between the groups for the total erythrocyte, leukocyte, or platelet count, as well as for the differential leukocyte count and other erythrogram parameters (Table 5).

While farmed fish meat samples showed no relevant modification of heavy metals content, fish meat from the Cachoeira River showed an average five-fold significant increase of  $\text{Al}^{+3}$  and  $\text{Zn}^{+2}$ . The increase in  $\text{Cr}^{+6}$  and  $\text{Cd}^{+2}$  in the meat from the Cachoeira River compared to the farmed fish did not reach statistical significance, but this does not exclude the possibility of bioaccumulation due to chronic exposure over longer periods of exposure. There was no significant difference in the amounts of  $\text{Ni}^{+2}$ ,  $\text{Pb}^{+2}$ ,  $\text{Cu}^{+2}$  and  $\text{Hg}^{+2}$  among the samples (Table 6).

Table 5 – Hematologic parameters after one month of exposure to standard ration, farmed fish, and fish meat from the Cachoeira river.

Parameter	Feed (n = 8)	Farmed fish (n = 8)	Fish from Cachoeira (n = 8)
Total leukocytes ( $\times 1000/\mu\text{L}$ )	4.76 ± 0.60	4.26 ± 0.26	4.10 ± 0.76

Segmented (%)	17.80 ± 2.17	22.00 ± 1.67	17.12 ± 1.00
Rod Cells (%)	0	0	0
Lymphocytes (%)	70.60 ± 2.15	66.16 ± 1.49	64.87 ± 1.14
Monocytes (%)	9.60 ± 0.67	9.33 ± 0.61	12.50 ± 1.06
Eosinophils (%)	2.00 ± 0.54	1.83 ± 0.83	3.25 ± 0.36
Basophils (%)	0	1.00 ± 0.25	1.00 ± 0.26
Total erythrocytes (million/mm <sup>3</sup> )	7.10 ± 0.14	7.03 ± 0.10	6.99 ± 0.09
Hemoglobin (g/dL)	14.84 ± 0.22	14.31 ± 0.43	14.52 ± 0.19
Hematocrit (%)	39.50 ± 0.51	38.61 ± 1.21	38.83 ± 0.48
MCV (fL)	55.80 ± 0.66	55.50 ± 0.61	55.50 ± 0.32
MCH (ng)	20.86 ± 0.44	20.66 ± 0.31	20.80 ± 0.19
CHCM (g/dL)	37.54 ± 0.31	37.15 ± 0.25	37.42 ± 0.20
RDW (%)	10.94 ± 0.25	10.80 ± 0.23	11.07 ± 0.12
Total platelets (x 1000/ $\mu$ L)	634.50 ± 54.43	639.00 ± 102.2	746.9 ± 31.82

Source - the authors (2022).

Table 6 – Quantity of heavy metals in fish meat from farmed fish and from the Cachoeira river

Metal (ppm)	White	Farmed Fish	Fish from Cachoeira
Al <sup>3+</sup>	16.600 ± 0.008	10.580 ± 0.073	<b>56.520 ± 0.018*</b>
Cr <sup>6+</sup>	0	1.170 ± 0.029	4.35 ± 0.007
Zn <sup>2+</sup>	0.155 ± 0.006	59.700 ± 0.002	<b>381.900 ± 0.003***</b>
Ni <sup>2+</sup>	0	0	0
Pb <sup>2+</sup>	0	0	0

Cu <sup>2+</sup>	0.014 ± 0.028	2.940 ± 0.006	3.720 ± 0.019
Cd <sup>2+</sup>	0	0	0.930 ± 0.056
Hg <sup>2+</sup>	0	0	0

Source - the authors (2022).

#### IV. DISCUSSION

In the present study, among the animals that consumed fish meat from the Cachoeira river, a significant increase in lipid peroxidation was observed in the cerebellum, liver, and plasma, and also an increase in CP in the heart and liver. A relevant reduction of SH occurred in the heart and liver. These data highlight the increased oxidative stress to which the animals were exposed by consuming fish meat with significantly higher levels of Al<sup>3+</sup> and Zn<sup>2+</sup> compared to farmed fish meat. Still, there was a decrease of SOD activity in the liver and CAT activity in the kidneys. The hepatic toxicity is remarkable, which, if considered associated with the elevation of GPT (even though it did not reach statistical significance), is not negligible considering that the exposure period was only one month.

TBARS are biomarkers of lipoperoxidation derived from the reaction of malondialdehyde with thiobarbituric acid (Keshari et al., 2015). SH groups are the largest and most frequent antioxidants in plasma and the erythrocyte membrane contains high concentration of these groups, which can be converted by oxidizing agents into disulfide agents and cause denaturation of membrane proteins, and intracellular damage can also occur, such as oxidation of hemoglobin into methemoglobin (Van Dijk et al., 2020).

CPs are formed by structural oxidative cleavage of proteins, by deamination of amino acids, such as lysine and glutamic acid, and their increase is present in conditions such as: aging, neurodegenerative diseases, obesity, diabetes, age-related macular degeneration, anemia, hepatocellular carcinoma, acquired immunodeficiency syndrome (Frijhoff et al., 2015). Due to the widespread potential for cellular damage caused by the imbalance between ROS production and antioxidant defense, the protective elements include endogenous enzymatic and non-enzymatic systems. The former includes the enzymes: SOD, which performs the dismutation of superoxide ions by accelerating their conversion to hydrogen peroxide in the mitochondria and cytosol; CAT, which converts hydrogen peroxide to water and oxygen; and GSH-Px, which is the most important H<sub>2</sub>O<sub>2</sub> scavenging enzyme using glutathione as a cofactor, and the non-enzymatic systems include ROS scavengers such as vitamins A, C, and E (Keshari et al., 2015).



$Al^{+3}$  is the third most common element in the earth's crust, has a wide variety of uses, and its concentration in beverages and food has increased because of soil acidification, which allows greater transfer of this metal to the aquatic medium, and anthropogenic activities, such as mining and industry. Diet is the main form of exposure to metals, and  $Al^{+3}$  is found in water, where it is added as a flocculant ( $Al_2(SO_4)_3$ ), processed foods, packaging, and in fresh foods (vegetables and fruit) due to its presence in the soil. Also, utensils containing  $Al^{+3}$  are responsible for its increased presence in the diet. However, it has no function in the human and animal organism and tends to accumulate in the brain, bones, liver and kidneys, so that chronic exposure can cause relevant toxicity, since  $Al^{+3}$  can: interfere with the function of calcium and replace it in bone mineralization and cell growth, as well as increase the stability of iron regulatory protein 2 (cytosolic protein that helps maintain iron level), trigger the development of Alzheimer's disease and other neurological and cognitive disorders (Hardison et al., 2017).

The pathophysiological mechanisms surrounding  $Al^{+3}$  toxicity include very basic cellular functions, such as enhancement of oxidative stress damage, which results in oxidation of proteins and lipids by free radicals (Igbokwe et al., 2019) and decreased activity of the antioxidant enzymes CAT, SOD and GSH-Px (Slaninova et al., 2014), in addition to disrupting calcium-mediated intracellular signaling, which will systematically lower cellular defenses, inhibit enzyme action, and impair mitochondrial function, thus making it a great villain of the tissues in which it accumulates, and can cause anything from anemia and hepatic or renal toxicity to neurodegenerative and reproductive diseases (Exley, 2014).

Yuan et al. (2012) found significant accumulation of  $AlCl_3$  in newborn rats exposed for 14 days intraperitoneally once a day (doses of 0.7 and 35 mg/Kg of  $AlCl_3$ ) in the cerebellum, hippocampus, and diencephalon of the animals, in addition to significant increase of TBARS and decrease of SOD activity but increase of GSH-Px activity in these regions. The authors explain that brain tissue is more susceptible to oxidative damage because it consumes more oxygen, has more polyunsaturated fatty acids in cell membranes, high iron content, and low activity of antioxidant enzymes.  $Al^{+3}$  can cause oxidative damage to the brain by binding to negatively charged phospholipids, which contain polyunsaturated fatty acids that are easy targets for ROS, stimulating iron-induced lipid peroxidation (Fenton reaction), and directly forming  $Al-O_2^-$  from the reaction of  $Al^{+3}$  with superoxide anion, which elevates the oxidative capacity of  $O_2$ .

Labbar et al. (2021) observed significant drop in CAT and SOD activity in astrocyte culture incubated with  $AlCl_3$ . In rats exposed for only three days to different doses (25, 50 and 100 mg/Kg, intraperitoneally) of  $AlCl_3$ , there was significant astrogliosis in the motor cortex and hippocampus of the animals.

Nathya & Nandhini (2014) evidenced the toxicity on the antioxidant system of  $AlCl_3$  (300 mg/Kg, orally, once a day, for 31 days) in several organs: they observed significant increase of TBARS in liver, kidney, heart, and lungs of rats, as well as drop of CAT, SOD and GSH-Px activity. Hawas et al. (2020) found that exposure to  $AlCl_3$  100 mg/Kg, orally, for 21 days (once daily) caused edema, disorganization of myofibrils and destruction of cardiac striated muscles. Liu et al. (2016) found in 5-week-old rats that  $AlCl_3$  included in the water ingested by the animals, at all doses (0.4; 0.8 and 1.6 g/L) significantly lowered GSH-Px activity, that the higher dose reduced SOD activity, and that doses of 0.8 and 1.6 g/L significantly increased the level of TBARS.

Othman et al. (2017) reaffirmed the preclinical hepatic and renal toxicity in rats (ten weeks old) that received  $AlCl_3$  (34 mg/Kg, orally) for eight weeks and resulted in significant increase in TBARS and reduced activity of CAT, SOD and GSH-Px, in addition to increasing the level of inflammatory cytokines in these organs (interleukin 1beta and tumor necrosis factor alpha). Degeneration, vacuolization, and cellular necrosis were found in the hepatocytes and apoptosis and glomeruli collapse in the kidneys, and also increased blood activity of GOT, GPT, and bilirubin concentration (biomarkers of liver function) and urea and creatinine (biomarkers of kidney function). Chary et al. (2017) observed significant drop in blood level of HDL, VLDL, and triglycerides in rats that received aqueous  $AlCl_3$  solution (50 and 100 mg/Kg, orally, once daily) for 28 days. Histological toxicity was also observed which may have contributed to lower hepatic synthesis of lipoproteins. Gaballa et al. (2013) also found significant reduction in blood HDL level in humans occupationally exposed in a factory to  $Al^{+3}$  dust between 0.33-3.4 mg/m<sup>3</sup> in air (which was still within the acceptable limit - 5 mg/m<sup>3</sup>).

The accumulation of  $Al^{+3}$  in hepatocytes may affect protein secretion and vacuolization promoting hepatosteatosis, which is the accumulation of lipids in cytoplasmic vesicles (Belaïd-Nouira et al., 2013), motivating dyslipidemia mediated by  $Al^{+3}$  toxicity in hepatocytes. In animals that consumed farmed fish meat, the drop in HDL found may be due to contaminants other than heavy metals.

$Zn^{+2}$  is an essential mineral for humans, since it acts as a cofactor for more than 300 enzymes and 200 transcription factors, besides being an important mediator of cell signaling. In the antioxidant system,  $Zn^{+2}$  protects cells against oxidative stress because it acts as a membrane stabilizer, is a cofactor for SOD and GSH-Px, inhibits the pro-oxidant enzyme, nicotinamide adenine dinucleotide phosphate oxidase, and promotes the synthesis of metallothionein, which catalyzes the reduction of hydroxyl radicals and sequesters ROS. Further,  $Zn^{+2}$  competes with iron and  $Cu^{+2}$  for binding sites on the cell membrane, preventing lipid lipoperoxidation caused by them, since it is catalytically inert (Marreiro et al., 2017).  $Zn^{+2}$  also interacts with thiol or SH groups on proteins and peptides, reducing their susceptibility to oxidation (Choi et al., 2018).

$Zn^{+2}$  is neither cytotoxic, carcinogenic, mutagenic, nor teratogenic, and intoxications with this metal are rare and primarily related to  $Cu^{+2}$  deficiency. On the other hand,  $Zn^{+2}$  deficiency presents a risk for the health of individuals, since, after iron, it is the second most prevalent trace element in the human body, and its lack is related to: growth retardation, drop in immunity, increased oxidative stress and synthesis of inflammatory cytokines, mental lethargy, cognitive impairment, symptoms of depression, and Alzheimer's disease (Jarosz et al., 2017). Still, the protective effect on rat brain oxidative stress mediated by  $Al^{+3}$  and  $Cd^{+2}$  ( $ZnCl_2$  30 and 60 mg/L in water for 60 days) and also on liver and kidneys of diabetic rats ( $ZnSO_4$  mg/Kg for 21 days) for therapeutic exposure to  $Zn^{+2}$  was described by Brzóška et al. (2021), corroborating its protective potential. However, at the intracellular level, excess free  $Zn^{+2}$  promotes the activation of protein kinase C, which leads to the production of ROS via NADPH oxidase. Mitochondria and lysosomes are  $Zn^{+2}$ -storing organelles that, when having  $Zn^{+2}$  in excess, suffer membrane permeabilization, and the release of their contents may trigger cell death, as well as the activation of the caspase-3 pathway. Hence, in excess,  $Zn^{+2}$  can become cytotoxic (Kim et al., 2020).

Singh et al. (2012) exposed rats to diet with 20, 40 and 80 mg/Kg of  $Zn^{+2}$  for 6 months and observed in blood increased TBARS, increased activity of CAT, SOD and GSH-Px enzymes, increased blood level of triglycerides, LDL, VLDL and decreased HDL for the two highest doses. These data were associated with higher concentration of  $Zn^{+2}$  and lower concentration of  $Cu^{+2}$ ,  $Mg^{+2}$  and  $Mn^{+2}$  in liver and kidney of the animals, suggesting that excess of chronic  $Zn^{+2}$  may result in change of oxidative stress by altering the level of other minerals. Taken together, these studies suggest that  $Zn^{+2}$

does not have a solely antioxidant function but may also be pro-oxidant.

Accordingly, the findings of the present study are understood, which were parallel to the toxicity mechanisms in the sites where the accumulation of  $Al^{+3}$  was sufficient to evoke increased oxidative stress (cerebellum, heart, liver, and plasma) and decreased activity of antioxidant enzymes (liver and kidney). Nonetheless, it is important to emphasize that in the present study the exposure was related to alterations linked to the consumption of fish meat in nutritionally recommended amounts and that it occurred in the second trophic level of the food chain, suggesting that oxidative stress and relevant toxicity may arise from chronic ingestion of food contaminated with heavy metals.

Reduced synthesis and secretion of erythropoietin, of heme group and globulins, inhibition of intestinal iron absorption and increased hemolysis are mechanisms that attribute anemia to  $Al^{+3}$  (Ige & Aiyeola, 2017). Nevertheless, no hematological parameters were changed in the present study, possibly due to the low exposure time. As a result of acidification of soils, soluble  $Al^{+3}$  can reach the aquatic environment easily, hence seafood is the greatest accumulator of this metal, with an average concentration of 204.6 mg/Kg having been found in sea squirts from South Korea (Choi et al., 2014), which filter water and thus accumulate more metals.  $Al^{+3}$  content is higher in algae than in fish, the former being indicators of contamination as a biomarker to monitor environmental pollution. The presence of five-fold  $Al^{+3}$  and  $Zn^{+2}$  higher in the fish meat from the Cachoeira river than in farmed fish can be attributed to the different degree of environmental pollution (the Cachoeira river receives effluents from domestic and industrial waste and factors linked to fish (species, sex, age). However, considering WHO (2011) weekly intake recommendations of 2 mg/Kg of this metal, it is noticeable that the amount contained in the fish from Cachoeira river exceeds this recommendation, making chronic exposure dangerous for children, the elderly, and renal disease patients (since the main route of elimination of  $Al^{+3}$  is urinary).

In the study by Abdelazim et al. (2018), exposure of tilapia to ZnO nanoparticles (1 and 2 mg/L) for two weeks resulted in several changes in the muscles of the fish at the oxidative stress level: the activity of the enzymes CAT, SOD, and GSH-Px was significantly decreased, as well as the expression of genes for those. There was also elevation of lipid peroxidation, and since these changes were prevented by vitamins C and E, the authors attributed the findings of increased oxidative stress to ZnO nanoparticles. In the study by Tawell et al. (2012), between 11-16 ppm  $Zn^{+2}$  was found in tilapia muscle, an

acceptable amount for human consumption. Dwivedi et al. (2015), on the other hand, found low level of  $Zn^{+2}$  contamination in tilapia muscle, but which slightly exceeded the limit for consumption. In both studies,  $Zn^{+2}$  was the most found metal in fish muscle, which converges with the findings of the present study. However, considering the maximum allowable limit for  $Zn^{+2}$  established by FAO/WHO (2006), which is 100 mg/Kg (ppm), it can be noticed that the muscle of tilapia from Cachoeira river exceeds it by more than three times.

Therefore, the fact that the changes were associated with the consumption of cooked fish meat in the present study supports the hypothesis of concern for the risk of chronic problems linked to toxicity along the food chain, which is the most important differentiator of the present study because it comes closest to the actual exposure to which the organisms are subjected.

Despite the initial toxicity being at the cellular level, in the long term, as the consumption of contaminated fish meat becomes more chronic, it is possible that it reaches systemic levels and thus incurs a greater insidious threat to public health, since the citizens of the municipality have already adopted the practice of fishing and consuming fish meat from the Cachoeira river. However, among the studies conducted on the toxicity of heavy metals in humans, these refer to occupational toxicity. As such, although the predictive power (in terms of extrapolation of pre-clinical findings to the risk to humans) is limited, the evidence that consuming meat from a polluted river may incur significant disruption of the oxidative system that may accumulate along the food chain must receive attention from the authorities in terms of strategic planning to sensitize the population to the existence of the risk, in addition to the adoption of measures to improve the quality of the water of the river.

## V. CONCLUSION

Consumption of cooked tilapia meat from the Cachoeira river for one month promoted a significant increase of ROS in the heart, cerebellum, liver, and plasma and a significant reduction of CAT activity in the liver and SOD activity in the kidney of the animals; and these changes may be related to the higher amount of  $Al^{+3}$  and  $Zn^{+2}$  present in the fish meat from the polluted river. These data suggest that chronic consumption of fish meat contaminated by environmental pollution with heavy metals has the potential for long-term health endangering toxicity that may result in clinical presentation of pathologies, as oxidative stress causes chronic and cumulative cellular damage.

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# Occurrence and type of complications associated with mandibular bilateral removable partial denture: Prospective cohort data

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**Keywords** — *removable partial denture, partially edentulous arch, mandible, complications.*

**Abstract**— *Purpose. The aim of this study was to assess the occurrence and type of complications with mandibular Kennedy Class I removable partial denture (RPD) over time. Materials and Methods. A total of 65 patients wearing mandibular free-end RPD and maxillary complete denture (CD) treated at the Department of Dentistry of Federal University of Rio Grande do Norte (UFRN) were evaluated. The tests were conducted after 2, 6 and 12 months. Annual follow-up was also accomplished after the 12-month evaluation. Complications or failures were recorded in a specific clinical report over 39 months. The failures were classified as: ulceration after 2 months of denture insertion, loss of retention, fracture or caries in rest seat, fracture or displacement of artificial teeth, fracture of a major connector, fracture of a clasp, fracture of the rest, relining and fracture of the denture. Results. Low complication rate was reported and most of the cases occurred after 2 years of denture insertion. Loss of retention was the most common complication (31.57%). Fracture of the metallic framework components was not a frequent occurrence and only one patient reported a fracture of a major connector (5.3%). Conclusion. The treatment with mandibular free-end RPD showed low failure rates after 39 months of periodical follow-up.*

## I. INTRODUCTION

Free-end removable partial dentures (RPDs) have a dual support system (teeth and fibromucosa) with different resilience, anatomical characteristics and transfer of masticatory loads.<sup>1</sup> Therefore, this type of denture is

associated with biomechanical problems (retention and stability) that compromise masticatory efficiency.<sup>2</sup> Also, its limited functional and aesthetic properties,<sup>3</sup> as well as its relatively high complication rates<sup>4-6</sup> may explain the discomfort and dissatisfaction reported by patients.<sup>7,8</sup>

For these reasons, some patients rehabilitated with RPD do not regularly wear their dentures, and clinicians need to consider different treatment alternatives, such as dental implants. However, the presence of bone defects at the implantation location or limitation of height and bone thickness limits the installation of conventional implants, which can be circumvented by solutions such as: short implants,<sup>9</sup> preliminary bone reconstruction of the edentulous mandible, through the combination of bone substitutes with autologous mesenchymal stem cells or autologous bone graft<sup>10-12</sup> or bone substitutes of animal, human or synthetic origin used alone,<sup>13</sup> as well as implant-supported removable and fixed partial dentures.<sup>1</sup>

The performance of alternative treatments is associated with high cost, treatment time and even postoperative morbidity. That said, conventional DPR's are an economical and easy treatment modality for partially edentulous patients and are still widely used.<sup>14</sup> Some clinical trials reported the occurrence and type of prosthetic complications for different removable partial denture (PPR) designs.<sup>8,15,16</sup> It was observed that loss of retention, presence of ulcers, increased vertical dimension, inadequate centric relationships,<sup>8</sup> as well as aesthetic and phonetic problems, chewing pain, gag reflex<sup>16</sup> and fracture of artificial teeth and/or prosthesis<sup>15</sup> are the main complications associated with PPR's.

Most of the reported failures are recurrent from the destructive action of poorly designed and manufactured prostheses, considering that most clinicians delegate planning to technicians and, when they do so, commonly disregard the planning principles for tooth-mucosal-supported removable prostheses (REF).<sup>8</sup> For these reasons, when planned according to the biomechanical principles of performance of this type of prostheses, followed by regular follow-up visits to the dentist, they can minimize the complications normally associated with them and demonstrate long-term success. Although some studies<sup>6,15,17,18</sup> have evaluated factors related to treatment success, there is a lack of data on the characteristics that influence the prognosis and the occurrence of complications or technical and mechanical failures in Kennedy Class I RPDs. Therefore, considering the lack of evidence on the prognosis of RPD with tooth-mucosal support, the aim of this study was to assess the occurrence and type of failures and complications with Kennedy Class I mandibular RPD.

## II. MATERIALS AND METHODS

### *Study design*

This individualized, observational and longitudinal cohort study was carried out at the

Department of Dentistry of the Federal University of Rio Grande do Norte (UFRN), which was approved by the Research Ethics Committee (CEP-UFRN/protocol 60244) and by the Brazilian Registry of Clinical Trials (RBR-8fs5ww protocol), in addition to having followed the recommendations of the 1975 Declaration of Helsinki (revised August 26, 2018). The guidelines of the Report of Observational Studies in Epidemiology (STROBE)<sup>19</sup> were followed to carry out this study.

The sample was calculated using the OpenEpi software using the results of a previous study authored by Bilhan, et al. (2012),<sup>8</sup> which evaluated the frequency and type of prosthetic complications in relation to the type of prosthesis. Fourteen (66.7%) of the patients rehabilitated with a complete upper denture and a lower removable partial denture (n=21) had loss of denture retention. Therefore, 7 (n=21) patients showed no loss of retention of their dentures, that is, 33.3% (not exposed) and 66.7% (exposed). A significance level and a power of 95% (1-beta, % of detection probability) of 80% were considered, totaling 41 patients.

### *Population*

The sample was non-probabilistic and voluntary, composed of 65 patients, with a mean age of 53.9 years, users of upper conventional total dentures and bilateral free extremity lower removable partial dentures, of both genders, with a good health status, or general health rehabilitated in the clinics of the Department of Dentistry at UFRN. In addition, according to the individualized clinical examination for each patient, they should present the ridge in the posterior region of the mandible classified as resorbed.

Patients with any systemic health deficiency were excluded, as well as those who met the inclusion criteria, but did not sign the free and informed consent form, considered essential for inclusion in the study.

### *Fabrication of removable partial dentures (RPD)*

Initially, patients underwent anamnesis (intraoral and extraoral clinical examination) to assess their general health status, history and expectation with treatment, as well as soft tissue conditions, ridge height, type of mucosa, in addition to radiographs, intraoral implants of the abutment teeth for the prosthesis.

Afterwards, a preliminary image of the mandibular arch was performed (Jeltrate, Dentsply, Brazil), followed by the continuation of the study model, whose study was carried out using a parallelometer (Bio-art) regarding the lack of retentive areas and/or absence of retentive areas and guide planes on the abutment teeth of the RPD for, later, the mouth preparation. Then, the

prepared arches were molded again to the working models, and using the parallelometer, it was then sent to the laboratory for the fabrication of the structure.

The metallic structure was tested in the mouth, observing its insertion and removal, and the total seating of the supports on the niches. Then, the impression technique of the altered model was carried out, whose metallic structure was positioned on the working model to obtain an acrylic tray (Dencor, Rio Branco, Brazil) in the region corresponding to the prosthetic space. Afterwards, the tray was adjusted in the mouth, followed by peripheral molding with low-melting compound (Exata, DFL Indústria e Comércio Ltda, Brazil) and body molding with polyether (ImpregumTMSoft, 3M ESPE, Germany) to obtain the functional model. Based on this, the test base and wax plane were made, adjusted in the mouth and then the maxillomandibular registration was performed in the central position and mounted in a semi-adjustable articulator (Bio-art, Brazil). The artificial teeth (Biotone, Dentsply, Brazil) were mounted, followed by the clinical trial and conventional workflow for acrylization of the denture base. After acrylization, the model was reassembled in an articulator for occlusal adjustment of the prosthesis.

At the time of prosthesis installation, stability, retention, possible areas of understanding and occlusion were evaluated. All patients were instructed on hygiene procedures and prosthesis care.<sup>20</sup>

#### *Presence of traumatic ulcers after two months of RPD installation*

The integrity of the fibromucosa was evaluated in the periodic control sessions by a single evaluator. After the installation of removable partial dentures, controls were performed at 24 hours, 7, 15, 30 and 60 days, and 6 months, with the aim of identifying the occurrence of whitish traumatic ulcers, with small dimensions and well-defined flat edges with an erythematous halo.<sup>21,22</sup>

#### *Occurrence of prosthetic failures and complications*

To assess the occurrence of complications related to the lower removable partial denture, the patients were followed up over time, through the determination of periodic returns for control and maintenance of the prostheses, and all the information collected in these consultations was recorded in the clinical record of each patient. Controls for the evaluation of complications took place at predetermined times, which were: 2, 6, 12, 24, 36 and 41 months after the installation of the prostheses.

Complications were classified into 9 categories: ulceration, loss of retention, fracture or caries in rest seat, fracture or displacement of artificial teeth, fracture of the

major connector, fracture of the clasp, fracture of the rest, inefficient support (denture relining), and fracture of the denture. Each category was subdivided into “presence” or “absence” of complications.

An independent professional, different from the one who performed the prosthetic rehabilitation, performed the data collection with the objective of making the patient comfortable and to report any type of intercurrent in the follow-up sessions. Repairs were made if any complications were observed. The complexity of each failure was evaluated according to its influence on treatment prognosis and reparability. New prostheses were manufactured in cases of serious failure. Repairable cases were kept in the original sample, while cases that required the fabrication of new prostheses were excluded from the next follow-up.

#### *Statistical analysis*

Variables were described as numbers and proportions of frequency and type of complications, from the 2-month follow-up after mandibular PPR insertion.

### **III. RESULTS**

Initially, 70 patients were included in the study. After loss of data of 5 individuals, the sample was composed by 65 patients wearing mandibular Kennedy Class I RPD and maxillary CD (mean age of 53.9 years, comprised of 8 men-12.3%, and 57 women-87.7%).

Table 1 shows data about the occurrence and distribution of complications within the failure criteria during 39 months.

At the 2-month follow-up, ulceration was the only complication observed among 53 patients (5.66%). No complications were found in the remaining sample.

In the evaluation after 6 and 12 months, RPD complications were loss of retention (n=2), inefficient support (n=1), and severe fracture of the denture (n=1). The highest failure rate was observed after 2 and 3 years of denture insertion (Table 1). After the 2-year follow-up, loss of RPD retention was the most common prosthetic complication reported. However, this failure is not catastrophic as composite resin can be added to restore the retentive area. In general, 19 complications were reported, including ulceration (31.57%) and loss of retention (31.57%) as the most representative failure patterns.

Actuarial method was used to calculate cumulative survival, which represents denture reliability without occurrence of complications (Fig. 1).

The cumulative survival should be represented in percentage (i.e., 1.0 means 100% of cumulative survival). The length of time of RPD wearing was shown in periods: period 0 (baseline), 1–12-month follow-up, 2–24 month

follow-up, 3–36 month follow-up, and 4 – to more than 36 months. The cumulative survival was 66% at the end of the analysis (period 4). This data does not represent the number of patients wearing dentures, but that the probability of denture wearing without complications

during this period was over 60% within the conditions of this study.

A total of 5 patients were excluded from the study and stopped wearing the RPD because of abutment fracture and denture loss. No patient stopped wearing RPD due to problems with adaptation to the treatment.

