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Application of artificial neural networks to predict the behavior of stocks

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***Keywords*— Stocks, Artificial Neural Networks, Multi-Layer Perceptron with Backpropagation, Probability of series behavior.**

***Abstract*—** *Statistical data point to the fact that the vast majority of the world population, even after working for a lifetime, when they retire, do not have significant reserves of financial resources in order to guarantee a good quality of life in the elderly. Bearing in mind that the financial stock market offers a viable opportunity for lifelong capital expansion; Through this work, we sought to develop an innovative technique to allow a simple support based on mathematical models, for support decision making by common people, for buying or selling market stocks. This is because the techniques that support decision-making are relatively complex and not widely mastered by the majority of the Brazilian population. The algorithm was proposed to better perform this task. It was made by one corresponding Artificial Neural Network of the "Multi-Layer Perceptron" type with "Backpropagation". Because this ANN is suitable for learning patterns of historical series, which are usually the object of study of stock price behavior by technical analysis methodologies, that are widely used by the market. Therefore, a comparative study was carried out between the results found using the proposed ANN methodology versus the results obtained from simple technical analysis versus single purchase and sale operations in a period of one year. It was found that the ANN model used guided the achievement of superior results for operations with all the Stocks tested, thus proving to be a promising way to solve problems of this nature; related to the identification of mathematical patterns of historical series of the behavior of stock prices on the São Paulo stock exchange.*

I. INTRODUCTION

It is important to contextualize the motivation of this experiment performed with stocks on the São Paulo stock exchange called BOVESPA.

Let's address some statistical data, according to [1] Wolwacz, A & Stormer (2014), which point to the problem to be worked on:

- Only less than 2% of the world's population has more than U$60.000,00 in the bank.
- 93% of Americans reach age 65 with less than U$10,000 in their bank account.
- Working your whole life does not mean securing your future.
- Work should be associated with better resource management of the fruit of that lifetime work.

These data make us reflect on the fact that the typical professional conduct of ordinary citizens, of obtaining their livelihood through formal paid work, even over years of a professional career, does not guarantee stability and a good quality of life after retirement.

Therefore, this proposed model aims to offer a viable alternative for self-employed professionals to multiply

their savings in order to guarantee good financial stability after the end of their formal professional careers.

But, how to do it using computational modeling as a decision support and witch results could be achieved?

II. ARTIFICIAL NEURAL NETWORKS

In this work, we present the methodology for applying Artificial Neural Networks in the process of predicting the behavior of stocks based on data from historical series of prices and trading volumes of stocks present on Bovespa, the São Paulo, Brazil Stock Exchange. ANNs (Artificial Neural Networks) are actually computational models that aim to mathematically simulate the behavior of biological nervous systems in human beings. These ANNs models have characteristics of adaptation by experience, learning capacity, generalization ability, fault tolerance and ease of interpretation of their architectures, characteristics that are very relevant as described by [2] Silva, I. N. D. & Spatti, H. & Flauzino, R. (2010).

Neurons are the main biological cells of the nervous system, also called the basic units of this system. According to Figure 1, a Neuron is basically composed of dendrites, which are the input terminals for information; the cell body, which has the function of processing information and finally, the axon, which corresponds to the output terminals responsible for conducting information between different neurons.

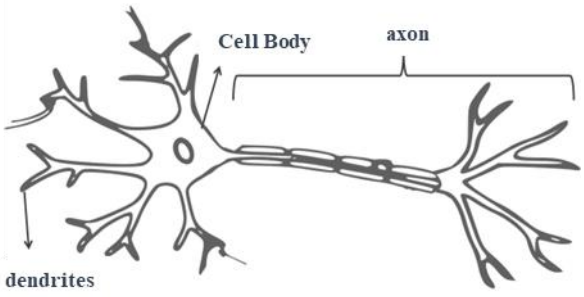

Fig.1: Scheme of a biological neuron.

According to [3] Zorzetto, R. (2012), "The cell count revealed that the human brain has, on average, 86 billion neurons. This number is 14% lower than the previous estimate and close to that proposed in 1988 by Karl Herrup, from Rutgers University (New Jersey - USA)". In addition, the same article reveals two more interesting and curious aspects of the human brain: the first is its disharmony in relation to the number of neurons versus the weight of the brain itself and its smaller component called the cerebellum (which has the original Latin meaning, being "small brain"). The brain is 1,200 grams and occupies more than half of the skull, but houses only 16 billion neurons. The cerebellum, with its only 150 grams, has 69 billion neurons, which we can describe in computational language as "basic data processing units". It follows, therefore, from this fact that the size of an organ does not in itself represent a greater processing capacity. The second curiosity refers to the number of other cell types in the brain, such as "glial" cells. These cells, previously considered only physical support for neurons, perform other essential functions such as helping in the transmission of nerve impulses, nourishing neurons, defending the central nervous system from invading microorganisms and also obviously occupying space. The dogma itself was that the total number of "glial cells" (10 times greater than that of neurons – origin of the idea that we only use 10% of the brain. However, "This high rate of glial cells was taught in books didactic, although experiments already indicated that the ratio was actually 1 to 1", says by Helen Barbas, from the University of Boston.

More than the number of glial cells, which are 85 billion in humans, more concentrated in the brain than in the cerebellum, but what most surprised Suzana was the fact that they practically did not undergo morphological changes during the so-called "evolution". Their size is almost constant between monkeys and humans, while that of neurons size varies 250 times. The researcher went so far as to state that: "The functioning of glial cells must be adjusted in such a fundamental way that nature has eliminated any change that has arisen". This statement leads to the interpretation that only a part of the brain organism would have evolved and another vital part would have already "hypothetically emerged" so well elaborated that it dispensed with the need to evolve, a really intriguing statement.

The fact is that we can scientifically state that we use 100% of the brain, and not just 10% as we could previously imagine; it should only be understood that about 50% of the brain mass has the role of data processing itself (neurons) and the other half (glial cells) have other roles that are equally important and necessary for the maintenance of the entire system. Therefore, it can be said that the neurological system is composed of qualitatively and quantitatively complex cellular elements.

Artificial neurons are simplified mathematical models of biological neurons. As well as Artificial Neural Networks, which in a more simplified mathematical way than biological networks, aim to simulate the behavior of a natural human neural system as well as its learning process.

In figure 2 we can see a simplified artificial neuron. Where the sum of the product of all entries with their

respective weights can also be represented by equation (1) below:

$$net_j = \sum_{i=1}^{n} x_i w_{ij} \quad (1)$$

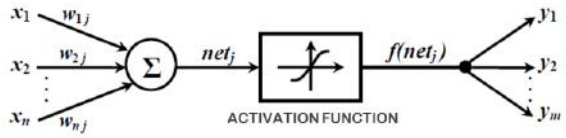

Fig.2: Artificial Neuron Model. Source: [4] Lopes, P.S. (2007).

In this model, the dendrites are represented by the input signals *x1,...,xn*; the values of *w1,...,wn* represent the synaptic weights. The symbol ∑ represents the linear combination that aggregates all the input signals that were weighted by the synaptic weights that result in the *netj* value, which is the input value of the activation function, which in turn filters the input by activating or inhibiting the neuron. *f(netj)* is the output value of the function when the neuron is activated, which results in the m output terminals *y1,..., ym*.

Before talking about the "Backpropagation" algorithm itself, we must first mention its origin in MLP (Multilayer Perceptron Networks). This type of network is characterized by the presence of at least one hidden intermediate layer of neurons, which is positioned between the input and output layers. Therefore, these networks have at least two layers of neurons before the output.

MLP-type networks are quite versatile in terms of application possibilities in different types of problems such as function approximation, system optimization, process identification and control, and even for pattern recognition and for forecasting time series, these last two applications are the ones that really interest us in the study of predicting the behavior of stocks on the stock exchange.

MLP networks have the "feedforward" architecture, which means that the flow of information that starts in the input layer and goes through one or more intermediate layers and ends its course in the output layer, follows its flow in only one direction, therefore without any type of feedback, as shown in Figure 3.

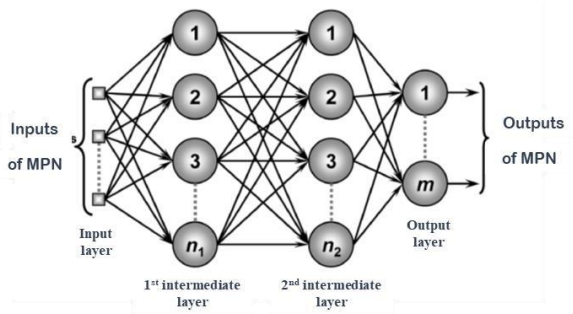

Fig.3: Illustration of a Multilayer Perceptron Network

The figure above illustrates a type of "Perceptron" network known as "Adaline", it consists of a topology that has an output network, which can be composed of several (m) neurons.

The central issue of applying a network to solve a given problem is the choice of the best network topology that allows obtaining the results with less error and more assertive. This question refers to the choice of the number of intermediate layers, as well as the number of their respective neurons, for example. The choice of network topology depends on several factors such as the class of the problem to be solved, the spatial arrangement of the samples and the initial values assigned as well as their synaptic weights, as described by [5] Lopes, P.S. (2010).

However, even if the best topology of a PMC network is chosen for a given problem, the choice of the best values for the synaptic weights from the first interaction is a task, in most cases, of extreme difficulty. To get around this situation, supervised training associated with the learning algorithm called "Backpropagation" or "error retropropagation algorithm" is applied. Because in this way it is possible, from the evaluation of the error in the output, to feed back the algorithm by correcting the synaptic weights to obtain a result that is increasingly closer to the solution of the problem at each interaction of the system.

This training process of MLP networks using the "backpropagation" algorithm can be described by two specific phases: the first phase is the "forward" propagation and the second phase is the "backward" reverse propagation.

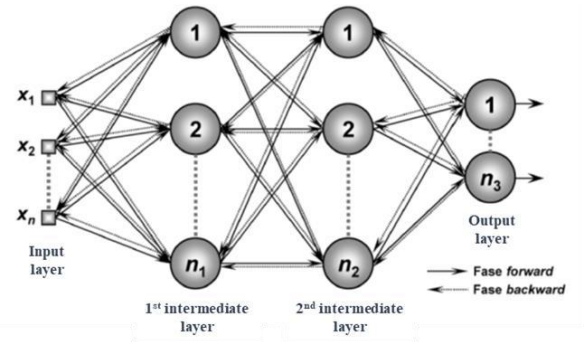

Fig.4: Illustration of the two PMC network training phases.

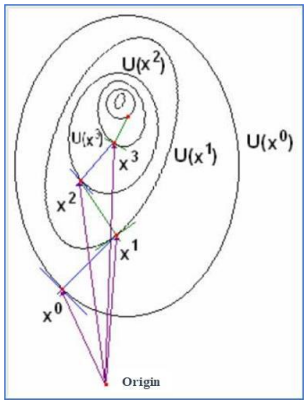

Fig.5: Geometric interpretation of the gradient method.

As illustrated in Figure 4, in the first phase, which consists of forward propagation, the input signals, {X1 to Xn} from a sample of the training set are applied to the neurons of the input layer and propagated to the first layer, later to second layer and finally produce their respective outputs in the last layer entitled "output layer". It is noteworthy that in this propagation phase the responses are obtained through the initial values of the synaptic weights and thresholds of its neurons, therefore these will remain unchanged at each execution of this same phase.

As this is a supervised learning process, right after this first phase, the answers obtained will be compared with the answers already available and their respective errors calculated. The result of these calculations will be later used to adjust both the synaptic weights and the thresholds of all neurons in the system. It is precisely this adjustment that corresponds to the second phase mentioned above, the "reverse propagation".

According to [5] Lopes, P.S. (2010), during the programming of the backpropagation algorithm, the updates of the synaptic weights are applied in the negative direction of the gradient of the quadratic error function.

We can understand the gradient method by the geometric interpretation of Figure 5. Where X0 would be a point on the outermost closed circular surface U(x). The negative gradient is the perpendicular direction that meets X1 such that U(x1) is less than U(x0). And λ is the distance traveled between X0 and X1.

In short, the gradient method, applied to update the synaptic weights, allows each new interaction to get closer and closer to the solution of the problem or model, as each interaction reduces the error of the system output.

Therefore, it is correct to state that the successive phases of "forward propagation" and "reverse propagation" allow the synaptic weights and neuron thresholds to be adjusted at each iteration.

III. METHODOLOGY

For this work, the basic concepts of Technical Analysis were applied, a specific architecture was defined for the network, historical series available on finance websites were retrieved, data treatment was carried out with the support of electronic spreadsheets and the ANN learning with support of functions available in "Matlab".

The data used as an input referred to weekly recordings, it means weekly candles of historical periods of approximately one year, of certain stocks on the Brazilian stock exchange. It was defined as output, the estimate of valuation or devaluation of these certain papers, always for the coming weeks.

Below is the methodological flowchart applied on this study:

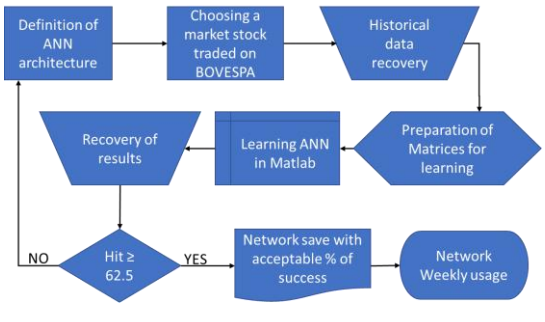

Fig.6 - Applied methodological flowchart

Regarding the Network architecture, seven input data were considered for each weekly interval retrieved: High Value, Open Value, Close Value, Close Value, Close Value adjusted, Volume and Moving Average 8 weeks.

Therefore, the network had the architecture of an input layer with seven inputs, a first hidden layer, a second hidden layer and an output layer with only one output that refers to the tendency of valuation or devaluation of one Stock Exchange.

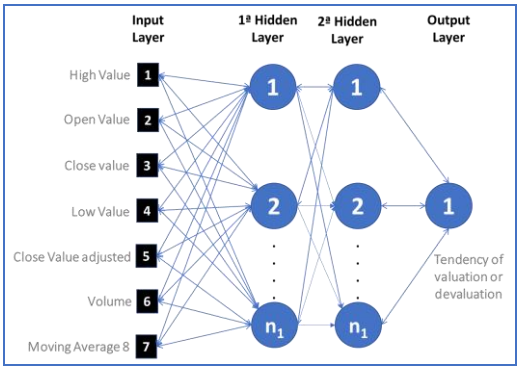

Fig.7 - Architecture of the artificial neural network chosen for this work.

From fifty-three weeks retrieved in .CSV file format and with the aid of an electronic spreadsheet, the calculation of the arithmetic mean of eight periods from the closing to the ninth week was carried out with the first eight weeks. Subsequently, the arithmetic averages of all the other forty-five weeks were calculated, since the arithmetic averages are not available along with the historical data. Then, the results of the exits of each week until the fifty-second week are obtained, which simply corresponds to the value 1 (one) when in week +1, there is appreciation of the stock and 0 (zero) when in week +1 there is devaluation of the paper. And finally, 36 weeks are separated for learning the network and 8 weeks for testing the network, dispensing with the last week that was used only to obtain the output of the fifty-second week, see the explanatory figure below:

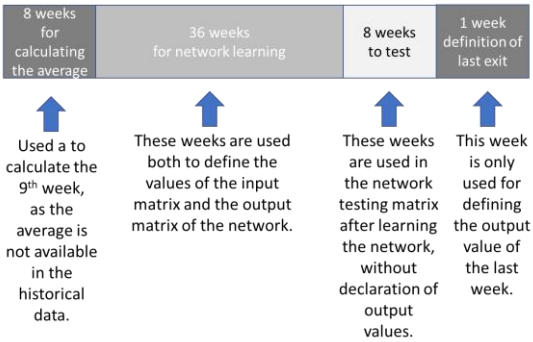

Fig.8: Illustration of preparing the tables

After processing these data, files are created: data entry for learning for the 36 weeks; output for the same 36 weeks and test with the 8 weeks used for testing the network accuracy.

IV. RESULTS

The Stocks studied were AMAR3, RRRP3, TRPL4 and WEGE3.

Results from 3 different methods were compared:

- A purchase at the beginning of the one-year period and a sale at the end of the period.
- Purchases and sales guided by the arithmetic average of 8 weeks.
- Purchases and sales guided by ANN.

At this article we will present the stock that we have obtain the best result using ANN that was RRRP3.

This role corresponds to that of the company RRRP3 Petroleum Oleo and Gas SA; company that operates in the oil and gas sector.

A period of one year was chosen for learning, always taking into account data corresponding to the weekly results of this paper for the study.

Fig.9: Graph of RRRP3 stock during the analyzed period.