*Table 1. Distribution of occurrence and type of complications with mandibular Kennedy Class I removable partial denture of each patient (n=65) during 39 months of follow-up. Absolut values (n).*

RPD complications	Time length between denture insertion and follow-up				
	2 months (53 patients)	From 6 to 12 months (48 patients)	From 13 to 24 months (65 patients)	25 months and over (65 patients)	Total of complications for each type
	n (%)	n (%)	n (%)	n (%)	n (%)
Ulceration	3 (5.66%)	3 (6.25%)	0 (0%)	0 (0%)	6 (31.57%)
Loss of retention	0 (0%)	0 (0%)	2 (3.07%)	4 (6.15%)	6 (31.57%)
Fracture or caries in rest seat	0 (0%)	1 (2.08%)	0 (0%)	0 (0%)	1 (5.3%)
Fracture or displacement of artificial teeth	0 (0%)	0 (0%)	0 (0%)	2 (3.07%)	2 (10.5%)
Fracture of major connector	0 (0%)	0 (0%)	0 (0%)	1 (1.53%)	1 (5.3%)
Fracture of clasp (retention or opposition)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Fracture of rest	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Inefficient support	0 (0%)	1 (2.08%)	1 (1.53%)	0 (0%)	2 (10.5%)
Fracture of denture	0 (0%)	0 (0%)	1 (1.53%)	0 (0%)	1 (5.3%)
<b>Total</b>	<b>3 (5.66%)</b>	<b>5 (10.41%)</b>	<b>4 (6.13%)</b>	<b>7 (10.75%)</b>	<b>19 (100%)</b>

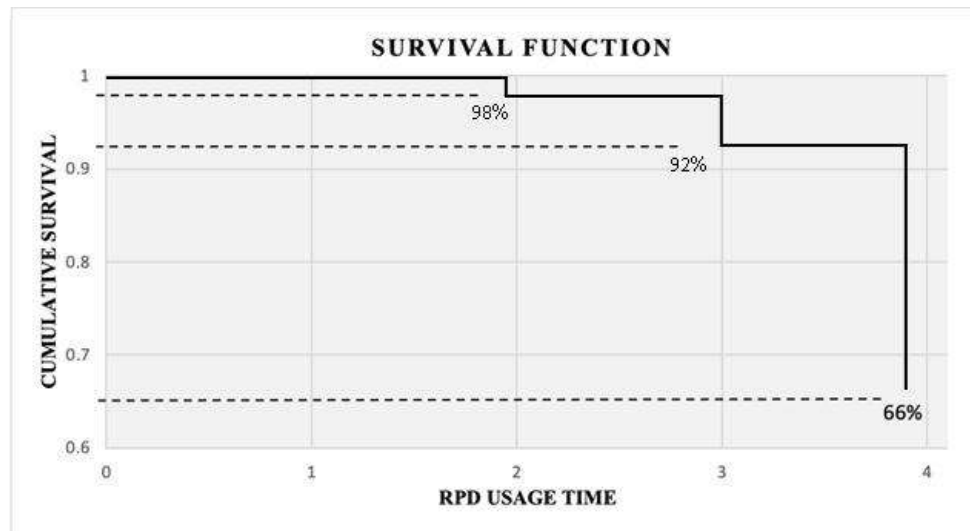


Fig.1. Cumulative survival, denture reliability without occurrence of complications (actuarial method).

#### IV. DISCUSSION

Despite the functional limitations inherent to a dentomucosal-supported mandibular removable prosthesis, in the present study, treatment with Kennedy class I free-end RPD had a low failure rate after 39 months of periodic follow-ups. Therefore, it is advantageous, especially when a minimally invasive and low-cost treatment is required.

Knowing that mandibular tooth-mucosal prostheses are more technically sensitive, we justify the good performance of the prostheses accompanied in this study by the rigor in the fulfillment of all clinical steps, from the initial planning, preparation of the abutment elements, functional molding, clinical tests, and the follow-up after installation. The laboratory steps were also strictly followed and as a differential, we highlight the reassembly in an articulator for occlusal adjustment after acrylicization.<sup>20</sup>

Among the complications found, loss of retention and the presence of ulcers were the most common. Traumatic ulcers are characterized by ulcerations, usually of small dimensions, well delimited, surrounded by an erythematous halo, without elevations of the margins and with a whitish color.<sup>21,22</sup> The lack of integrity of the fibromucosa at the first moment after the installation of new prostheses is relatively common, due to the initial period of adaptation of the patients. However, after the initial stage of the adaptation has passed, the patient's oral conditions, regarding the appearance of areas of redness or lesions, should become stable, no longer bothering the patient, with greater comfort over time. The presence of traumatic ulcers is associated after the initial period of adaptation to the biomechanical characteristics related to the partial free extremity denture, due to the difference in

resilience between the periodontal ligament of the abutment teeth and the fibromucosa.<sup>1</sup>

In the present study, there was a low percentage of occurrence of ulcers after the initial adaptation period (2nd month of prosthesis use). Among the clinical steps, we believe that the functional impression played a fundamental role, as it aims to extend the prosthesis within the limits of the patchable area and allow intimate contact between the base of the prosthesis and the fibromucosa.<sup>23</sup> It is also important to assess the need to relines in the control sessions, since the installation of a free-end prosthesis increases the tendency for an imbalance in the ridge resorption process due to the power arm, represented by the prosthesis base, being in most cases, larger than the resistance arm, represented by the segment of teeth remaining in the arch. Thus, no matter how stable the prosthesis is, there will always be greater compression at the distal end and thus resorption occurs in an increasing way from the mesial to the distal.<sup>24</sup> In these cases, relining the PPR may be indicated, as observed in two patients, with 3 and 4 years, respectively, of using the prosthesis.

Another factor that negatively influences the use of the prosthesis is the loss of retention, which can discourage the use of the prosthesis, as well as to make it not correctly perform the functions assigned to it as a rehabilitative treatment option. To fabricate the dentures for the patients in this research, in the design stage, the retention clips were properly planned in appropriate retentive areas, and in the absence, they were made in composite resin in the mouth preparation stage. However, there may be other factors potentially related to this type of failure, such as the lever movement at the free end and the possibility of deformation of the retaining clip, as well as wear of the retaining area over time.<sup>24</sup> Thus, we justify the



loss of retention observed only after the 13th month of prosthesis installation.

Regarding the integrity of the abutment teeth, during the follow-up period of the present study, the occurrence of caries under the previously prepared niche was not recorded and the niche fracture was observed only in one abutment element. Although abutment teeth are more susceptible to caries and periodontal problems than other teeth due to the fact that the components of the PPR structure around them facilitate the accumulation of dental biofilm,<sup>25</sup> we believe that oral hygiene guidelines and periodic controls after installation acted preventively. These data emphasize the importance of periodic check-ups for the longevity of the prosthesis and preservation of biological support elements.<sup>27</sup>

Regarding the integrity of the prosthesis, the detachment of artificial teeth from the PPR occurred infrequently. This type of failure is related, among other factors, to laboratory procedures for fabrication of the prosthesis as well as the type of artificial tooth used, regardless of the type of prosthesis.<sup>27</sup> According to Koyama et al. (2010)<sup>28</sup> in addition to planning the prosthesis, the quality of the material is also a factor that will have an impact on the prognosis of the treatment. Thus, the quality of artificial teeth is another factor that interferes in this type of technical failure. Adequate control of the occlusion should also be considered in this case, as it will avoid the occurrence of excessive forces on isolated teeth, as well as provide better direction of the forces generated during masticatory efforts.

Fracture of the metallic structure was also infrequent, with only one case of fracture of the greater connection being recorded, as observed in the study by Saito et al. (2002).<sup>27</sup> We emphasize the importance of respecting the steps of fabricating the metallic structure, from the design characteristics to the methods of making, finishing and polishing.<sup>29</sup> Lewis (1978)<sup>30</sup> examined 45 fractures in connectors larger than 41 PPRs that had been damaged. In 13 sites, failures were related to low fatigue strength, indicating possible problems during laboratory fabrication, which did not occur in the present study. In addition, the fracture of the prosthesis can also be related to the incorrect handling of the prosthesis by the patient themselves.

The collected data were analyzed considering a sample of 65 patients. It is considered this is a reasonably relevant sample, considering the fact that the group is quite homogeneous regarding the conditions of edentulism and rehabilitation treatment, including the antagonist arch target of the investigation. One of the limitations of this study is related to the respondent's memory bias, in this

case the patients. Because of this, it was not possible to accurately determine the period in which the complication occurred.

The results may vary in the general population that uses removable partial dentures and to increase the generalizability of the results of this study, more research in different centers and with a greater number of cases is necessary. However, the relevance of the present research is highlighted in view of the absence of prospective studies that assess the complications of prosthetic treatment with this type of patient and with a similar sample.

The removable partial denture is a treatment alternative widely indicated for the rehabilitation of partially edentulous patients, since the literature has suggested it as a safe, versatile, conservative, reversible and relatively low-cost option.<sup>31-33</sup> However, it is important to consider that the biomechanical behavior, the success or failure of this treatment will also depend on the quality of the planning and construction of the metallic structure and the prosthesis as a whole.<sup>33</sup>

Despite the limitations of free-end mandibular PPR, it was observed that even after almost 4 years after its installation, patients continue to use the prostheses and the occurrence of prosthetic complications was relatively low, with an accumulated survival of 66% after more than 36 months of use of the prosthesis. The probability of not having any complications during this period was considered high. Periodic return of patients for control and maintenance of prostheses can be considered a great alternative to prevent the existence of such complications.

## V. CONCLUSION

Treatment with mandibular free-end removable partial dentures showed low failure rate after 39-months of periodical follow-up.

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## Food Consumption and Anthropometric Evaluation of Students in Elementary School: Literature Review

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**Keywords** —Food Consumption, Nutritional  
Assessment, Nutritional Status,  
Schoolchildren, School Health.

**Abstract**—Food presents as a vital necessity, necessary for the conservation of life and well-being of individuals. This process is considered a basic requirement for health promotion, contributing to human growth and development with quality. Healthy food is one that keeps the body in a state of health, when it prioritizes adequate food, in quantities and quality, at the right times, and that contains varied nutrients to achieve satisfactory benefits for the health of the body and thus contribute to the acquisition of quality of life (BUSATO et al., 2021). The objective of this work was to discuss the main factors associated with Food Consumption and Nutritional Status of schoolchildren, based on a critical review on the subject. To review the topic, the following databases were consulted: BIREME and CAPES journal, covering the period from 2018 to 2021. The descriptors used in the search were: "food consumption", "nutritional assessment", "nutritional status," "school" and "school health". The research results indicate, through the analysis of the scientific literature, a low consumption of in natura and healthy foods among schoolchildren, in addition to the high consumption of processed and ultra-processed foods, resulting in changes in the nutritional status and consequently in the health of the investigated population, with the presence of overweight and obesity, dyslipidemia and increased blood glucose, predisposing factors for cardiovascular diseases. Thus emphasizing the importance of the debate on the subject in future research.

### I. INTRODUCTION

Food presents as a vital necessity, necessary for the conservation of life and well-being of individuals. This process is considered a basic requirement for health

promotion, contributing to human growth and development with quality. Healthy food is one that keeps the body in a state of health, when it prioritizes adequate food, in quantities and quality, at the right times, and that contains varied nutrients to achieve satisfactory benefits

for the health of the body and thus contribute to the acquisition of life quality[1].

With the beginning of school life, the child becomes susceptible to the influences of dietary patterns. In this sense, it is worth mentioning that this is one of the most important phases for the formation of eating habits and behaviors of the little ones, which can last throughout adult life. In the last decade, studies carried out on food consumption in the school environment have revealed a high consumption of foods with low nutritional value (sweets) and high energy density (rich in low value-added carbohydrates), whether these foods are purchased in school canteens, or even , taken from home to be consumed at school [2].

Each child grows and develops from different standards, in this sense; the assessment of nutritional status is one of the most effective instruments to help identify nutritional disorders in all life cycles, being closely linked to ingestion, absorption, use and excretion of nutrients [3]. Thus, when food consumption is inadequate and/or insufficient to meet the needs of each individual, so-called nutritional deficiency can be triggered, such as protein energy malnutrition, overweight and obesity.

Seeking to observe the conjunctures of the current scenario regarding the topic addressed, the work aims to investigate in the available literature articles from the last five years that address the theme "food consumption and anthropometric assessment of elementary school students".

## II. METHODOLOGY

### 2.2 Type of study

This is a qualitative, exploratory study, applying the rules of a bibliographic review.

#### 2.2.1 Study Period

A literature review was carried out through an investigation of articles available in electronic media and published in the period of five years (2018 to 2021). Data collection took place from December 2021 to January 2022.

#### 2.2.2 Sampling

The samples were collected from the academic database BIREME and the CAPES journal using the descriptors: food consumption, nutritional assessment, nutritional status, schoolchildren and school health. The

AND connective was applied between the descriptors. After this selection, there was the moment of analysis, through selective reading of the articles related to the research topic and they were judged according to the research objectives. The chosen language was Portuguese.

#### 2.2.3 Inclusion Criteria

Completed articles were included in this work, which investigated the specific topic addressed in this research, on food consumption and anthropometric assessment of elementary school students.

#### 2.2.4 Exclusion Criteria

Duplicate articles, dissertations, non-indexed publications, theses and monographs were excluded from the research.

#### 2.2.5 Ethical aspects

This research uses the norms of a literature review, and in the approach of ethical aspects, it exempts the submission to the evaluation of the Research Ethics Committee in accordance with Resolution 466/12 of the National Health Council (CNS). However, all established ethical precepts will be considered to ensure the legality of information, privacy and data confidentiality.

#### 2.2.6 Data collection and analysis

After reading the selected articles, the data for the work were obtained, following a synchronized, ordered and divided methodology. Initially, the selection of articles was made, followed by a structured organization highlighting the most relevant points that were addressed in the work and finally the separation and assembly of the final Excel was carried out, with the most relevant results.

#### 2.2.7 Financing

The study received no funding; all costs were borne by the researchers.

#### 2.2.8 Conflict of interests

The authors declare no conflict of interest.

## III. RESULTS AND DISCUSSION

Table 1 represents the summary of the analyzed articles.

Table 1 – Summary of the articles

Year	Author	Title	Aim	Results	Conclusion
2018	PAIVA, A. C. T. <i>et al.</i> [4]	Childhood Obesity: Anthropometric, biochemical, food and lifestyle analysis.	To identify changes in BMI in schoolchildren in the city of Poços de Caldas - MG - BR, aged between 6 and 12 years, in addition to evaluating biochemical analyses, anthropometric data and dietary pattern.	The results showed a significant increase in food intake from the sugar group.	It is an important study in the area in order to map and improve the nutritional profile to reduce the risks to which children are exposed.
2018	SCHISLER, C.; PERETTI, G; BARATTI, L. [5]	Nutritional status and food adequacy of children in a school in the city of São Jorge d'Oeste - PR.	To trace the nutritional profile of schoolchildren and verify the adequacy of energy, proteins, calcium and iron of the school lunch in the morning and afternoon, verifying if they reach the recommendations of the FNDE.	The children included in the study were evaluated grouped by sex (36 females and 41 males). No significant differences were observed between the groups in terms of nutritional status.	The results showed the majority of schoolchildren in adequate nutritional status, however, the foods offered do not meet the nutrient recommendations.
2019	DA SILVA, K. M; SILVA, K. L. G. D; SANTOS, M. M. D.[3]	Assessment of nutritional status and food consumption of preschoolers and schoolchildren residing in Caetés-PE	To evaluate the nutritional status, food consumption and socioeconomic level of children attending the public school system in the city of Caetés - PE.	Most children had a low intake of fruits, vegetables, legumes, offal, milk and dairy products. The analysis of the socioeconomic profile pointed to a context of social vulnerability, due to the large number of parents with low education and unemployed.	There was a relevant association between physical inactivity, poor diet quality and high rate of excess weight. Therefore, it is necessary to promote strategies that stop the obesogenic factors found, as they favor the emergence of clinical and nutritional disorders.
2019	CORDEIRO, M. C. <i>et al.</i> [6]	Food habits consumption of ultra-processed foods and its	To evaluate the eating habits, the consumption of ultra-processed	The occurrence of overweight/obesity in schoolchildren was highlighted,	It was found that although there was a high consumption of ultra-processed foods, no



		correlation with the nutritional status of schoolchildren in the private network.	foods and their correlation with the nutritional status of schoolchildren from the private network in Teresina - PI.	with excess abdominal adiposity, a factor that indicates risk for cardiovascular diseases.	significant relationships were found between nutritional status and consumption of these foods.
2019	ROSSI, C. E. <i>et al.</i> [2]	Factors associated with food consumption at school and overweight/obesity in schoolchildren aged 7-10 years in Santa Catarina, Brazil.	To investigate the association between the origin of snacks consumed at school, their nutritional value and overweight/obesity.	The research results showed that students from the private network consumed snacks of high nutritional value with significantly higher frequency than students from the public network.	The results show not only the need to expand legislative measures in order to minimize the availability of risky foods in school canteens nationwide, as well as the greater availability/consumption of healthy foods in canteens.
2019	BATALHA, T. B. <i>et al.</i> [7]	Nutritional status and food profile of a female Futsal school team in the city of Caxias do Sul - RS.	To evaluate the nutritional status and food profile of a futsal school team in the city of Caxias do Sul.	The schoolchildren were well-nourished, according to waist circumference, and were not at risk for cardiovascular disease. The percentage of fat was adequate and the athletes have good eating habits, although the associations between the variables studied were not statistically significant.	The research findings showed that the players studied have a balanced diet with a high consumption of vegetables, but also consume candies, breads and pasta with some regularity.
2019	MELO, A. P. R <i>et al.</i> [8]	Nutritional status, eating habits and oral health in a group of schoolchildren.	To investigate the nutritional status, eating habits, caries experience and oral hygiene practices in a group of schoolchildren.	Of the children evaluated, 25% were overweight and 3.5% were underweight. Regarding food consumption, there was a high frequency of ultra-processed foods and sugars.	The findings showed that the nutritional status did not present satisfactory results, showing to be in disagreement with the current guidelines and recommendations of the World Health Organization.
2020	CESAR, J.	Adherence to school meals and	To analyze the rate of adherence	The results showed that the rate of	The findings indicate that the low rate of adherence to

	T. <i>et al.</i> [9]	associated factors in adolescents from public schools in the southern region of Brazil.	to school meals and associated factors in adolescents enrolled in state public schools in the city of Lapa, Paraná, southern Brazil.	adherence to school meals, regardless of the frequency of consumption, was 70.9%, it is observed that the effective adherence rate, four to five times a week, was also higher among adolescents enrolled in a school in the rural area (30.1%).	school meals, in attendance is not being reached. The mentioned factors can help to improve the execution of the program.
2021	OLIVEIRA, R. R; PETER, N. B; MUNIZ, L. C. [10]	Food consumption according to the degree of processing among adolescents in the rural area of a municipality in southern Brazil.	To evaluate food consumption according to the degree of processing and nutrient intake among adolescents in the rural area of Pelotas - RS.	The research results indicate that the average daily consumption was 1,921 calories, 48.2% from natural or minimally processed foods and 31.9% from ultra-processed foods.	The findings of the study indicate that adolescents in rural areas have a higher energy intake from the consumption of in natura or minimally processed foods, even though ultra-processed foods are also part of their diet, demonstrating the nutritional transition.
2021	FERREIRA, C. S. e ANDRADE, F. B [11]	Socioeconomic inequalities associated with overweight and sedentary lifestyle in Brazilian adolescents.	To estimate the prevalence of overweight and physical inactivity in Brazilian schoolchildren aged between 13 and 17 years, and to investigate the magnitude of socioeconomic inequalities related to these outcomes.	The prevalence of overweight in Brazil was 24.2%, ranging from 20.7% in the Northeast region to 27.8% in the South region. The prevalence of sedentary lifestyle in Brazil was 67.8%, ranging from 61.8% in the North region to 70.3% in the Southeast region.	Those in this research point out that it is necessary to restructure and strengthen existing public policies that include adolescents, such as: PNAE and PSE, in order to improve a healthy lifestyle and reduce inequalities.
2021	BEZERRA, M. K. A. <i>et al.</i> [12]	Lifestyle of adolescent students from public and private schools in Recife: ERICA.	To analyze lifestyle-related behaviors of adolescents in Recife, Brazil.	In the research, it was possible to notice that 60% of the adolescents had inappropriate eating behaviors, and ended up	As a result, this research shows that adolescents in Recife have a low frequency of health protection eating behaviors and regular practice of physical activity.

				having breakfast, water/day and meals in front of the TV, around 40% did not have meals with their responsible parents.	
2021	CARVALH O, M. J. L. N. et al. [13]	Perception of above-ideal body weight, anthropometric profile and lifestyle in adolescents from Recife, PE, Brazil.	To analyze the perception of above-ideal body weight in adolescents from Recife/PE and its association with anthropometric profile and lifestyle.	Weight perception was answered by 48.8% of adolescents, of which 36.8% and 63.2% perceived themselves as underweight and overweight, respectively.	The data found in this research suggest that there is an association between the perception of body weight above the ideal and the sociodemographic, anthropometric and lifestyle factors of adolescents aged 12 to 17 years in the city of Recife.

**Fonte:** Authors, 2022.

### 3.1 Assessment of food consumption

Melo et al. [8] demonstrated in their research that 27% of their total sample was not in the habit of ingesting fruits and vegetables; this consumption profile contributes to changes in nutritional status, since these foods are rich in fiber and nutrients, and are linked to increased satiety. Similarly to what was observed in this research, Silva et al. [14] in their study on nutritional assessment and food consumption in schoolchildren aged 10 to 14 years, found that the intake of fruits, vegetables, milk and dairy products was below the recommended, and such factors were correlated with socioeconomic characteristics and favorable eating habits; food with products with more accessible prices, being considered nutritionally inadequate. Similarly, Spinelli et al. [15] observed that adequate intake of fruits and vegetables is related to lower BMI values, thus suggesting that both the energy value of the food consumed and the quality of the diet offered will contribute to body weight control, and in the condition adequate health of the individual.

Also in this sense, the results found by Melo et al. [8] of overweight schoolchildren are similar to the study by Henrique et al. [16], in which 105 children participated, of which 28.8% were overweight, data similar to those found in the study. Regarding eating habits Henrique et al. [16], through the food frequency questionnaire, observed that the students had a monthly food consumption of stuffed cookies (62.8%) and sweets (28.6%), similar to that observed in the study. Lopes et al. [17], points out in their study a high consumption of cakes, stuffed cookies,

soft drinks and sugars that are identified as cariogenic foods. The study by Carteri et al. [18], in which 50 children were part of the studied sample, in which the prevalence of caries was 46% and 24% of the children had at least one tooth with untreated caries. In summary, it was possible to observe that schoolchildren have worrying levels of poor eating habits, overweight and compromised oral health.

In the research by Schissler et al. [5], the example of inadequate nutrition can be observed, in which the results of the study with schoolchildren showed the amount of calcium below the recommended range, with only 53.37% of the indicated total being consumed in the afternoon and 50, 92% in the morning, and it was found that values consumed in the present study are below the recommended, such results can promote a series of nutritional deviations and cause changes in health. Similarly, Verly-Junior et al. [19], observed in their study on school menus that the amount of calcium was not achieved in inflexible meal models, that is, which did not allow adjustments, in menus with 30% of the RDI, it was easily possible to supply 60% of the need for these nutrients, on the menus with 20% of the RDI, this fact was more difficult. It is not enough just to introduce these foods into the diet, it is necessary that they are consumed in adequate quantity and frequency.

### 3.2 School Meals

Cesar et al. [9] in their research with adolescents enrolled in state public schools in the municipality of Lapa, Paraná, southern Brazil, which includes 5 urban and

5 rural schools in the municipality, observed that the rate of adherence to school meals was high (70.0 %) according to the classification proposed by Sturion [9], mainly among schools in rural areas. Similarly, it was possible to observe in the study by Ferro et al. [20] (2019), where 41 students were analyzed, in a school in the interior of São Paulo, and in which it was possible to verify that 70.7% of the total of the evaluated children consumed in the canteen daily, in addition, the snacks eaten were mostly composed of processed and high-calorie foods, which may be related to the low variety of healthy foods sold in the canteen and the high supply of low-nutrition products available for this public to access, such as: industrialized beverages (juices and soft drinks); stuffed dumplings; chips; chocolates and sweets, among others.

Likewise, the work by Rossi et al. [2] presented results of an investigation into the association between the origin of snacks consumed at school, their nutritional value and overweight/obesity. As a result, it was noticed in the study that overweight/obesity was associated with the consumption of food from canteens in the private network. And the fact that students brought food from home was associated with a higher consumption of snacks of low nutritional value in public schools. Equivalently, Melim et al. [21] in their research on the eating habits of students in the metropolitan region of Rio de Janeiro, it can be observed that there was a greater consumption of carbohydrate foods such as cookies and bread for breakfast, mainly; such habits were also reflected in the other meals with the consumption of hypercaloric and unhealthy foods.

### 3.3 Consumption of ultra-processed foods

The results of the work by Oliveira et al. [10] with the rural school community, in the city of Pelotas-RS, showed that even in the rural area, where the availability of natural food is greater, industrialized products become more accessible to adolescents, who integrate them into their daily consumption. Furthermore, a lower contribution of fruits and vegetables to daily caloric intake was observed. Likewise, in their study Valença et al. [22], when investigating the influences and preferences in the food consumption of ultra-processed foods in rural areas, could see that the factor that most influences the food preferences of their target population was the taste of food, in which this was formed since early childhood. In this sense, the school must work on Food and Nutrition Education in a present way since the first cycles of education, in order to minimize the impacts on the health of individuals over time.

In their research, Cordeiro et al. [6] evaluated the percentage of consumption of ultra-processed foods by

children from a private school in Teresina-PI. The results showed expressive percentages of consumption of ultra-processed foods, and highlighted that most of the caloric intake of these children is composed of high glycemic index carbohydrates and total fat. Similarly, Andretta et al. [23] in their study on food consumption of ultra-processed foods observed a high percentage of consumption of ultra-processed foods in schoolchildren aged 6 to 16 years enrolled in schools in the municipal education network of Caxias do Sul-RS. This fact highlights the need to promote preventive health programs aimed at informing schoolchildren, parents and guardians about healthy eating. Likewise, the results of the study by Landim et al. [24], were similar to the findings in the research on the food consumption of ultra-processed foods in schoolchildren, in which a high intake of ultra-processed foods was observed, making it possible to correlate these results with the overweight and obesity presented, as well as a greater susceptibility to risk of cardiovascular disease.

### 3.4 Nutritional status of schoolchildren

In a research on the assessment of the nutritional status and food profile of a school team of futsal players, carried out by Batalha et al. [7], the results showed that more than 90% of schoolchildren were classified as eutrophic. Even with a high consumption of carbohydrates and industrialized products, the adolescents managed to maintain an adequate weight and BMI within the eutrophic classification. Still in this context, in a study proposed by Silva et al. [25], responsible for evaluating the nutritional composition of school meals in a state school in Paraná, it was possible to observe that 66.88% were eutrophic, and to a lesser extent 31.17 % were overweight. Similar to this study, Conceição et al. [26] in their study that addressed food consumption in schoolchildren from public and private schools in the city of São Luís do Maranhão, found that there was insufficient consumption in 66.3% of the students participating in the study, however, 30, 1% had high consumption. In this context, it is important to emphasize the relevance of good eating practices in the school environment.

In the research by Carvalho et al. [13], who worked with schoolchildren enrolled in the public and private school system in the city of Recife, and addressed the perception of body weight, it was highlighted that more than 50% of the participants reported a different body image from the ideal, and, most respondents reported being overweight or very overweight. On the other hand, in the study by Cutchma et al. [27] carried out in the city of Colombo-PR, overweight was present in 7.1%. In this way, it is necessary to carry out, whenever possible, a survey regarding health and well-being conditions within

schools, as well as psychological monitoring whenever necessary, in order to improve the perception of their own image by young people today.

### 3.5 Changes in health

In their studies Romanholo et al. [28] observed the relationship between biological maturation and the image of schoolchildren aged 7 to 12 years old in a municipal school in Cacoal in Rondônia, and their results showed that sexual maturation in girls was related to obesity, the same was not observed in the sample of boys. The results of this study corroborate the findings of Carvalho et al. [13], in which it was also possible to observe a greater tendency of overweight among the analyzed girls, to the detriment of the boys who composed the sample. Thus, it can be intuited that they present a high success rate for this pattern, a fact linked mainly to the period of body development and hormonal changes, to which they are subject.

In the research by Bezerra et al. [12], which analyzed the behaviors related to the lifestyle of adolescents in Recife-PE, it was observed that the most prevalent lifestyle areas among adolescents were inappropriate eating behavior and physical inactivity, as well as consumption of alcohol and smoking. These behaviors also revealed different patterns between sex, higher and lower social classes and by type of school (public and private). Similarly, in the study by Barbalho et al. [29] with school adolescents in the city of Sobral-CE, it was also possible to observe inadequate eating habits, associated with the increasing prevalence of overweight/obesity cases in the evaluated schoolchildren, as well as a plurality in the prevalence of overweight/obesity in relation to the women. Regarding physical activity, there was also a predominance of physical inactivity among adolescents. Thus, it is considered important to monitor the lifestyle during adolescence, especially in the school environment, so that health intervention strategies can be subsidized, with the objective of preventing Chronic Non-Communicable Diseases (NCDs) in adult life.

### 3.6 Socioeconomic profile

Ferreira and Andrade's [11] research carried out with Brazilian schoolchildren, in which they demonstrated in their results that the prevalence of overweight and sedentary behaviors is greater in the South, Southeast and Midwest regions, where they have a higher level of economic development, when compared to the North and Northeast regions. Another fact also observed in the study correlated with these factors is the inequality in relation to the schooling of the adolescents' mothers. The results of the study by Rosa & Araújo [30] corroborate these findings,

in which it was observed that the mother's education has been indicated as a condition related to the intensification of childhood obesity. With regard to family income, it was noted that the height deficit between the thresholds of the purchasing power classes is up to three times, with growth retardation in childhood being centralized in the socioeconomically less favored classes. It can be inferred that these occurrences are related to difficulties in obtaining food and higher caloric expenditure among the most disadvantaged.

## IV. CONCLUSION

The present study obtained significant results through the analysis of the scientific literature on the current situation of food consumption in elementary school students. In this context, it was possible to observe that there is a low consumption of fresh and healthy foods among schoolchildren, in addition to the high consumption of processed and ultra-processed foods, resulting in changes in the nutritional status and consequently in the health of the investigated population, with the presence of overweight and obesity, dyslipidemia and increased blood glucose, predisposing factors for cardiovascular diseases.

These factors reinforce the need to improve the child's dietary pattern, which is outside the recommended range by Organs responsible bodies. With regard to socioeconomic conditions, low schooling is closely associated with the quality of the diet offered, since low knowledge about healthy eating and the difficulty in acquiring food impairs adherence to this practice.

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# Food Consumption and Anthropometric Evaluation of Students in Elementary School: Literature Review

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**Keywords** —Food Consumption, Nutritional  
Assessment, Nutritional Status,  
Schoolchildren, School Health.

**Abstract**—Food presents as a vital necessity, necessary for the conservation of life and well-being of individuals. This process is considered a basic requirement for health promotion, contributing to human growth and development with quality. Healthy food is one that keeps the body in a state of health, when it prioritizes adequate food, in quantities and quality, at the right times, and that contains varied nutrients to achieve satisfactory benefits for the health of the body and thus contribute to the acquisition of quality of life (BUSATO et al., 2021). The objective of this work was to discuss the main factors associated with Food Consumption and Nutritional Status of schoolchildren, based on a critical review on the subject. To review the topic, the following databases were consulted: BIREME and CAPES journal, covering the period from 2018 to 2021. The descriptors used in the search were: "food consumption", "nutritional assessment", "nutritional status," "school" and "school health". The research results indicate, through the analysis of the scientific literature, a low consumption of in natura and healthy foods among schoolchildren, in addition to the high consumption of processed and ultra-processed foods, resulting in changes in the nutritional status and consequently in the health of the investigated population, with the presence of overweight and obesity, dyslipidemia and increased blood glucose, predisposing factors for cardiovascular diseases. Thus emphasizing the importance of the debate on the subject in future research.

## I. INTRODUCTION

Food presents as a vital necessity, necessary for the conservation of life and well-being of individuals. This process is considered a basic requirement for health

promotion, contributing to human growth and development with quality. Healthy food is one that keeps the body in a state of health, when it prioritizes adequate food, in quantities and quality, at the right times, and that contains varied nutrients to achieve satisfactory benefits

for the health of the body and thus contribute to the acquisition of life quality[1].

With the beginning of school life, the child becomes susceptible to the influences of dietary patterns. In this sense, it is worth mentioning that this is one of the most important phases for the formation of eating habits and behaviors of the little ones, which can last throughout adult life. In the last decade, studies carried out on food consumption in the school environment have revealed a high consumption of foods with low nutritional value (sweets) and high energy density (rich in low value-added carbohydrates), whether these foods are purchased in school canteens, or even , taken from home to be consumed at school [2].

Each child grows and develops from different standards, in this sense; the assessment of nutritional status is one of the most effective instruments to help identify nutritional disorders in all life cycles, being closely linked to ingestion, absorption, use and excretion of nutrients [3]. Thus, when food consumption is inadequate and/or insufficient to meet the needs of each individual, so-called nutritional deficiency can be triggered, such as protein energy malnutrition, overweight and obesity.

Seeking to observe the conjunctures of the current scenario regarding the topic addressed, the work aims to investigate in the available literature articles from the last five years that address the theme "food consumption and anthropometric assessment of elementary school students".

## II. METHODOLOGY

### 2.2 Type of study

This is a qualitative, exploratory study, applying the rules of a bibliographic review.

#### 2.2.1 Study Period

A literature review was carried out through an investigation of articles available in electronic media and published in the period of five years (2018 to 2021). Data collection took place from December 2021 to January 2022.

#### 2.2.2 Sampling

The samples were collected from the academic database BIREME and the CAPES journal using the descriptors: food consumption, nutritional assessment, nutritional status, schoolchildren and school health. The

AND connective was applied between the descriptors. After this selection, there was the moment of analysis, through selective reading of the articles related to the research topic and they were judged according to the research objectives. The chosen language was Portuguese.

#### 2.2.3 Inclusion Criteria

Completed articles were included in this work, which investigated the specific topic addressed in this research, on food consumption and anthropometric assessment of elementary school students.

#### 2.2.4 Exclusion Criteria

Duplicate articles, dissertations, non-indexed publications, theses and monographs were excluded from the research.

#### 2.2.5 Ethical aspects

This research uses the norms of a literature review, and in the approach of ethical aspects, it exempts the submission to the evaluation of the Research Ethics Committee in accordance with Resolution 466/12 of the National Health Council (CNS). However, all established ethical precepts will be considered to ensure the legality of information, privacy and data confidentiality.

#### 2.2.6 Data collection and analysis

After reading the selected articles, the data for the work were obtained, following a synchronized, ordered and divided methodology. Initially, the selection of articles was made, followed by a structured organization highlighting the most relevant points that were addressed in the work and finally the separation and assembly of the final Excel was carried out, with the most relevant results.

#### 2.2.7 Financing

The study received no funding; all costs were borne by the researchers.

#### 2.2.8 Conflict of interests

The authors declare no conflict of interest.

## III. RESULTS AND DISCUSSION

Table 1 represents the summary of the analyzed articles.

Table 1 – Summary of the articles

Year	Author	Title	Aim	Results	Conclusion
2018	PAIVA, A. C. T. <i>et al.</i> [4]	Childhood Obesity: Anthropometric, biochemical, food and lifestyle analysis.	To identify changes in BMI in schoolchildren in the city of Poços de Caldas - MG - BR, aged between 6 and 12 years, in addition to evaluating biochemical analyses, anthropometric data and dietary pattern.	The results showed a significant increase in food intake from the sugar group.	It is an important study in the area in order to map and improve the nutritional profile to reduce the risks to which children are exposed.
2018	SCHISLER, C.; PERETTI, G; BARATTI, L. [5]	Nutritional status and food adequacy of children in a school in the city of São Jorge d'Oeste - PR.	To trace the nutritional profile of schoolchildren and verify the adequacy of energy, proteins, calcium and iron of the school lunch in the morning and afternoon, verifying if they reach the recommendations of the FNDE.	The children included in the study were evaluated grouped by sex (36 females and 41 males). No significant differences were observed between the groups in terms of nutritional status.	The results showed the majority of schoolchildren in adequate nutritional status, however, the foods offered do not meet the nutrient recommendations.
2019	DA SILVA, K. M; SILVA, K. L. G. D; SANTOS, M. M. D.[3]	Assessment of nutritional status and food consumption of preschoolers and schoolchildren residing in Caetés-PE	To evaluate the nutritional status, food consumption and socioeconomic level of children attending the public school system in the city of Caetés - PE.	Most children had a low intake of fruits, vegetables, legumes, offal, milk and dairy products. The analysis of the socioeconomic profile pointed to a context of social vulnerability, due to the large number of parents with low education and unemployed.	There was a relevant association between physical inactivity, poor diet quality and high rate of excess weight. Therefore, it is necessary to promote strategies that stop the obesogenic factors found, as they favor the emergence of clinical and nutritional disorders.
2019	CORDEIRO, M. C. <i>et al.</i> [6]	Food habits consumption of ultra-processed foods and its	To evaluate the eating habits, the consumption of ultra-processed	The occurrence of overweight/obesity in schoolchildren was highlighted,	It was found that although there was a high consumption of ultra-processed foods, no

		correlation with the nutritional status of schoolchildren in the private network.	foods and their correlation with the nutritional status of schoolchildren from the private network in Teresina - PI.	with excess abdominal adiposity, a factor that indicates risk for cardiovascular diseases.	significant relationships were found between nutritional status and consumption of these foods.
2019	ROSSI, C. E. <i>et al.</i> [2]	Factors associated with food consumption at school and overweight/obesity in schoolchildren aged 7-10 years in Santa Catarina, Brazil.	To investigate the association between the origin of snacks consumed at school, their nutritional value and overweight/obesity.	The research results showed that students from the private network consumed snacks of high nutritional value with significantly higher frequency than students from the public network.	The results show not only the need to expand legislative measures in order to minimize the availability of risky foods in school canteens nationwide, as well as the greater availability/consumption of healthy foods in canteens.
2019	BATALHA, T. B. <i>et al.</i> [7]	Nutritional status and food profile of a female Futsal school team in the city of Caxias do Sul - RS.	To evaluate the nutritional status and food profile of a futsal school team in the city of Caxias do Sul.	The schoolchildren were well-nourished, according to waist circumference, and were not at risk for cardiovascular disease. The percentage of fat was adequate and the athletes have good eating habits, although the associations between the variables studied were not statistically significant.	The research findings showed that the players studied have a balanced diet with a high consumption of vegetables, but also consume candies, breads and pasta with some regularity.
2019	MELO, A. P. R <i>et al.</i> [8]	Nutritional status, eating habits and oral health in a group of schoolchildren.	To investigate the nutritional status, eating habits, caries experience and oral hygiene practices in a group of schoolchildren.	Of the children evaluated, 25% were overweight and 3.5% were underweight. Regarding food consumption, there was a high frequency of ultra-processed foods and sugars.	The findings showed that the nutritional status did not present satisfactory results, showing to be in disagreement with the current guidelines and recommendations of the World Health Organization.
2020	CESAR, J.	Adherence to school meals and	To analyze the rate of adherence	The results showed that the rate of	The findings indicate that the low rate of adherence to



	T. et al.[9]	associated factors in adolescents from public schools in the southern region of Brazil.	to school meals and associated factors in adolescents enrolled in state public schools in the city of Lapa, Paraná, southern Brazil.	adherence to school meals, regardless of the frequency of consumption, was 70.9%, it is observed that the effective adherence rate, four to five times a week, was also higher among adolescents enrolled in a school in the rural area (30.1%).	school meals, in attendance is not being reached. The mentioned factors can help to improve the execution of the program.
2021	OLIVEIRA, R. R; PETER, N. B; MUNIZ, L. C. [10]	Food consumption according to the degree of processing among adolescents in the rural area of a municipality in southern Brazil.	To evaluate food consumption according to the degree of processing and nutrient intake among adolescents in the rural area of Pelotas - RS.	The research results indicate that the average daily consumption was 1,921 calories, 48.2% from natural or minimally processed foods and 31.9% from ultra-processed foods.	The findings of the study indicate that adolescents in rural areas have a higher energy intake from the consumption of in natura or minimally processed foods, even though ultra-processed foods are also part of their diet, demonstrating the nutritional transition.
2021	FERREIRA, C. S. e ANDRADE, F. B [11]	Socioeconomic inequalities associated with overweight and sedentary lifestyle in Brazilian adolescents.	To estimate the prevalence of overweight and physical inactivity in Brazilian schoolchildren aged between 13 and 17 years, and to investigate the magnitude of socioeconomic inequalities related to these outcomes.	The prevalence of overweight in Brazil was 24.2%, ranging from 20.7% in the Northeast region to 27.8% in the South region. The prevalence of sedentary lifestyle in Brazil was 67.8%, ranging from 61.8% in the North region to 70.3% in the Southeast region.	Those in this research point out that it is necessary to restructure and strengthen existing public policies that include adolescents, such as: PNAE and PSE, in order to improve a healthy lifestyle and reduce inequalities.
2021	BEZERRA, M. K. A. et al. [12]	Lifestyle of adolescent students from public and private schools in Recife: ERICA.	To analyze lifestyle-related behaviors of adolescents in Recife, Brazil.	In the research, it was possible to notice that 60% of the adolescents had inappropriate eating behaviors, and ended up	As a result, this research shows that adolescents in Recife have a low frequency of health protection eating behaviors and regular practice of physical activity.

				having breakfast, water/day and meals in front of the TV, around 40% did not have meals with their responsible parents.	
2021	CARVALH O, M. J. L. N. et al. [13]	Perception of above-ideal body weight, anthropometric profile and lifestyle in adolescents from Recife, PE, Brazil.	To analyze the perception of above-ideal body weight in adolescents from Recife/PE and its association with anthropometric profile and lifestyle.	Weight perception was answered by 48.8% of adolescents, of which 36.8% and 63.2% perceived themselves as underweight and overweight, respectively.	The data found in this research suggest that there is an association between the perception of body weight above the ideal and the sociodemographic, anthropometric and lifestyle factors of adolescents aged 12 to 17 years in the city of Recife.

**Fonte:** Authors, 2022.

### 3.1 Assessment of food consumption

Melo et al. [8] demonstrated in their research that 27% of their total sample was not in the habit of ingesting fruits and vegetables; this consumption profile contributes to changes in nutritional status, since these foods are rich in fiber and nutrients, and are linked to increased satiety. Similarly to what was observed in this research, Silva et al. [14] in their study on nutritional assessment and food consumption in schoolchildren aged 10 to 14 years, found that the intake of fruits, vegetables, milk and dairy products was below the recommended, and such factors were correlated with socioeconomic characteristics and favorable eating habits; food with products with more accessible prices, being considered nutritionally inadequate. Similarly, Spinelli et al. [15] observed that adequate intake of fruits and vegetables is related to lower BMI values, thus suggesting that both the energy value of the food consumed and the quality of the diet offered will contribute to body weight control, and in the condition adequate health of the individual.

Also in this sense, the results found by Melo et al. [8] of overweight schoolchildren are similar to the study by Henrique et al. [16], in which 105 children participated, of which 28.8% were overweight, data similar to those found in the study. Regarding eating habits Henrique et al. [16], through the food frequency questionnaire, observed that the students had a monthly food consumption of stuffed cookies (62.8%) and sweets (28.6%), similar to that observed in the study. Lopes et al. [17], points out in their study a high consumption of cakes, stuffed cookies,

soft drinks and sugars that are identified as cariogenic foods. The study by Carteri et al. [18], in which 50 children were part of the studied sample, in which the prevalence of caries was 46% and 24% of the children had at least one tooth with untreated caries. In summary, it was possible to observe that schoolchildren have worrying levels of poor eating habits, overweight and compromised oral health.

In the research by Schissler et al. [5], the example of inadequate nutrition can be observed, in which the results of the study with schoolchildren showed the amount of calcium below the recommended range, with only 53.37% of the indicated total being consumed in the afternoon and 50, 92% in the morning, and it was found that values consumed in the present study are below the recommended, such results can promote a series of nutritional deviations and cause changes in health. Similarly, Verly-Junior et al. [19], observed in their study on school menus that the amount of calcium was not achieved in inflexible meal models, that is, which did not allow adjustments, in menus with 30% of the RDI, it was easily possible to supply 60% of the need for these nutrients, on the menus with 20% of the RDI, this fact was more difficult. It is not enough just to introduce these foods into the diet, it is necessary that they are consumed in adequate quantity and frequency.

### 3.2 School Meals

Cesar et al. [9] in their research with adolescents enrolled in state public schools in the municipality of Lapa, Paraná, southern Brazil, which includes 5 urban and

5 rural schools in the municipality, observed that the rate of adherence to school meals was high (70.0 %) according to the classification proposed by Sturion [9], mainly among schools in rural areas. Similarly, it was possible to observe in the study by Ferro et al. [20] (2019), where 41 students were analyzed, in a school in the interior of São Paulo, and in which it was possible to verify that 70.7% of the total of the evaluated children consumed in the canteen daily, in addition, the snacks eaten were mostly composed of processed and high-calorie foods, which may be related to the low variety of healthy foods sold in the canteen and the high supply of low-nutrition products available for this public to access, such as: industrialized beverages (juices and soft drinks); stuffed dumplings; chips; chocolates and sweets, among others.

Likewise, the work by Rossi et al. [2] presented results of an investigation into the association between the origin of snacks consumed at school, their nutritional value and overweight/obesity. As a result, it was noticed in the study that overweight/obesity was associated with the consumption of food from canteens in the private network. And the fact that students brought food from home was associated with a higher consumption of snacks of low nutritional value in public schools. Equivalently, Melim et al. [21] in their research on the eating habits of students in the metropolitan region of Rio de Janeiro, it can be observed that there was a greater consumption of carbohydrate foods such as cookies and bread for breakfast, mainly; such habits were also reflected in the other meals with the consumption of hypercaloric and unhealthy foods.

### 3.3 Consumption of ultra-processed foods

The results of the work by Oliveira et al. [10] with the rural school community, in the city of Pelotas-RS, showed that even in the rural area, where the availability of natural food is greater, industrialized products become more accessible to adolescents, who integrate them into their daily consumption. Furthermore, a lower contribution of fruits and vegetables to daily caloric intake was observed. Likewise, in their study Valença et al. [22], when investigating the influences and preferences in the food consumption of ultra-processed foods in rural areas, could see that the factor that most influences the food preferences of their target population was the taste of food, in which this was formed since early childhood. In this sense, the school must work on Food and Nutrition Education in a present way since the first cycles of education, in order to minimize the impacts on the health of individuals over time.

In their research, Cordeiro et al. [6] evaluated the percentage of consumption of ultra-processed foods by

children from a private school in Teresina-PI. The results showed expressive percentages of consumption of ultra-processed foods, and highlighted that most of the caloric intake of these children is composed of high glycemic index carbohydrates and total fat. Similarly, Andretta et al. [23] in their study on food consumption of ultra-processed foods observed a high percentage of consumption of ultra-processed foods in schoolchildren aged 6 to 16 years enrolled in schools in the municipal education network of Caxias do Sul-RS. This fact highlights the need to promote preventive health programs aimed at informing schoolchildren, parents and guardians about healthy eating. Likewise, the results of the study by Landim et al. [24], were similar to the findings in the research on the food consumption of ultra-processed foods in schoolchildren, in which a high intake of ultra-processed foods was observed, making it possible to correlate these results with the overweight and obesity presented, as well as a greater susceptibility to risk of cardiovascular disease.

### 3.4 Nutritional status of schoolchildren

In a research on the assessment of the nutritional status and food profile of a school team of futsal players, carried out by Batalha et al. [7], the results showed that more than 90% of schoolchildren were classified as eutrophic. Even with a high consumption of carbohydrates and industrialized products, the adolescents managed to maintain an adequate weight and BMI within the eutrophic classification. Still in this context, in a study proposed by Silva et al. [25], responsible for evaluating the nutritional composition of school meals in a state school in Paraná, it was possible to observe that 66.88% were eutrophic, and to a lesser extent 31.17 % were overweight. Similar to this study, Conceição et al. [26] in their study that addressed food consumption in schoolchildren from public and private schools in the city of São Luís do Maranhão, found that there was insufficient consumption in 66.3% of the students participating in the study, however, 30, 1% had high consumption. In this context, it is important to emphasize the relevance of good eating practices in the school environment.

In the research by Carvalho et al. [13], who worked with schoolchildren enrolled in the public and private school system in the city of Recife, and addressed the perception of body weight, it was highlighted that more than 50% of the participants reported a different body image from the ideal, and, most respondents reported being overweight or very overweight. On the other hand, in the study by Cutchma et al. [27] carried out in the city of Colombo-PR, overweight was present in 7.1%. In this way, it is necessary to carry out, whenever possible, a survey regarding health and well-being conditions within

schools, as well as psychological monitoring whenever necessary, in order to improve the perception of their own image by young people today.

### 3.5 Changes in health

In their studies Romanholo et al. [28] observed the relationship between biological maturation and the image of schoolchildren aged 7 to 12 years old in a municipal school in Cacoal in Rondônia, and their results showed that sexual maturation in girls was related to obesity, the same was not observed in the sample of boys. The results of this study corroborate the findings of Carvalho et al. [13], in which it was also possible to observe a greater tendency of overweight among the analyzed girls, to the detriment of the boys who composed the sample. Thus, it can be intuited that they present a high success rate for this pattern, a fact linked mainly to the period of body development and hormonal changes, to which they are subject.

In the research by Bezerra et al. [12], which analyzed the behaviors related to the lifestyle of adolescents in Recife-PE, it was observed that the most prevalent lifestyle areas among adolescents were inappropriate eating behavior and physical inactivity, as well as consumption of alcohol and smoking. These behaviors also revealed different patterns between sex, higher and lower social classes and by type of school (public and private). Similarly, in the study by Barbalho et al. [29] with school adolescents in the city of Sobral-CE, it was also possible to observe inadequate eating habits, associated with the increasing prevalence of overweight/obesity cases in the evaluated schoolchildren, as well as a plurality in the prevalence of overweight/obesity in relation to the women. Regarding physical activity, there was also a predominance of physical inactivity among adolescents. Thus, it is considered important to monitor the lifestyle during adolescence, especially in the school environment, so that health intervention strategies can be subsidized, with the objective of preventing Chronic Non-Communicable Diseases (NCDs) in adult life.

### 3.6 Socioeconomic profile

Ferreira and Andrade's [11] research carried out with Brazilian schoolchildren, in which they demonstrated in their results that the prevalence of overweight and sedentary behaviors is greater in the South, Southeast and Midwest regions, where they have a higher level of economic development, when compared to the North and Northeast regions. Another fact also observed in the study correlated with these factors is the inequality in relation to the schooling of the adolescents' mothers. The results of the study by Rosa & Araújo [30] corroborate these findings,

in which it was observed that the mother's education has been indicated as a condition related to the intensification of childhood obesity. With regard to family income, it was noted that the height deficit between the thresholds of the purchasing power classes is up to three times, with growth retardation in childhood being centralized in the socioeconomically less favored classes. It can be inferred that these occurrences are related to difficulties in obtaining food and higher caloric expenditure among the most disadvantaged.

## IV. CONCLUSION

The present study obtained significant results through the analysis of the scientific literature on the current situation of food consumption in elementary school students. In this context, it was possible to observe that there is a low consumption of fresh and healthy foods among schoolchildren, in addition to the high consumption of processed and ultra-processed foods, resulting in changes in the nutritional status and consequently in the health of the investigated population, with the presence of overweight and obesity, dyslipidemia and increased blood glucose, predisposing factors for cardiovascular diseases.

These factors reinforce the need to improve the child's dietary pattern, which is outside the recommended range by Organs responsible bodies. With regard to socioeconomic conditions, low schooling is closely associated with the quality of the diet offered, since low knowledge about healthy eating and the difficulty in acquiring food impairs adherence to this practice.

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# The Portuguese Police System: Conflicts and Tension<sup>i</sup>

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**Keywords—** Conflicts, ethnography,  
Portuguese Police System, Public Security  
Police, Republican National Guard

**Abstract—** The article aims to discuss conflicts and tensions in the Portuguese police system, from its historical process, from Monarchy to the Republic, from the New State to the present day. A structure and understandings they have about the police system are reflected in the Portuguese bibliography and in the perceptions of police officers who live with these tensions in their activities. In this investigation, information was collected from the GNR through ethnography and the application of questionnaires to guards, cables and officers. The questionnaire was prepared in view of the questions and objectives of this article and was applied to the Detachment of Sintra in its sub-stations: Sintra, Alcabideche and Colares. The structure of the Portuguese police system has institutional advances in the European context and they are a substantial part of the success in controlling crime and the system's flexibility to adapt to the context of political, cultural and technological changes. On the other hand, the corporate and individual ethos conditioned by the identity tension of each police force and the pressure from the political field keeps disputes between the monitored organizations.

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## I. INTRODUCTION

The article aims to discuss the conflicts and tensions in the Portuguese police system, from its historical process, from the Monarchy to the Republic, from the New State to the present day and, consequently, to know its historical process and its institutional organization. The tensions in the Portuguese police system have their origins in the historical and political process that precedes the monarchic period, others arise with the creation of various police agencies that decentralize security activities and services and, finally, part of the tensions that reach the guards and agents because of their commanders' views on the current Portuguese police system.

The main Portuguese security forces, the National Republican Guard (GNR), the Public Security Police

(PSP) and the Judiciary Police dispute territorial space, functions and hegemony over the Portuguese police system. Notably, the GNR and the PSP stand out in this dispute, given the greater number of police officers and the greater policing area, with the GNR responsible for the rural area and the PSP for the urban regions.

The bibliographic research on the Portuguese police system brings the consolidation of the security forces from the changes in the political system and, parallel to the bibliographic information, the coexistence with the police of the GNR Detachment and other professionals of the security forces through ethnography (annotated in a field diary) held in Sintra and at academic meetings, and the application of questionnaires consolidate the data and results of this article.

The article is structured in two sections preceded by an introduction and followed by a conclusion. The introduction highlights the research question and how the investigation was carried out. The second section deals with the development of the Portuguese police system and the emergence of the PSP as a civil police force and; the third section is devoted to ethnographic data and the results of the questionnaires applied to guards, corporals, sergeants and GNR officers. Finally, the conclusions that from the data bring to light that the existing conflicts in the Portuguese police system do not affect the functioning of its main security forces.

## II. THE PORTUGUESE POLICE SYSTEM AND ITS TRANSFORMATIONS

The idea of policing Portuguese society emerged in the twelfth century with the creation of the court policeman, however, the obligation to present oneself to the royal summons, the non-receipt of remuneration and the precarious working conditions did not guarantee the safety of people, not even of the guards. Only in the earthquake of 1755, in Lisbon, it was possible to perceive the need to structure security forces that could guarantee public order.

The General Intent Court and Kingdom Police begins to structure and manage matters of public order. The centric figure in this organization is Pina de Manique, appointed to the position in 1780. The action of the Intendency in this period resulted in the reduction of crime and the creation of a militarized body on horseback, the Royal Police Guard (1801). This same Guard accompanies the Royal Family to Brazil, which modifies the structuring bases of the security forces in the Colony.

The Portuguese political context is troubled and the Guard is dissolved and replaced by the National Guard, which had a short period of existence, in 1846 it is dissolved (Rodrigues, 2014). The municipal guards (1834) appear inheriting the physical space and the human resources of the previous forces. The changes in the police forces, after the return of the Court of Brazil, resulted from the distrust of the parties that proposed the reduction of power or even the end of the monarchy. As Oliveira (2010) says, these police bodies were committed to the defense of the Regime and recruited from the ranks of the army.

Parallel to the tensions related to the forces linked to the regime, ideas of creating police forces of a civilian nature run through the country. In 1865, the city of Porto created its Civil Police, on the occasion of an international exhibition, a fact that preceded the creation of the Civil Police of Lisbon. Part of the current tensions stem from the

Charter of 1867, which, in addition to establishing the Civil Police, subordinated to the civil governor, intended to replace the municipal guards with the new police, but this did not happen (Santos, 2006, Cerezales, 2006, 2017). The Municipal Guard, as heir to the Royal Police Guard, was identified as a defender of the Monarchy and viewed with suspicion by movements against the Monarchy.

With the establishment of the Republic in 1910, the Municipal Guards are dissolved and their estate remains with the new institution, the Republican National Guard. This arises with the aim of replacing the army guards in the rural part of the country. In addition to these actors, the police cables persisted even in the New State, these police forces, with the exception of the Cabos, were distributed throughout the national territory, following the position of European countries, especially France and Spain, of having a French Gendarmerie and the Spanish Civil Guard.

In the Republican period, the way of dealing with disturbances and the people remained similar to the ways of the Monarchy and, for that, the regime needed a strong and centralized police force, which made it impossible to discredit the old police forces, incorporated in the GNR, to the detriment of the Civil Police, as Cerezales says (2006, p.158).

With regard to the civil police officers of the various cities in the country, during the Old Republic reforms were proposed to increase their capacity to act in the face of public disorders, such as the motorization of reserve pickets and, especially, the transport of prisoners, since their escort the streets used to provoke situations of tension and fights. However, police commanders were faced with budgetary constraints and the distrust of republican leaders, who preferred to trust "their" GNR in which they instilled strong republican loyalty, rather than rearm a police suspected of monarchical sympathies (free translation).