The first hypothesis considered only a simple purchase and sale, respectively at the beginning and at the end of the studied period. Starting from the hypothesis of initial capital in the amount of R$10,000.00 (Brazilian currency), the results obtained were:

Table 1: RRRP3 simple purchase and sale operation.

Simple purchase and sale			
Operation	**Price**	**Quantity**	**Amount Operated**
1ª purchase	R$ 40,99	243	R$ 9.960,57
1ª sale	R$ 43,66	243	R$ 10.609,38

So, the gain for the period was approximately 7%.

In the second hypothesis, purchase and sale operations were simulated using as a decision factor only the upward or downward trend of the 8-period arithmetic mean, one of the simplest methods of operating stocks on the market. Starting from the hypothesis of initial capital in the amount of R$10,000.00 (Brazilian currency), the results obtained were:

Table 2: Operations using the arithmetic mean of RRRP3.

Operating by the 8-week Arithmetic Mean			
Operation	Price	Quantity	Amount Operated
1ª purchase	R$ 45,50	219	R$ 9.964,50
1ª sale	R$ 42,09	219	R$ 9.217,71
2ª purchase	R$ 36,40	253	R$ 9.209,20
2ª sale	R$ 41,33	253	R$ 10.456,49
3ª purchase	R$ 33,50	312	R$ 10.452,00
3ª sale	R$ 32,00	312	R$ 9.984,00
4ª purchase	R$ 34,13	292	R$ 9.965,96
4ª sale	R$ 43,66	292	R$ 12.748,72

So, the gain for the period was approximately 28%.

In the third hypothesis, it was used an ANN with seven inputs, two intermediate layers of 100 neurons each and one output. After the learning period using the backpropagation method, we obtained an accuracy level of 62.5%. Considering the same initial capital of R$ 10,000.00, we calculated the week-by-week forecast of the historical series using the network saved after the learning process. And in this case the results obtained were:

Table 3: Operations using ANN for decide operations.

Operating through RNA with 62.5% accuracy			
Operation	Price	Quantity	Amount Operated
1ª purchase	R$ 40,66	245	R$ 9.961,70
1ª sale	R$ 46,79	245	R$ 11.463,55
2ª purchase	R$ 42,09	272	R$ 11.448,48
2ª sale	R$ 42,09	272	R$ 11.448,48
3ª purchase	R$ 35,09	326	R$ 11.439,34
3ª sale	R$ 38,00	326	R$ 12.388,00
4ª purchase	R$ 32,99	375	R$ 12.371,25
4ª sale	R$ 42,82	375	R$ 16.057,50
5ª purchase	R$ 41,20	389	R$ 16.026,80
5ª sale	R$ 41,33	389	R$ 16.077,37
6ª purchase	R$ 33,50	479	R$ 16.046,50
6ª sale	R$ 36,04	479	R$ 17.263,16
7ª purchase	R$ 28,38	608	R$ 17.255,04
7ª sale	R$ 31,68	608	R$ 19.261,44
8ª purchase	R$ 30,49	631	R$ 19.239,19
8ª sale	R$ 34,13	631	R$ 21.536,03
9ª purchase	R$ 33,48	643	R$ 21.527,64
9ª sale	R$ 36,84	643	R$ 23.688,12
10ª purchase	R$ 35,40	669	R$ 23.682,60
10ª sale	R$ 38,56	669	R$ 25.796,64
11ª purchase	R$ 37,40	689	R$ 25.768,60
11ª sale	R$ 39,59	689	R$ 27.277,51
12ª purchase	R$ 33,88	805	R$ 27.273,40
12ª sale	R$ 39,47	805	R$ 31.773,35
13ª purchase	R$ 42,66	744	R$ 31.739,04
13ª sale	R$ 43,66	744	R$ 32.483,04

So, the gain for the period was approximately 226%, it means strongly larger.

V. CONCLUSION

This example show that ANN was really usefully for identify the best moment to purchase and to sale this specific stock comparing with a simple purchase and sale operation and either using the arithmetic mean.

It is understood that the results obtained were quite satisfactory and encouraging to continue improving and studying the potential of expanding the application of this model.

However, is important to highlight that a learned network could suffer wear over the weeks due to changes in market patterns and therefore tends to lose its effectiveness as we have and new re-learnings become necessary to continue to obtain positive ANN results.

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The use of Sodium Bicarbonate Inhaled Solution in Moderate/Severe Cases of Covid-19 in the City of Aquidauana, Mato Grosso do Sul, Brazil

Utilização da Solução Inalatória de Bicarbonato De Sódio em Casos Moderados/Graves de Covid-19 na Cidade de Aquidauana, Mato Grosso Do Sul, Brasil

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Abstract— *On March 11, 2020, the World Health Organization declared the new Coronavirus a pandemic, due to the large number of cases and*

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deaths worldwide. The upper inhalation routes are the gateway for any viral variant, with the installation of SAR-CoV-2 in the respiratory epithelium, which, belonging to the Coronovidae family, has an acidic pH. Alkalization is a way to destabilize the pathophysiology of COVID-19. In this way, the introduction of saline solutions into the upper respiratory system would be a way of interfering with the symptomatology and behavior of the virus. Objective: To evaluate the role of inhaled 3% sodium bicarbonate solution in improving respiratory symptoms and destabilizing SAR-CoV-2 in COVID-19. Materials and methods: Randomized clinical trial, with people diagnosed with COVID-19 through the RT-PCR assay. The participants included were of any age and gender undergoing hospital treatment at the COVID-19 ward unit at the Hospital Regional Doutor Estácio Muniz, located in the municipality of Aquidauana in the State of Mato Grosso do Sul, between September/2020 and November/2021. Results: It was observed that moderate/severe patients who received inhaled treatment with a 3% sodium bicarbonate solution had a good prognosis for their respiratory condition, progressing to hospital discharge. Conclusion: Treatment with sodium bicarbonate solution has a high potential in the treatment as an adjunct to COVID-19.

Resumo— *Em 11 de março de 2020 a Organização Mundial da Saúde declarou pandemia pelo novo Coronavírus, devido ao grande número de casos e óbitos a nível mundial. As vias inalatórias superiores são a porta de entrada de qualquer variante viral, ocorrendo a instalação do SAR-CoV-2 no epitélio respiratório, que, pertencente à família Coronovidae possui um pH ácido. A alcalinização é uma forma de desestabilizar a fisiopatologia da COVID-19. Desta forma a introdução de soluções salinas no sistema respiratório superior seria uma forma de interferir na sintomatologia e no comportamento do vírus. Objetivo: Avaliar o papel da solução de bicarbonato de sódio a 3% de forma inalatória na melhoria da sintomatologia respiratória e na desestabilização do SAR-CoV-2 na COVID-19. Materiais e métodos: Ensaio clínico randomizado, com pessoas diagnosticadas com a COVID-19 por meio do ensaio de RT-PCR. Os participantes incluídos eram de qualquer idade e sexo em tratamento hospitalar na unidade da enfermaria de COVID-19 no Hospital Regional Doutor Estácio Muniz, localizado no município de Aquidauana no Estado de Mato Grosso do Sul, entre setembro/2020 e novembro/2021. Resultados: Observou-se que os pacientes moderados/graves que receberam o tratamento inalatório com a solução de bicarbonato de sódio 3% tiveram um bom prognóstico do quadro respiratório, evoluindo para alta hospitalar. Conclusão: O tratamento com a solução de bicarbonato de sódio possui um alto potencial no tratamento como coadjuvante da COVID-19.*

I. INTRODUÇÃO

No final de 2019, detectou-se o surto do novo Coronavírus (SARS-CoV-2) na cidade de Wuhan na China, o qual culminou em uma pandemia, declarada pela Organização Mundial da Saúde, em 11 de março de 2020, atingindo, após 6 meses, 216 países[1]. Os casos aumentaram em um curto espaço de tempo, sendo notificados mais de 160 milhões de pessoas no mundo, totalizando 3 milhões de óbitos[2.] No Brasil, o primeiro caso da COVID-19 confirmado ocorreu no dia 26 de fevereiro de 2020 registrado em São Paulo, epicentro da pandemia no país, notificando o primeiro óbito no dia 16 de março de 2020[3].

No estado do Mato Grosso do Sul, segundo os microdados do Boletim Coronavírus, o primeiro óbito por COVID-19

ocorreu na cidade de Aquidauana em, 27 de março de 2020, em paciente do sexo feminino, 44 anos de idade sem comorbidades. Com o número exponencialmente crescente de casos, no dia 7 de abril de 2020, foi decretado "Estado de calamidade pública no Estado do Mato Grosso do Sul" pelo Ministério do Desenvolvimento Regional, através da Portaria nº 870/SNPDC/MDR[4].

Nesse mesmo Estado, há a presença de populações indígenas, em especial na cidade de Aquidauana, onde encontram-se diferentes localidades Taunay, Miranda, Nioaque e Aldeinha. O primeiro caso de óbito na comunidade indígena, registrado em 30 de junho de 2020, tratava-se de um homem residente na terra indígena de Taunay. Comparando a letalidade do vírus, os territórios indígenas apresentaram 6,8%, enquanto em não-índios no Estado de Mato Grosso do Sul foram 1,8%, sendo, o município de Aquidauana, a cidade que mais registrou mortes por COVID-19 em aldeias[5].

A transmissão do vírus SARS-CoV-2 se dá por via inalatória, em que ocorre a ligação do vírus ao seu receptor especifico de ECA-2. Uma das regiões em que encontramos esse receptor é no epitélio respiratório, dando início às complicações de trato respiratório superior, apresentando, inicialmente, sintomas gripais, evoluindo para o agravamento do quadro clínico do paciente. Em pacientes idosos, pela debilidade natural do sistema imunológico, a evolução COVID-19 ocorre rapidamente para a forma grave[1].

O surgimento das vacinas contra o SAR-CoV-2 possibilitou a redução dos casos graves da COVID-19 de forma mundial. Ao que se sabe, as vacinas protegem e impedem o agravamento da doença em grande parte da população, mesmo mediante ao contato com novas variantes. Dessa forma, como meio de tratamento para a COVID-19, vários grupos de pesquisa têm estudado medicamentos antivirais que sejam eficazes no tratamento do SARS-CoV-2. Na tentativa de controlar a doença, grupos de pesquisadores analisaram em cultivo de células renais infectadas com o SARS-Cov-2, retrovirais que funcionariam no impedimento da replicação viral[6].

O vírus SARS-CoV-1, membro da família *Coronavidae*, ao qual o vírus SARS-Cov-2 pertence, tem um perfil ácido com um pH em torno de 6.0, se desestabilizando em pH alcalino acima de 8.4 e com uma temperatura acima de 37°C[7,8,9]. Em relação à temperatura, o SARS-CoV-2 somente sofre alteração com temperaturas acima de 72ºC[10]. Sendo assim, pesquisas apontam para a importância da alcalinidade para modificar a ação do vírus no [11].

Seguindo o princípio da alcalinidade, a solução de bicarbonato de sódio ($NaHCO_3$) é amplamente usada na medicina em várias concentrações, em tratamento de doenças do trato respiratório superior, sendo recomendado pelo seu poder de diminuição da viscosidade do muco presente na superfície do epitélio respiratório[12].

a efetividade da nebulização da solução de $NaHCO_3$ FOI DEMONSTRADA na primeira onda da COVID-19 em uma aldeia indígena localizada no Alto Juruá no Acre, com excelentes resultados nos pacientes tratados, evitando o deslocamento para o hospital de campanha mais próximo, em Cruzeiro do Sul[13]. Assim como no município de Tarauacá, acre onde o mesmo protocolo de nebulização com a solução de $nahco_3$ a 3% foi utilizada na pediatria em crianças com idade de 1 a 5 anos, no grupo tratado e, no grupo controle, nebulização com soro fisiológico 0,9%. Em crianças de 1 a 5 anos foram divididos em dois grupos de tratamentos: Grupo medicamentoso convencional e o grupo de tratamento com a solução de bicarbonato de sódio. O grupo das crianças tratadas com a nebulização com a solução de bicarbonato de sódio evoluiu para a alta domiciliar mais rapidamente em relação ao grupo que utilizou o tratamento medicamentoso convencional[14]. A utilização da solução de $NaHCO_3$ 3% também foi utilizada em um grupo de pacientes graves intubados, no protocolo de lavagem broncoalveolar, em que os pacientes evoluíram para o desmame e alta hospitalar[15].

Devido à grande complexidade de um protocolo definido para tratamento da COVID-19 o que dificultou analisar o resultado da solução de $NaHCO_3$ 3%, abrindo um viés, e mediante a OMS restringir o uso da aerossolterapia nos ambientes hospitalares procuramos um centro que pudesse ser aplicado o protocolo de tratamento sem outra terapia respiratória como pressão positiva (CPAP) que pudesse mascarar o resultado do tratamento. Dessa forma, a implantação deste projeto de pesquisa no Hospital Regional Doutor Estácio Muniz no município de Aquidauana, nos fornecerá informações para analisar a utilização da solução de $NaHCO_3$ 3% nas complicações respiratórias nos casos moderados/graves da COVID-19, cujo objetivo é avaliar o papel da solução bicarbonato de sódio em uma concentração de 3% ($NaHCO_3$ 3%) na forma inalatória, através da nebulização, no tratamento da infecção por SAR-CoV-2/COVID-19 em indivíduos com quadro clínico moderado/grave internados do município de Aquidauana com uso de tratamento medicamentoso convencional sem tratamento respiratório.

II. MATERIAIS E MÉTODOS

O estudo trata-se de um ensaio clínico randomizado, retrospectivo e prospectivo, realizado no Hospital Regional Doutor Estácio Muniz no município de Aquidauana, Mato Grosso do Sul, Brasil, no período de setembro de 2020 a novembro de 2021.

Foram convidados a participar desse estudo com tratamento com a solução de bicarbonato de sódio 3% ($NaHCO_3$ 3%) pacientes diagnosticados com a COVID-19 por meio do RT-PCR, baseados no protocolo de *Wiikmann* (2002) e já utilizado pelo grupo de pesquisa com resultados favoráveis tanto casos leves, moderados e graves[16,15,14]. Em ambos os grupos foram incluídos os pacientes de qualquer idade e sexo em tratamento hospitalar na unidade semi-intensiva sem intubação. A unidade preservava toda a orientação da OMS de não realizar nenhum tratamento que oferecesse um aumento de vírus no ar, incluindo a Pressão Positiva Contínua nas Vias Aéreas (CPAP) muito utilizada para evitar intubação nos pacientes. Foram excluídos indivíduos com suspeita clínica, diagnóstico e notificação de qualquer outra infecção viral. Os pacientes foram separados em dois grupos através de um sorteio mono-cego: 1) Grupo controle (G1): Realizaram tratamento convencional medicamentoso (N=10); e 2) Grupo Tratado: Tratamento convencional medicamentoso associado a nebulização com 10 ml de solução de $NaHCO_3$ 3% com pH de 8.4 por 20 minutos de 8/8 horas (N=9) por 7 dias consecutivos. Eles foram acompanhados durante os 7 dias, com coleta dos dados: tomografia computadorizada de tórax no primeiro e terceiro dia; saturação periférica de oxigênio (SPO_2), frequência cardíaca, frequência respiratória antes e após a nebulização; pH da saliva antes do tratamento e na alta do participante e os exames laboratoriais, como hemograma, eletrólitos, função hepática e renal no primeiro, terceiro e sétimo dia de acompanhamento.

Ademais, os outros dados coletados foram: sexo, idade, cor/etnia, residência, vacinação para Covid-19, medicações em uso, comorbidades prévias, sinais e sintomas. Assim como, foram consideradas informações sobre o tempo de internação e o desfecho dos casos, se óbito, alta ou transferência para unidade terapia intensiva (UTI) nos hospitais de campanha.

Os dados foram coletados e armazenados por meio da plataforma do RedCap. A análise das variáveis foi realizada por planilha Excel®. A análise estatística para dados não-paramétricos, utilizamos o teste dos postos sinalizados de Wilcoxon. Os dados foram analisados a um nível de 0,05 de significância e todas as análises foram conduzidas no programa Stata 13.0.

Este estudo foi aprovado pelo Comitê de Ética em Pesquisa da Universidade Federal do Acre sob o número CAAE: 30567320.1.0000.0008. Os pacientes tiveram o consentimento de seus familiares para realização do protocolo mediante termo de aceite assinado pelo responsável.

III. RESULTADOS

No hospital foram recebidos 455 pacientes, no período de 2020 a 2021, na primeira e segunda onda da COVID-19, sendo que 96 foram a óbito, 16 foram transferidos devido à gravidade do quadro clínico e 343 tiveram alta.

O período de implantação do projeto se deu na segunda onda, em que o grupo G1 foi composto de 10 pacientes tratados com o protocolo medicamentoso convencional da época, que tiveram agravamento do quadro clínico, sendo transferidos para a unidade de terapia intensiva. Destes, houve 9 óbitos e uma alta com sequela respiratória, para continuidade no tratamento em domicílio com uso da oxigenioterapia.