In the first phase of the Portuguese Republic, public security forces of a civil nature did not have the first look at the regime, despite identifying the other police force as heir to a monarchist past and, that this characteristic, at some point, could turn against the Republic. . About this, in the Revirahista Movement, there was the expulsion of members who still remained faithful to monarchist ideas. At the same time, the civil police were regrouped in a national coordination, called the Public Security Police (PSP).

After several acts, in 1932 the General Intendence of Police was extinguished and the Public Security Police was established, covering the entire Portuguese territory. In a study on public policies and policing, Oliveira [6] highlights three axes and three periods for public security policy in Portugal: 1) The consolidation of the democratic rule of law, period 1974-1980; 2) Policy of reaffirming internal security and legislative reform, period 1980-1995; 3) Public security policies, period from 1995 to 2004.

In the first phase, unlike what happened in Brazil after the Military Regime (1964-1985), the reforms aimed to restrict the power of the security forces, which acted in a violent and abusive way during the Salazar dictatorship. This political attitude demonstrated the strength and interest of the political power with regard to its police forces, even though they were present and collaborating in the movements of institutional rupture.

In the second period, the political system organizes and publishes Law n° 20/87, the Internal Security Law (LSI), which, among other measures, transformed the PSP into a civil police force, created the Escola Superior de Polícia, currently of Police Science and Homeland Security (ISCPSI) and the Safe School Program.

During this period, relevant changes took place in terms of the distribution of PSP and GNR personnel in Portuguese territory. One of them is the removal of the PSP from medium and small-sized locations and replacing it with the GNR. Elias (2011) states that of the 47 locations planned for replacement, only 17 were carried out. Even if the reasons demanded by the political power were more rationalization and articulation of the security forces, more economy with less effective, the reduced number of substitutions has to do with the internal dispute of power of the two great police forces, what if it perceives the reflexes in the positions of GNR actors. For Oliveira, these actions hampered the implementation of proximity policing, since it redefined the number of police officers, which resulted in the closure of small police stations.

In the third period, several actions have led to the updating of the security forces, among them: the confirmation of the civilian nature of the PSP (Law n° 05/99) and, consequently, the definition of the dual model of the police system; the creation of an Advisory Council for the Training of Security Forces and Services; the Organic Law of the PSP (Law n° 14/2002), the military disciplinary statute for the GNR, distinguishing it from the Army, for Elias (2011, p. 146):

Since then, PSP has gone through a process of reforming its organization, training and gradual reformulation of the operating

philosophy, in the areas of finance, human resources and logistics. Deep down, he is still in a kind of search for identity. (emphasis ours).

The transformations in the Portuguese police system are positive for demonstrating that the legislator and the government have been sensitive to the demands of the security forces and Portuguese society, on the other hand, the police forces question their organizational capacity within the system. The works Oliveira (2006; 2010), Elias (2011) and Rodrigues (2014), all PSP staff, call into question the efficiency of the current system. In the case of the PSP, it is evident from the quote above that the changes in the police system and its recent institutional history make it difficult to consolidate the identity of this security force, even considering that the transformations have benefited it with more territory for policing.

The different stages of organization and the proximity to the political power of the two great police forces in Portugal made it possible to produce different structures and privileges for each one. In the case of the GNR, even without police in Lisbon, it maintains a significant contingent in the General Command and in other activities in the country's capital.

### III. ETHNOGRAPHIC DATA AND PERCEPTIONS ABOUT THE POLICE SYSTEM

This structure and the understandings that one has about it are reflected in the perceptions of police officers and coexist with them in their activities. In this investigation we collected information from the GNR through ethnography and the application of questionnaires to guards, corporals and officers.

The questionnaire was prepared in view of the questions and objectives of this article and was applied in the Sintra Detachment, in its sub-detachments: Sintra, Alcabideche and Colares.

Elias (2011) adds a fourth period to Oliveira's (2006) periodization (2006), which begins in 2005 and continues to the present day. For Elias, this period stands out for changes in the command structures, but that little affects the actors of the police system. He calls these changes delayed reform and mitigated change of the homeland security system.

The criticisms of Oliveira (2006), Elias (2011) and Rodrigues (2014) stem from not positively affecting the PSP as much as they affect the GNR. Constitutional governments have expanded the presence and improved the structure of other police forces, but the discrediting and decreasing influence of the GNR has not happened.

The rationalization propositions of the Portuguese police system, which in the perspective of Oliveira, Elias and Rodrigues, would result in the unification of the security forces around the PSP collide with the prestige and presence of the GNR and the Judiciary Police in the Internal Security System (SSI).

The distribution was carried out by the Detachment, which sent the questionnaires to the commanders' e-mails and, when possible, to the guards, corporals and officers themselves. While the researcher was visiting the sub-departments or driving around in the vehicle, the guards told me that they had received them and that they were responding, the last day for delivery being a Friday, when the researcher ended his activities with them. The tables below describe the respondents.

The data in table 01 refer to all the professionals existing in the Detachment and in the sub-detachments of Sintra, and the respondents who returned the questionnaires, since there was no obligation to participate in the investigation, are shown in tables 02 and 03. age (Table 05), by sex (Table 06) and by patent (Table 02).

Table 01 shows the lack of renewal of the professional staff and the reduction in their numbers in the secondments. The reduction in the number of guards is more severe, especially from 2015 to 2016. This number may be impacted by the increase in the number of cables. These professionals are indispensable to the nature of the ostensive and preventive work. Guards and corporals are the “owners of the tour”, since the sergeants are there to assist the officer in organizing the detachment and inspecting establishments and private surveillance services.

On the first day that I was with the team of guards and corporals in Alcabideche to turn the vehicle around, I accompanied the sergeant on an inspection of the private security contract in a supermarket. Upon arriving, he asked the supermarket employee for the manager, at the same time we saw the private security, the sergeant approached and checked if the uniform and identification were adequate. A broader look at the facilities saw electronic surveillance equipment, asked the manager for authorizations to this service, which he replied that he did not have. In this case, the sergeant recommended the manager to go to the GNR website on the internet and register, without this it can be changed, said the sergeant.

When we arrived at the GNR unit in Alcabideche, the sergeant introduced me to the facilities, which, in addition to the space for receiving people and complaints, also have the part of the laboratories, part of the investigation function.

The sergeant arrives and invites me to enter the sub-detachment and introduces me to the facilities. We arrived in an area where there are several places, where people who file complaints and go through the reception sieve, at the moment they are talking to a guard, more internally, I understand a total of 4 places, of which there are people in two of them. Then he introduces me to the inmates' deposition room, when they are brought in to be heard. It has a specific room for dealing with domestic violence.

Then take me to the third building. In fact, it is a construction that is in the middle of the other two. This is one of the GNR's criminal investigation laboratories. It starts in the part of the building where the guards' quarters are located. Sergeant {name subtracted} invites another colleague, also a sergeant, to accompany me and introduce the facilities and laboratories. Criminal investigation personnel are selected internally, the lab sergeant explains to me. The various laboratories he presents to me are for the GNR to fulfill its role of judicial police in less complex crimes. (field diary notes)

With regard to table 01, I had the opportunity to read, while I was in a waiting room at the Sintra Command, located in the Sintra National Palace, the Guarda Informative Bulletin. One of the pieces of information was that the Ministry of Internal Administration could not meet the total number of requests for promotions requested, responding to only 30%, of which the oldest .

TABLE 01 NUMBER OF PROFESSIONALS IN GNR  
UNITS IN SINTRA

YEAR/profe ssional	2014	2015	2016
GUARD	130	139	90
CABLE	61	59	53
SERGEANT	9	12	8
OFFICERS	4	4	4
Total	204	214	155

Source: DTSintra/GNR

Decree-Law n° 30/2017, designated the Statute of the Military of the GNR expands the achievements and rights of the GNR in relation to other Portuguese security



forces. By approving its own statute, it distinguishes it as a military force, distancing it from the Army. In this legislation, the rank of Brigadier-General was created for the access of GNR colonels. Before, the officers who chose to serve in the GNR did not reach the rank of general officers. With this measure, officers have a distinct career from the Army.

Another measure of the new Statute is the opening of the GNR officer cadre for sergeants who have a master's degree in an area of interest to the Guard. Likewise, sergeants who are qualified in the area of medicine, with qualification recognized by the Order of Nurses.

**TABLE 02 - GNR/SINTRA GENERAL TOTAL / RESPONDENTS BY PROFESSIONAL PATENT**

PATENTE	GUA RD	CABLE	SERGEA NT	OFFIC ERS
The amount	40	16	07	03

Source: DTSintra/GNR

The promotion framework is stagnant in the Portuguese police forces, according to information from the Bulletin and a police officer from the Judiciary Police (PJ), obtained in an informal conversation. He informed that careers in the PJ are frozen, the government has no interest and, for that, he informs that he has no resources. Although, the GNR is privileged to have 30% of its police officers promoted in 2017. On the other hand, the number of officers has changed.

**TABLE 03 - QUANTITY OF RESPONDENT PER UNIT**

UNIT	SINTRA AND COMMAN D	ALCABIDECH E	COLARE S
THE AMOUN T	33	22	11

Source: DTSintra/GNR

Table 4 (below) informs that the proportion of police per inhabitant has increased, the GNR is responsible for a growth of 7.5, the PSP by 0.5 and the PJ by 0.6. These data point to a greater growth of Guarda at the expense of PSP.

The former facts have reduced force in the present. In the early 1920s, the GNR's strength was reduced in order to curb the influence of this police force

on political movements. It succeeded, says Póvoa (2017, p. 132):

By decreasing the capacity of the GNR, democratic governments carried out an important reform to reduce and annihilate the radical nuclei of the corporation, but this was the same as shooting in the foot, as it increased the political weight of the conservative military in the Army.

The 'forgetfulness' of the past and the permanence of the GNR at the center of the interests of republican governments has provoked criticism and proposals for change in the Portuguese police system (OLIVEIRA, 2017; RODRIGUES, 2014).

The greater territorial and population extension under its responsibility, participation in international conflicts as a military force of conflict and peace, and the rise of its officers to generals, even opting to act in the GNR, tend to point to the GNR, the Portuguese security force, in the 21st century.

**TABLE 04 POLICE OFFICERS PER 100,000 Inhabitants -2014 AND 2015**

Police /year	Judiciary Police	Public Security Police	Republican National Guard
2014	9.5	206.0	214.6
2015	10.1	206.5	222.1

Source: INE, DGPI/MJ, PRODATA-2016

The age range of the guards (Table 05) shows that the Sintra Detachment receives professionals after passing through the more distant units and who are still passing through to reach their final unit, probably in the interior of the country. On the other hand, the age group means stability in the profession. The definitive option for Guarda provides training courses and, consequently, professional advancement. Table 01 informs that of the total of 143 guards and corporals, 37% managed to ascend to corporal, some of them being main corporal, in 2016. One of the corporals that I accompanied is main corporal and had participated in training and intervention forces.

**TABLE 05 GNR/SINTRA GENERAL TOTAL / AGE GROUP**

AGE RANGE	Up until 29	Up until	Up until
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		30-45	46-60
The amount	16	38	12

Source: DTSintra/GNR

The training of guards, corporals and sergeants takes place at Escola da Guarda, based in Queluz and with training units in Figueira da Foz and Portalegre. In these training centers, the various qualification and updating courses take place. Candidates for the 2017/2018 competition are finishing their training course in Figueira da Foz and Portalegre.

The relevance of female participation in the Guarda Nacional Republicana (Chart 06) cannot be disregarded, since a significant part of the assistance in the detachments or in the guard tours involves women. The non-attendance of women by women causes embarrassment to the one who attends with the one who is cared for. As Durão (2016, p. 103) says in his study on the PSP: "The reduced number of women in patrol services makes the right to be attended by an agent or chief dependent on a call to neighboring police stations, which nothing practical is revealed in the day-to-day of police activity".

In the GNR it is no different, the female presence is still a difficulty, despite the increase in the participation of women in professional staff. In the Sintra detachment, only 10% of the respondents are women. However, of these, two occupy command positions. In Alcabideche, I met two other guards who participate in police activities. One of them informed me that she knew the movie 'A tropa de elite' and shows that she wants police activities in Portugal to have the same pace, with regard to confrontations with criminals.

TABLE 06 GNR/SINTRA GENERAL TOTAL/SEX

SEX	FEMININE	MASCULINE
The amount	06	60

Fonte: DTSintra/GNR

At the end of 2015, according to data from the Ministry of Internal Administration, the GNR had 22,416 military personnel, of these 1,225 were women, of these 1041 are guards, 132 sergeants and 52 officers.

In the 2017/2018 admission contest, 42 women, out of a total of 584, were approved for the Guard Training Course. The path to a more significant participation of women in the GNR is not easily presented by the numbers. However, its relevance has attracted the attention of

military and civil authorities, who have debated about the organization of the police system.

In the following tables, guards, corporals, sergeants and officers express their positions on the current Portuguese police system and on the relationship with the PSP with regard to territorial division and their skills in policing and investigation functions. In a conversation with one of the officers of the GNR Detachment in Sintra, dissatisfaction with the current policy of reducing the territories policed by the Guard is demonstrated.

[...] the Detachment, the territory for which the Detachment is responsible. When talking about the territory, he informs me that in the past, the GNR policed the Cascais part, but by deliberation of the competent body, it started to be managed by the PSP, in view of its degree of urbanization. He showed dissatisfaction and made it visible that it is a relationship of political strength. He showed me a powerpoint with information about the Detachment and said he would email it to me. Next comes Lieutenant {name subtracted}. Begins a set of questions formulated by the captain to the lieutenant about the activities and information that she should know. He respectfully answers questions (field diary notes)

The GNR is distributed in most of Portugal and, according to the information that the lieutenant gave us, it polices a larger number of the population, however, concerns about this scenario are constant, due to the spatial changes being subject to political decision.

Because of this, the training process is taken seriously by the Portuguese police. Before Law nº 30/2017, which requires the criterion of the 12th year or equivalent course for the GNR, we were able to find, through this survey, guards in the 6th school year, according to table 07.

TABLE 07 GENERAL TOTAL – POLICE OFFICERS/SCHOOL TRAINING BY UNIT OF SINTRA DEPARTMENT

UNITY/ SCHOOL TRAINING	Command and Sintra	Alcabideche	Colares
6th to 9th grade	10	03	04
11th grade	06	08	01
12th grade	14	10	05

Graduation	01	00	01
Master	01	01	00

Source:: DTSintra/GNR

Table 07 presents a worrying diagnosis regarding the school training of guards, corporals and sergeants, in view of the significant number, in the Sintra detachment, of police officers from the 6th to 11th school year, that is, without complete basic training. Low education makes cognitive processes and interaction with the technological world and speech production difficult, which are necessary elements in a knowledge and technological society. In this same context, proximity programs are included, which require police officers in constant training and dialogue with the community. In this sense, it is worth highlighting the position of Major General, who opened the school year of Guard school, in 2007, after Law n° 63/2007.

It is a modern model that, in our opinion, will be a factor of success and excellence. We live in a time when societies, based on the democratic rule of law, are increasingly confronted with the specter of threats directed at their fundamental values.

The rights, freedoms and guarantees of citizenship, as well as their exercise, are often the target of various attacks, boosted by the globalization process, which gives special importance to all issues related to the topic of security.

With the approval of Decree Law n° 30/2017, training becomes a relevant criterion for the Guard. In this case, the requirement of complete basic training (12th grade or equivalent) for entry into the guard career means that this police force looks at a contemporary, pluralistic and technological society. On the other hand, a higher level of schooling is no antidote to poor professional training and corruption. When we analyze the trajectory of civil police officers in Piauí, in the period of 2001, we realize that the high level of training was not enough to avoid the involvement of a significant part of the police in the world of crime.

The numbers of educational background contrast with the length of service in the police, as one might think that less schooling would be associated with a longer time with the police, but this is not what the data indicate.

The data in table 08 show that a significant part of the guards, corporals and sergeants of the GNR are in the period from 0 to 15 years of service. Of the police officers who answered the questionnaire, most joined the Guard after the Dictatorship. Professional time can identify

guards that are more sensitive or flexible to new concepts of policing, especially proximity.

What can be reflected, having as variables, the time of entry and the reduction of the effective in the Sintra Detachment, according to table 01, is the existence of an intense turnover. In this sense, it can be concluded that the oldest police officers do not stay in Sintra, they move to other regions of the country.

**TABLE 8 GENERAL TOTAL POLICE OFFICERS /  
POLICE TIME BY UNIT OF SINTRA DEPARTMENT**

UNITY/ POLICE TIME	Command and Sintra	Alcabideche	Colares
00-05 years	05	05	02
06-10 years	05	08	02
11-15 years	10	01	02
16-20 years	05	05	01
21-25 years	01	02	01
26-30 years	05	01	03
30...	00	00	00

Fonte: DTSintra/GNR

The data in Table 08 explain the difficulty I had in finding the GNR police officers who collaborated with the research at the first moment I was in Sintra and Alcabideche. Upon returning to the detachment and to the unit in Alcabideche to supplement information, it was not possible to find the officers, as they had been transferred, with the large flow of guards to the interior of the country.

The transitoriness of the police in the operational units produces another difficulty, the implementation of proximity programs. The Sintra Detachment has several proximity programs, as described above, but the selection of police officers identified with this philosophy is a challenge for unit commanders. Most police officers understand the role of the police is in fighting crime, criminals. There are barriers to understanding proactive and preventive action.

### **3.1 Territorial distribution and skills to police and investigate**

The issue of territorial division has caused debates between the three police forces, the PSP, the GNR and the PJ, however, due to the limitations of the investigation, we will analyze the versions obtained from the GNR in the sample universe described above in this chapter.

The questionnaire made available to the GNR contains six questions, which I group into two aspects: the

first, territorial division and skills, the second, the axis of the police system. The categories that guide the questionnaire are: organization of security forces, structure of the police system, territorial division of security forces, capacities to police and investigate.

Four categories that are intertwined with each other and that can bring to light the actors' view of the current organization of the Portuguese police system. To follow the thought of exposition of the text, we will initially highlight the questions from A to D that deal with territorial distribution and the skills of police forces for policing and investigation. The answers were organized from A to C in; bad, enough, good and great. In D, the answers were yes or no.

The questionnaire is a complementary tool to field activities to provide the necessary information about the subjects collaborating in the research and the research problems. The table below presents the results of the responses of the Sintra Detachment Command, in the units of Sintra, Alcabideche and Colares.

**TABLE 09 TERRITORIAL DIVISION AND SKILLS**

- What is your assessment of the territorial division of the security forces, especially the GNR and the PSP?
- What is your assessment of your institution's overt policing and investigative skills?
- How do you assess the policing and investigative capacity of PSP officers?
- Do you think that the GNR could police and investigate the same or better than the PSP in urban centers?

Items	Bad		Sufficient		Good		Great	
		%		%		%		%
A	17	26	35	53,0	12	18,2	02	3
B	03	4,5	36	54,5	25	38,0	02	3
C	03	4,5	24	36,4	37	56,1	02	3

Source: Author of the investigation

Although the modern process of training the Portuguese police forces ensured defined territorial spaces, in this case the GNR, which replaced the municipal guards and occupied the spaces of the Army forces in the interior of the country, but continued to police the crowds, that is,

maintained its role in urban areas. In the case of the civil forces, they did not have an adequate structure to face the conflicts (Cerezales, 2006, 2017; Póvoa, 2017) nor the confidence of the new republican leaders.

In the current phase of Portuguese democracy, police forces have their spaces determined by the tradition of the rural police force and by political convenience. In this sense, discontent appears in academic publications (Oliveira, 2017; Elias, 2011, Rodrigues, 2014) and through polls.

The results shown in tables 09 and 10 point to a dissatisfaction of the GNR members about the territorial division and the organization of the Portuguese police system, in view of the constant changes in the policing structure. 79% of respondents assess the territorial division involving the GNR and the PSP as bad and sufficient. In question b, 95.5% evaluate the GNR's competences and abilities to carry out policing and criminal investigation activities as sufficient, good and excellent. In question c, 40.9% rated the PSP's ability to police and investigate as poor and sufficient. In question d, 87.8% agree that the GNR does the same or better policing and investigation than the PSP in urban areas.

The data bring to light a reality, although the GNR was formed as a rural police force, like other European security forces, currently, the Guard overflows these characteristics. Not only because it always polices large populations in urban centers, but because it is present in large cities.

Another device that allows the GNR and its staff to compete for urban spaces is what is stated in the Organic Law of the GNR, 63/2008, in its article 5, when stating that the area of responsibility of the GNR is defined by an ordinance issued by the supervising minister.

Elias (2011) states that the PSP was replaced in 17 territories, out of the 47 in which the competent authority had foreseen. This difference was due to the resistance movements of the PSP in accepting the reduction of its field of action.

The data and the academic debate point to the discontent of the security forces, both the GNR and the PSP, in relation to their area of activity. On the other hand, the judicial and administrative authorities draw up common public security programs for the two security forces, especially the proximity police.

The Sintra Detachment Command identifies projects in operation in its units linked to the philosophy of proximity: Safe School, Safe Elderly, Safe Commerce, Safe Supply, Safe Pharmacy, SOS Azulejo, Safe Taxi, Santo António and AGRISEGUR.

Community philosophy projects are found in both the GNR and the PSP, Poiaras (2013) in his work on the PSP in Beja highlights several projects carried out in this city by the PSP, among them: Escola Segura, Comércio Seguro, Idosos em Segurança, Operação Férias and University Education/Higher Security.

Police activities are not strange to the GNR, despite having a military identity, it is a hybrid institution (military and police nature) and, to respond specifically to police activities, the Ministry of Internal Administration (MAI) organizes a Statute of the GNR Military, Decree n° 30/2017, which in addition to expanding rights, distinguishes them from the Army. According to Elias (2011, p. 145) this military identity is not just a matter of the GNR, only with Law n° 5/99 the PSP had its civil nature consecrated.

Since then, PSP has gone through a process of reforming its organization, training and gradual reformulation of the operating philosophy, in the areas of finance, human resources and logistics. Deep down, he is still in a kind of search for identity. Equally relevant is the approval of a disciplinary statute for the GNR108, no longer applying the military discipline regulation.

These facts demonstrate that the Portuguese security forces have undergone transformations in the periods described by Oliveira in order to adapt them to the democratic system, especially with the activities of proximity policing and the creation of the Consultative Council for the Training of Security Forces and Services. (CCFFSS). This last body to enable continuous training based on human rights and proximity policing (OLIVEIRA, 2006).

The definition of rules for the performance of institutions and police forces to reduce conflicts and competition between security forces, however, the operational base, that is, guards, corporals, sergeants and officers, by the Guard; the agents and officers, by the PSP, when provoked for an evaluation of the organization of the security forces and evaluation of the police system, present tensions and conflicts about them.

TABLE 10 ORGANIZATION OF SECURITY FORCES /  
STRUCTURE OF THE POLICE SYSTEM

- How do you evaluate the organization of the Portuguese security forces?
- How do you evaluate the structure of the Portuguese police system?

Items	Bad		Sufficient		Good		Great	
		%		%		%		%
A	08	12	31	46	26	39.3	01	1.5
B	06	09	38	57.5	20	30.3	02	03

Source: Author of the investigation

Law n° 049/2008, Law on the Organization of Criminal Investigation (LOIC) assigns the same powers to the GNR and the PSP.

It is the general competence of the Guarda Nacional Republicana and the Public Security Police to investigate crimes whose competence is not reserved for other criminal police bodies and also crimes whose investigation is committed by the competent judicial authority to direct the process, under the terms of article 8°.

The powers of the police are carried out in different territories determined by order of the Ministry of Internal Administration (MAI). According to a report by one of the PJ inspectors, the overlapping of competences affects the Judiciary Police, which often comes up against guards or agents acting in crimes that are investigated by their institution.

#### IV. CONCLUSION

The conflicts between the GNR and PSP stem from the attributions of the police to a military security force and from the territorial space occupied by this military force. The first characteristic is historical and is part of Portuguese society, consolidated by DL n° 30/2017. As for the territorial space, despite the fact that a rural police force is a European tradition and, in Portugal, the GNR occupies this space, the territorial distribution is made by ministerial decree, that is, there is a political variable in the dynamics of the distribution of security forces. .

The Portuguese police system has a structure and organization compatible with the needs of the social, political and cultural system of its context and time. The efficiency framework of the security forces and services may be associated with the reduced degree of social tension, that is, social inequalities exist, but they do not threaten the security system or democracy.

The dual aspect, the complete cycle, the plurality of police authorities, the proximity of the public prosecutor and the coordination and integration of the police forces

carried out by bodies superior to the police forces contribute to the effective operationalization of the police system. However, some elements, considered negative, remain in the two major security forces, the GNR and the PSP, the double entry, one for guards and one for officers, in the case of the GNR, restricting the functional ascension of the former; is not distinct on the PSP, an entry for agents and another for officers.

Therefore, the structure of the Portuguese police system has institutional advances compared to the Brazilian one and they are in them a substantial part of the success in crime control and in the flexibility of the system to adapt to the context of political, cultural and technological transformations. On the other hand, the corporate and individual ethos conditioned by the identity tension of each police force and by the pressure of the political field keeps disputes between police organizations, which in this case, favors the good performance of these institutions in citizen security.

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# Nutritional status of children under five years of age in the metropolitan health region I state of Pará: SISVAN web 2016 to 2020

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**Keywords—** Children, Nutrition, Nutrition Status, SISVAN.

**Abstract** — The present study aimed to characterize the nutritional status of children aged zero to five years in the Metropolitan Health Region I between the years 2016 to 2020. This is a descriptive quantitative study with secondary data from the National Food and Nutrition Surveillance System (SISVAN - WEB). The collection of these data was carried out from June to July 2021. The results showed high percentages of children with nutritional deficits, such as Low Weight for Age, Low Height for Age and Low BMI for Age, as well as a significant percentage of eutrophic children and with High Weight for Age in the five municipalities from which the data were extracted (Belém, Ananindeua, Benevides, Marituba and Santa Barbara do Pará). It was possible to identify that nutritional problems caused by economic, demographic and social factors are directly impacting the nutritional status of children belonging to metropolitan health region I.

## I. INTRODUCTION

Child development is directly linked to genetic and environmental factors to which children are exposed. Adequate nutrition in early childhood is of great importance for the growth of little ones. Likewise, for the success of this process it is necessary that it be introduced at the beginning of the individual's life cycle. Exclusive breastfeeding for the first 6 months not only helps to meet all the needs of infants, but also helps to prevent the onset of other diseases such as allergies, type 1 diabetes, leukemia and obesity [1].

To identify possible nutritional problems in the Brazilian population, the Food and Nutrition Surveillance System (SISVAN) was created, a tool that helps in monitoring the food and nutritional situation. Its first milestones date back to 1970, but it was only in 1990 that the first legal milestones that supported its actions were observed. To improve the flow of data and the way in which these are recorded, the SISVAN Web was developed, an online version of the system launched in 2008. Over the years, this system has focused on the support of health professionals, mainly in the care basic care, contributing to the local diagnosis of food and

nutritional conditions and disorders of the population served in Primary Care services in Brazil [2, 3].

The present research aimed to characterize the nutritional status of children under five years of age in the metropolitan health region I in the state of Pará/Brazil, from 2016 to 2020, registered in the SISVAN- Food Surveillance System. and Nutritional, through reports available in the SISVAN WEB database, observing P/A, A/A and BMI/A indexes during the years 2016 to 2020.

## II. METHODOLOGY

This is a quantitative and descriptive study, with secondary data from the National Food and Nutrition Surveillance System (SISVAN - WEB). The collection of these data was carried out from June to July 2021. The sample of this study consisted of children aged 0 to 5 years living in the municipalities of Belém, Ananindeua, Benevides, Marituba and Santa Bárbara do Pará, which

make up the Region of Metropolitan Health I in the state of Pará, data extracted from the SISVAN WEB public reports. All reports available on the platform of the National Food and Nutrition Surveillance System for the years 2016 to 2020 of the Metropolitan Health Region I - PA were included. After defining the reports to be used, there was no data exclusion.

Regarding the ethical aspects of the present research, secondary data from the SISVAN WEB public reports were used, which exempts the submission to the evaluation of the Research Ethics Committee in accordance with Resolution 466/12 of the National Health Council (CNS). However, all established ethical precepts will be considered to ensure the legality of information, privacy and confidentiality of data. The study received no funding, and the authors declared no conflict of interest.

## III. RESULTS AND DISCUSSION

*Table 1. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2016 registered in the SISVAN- Food and Nutrition Surveillance System, according to the Weight/Age parameter.*

Metropolitan I /2016									
Counties	Weight/Age								
	Very low weight for age	%	Low weight for age	%	Adequate or eutrophic weight	%	High weight for age	%	Total
Belém	136	0,74	441	2,4	16.627	90,64	1.141	6,22	18.345
Ananindeua	99	1,69	238	4,08	5.040	86,04	481	8,24	5.858
Benevides	29	2,78	72	6,9	879	84,28	63	6,04	1.043
Marituba	46	1,59	107 3	3,71	2,408	83,4	324	11,23	2.885
Santa Bárbara do Pará	11	1,66	44	6,64	561	84,62	47	7,09	663

Source: Authors, 2022

Table 2. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2017 registered in the SISVAN- Food and Nutrition Surveillance System, according to the Weight/Age parameter.