Todos apresentavam saturação abaixo do recomendado com indicação de intubação e eram diretamente direcionados a unidade de terapia intensiva, onde o grupo de pesquisa não tinha acesso aos dados, por não realizarem tratamento com aerossolterapia (nebulização).

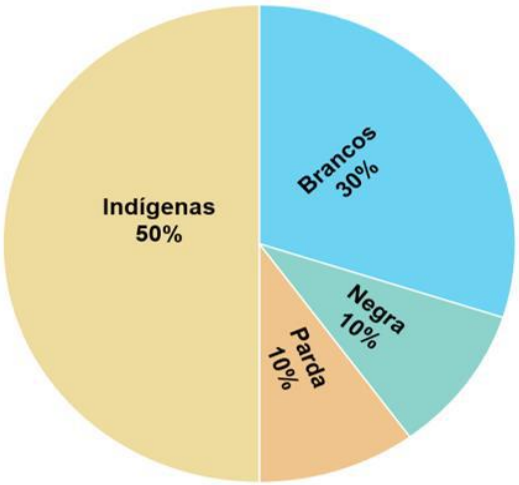
Em relação ao grupo tratado G2, foram acompanhados 9 pacientes internados na unidade semi-intensiva para COVID-19, que também foram submetidos ao tratamento medicamentoso convencional da época para a COVID-19, mediante a avaliação médica, era prescrito o medicamento específico para a clínica do paciente. Dentre os medicamentos utilizados para a COVID-19 podem-se citar: Predinizolona, Dexametasona, Dipirona, Cimetidina, Azitromicina, Tazocim, Ceftriaxona, Meropenem, Teicoplanina, Heparina, Clindamicina, Vancomicina, Complexo B, Decardon, Flumecil, Promexina, Ivermectina, Antinflamatórios e Anticoagulantes. Em relação ao tratamento medicamentoso, antes da internação na unidade semi-intensiva, dois participantes fizeram tratamento prévio medicamentoso para COVID-19, sendo as medicações utilizadas Azitromicina, Levofloxacina, Amoxacilina, Ceftraxiona, Dexametasona, Furosemida.

Estes 9 participantes do grupo G2 foram submetidos ao tratamento com a associação da nebulização com a solução de $NaHCO_3$ 3% (Feminino, n=4; Masculino, n=5). A faixa etária que predominou com internação na forma moderado/grave foi entre 60-80 anos (50%), com 40% dos participantes entre 20- 39 anos e 10% entre 40-59 anos. No grupo G1 que foram submetidos ao tratamento convencional os 10 pacientes era do sexo masculino, onde a faixa etária que predominou com a internação na forma moderado/grave evoluindo para forma grave em menos de 24 horas foi entre 40-80 anos evoluindo para o óbito em 48h.

Quanto ao local da residência do grupo de tratamento (G2) com a $NaHCO_3$ 3%, todos os 9 participantes moravam em Mato Grosso do Sul, provenientes dos municípios de Aquidauana (6 pacientes), Miranda (2 pacientes) e de

Anastácio (2 pacientes). Metade dos participantes são indígenas, moradores dos municípios Aquidauana, Miranda e Anastácio, todos da etnia Terena (Gráfico 1).

Gráfico 01. Cor e etnia dos participantes do estudo do tratamento com a solução de $NaHCO_3$ 3%.



Legenda gráfico 01. Cor e etnia dos participantes (grupo G2) do estudo do tratamento com a solução de $NaHCO_3$ 3%, mostrando que 50% da população do grupo de tratamento era indígena da etnia Terena. Em relação ao grupo G1 não foi possível ter acesso a cor e etnia, somente ao sexo onde todos era do sexo masculino.

Em relação às comorbidades, em ambos os grupos havia participantes com diagnóstico de diferentes comorbidades, dentre as quais se destacaram: principalmente doença renal crônica (DRC), diabetes melittus (DM) e hipertensão. No grupo G2, tratado com a solução de bicarbonato de sódio, 33,3% dos participantes apresentaram DM, 33,3% DRC, 33,3% hipertensão e apenas um participante relatou ter DPOC. Nenhum participante apresentou diagnóstico para asma, doença autoimune, HIV, cirrose e neoplasias. Além disso, não havia tabagistas entre os participantes e, em relação às medicações de uso contínuo, apenas dois participantes faziam uso, sendo elas: Losartana, Furosemida e Metildopa.

Durante o pico da pandemia muitos estados orientavam a população a não saírem de casa, mesmo assim, dos pacientes do grupo G2, sete relataram terem saído mais de 2 vezes durante a semana, para realização de atividades rotineiras (supermercado e trabalho). Os pacientes renais crônicos tiveram que sair para fazer hemodiálise. Todos os participantes fizeram uso dos cuidados orientados pela Organização Mundial da Saúde (OMS) como: uso de máscara, higienização das mãos e uso do álcool em gel.

Os participantes foram questionados quanto à vacinação da gripe e COVID-19. Em relação a vacina da influenza, três participantes se vacinaram, seis participantes ignoraram a pergunta e somente um relatou não ter se vacinado. Quanto à vacina da COVID-19, somente dois participantes não se vacinaram e um não soube responder. Todos os que se vacinaram receberam a primeira dose da CORONAVAC, sendo que dois participantes completaram o esquema até a segunda dose que era a recomendada à época.

Os participantes dos grupos G2 estiveram internados pela COVID-19 com diagnóstico concomitante de pneumonia. Os sinais e sintomas que predominaram foram: tosse, dispneia, fadiga, odinofagia, anosmia e ageusia, como mostra na Tabela 1, onde todos os pacientes apresentavam a tosse continua característica da COVID-19. Em relação a outros sinais e sintomas os participantes apresentavam: dor generalizada, hipóxia e estertores pulmonares. Vale destacar que, segundo vários estudos, a tosse é um dos grandes agravantes da dispneia do paciente levando-o a um aumento da oxigenioterapia em altas concentrações.

Tabela 01. Sinais e sintomas relatados pelos participantes (grupos G1 e G2) antes do tratamento com a solução $NaHCO_3$ 3%.

SINAIS E SINTOMAS RELATADOS PELOS PARTICIPANTES ANTES DO TRATAMENTO COM A SOLUÇÃO DE BICARBONATO DE SÓDIO	
N=19	**Porcentagem (%)**
Febre Leve	10
Febre moderada	60
Cefaleia	30
Náusea	40
Vômito	40
Coriza	40
Congestão Nasal	30
Odinofagia	70
Tosse*	100
Astenia	40
Dispneia**	90
Mialgia	50
Artralgia	30
Dor abdominal e Dor torácica	20
Dor nas costas	20
Dor nas pernas	60
Diarreia	80
Fadiga	70
Anosmia	70
Ageusia	70
Sem queixa outros	10

Legenda Tabela 01. Pode-se observar os dois sintomas mais prevalentes em pacientes com COVID-19. Em primeiro lugar, a tosse e, em segundo lugar, a dispneia, que está associada ao quadro intenso de tosse, levando o

paciente a saturar. Outros sintomas foram relatados como: diarreia, fadiga, anosmia, odinofagia, febre moderada, dores nas pernas, náuseas, vômito, artralgia e congestão nasal.

Foram avaliados os comprometimentos pulmonares dos participantes na entrada e após 48h de uso da solução $NaHCO_3$ 3% através do exame de imagem padrão ouro para COVID-19 que é a tomografia computadorizada de tórax (Tabela 02). Dos 5 pacientes do grupo tratado que realizaram os exames de tomografia não foi possível observar uma melhora significativa após 48h, porém eram pacientes que já não estavam mais fazendo uso da oxigenoterapia e apresentaram melhora na saturação periférica (tabela 3).

Para verificar o efeito da alcalinidade da solução de bicarbonato de sódio 3% foi verificado antes e após a nebulização nos dias 1, 2, 3 e 4. Podemos observar que todos os pacientes apresentavam pH ácido e após a nebulização neutraliza ou no caso do paciente (P5) alcaliniza. Ao mesmo tempo era coletado a saturação periférica do paciente antes e após 10 minutos do tratamento, onde podemos observar uma melhora gradativa da saturação periférica dos pacientes ao longo dos dias e os 10 pacientes tiveram alta hospitalar entre o dia 3 e 4 não completando o tratamento de 7 dias sem sequelas respiratórias (Tabela 3).

Tabela 02. Porcentagem de comprometimento pulmonar na Tomografia Computadorizada de tórax de entrada e após 48h de uso da solução de bicarbonato por número de participantes não houve uma redução do comprometimento pulmonar e somente o P1 e P8 houve um avanço, porém, sem afetar a saturação periférica (grupo G2).

	ENTRADA	APÓS 48H
P 1	20-29%	50-59%
P 2	0%	0%
P 3	N	50-59%
P 4	40-49%	N
P5	30-39%	N
P 6	0%	0%
P 7	50-59%	50-59%
P 8	20-29%	50-59%
P 9	0%	N

Legenda: N – dado não coletado do participante do estudo. P1: participante 1; P2: participante 2; P3: participante 3; P4: participante 4; P5: participante 5; P6: participante 6; P7: participante 7; P8: participante 8; P10: participante 10.

Tabela 03. Valores do pH antes da primeira nebulização (1-2) e na última nebulização (3-4), juntamente com os valores da saturação de oxigênio (SPO2%) antes e depois (inicial e final) dos dias 1, 3 e 4 de tratamento, para o grupo G2.

Participantes	pH 1	pH 2	pH 3	pH 4	DIA 1 SPO2 (%) INICIAL	DIA1 SP02 (%) FINAL	DIA 3 SPO2 (%) INICIAL	DIA 3 SPO2 (%) FINAL	DIA 4 SPO2 (%) INICIAL	DIA 4 3ªSAT FINAL
P 1	5	6	7	7	95	93	95	93	95	95
P 2	6,5	7	6	6,5	96	93	92	94	N	N
P 3	6	6,5	6,5	7	99	91	93	94	N	N
P 4	6	6	N	N	95	94	91	91	92	96
P 5	6	6,5	7	6,5	96	98	97	96	N	N
P 6	6	6,5	7	7	97	76	98	96	93	97
P 7	6	6,5	6,5	7	94	88	92	91	96	97
P 8	6	6	6	6,5	99	97	98	97	97	96
P9	6	6	6	6,5	90	96	94	95	93	96

Legenda: Participantes: P1, P2, P3, P4, P5, P5, P7, P8, P9 e P9. N – dado não coletado do participante do estudo. pH 1: valor de pH antes da primeira nebulização de cada participante; pH2: valor de pH após a primeira nebulização de cada participante; pH 3: valor de pH antes da última nebulização de cada participante; pH 4: valor de pH após a última nebulização de cada participante.

Mediante ao padrão ácido do vírus ocasionar uma mudança no pH sanguíneo[17] e na saliva dos pacientes com a COVID-19 da variante GAMA[15]. Foram avaliados o valor do pH da orofaringe no primeiro e no terceiro dia de tratamento antes do início do uso da solução de nebulização com a solução de $NaHCO_3$ 3% e no final do tratamento depois da última nebulização. Observa-se que 77.7% dos participantes evoluíram com aumento do pH da orofaringe após o uso da solução, demonstrando eficácia na alcalinização do sistema respiratório superior.

O grupo controle (G1) deu entrada na enfermaria mediante a gravidade e desestabilização hemodinâmica evoluíram para a intubação, sendo transferidos para a UTI e evoluindo ao óbito em 24h. Sobre os participantes no pós-COVID-19, foram incluídos no grupo tratado dois pacientes que ficaram internados na Unidade de Tratamento Intensivo, um deles por mais de 16 dias. Após saírem da UTI, receberam, junto com todos os outros participantes, a nebulização com a solução de $NaHCO_3$ 3% na unidade semi-intensiva como forma de tratamento pós-COVID, em que 5 participantes receberam nebulização de 1 a 4 dias, 3 receberam de 5 a 7 dias e 2 por mais de 8 dias com suplementação de oxigenoterapia, sendo reduzida gradativamente até o 6º dia de internação (tabela 04).

Tabela 04. Desfecho e dias de internação dos pacientes em tratamento convencional e tratamento com nebulização com solução de $NaHCO_3$ 3%, internados na enfermaria semi-intensiva do hospital Doutor Estácio Muniz no município de Aquidauana, Mato Grosso do Sul, Brasil (N experimental de 19). Os 100% é a porcentagem referente aos participantes de cada grupo G1 e G2.

DESFECHOS							
Grupo / Desfecho	Alta	(%)	UTI	(%)	Óbito	(%)	p
Tratamento convencional	1	10%	0	0	9	90%	0.05
Tratamento NAHCO3	9	100%	0	0	0	0%	

DIAS DE INTERNAÇÃO						
Grupo	Alta	p	UTI	p	Óbito	p
Tratamento convencional	16°dia	0.00	0	0.00	9	0.05
Tratamento NAHCO3	3°dia		0		0	

Teste de pontos sinalizados de Wilcoxon, p=0,00

A maioria dos participantes obteve alta no quarto dia de tratamento com a solução de $NaHCO_3$ 3%, devido a uma melhoria significativa, confirmada pelo resultado tomográfico e exame clínico dos pacientes, não completando o esquema de sete dias de tratamento com a nebulização. Isso sugere que a solução obteve eficácia quanto à diminuição do tempo de internação, diminuição da gravidade e diminuição de sequelas pulmonares como a fibrose pulmonar, não necessitando de tratamento domiciliar pois não tiveram perda de capacidade.

Em relação à evolução das frequências respiratórias antes e depois do uso da nebulização com bicarbonato de sódio, não observamos observou-se mudanças significativas em nenhum dos pacientes do estudo, já em relação às frequências cardíacas diárias coletadas antes e depois do uso da solução do estudo, concluiu-se que se mantiveram estáveis e dentro dos limites de normalidade para todos os pacientes durante todo o tratamento e os pacientes com taquicardia regularizaram a sua frequência cardíaca.

Em relação aos dados dos exames laboratoriais dos participantes (tabela 05), observou-se um aumento dos valores de hemoglobina, hematócrito, VCM, CHCM e RDW, assim como as plaquetas. Já os valores do leucograma apresentaram uma queda dos leucócitos totais para os níveis de normalidade, assim como as outras séries desse exame, exceto os linfócitos atípicos, metamielócitos e mielócitos. Houve também uma redução nos valores dos eletrólitos, das enzimas hepáticas (TGO e TGP), da DHL e da PCR do primeiro dia para o terceiro dia de tratamento. Mostrando uma melhora significativa dos exames laboratoriais, demonstrando, desta forma, que a solução de $NaHCO_3$ a 3% pode ser utilizada, de forma coadjuvante, ao tratamento da COVID-19, bem como no tratamento pós-COVID para melhora do quadro clínico do paciente e para minimizar possíveis sequelas respiratórias.

Tabela 05. Dados laboratoriais do hemograma completos de cada participante do grupo G2, do primeiro dia de acompanhamento.

Dia 1	Hm	Hb	Ht (%)	Eritro blasto	VCM	HCM	CHCM	RDW	Leucócitos totais	Segmentados (%)	Bastos (%)	Eosinófilos (%)	Basófilos (%)	Linf. Típicos (%)	Linf. Atípicos (%)	Monócitos (%)	Mielócitos (%)	Metamielócitos (%)	Plaquetas
P1	4,75	13,4	39,2	0	82,52	28,21	34,18	13,1	18600	76	12	3	4	7	0	2	0	0	252000
P2	3,71	11	3,1	0	86,52	29,64	34,26	13,7	14100	83	12	0	0	4	0	1	0	0	257000
P3	3,9	10,5	30,7	0	78,71	26,92	34,2	13,5	16700	82	4	0	0	10	0	4	0	0	314000
P4	4,3	12,7	37,6	0	86,04	29,06	33,77	15,08	5000	81	7	0	0	8	0	4	0	0	422000
P5	5,05	14	41,06	0	82,37	27,72	33,65	14	12900	57	5	1	0	27	5	5	0	0	576000
P6	3,59	10,7	33,4	0	93,03	29,8	32,03	16,08	22000	73	13	1	0	5	0	8	0	0	174000
P7	4,47	11,1	31,1	8	78,52	24,83	31,62	16,1	23200	79	9	0	0	8	0	4	0	0	286000
P8	2,86	8,4	25,8	0	91,16	29,68	32,55	14,7	2800	75	10	2	0	9	0	4	0	0	99000
P9	3,32	9,05	28,5	0	85,84	28,61	33,33	14,08	11900	83	7	0	0	8	0	2	0	0	126000

Legenda: Hm - hemácias, Hb - Hemoglobina, Ht - hematócrito. P1: participante 1; P2: participante 2; P3: participante 3; P4: participante 4; P5: participante 5; P6: participante 6; P7: participante 7; P8: participante 8; P9: participante 9. N – Dado não coletado do participante do estudo.