Metropolitan I /2017									
Counties	Weight/Age								
	Very low weight for age	%	Low weight for age		Adequate or eutrophic weight	%	High weight for age	%	Total
Belém	115	0,72	500	3,15	14.420	90,81	845 532	5,32	15.880
Ananindeua	49	1,15	155	3,65	3.764	88,61	280	6,59	4.248
Benevides	27	1,14	83	3,5	2.020	85,23	240	6,59	2.370
Marituba	44	1,23	159	4,45	2.964	82,89	409	11,44	3.576
Santa Bárbara do Pará	13	1,82	27	3,77	639	89,25	37	5,17	716

Source: Authors, 2022

Table 3. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2018 registered in the SISVAN- Food and Nutrition Surveillance System, according to the Weight/Age parameter.

Metropolitan I /2018									
Counties	Weight/Age								
	Very low weight for age	%	Low weight for age	%	Adequate or eutrophic weight	%	High weight for age	%	Total
Belém	297	1,61	543	2,95	16.570	89,93	1,016	5,51	18,426
Ananindeua	186	3,22	248	4,3	5,004	86,71	333	5,51	5.771
Benevides	22	0,77	83	2,89	2.540	88,38	229	7,97	2.874
Marituba	50	1,27	118	3,01	3.560	90,68	198	5,04	3.926
Santa Bárbara do Pará	9	0,95	45	4,75	847	89,35	47	4,96	948

Source: Authors, 2022

Table 4. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2019 registered in the SISVAN- Food and Nutrition Surveillance System, according to the Weight/Age parameter.

Metropolitan I /2019									
Counties	Weight/Age								
	Very low weight for age	%	Low weight for age	%	Adequate or eutrophic weight	%	High weight for age	%	Total
Belém	300	1,55	458	2,37	16.445	85,19	2.100	10,88	19.303
Ananindeua	685	7,75	404	4,57	7.331	82,59	418	4,73	8.838
Benevides	28	0,95	91	3,1	2.626	89,35	194	6,6	2.939
Marituba	61	1,84	115	3,47	2.959	89,18	183	5,52	3.318
Santa Bárbara do Pará	6	0,74	40	4,9	732	89,71	38	4,66	816

Source: Authors, 2022

Table 5. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2020 registered in the SISVAN- Food and Nutrition Surveillance System, according to the Weight/Age parameter.

Metropolitan I /2020									
Counties	Weight/Age								
	Very low weight for age	%	Low weight for age	%	Adequate or eutrophic weight	%	High weight for age	%	Total
Belém	547	4,96	441	4	9.296	84,22	754	6,83	11.038
Ananindeua	235	3,02	372	4,79	6.744	86,81	418	5,38	7.769
Benevides	22	1,26	57	3,27	1.492	85,65	171	9,82	1.742
Marituba	33	1,6	58	2,81	1.843	89,42	127	6,16	2.061
Santa Bárbara do Pará	4	0,51	26	3,334	678	89,42	71	9,1	779

Source: Authors, 2022

Table 6. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2016 registered in the SISVAN- Food and Nutrition Surveillance System, according to the Height/Age parameter.

Metropolitan I 2016							
Counties	Height/Age						
	Very low height for age	%	Low height for age	%	Age-appropriate height	%	Total
Belém	1.133	6,18	1.661	9,05	15.551	84,77	18.345
Ananindeua	455	7,77	577	9,85	4.826	82,38	5.858
Benevides	2.178	8,27	190	7,24	2.218	84,5	2.625
Marituba	209	7,24	263	9,12	2.413	83,64	2.885
Santa Bárbara	36	5,43	85	12,82	542	81,75	663

Source: Authors, 2022

Table 7. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2017 registered in the SISVAN- Food and Nutrition Surveillance System, according to the Height/Age parameter.

Metropolitan I /2017							
Counties	Height/Age						
	Very low height for age	%	Low height for age	%	Age-appropriate height	%	Total
Belém	667	4,2	1.278	8,05	13.935	87,75	15.880
Ananindeua	244	5,74	428	10,08	3.576	84,18	4.248
Benevides	193	8,14	199	8,4	1.978	83,46	2.370
Marituba	278	7,77	347	9,7	2.951	82,52	3.576
Santa Bárbara do Pará	43	6,01	97	13,55	576	80,45	716

Source: Authors, 2022

Table 8. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2018 registered in the SISVAN- Food and Nutrition Surveillance System, according to the Height/Age parameter.

Metropolitan I /2018							
Counties	Height/Age						
	Very low height for age	%	Low height for age	%	Age-appropriate height	%	Total
Belém	917	4,98	1.559	8,46	15.950	86,56	18.426
Ananindeua	536	9,29	626	8,46	4.609	79,86	5.771
Benevides	142	4,94	237	8,25	2.495	86,81	2.874
Marituba	253	6,44	333	8,48	3.340	85,07	3.926
Santa Bárbara do Pará	53	5,59	98	10,34	797	84,07	948

Source: Authors, 2022



Table 9. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2019 registered in the SISVAN- Food and Nutrition Surveillance System, according to the Height/Age parameter.

Metropolitan I /2019							
Counties	Height/Age						
	Very low height for age	%	Low height for age	%	Age-appropriate height	%	Total
Belém	826	4,28	1.183	6,13	17.294	89,59	19.303
Ananindeua	1.770	20,03	842	9,53	6.226	70,45	8.838
Benevides	152	5,17	262	8,91	2.525	85,91	2.939
Marituba	182	5,49	210	6,33	2.926	88,19	3.318
Santa Bárbara do Pará	41	5,0	81	9,93	694	85,05	816

Source: Authors, 2022

Table 10. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2020 registered in the SISVAN- Food and Nutrition Surveillance System, according to the Height/Age parameter.

Metropolitan I /2020							
Counties	Altura/Idade						
	Very low height for age	%	Low height for age	%	Age-appropriate height	%	Total
Belém	519	4,7	593	5,37	9.926	89,93	11.038
Ananindeua	1.376	17,71	786	9,89	5.624	72,4	7.768
Benevides	128	7,35	149	8,55	1.465	84,1	1.742
Marituba	79	3,83	110	5,34	1.872	90,83	2.061
Santa Bárbara do Pará	36	4,62	77	9,88	666	85,49	779

Source: Authors, 2022

Table 11. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2016 registered in the SISVAN- Food and Nutrition Surveillance System, according to the BMI/Age parameter.

Metropolitan I 2016													
Counties	BMI/Age												
	Pronounced thinness	%	Thinness	%	Eutrophy	%	risk of overweight	%	Overweight	%	Obesity	%	Total
Belém	327	1,78	344	1,88	11.073	60,36	3.998	21,79	1.639	8,93	964	5,25	18.345
Ananindeua	275	4,69	171	2,92	3.234	55,21	1.088	8,57	539	9,2	551	9,41	5.858
Benevides	91	3,47	79	3,01	1.540	58,67	439	16,72	203	7,73	273	10,4	2.625

<b>Marituba</b>	141	4,8 9	96	3,3 3	1.598	55,3 6	491	17,0 2	258	8,9 4	301	10,4 3	2.88 5
<b>Santa Bárbara</b>	31	4,6 8	29	4,3 7	411	61,9 9	95	14,3 3	58	8,7 5	39	5,88	663

Source: Authors, 2022

Table 12. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2017 registered in the SISVAN- Food and Nutrition Surveillance System, according to the BMI/Age parameter.

Metropolitana I /2017													
Counties	BMI/Age												
	Pronounced thinness	%	Thinness	%	Eutrophy	%	Risk of overweight	%	Overweight	%	Obesity	%	Total
<b>Belém</b>	203	1,2 8	289	1,8 2	10.443	65,7 6	3.091	19,4 6	1.144	7,2	710	4,47	15.8 80
<b>Ananindeua</b>	119	2,8	140	3,3	2.444	65,7 6	859	20,2 2	369	8,69	317	7,46	4.24 8
<b>Benevides</b>	89	3,7 6	61	2,5 7	1.378	58,1 4	377	15,9 1	197	8,31	268	11,3 1	2.37 0
<b>Marituba</b>	123	3,4 4	149	4,1 7	1.980	55,3 7	589	16,4 7	375	10,4 9	360	10,0 7	3.57 6
<b>Santa Bárbara do Pará</b>	17	2,3 7	33	4,6 1	454	63,4 1	119	16,6 2	52	7,2 6	41	5,73	716

Source: Authors, 2022

Table 13. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2018 registered in the SISVAN- Food and Nutrition Surveillance System, according to the BMI/Age parameter.

Metropolitan I 2018													
Coounties	BMI/Age												
	Pronounced thinness	%	Thinness	%	Eutrophy	%	Risk of overweight	%	Overweight	%	Obesity	%	Total
<b>Belém</b>	285	1,5 5	398	2,1 6	11.882	64,4 8	3.669	19, 91	1.328	7,2 1	864	4,6 9	18.4 26
<b>Ananindeua</b>	191	3,3 1	205	3,5 5	3.332	57,7 4	1.092	18,9 2	524	9,0 8	427	7,4	5.77 1
<b>Benevides</b>	70	2,4 4	87	3,0 3	1.733	60,3	482	16,7 7	284	9,8 8	218	7,5 9	2.87 4
<b>Marituba</b>	83	2,1 1	77	1,9 6	2.439	62,1 2	819	20,8 6	293	7,4 6	215	5,4 8	3,92 6

<b>Santa Bárbara do Pará</b>	28	2,9 5	34	3,5 9	563	59,3 9	172	18,1 4	82	8,6 5	69	7,2 8	948
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Source: Authors, 2022

Table 14. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2019 registered in the SISVAN- Food and Nutrition Surveillance System, according to the BMI/Age parameter.

Metropolitan I /2019													
Counties	BMI/Age												
	Pronounced thinness	%	Thinness	%	Eutrophy	%	Risk of overweight	%	Overweight	%	Obesity	%	Total
<b>Belém</b>	1.100	5,7	1.010	5,2 3	12.405	64,2 6	2.842	14,7 2	1.157	5,9 9	790	4,09	19.304
<b>Ananindeua</b>	865	9,7 9	384	4,3 4	4.780	54,0 8	1.167	13,2	597	6,7 5	1,045	11,8 2	8.838
<b>Benevides</b>	103	3,5	126	4,2 9	1.808	61,5 2	494	16,8 1	225	7,6 6	183	6,23	2.939
<b>Marituba</b>	145	4,3 7	127	3,8 3	2,157	65,0 1	489	14,7 4	237	7,1 4	163	4,91	3,318
<b>Santa Bárbara do Pará</b>	26	3,1 9	39	4,7 8	538	65,9 3	108	13,2 4	57	6,9 9	48	5,88	816

Source: Authors, 2022

Table 15. Nutritional status of children under five years of age in Metropolitan Region I in the State of Pará in 2020 registered in the SISVAN- Food and Nutrition Surveillance System, according to the BMI/Age parameter.

Metropolitan I 2020													
Counties	IMC/Idade												
	Pronounced thinness	%	Thinness	%	Eutrophy	%	Risk of overweight	%	Overweight	%	Obesity	%	Total
<b>Belém</b>	1.464	13,2 6	451	4,0 9	6.617	59,9 5	1.483	13,4 4	551	4,9 9	472	4,2 8	11.038
<b>Ananindeua</b>	385	4,96	243	3,1 3	4.820	62,0 4	1.015	13,0 6	566	7,2 9	740	9,5 3	7.769
<b>Benevides</b>	50	2,87	54	3,1	1.021	58,6 1	314	18,0 3	161	9,2 4	142	8,1 5	1.742
<b>Marituba</b>	63	3,06	63	3,06	1.362	66,08	313	15,19	160	7,76	100	4,85	2.061
<b>Santa Bárbara do Pará</b>	27	3,47	30	3,85	454	58,28	138	17,72	61	7,83	69	8,86	779

Source: Authors, 2022

### Weight for age

In table 1, it is possible to observe the data referring to the weight-for-age index in the year 2016, which is classified into 4 cut-off points (very low weight for age, low weight for age, eutrophic and high weight). When analyzing the data, it was noted that the city of Benevides had the highest value, 2.78% (n=29) of children within the classification of very low weight for age, as well as for low weight for age 6.90% (n=72) of children in this situation. When taking into account the eutrophic classification, the city of Marituba is in the worst situation with a percentage of 83.40% (n=561). 11.23% (n=324).

In a study carried out by Araújo et al. [4] with children aged 0 to 59 months living in the municipality of Jordão, state of Acre, it was possible to observe that the general deficit in weight for age was 7.3%, with a higher occurrence among children with indigenous ancestry residing in the state of Acre rural area, highlighting in the work the influence of the place of origin in the presence of this place. The results of this study corroborate those observed in this research, with emphasis on the geographic location of both, the northern region, which, due to social, economic and environmental factors, is historically more susceptible to nutritional deficits.

On the other hand, Santos et al. [5] in their study carried out in a city in the interior of Minas Gerais, regarding the influence of the Bolsa Família Program on the anthropometric index such as weight for age of beneficiary children, observed a high percentage of weight for age of 15.4% of children. Likewise, Junior et al. [6], when analyzing the prevalence of overweight in children admitted to a maternal and child referral hospital in the state of Pernambuco, observed that 17.6% of the children who made up the sample were under the condition of high weight for their age. These data are higher than those observed in the municipality of Marituba, in which lower values can be observed in relation to this finding, but significant when compared to the municipalities of its own health region.

In table 2, it is possible to observe the data referring to the weight for age index in the year 2017, in the very low weight for age classification (PMBI), the municipality of Santa Bárbara do Pará obtained the worst indicator 1.82% (n=13). In the classification of low weight for age (PBI), Marituba had the highest percentage 4.45% (n=159), in addition to having presented an increase of 20% in relation to the previous year, as well as remaining with the smallest eutrophy values of 82.89% (n=2,964), and with the highest value of weight for age 11.44%.

In a study carried out on the prevalence of malnutrition and overweight in children under five years of age and its relationship with socioeconomic, health and demographic factors in six of the largest cities in Maranhão, it was observed that, according to the weight-for-age criterion, the prevalence of malnutrition was 4.5% [7]. These results differ from this study, as they present higher values of weight deficit, with high risk for children exposed to this scenario, since this situation can directly impact the development and growth of these individuals in the long term. However, the prevalence of overweight in the study by Chagas et al. [7] surpassed malnutrition in children under five living in the six most populous municipalities in Maranhão.

In table 3, it is possible to observe the data referring to the weight for age index in the year 2018, in the classification of very low height for age, it can be observed that the city of Ananindeua had the highest percentages 3.22% (n=186). In the classification of low weight for age, the city of Santa Bárbara do Pará presented the highest percentages, 4.75% (n=45). In the classification of normal weight and high weight for age, the city of Benevides had the lowest percentage 88.38% (n=2,540) for normal weight, and the highest percentage for high weight for age 7.97% (n=229).

In a research that sought to identify the prevalence of food insecurity in families benefiting from the Bolsa Família Program and the factors related to this condition, as well as to describe the nutritional status of children under five years of age residing in the city of Colombo, metropolitan region of Curitiba, it was possible to observe that for the parameter studied, 11.6% of the children had high weight for their age, whereas among children aged 2 to 5 years, the prevalence was 8.3% [8]. In addition, the authors of the study attest that malnutrition characterized by stunting and overweight is shown to be a key factor in confirming the nutritional transition in this population [8]. When taking into account the observed data, it is noted that the children in the study, residents of the northern region of the country, present lower percentages of the same parameter, when compared to those from the southern region, since the living and development conditions of each location differ greatly.

On the other hand, the research by Oppitz et al. [9] pointed out that the weight deficit for age (-2 Z scores) had a reduction from 6% in 1989 to 2% in 2006. However, these data reflect the reality of municipalities in the northeast region of the country, which even with a socioeconomic configuration similar to the north still has its particularities. So when we try to compare the data, they don't show big discrepancies, but they still represent different scenarios.

In table 4, it is possible to observe the data regarding the weight for age index in the year 2019. In the very low weight for age classification, the city of Ananindeua had the highest percentages 7.55% (n=185) and also the highest percentages of low weight for age 4.55% (n=404), and in relation to eutrophy, Ananindeua also presented the lowest percentages 82.59% (n=7,331), in the classification of high weight for age, the city of Belém presented the highest percentages 10.88% when comparing with data from other municipalities.

In a cross-sectional study carried out in 17 indigenous villages located in a region between Brazil and Venezuela, with the aim of verifying the nutritional status of individuals residing in that place, through the growth curves, it was determined that the prevalence of low W/A among children under five it was 50.0% [10]. The results found in the study with Yanomami children are quite different from those observed in children from the metropolitan health region I, which is in a better situation in relation to this parameter, even due to the ills faced in this society. Thus, it can be seen that socioeconomic conditions, place of residence and logistical problems directly influence aspects related to the development of the subject.

In the National Survey of Demography and Health of Children and Women - PNDS for the year 2009 [11] the frequency of P/A deficits estimated for the group of children was 1.9%, with the northern region showing an even lower percentage with a P/I deficit of 3.3%, one of the largest among the country's regions. When analyzing the situation of the metropolitan health region I, even higher values of malnutrition are noted, however, it is worth mentioning that there was a large passage of time between the data compared, but even so, the framework for the worsening of the situation remains consistent.

In table 5, it is possible to observe the data referring to the weight for age index in 2020. When classifying very low weight for age, the highest percentage was identified in the city of Belém, with approximately 4.96% (n=547), observed in the low weight classification for age, Ananindeua showed a higher percentage of 4.79% (n=372). With regard to eutrophy, the municipality of Belém had the lowest percentage, 84.22% (n=9,296). In the classification of high weight for age, the municipality of Benevides had the highest percentage, 9.82% (n=171).

In the study by Saldiva, Silva and Saldiva [12] in the northeast region of the country, about a decade ago, about the health and nutrition conditions of children under five years of age, associated with the quality of food consumption by beneficiaries of the Bolsa Família Program from a municipality in the Brazilian semi-arid

region, it was possible to observe that the weight/age deficit was 4.3%, with a high prevalence of malnutrition. This finding is similar to that found in this study, with similar PMBI values, a fact that may be associated with similar development conditions in both regions, configuring a scenario of "food and nutritional risk" for these individuals.

Pereira et al. [13] presented a panoramic configuration of the nutritional status of children in the country, which is considered an important instrument for measuring the health conditions and quality of life of a population. The results observed in their studies show that the North Region showed a tendency towards the presence of nutritional deficits. However, the situation changed with the influence of income transfer programs, corroborating how the findings of this study, which, based on the temporal analysis, showed a direction contrary to the past, with an increase in the numbers of children within the score of high weight for age.

#### Height for age

From the analyzed data, it is possible to observe, in table 6, the data referring to the A/I index in the year 2016, in which the 3 classifications can be verified (very low height for age (AMBI), low height for age (ABI) and age-appropriate height (AAI)). In the AMBI classification, the municipality of Benevides presented the highest percentage, being 8.27% (n=2,178). In the ABI classification, Santa Bárbara do Pará presented the highest percentage, with 12.82% (n=85) when compared to the other municipalities. Regarding the AAI classification, the city of Ananindeua had the lowest percentage, which was 82.38% (n=4,826).

According to Corrêa et al. [14], the north of the country is the region with the highest percentages of children with AMBI and ABI. A cross-sectional study carried out with children aged 0 to 59 months in the city of Jordão, state of Acre, North of the country, corroborates what was said by Corrêa et al [14], as the results showed a very high percentage in the number of children with AAI deficit, representing a percentage of 35% of the total number of children evaluated [4]. In relation to our findings, we can observe that in the AAI classification, the percentages of the AMB and ABI classifications corresponded to values still considered high, demonstrating that in the metropolitan health region I, cases of malnutrition due to AAI deficit are still visible, leading us to reflect on the situation in which these children find themselves, because, if effective measures are not taken by our governments, the malnutrition caused by the AAI deficit, compromises the entire development of



these children, which can bring harm that lasts for a lifetime adult.

It can be seen in table 7 the data referring to the AI index in the year 2017. When analyzing the percentages, it was possible to verify that, in the AMBI classification, the city of Benevides had the highest percentage 8.14% (n=193). When classifying ABI, the city of Santa Bárbara do Pará presented the highest percentage 13.55% (n=97). In relation to AAI, the city of Marituba had the lowest percentage when compared to the other municipalities 82.52% (n=2,951).

The percentages of AI deficits identified in a study carried out with children aged 06 to 59 months from the Karapotó people - state of Alagoas, identified a percentage equal to 13.4%, a fact that highlights the problems linked to short stature in these individuals, these values are considered high and characterized as public health problems. The factors associated with this prevalence are maternal schooling, low birth weight, family income and housing conditions [15]. These conditions mentioned above are very similar to those found in the northern region, where the highest percentages of children with a height-for-age deficit are found among indigenous and Quilombolas children who live in conditions of poverty or extreme poverty in areas of difficult access and children of illiterate mothers [16, 17]. The percentage found of children from the Karapotó people is very close to that found in the city of Santa Bárbara do Pará, in relation to the AMBI classification.

In table 8, it is possible to observe the data referring to the AI index in the year 2018. In the AMBI classification, the city of Ananindeua had the highest percentage 9.29% (n=253). The municipality of Santa Bárbara do Pará presented the highest percentage 10.34% (n=98) in the ABI classification. The city of Ananindeua had the lowest percentage in the AAI classification, 79.86% (n=4,609).

In the study by Lopes et al. [17], when evaluating the nutritional status of children aged 6 to 59 months, in the state of Maranhão, identified a prevalence of AMBI of 7.7% among the children followed up. Such results are worrying, as they demonstrate a high percentage of children with AAI deficits. These data are considered close to those found in the metropolitan health region I, in the municipality of Ananindeua, where the percentage of children with AMBI was 9.29%, demonstrating that the north and northeast of the country still have high percentages in cases of malnutrition. These results may be associated with social, demographic and economic factors in both regions.

In table 9, it is possible to observe the data referring to the AI index in the year 2019. As for the values referring to the AMBI classification, Ananindeua presented a very high percentage 20.03% (n=1,770). In the ABI classification, the highest percentage was found in the city of Santa Bárbara do Pará 9, 93% (n=81). Regarding the AAI classification, the city of Ananindeua had the lowest percentage, 70.45% (n=6,226).

As for the data found in the city of Ananindeua (20.03%) in the AMBI classification, the percentage was much higher than that observed among children in Porto Alegre when assessing the nutritional status of children aged 0 to 7 years, beneficiaries of the Program Bolsa Família, registered in a health unit in Porto Alegre. The results showed that, of the total of 74 children, only 1.4% had ABI. This study demonstrates the socioeconomic, geographic, environmental, and ethnic differences that exist between the regions and, finally, demonstrates the importance of access to public policies in the prevention of nutritional problems in the country [18].

It was possible to observe, in table 10, the data referring to the AI index in the year 2020. In the AMBI and ABI classification, the city of Ananindeua presented the highest percentages 17.71% (n=1,376) and 9.89% (n=786), respectively. In relation to the classification of AAI, that city had the lowest percentage, 72.4% (n=5,624).

In a review study carried out by Corrêa et al. [14], with the objective of describing the magnitude of the growth deficit in children under five years of age in the states of the northern region, in the period from 2008 to 2017, 35% of the analyzed studies showed a prevalence of growth deficit below 10%, already in 24% of studies that also included indigenous children or only indigenous children, the prevalence of chronic malnutrition was above 30%.

The data obtained in each state in the northern region show high prevalence of stunting among children in these states, the percentage found in the state of Rondônia was 6.3%, in the state of Amapá the prevalence was 31.1%, in the state of Acre the percentage was 30.3%, in the state of Pará 29.5%, and in the state of Amazonas 25.1%. The results found in our research, mainly in the city of Ananindeua, corroborate the study by Corrêa et al. (2020), as the percentages found in the municipality are high, and when comparing with what was found in the state of Pará, we realize the magnitude of the nutritional problem installed in this municipality.

#### BMI for age

In table 11, it is possible to observe the data referring to the BMI for age in the year 2016, and 6 classifications can be observed (marked thinness, thinness,

normal weight, risk of overweight, overweight and obesity). In the severe thinness classification, Marituba had the highest percentage, 4.89% (n=141). Regarding the thinness classification, Santa Bárbara do Pará presented the highest percentage, 4.37% (n=29). Regarding the eutrophic classification, the city of Ananindeua had the lowest percentage, 55.21% (n=3,234). Regarding the overweight risk classification, the city of Belém had the highest percentage, 21.79% (n=3,998). Regarding the classification of overweight, the city of Ananindeua presented the highest percentage, 9.02% (n=539). In terms of obesity, the municipality with the highest percentage was Marituba, 10.43% (n=301).

With regard to the indices of marked thinness and thinness, indicated through BMI by age, it was found that there was an increase in cases in the cities of Marituba and Santa Bárbara do Pará. In line with this, Gonçalves et al. [19], identified that there was a prevalence of 5.7% for a low Body Mass Index (BMI) in relation to age in children under 6 months of age, monitored by the Food and Nutrition Surveillance System (SISVAN), in Brazil, in the year de 2015. Santos and Bottega [20] pointed out the Bolsa Família Program as a protective factor against infant mortality from malnutrition, showing that the number of families monitored by the program directly influenced these death rates, given that such a government program guarantee to these families the right of access to basic services.

For Torquato et al. [21] just over 24% were overweight. In line with this, an increasing trend of both overweight and obesity was found in the state of Espírito Santo [22]. Such data corroborate the findings of the present study, where an increase in notifications for risk of overweight and overweight and obesity could be observed.

Furthermore, Crescente et al. [23] points to a correlation between the BMI of the child and the parents, such data brings a reflection on the changes in consumption and family lifestyle, where there is a greater intake of foods with high energy density and little nutrition, associated with a sedentary lifestyle children resulting from the overvaluation of the use of electronic media and abandonment of recreational activities.

In table 12, it is possible to observe the data referring to the BMI index for age in the year 2017. In the classification of severe thinness, Benevides had the highest percentage, 3.76% (n=89). Regarding the thinness classification, Santa Bárbara do Pará obtained the highest percentage, which was 4.61% (n=33). In relation to eutrophy, a lower percentage can be observed in the municipality of Marituba, with 55.37% (n=1,980). With regard to the classification of overweight risk, the city

Ananindeua had the highest percentage, 20.22% (n=859), when compared to the other municipalities. Regarding the classification of overweight, the municipality of Marituba presented a very high percentage of 10.49% (n=375). In the classification of obesity, it was observed that the municipality with the highest percentage of children was Benevides, with 11.31% (n=268).

For Torquato et al. [21], during the analysis of the nutritional status of children under two years of age in six public day care centers in Paraíba, a percentage of 5.2% was identified for children in a state of thinness according to BMI for age, with the percentages of healthier children were higher in the urban area of the city. Such data are considered close to those presented in the classification of pronounced thinness and thinness, in the cities of Benevides and Santa Bárbara do Pará, representing that the north and northeast regions of Brazil are still affected with high rates of reported cases of malnutrition.

However, when analyzing the nutritional status of children on prolonged exclusive breastfeeding in the State of Pernambuco, Azevedo et al. [24] found a prevalence of 31.9% for overweight and obesity in children in the control group. This factor may be related to the lack of a set of effects considered beneficial during non-exclusive breastfeeding, such as nutritional, immunological and metabolic ones, which are essential for the protection of the child against the development of possible chronic conditions, as is the case of overweight and obesity.

In table 13, it is possible to observe the data referring to the BMI index for age in the year 2018. In the classification of severe thinness, Ananindeua had the highest percentage, this being 3.31% (n=191), in relation to the classification of eutrophy it presented the lowest percentage 57.47% (n=3,332). With regard to thinness, it was observed that the highest percentage was found in the municipality of Santa Bárbara do Pará, 3.59% (n=34). In the classification of overweight risk, the municipality with the highest percentage was Marituba with 20.86% (n=818). Regarding overweight and obesity, Benevides presented the highest percentages, being 9.88% (n=284) and 7.59% (n=218), respectively.

According to Santos et al. [25], 3.6% of the children analyzed in a day care center in the city of Cuité/PB were in a state of thinness according to the BMI/age parameter, a number similar to that identified in the present study in the cities of Ananindeua and Santa Catarina. Barbara do Pará. Thus, this persistent predominance of thinness in this population may be related to certain sociodemographic characteristics of these families.

Corroborating both studies, Costa et al. [26] pointed out in their findings that 20.8% of preschoolers from private schools in the city of Teresina/PI were at risk of being overweight, 5.2% of children were already overweight and 12.7% were obese. This perspective may be associated with the nutritional transition process that Brazil has been facing, where the presence of lower numbers of malnutrition and a growing prevalence of overweight and obesity cases can be observed, as a result of changes in lifestyle and the process of globalization.

In table 14, it is possible to observe the data referring to the BMI index for Age in the year 2019. In the classification of severe thinness, it can be observed that Ananindeua presented the highest percentage, with 9.79% (n=865), since in relation to eutrophy, the mentioned city had the lowest percentage 54.08% (n=4,780). Regarding the classification of thinness, Belém was the municipality that presented the highest percentage, 5.23% (n=1,100). Regarding the classification of overweight risk, Benevides had the highest percentage, 16.81% (n=494), the same city also had the highest percentage of overweight, 7.66% (n=225). With regard to obesity, the highest percentage was found in the city of Ananindeua, 11.82% (n=1,045).

Alves et al. [27] seeking to assess the nutritional status of children between zero and five years of age in Sobral/CE, identified a prevalence of 5.12% of marked thinness and thinness within their sample. In line with this, Vieira et al. [28] highlights as risk factors for child malnutrition both the family's food insecurity and the inadequacy of the mother and child binomial.

Corroborating the findings of the present study, Vasconcelos et al. [29] found that there was a decline in excess weight in infants between 2008 and 2018, with regard to preschoolers, an increase in this prevalence was identified by about 3.1% per year until 2015, after that, there was a drop in the percentages until the year 2018. Within these two groups, the northern region of Brazil was the one with the lowest prevalence. Thus, it is associated that breastfeeding can be of fundamental importance for the reduction of cases of excess weight in infants, since it can reduce the chances of overweight in childhood.

In table 15, it is possible to observe the data referring to the BMI index for age in the year 2020. In the classification of severe thinness, the highest percentage was identified in the city of Belém, 13.26% (n=1,464). In the classification of thinness, Belém also presented the highest percentages, 4.09% (n=451). With regard to eutrophy, Santa Bárbara do Pará had the lowest percentage, 58.28% (n=454). Regarding the classification of risk of overweight and overweight, the municipality of

Benevides had the highest percentages, 18.03% (n=314) and 9.24% (n=161), respectively. In terms of obesity, the municipality with the highest percentage compared to the others was Ananindeua, with 9.53% (n=740).

When monitoring malnourished children to identify possible risk factors, Eickhoff and Nogueira [30] reveal that such children are more prone to more humid housing conditions, offering food of low nutritional value and living in high-violence neighborhoods. Such factors are considered to have a high influence on the involvement of these children by infectious diseases, in addition to conditioning for an unhealthy lifestyle that can negatively affect the entire life of these individuals.

When analyzing overweight in schoolchildren in the city of Carapicuíba/SP, Eskenazi et al. [31] identified that 26.7% of five-year-old children were overweight, while 10.8% were obese, a figure that can be similar to the present research. These data can be associated with an increase in family income, when these families express their preferences for the purchase of processed foods with low nutritional content, a decrease in the practice of physical activity by children, to the detriment of the overestimation of time in front of the screens and greater active participation of women in the labor market.

#### Historical series of BMI for age

The historical series was assembled in order to present a set of data related to the main findings of the work. In graph 1, it is possible to observe the data referring to the BMI/A index, in which the eutrophic classification was highlighted during the years 2016 to 2020, however, the city that presented the highest percentage of children with adequate BMI in the year of 2020 was the municipality of Marituba, with a percentage of 66.08% (n=9,536). As for children outside the normal range, the municipality of Santa Bárbara do Pará had the highest percentage of children, 41.72% (n=6,530), in 2020.

A survey analyzed the nutritional status of children from 0 to 5 years of age in 5 health districts of Foz do Iguaçu-PR, and found that 4.3% of them were thin, 62.8% eutrophic, 20.2% risk of overweight and 12.7% obesity [32]. In this sense, about 37.2% of these individuals were outside the normal range, a worrying fact when considering that 32.7% were above the ideal parameter and 4.3% were below it, evidencing serious epidemiological problems linked to the lack of public policies for the less favored.

In the study by Castro [33], where the nutritional status of children benefiting from the PBF before and during the pandemic was analyzed, he observed that in the states of the Northeast region, in 2019, the percentage of eutrophy was 58.07% and in 2020 was 58.25%, showing a

slight improvement in this scenario. But, despite observing very similar parameters in the two years analyzed, the study points to the occurrence of a great difference in relation to the number of children monitored, this can also be observed in this study in metropolitan region I, with different numbers of children approached in different areas each municipality and better percentages in those with fewer children.

#### Height for age historical series

In graph 2, showing a historical series with data referring to the A/I classification, the AA/I classification was highlighted between the years 2016 to 2020. It was possible to observe that the municipality of Marituba had the highest percentage of children within the normal range 90.83% (n=1,872), in 2020. Ananindeua was the city that presented the highest percentages outside the normal range in all years of the survey, obtaining the highest percentage in 2019, 29.55% (n=2,162).

In a study carried out in the context of the Family Health Strategy/PB, a prevalence of 7.9% of children outside the normal range was identified, for Oliveira et al. [34]. The factors associated with this prevalence in Paraíba are directly linked to the mother's nutritional status, as well as factors related to food and nutritional insecurity to which children are exposed, with inadequate and irregular food having a direct impact on the growth of the little ones.

## IV. CONCLUSION

In summary, the results of this study made it possible to identify, with the aid of a temporal analysis, the percentages of children with deficits in W/A, H/A and BMI/A, based on a small sample taken from the North region of the country. In this way, it is possible to identify the nutritional problems caused by the absence or poor diet, which directly impact the nutritional status of children belonging to the metropolitan health region I, in the state of Pará.

The results showed a high number of children with inadequate BMI/A and A/A, demonstrating a pattern outside the normal range, especially in 2019, which may highlight the political and economic crisis that the country has been going through in recent years, in which the scenario of hunger starts to be seen again and affects millions of Brazilians. However, it is worth emphasizing the importance of the ESF program, and SISVAN, in monitoring and identifying these children, so that assertive measures are taken, such as, for example, their inclusion in public health programs and income access programs that can help access to healthy and regular food.

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# Colorectal Cancer Prevention and Screening before the Economic and Social Impact of Costs for Cancer Treatment In Brazil

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**Keywords**— *Colorectal cancer, Prevention,  
Public policy, costs.*

**Abstract** — According to the INCA National Cancer Institute, cancer is a term that encompasses more than 100 different types of malignancies that have in common the disordered growth of cells, which can invade adjacent tissues or distant organs. The evolution of cancer is directly correlated with preventive actions, which aim to prevent it from developing, encompassing actions to reduce the risks of having the disease. Cancer prevention encompasses actions taken to reduce the risks of having the disease. By avoiding exposure to risk factors and adopting a healthier lifestyle, early detection and treatment of pre-malignant diseases (e.g. polyps in the intestinal walls) or early asymptomatic cancers that often enables successful treatment, even leading to cure. The present work makes a reflective study on the challenges of implementing public policies for the prevention of colorectal cancer and its economic and social impact. We take as a theoretical basis the considerations of CANCELA (2019), LIMA (2015) and SCANDIUZZI et al (2019) in addition to the data provided by INCA and the Ministry of Health. The bibliographic analysis reveals that public policies for the prevention of colorectal cancer are still very scarce in view of the magnitude in which the disease has been growing. Screening and early detection is an action aimed at the population in the subclinical phase with the objective of reducing the incidence of invasive cancer and the mortality rate, still so little explored by public managers. It is concluded that access to treatment for colon and rectal cancer is unequal in Brazil, and depends on the resources available in each region of the country and that socioeconomic and clinical factors are associated with the waiting time for the start of treatment, thus reflecting, barriers to timely access to treatment. There is an urgent need to create screening protocols and conditions for the implementation of public policies that value the work of colorectal cancer prevention. There are also strategies that require greater encouragement even from the Ministry of Health itself, such as health education actions to raise awareness of the population, training of health professionals and articulation of the system with the service network, seeking to carry out diagnostic tests. and facilitating access to treatment.

## I. THE COLORECTAL CANCER AND PUBLIC HEALTH

Cancer is an ancient disease that is still greatly feared by people and, despite the advancement of medicine, it is a disease that carries the stigma of past times, when many died. Currently, cancer is defined as a group of diseases that are characterized by the disorderly multiplication of malignant cells, that is, normal cells that have undergone changes in their DNA. The development of these cells in an aggressive and uncontrollable way, the formation of malignant tumors (malignant neoplasms) occurs, and when they invade neighboring and distant cells, metastasis is characterized.

Colon and rectal cancer (CRC) is classified based on the International Classification of Diseases (ICD 10) as Malignant Neoplasm of Colon (C18), Malignant Neoplasm of Rectosigmoid Junction (C19) and Malignant Neoplasm of Rectum (C20) (MINISTRY OF HEALTH, 2014). The colon and rectum form the large intestine, forming part of the gastrointestinal system. It is a tubular organ, located in the final portion of the digestive tract with the function of absorbing water, nutrients, creating and excreting feces. According to its specific characteristics, the colon is divided into: cecum, ascending colon, transverse colon, descending colon, and sigmoid colon. The last 15 cm of the digestive tract after the sigmoid is called the rectum (INCA, 2003).

The causes of cancer are varied and there are several factors that make it possible for it to develop. As main causes of cancer: genetic predisposition, dietary habits, lifestyle and environmental conditions. The colon and rectum are part of the large intestine, with the function of absorbing nutrients and excreting substances not used by the body in the form of feces. We have factors that predispose the occurrence of colorectal cancer (CRC): family history of cancer, history of previous cancer, appearance of polyps, inflammatory bowel disease, obesity, individuals over 50 years of age, smoking, sedentary lifestyle, alcohol consumption.

Statistical data have shown us that, unfortunately, colorectal cancer is growing between second and third in incidence in Brazil and fourth in mortality from malignant tumors. Early detection is still incipient, unfortunately most people get the diagnosis when they present some symptoms and signs, where the disease is already in a more advanced stage.

This reality makes the treatment more complex, invasive and at a higher cost. Surgical interventions, chemotherapy and radiotherapy are required. The result of this situation is a very negative psychological, social and economic impact. However, CRC is considered a disease

that can be detected early or secondary, being able to avoid a good part of the deaths that could have been avoided to the extent that the disease is known.

Adenocarcinoma to turn into a cancer usually goes through a 10 to 15 year journey. This period allows for appropriate and relevant interventions to be carried out to screen for the disease. Such as fecal occult examination and colonoscopy and follow-up by the coloproctologist, with the aim of reducing the incidence of invasive cancer and the mortality rate.

Even though there is tracking in the Primary Care Notebook issued by the Ministry of Health, in Brazil it is still unknown population-based screening programs for colorectal cancer effectively implemented in states and municipalities, and early screening is still a challenge. For this reason, there is still great difficulty in articulating the levels of care and carrying out more complex complementary exams for diagnosis and follow-up. This fact makes early diagnosis impossible and leads to a worse prognosis for the patient. The critical nodes faced are: habits and lifestyles that predispose to the disease, carrying out complementary exams and articulation with specialties when necessary.

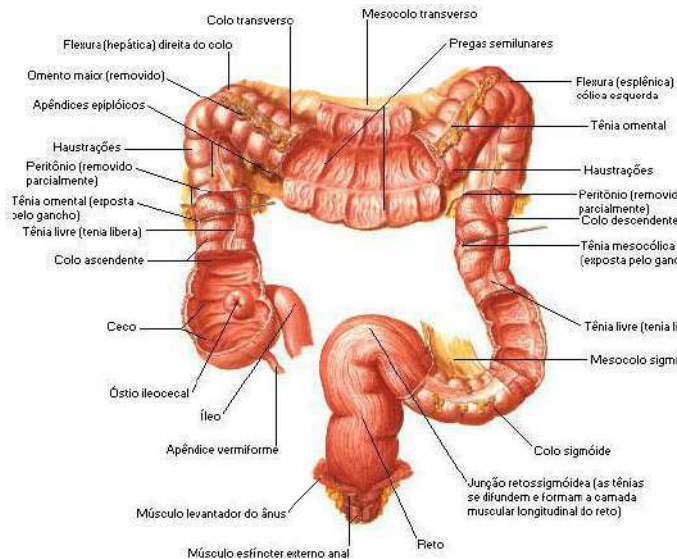
### 1.1 Bowel cancer and its complications

Bowel cancer is associated with tumors that reach from the part of the large intestine called the colon and into the rectum, which is the final structure of the intestine near the anus. Hence, it is also called colon and rectal or colorectal cancer.

INCA researcher Marianna Cancela explains that the symptoms of bowel cancer can be confused with those of other diseases. The most frequent signs are blood in the stool, change in bowel habits, such as diarrhea and constipation, abdominal pain or discomfort, weakness and anemia, weight loss with no apparent cause, change in the shape of stools and the presence of nodules in the abdominal region. .

The diagnosis can be made from the biopsy, which consists of removing tissue fragments for analysis. The sample is collected through a device introduced through the rectum, called an endoscope.

We can see in the image below the anatomical division of the intestine:



Source: NETTER, Frank H.. Atlas of Human Anatomy. 2nd edition Porto Alegre: Artmed, 2000.

Treatment is effective and can lead to a cure, especially when the diagnosis is made at an early stage and the disease has not yet spread to other organs. In addition to surgery, radiation therapy or chemotherapy may be required.

### 1.2 Importance of early screening

The change in this public health scenario in our country is directly related to the capacity of primary care with its service organization and the quality of service provided by the Family Health Strategy (ESF) to carry out an adequate screening and from there indicate screening methods. The performance of this professional who assists this user of the Unified Health System (SUS) is a

structuring factor of this entire chain of possible CCR tracking. It is at the base where a greater bond between this professional and the SUS user is possible, since the service is located in that individual's territory, thus enabling greater population adherence to initial exams and specialist indication if necessary. This is the moment when communication will produce information, guidance and clarification.

Usually, the initial phase of treatment is the request for non-invasive tests such as the fecal occult blood test, then colonoscopy, among other imaging tests if necessary. There are also other issues identified, such as accessibility to the SUS for specialist proctologist medical care and prompt examinations and prevention campaigns. It is important to remember that the costs of these actions such as the fecal occult blood test and prevention campaigns are low, but there is no organized system so far that has brought effective responses in CRC screening.

### 1.3 cancer statistics

Analyzing the information published in INCA, related to the profile of different types of cancer, we observed that this information is the basis for the construction of safe indicators on combating and reducing this.

According to the tables below, we can analyze thereincidenceestimated according to the primary location of the tumor and sex. These data are from 2020 and were published on 06/10/2021:

In men, Brazil 2020

Primary Location	New Cases	%
Prostate	65,840	29.2
<u>Colon and Rectum</u>	<u>20,540</u>	<u>9.1</u>
Trachea, bronchus and lung	17,760	7.9
Stomach	13,360	5.9
Oral cavity	11,200	5.0
Esophagus	8,690	3.9
Bladder	7,590	3.4
Larynx	6,470	2.9

leukemias	5,920	2.6
Central Nervous System	5,870	2.6
All Neoplasms except non-melanoma skin	225,980	100.0
All Neoplasms	309,750	

Source: MS/INCA Cancer Estimate in Brazil, 2020. MS/INC / Prevention and Surveillance Coordination - Surveillance and Situation Analysis Division

In women, Brazil 2020:

Primary Location	New Cases	%
female breast	66,280	29.7
<u>Colon and Rectum</u>	<u>20,470</u>	<u>9.2</u>
cervix	16,710	7.5
Trachea, bronchus and lung	12,440	5.6
Thyroid gland	11,950	5.4
Stomach	7,870	3.5
Ovary	6,650	3.0
uterus body	6,540	2.9
non-Hodgkin's lymphoma	5,450	2.4
Central Nervous System	5,230	2.3
All Neoplasms except non-melanoma skin	223,110	100.0
All Neoplasms	316,280	

Source: MS/INCA Cancer Estimate in Brazil, 2020. MS/INC / Prevention and Surveillance Coordination - Surveillance and Situation Analysis Division.

We can now observe in the tables below, the mortality according to the primary location of the tumor and sex. These data are from 2019 and were published on 07/10/2021:

In men, Brazil 2019

Primary Location	Deaths	%
Trachea, Bronchi and Lungs	16,733	13.8
Prostate	15,983	13.1
<u>Colon and Rectum</u>	<u>10,191</u>	<u>8.4</u>

Stomach	9,636	7.9
Esophagus	6,802	5.6
Liver and intrahepatic bile ducts	6,317	5.2
pancreas	5,905	4.9
Oral cavity	5,120	4.2
Central Nervous System	5,049	4.1
leukemias	4,014	3.3
all neoplasms	121,686	100.0

Source: MS / SVS / DASIS / CGIAE / Mortality Information System, 2021 MS / INCA / Prevention and Surveillance Coordination / Surveillance and Situation Analysis Division,

In women, Brazil 2019

Primary Location	Deaths	%
mama	18,068	16.4
Trachea, Bronchi and Lungs	12,621	11.4
<u>Colon and Rectum</u>	<u>10,385</u>	<u>9.4</u>
cervix	6,596	6.0
pancreas	5,893	5.3
Stomach	5,475	5.0
Central Nervous System	4,663	4.2
Liver and intrahepatic bile ducts	4,584	4.2
Ovary	4,123	3.7
leukemias	3,356	3.0
all neoplasms	110,344	100.0

Source: MS / SVS / DASIS / CGIAE / Mortality Information System, 2021 MS / INCA / Prevention and Surveillance Coordination / Surveillance and Situation Analysis Division, 2021

## II. COLORECTAL CANCER IN THE TRIENNIO 2020-2022

Most colon and rectal cancer starts as a polyp. Polyp is the abnormal growth of cells inside the intestine, with possible evolution to cancer. The type of polyp that often becomes a cancer is adenomatous polyps, of

epithelial origin, corresponding to 95% of cases of colon and rectal cancer (THRUMURTHY, 2016; FLEMING, 2012 in LIMA 2019).

Epidemiology reveals that colon and rectal cancer is the third most common cancer in men and the second most common in women worldwide. With no significant



difference between the sexes, colon and rectal cancer represents 10.9% of cancer cases in men and 9.5% of cases in women.

For Brazil, it is estimated that for each year of the triennium 2020-2022, 20,520 cases of colon and rectal

cancer in men and 20,470 in women. These values correspond to an estimated risk of 19.63 new cases per 100,000 men and 19.03 per 100,000 women.

We can see in detail in the table below, according to INCA:

Primary location of malignant neoplasm	Men						Women					
	States			capitals			States			capitals		
	cases	gross rate	Adjusted Rate	cases	gross rate	Adjusted Rate	cases	gross rate	Adjusted Rate	cases	gross rate	Adjusted Rate
Prostate	65,840	62.95	50.78	13,640	60.53	57.33	-	-	-	-	-	-
female breast	-	-	-	-	-	-	66,280	61.61	43.74	19,820	78.88	45.90
cervix	-	-	-	-	-	-	16,710	16.35	15.38	3,780	14.98	12.26
Trachea, bronchus and lung	17,760	16.99	16.19	3,180	14.17	16.11	12,440	11.56	9.24	3,760	14.96	11.32
Colon and Rectum	20,540	19.64	18.80	5,320	23.59	21.26	20,470	19.03	13.36	6,260	24.90	15.59
Stomach	13,360	12.81	11.37	2,430	10.85	11.23	7,870	7.34	5.95	1,920	7.71	6.61
Oral cavity	11,200	10.70	9.25	2,040	9.03	9.19	4,010	3.71	2.66	970	3.73	3.21
Larynx	6,470	6.20	5.75	1,150	5.00	4.97	1,180	1.06	0.92	360	1.06	0.79
Bladder	7,590	7.23	4.61	1,800	7.87	7.12	3,050	2.80	2.03	900	3.44	2.61
Esophagus	8,690	8.32	6.48	1,160	5.00	6.27	2,700	2.49	1.76	460	1.60	1.42
Ovary	-	-	-	-	-	-	6,650	6.18	4.84	1,870	7.50	5.19
Hodgkin's Lymphoma	1,590	1.52	1.33	450	1.71	1.93	1,050	0.95	0.88	430	1.35	1.04
non-Hodgkin's lymphoma	6,580	6.31	5.67	1,430	6.41	7.27	5,450	5.07	3.37	1,260	4.96	4.27
Thyroid gland	2,310	2.17	1.52	1,090	4.52	1.81	11,950	11.15	8.13	4,650	18.47	8.13
Central Nervous System	5,870	5.61	5.22	1,150	5.07	6.27	5,230	4.87	4.17	1,280	5.03	4.55
leukemias	5,920	5.67	5.55	1,210	5.43	5.93	4,890	4.56	3.95	1,180	4.69	4.64
body of uterus	-	-	-	-	-	-	6,540	6.07	5.22	1,930	7.61	6.14
Melanoma skin	4,200	4.03	2.01	790	3.36	3.40	4,250	3.94	1.78	870	3.28	2.49

Primary location of malignant neoplasm	Men						Women					
	States			capitals			States			capitals		
	cases	gross rate	Adjusted Rate	cases	gross rate	Adjusted Rate	cases	gross rate	Adjusted Rate	cases	gross rate	Adjusted Rate
Other Locations	48,060	45.97	41.48	9,320	41.34	48.09	42,390	39.43	29.40	9,790	38.88	26.48
All Neoplasms except Non-Melanoma Skin	225,980	216.15	215.86	46,160	204.92	238.47	223,110	207.48	145.00	61,490	244.73	159.85
non-melanoma skin	83,770	80.12	-	20,010	88.84	-	93,170	86.66	-	19,090	75.98	-
All Malignant Neoplasms	309,750	296.28	-	66,170	293.75	-	316,280	294.13	-	80,580	320.71	-
All malignant neoplasms corrected for underreporting	387,980	371.11	-	-	-	-	297,980	277.11	-	-	-	-

TheWorld standard population (1960). / \*Numbers rounded to multiples of 10.

The main factors at the highest risk of developing colon and rectal cancer are: age 50 years or older, obesity, physical inactivity, prolonged smoking, high consumption of red or processed meat, low calcium intake, excessive alcohol consumption and diet. low in fruit and fiber. There are hereditary factors that increase the risk, which include a family history of colorectal cancer and/or adenomatous polyps, certain genetic conditions such as familial adenomatous polyposis and hereditary nonpolyposis colorectal cancer, a history of chronic inflammatory bowel disease (ulcerative colitis or Crohn's disease) and type 2 diabetes; and also factors such as occupational exposure to ionizing radiation (AMERICAN CANCER SOCIETY, 2019a; INSTITUTO NACIONAL DE CANCER JOSÉ ALENCAR GOMES DA SILVA, 2019, p. 36).

The factors associated with delay in the treatment of rectal cancer in Brazil were: age between 50 and 79 years and 80 years or older, black and mixed race/skin color, illiteracy and low education. It is interesting to note that the lower the level of education, the greater the chance of delay in treatment. In addition to these factors, there was also a greater chance of delay in treatment in individuals whose treatment was carried out in a different municipality from their residence.

Brazilian public managers need a more accurate look at public health, at the cancer disease, designing actions that make it possible to reduce the incidence of CRC in the population, as well as a better prognosis and lower morbidity and mortality of individuals with the disease. Encompassing actions such as the wide dissemination of warning signs to the population and health professionals, articulation of the system seeking immediate access to diagnostic procedures for suspected cases and access to adequate and timely treatment. Therefore, the elaboration of a plan for the prevention and reduction of the incidence of colorectal cancer is of essential importance for the fight and prevention of the disease.

Promote prevention and training campaigns for health professionals regarding colorectal cancer. Educate the population about the signs and symptoms, risk factors and possible changes in lifestyle that make it possible to prevent the disease. Develop a care protocol for patients with suspected colorectal cancer in state bodies to guide the work of the municipalities, aiming at easier paths for the prevention and early diagnosis of the pathology in question. When diagnosed at an early stage, the cancer is potentially curable (MENDONÇA et al., 2012). The 5-year

survival rate for patients with early-stage colon and rectal cancer is up to 90% (SIEGEL et al., 2012).

In Brazil, Federal Law No. 12,732 was enacted in November 2012 to ensure that the time between diagnosis and initiation of treatment does not exceed 60 days. However, studies on breast, cervical and prostate cancer found a long waiting time for treatment to begin, as well as socioeconomic and geographic inequalities in accessing treatment (MEDEIROS et al., 2015; FERREIRA DA SILVA et al., 2019; SACRAMENTO, et al., 2016).

In relation to colon and rectal cancer, despite the high incidence and mortality in Brazil, there are few studies that assess the association between socioeconomic/clinical characteristics and the time between diagnosis and initiation of treatment.

Therefore, this study aims to identify factors associated with the delay between diagnosis and initiation of treatment for colon and rectal cancer in Brazil. In this way, it is expected to contribute to the identification of socioeconomic and geographic barriers in accessing treatment in a timely manner in Brazil.

Todos Juntos Contra o Câncer (TJCC) is a movement of Brazilian society that brings together representatives from different sectors focused on the care of cancer patients, such as health managers, medical entities, hospitals, health professionals, researchers, press professionals, patients and others, committed to guaranteeing the patient's right to universal and equal access to health. This movement announced on 11/29/21 that researchers project increased public spending for bowel cancer or colorectal cancer in Brazil.

The projection of SUS expenses with hospital and outpatient procedures for patients with CCR may reach

R\$ 1 billion in 2030, according to information from INCA. Such expense refers to patients who developed the disease due to exposure to avoidable risk factors, it will be 88% higher than the amount spent in 2018.

In 2018, the SUS disbursed approximately R\$545 million for hospital and outpatient procedures to care for patients with colorectal cancer aged 30 years or older. For 2030, INCA projects that this expenditure could reach R\$ 1 billion.

According to the TJCC each year, about 40,000 new cases of the disease are diagnosed among men and women. Of this total, about 30% are associated with behavioral factors, such as inadequate diet, smoking and physical inactivity.

INCA researchers identified that risk factors related to food, nutrition and lack of physical activity were responsible for about BRL 160 million in public expenditure on colorectal cancer in 2018.

According to the study, the highest attributable expenses were with low consumption of dietary fiber (R\$ 60 million), insufficient physical activity (R\$ 47 million), consumption of processed meat (R\$ 28 million), red meat above recommended (R\$ 19 million), alcoholic beverages (R\$ 15 million) and overweight (R\$ 12 million). The projection shows that, in 2030, these same causes could be responsible for up to R\$ 395 million of federal disbursement with this type of cancer alone.

And what are the social costs of cancer? For Cancela (2018), we have these costs illustrated in the image below, emphasizing the socio-economic dimension that cancer affects:



Source: Presentation by Marianna Cancela at the Oncoguia Forum on 04/25/2018

To estimate these impacts of bowel cancer on the country's economy, INCA researchers analyzed mortality data from DataSUS (Department of Informatics of the Unified Health System). Using models, experts estimated the number of deaths from the disease and the time of life lost due to early death.

Base data from the IBGE, from the continuous PNAD, were used, where it was calculated in some projections how much these people would no longer receive in terms of work. The researchers performed “estimates for the Brazilian population as a whole, considering salary values” (CANCELA, 2018). Still according to IBGE data, from PNAD continues and with CANCELA (2018), Considering the impacts of colorectal cancer for this decade, from 2021 to 2030, we will have around 6 million years of life lost adding all these deaths and the length of time these people stopped living. According to the analysis, economic losses in productivity, due to death, will reach US\$ 12.7 billion (about R\$ 70 billion), in the same decade.

### III. MATERIAL AND METHOD

The literature review was carried out by searching for articles using the following descriptors: “colorectal cancer”, “prevention”, “public policies” and “costs”. Additionally, there were publications of the National Cancer Institute and the Ministry of Health were consulted. A reflective study was carried out on the challenges of implementing public policies for the prevention of colorectal cancer and its economic and social impact. The entire study was based on the legislation in force in Brazil that deals with cancer prevention and control. It presents us with several laws, ordinances, decrees and guidelines for the work of public health management.

THE Ordinance No. 874, of May 16, 2013, of the Ministry of Health, institutes the National Cancer Prevention and Control Policy in the Health Care Network for People with Chronic Diseases within the scope of the Unified Health System (SUS).

We consulted and analyzed the National Cancer Prevention and Control Policy, which has the objective of reducing the occurrence, mortality and disabilities caused by cancer, as well as improving the quality of life of patients through actions of promotion, prevention, early detection, timely treatment and palliative care. This policy is organized in such a way as to enable the continuous provision of health care actions, through the articulation of the different points of care, and establishes:

#### General principles

- Ordinance 4279/2010 - Establishes guidelines for the organization of the Health Care Network
- Ordinance 571/ 2013 - Updates the Guidelines for Attention to Smokers

#### Health promotion

- Law 12,715/2012 - Establishes the National Oncology Support Program
- Ordinance 2446/2014 - Redefines the National Health Promotion Policy (PNPS)

#### Cancer prevention

- Law 8069/1990 - Provides for the Statute of Children and Adolescents
- Law 9249/1996 - Provides for restrictions on the use of advertising of cigarettes, alcoholic beverages, medicines, therapies and agricultural defensives.
- Resolution 304 of Anvisa/2002 - Prohibits the production, import, propagation and distribution of food in the form of cigarettes and cigars.
- Decree 5658/2006 - Enacts the prevention framework on tobacco control
- Ordinance 29/2015 - Approves the National Guidelines for the Early Detection of Breast Cancer within the scope of the SUS.
- Ordinance 2898/2013 - Updates the National Mammography Quality Program (PNQM)

#### education

- Law 7488/1986 - Creates the National Day to Combat Tobacco and determines the holding of Celebrations on August 29 throughout the national territory.