IV. DISCUSSION

Nesta pesquisa utilizamos como parâmetros de avaliação a oximetria periférica (SPO_2%), como padrão ouro de avaliação do comprometimento pulmonar a tomografia computadorizada onde tínhamos acesso ao laudo, verificação do pH da saliva do paciente que se encontrava na enfermaria COVID-19 e exames laboratoriais para confirmação se a solução de bicarbonato de sódio faria a alcalinização. Foi adotada a oximetria de pulso para indicar a gravidade do quadro clínico de acordo com o estudo realizado com pacientes da COVID-19. Devido aos pacientes apresentarem a "hipóxia silenciosa", em que não aparentam cansaço respiratório, somente ao mensurar a SpO_2 é que observamos a hipoxemia[18]. Nossos pacientes tratados chegavam à unidade hospitalar com saturação com indicação de intubação, porém como observados todos responderam positivamente a nebulização com a solução de bicarbonato de sódio.

Através dos exames laboratoriais que são rotina nos ambientes hospitalares pode-se observar e ter controle se durante o tratamento da parte pulmonar esses pacientes estavam entrando na fase inflamatória. Para controle hemodinâmico do paciente eram realizados exames laboratoriais em que os pacientes evoluíram para a melhora do quadro clínico. Os riscos de entrarem na fase inflamatória é maior, e em se tratando de pacientes moderados e/ou graves nas comunidades indígenas a preocupação aumenta devido à localização das aldeias serem mais de 10h do hospital de campanha mais próximo[18].

Os pacientes tratados apresentaram melhora significativa nas primeiras 24h de uso da solução de $NaHCO_3$ a 3%, com aumento do SpO2 % e alcalinização do meio da orofaringe. Corroborando com o estudo recente, *in vitro onde* demonstraram o uso isolado da solução salina ao comparar em diferentes concentrações verificando que o uso da solução a 1,5% de NaCl inibiu, *in vitro*, a replicação do SARS-CoV-2 em 100% em células de cobaias. Já nos testes com células epiteliais de pulmão humano, a solução a 1,1% foi suficiente para impedir a replicação do vírus em 88%[19]. Os nossos resultados demonstram uma resposta clínica benéfica que deve ser investigada em ensaios *in vitro*.

Os resultados dos tratamentos e evoluções clínicas relacionados a COVID-19 ainda são muito limitados, existindo necessidade de mais investigação e descrição a respeito das apresentações clínicas, tratamentos e resultados práticos para todos os pacientes, principalmente com o aparecimento de novas variantes que mudam o padrão dos sintomas. Atuamos no município de Aquidauana na terceira onda com aparecimento de novas variantes, porém os resultados se assemelham com os obtidos na primeira e segunda onda com os estudos já publicados pelo nosso grupo [20,16,15,14].

Após 24 horas foi observado uma melhora significativa na expectoração de secreção dos pacientes tratados do grupo G2, corroborando com estudos que revelaram que, no sistema respiratório, as soluções tamponadas com bicarbonato de sódio demonstram melhorar o transporte mucociliar *in vivo* e no tratamento de afecções

nasossinusais[20]. No tratamento e asma aguda utilizou-se a solução de bicarbonato de 10 ml a 2,1 % durante a nebulização de uma paciente internada com quadro grave de asma[21].

Outro estudo avaliou que a inalação da solução de $NaHCO_3$ através da nebulização na concentração de 8,4% demonstrando ser um potencial agente terapêutico seguro e bem tolerado no tratamento da Fibrose Cística, já que eleva temporariamente o pH líquido das vias aéreas e reduz a viscosidade e viscoelasticidade do escarro, não alterando os níveis de bicarbonato sanguíneo podendo levar o paciente a alcalose metabólica[22]. Os pacientes dos presentes estudo, tratados com a solução de $NaHCO_3$ a 3%, tiveram melhora do desconforto respiratório resultando em um aumento da saturação periférica (SPO_2%) e sem alterações dos níveis de bicarbonato de sódio sanguíneo.

São condições clínicas de risco para desenvolvimento de complicações: pessoas com 60 anos ou mais; cardiopatas graves ou descompensados (insuficiência cardíaca, infartados, revascularizados, portadores de arritmias, hipertensão arterial sistêmica descompensada); pneumopatas graves ou descompensados (dependentes de oxigênio, portadores de asma moderada/grave, DPOC); imunodeprimidos; doentes renais crônicos em estádio avançado (graus 3, 4 e 5); diabéticos, conforme juízo clínico e gestantes de alto risco[23,24,25,26]. Em nosso estudo os dados apresentados do grupo G2 mostram que a faixa etária predominante com internação na forma moderado/grave foi entre 60-80 anos e com prevalência das comorbidades DRC, diabetes e HAS.

Segundo a Organização Mundial da Saúde (OMS), os sinais/sintomas iniciais da doença lembram um quadro gripal comum, mas variam de pessoa para pessoa, podendo se manifestar de forma branda, em forma de pneumonia, pneumonia grave e SRAG. O espectro clínico da infecção por coronavírus é muito amplo e varia de um simples resfriado até uma pneumonia grave. De acordo com o Protocolo de Manejo Clínico para o Novo Coronavírus, publicado pelo Ministério da Saúde, os principais sintomas são febre (83%), tosse (82%), dispneia (31%), mialgia (11%), confusão mental (9%), cefaleia (8%), dor de garganta (5%), rinorreia (4%), dor torácica (2%), diarreia (2%) e náuseas e vômitos (1%)[27]. Nossos pacientes do grupo G2 apresentaram sinais e sintomas onde predominaram dispneia, fadiga, odinofagia, anosmia e ageusia. Todos os pacientes apresentavam principalmente a tosse continua característica da doença.

A saturação de oxigênio constitui uma medida considerável para prever complicações e mortalidade por COVID-19 e, em casos graves de doenças respiratórias, a baixa saturação e a hipoxemia são esperadas[28]. Assim, no presente estudo, os pacientes que fizeram o tratamento adjuvante através da nebulização com a solução de $NaHCO_3$ 3% na unidade semi-intensiva, demonstrando melhores resultados em relação aos pacientes com tratamento convencional (G1), chegando a zero o número de óbitos e diminuindo a porcentagem de comprometimento pulmonar após 48h de tratamento. Desta forma foi possível observar a diminuição de sequelas pulmonares, como a fibrose pulmonar, não tendo perda da capacidade pulmonar e não necessitando de tratamento domiciliar como a oxigenoterapia.

Quando se tratava da verificação do pH, uma das hipóteses de tratamento da infecção de SARS-CoV-2 é através dos inibidores da acidificação do endossoma. O bicarbonato de sódio pode trazer o nível de pH do corpo humano ao equilíbrio, na faixa de 7,35-7,45 para manter o pH e executar suas funções, impedindo que os vírus invadem as células e se repliquem. No presente estudo, observou-se que 77.7% dos participantes tratados tiveram um aumento do pH da orofaringe após o uso da solução, demonstrando eficácia na alcalinização do sistema respiratório superior.

A frequência respiratória e a frequência cardíaca constituem uma medida considerável para prever complicações e mortalidade por COVID-19 e, em casos graves de doenças respiratórias, a baixa saturação e a hipoxemia são esperadas[27]. Porém, no presente estudo foi observado que a frequência respiratória de grande parte dos participantes não diminuiu para faixa de normalidade, no entanto, a frequência cardíaca se manteve estável na maioria durante o uso da solução.

Para atender às demandas urgentes, ao longo desses anos de pandemia, vários medicamentos foram testados e as principais classes terapêuticas investigadas são antivirais, anticâncer, anti-hipertensivos, imunossupressores, antiparasitários e anti-inflamatórios. Um longo caminho foi percorrido na busca do reposicionamento de fármacos para a COVID-19, mas nenhum novo tratamento específico foi aprovado pela ANVISA no ano de 2021 além das vacinas[29]. Assim, os locais acabaram aderindo ao uso de medicamentos específicos para a clínica de cada paciente, que variavam de acordo com o protocolo de atendimento de cada unidade e que atualizavam ao longo da pandemia. Dentre os medicamentos que foram utilizados nos pacientes deste estudo podem-se citar: Predinizolona, Dexametasona, Dipirona, Cimetidina, Azitromicina, Tazocim, Ceftriaxona, Meropenem, Teicoplanina, Heparina, Clindamicina, Vancomicina, Complexo B, Decardon, Flumecil, Promexina, Ivermectina, Antinflamatórios e Anticoagulantes.

Em relação à solução de $NaHCO_3$ 3% utilizada nesta pesquisa, observou-se uma série de alterações benéficas através da alcalinização das vias aéreas, que a tornam um

aliado ao combate à infecção pelo Sars-CoV-2 nas formas leves e moderadas[20,13]. O uso da nebulização com a solução do bicarbonato é uma forma de potencializar os outros medicamentos nas vias aéreas, levando a uma melhor e mais rápida recuperação do sistema respiratório, consequentemente aumentando as chances também de uma melhora sistêmica, como em crianças e pacientes graves na terapia intensiva [16,15,14].

Mediante o projeto ter sido implantado em outro estado somente possibilitando o acompanhamento por telemonitoramento limitando o grupo e pesquisadores a terem acesso a mais dados dos pacientes de ambos os grupos (G1 e G2), o que possibilitaria uma elevação do número de participantes em cada os grupos. Vale pontuar que, embora ainda haja poucos estudos em humanos com um grande número de participantes, é notável que a solução tem seu efeito clínico na COVID-19 em pacientes apresentando comorbidades, principalmente renais.

V. CONCLUSÕES

O estudo possibilitou uma ampla visibilidade da possível implantação do tratamento com a solução de bicarbonato de sódio através da nebulização como terapêutica coadjuvante da COVID-19. A solução de $NaHCO_3$ 3% como as demais concentrações de 2 a 9% são soluções terapêuticas aplicadas nas doenças pulmonares atualmente, podendo ser uma das ferramentas utilizadas no tratamento da COVID-19 nas formas moderada/grave, já apresentando resultados em todas as variantes.

Por termos tido um número pequeno de participantes, mas estudos randomizado, controlado em grandes centros que recebem uma grande quantidade de pacientes devem ser realizados.

Assim, concluímos que o uso da solução $NaHCO_3$ 3% tem um papel importante na melhora do quadro clínico respiratório dos pacientes dando a possibilidade de reagirem a medicação adotada pelo médico, além de ser um fármaco de fácil acessibilidade e de manipulação acessível quando prescrito.

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Integration of DICTs in Education: The Educational Demand Faced with the Profiles of Immigrants and Digital Natives

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***Abstract*—** *Proposes here in this work that the implementation and use of TDIC", necessarily, need to be absorbed by teachers and that for this to happen it is important to have an adequate understanding of their role as a mediator of knowledge and not a supplier; that there is a need for understanding that the saboteur positions that many teachers have is due to their paradigmatic positions and that it is important to understand this dysfunctional maladaptive condition through a cognitive restructuring so that their role as a mediator of knowledge is understood. That done, these digital immigrant teachers must be inserted in intensive training policy to know the tools of TDIC"s and be able to adapt their new role in the mediation between information and their native digital students. These, in turn, need to be "educated" about the use of digital information and communication technologies not only as an instrument of chatting or games, without a mediating application of knowledge.*

I. INTRODUCTION

Being prepared for the new is not always a reality for those who are its targets. The human structure is distressed when new challenges are imposed on it. Leaving that comfortable, pleasant and familiar place is frightening. It seems to be easier to work on something that is already ready than having to deal with a perspective of creating.

The world of Digital Information and Communication Technologies (TDICs) is challenging due to its dynamism, it has a life of its own. Just like your birth, your course of life is independent of whether or not you want to expand. It has become necessary for human existence throughout its course of globalization. It was born from the human intellect, but its cognitions were not prepared to give way to what its beliefs were established.

Human beings have been adapted to certain modes of operation. And when TDICs began to gain ground, society returned to internal chaos. Because, with the advent of the internet, people entered their private worlds of navigation, using it as a technological resource in favor of maximizing their maladaptive affective relationships, their dysfunctional beliefs. However, Coutinho and Lisbôa assert that: " The important thing in this society is not the technology itself, but the **possibilities of interaction** that they provide through a digital culture". (COUTINHO & LISBÔA, 2011)BR

Thus, impasses arise in the establishment of a digital culture, demanding more time for its acceptance with all the possibilities it provides, considering that those who would be its applicators are still in an inadequate psychic process, sabotaging the teaching process learning and students seeing TDICs as something that detracts from their real educational potential.

II. DEVELOPMENT - LITERATURE REVIEW

2.1 THE PARADIGM OF CHANGE

Despite having been coined for a restricted means of scientific knowledge, the term paradigm shift is understood as a change in foundations and ways in which a given circumstance is perceived and Thomas Kuhn ponders that what should be guided by very specific rules ended up following a paradigmatic path, depending on the scientific field to which it is submitted, to the point that revolutionary changes in a field of traditional knowledge will not be extended by demand to another field (KUHN, 1962, pp. 74-75).

The resulting effects from one science to another can be perceived and their connections are notorious; this interdependence between the fields of knowledge has been positively discussed, given the adoption of measures that include the interdisciplinary and the multidisciplinary.

Thus understood, the idea of owning a certain tool that contemplates a more dynamic learning or its non-use by retrograde positions needs to be restructured in order to favor a better use of the scientific potentials that are available to be used for the educational context, like TDIs.

2.2 ADAPTIVE X DISADAPTIVE

The beliefs and internal schemes of each subject are created within a time when he was subjected to certain circumstances that made him develop internally strategies to deal with that situation in which he found himself at the time.

However, as time goes by, those behaviors that were previously acceptable for a certain situation have become inappropriate over the course of their history, especially if such strategies are used in all other events in their lives.

For (LOPES & MELO, 2014), among the many obstacles found for the implementation of Information and Communication Technology - ICT in the educational context is the “difficulty of dealing with something new, which requires changes in individual beliefs and practices”. Sandra Teixeira (2011) demonstrates concern about the treatment given in relation to inadequate beliefs with existing resources, showing that such conduct can harm cognitive conditions as well as deprive students of specific knowledge needed:

> This attitude points to two worrying factors in the school environment: the use of textbooks by teachers as the only source of information and the belief that there is more incorrect information than correct information on the internet. Such behaviors can harm the research practice, since they end up preventing the student from getting in touch with several sources of information, in addition to harming the development of skills that would help the student to select relevant information to carry out a research (TEIXEIRA, 2011, pp. 65, 66).

Although maladaptive beliefs are usually related to affective interactions developed in stages of the initial formation of the human personality, they can very well be compared to those that are connected with the process of establishing a digital educational culture. These beliefs were born adaptively; served at a given moment to get rid of an anguish suffered, an absence, a lack. However, if this behavior continues to be fostered , it becomes inappropriate, like an adult putting his hands in his mouth, just as he did when he was a baby, to demonstrate that he is hungry.

The chalk and the old blackboard can demonstrate an emotional anchoring condition that provides security, control and an escape from the teacher's feeling of helplessness, in a process of change. And it is not just being inserted in a technological information environment that guarantees knowledge that meets the needs. There needs to be a deconstruction or cognitive restructuring of beliefs so that internal impediments do not intervene as saboteurs:

> For this to happen, it is necessary that, given the information presented, people can re-elaborate their knowledge or even deconstruct it, aiming at a new construction. This construction should be based on cognitive parameters that involve self-regulation, motivational aspects, reflection and criticality in the face of a flow of information that is permanently updated. (TEIXEIRA, 2011, p. 8)

With a restructured cognitive apparatus, the teacher would be in adequate conditions to understand that the insertion of TDICs in the educational scope would not be a replacement channel, but a support and facilitator of the emerging educational demands of recent times. He would understand that his role within the teaching/learning structure would be one of mediation between student and knowledge and not responsible for its transmission.

2.3 THE DIGITAL IMIGRANT IN THE CLASSROOM

That done, now comes another process that would be the insertion of this teacher in the context of learning these technologies, considering that a large part of them would be digital immigrants or their former students:

> [...] there is an urgent need to continually train working teachers to use technological resources fully and efficiently. It is also urgent to reformulate a large part of the teacher training programs at universities, in order to include the training of digital teachers in their pedagogical proposals. (FRANNK, 2010)

The way in which digital immigrants absorb this knowledge of technologies, preserves, according (PRENSKY, 2001)to , the “accent” that is perceived in the way they use technological resources and shows that learning these resources is as if they were learning a new language, which has different functionality if was learned at an early age, crediting the fact that this language "goes to a different part of the brain".