#### Health Communication

- Law 10,167/2000 - Prohibits tobacco advertising by electronic means, indirect and in stadiums, tracks, stages or similar places. Prohibits the sponsorship of sporting and cultural events.

#### guidelines

- Establish methods and mechanisms for the analysis of the economic-sanitary feasibility of public enterprises in the Health Industrial Complex;
- Implementation of the research network for the prevention and control of cancer in accordance with the objectives of the National Policy on Science, Technology and Innovation in Health;

- Implementation of practices for the preparation of scientific technical opinion, ATS and AE to support decision-making in the process of incorporating new SUS technologies.

#### IV. CONCLUSION

In Brazil, colorectal cancer has a high incidence and mortality. There is a high proportion of cases with advanced diagnosis, although there is a diagnostic test capable of eliminating polyps before the appearance of cancer, as well as the detection of cancer at an early stage. Technological advances are used in cancer treatment, but economic and geographic barriers can influence the time to start treatment, in addition to the barriers caused by critical nodes that need to be detected.

Critical nodes bring the idea of something that can be intervened, that is, what is within the governance limits of those who are planning. Among the main critical nodes identified are: Inadequate habits and lifestyles of the population; Identification and tracking in individuals at increased risk and; Difficulty in articulating secondary care and performing more complex tests, making early diagnosis impossible and leading to greater morbidity and mortality.

After detecting the critical nodes to be faced, considered the most important and the ones that can be modified, we see that these are essential for the construction of a better public policy in the prevention of cancer and consequently of the correct cancer, object of this work.

From the documentary analysis, we can see that access to cancer treatment is unequal in Brazil. Socioeconomic determinants influence the waiting time for treatment, making it necessary to make improvements in the coordination of health services, with the objective of providing cancer treatment in a more equitable way for the population.

With the "law of 60 days" the time between diagnosis and the beginning of treatment was established, but there is a need for other measures to achieve this. It is essential to strengthen the conduct of early diagnosis in Brazil, through public awareness and access to diagnosis in a timely manner.

We reached this conclusion after several researches carried out and after understanding what Cencela (2018) tells us:

“Cancer causes a great impact on the family and also on the economy, loss of productivity

resulting from the disease and the deaths caused by it. Given this reality, an international study was presented that evaluated the costs of cancer on the economy. Among the objectives was to draw attention to how cancer affects society as a whole and to understand how public policies can also mitigate the economic impact of the disease. In addition, the difficulties faced by cancer patients in accessing employment and study opportunities and, in cases where the disease is incapacitating, the challenges to leave work and follow treatment were addressed.”

Cancer control actions are based on the natural history of the disease, from the monitoring and assessment of risk factors to the organization of the comprehensive care line for prevention, early diagnosis, treatment and palliation. Policies that encourage lifestyle changes that reduce cancer risk can have positive effects on the economy.

We observed in several governmental documents and articles by INCA researchers that primary prevention strategies aimed at promoting healthy eating, regular physical activity, maintaining adequate body weight, reducing the consumption of alcoholic beverages and stopping the use of tobacco are fundamental and have great potential to reduce the costs associated with colorectal cancer not only in the world, but in the entire global community.

Combining tobacco control, vaccination programs and cancer screening with access to adequate treatment could generate significant gains for both public health and economic performance. Therefore, we conclude that cancer affects the economy as a whole, in addition to the health system. Additional perspective is important for policymakers and decision makers to identify priorities for cancer prevention and control.

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# The Challenges of Marketing Organic Products: leafy vegetables in the Municipal Organic Market in Petrolina-PE

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**Keywords—** Fairs, Losses, Organic  
vegetables, Sale,

**Abstract—** The offer of organic vegetables, such as leafy vegetables, is increasingly frequent in small community fairs, such as the one that takes place at the Municipal Organic Market in Petrolina-PE. Considering that the research points to losses in the process that involves the post-harvest and commercialization of in natura products, but need to be more frequent in interior cities, the present study aimed to verify the existence of losses in the commercialization of coriander (*Coriandrum sativum*), chives (*Allium schoenoprasum*), lettuce (*Lactuca sativa*) and kale (*Brassica oleracea*) among four producers that sell in the market. The methodology used was a field study with site visits during the fairs from 02/27/2022 to 03/27/2022 and conducting an interview with the producers. Although the results have pointed to low levels of losses in the sale of leafy vegetables in the market, they have elucidated some determining factors of the same, which need to be corrected to improve the activity in the place. It is noteworthy that the low quantity of losses identified during the study may be correlated with the cooperation present in the group, the friendly relationship between the group and the customers, the small number of products offered, or the fact that they are organic being well evaluated by consumers.

## I. INTRODUCTION

The demand for organic products has become a growing phenomenon among the population that seeks healthy and environmentally sustainable food. For producers, they represent a business opportunity since the planting of organic vegetables requires low capital investment and the possibility of multiple crops; in addition to being carried out by family farmers [1].

Organic agriculture has been growing in many countries, driven by the demand for products that increasingly generate interest in consumers. Lemes, Oikawa & Michellon [2] discussed the expansion of the global organic market in monetary terms in their research. According to them, between 1999 and 2015 there was a growth of 426.3%, from 15.2 billion dollars to 80 billion, respectively. For Coutinho, Koefender, De Mera, & Camera, [3] the activity has generated interest both in trade at fairs and in large retail chains.

In parallel with this growth, there is also an increase in the number of production units in the country (from 5,406 in 2010 to 22,064 in 2018) and registered organic producers (from 5,934 in 2012 to 17,730 in 2019); according to data from the Ministry of Agriculture, Livestock and Supply [4].

However, a factor that needs to be considered in cultivation in agriculture is losses since they can be present in all stages of the process that involves cultivation, harvesting, transport, and sales of products. And although there are no precise numbers regarding their quantity, studies indicate that a third of agricultural production ends up being lost, mainly because they are perishables [5]. Thus, the present research focuses on the losses in vegetables that occur after harvest, specifically during the commercialization stage.

As they are ephemeral, *in natura* products such as Fruits and Vegetables) suffer damage mainly in the post-harvest, given that they are primarily composed of turgidity, keeping their vital biological processes active; and may suffer damage caused by transport, environmental conditions, inadequate classification, and excess offers [6,7,8].

Considering that it is not common to find literary studies that point to data on losses in the sale of vegetables in retail in interior cities, which are more present in supply centers [8], the current research was based on the investigation of losses in the commercialization of organic leafy vegetables (coriander, cabbage, lettuce, chives) in a small open market held among small organic farmers in the municipality of Petrolina-PE..

As for the motivation for the study, it should be noted that the vegetables mentioned are among the products that are not lacking for sale at all fairs held and that the space where they take place is a recent achievement for producers and the community, providing direct sales between these and the final consumers.

Therefore, we sought to verify the existence of losses in the process of marketing leafy vegetables at the Municipal Organic Market in Petrolina-PE during the months of February and March 2022, based on the following specific objectives: (a) To present the socio-economic profile of the study group; (b) Observe interactions between producers and customers during fairs; (c) Discuss leafy vegetable sales on the market; (d) Know the possible causes of leafy vegetable losses during the fair; (e) Describe the process of handling, packaging and transporting the products.

The results pointed to low amounts of losses in leafy vegetable sales, which can be understood from some variables identified in the research, such as the existence of

cooperation in the group, friendship between the group and the customers, low quantity of goods offered during the research or the fact that they are organic products, being well evaluated by consumers. However, although the levels of losses in the commercialization of leafy vegetable were not expressive, the research showed that the factors related to them constitute aspects to be corrected for the quality of the activity in the place. Furthermore, the research was carried out after approval by the Research Ethics Committee (CAAE 56033722.0.0000.9227).

In addition to the summary and introduction presented, the work is structured as follows: Production and sale of organic products in Brazil and worldwide; The municipal organic market in Petrolina-PE; Losses in the process of marketing vegetables; Methodology; Results and discussions; Conclusions and References.

## II. PRODUCTION AND MARKETING OF ORGANIC IN BRAZIL AND THE WORLDEADINGS

According to Darolt [9] organic agriculture emerged in the 1940s and had as its precursor the English agronomist Albert Howard. Being contrary to any addition of chemical fertilizer in production, based on natural biological processes for the continuous improvement of soils. Thus, unlike the actions of conventional agriculture, where there is the commonly intensive use of soils, organic agriculture uses combined cultivation techniques that work in harmony to form an organism or system, favoring the environment and sustainability [10]

Conceived as a system, organic agriculture requires rational use of natural resources from the beginning to the end of the production process. From soil preparation through the stages of planting, transport, storage, and marketing of products [10]. Thus, there must be practices for the preservation of fauna, flora, and recycling of waste, among others ecologically sustainable, at all stages of the organic production chain.

Concerning this activity, research has shown exponential growth worldwide, providing more significant gains to producers and changes in consumers' eating habits, who are increasingly looking for a healthy diet. The increase in organic production worldwide can be proven by expanding arable areas. According to the Research Institute of Organic Agriculture and the International Federation of Organic Agriculture Movements [11], 74.9 million hectares of organic agriculture were cultivated in 2020 (Fig.1).

Among the continents with the highest production in Oceania with almost half of the total arable areas and

Europe with 17.1 million hectares. The countries with the largest extensions of organic agricultural land are Australia with 35.69 million hectares, followed by Argentina with 4.45 and Uruguay with 2.74. So, together, these countries are responsible for 80% of all cultivated areas [11].

The data show that the growth of organic agriculture follows the increase in consumption. According to the Institute of Economic and Applied Research [12] the increase in sales of organic products in retail at the international level has been greater than 11% since the 2000s. This fact is due to the demand for food and beverages from organic agriculture in Europe, North America, and China, in addition to being related to the Coronavirus pandemic, which has driven many consumers to seek healthier food [11]. In this way, as the coronavirus pandemic continues, people continue to change how they live and eat, caring more about health, well-being, and prevention.

Although only 25% of the countries with organic activities have available data on retail sales in 2020, the international market accounted for 121 billion euros in sales in this modality for that period. Some countries were experiencing double-digit growth, such as Denmark (13%), Austria (11.3%), and Switzerland (10.8%) [11].

The indicated data generate expectations that sales in the sector will continue to grow, as has been happening for over two decades. Revenues from organic agriculture in the 1990s were only a few billion dollars, rising to 18 billion in 2000, exceeding 100 billion in 2018, and accounting for 129 billion in 2020 (Fig. 2) [11]. Organic agriculture is a growing market driven by health, quality of life, and the environment. According to [12], American organic consumers are not only consuming food but also different products from this activity.

Regarding the Brazilian organic market and the areas reserved for cultivation, its increase has also been occurring gradually. According to [4], there was a variation of almost 200% in the number of registered producers between 2012 and 2019, from 5,934 to 17,730; and in the number of production units by 300%, from 5406 in 2010 to 22,064 in 2018 (Fig. 3). However, despite the numbers representing large additions to the activity, it is estimated that many more organic producers have not registered for the activity with the competent body.

As in other countries, the commercialization of Brazilian organic products has been stimulated by the increase in consumer interest, not only domestically but also internationally. Data from [11] pointed the country in ninth place in terms of volume of exports to the European Union in 2019, totaling 75,676 tons of products. The main

export items of Brazilian organic agriculture are rice, sugar, and organic honey [12].

To produce and commercialize organic products in Brazil, the producer must be certified or associated with a Social Control Organization. Thus, there are three control mechanisms in the country for the production and commercialization of organic products: the Participatory Guarantee Systems (SPG), Audit Certification, and Social Control Organizations (OSC) [13]. They must be used according to the way in which the products are sold to customers, that is, whether this occurs directly or indirectly.

When marketing takes place directly at fairs, homes, production units, or even through government programs such as the National School Feeding Program (PNAE) or Food Acquisition Program (PAA), it is not necessary to place the seal on the products. Only the producer is associated with an (*Organização de Controle Social* (OCS)) Social Control Organization [13]. Furthermore, these institutions are formed by family farmers registered with MAPA, receiving a declaration from the agency authorizing the marketing of their products through direct sales. These institutions comprise: “a group, association, cooperative or consortium, with or without legal personality, of family farmers” [14, p. 366].

Still, concerning the growth of the Brazilian organic trade, it is noteworthy that this is related not only to external demands but also to the opening of internal markets. Such as the initiatives to stimulate offers in schools and other government institutions promoted by the National School Feeding Program (PNAE) and Food Acquisition Program (PAA). Which contributed to the appreciation of organics and family farming [12].

Therefore, as more producers and companies are regulated in Brazil, more parts of the population will become organic consumers, as there will be more products for sale at more attractive prices. However, although there is a growing trend in the country, some factors constitute bottlenecks in the activity, such as the concentration of land and the practice of monoculture, which make it challenging to convert organic areas [12].

### III. THE MUNICIPAL ORGANIC MARKET IN PETROLINA-PE

The municipal organic market of Petrolina is a space where there is a fair held by organic producers directly to customers. This form of trade is understood as a short trade chain quite common in Brazilian regions. In it, the producer sells his products now on his property or at fairs, markets, and other establishments; there may still be



a single intermediary between the producer and the consumer [15].

Short marketing chains promote socialization and interaction between the producer and the final customer. It is possible for this to know information about who produced the goods, what inputs were used, and how the production process was. Goodman (2012, as cited in [9]) highlights that short marketing chains constitute significant cooperation networks between consumers and producers in producing sustainable, ecologically based food, such as organic foods. In addition to strengthening the culture and appreciation of local spaces

Thus, the municipal organic market, a space destined for direct sales by producers, was opened in July 2019 and is also the first in the northeast; aiming to provide an adequate space where organic producers in the region can market healthy products without the addition of chemical fertilizers [16].

An interview with Auzira, president of the (*Associação dos Produtores e Produtoras de Orgânicos do Vale do São Francisco (Aprovasf)*), Association of Organic Producers of the São Francisco Valley, an OCS that enables the production and sale of products at the fair, it was reported that the great challenge since the beginning of activities was to have a space where associates could offer their products to the public. Also, according to the manager's reports, the (*Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba – (Codevasf)*), São Francisco and Parnaíba Valley Development Company, a vital development company for the northeast of Brazil, was the first to encourage and believe in the cause.

Thus, it initially promoted the creation of an island of stalls at the Areia Branca neighborhood fair and Codevasf headquarters. But, as there was an increase in the number of stalls, the fair had to be transferred to the Josefa Coelho municipal park, where it remained for some time. Later, it moved to the parking lots of the River Shopping Convention Center, and Casa do Artesão in the neighboring city of Juazeiro-BA.

Finally, after a long wait for a definitive location that would meet the demands of producers in the sale of their products, the then-mayor Miguel Coelho inaugurated the Municipal Organic Producer Market in July 2019, passing its Assignment to Aprovasf.

Thus, the place comprises the space where producers directly sell their products to customers who attend the fairs on Sundays, from 6 am to noon. According to some producers, the place has become a point of reference for customers looking for organic products, in addition to contributing positively to business

#### IV. LOSSES IN THE VEGETABLE MARKETING PROCESS

As they are highly perishable products, fruits and vegetables suffer losses mainly post-harvest since they are primarily composed of water, keeping their vital biological processes active. They may suffer damage caused by ambient temperature, and inadequate transport, among other reasons [7, 17]. For the authors, temperature management is an essential factor in the conservation of vegetables and loss control.

Regarding refrigeration for vegetable canning, the authors Silva et al. [5] found in their research that the most significant losses occurred with tomatoes (21.73%), tangerines (21.73%), and leafy vegetables (17.39%). According to the authors, both tomatoes and leafy vegetables are very sensitive to changes in temperature and humidity, requiring adequate refrigeration as well as proper packaging and sanitization.

In addition to the causes related to temperature, losses in the marketing of vegetables are also related to other factors, such as storage conditions, incorrect handling, transport, inadequate classification, and inappropriate packaging [6, 18, 19, 20, 8]

Concerning these circumstances, Guerra et al. [19] conducted studies on post-harvest losses caused by vegetables: potatoes, onions, and peppers sold at fairs and supermarkets in Santarém-PA. In their research, the authors found that the primary loss factors in these products are caused by inadequate classification (types, groups, sizes), incorrect handling, and improper packaging..

The authors Lourenço and Katz [20] showed that the losses related to handling and transport of a load with 10,000 kg of fruits and vegetables to be marketed in *Centrais Estaduais de Abastecimento* (Ceasa) -RJ [State Supply Centers] could reach 4,500 kg, that is, almost 50% of the content of the same. Although this amount is already quite expressive, it is noteworthy that it is not the only one, as there are also losses caused in the field and at points of sale such as supply centers and supermarkets.

As for the transport factor, it is noteworthy that this is an important variable to be observed in the aggravation caused at the fruits and vegetables. This is because another agent also contributes jointly: the Brazilian road network. According to Weis and Santos (2012, as cited in [5]), some Brazilian road structures are not in normal condition; when the load is not positioned correctly, it helps to further contribute to the deterioration of products along the way.

Still, concerning transport, Costa, et al, [18] highlighted in their research that there is a percentage of



18% more losses of fruits and vegetables in the processing and packaging phase in Latin American countries, including Brazil, if compared to high-income countries groups such as Europe, North America, and Oceania. For the authors, this fact is due to the deficient infrastructure in these countries, including transport.

Another reason for vegetable losses is improper handling. The authors Ceccato and Basso [6] verified in their research that the losses in the commercialization of vegetables are caused by incorrect handling of employees and customers. They reported that unprepared employees dumped the products on the supermarket shelves without proper care, causing dents and injuries to them. On the other hand, customers caused cracks in the products with their nails, swapped them, dropped them, squeezed, crushed and at times even ingested them. In this way, this factor is also an agent of the damage suffered in vegetables.

For further clarification on the damage caused to vegetables, it is essential to distinguish them into three types. Those of physiological origin (occurring through the plant's metabolism or during its storage); microbiological damage (caused both by storage and by the attack of insects and microorganisms), and mechanical damage (the latter related to the operational activities of people and equipment that carry out the transport, handling, and packaging) [21-19].

Studies indicate that the damage to vegetables during marketing can occur from the joint action of different factors. For example, when they are not packaged or mishandled, they may suffer minor cuts that favor the entry of microorganisms, causing fruit rot and causing physiological damage [22, 5]. Likewise, high or low temperatures impact fruits and vegetables, decreasing their turgidity and causing mass loss and wilting [21, 19, 17].

Because of the issues mentioned above, the factors that generate losses in fruits and vegetables must be discussed through the development of research focusing on the paths taken from the field to commercialization—looking for estimates about the amounts of losses existing in this route in order to make this reality increasingly explicit.

This is necessary because, unlike other consumer goods in which it is possible to add value after production, agricultural products, such as vegetables, have their quality already defined when harvested in the field [22]. The emphasis on this fact becomes relevant as it denotes attention to the integrity of the properties of these products until they reach the final consumer.

Therefore, losses in agricultural production, especially in fruits and vegetables, can be caused by several factors, which demand knowledge, diagnosis, and corrective action

on its causes to minimize them—considering that the defects caused to the products, regardless of their origin, harm the quality and commercialization of vegetables..

## V. MATERIALS AND METHODS

Scientific research is a systematic way of organizing methods for the knowledge of concrete reality and can be carried out based on experiences [23]. Thus, it is clear that it allows a greater understanding of the phenomena studied and the consequent breadth of scientific knowledge. However, it requires a lot of dedication, commitment, and availability from the researcher and ethical compliance at all stages of the investigation process.

As for the objectives, the research is characterized as exploratory-descriptive. The exploratory study is necessary when the researcher uses bibliographic sources, also aiming to provide an overview of a given fact [24]. It allows, therefore, the possibility of forming new knowledge from the interaction with the reality studied. However, due to the flexibility of planning and the use of different instruments, the researcher may face doubts or uncertainties regarding their choice.

Regarding the approach, it is a qualitative-quantitative study since it presents numerical aspects represented by graphs, as well as an interpretative analysis of the observations made by the researcher [25], with the qualitative aspect intrinsically related to the researcher's subjectivity, from their experiences and prior knowledge. Thus, a quality-quantitative approach composes an objective and particular structure; at the same time

Regarding the procedures, it is characterized as a field study, which "consists in the observation of facts and phenomena as they occur spontaneously, in the collection of data referring to them and in the recording of variables that we presume relevantly, to analyze them" [23, p. 59]. Thus, the aforementioned study used some specific operationalizations, such as: focus on the work community, interviews, notes through observation in the field diary, that is, the instruments appropriate to the reality studied were applied, which, according to Gil [26] are necessary procedures for this category of study.

Thus, the research was carried out with a sample of four organic producers who sell leafy vegetables: coriander, chives, lettuce, and cabbage in a short marketing chain at the Municipal Organic Market in Petrolina-PE. With the purpose of verifying the existence of losses in the commercialization of these vegetables, since several studies point to their existence during the process that comprises the harvest, transport, and exposure for sale [6, 19, 27].

The choice of subjects refers to the fact that they all produce and sell leafy vegetables in the space, which does not happen to the others. The option for the aforementioned vegetables is due to the fact that they are quite common in the region and are among the most sought after at the fair.

Finally, it should be noted that the research was carried out after approval by Comitê de Ética em Pesquisa (CEP) Centro Universitário da Vitória de Santo Antão, (Research Ethics Committee), according to opinion substantiated no. 5.257.247 e Certificate of Presentation of Ethical Appreciation (CAAE 56033722.0.0000.9227)

## VI. RESULTS AND DISCUSSION

The field research was carried out during the period from February 27 to March 27, 2022. The field diary was used throughout the interval to record the quantities of leafy vegetables offered for sale at each fair and the total sales made, in addition to other information, such as: customer behavior during purchases and cooperation between the group. Thus, the results and analysis followed the objectives outlined, as shown below:

### *(a) Socio-economic profile of the study group*

The research focus group comprises four small farmers who cultivate in modest areas and sell their products directly to the final consumer in the organic market. In addition to the above-mentioned leafy vegetables, they also plant other vegetables and fruits, namely: sweet potato (*Ipomoea batatas*), beetroot (*Beta*), carrot (*Daucus carota*), zucchini (*Cucurbita pepo*), pepper (*Capsicum annum* Group), cherry tomato (*Solanum Lycopersicum* var. *cerasiforme*), orange (*Citrus X Sinensis*), passion fruit (*Passiflora edulis*), lemon (*Citrus limon*), spinach (*Spinacia oleracea*), arugula (*Eruca vesicaria* ssp. *sativa*) hot pepper (*Capsicum chinense* 'Adjuma'), okra (*Abelmoschus esculentus*), onion (*Allium cepa*), leek (*Allium porrum*), eggplant (*Solanum melongena*), gherkin (*Cucumis anguria*) pumpkin (*Cucurbita*), star fruit (*Averrhoa carambola*), among others.

About the experience with organic agriculture, producers have been practicing this crop for an average of twelve years (Table 1). As for education, only producer 4 has completed high school while the others have an only incomplete elementary school. Regarding the number of people in the family who share the income from the sale of organic products, it varies between two and three per family. This is because, according to them, the children have already grown up, and some have managed to obtain other means of subsistence

Even though it is made up of a few members, the farmer himself, the spouse, and the children carry out the work in the field and also at the fair, with the exception of producer 4, which had to hire three employees to help with fieldwork and deliver the products. In addition, all the producers surveyed sell at other points of sale, in addition to the organic market. Producers 1, 2, and 3 sell their products at the organic fair that is located outside the Casa do Artesão in Juazeiro-BA, in the "fairs" of the neighborhoods where they live and on the property.

Producer 4, on the other hand, opened a company, created a logo with the initials of its name, and distributes its products with the organic seal in some supermarkets and produce in the city through the audit certifier: Instituto Chão Vivo, linked to (*Ministério da Agricultura Pecuária e Abastecimento* - MAPA). Standing out that it is the only one with complete high school in the studied group.

### *(b) Interactions between producers and customers during fairs*

There are strong bonds of friendship and companionship between the producers, so they care about each other. For example, when some goods are sold faster in a specific stall, the owner of the same offers to put his colleague's goods for sale in his stall. This practice is very common in the group. According to them, it also helps to attract customers. "*Stall with little merchandise do not attract customers*" said producer 1, who is always on the lookout to share his products with his stall neighbor. Solidarity and friendship are usually common among fairground vendors, whether helping with sales from colleagues or sharing topics that interest the group [28].

The space of free fairs is usually quite conducive to forming bonds of friendship between the fairground and its customers. So personalized service is one of the characteristics of the street market [29]. In an interview with producer 4, it was reported that some of its customers call in advance requesting the goods so that many products are already sold before they even arrive at the place, allowing better management of the supply and control of losses.

### *(c) Sales and losses of leafy vegetables during the fair in the organic market*

The producers' survey showed that leafy vegetables among the most sold are lettuce and coriander (Fig. 4). The first is a vegetable of great social and economic importance in Brazil. Being the most consumed in the country, occupying third place in the classification of vegetable production, with its highest concentration in the southeast, south, and northeast regions [27].

Coriander, or green smell, as it is known in some localities by country, is also a widely consumed vegetable in the northeast region of Brazil [30]. According to the producers, this leafy vegetable is preferable to parsley (*Petroselinum crispum*) and cannot be missed at the fair. "Here, customers do not like salsa very much, no. They always prefer cilantro." A highlight of producer 3's speech in an interview.

Regarding chives, the least commercialized vegetable among the group, all four producers answered in a structured interview that they usually take between ten and twenty packages of it at each fair during the year. They also stated that the vegetable bulbs are removed for replanting when they are not sold. Thus, according to them, it is possibly better to control the production and supply of these leafy vegetables.

Thus, a relatively low percentage of losses was verified in the sales of leafy vegetables, although the producers have stated that it is common for there to be losses of their goods at the fair. However, considering that these are highly perishable products and come from a small-scale economy, the effective management of loss control in family farming, even when they occur at low levels, is a preponderant factor for the continuity of activities.

Some explanations provided by the producers themselves may contribute to a better understanding of this result. According to them, during the study period, there was a small number of products offered as a result of losses suffered in the field by the action of rain and insect attacks. Producer 4's report, referring to the lack of coriander in a certain fair, specifies this fact well: "If I had brought more vegetables, I would have sold everything; the goods ran out too soon." By reducing losses in the field, it is possible to increase the income of producers, in addition to minimizing the costs of intermediate and final consumers [6].

Producers 1 and Producer 3 have two stalls in the market and always distribute their products in such a way as to occupy their entire space. They were also the top sellers of leafy vegetables during the survey. (Fig. 5). The first one usually has a higher quantity of leafy vegetables than the others, so its products are very commonly offered for sale in other stalls when their owners have already sold their goods. Producers 2 and 4 are the ones that most collaborate with these sales.

Concerning this fact, Araújo and Ribeiro [28] showed that 41% of the merchants interviewed in their research used to be supportive, reselling products from other stalls, mainly from friends and neighbors. This corroborates the information collected in this study, given that this

cooperation is common among the four producers who collaborated with the research.

Still, regarding the low quantity of unsold goods, this fact may be related to the specificity of the products offered at the fair, given that they are organic and, therefore, tend to be more valued by customers. However, to better elucidate this hypothesis, it is recommended to carry out a new survey among small farmers who cultivate leafy vegetables in traditional and organic agriculture in order to make a comparison in the sale of products.

#### *(d) Causes of leafy vegetable losses at the organic market fair*

The quality of the product is something that impacts its acceptance. Although few stands sell leafy vegetables on the market, it is possible to see that customers observe and make comparisons between the same goods. According to producer 4, one of the reasons why the merchandise is not sold is low quality. She argued in an interview that the customer does not like it when the vegetables are not packaged correctly. "If the package is too open, wind and other debris such as hair, for example, can enter, and the customer will not want to take it."

Concerning the report, it was observed that at a specific fair, some packages of coriander at Producer 1's stand were not packed correctly (Fig. 6). Therefore, there were losses of 09 units of the vegetable that day. The correct packaging of fresh products in appropriate packaging is a crucial factor for their conservation, avoiding losses [6].

Another aggravating factor concerns the sunlight, which reflects directly on some stalls (Fig. 7), causing the products to become shriveled. This is what happened with some leafy vegetables from the stand of producer 3 (Fig. 7). According to the producer, the vegetables arrived at the fair still fresh, but they could not withstand the heat caused by the action of sunlight on her stall. Silva et al. [5] warn of this fact when they state that heat can cause turgidity, where the main aggravating factor is the loss of appearance of the vegetables, leaving them withered and wrinkled, making their sales difficult.

In addition to the heat exerted by the sun on the site, there is also the problem caused by the water coming from the rain. According to the producers, in an interview, there should be a cover made of canvas material (awnings) on the market to protect the products.