> There are hundreds of examples of digital immigrant accents. These include printing your e-mail (or asking the secretary to print it for you – an even “more pronounced” accent); the need to print out a written document from the computer to edit it (instead of editing it on the screen; and personally bringing people to your office to see an interesting web site (instead of sending them the URL). I'm sure you can think of an example or two without much effort. My favorite example is "You got my email" over the phone. Those of us who are Digital Immigrants can, and should, laugh at ourselves and our " accent". (PRENSKY, 2001, p. 2)

So, if this communication is compromised because teachers and students are using different languages, what resources could be used to minimize this cultural distance? It is seen that, once data and information are available and access to it has become more dynamic in relation to an expository class or a tiring lecture, the learning of the teacher who returns to the “school bench” would be like being a manager of conflicting emotions that arise in the face of the anguishes that involve the heap of information and data to which their students are submerged. In this regard, the technical knowledge of a technological tool would not be so important if psychic management and emotional regulation were not up to date, as well as pedagogical competence:

> For this, it is not enough for the teacher to have technological skills, that is, to know how to navigate the Internet or to master skills in handling some *software* , but above all, to have pedagogical competence so that he can make a critical reading of the information that is disorganized and diffuse in the classroom. network.(COUTINHO & LISBÔA, 2011)

Thus, for (SANTOS & et al, 2011)“it is important that teachers think of new methodological models of teaching and learning that meet the demand of native speakers, since the traditional model becomes incompatible with their profile”.

2.4 PROFILE OF DIGITAL NATIVES

The so-called digital natives would perceive the DICT scenario in a somewhat different way. It is possible that they do not assimilate it as an instrument of educational interaction, but of entertainment, and in this way they learn:

> Digital Natives are used to receiving information very quickly. They like to process more than one thing at a time and multitask. They prefer their graphics before text rather than the other way around. They prefer random access (like hypertext). They work best when connected to a network of contacts. They thrive on instant gratification and frequent rewards. They prefer gaming to “serious” work. (PRENSKY, 2001)BR

And here the shocks, the bumps, begin. On the one hand, there is teaching with a training profile, secondly (SANTOS & et al, 2011)oralist and face-to-face, where their interactions are physical and synchronous; at the other extreme, digital natives have a virtual identity, which identifies their ways of socializing to such an extent that many of them do not separate *online* from *offline* .

III. CONCLUSIONS

So, in view of all this dynamics involving DICTs, their implementation in the educational context, the distancing of professors in terms of knowledge of themselves, technologies and appropriate pedagogy and students, born in the midst of a whole whirlpool of information, which have the necessary skills to deal with all the technology around them, needing an intersection that makes this connection between them and the specific knowledge, which would be the use of this apparatus in education, it is clear that there needs to be a point of contact where teachers and students meet to resolve differences and propose a common term for all.

It is clear that:

> Immigrants were born in another environment, not dominated by digital technologies, their way of learning was another. Thus, the coexistence between natives and immigrants can be conflicting. The training of immigrant teachers differs from the way their students, digital natives, perceive knowledge and the environment in which they live. (SANTOS & et al, 2011)BR

However, the responsibility of raising psychic and pedagogical resources that make this approximation weighs on the shoulders of the teacher. Their inner emotional hang-ups and their cognitive abilities need to be properly regulated so that they can deal with this great challenge of

learning about themselves, learning for themselves and learning to teach in a way that their students understand.

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Some Contributions of Neuroscience at School, through the Continuing Teacher Training Offered

Algumas Contribuições da Neurociência na Escola, Através da Formação Docente Continuada Ofertada

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***Palavras-chave*— Neurociência; Formação Docente; Neurodidática; Aprendizagem; Educação.**

***Abstract*—** *This article seeks to investigate the contributions of neuroscience to the process of teaching and its relationship with the methodologies used in the classroom. this research discusses data obtained in the continuing education offered by the municipality of Vila Velha in Espírito Santo, which analyzes the teaching understanding of topics such as neurodidactics and neurosciences, and how this knowledge can contribute to practice in classroom. It also presents the data collected through training actions. Continued, as well as about the pedagogical practice and the methodologies used by participating teachers, thus analyzing the relationship between neurosciences and practice teacher. We seek to understand how active and pedagogical methodologies can be relate to neuroscientific knowledge and their contributions to the process of teaching and learning, also through bibliographic reviews. Starting from indicative data on the subject of Neuroscience in Education are evident from need for investment in the initial and continuing training of teachers, in order to that the teaching and learning process promoted in a collaborative perspective, in which teachers and students can interact. The research field was composed of regent teachers of the classes of the Municipal Education Network of Vila Velha/ES, UMEF Municipal Unit of Elementary Education Pedro Herkenhoff. The methodology used this study presents a qualitative approach applied by a random sample, consisting of teachers who attend the Municipal Education Network of Vila Velha/ES.*

***Resumo*—** *O presente artigo busca investigar as contribuições da neurociência para o processo de ensino e a relação desta com as metodologias utilizadas em sala de aula. Esta pesquisa aborda dados obtidos na formação continuada ofertada pelo município de Vila Velha no Espírito Santo, onde se analisa a compreensão docente de temas como neurodidática e neurociências, e a forma que esses conhecimentos podem contribuir para prática em sala de aula. Também se apresenta os dados coletados através das ações da formação continuada, bem como acerca da prática pedagógica e as metodologias utilizadas pelos docentes*

participantes, analisando assim, a relação entre as neurociências e a prática docente. Busca-se compreender como as metodologias ativas e pedagógicas podem se relacionar com os saberes neurocientíficos e as contribuições destes para o processo de ensino e aprendizagem, através também de revisões bibliográficas. A partir dos dados indicativos sobre a temática da Neurociência na Educação fica evidente a necessidade de investimento na formação inicial e continuada dos professores, de forma que o processo ensino e aprendizagem ocorra em uma perspectiva colaborativa, em que professores e alunos possam interagir. O campo de pesquisa foi composto por docentes regentes das turmas da Rede Municipal de Ensino de Vila Velha/ES, UMEF- Unidade Municipal do Ensino Fundamental Pedro Herkenhoff. A metodologia utilizada neste estudo apresenta uma abordagem qualitativa de natureza aplicada por uma amostra aleatória, constituído por docentes que atuam na Rede Municipal de Ensino de Vila Velha/ES.

I. INTRODUÇÃO

A aprendizagem é um processo inerte ao ser humano e ocorre durante toda a vida do indivíduo, onde "[...] não importa qual a bagagem hereditária de um indivíduo, ele traz uma capacidade de aprender própria da espécie humana" (BECKER, 2012, p. 32).

Desde o nascimento até o fim da vida recebemos constantes e diferentes informações externas. É o contato com essas novas informações que nos permite novas aprendizagens. Portanto, pode-se dizer que temos uma aprendizagem quando captamos as informações do ambiente, as guardamos e, por conseguinte a utilizamos para gerar um comportamento.

Os desafios que englobam a aprendizagem e a prática docente se tornam cada vez maiores, tendo em vista que a área da educação passa por constantes transformações. Como consequência dessas transformações, os estudos na área da educação aumentaram contínua e gradativamente, e um dos campos de pesquisa que tem se destacado são as neurociências. As neurociências buscam compreender como o sistema nervoso funciona, seus mecanismos moleculares, suas estruturas e seu processo de desenvolvimento (BEAR, CONNORS & PARADISO, 2008).

As neurociências tiveram seu ápice no ano de 1990, a denominada década do cérebro. Neste período, surgiram novas pesquisas relacionadas ao Sistema Nervoso e com elas a possibilidade de estudar o encéfalo em tempo real, através da neuroimagem e da eletrofisiologia, fato esse que revolucionou a área médica.

Quando relacionadas com a educação, os avanços das neurociências possibilitam "uma abordagem mais científica do processo de ensino e aprendizagem, fundamentada na compreensão dos processos cognitivos envolvidos" (COSENZA & GUERRA, 2011, p.143).

E ainda, o conhecimento acerca das neurociências pode modificar e potencializar a prática pedagógica, visto que,

> Ao conhecer o funcionamento do Sistema Nervoso, os profissionais da educação podem desenvolver melhor seu trabalho, fundamentar e melhorar sua prática diária, com reflexos no desempenho e na evolução dos alunos. Podem interferir de maneira mais efetiva nos processos do ensinar e aprender, sabendo que esse conhecimento precisa ser criticamente avaliado antes de ser aplicado de forma eficiente no cotidiano escolar. Os conhecimentos agregados pelas Neurociências podem contribuir para um avanço na educação, em busca de melhor qualidade e resultados mais eficientes para a

> qualidade de vida do indivíduo e da sociedade (COSENZA; GUERRA, 2011, p.145).

O conhecimento sobre as neurociências proporciona aos docentes a base para a compreensão de como seus alunos aprendem. Desta forma os docentes podem compreender melhor o funcionamento cerebral, favorecendo as operações mentais implícitas na aquisição do conhecimento que pretendem alcançar com o processo ensino e aprendizagem (OLIVEIRA, 2011). Os avanços médicos e principalmente os avanços tecnológicos, propiciaram esta compreensão. Nesse sentido, Lima (2007, p. 1) afirma que

> A tecnologia disponível para estudar o cérebro em funcionamento possibilita acompanhar quais áreas do cérebro são mobilizadas a cada tarefa que a pessoa realiza, os processos internos de modificação cerebral quando a pessoa aprende e como o cérebro responde a mudanças no mundo externo ou a mudanças na interação entre a pessoa e seu contexto de desenvolvimento.

É de suma importância aos docentes terem estes conhecimentos, uma vez que todos os ambientes em que a criança está inserida, assim como a qualidade de seus relacionamentos com os adultos têm impacto significativo em seu desenvolvimento cognitivo, emocional e social (SHONKOFF, 2009).

As neurociências e as metodologias utilizadas em sala de aula estão amplamente relacionadas. Conforme a metodologia utilizada, o encéfalo reage de maneiras diferentes. A metodologia de ensino tradicional, por exemplo, faz com que os educandos se tornem sujeitos passivos diante da aprendizagem, o que não gera uma aprendizagem eficaz (PESSOA, 2018). Já ao utilizar uma metodologia que torne o educando o sujeito central do processo de ensino, como a metodologia ativa, a aprendizagem se torna eficaz uma vez que "atividades participativas tem maior eficácia pedagógica do que atividades passivas" (LENT, 2019, p. 109).

Desta maneira, se faz necessário a utilização de metodologias que permitam investigar a natureza dinâmica das interações, instigar desafios e que proporcionem atividades participativas (LENT, 2019), uma vez que estes tipos de atividades estão amplamente relacionados com a emoção, com a curiosidade, com o desafio e principalmente com a motivação (FONSECA, 2016 apud PESSOA, 2018). O processo de motivação ocorre quando o cérebro está ativo e recebe informações positivas, gerando uma sensação de bem estar. "Uma vez motivados, perseguimos o alvo do desejo até que as necessidades sejam satisfeitas, reforçadas e recompensadas, confirmando, assim, a existência de uma estreita conexão entre a emoção, cognição e a motivação" (FONSECA, 2016 apud PESSOA, 2018, p. 72-73).

Nesse sentido, presume-se que esta pesquisa seja relevante para uma maior compreensão de como os conhecimentos neurocientíficos e as metodologias utilizadas em sala de aula estão relacionas. Acredita-se que as revisões bibliográficas feitas e os resultados obtidos poderão demonstrar como as neurociências podem contribuir para reflexão sobre a prática pedagógica e, posteriormente, a modificação da mesma.

A Neurociência é conceituada como uma área que estuda o sistema nervoso central (SNC) e suas ações no corpo humano. Está presente em diferentes campos do conhecimento e interfere em diferentes áreas como a Linguística e Medicina, entre outras. Segundo Malloy-Diniz et al., a Neuropsicologia é um dos ramos da Neurociência que se preocupa com a complexa organização cerebral, que trata da relação entre cognição e comportamento e a atividade do SNC em condições normais e patológicas; sendo assim, a Neuropsicologia é de natureza multidisciplinar, e que permite a elaboração de um estudo prático do cérebro, contribuindo para diagnósticos precoces e precisos das patologias e de alterações das funções cerebrais superiores.

Compreendendo que, na educação, a Neurociência busca entender como o cérebro aprende e como o mesmo se comporta no processo de aprendizagem, são definidos métodos para identificar como os estímulos do aprendizado podem chegar neste órgão central. Sabe-se que os estados mentais são provenientes de padrões de atividade neural, então, a aprendizagem é alcançada por meio da estimulação das conexões neurais, que podem ser fortalecidas dependendo da qualidade da intervenção pedagógica.

Segundo Pantano e Zorzi, o estudo da Neurociência considera o conhecimento das funções cerebrais como peça chave para o estímulo de um desenvolvimento cognitivo saudável. Sabendo que o cérebro se reorganiza constantemente, em acordo com os estímulos externos, o desafio é facilitar a absorção do estímulo correto e positivo. Os autores comentam que os primeiros mecanismos para tal absorção são a atenção e a memória.

Em razão dessas concepções neuropsicológicas, faz-se necessário verificar a visão de Gadotti, este afirma que a qualificação do professor é estratégica quando se refere à educação de qualidade. Contudo, encontrar os parâmetros adequados para essa qualificação é algo complexo. Visto que tanto os conteúdos quanto a metodologia dos cursos de formação dos professores são geralmente ultrapassados, são baseados numa velha concepção de métodos tradicionais da docência. Necessitam de profundas mudanças.

A sociedade atual está diretamente relacionada aos avanços tecnológicos quanto ao acesso às informações, seja de fatos, seja de conhecimentos e técnicas, o que gera a necessidade de uma educação que vise uma cultura de aprendizagem que propicie uma formação adequada a essa nova realidade. O principal desafio da educação é a complexidade do processo de ensino-aprendizagem, pois para seu desenvolvimento e aperfeiçoamento faz-se necessário um sistema educacional democrático e atualizado que assuma o compromisso de fomentar um cenário real de aprendizagem, atendendo as exigências da sociedade moderna.

A partir desse aspecto é essencial definir objetivos, metas estratégicas e o plano de ação que tal sistema deve possuir para alcançá-los. Já que garantir o desenvolvimento do potencial cognitivo de cada educando é um requisito para certificarmos o desenvolvimento de capacidades e habilidades necessárias para a participação efetiva do mesmo na sociedade.

O Plano Nacional da Educação, PNE, projeto de lei aprovado em 2010, apresenta dez diretrizes objetivas e 20 metas. Uma destas a de número 15.7, visa "Promover a reforma curricular dos cursos de licenciatura de forma a assegurar o foco no aprendizado do estudante, dividindo a carga horária em formação geral, formação na área do saber e didática específica" (p. 44).

Mediante novas diretrizes, observa-se a afirmação de Freire, em que o educador é um profissional da aprendizagem, um profissional do sentido, um organizador da aquisição do conhecimento e não uma máquina reprodutiva instrucionista. As mudanças de ordem estruturais propõem, dentre muitos aspectos, novos métodos de ensino centrados na aprendizagem do aluno; uma nova concepção de trabalho docente com capacidade para fomentar, provocar no aluno aprendizagem significativa, habilidades de pensamento reflexivo e crítico.

Nesse sentido, os estudos científicos sobre o cérebro, que avançam de forma acelerada, podem contribuir para a renovação teórica na formação docente, ampliando seus conhecimentos com informações científicas fundamentais para compreender a complexidade do processo de ensino-aprendizagem. O estudo da Neurociência considera o conhecimento das funções cerebrais como peça chave para o estímulo de um desenvolvimento cognitivo saudável.

Fundamentada na obra de Fonseca, a educação cognitiva tem como finalidade proporcionar ferramentas psicológicas que permitam maximizar a capacidade de aprender a aprender, aprender a pensar e refletir, aprender a transferir e generalizar conhecimentos, aprender a estudar e a comunicar-se. Todo aluno tem o direito de desenvolver cada vez mais seu potencial cognitivo. Esta obra contempla a proposta do russo Luria, que enfatiza a organização neuropsicológica da cognição.

Na concepção de Luria (1903-1978), o cérebro é um sistema biológico que está em constante interação com o meio, ou seja, as funções mentais superiores são desenvolvidas durante a evolução da espécie, da história social, e do desenvolvimento de cada indivíduo. Pode-se dizer que se tem aqui o conceito de plasticidade cerebral.

Compreendendo-se que o cérebro humano possa revitalizar (neuroplasticidade), têm-se outras possibilidades para trabalhar o processo de ensino e aprendizagem, já que o cérebro é dinâmico, tem a capacidade de mudar em resposta aos desafios da sociedade moderna. Essa visão permite mudanças nas ações dos educadores compreendendo que nada é determinante, podendo-se obter resultados cada vez melhores a partir de novas práticas pedagógicas.

A atividade docente é prática social complexa, que combina conhecimentos, habilidades, atitudes, expectativas e visões de mundo condicionadas pelas diferentes histórias de vida dos professores. É, também, bastante influenciada pela cultura das instituições onde se realiza.

Gonçalves alerta sobre o discurso do professor que prima por uma aprendizagem sem o corpo, em que o conhecimento se dá de forma descontextualizada. A maneira como a criança pensa e se expressa pelo corpo não é levada em consideração pela escola.

Desse modo, nota-se a ideologia que separa corpo e mente, enfatizando os aspectos cognitivos distanciados em sua complexidade. Em função da pouca contestação, a escola não está habituada a considerar as relações entre o corpo e os processos que envolvem o aprender e o ensinar.

A intervenção pedagógica se faz necessária para o desenvolvimento do sujeito, já que conduzir uma sala de aula requer competências básicas que não podem ser desconsideradas. Ser educador exige saber, saber fazer, e, sobretudo, saber ser. A competitividade do mundo contemporâneo, as novas tecnologias que surgem em espaços curtos de tempo, provocam a busca por uma aprendizagem contínua e satisfatória.

A aprendizagem começa com o processo neuro maturacional e, portanto, o aprendizado escolar faz parte da evolução normal do ato de aprender. O avanço dos estudos da Neurociência é de suma importância para o entendimento das funções corticais superiores envolvidas no processo da aprendizagem, haja vista que o sujeito aprende por meio de modificações funcionais do SNC.

II. CONTEXTO DA PESQUISA

A autora da presente pesquisa iniciou sua trajetória acadêmica no curso de Licenciatura em Pedagogia pela Federação das Faculdade Celso Lisboa – no Rio de Janeiro no Bairro Sampaio, com término no ano de 1993.

Esteve como Pedagoga Escolar e durante sua atuação, percebeu muitos alunos com dificuldades no aprendizado e nas questões cognitivas, esteve trabalhando e percebendo junto aos docentes, as frustrações em garantir este acesso a disponibilidade do aluno em aprender. Percebeu-se que independente da didática, alguns alunos não conseguiram aprender, reter conteúdos e se apropriar de conhecimentos ofertados. Os professores reclamavam do comportamento e das demandas das salas de aulas. Deste modo, surgiu a necessidade em entender melhor sobre as possibilidades para a aprendizagem e sobre a neurociência e seus conhecimentos nos favorecendo desta relação na sala de aula junto as metodologias utilizadas.

O esboço inicial para a presente pesquisa surgiu através da sua participação e estudos escolares acerca do contato que a autora teve com diferentes docentes, ao longo da sua vida profissional. No decorrer de um trabalho pedagógico na Escola Pública, em contato com docentes no trabalho de treinamento na formação continuada do município. observou que alguns docentes (a maioria atuante há mais de 20 anos no magistério) apresentavam discrepâncias ao explanarem acerca da metodologia que costumavam utilizar em sala de aula e a sua prática pedagógica, ignorando muita das vezes o aprendizado existente e trazido pelos alunos no contexto escolar e de sala de aula.

As neurociências se tornaram tema na vida da autora ainda em 2018, quando iniciou um curso de Neuropsicopedagogia Clinica, Hospitalar e institucional para entender suas perguntas, vivencias e questões vivenciadas na escola pública pôde ver de perto a extraordinária capacidade do cérebro de se reinventar. Desde então, este é um tema que lhe chama a atenção e rende inúmeras leituras em favor da aprendizagem escolar do indivíduo na educação básica.

2.1 - Problema Norteador da Pesquisa

Quais as contribuições da formação continuada pautada na neurociência, que favoreça o trabalho pedagógico para a aprendizagem e seja voltada a docentes do Ensino Fundamental?

2.2 – Objetivos da Pesquisa

2.2.1. - Objetivo Geral da Pesquisa

Investigar as contribuições da neurociência na Escola, através da formação docente continuada, ofertada aos docentes da Rede Municipal de Ensino de Vila Velha/ES.

2.2.2. - Objetivos Específicos da Pesquisa

¬ Investigar o que os professores compreendem por neurociências e a forma que esses conhecimentos podem contribuir para a prática pedagógica;

¬ Identificar a relação da Neurociência com a prática em sala de aula e suas possibilidades para aprendizagem;

¬ Investigar o que os professores compreendem por neurociências e a forma que esses conhecimentos podem contribuir para a prática pedagógica;

¬ Pesquisar a relação das Neurociências com a prática em sala de aula e suas possibilidades para aprendizagem;

2.3 - Espaço da Pesquisa

A presente pesquisa inicialmente apresentou como campo de trabalho a Escola Pública, os docentes em atuação, durante os anos de 2021 e 2022, nas escolas da Rede Municipal de Ensino de Vila Velha/ES. Através das palestras, encontros, treinamentos e formação continuada, ofertada aos professores da Educação Básica, atuante.

III. CONTEXTUALIZAÇÃO DO UNIVERSO PESQUISADO

Tentando entender melhor este cenário já demonstrado acima no desenvolvimento da presente pesquisa e querendo reafirmar este contexto com o que pesquisamos, resolvemos dissertar sobre o tema com a finalidade de verificar o que pensam os educadores a respeito da formação continuada para inserir no contexto escolar a Neurociência como apoio aso professores no trabalho e no exercício da aprendizagem dos alunos. Precisamos ressignificar e corroborar para a discussão desta temática pela sociedade e ainda influenciar as práticas pedagógicas no pós pandemia e contexto contemporâneo.

Concordamos com Gil (2002) que diz que "a pesquisa é requerida quando não se dispõe de informação suficiente para responder ao problema, ou então quando a informação disponível se encontra em tal desordem que não possa ser adequadamente relacionada ao problema" (p.17); e com Oliveira & Jacinski (2017) que esse processo tem como resultado a construção de um saber/conhecimento através do confronto de dados, informações coletadas e conhecimentos teóricos acumulados a respeito do que é estudado. (p.9).

Assim, o estudo fundamenta-se em documentos e prática pedagógica do dia a dia da Escola Pedro Herkenhoff, além da coleta de dados, para a obtenção dos resultados.

Para a pesquisa descritiva de levantamento justifica-se por ser "desenvolvida com o objetivo de proporcionar informações e visão geral, acerca de determinado fato, prática ou opiniões atuais de um determinado núcleo populacional. Podendo utilizar de outras questões através de: legislações, pesquisas realizadas, artigos, entrevistas e de outros embasamentos pertinentes. Para a coleta de dados, a pesquisadora utilizou-se de um questionário que "refere-se a um meio de obter respostas às questões, que o próprio informante preenche" (Cervo & Bervian, 2002, p. 48).

IV. ESTRUTURA DA PESQUISA

Implantando-se na linha de pesquisa "Educação e Sociedade: processos de ensino e aprendizagem na escola, entendendo a Neurociência na prática e no Contexto Escolar e Suas Possibilidades a partir da Formação Continuada. Segue o Programa de Pós Graduação da EBWU, Miami. Esta Tese demonstra-se organizada a partir de um objetivo geral e de objetivos específicos, que no decorrer da pesquisa serão tratados e respondidos.

No primeiro momento, "Breve Histórias da Neurociência: aproximando saberes neurocientíficos da prática docente na educação básica" são apresentados os dados recolhidos na formação continuada, de modo a descrever com a metodologia das narrativas objetivando demonstrar os conhecimentos prévios dos docentes participantes acerca dos saberes neurocientíficos e relacionando estes aos conhecimentos obtidos na formação, através dos temas e assuntos focados.

O momento que falamos sobre "A construção da aprendizagem: A Relação entre Educação e Neurociência" se discorre sobre dados obtidos na formação continuada, tendo como objetivo relacionar as neurociências com a prática pedagógica e as possíveis metodologias utilizadas pelos docentes participantes.

No decorrer da escrita a "Neurodidática e Educação" se discorre sobre como as metodologias ativas podem se relacionar com os saberes neurocientíficos e as contribuições destes para o processo de ensino e aprendizagem, na prática docente na Escola de Ensino Fundamental.

Os resultados comparativos, coletos em forma de narrativas sugerem que, ao longo do término da formação continuada ofertada, os docentes apresentaram diferentes conceitos acerca das neurociências e conseguiram relacionar estas com as metodologias utilizadas em sala de aula, indicando que pode contribuir para o processo de ensino e de aprendizagem.

V. REFERENCIAL TEÓRICO

Contextualiza-se o que é aprendizagem na perspectiva da neurociência com o contexto educativo, no que se refere ao trabalho docente. Serão tratados os fatores estruturantes do processo de aprendizagem: plasticidade, emoção, atenção, motivação e memória, relacionando-os à aprendizagem escolar e a consolidação da aprendizagem.

O nosso referencial teórico ocorrerá através da construção da aprendizagem, onde enfocaremos a relação da educação com a neurociência.

A educação visa ao desenvolvimento de novos conhecimentos ou comportamentos, por meio da mediação de um processo que envolve a aprendizagem (COSENZA; GUERRA, 2011). Para Spitzer (2007), o aprender é um processo ativo que promove transformações cerebrais em quem aprende e, como afirma Valle (2014), esse aprendizado é resultante da mudança comportamental provocada pela experiência à qual o indivíduo é exposto, situação que acaba por exigir tanto a aquisição de conhecimentos quanto a capacidade de armazená-los. Portanto, tem-se que as experiências contribuem para o aprendizado por meio de uma mudança comportamental exigida pelo meio, que resulta na aquisição e

armazenamento de conhecimentos para utilização em momento oportuno.

Nesse sentido, um indivíduo "aprende quando adquire competência para resolver problemas e realizar tarefas, utilizando-se de atitudes, habilidades e conhecimentos que foram adquiridos ao longo de um processo de ensino-aprendizagem" (COSENZA; GUERRA, 2011, p.141). Dessa forma, percebe-se que o indivíduo que aprendeu consegue aplicar os conhecimentos, as habilidades e as atitudes em novas situações que se apresentam em seu contexto, o que também evidencia a capacidade de armazenar e recuperar o que foi aprendido. Assim, torna-se relevante destacar que o aprendizado tem importância tanto para os humanos quanto para os demais animais, pois é o modo pelo qual adquirimos conhecimento sobre o mundo (KANDEL; SCHWARTZ; JESSELL, 1997). É esse conhecimento que nos permite interagir adaptativamente e responder às situações do meio.

A aprendizagem modifica os indivíduos, assim como afirma Spitzer (2007): quem aprende muda, pois a recepção de algo novo sempre modifica quem recebe e "não só aprendemos mais material, como também nos transformamos" (SPITZER, 2007, p. 27). Em termos biológicos a aprendizagem é resultado da facilitação da passagem de informação ao longo das sinapses, traduzida pela formação e consolidação de ligações entre as células nervosas, o que acaba por exigir tempo e energia para que possa ser manifestada (COSENZA; GUERRA, 2011). Também, há necessidade de que a rede neural esteja ativada para que possam ocorrer mudanças nas intensidades de transporte nas sinapses, e consequentemente aprendizagem (SPITZER, 2007).

Para ampliar a capacidade de aprendizagem, é importante proporcionar às células nervosas informações e atividades, o que aumenta tanto a capacidade de conexões entre células nervosas, quanto à agilidade mental, influenciando diretamente na capacidade de aprender (VALLE, 2014). Essas conexões entre as células nervosas são as sinapses, que permitem que o estímulo que gera o impulso nervoso que passou pelo corpo do neurônio, seja transmitido na fenda sináptica por meio de mediadores químicos (neurotransmissores) para o neurônio seguinte.

5.1- Aprendizagem e Educação.

O aprender e o lembrar do estudante ocorre no seu cérebro. Conhecer como o cérebro funciona não é a mesma coisa do que saber qual é a melhor maneira de ajudar os alunos a aprender. A aprendizagem e a educação estão intimamente ligadas ao desenvolvimento do cérebro, o qual é moldável aos estímulos do ambiente (Fischer e Rose, 1998). Os estímulos do ambiente levam os neurônios a formar novas sinapses. Assim, a aprendizagem é o processo pelo qual o cérebro reage aos estímulos do ambiente, ativando sinapses, tornando-as mais "intensas". Como consequência estas constituem-se em circuitos que processam as informações, com capacidade de armazenamento molecular (Shepherd, 1994; Mussak, 1999; Koizumi, 2004).

O estudo da aprendizagem une a educação com a neurociência (Livingstone, 1973; Saavedra, 2002; Mari, 2002, Flores, 2003). A neurociência investiga o processo de como o cérebro aprende e lembra, desde o nível molecular e celular até as áreas corticais. A formação de padrões de atividade neural considera-se que correspondam a determinados "estados e representações mentais" (Kelso, 1995; Shepherd, 1998).

O ensino bem sucedido provocando alteração na taxa de conexão sináptica, afeta a função cerebral. Por certo, isto também depende da natureza do currículo, da capacidade do professor, do método de ensino, do contexto da sala de aula e da família e comunidade. Todos estes fatores interagem com as características do cérebro dos indivíduos (Lowery, 1998; Westwater & Wolfe, 2000; Ramos, 2002). A alimentação afeta o cérebro da criança em idade escolar. Se a dieta é de baixa qualidade, o aluno não responde adequadamente à excelência do ensino fornecido (Given, 1998).

A Neurociência proporciona para os educadores novas estratégias de ensino e aprendizagem. Sendo assim, quando os estudantes são estimulados e valorizados em sala de aula por meio de um método dinâmico e prazeroso, surgem alterações na quantidade e qualidade de conexões sinápticas, resultando em um processo cerebral positivo, que aumenta as suas possibilidades de resultados eficazes. No desenvolvimento de ações dinâmicas relacionadas à aprendizagem, existem diferentes maneiras de implementar inovações de ensino, como o uso de jogos pedagógicos e didáticos, métodos de associação de informações e imagens e atividades envolvendo os cinco sentidos.

Cosenza e Guerra afirmam ainda que não aprendemos tudo o que estudamos de um dia para o outro e muito menos o que apenas presenciamos na sala de aula. É importante que assuntos estudados possam ser examinados em diferentes contextos, pois a consolidação, resultante de novas conexões entre as células nervosas e do reforço de suas ligações, demanda tempo e nutrientes e, portanto, não ocorre de imediato. Compreendendo que estudar é uma ação aprendida, considera-se necessário proporcionar aos educandos o desenvolvimento de suas habilidades de estudo, e os educadores devem se posicionar como mediadores e facilitadores desse processo, explicando as regras do jogo, ou seja, que é necessário utilizar métodos específicos para que haja resultados mais eficazes.

Pode-se definir o aprendizado como a modificação de um comportamento que surge em resposta a uma imposição exercida pelo meio. A principal característica do aprendizado é a aquisição de uma determinada informação. Em animais, essa aquisição é determinada pela intensidade dos estímulos e nos seres humanos ela também está relacionada a fatores motivacionais.

A amígdala é um centro nervoso regulador dos processos emocionais. Esses processos estão envolvidos no fenômeno da motivação, que é importante para a aquisição do conhecimento. As emoções podem facilitar a aprendizagem, mas o estresse tem efeito contrário. O ambiente escolar bem planejado pode facilitar as emoções positivas e evitar as emoções negativas.

A motivação para a aprendizagem pode ser verificada por meio de observações diretas de comportamentos, pelo julgamento de outros e por relatos e autoavaliações. As observações diretas estão associadas à análise dos comportamentos de um estudante que poderiam ser indicativos de aspectos motivacionais. Como exemplo, pode-se colocar o estudante de frente a algumas opções de atividades e averiguar como este escolhe a tarefa, seu esforço na manutenção e realização da ação e a persistência frente às dificuldades ou obstáculos.

Algumas definições de motivação apresentadas por Pfromm e Pintrich e Schunk consideram a importância da motivação para que uma ação seja iniciada e sustentada. O envolvimento e a persistência nas tarefas escolares são essenciais e mostram adequadamente esta característica da motivação relacionada à iniciação e à sustentação de um comportamento. O envolvimento também possibilita a aquisição de novos conhecimentos e habilidades, o que atinge a motivação, aumentando o valor da atividade no futuro. Além disso, alunos motivados demonstram interesse pelas tarefas e geralmente trabalham com mais vontade.

Cosenza e Guerra alertam a respeito do uso destes conhecimentos em soluções simplistas: "Embora muitas vezes se observe certa euforia em relação às contribuições das neurociências para a educação, é importante esclarecer que elas não propõem uma nova pedagogia nem prometem soluções definitivas para as dificuldades da aprendizagem". Então, estes conhecimentos representam uma reorientação de direção e um acréscimo para romper com os conceitos conservadores, historicamente cultivados sobre o aprender e ensinar.

Segundo a teoria de Ausubel, os conhecimentos prévios dos alunos devem ser valorizados para construir estruturas mentais, utilizando como meio mapas conceituais que permitem descobrir e redescobrir outros conhecimentos.