#### *(e) Handling, packaging, and transport of products to the fair*

Also, in interviews with the producers, it was found that the leafy vegetables were harvested the day before the fair. This eliminates the need to use refrigeration. This is also possible because the distance between the vegetable

gardens and the point of sale is relatively short, and transport is carried out during the early hours of the morning. When the goods need to be transported over long distances, care must be taken to maintain the refrigeration of the products; otherwise, they may suffer mechanical damage [19].

Producers prefer to pack leafy vegetables after they reach the market, avoiding excessive handling and touching the products. Thus, after harvesting in the gardens, they separate them into bundles, organize them in containers or agricultural boxes measuring 55x36x51 cm, sprinkle a little water, and cover them with wet cloths.

Producers claim that this process allows the products to be kept fresh until the moment of sale, which sometimes begins even before six in the morning when the first customers begin to arrive.

Thus, about the handling, packaging, and transport process that occurs before the commercialization of leafy vegetables, the research showed that they are minimal and do not impact the loss of quality of the products. This fact is attributed to other causes, such as the heat exerted by sunlight on products and inadequate packaging during sales.

## VII. FIGURES AND TABLES

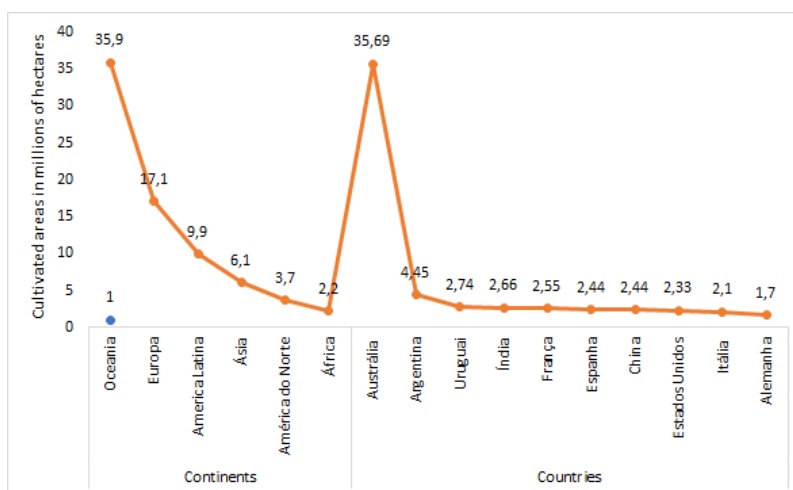


Fig. 1: Cultivated areas in millions of hectares by continents and countries.

Source: [11]

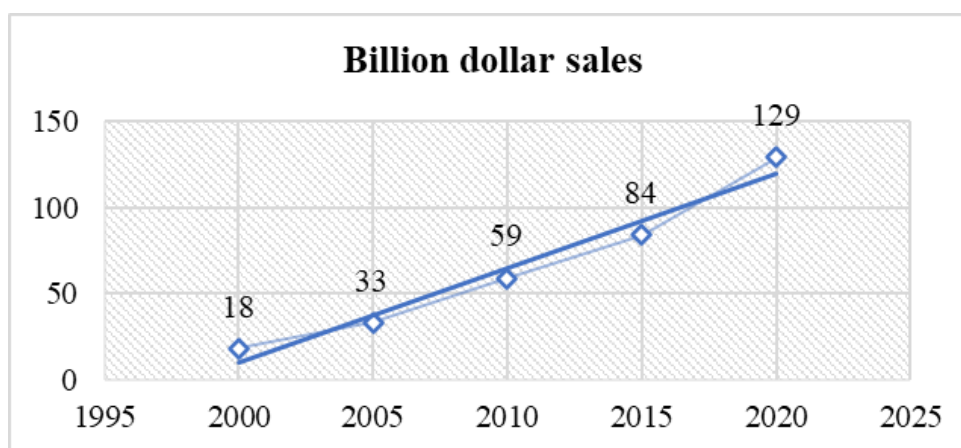


Fig. 2: Expansion of the organic trade in the world.

Source: [11]

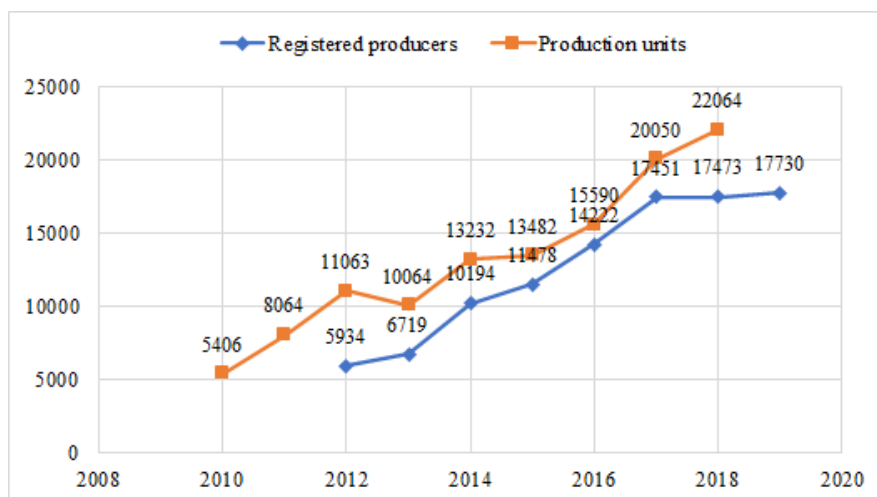


Fig. 3: Number of organic producers registered with MAPA and production units.

Source: [4]

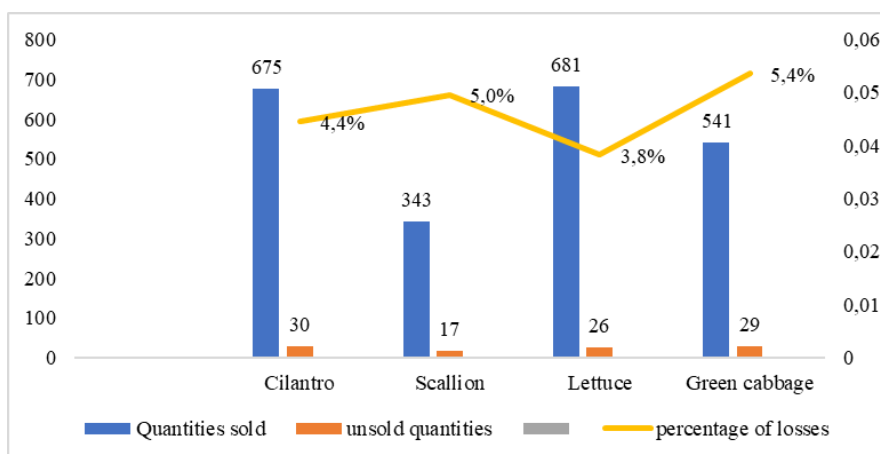


Fig. 4: Total leafy vegetables sold and losses.

Source: Field research

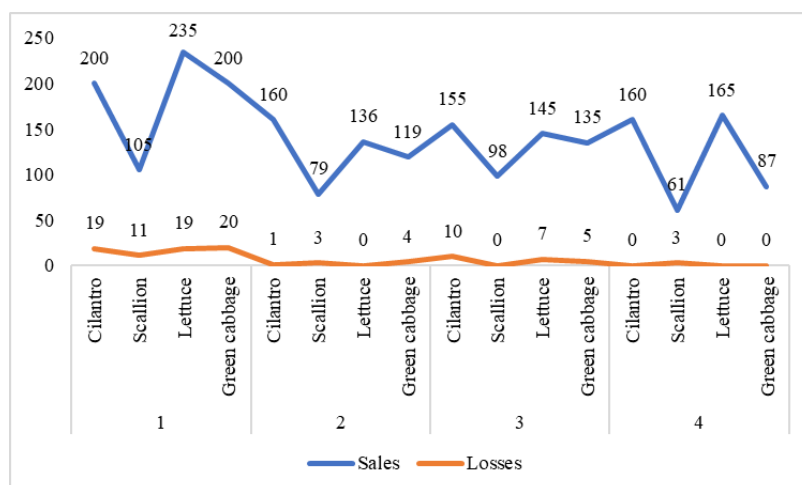


Fig. 5: Total leafy vegetables sold and losses by producer and product Source: Field research





Fig. 6: leafy vegetable packages improperly packed. Source: Field research.



Fig. 7: Products wilted by the action of the sun. Source: Field research.

Table.1: Information about producers. Source: Field research

Producers	Education	Years of experience with organic farming	Commercialization locations	Control bodies
1	incomplete elementary school	5	Fairs and property	Social control organization (SCO)
2	incomplete elementary school	14	Fairs and property	Social control organization (SCO)
3	incomplete elementary school	20	Fairs and property	Social control organization (SCO)
4	High school	10	Fairs, supermarkets, and hortifrutis	Social control organization (SCO)/ Audit certification

## VIII. CONCLUSION

Commercializing organic vegetables is increasingly present in open markets, seen as short marketing channels. Thus, the Municipal Organic Market of Petrolina-PE was created to provide small producers with the possibility of offering their goods directly to customers who frequent the place in search of healthier foods.

The investigation carried out with the commercialization of leafy vegetables: coriander, lettuce,

chives, and cabbage in the market showed a low level in the number of losses during sales. About this finding, some aspects can be considered: the group's unity in helping each other in sales, the friendship they maintain with customers and the low supply of products resulting from losses in the field. And also the fact that the vegetables are organic, which can be considered attractive to customers.

As for the leafy vegetables that were not sold at fairs during the research period, some observations made during

the study contributed to the understanding of this fact, such as inadequate product packaging to protect it from external agents during the sale, in order to maintain its quality and acceptance by the customer and incidence of sunlight directly on the stalls of some producers during the fair, causing wilting of the products.

In addition, the lack of protection in the space allows not only the penetration of sunlight but also the entry of water into the place when the rains occur. According to the producers, in an interview, placing an awning on the site would solve both the problem of the sun on the products and the invasion of rainwater.

Still, the work contributes to the improvement of management among producers, as it presents results of some practices that can be improved, as well as helps to elucidate facts that directly harm business, suggesting improvements to the local infrastructure.

However, taking into account some limitations, such as the short time to carry out the field study and some problems reported by producers, such as the low supply of leafy vegetables during the research, it is suggested to carry out further investigations with producers in periods in which there were no losses in the field. Preferably between those who produce organic leafy vegetables and those who cultivate in conventional agriculture. Thus, new analyzes can be made regarding consumer preferences for one or another type of product. This may allow new comparisons between the amounts of losses.

## ACKNOWLEDGEMENTS

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# Residential Graywater Treatment Through Phytoremediation

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**Keywords - Depollution, Phytoremediation, Reuse of Greywater, Wetlands.**

**Abstract—** In a globalized world with information on environmental issues, it is observed an increasing number of researches focusing on issues related to soil and water pollution. In this context, the reuse of domestic waters (gray waters) for reuse in agriculture with ecological technology, appears as one of the alternatives to equate water demand and supply, especially in the caatinga biome of the semiarid northeast, characterized by low rainfall. Several techniques are being studied and phytoremediation among the other techniques has had a differentiated attention due to its efficiency and low cost. This study is based on the literature review of several works developed in Brazil and in the world, all related exclusively to the theme. This Review was developed through the analysis of the available material on the in the international databases SciELO, Science Direct, Springer Journal, Embase and PubMed, as well as dissertations and theses that were developed in the area of the use of phytoremediation for effluent treatment.

## I. INTRODUCTION

The development of Brazil has strong characteristics that contributed to the existence and repetition of a huge regional inequality with an enormous poverty concentration on north and northeast regions. On northeast especially on the semiarid region. (Fig.1).

From the housings' point of view, João Pinheiro Foundation, through its statistics and information directory (2018), stated that “in 2015, Brazil had 942.000

precarious houses, more the half, 517.000 on rural areas. Most of them are located on north and northeast, which concentrates 655.000 units.

Corroborating the above data, the 2010 Demographic Census reaffirms this precariousness by demonstrating that 29.07% of rural households in the country do not have bathrooms and that only 16.36% of these households have a general sewage network or septic tank.



The National Water Resources Policy (Law 9.433/97) gave greater scope to the Water Code from 1934, which centralized the decisions about the water resource management in the electricity sector. Establishing as a foundation the respect for multiple uses and as a priority the human supply and animal desedation in cases of scarcity. According to the National Water Agency (Agência Nacional de Águas – ANA) (2019), “Any human activity that changes the natural conditions of water is considered a type of use. Each type of use can be classified as consuntive or non-consuntive use.

A survey made by the United Nations (UN) predicts that by 2030 the planet will need 40% more water. In addition, there is another worrying fact: in some cities the water waste exceeds 50%. Considered as a renewable natural resource, the water for industrial and domestic use only can recover its qualities if it is correctly treated.

According to the IBGE (2017), “Brazilian semiarid region has an average annual rainfall of 800 mm or less; the Thornthwaite Aridity Index equal to or less than 0.50 and the daily percentage of water deficit equal to or greater than 60%, considering all days of the year”. So, the development of techniques to minimize this deficit is extremely urgent. The reuse of domestic water (greywater) appears as one of the alternatives to balance the demand and supply of water. Gray water comes from washbasins, showers, laundry tubs, etc. (water from toilets is not considered as such).

Nowadays, the use of water is carefully monitored by civil society. Thus, applying effluent treatment methods aimed at reusing them is essential for the conscious use of this precious asset. In this regard, some Sewage Treatment Plants (in Portuguese Estação de Tratamento de Esgotos - ETE ) have been using unconventional treatment systems. These ETE's do not use chemical products in their processes, it is used aquatic plants, which carry out the treatment process in an ecological and economic way called Phytoremediation.

The Phytoremediation uses plant systems to recover water and soil contaminated by organic or inorganic pollutants. Although this area of study is not new, it had an impulse at the last ten years, when it was verified that the root zone of plants is able to biotransform exogenous organic molecules. (DINARDI *et al.*, 2003).

The rhizosphere, as this zone is called, has been studied for its important function of using polluting molecules as a source of nutrients for the various microorganisms that cohabit in this region (DINARDI *et al.*, 2003).

Thus, the main objective of this study is to present phytoremediation as one of the alternatives for the

treatment of effluents, contributing to the preservation of the environment.

## II. METHODS

This study is a bibliographic review with an analytical character regarding the treatment practices for the reuse of residential gray water through Phytoremediation.

The bibliographic review was developed from the scientific production indexed in the following electronic databases: SciELO, Science Direct, Springer Journal, Embase e PubMed, in addition to dissertations and theses that were developed in phytoremediation of polluted waters area.

The time delimitation covered the period from January 2003 to October 2019. It was also sought to use textbooks that present a theoretical basis for understanding the concept and its application. It should be noticed that this is a conceptual approach since this theme only gained momentum in the 1990s.

Other criteria used for analysis were the selection of papers by the analysis of abstracts, including only those that were directly related to the proposed approach, and the use of keywords: depollution, phytoremediation, reuse of gray waters and wetlands.

After the selection of the papers and texts according to the previously defined inclusion criteria, it was followed the following steps: exploratory/interpretive reading, material choice which relates to the objectives and theme of this study, and finally the writing of the base text.

## III. RESULTS AND DISCUSSION

From the 38 papers and texts that were found initially, 15 were selected for reading and filing. All selected papers/texts are related to the topic Phytoremediation in the context of graywater treatment. The publications in Portuguese totalized eight publications, five in English, one in French and one in Spanish.

Phytoremediation is the use of plants in soils, waters and sediments contaminated with organic or inorganic substances in order to sanitize them. The word phytoremediation etymologically consists of the prefix "phyto", which indicates plants and "remedium" which means to restore, phytoremediation consists of removing through the use of plants a variety of residential, industrial and commercial compounds, such as: metals, metalloids, solvents, petroleum hydrocarbons, excess salts, etc. (Cuunningham & Ow, 1996, apud TCHANG, 2018).

Phytoremediation is a biological process and is carried out *in situ*, which means, directly in the type of



environment to be treated, where there is insertion of decontaminating plants, or *ex situ*, in greenhouses or in pots. (SUSARLA et al., 2002, apud TCHANG, 2018).

Phytoremediation of polluted areas is extremely useful for the environment, in order to appease or clean it up completely. It is necessary to use plants that have some characteristics like for example a great absorption capacity, deep root system, accelerated growth rate, easy harvesting, and a great resistance to pollutant (COUTINHO e BARBOSA, 2007).

Generally, native plants are preferred in phytoremediation techniques, as an example of native plants researched: Capim Elefante Roxo (*Pennisetum purpureum Schum*), Common water hyacinth (*Eichhornia crassipes*), Common Duckweed (*Lemna minor*), Alface-d'água (*Pistiastratiotes*), Orelha-de-onça (*Salvinia auriculata*), Taboa (*Typha domingensis*), etc. These species have many ecological and technical advantages due to the low maintenance cost, but also because of their local compatibility. In fact, they provide the best conditions for other organisms in the ecosystem. Besides, they adapt very well to the environmental conditions such as climate.

In accordance with Campos e Teixeira Filho, (2019), "Incorrect waste disposal, even after treatment, may cause negative impacts to riverbeds. Substances like nitrogen and phosphorus, especially, because of its concentration might become toxic for the aquatic organisms. These substances also can produce favourable conditions for the proliferation of vegetation, which can initiate eutrophication processes", This process makes a body of water acquires high levels of nutrients.

In other circumstances, it is possible, in the environment to be treated. The use of exotic species is possible when the plant is previously introduced into the environment, and it is considered part of the landscape and no longer poses a risk to the ecosystem.

Based on the world literature of 2016's on Web de Science and Scopus, Brazil participated of only 4% of the scientific papers related to bioremediation, biosorption and phytoremediation on the last 20 years. However, there was 190 research groups including state-owned enterprises, private enterprises and academic institutes related to these words. (TCHANG, 2018).

Regarding plants, Mota & Von Speling (2009) state that "phosphorus is an essential nutrient for the growth of microorganisms responsible for stabilizing organic matter, and phosphorus does not have health implications for water quality. The quantity of total phosphorus is due to the use of detergents and saponaceous in the washing of phytovolatilization clothes."

According to Van de Moortel *et al.* (2009), the release of oxygen by plant roots can increase the adsorption capacity of phosphorus through substrates. This may influence the item that plant treatment systems have a higher removal efficiency than plantless systems.

The ability of a plant to be phytoremediator will depend on the pollutant. So, several plants must be tested in order to define which plants have a greater resistance to the pollutant.

Due to the wide variety of pollutants, various specific surveys will be required. Thus, the characterization of the pollutant is essential for the recognition of the effectiveness of phytoremediation.

Phytoremediation can be classified depending on the technique to be used, the chemical nature or the pollutant property. There are five types of phytoremediation based on plant physiological processes: phytostabilization, phytovolatilization, phytodegradation, phytostimulation and phytoextraction (VIEIRA, G. E. G, et al., 2011). (Fig.2).

The basics characteristics of each process are:

- a) Phytostabilization: the pollutant is immobilized through its lignification or humification.
- b) Phytovolatilization: the pollutant is absorbed and converted into a volatile form, which is released into the atmosphere.
- c) Phytodegradation: the pollutant undergoes bioconversion inside the plant or on its surface
- d) phytostimulation: the presence of plants stimulates microbial biodegradation through exudates and/or supply of plant tissues.
- e) Phytoextraction: the plant absorbs the pollutant from the environment, and it is stored in the plant tissue, facilitating its later disposal.

The phytoremediation of this study is the one that uses floating macrophyte plants as wastewater treatment systems. The floating macrophyte plants comprise a wide and varied group of plants, among which Common water (*Eichhornia crassipes*) and some varieties of grasses might be used as biomass or animal feed stand out. (Fig.3).

According to Borrero and Martelo (2012) "at the photosynthesis, floating macrophytes use oxygen and carbon dioxide available in the atmosphere. The nutrients are taken from water through the roots, which is an excellent way of filtration/absorption of suspended solids. The root development happens because of the nutrient's availability in the water and the demand for nutrients by the plant".

In accordance with Bolaños (2008, p 39-48), “the first explorations with floating macrophytes in wastewater treatment were carried out in the 70s at the space Centre of the National Aeronautical and Space Administration - NASA, as a Potential system for wastewater treatment in space travel” (apud BORRERO e MARTELO, 2012, p. 227).

The authors also stated that the efficiency of floating macrophytes in the treatment of wastewater with organic matter content and nutrients was already studied by several authors and that during 1973 at the University of Florida. Harvey e Fox tested *Lemna minor* for nutrient removal and had reductions of 89% and 67% for nitrogen and phosphorus respectively”.

In this same line of results, Tomoaki et al. (2006), mentioned that “we usually use some kind of detergent in the kitchen and thus it is necessary to remove this compound. Phytoremediation is efficient in this removal process, however, the removal efficiency in summer is 60% higher than in winter”. These studies are the result of experiments of several years carried out on Shikoku Island in Japan.

Baracuh et al. (2015), state that “The treatment of gray water with phytoremediation is efficient, reducing total coliforms and very effectively in minimising the presence of faecal coliforms *E. coli*.”

#### IV. FIGURES AND TABLES

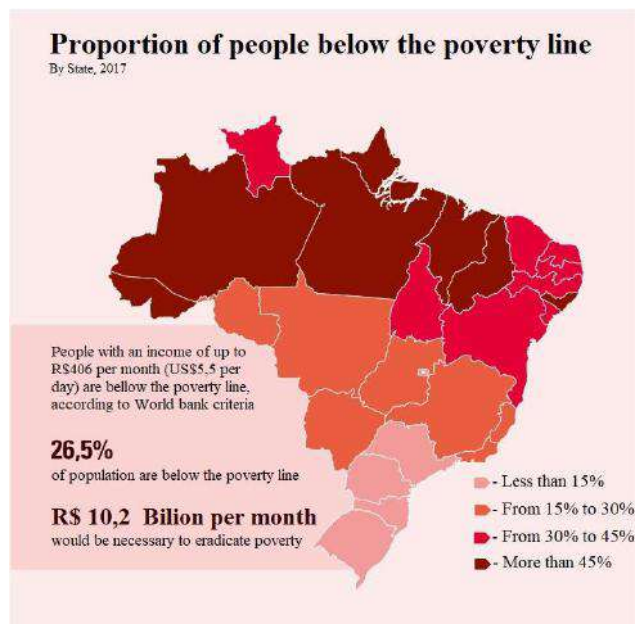


Fig.1 – Proportion of people below the poverty line

Source: IBGE

Adapted from - <https://agenciadenoticias.ibge.gov.br/agencia-noticias/2012-agencia-de-noticias/noticias/23299-pobreza-aumenta-e-atinge-54-8-milhoes-de-pessoas-em-2017> - Accessed on: September 2019.

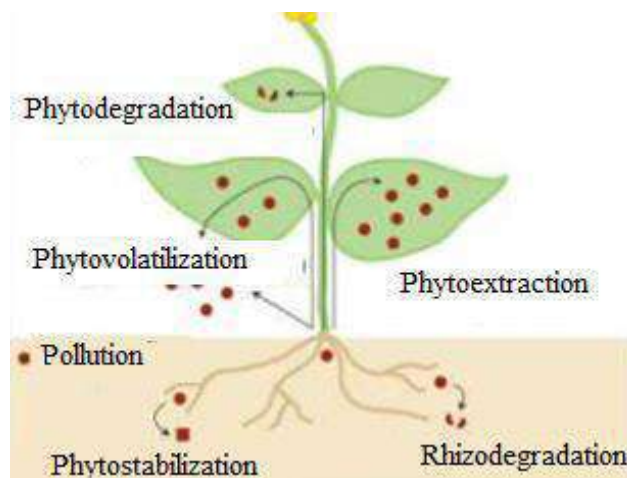


Fig.2 – Mechanisms involved in phytoremediation

Source: TCHANG, Valérie, (2018)

Adapted from – [https://savoirs.usherbrooke.ca/bitstream/handle/11143/14079/Tchang\\_Valerie\\_MEI\\_2018.pdf?sequence=1](https://savoirs.usherbrooke.ca/bitstream/handle/11143/14079/Tchang_Valerie_MEI_2018.pdf?sequence=1) - Accessed on: October 2019.



Fig.3 – Longitudinal cutting of a cultivated subsurface flow bed with *Eichhornia crassipes*

Source: CAMPOS and TEIXEIRA FILHO, (2019)

Available on – <http://dx.doi.org/10.1590/s1413-41522019133600> - Accessed on: October 2019.

#### V. CONCLUSION

Greywater treatment with phytoremediation is efficient in removing nutrients, pathogenic microorganisms and non-biodegradable compounds. Phytoremediation is a viable alternative that allows the reuse of gray water for the cultivation and food production.

Studies about phytoremediation are being developed aiming at many benefits for the environment and future generations. There are several pollutants and every day something new appears, bringing damage to the entire habitat.

This research reports some of the works that have been developed in environmental pollutant remediation area, as well as other techniques aimed at

decontaminating polluted areas. The necessary mechanisms are various, but organisms, especially plants, have specific ways to remove, immobilise or transform specific pollutants.

Therefore, it is necessary that more studies in this area be carried out to better understand the phytoremediating capacity of plants and their possible use in combatting pollution.

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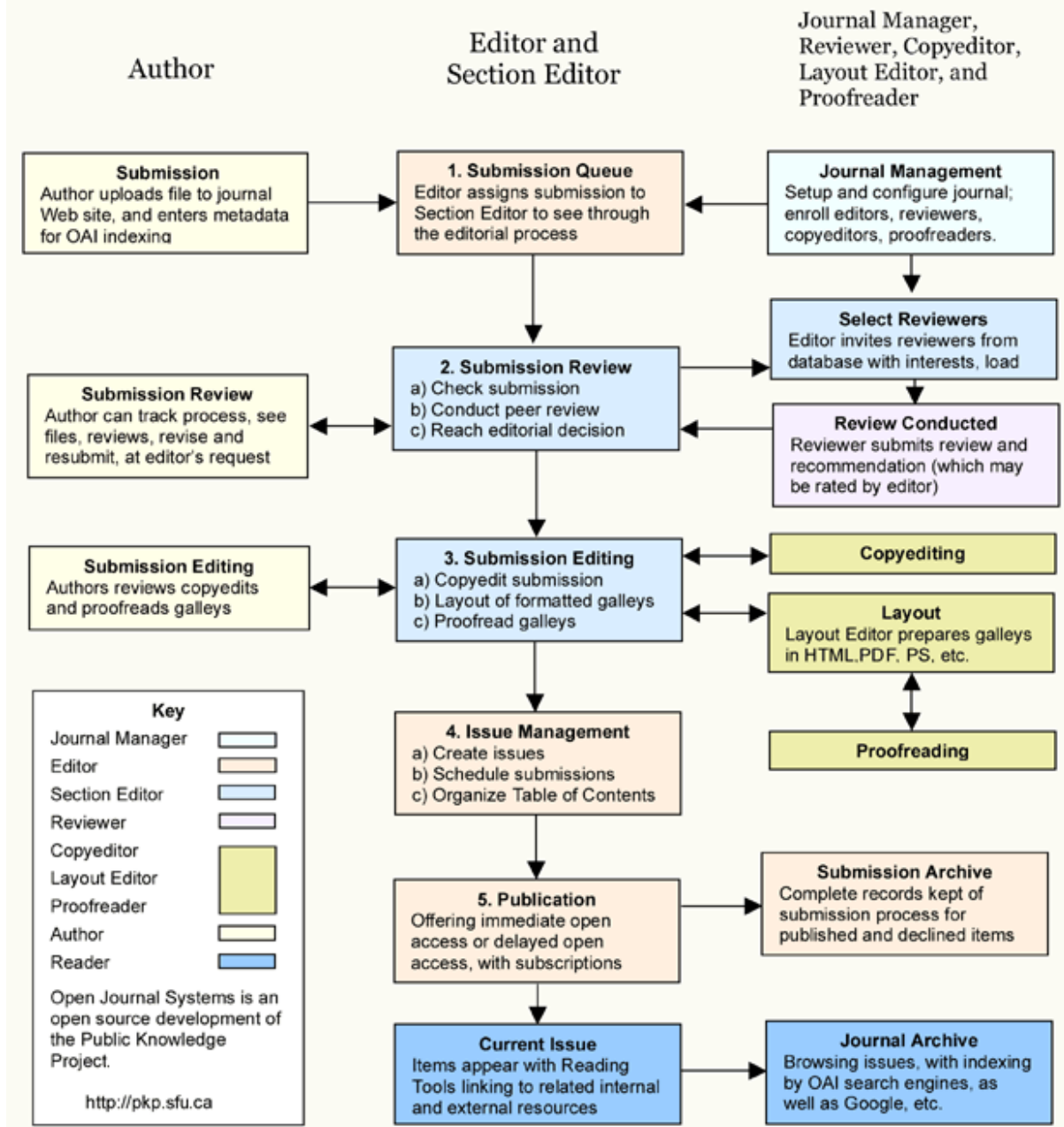
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