Os pesquisadores Fenker e Schütze atentam para a importância da apresentação de novos conteúdos aos alunos, antes da exploração e levantamento de conhecimentos prévios. Segundo estes pesquisadores, os conhecimentos prévios podem e devem ser trabalhados, mas não nos momentos iniciais das aulas. Tais dinâmicas podem favorecer a dispersão diante de temas já conhecidos pelos alunos. Saberes desconhecidos ativam áreas cerebrais que melhoram significativamente a memória. Estudos indicaram que as "novidades" potencializam as atividades no hipocampo, favorecendo o aprendizado e a memória, além de sua duração. Essas descobertas são de grande importância para a área educacional.

Os educadores podem utilizar tais descobertas para estruturar suas aulas de forma mais eficaz, desenvolvendo aulas nas quais serão apresentadas novas informações e, posteriormente, revendo os conteúdos anteriores, em que os alunos podem vivenciar situações que reflitam o contexto da vida real, de forma que a informação nova se "ancore" na compreensão anterior.

Aprendizagem, cognição, memória e ensino estão correlacionados e correspondem às atividades fundamentais que ocorrem na escola. A escola é, sobretudo, um lugar onde pessoas se reúnem para ensinar e aprender. As interações do sujeito com o ambiente levam a modificações sinápticas e ao surgimento de novas sinapses por reforço das conexões neurais com atividades úteis. Do contrário, as ligações sinápticas pouco usadas tornam-se mais fracas ou desaparecem. As escolhas das conexões que serão preservadas e potencializadas dependerão dos estímulos que o cérebro recebe.

Entende-se que é importante ser seletivo com as informações que devemos ou gostaríamos de processar, pois a memória de curto prazo, muitas vezes, não consegue processar tudo que é exigido dela. Em alguns momentos, torna-se necessário limitar os estímulos e privilegiar a informação que deve ser aprendida. Lembrando que o cérebro se dedica a aprender aquilo que ele entende como significante.

5.2- Neurociência e Prática Educativa.

A pesquisa em neurociência por si só não introduz novas estratégias educacionais. Contudo fornece razões importantes e concretas, não especulativas, porque certas abordagens e estratégias educativas são mais eficientes que outras (Reynolds, 2000; Smilkstein, 2003). A tabela 1 sugere como o cérebro aprende em determinado ambiente de sala de aula.

Tabela 1. Princípios da neurociência com potencial aplicação no ambiente de sala de aula.

Princípios da neurociência	Ambiente de sala de aula
1. Aprendizagem & memória e emoções ficam interligadas quando ativadas pelo processo de aprendizagem	Aprendizagem sendo atividade social, alunos precisam de oportunidades para discutir tópicos. Ambiente tranquilo encoraja o estudante a expor seus sentimentos e ideias.
2. O cérebro se modifica aos poucos fisiológica e estruturalmente como resultado da experiência.	Aulas práticas/exercícios físicos com envolvimento ativo dos participantes fazem associações entre experiências prévias com o entendimento atual.
3. o cérebro mostra períodos ótimos (períodos sensíveis) para certos tipos de aprendizagem, que não se esgotam mesmo na idade adulta.	Ajuste de expectativas e padrões de desempenho às características etárias específicas dos alunos, uso de unidades temáticas integradoras.
4. O cérebro mostra plasticidade neuronal (sinaptogênese), mas maior densidade sináptica não prevê maior capacidade generalizada de aprender.	Estudantes precisam sentir-se "detentores" das atividades e temas que são relevantes para suas vidas. Atividades pré-selecionadas com possibilidade de escolha das tarefas, aumenta a responsabilidade do aluno no seu aprendizado.
5. Inúmeras áreas do córtex cerebral são simultaneamente ativadas no transcurso de nova experiência de aprendizagem.	Situações que reflitam o contexto da vida real, de forma que a informação nova se "ancore" na compreensão anterior.
6. O cérebro foi evolutivamente concebido para perceber e gerar padrões quando testa hipóteses.	Promover situações em que se aceite tentativas e aproximações ao gerar hipóteses e apresentação de evidências. Uso de resolução de "casos" e simulações.
7. O cérebro responde, devido a herança primitiva, às gravuras, imagens e símbolos.	Propiciar ocasiões para alunos expressarem conhecimento através das artes visuais, música e dramatizações.

(Modificado de Rushton e Larkin, 2001; Rushton et al., 2003).

A neurociência oferece um grande potencial para nortear a pesquisa educacional e futura aplicação em sala de aula. Pouco se publicou para análise retrospectiva. Contudo, faz-se necessário construir pontes entre a neurociência e a prática educacional. Há forte indicação de que a neurociência cognitiva está bem colocada para fazer esta ligação de saberes. Políticas educacionais devem ser planejadas através da alfabetização em neurociência, como forma de envolver o público em geral além dos educadores. É preciso aprofundar o estudo de ambientes educativos não tradicionais, que privilegiem oportunidades para que os alunos desenvolvam entendimento, e que possam construir significado à partir de aplicações no mundo real.

Os educadores, ao conhecerem o funcionamento do sistema nervoso, podem desenvolver melhor seu trabalho e fundamentar sua prática diária com reflexos no desempenho e na evolução dos educandos. Podem intervir de forma mais efetiva nos processos de ensino e aprendizagem, sabendo que esse conhecimento precisa ser criticamente avaliado antes de ser aplicado de forma eficiente no cotidiano escolar. Os conhecimentos agregados pela Neuropsicologia podem contribuir para um avanço na educação em busca de melhor qualidade e resultados eficientes na vida do indivíduo e na sociedade.

Quando se trata da aprendizagem, existem alguns princípios e padrões comuns que podem ser adequados para todos, mas existem também situações que são específicas (individuais, resultantes da experiência vivida por cada um) e que, portanto, o educador precisa conhecer para poder relativizar ou tratar de maneira diferenciada. Não conseguiremos, de um momento para outro, romper com uma longa tradição centrada em ensinar e avaliar de uma única maneira e de forma padronizada.

A formação de educadores não se limita a um aprendizado de técnicas educativas, mas avança no sentido de constituição dos sujeitos, o que torna essencial a criação de modos de ser e fazer. É fundamental que educadores conheçam as estruturas cerebrais como interfaces da aprendizagem, já que os estudos da biologia cerebral vêm contribuindo para a práxis em sala de aula, para o

entendimento das dimensões cognitivas, motoras, afetivas e sociais, no redimensionamento do educando e suas formas de interferir nos ambientes pelos quais perpassam. É importante compreender que a dificuldade de aprender não é uma situação isolada e que diversas vezes apresenta a necessidade de uma avaliação diagnóstica de especialistas para o tratamento das desordens do aprender. É imprescindível entender que tal processo é sinalizado e, por isso, torna-se indispensável o conhecimento do educador com o objetivo de discernir os sinais que constantemente são manifestados em sala de aula[12].

O aprendizado é um processo complexo e dinâmico que resulta em modificações estruturais e funcionais do SNC. As alterações ocorrem a partir de um ato motor e perceptivo, que, elaborado no córtex cerebral, dá início à cognição. No processo neuropsicológico do ato de aprender, a atenção, a memória e as funções executivas assumem um papel de fundamental importância. Os distúrbios atencionais e das funções corticais de percepção, planejamento, organização e inibição comportamental também têm sua importância no processo neuropsicológico, visto que a memória é essencial em todos os processos de aprendizagem, e seus distúrbios não permitem reter as informações.

É essencial compreender que o SNC coordena as tarefas internas e externas do organismo, construindo uma integração e procurando manter o equilíbrio do sujeito com o mundo externo. A ativação de uma área cortical, determinada por um estímulo, provoca modificações também em outras áreas, pois o cérebro não funciona como regiões isoladas. O acontecimento se dá em virtude da existência de um grande número de vias de associações, precisamente organizadas atuando nas duas direções.

Segundo Oliveira et al., o processo de aprendizagem promove a plasticidade no momento em que ocorrem modificações estruturais e funcionais nas células neurais e suas conexões. Tais modificações também aparecem na representação dos mapas corticais (representações cognitivas) que sofrem alterações neste processo, decorrentes das experiências vivenciadas pelo sujeito.

Morris e Fillenz relatam que a eficácia da aprendizagem é influenciada pelo nosso estado emocional, já que apresentamos tendências para lembrarmos melhor os acontecimentos associados a experiências particularmente felizes, tristes ou angustiantes. Como também nos recordamos melhor dos acontecimentos quando estamos atentos.

O cérebro mostra plasticidade neuronal (sinaptogênese), entretanto, maior densidade sináptica não determina maior capacidade generalizada de aprender. Estudantes precisam sentir-se "detentores" das atividades e temas que são relevantes para suas vidas. O ambiente escolar precisa de atividades pré-selecionadas como possibilidade de escolha de tarefas, que aumenta a responsabilidade do aluno no seu aprendizado.

5.3- Neurociência Aplicada Em Treinamentos Acadêmicos. Para Promover Mudanças Na Prática Escolar De Ensino Aprendizagem.

Nos últimos anos, as escolas vêm percebendo vantagens de se aproximar da neurociência para desenvolver modelos de aprendizagem mais eficientes e significativos.

Nos últimos anos vivenciamos o avanço da neurociência e suas mais diferentes aplicações em áreas como marketing, educação, design, economia, entre tantas outras. O tema, antes desconhecido e de difícil entendimento, ganhou uma atenção expressiva desde que seus resultados começaram a se mostrar relevantes e transformadores em vários aspectos do dia a dia das pessoas, dos alunos e das empresas.

A Escola nos últimos anos vem percebendo vantagens de se aproximar da neurociência para desenvolver modelos de aprendizagem mais eficientes e significativos.

Afinal, já não é novidade que estamos vivendo um momento de mudanças aceleradas em relação ao ambiente educacional. Não apenas as expectativas das pessoas mudaram como também a maneira como desempenhamos nossas atividades e de como os alunos aprendem, ou se colocam a disposição da aprendizagem.

De fato, nunca foi tão importante entender de pessoas e é justamente neste cenário que a neurociência surge como ferramenta importante, capaz de oferecer um novo olhar a respeito de como melhorar a gestão do comportamento humano, nos mais diferentes desafios vividos pelas escolas hoje.

Por isso, cada vez mais a segurança psicológica tem sido pauta no universo educacional e a neurociência organizacional e escolar é uma ótima forma de estimular o bem-estar no trabalho e na escola. O aumento do interesse por essa área nada mais é que reflexo da necessidade em reduzir essa incidência de estresse e síndromes entre os alunos, algo que tem aumentado consideravelmente nos últimos anos no país.

Dificuldades no processo de ensino aprendizagem onde não se conseguem resultados satisfatórios ou de relevância para a aprendizagem individual e significativa.

No entanto, por mais que o assunto esteja em evidência, sabemos que nem sempre a qualidade e profundidade das informações disponíveis são suficientes,

gerando muitas dúvidas a respeito de como a aplicação da neurociência dentro das escolas pode realmente contribuir para melhorar a gestão de pessoas, aprendizagens e rotinas escolares significativas e eficientes.

5.3.1- Neurociência Aplicada A Treinamentos Corporativos E Escolares.

A aplicação da neurociência como ferramenta em treinamentos corporativos aliados à tecnologia – cada vez mais avançada – vem alcançando resultados expressivos. O estudo das respostas do cérebro no mundo corporativo acompanha a evolução tecnológica e já incorpora até exames de ressonância magnética que mapeiam as atividades cerebrais e associam as movimentações com situações do dia a dia profissional.

As diversas técnicas aplicadas nestes casos pela neurociência servem para compreender bases inconscientes que determinam o modo como a pessoa age em situações de pressão ou conflito, por exemplo. A partir dessa informação, é possível criar treinamentos que ajudem a aprendizagem para cada caso específico. Ou seja, os treinamentos com essa abordagem podem acontecer de diferentes formatos, como aulas expositivas, dinâmicas em grupo e até envolverem técnicas de gamificação, vídeos interativos e realidade virtual.

Com o avanço da tecnologia, a aplicação da neurociência em educação corporativa acontece de forma cada vez mais interativa, assertiva e qualificada. escolares já utilizam em sua rotina práticas e aprendizados oriundos dessa ciência para construção de políticas e estratégias mais eficientes, que ajudam a melhorar a performance e bem-estar de suas equipes, dos alunos e ativam o sucesso na aprendizagem do dia a dia na sala de aula.

5.3.2- Benefícios Da Neurociência Nas Escolas E Processos De Educação

As vantagens da neurociência na Educação têm o potencial de fazer com que os profissionais desenvolvam o autoconhecimento e o autocontrole, diminuindo o estresse e ampliando o potencial de aprendizado.

Ao fazer uso deste conhecimento, os professores ganham não apenas em resultados, mas na formação de uma equipe mais lúcida, engajada e voltada à melhoria contínua. Logo, aumenta-se a competitividade e a satisfação com as tarefas, tornando melhor a qualidade do que é produzido dentro e fora das salas de aula, com reflexões positivas e aprendizados permanentes.

O cérebro registra se a informação é útil. Portanto, quando você quiser que seus interlocutores memorizem as informações, especifique qual é o propósito e a utilidade das informações.

O que isso implica para o formato da aula:

– Adicionar um ponto de contato, ou uma questão única, específica informando sobre a utilidade do conjunto de aprendizagens em uma jornada digital.

Palavras positivas devem ser ditas por fortalecer o Ego e oferecer estímulo positivo.

- Verbalizando a utilidade da informação transmitida

Qual professor não viu seus alunos amorfos no período pós-refeição? Na sala de aula, verbalizar a utilidade da sequência terá o duplo efeito de despertar seus alunos e alertar seu cérebro para uma melhor memorização. Voltar as questões já vistas, após o lanche e o intervalo do recreio. Mais do que informar, precisamos convencer.

Trazer uma resposta chave para a pergunta: “Por que meus alunos devem registrar as próximas informações”. Você irá maximizar o benefício de seu treinamento. E ainda, garantir o processo de revisão e reflexão. Os alunos precisam entender que o registro escrito é melhor e faz parte quando junto com o registro visível e auditivo.

Nosso cérebro só pode dedicar-se inteiramente a uma coisa de cada vez, ou seja, não pode realizar duas tarefas de forma eficaz, conscientemente.

Quando pensamos em “fazer multitarefas”, na realidade nossa atenção muda de uma tarefa para outra. No contexto da aprendizagem, é necessário que o nosso cérebro se dedique plena e conscientemente à tarefa em questão e que vise a aquisição de uma habilidade, um conhecimento. Para isso, favoreceremos o mono-tasking, operando passo a passo.

As aulas devem ser organizadas de modo a fragmentar os conhecimentos e habilidades a serem adquiridos. Para isso:

Defina um objetivo final. Deve ser explícito e atingível pelos seus formandos.

Anote os passos a serem reunidos e os objetivos intermediários a alcançar até alcançar o destino.

O cérebro é plástico. Com isso, o cérebro é plástico em se reconfigurar constantemente, não importa quantos anos tenhamos.

Em todos os momentos da nossa vida, nosso cérebro reconfigura sua arquitetura interna. Cada estímulo tem um impacto na sua organização. Nossas células nervosas ativam, desativam, redes neurais são feitas e descartadas.

As conexões desconectadas são as menos usadas, quando aquelas que se desenvolvem são mais mobilizadas por experimentos repetidos.

Por exemplo, imagine uma região que você está explorando. Quanto mais você explorar, mais você descobrirá e tomará

caminhos diferentes. E quanto mais esses caminhos forem frequentados, mais eles serão mantidos e o progresso será mais fácil e mais fácil de ir de um ponto a outro. Aqueles a quem você atenderá muito pouco desaparecerão.

O que isso implicará para a aprendizagem?

Prever a repetição de experiências para ancorar o conhecimento

Diversificar experiências para desenvolver novas conexões.

Antes de começarmos a nossa conversa sobre como a neurociência pode de fato ser aplicada na escola, é importante deixarmos claro o que torna essa ciência merecedora de grande destaque e interesse nos dias atuais.

5.3.3- Neurociência E Educação: Como Utilizar Na Sala De Aula?

O aprendizado é algo inerente ao ser humano, pois desde o momento em que nascemos somos capazes de descobrir e reter informações — condição que acontece sem filtros e escolhas. Diante disso, aprender sobre neurociência e educação é fundamental para entender melhor como funciona o nosso cérebro e, assim, fazer abordagens mais efetivas junto aos seus alunos.

De modo direto, a neurociência pode ser definida como o campo científico que estuda as funcionalidades do sistema nervoso, que nada mais é do que o grande responsável pelo nosso aprendizado em todas as etapas da vida.

Ela se divide em três áreas: neuropsicologia, neurofisiologia e neurociência cognitiva, que juntas têm a finalidade de compreender como funciona a mente humana e quais são as técnicas possíveis para a otimização dos seus processos.

Vale ressaltar que o aprendizado se enquadra em um desses processos, uma vez que ele ocorre dentro do sistema nervoso, que inicialmente coloca os nossos sentidos para trabalhar e depois leva a informação para o cérebro, onde ela será processada, compreendida e armazenada. Caso não sejam aplicados os estímulos certos, é provável que esse aprendizado acabe sendo esquecido.

Alguns dos fatores que são capazes de estimular o sistema nervoso e a capacidade de aprendizado são: plasticidade cerebral: é a habilidade do cérebro de se modificar de acordo com as inferências do ambiente. Quanto mais plástico é o cérebro de uma pessoa, mais facilidade ela terá para aprender; memória: funciona por meio da ativação de circuitos neurais com base em associação. A partir do momento em que um circuito é ativado, ele automaticamente vai ativar o próximo; emoção: consiste no fator que pode deixar as sinapses mais fortes e estáveis, influenciando a memória e aprendizado. Um exemplo disso é a facilidade para lembrarmos das memórias da infância; motivação: trata-se da força que nos leva a realizar uma tarefa para alcançar determinado resultado; atenção: a atenção se relaciona com o nosso interesse e os estímulos aos quais somos expostos. Estímulos em demasia tiram o foco da atenção, evitando que o aprendizado seja retido.

Para a área da educação, a neurociência permite que os educadores entendam como o cérebro é impactado pelo ambiente e, assim, possam adotar os estímulos mais adequados para conduzir os processos de aprendizagem em sala de aula.

Nas últimas décadas, a neurociência vem sendo apontada como uma poderosa aliada para a educação, o que não é para menos, tendo em vista que direciona o professor para o entendimento das características de aprendizado dos seus alunos e para as estratégias de ensino mais eficientes para cada caso. Veja alguns dos benefícios da neurociência para o setor educacional:

5.3.4- Ajudar A Entender O Desenvolvimento Do Aluno.

Ao obter informações embasadas de como os discentes aprendem em cada faixa etária, os educadores conseguem enxergar novas possibilidades e estratégias para facilitar o aprendizado. O respeito ao tempo de cada aluno e a busca por ferramentas que derrubam barreiras são pontos primordiais para uma formação de qualidade e que garantem a afinidade da criança ou adolescente com o ambiente escolar.

Possibilitar a adoção de estratégias adequadas.

Todo professor precisa ter em mente que o estudante não é uma caixa fechada que abriga exatamente os mesmos componentes. Afinal, o modo como cada aluno aprende é único, logo a neurociência contribui para a adoção de estratégias adequadas e que contemplam as necessidades de aprendizagem da sua turma.

Para alunos que aprendem melhor de forma lúdica, por exemplo, uma das estratégias mais apropriadas é a gamificação, que se baseia em games para prender a atenção, estimular o raciocínio lógico e a concentração, e transmitir conhecimentos.

Melhorar a assimilação do conteúdo.

As descobertas da neurociência estão impactando as escolas e estudantes ao redor do mundo. De acordo com um estudo feito por cientistas britânicos, 30 minutos a mais dormindo por dia ajudam a melhorar a cognição e a atenção do aluno na aula. Isso tem levado muitas escolas a modificarem o horário de início das aulas no período da manhã.

Além disso, esse campo da ciência também propõe que os discentes escolham os conteúdos de acordo com as suas habilidades. A medida estimula o ensino personalizado, que se adequa às necessidades da pessoa.

Reduz o estresse dos estudantes.

Se o aluno enfrenta dificuldades para evoluir em uma disciplina, a busca pela melhoria do seu desempenho pode causar ansiedade e estresse. Nesse sentido, a neurociência também se faz valiosa, pois possibilita ao professor entender o estudante e quais são as suas barreiras, para que possa dar o suporte mais adequado possível, eliminando situações de estresse.

Envolva os alunos na construção do aprendizado. O protagonismo do aluno é uma das principais tendências quando se fala em educação. Por muito tempo os estudantes foram apenas figurantes no seu próprio processo de aprendizagem, cabendo a eles receber o conteúdo lecionado pelo professor sem fazer nenhum tipo de questionamento.

Na atualidade, os discentes estão no centro da aprendizagem, o que requer que eles sejam envolvidos nas aulas por meio de atividades inovadoras, das quais tenham uma participação mais ativa. Um exemplo disso são as oficinas, em que a turma é separada em equipes e cada uma fica responsável por apresentar uma parte do conteúdo que será introduzido na aula.

Assim, os alunos contribuem para com a aprendizagem um do outro e o professor atua como um mediador do conhecimento, ajudando a turma a tirar as suas dúvidas, compartilhar os seus sentimentos, refletir e ter discussões saudáveis sobre o tema proposto.

Entender as motivações da turma. É o que faz a sua turma engajar com a aula. Ter essa resposta na ponta da língua é crucial para que as suas aulas sejam mais produtivas. Para tanto, há que se entender quais são os interesses dos alunos e, a partir daí, trazer para a sala questões relacionadas à disciplina e que estejam dentro dos interesses da criança ou adolescente, o que contribui para prender a atenção deles.

5.3.5- A Contribuição Da Aprendizagem: A Relação Entre Educação E Neurociência.

Na neurociência cognitiva, estudam-se o cérebro e outros aspetos do sistema nervoso vinculado ao processamento cognitivo e, por conseguinte, o comportamento (STERNBERG, 2012), tendo como objetivos compreender a relação entre os fenômenos mentais e as estruturas neurais do cérebro (GAWRYSZEWSKI et al., 2006). Para a educação, os estudos em neurociência possibilitam uma abordagem diferenciada dos processos de ensino e aprendizagem, fundamentada na compreensão dos processos cognitivos envolvidos. Conforme Pozo (2002), a natureza do sistema cognitivo humano faz com que a aprendizagem esteja intimamente ligada ao bom funcionamento de determinados processos auxiliares, também compreendidos como condições da aprendizagem, que otimizam ou minimizam a eficiência dos processos de aprendizagem, sendo esses:

1) A motivação – a maior parte das aprendizagens, em especial as explícitas, requer uma prática contínua, que implica em esforço, exigindo que o aluno tenha algum motivo para se esforçar. Quando não há motivos para aprender, a aprendizagem torna-se bastante improvável.

2) A atenção – devido à capacidade limitada da memória de trabalho, é necessário selecionar e destacar a informação que o aluno deve considerar em função do objetivo de aprendizagem. Também é conveniente que haja gestão ou controle eficaz dos recursos cognitivos disponíveis, conseguindo-se, assim, que determinadas tarefas deixem de consumir atenção e consequentemente, incrementando-se a capacidade funcional da memória de trabalho.

3) A recuperação e a transferência das representações presentes na memória como consequência das aprendizagens anteriores – ao aprender um comportamento novo e não conseguir recuperá-lo em um momento adequado, a aprendizagem terá sido pouco eficaz. É necessário planejar as situações de aprendizagem com foco em como, onde e quando o aluno deve recuperar o que aprendeu, posto que a recuperação é mais fácil em situações similares. Quando a recuperação da aprendizagem é difícil, os resultados serão menos duradouros. O aprendido que não é utilizado tende a ser facilmente esquecido. Ao aprender a utilizar um dado conhecimento ou habilidade em diferentes situações, aumentam-se as chances de transferi-lo para novos contextos. Aumentam, também, as chances de relacionarem-se esses conhecimentos com novas situações, quando poderá ser compreendido o que se faz, atribuindo maior consciência a nossos conhecimentos.

4) A consciência e o controle dos próprios mecanismos de aprendizagem constituem um processo transversal aos anteriores – os processos anteriores podem ser controlados ou administrados externamente pelo professor, ao determinar as condições para as situações de aprendizagem. O ideal, é que o próprio aluno controle seus processos progressivamente, utilizando-os de maneira estratégica pela tomada de consciência dos resultados esperados da aprendizagem, dos processos por meio dos quais pode alcança-los e das condições mais adequadas para pôr em marcha esses processos.

Em síntese, a aprendizagem, para Pozo (2002), é auxiliada pela motivação, atenção, memória e consciência e controle dos mecanismos de aprendizagem. Para motivação é importante que o estudante tenha um motivo para o

esforço, enquanto em relação à atenção, é necessário que as informações sejam destacadas em função dos

objetivos de aprendizagem. Em relação à memória, o foco é a recuperação do que foi aprendido para utilização em outras situações, o que mostrará que a aprendizagem foi eficaz. E perpassando todos esses processos do sistema cognitivo envolvidos na aprendizagem, temos o controle desses processos, que pode ocorrer progressivamente por parte do próprio estudante, ao reconhecer o que conhece, mas também pela intervenção do professor.

Já Spitzer (2007, p. 133) defende que "quem, ao aprender, estiver atento, motivado e emocionalmente implicado, retém mais eficazmente". Para esse autor, a atenção, a motivação e a emoção são os fatores que influenciam a aprendizagem.

VI. UNIVERSO E AMOSTRA DA PESQUISA

O universo da pesquisa abrange, o Brasil, região sudeste, Estado do Espírito Santo, na cidade de Vila Velha na Comunidade Escolar da região IV, com profissionais que exercem a profissão de educador e que atuam na Educação Básica, no Ensino Fundamental, Séries iníciais.

A coleta dos dados foi realizada em 2021 e 2022 com a Comunidade Escolar da UMEF Pedro Herkenhoff. Situada à rua Octávio Borin, 746 – no bairro Cobilândia em Vila Velha no Espírito Santo.

VII. INSTRUMENTOS E COLETA DOS DADOS DA PESQUISA

Para a coleta de dados foi utilizado o questionário impresso em anexo, que permite opções de respostas em múltipla escolha, e resposta curta.

O modelo é interessante, simples e foi útil no caso de uso. Deve-se ainda levar em conta o fato de que as respostas de um formulário foram agrupadas em um gráfico para facilitar a visualização e ajudar os comentários e reflexões. O formulário é leve, rápido e objetivo.

Outra vantagem é que o questionário possibilita atingir um grande número de pessoas da escola, mesmo que estejam dispersas entre si. Podem participar de modo simples e prático.

Ressalta-se que a escolha do questionário como uma opção viável, se mostrou prático na vivência e expectativas para todos os envolvidos "a realização de pesquisas através de formulários é uma alternativa amplamente utilizada. A possibilidade de criação de formulários é um facilitador no que diz respeito à distribuição da pesquisa aos entrevistados e, posteriormente, à organização e análise dos dados então coletados. Existem várias vantagens associadas à utilização do formulário com utilização de papel, a facilidade na busca de dados, a utilização pessoal e contato físico, a distribuição fácil e rápida, são os pontos positivos para o processo.

VIII. RESULTADOS E DISCUSSÕES

Gráfico 2

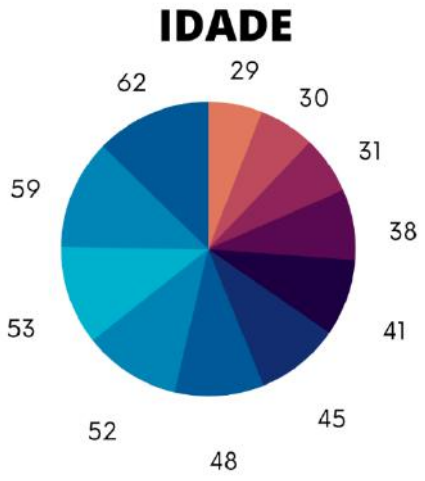


Gráfico 1

Analisamos professores de diversas idades, com níveis de maturidade e profissionalismo diferente, podendo comparar e vivenciar a diversidade, percebendo diversos pontos de vista e tempo de experiência profissional.

Todos os professores participantes são parte integrante desta Escola Pública, onde a maioria deles *é* efetivo, *concursado e a minoria* é concursado a partir do concurso de Designação Temporária por tempo de contrato.

Todos são profissionais capacitados e experientes em suas funções.

Todos os participantes são professores, com formação acadêmica na área da Educação. Especificamente a maioria dos profissionais também possuem em sua graduação o curso de Pedagogia.

Gráfico 3

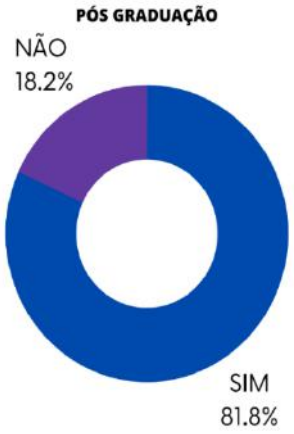


Gráfico 4

Uma minoria ainda não possui Pós-graduação e portanto, não estão situados, no plano do município de cargos e salários, participando apenas do piso inicial do trabalho docente. A maioria dos professores são graduados e pós graduados, especialistas em conteúdos pedagógicos específicos que geralmente apontam para o trabalho docente. Apoiando-os em seus afazeres, junto aos seus pares.

Todos os profissionais entrevistados e participantes desta pesquisa atuam de modo sistemático e permanente 100% no Ensino Fundamental, séries iniciais. Atendendo alunos de 6 anos a 10,11 anos; com sua prática docente escolar.

ráfico 5

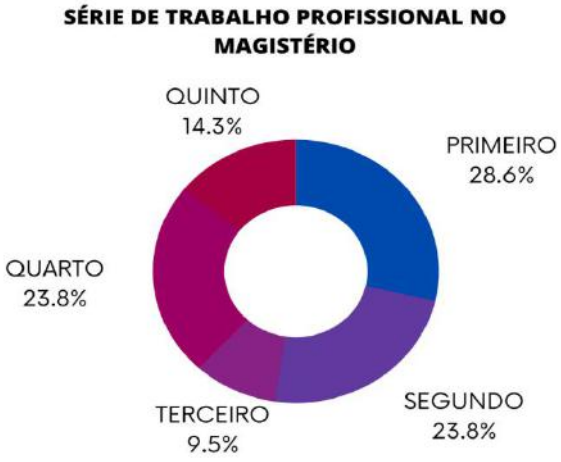


Gráfico 6

Todos os profissionais entrevistados possuem tempo expressivo de experiência e vivência profissional. Apenas uma minoria profissional está em estudo.

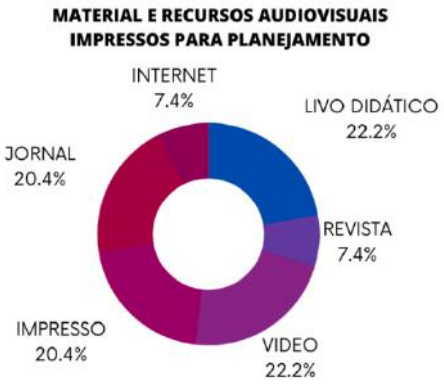
Sendo a Escola no turno matutino, atendendo do 1º ano ao 5º ano do Ensino Fundamental temos os anos mais atendidos pela maioria dos nossos entrevistados, professores, onde os primeiros, segundos e quartos anos são os anos onde os nossos profissionais tem mais experiências e prática docente.

Visualizamos que os 1º anos 28,6% dos profissionais atuam nessa prática, iniciando o processo de alfabetização e hábitos de estudos. Já os segundos e quartos anos possuem 23,8%, a mesma população experiente trabalhando nesse contexto com o grupo de alunos de 8,9 a 10 anos.

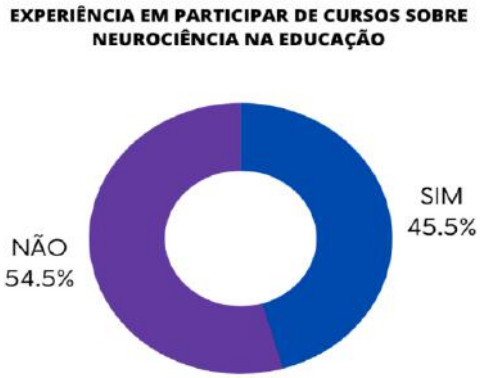
Sendo assim, o 3 º ano. Tempo de finalização do processo de alfabetização, conclusão da leitura, escrita e matemática. Temos 9,5% dos professores trabalhando no 3 ano do Ensino Fundamental.

E no 5º ano 14,3% dos profissionais possuem essa experiência no Ensino Fundamental Séries iniciais, terminado o processo de formação inicial do primeiro momento do Ensino Fundamental.

Gráfico 7



Grupo 8



Todo o material impresso e recursos audiovisuais são importantes e expressivos para a elaboração do planejamento. Deste modo, a utilização do livro didático, do vídeo e dos impressos são os mais expressivos materiais de apoio para o planejamento e elaboração das aulas e pesquisas sobre as aulas. Neste caso em 7,4% a internet não é um grande sucesso, é apenas importante para este processo.

Diante das diversidades e necessidades pedagógicas que surgem para o sucesso e adaptação curricular, a neurociência na Educação é uma possibilidade expressiva acadêmica para influenciar positivamente o potencial da aprendizagem e para favorecer o processo de ensino-aprendizagem na Escola.

45,5% dos profissionais já estão participando deste processo e assunto pertinente, e 54,5% dos nossos profissionais precisam ser inseridos para agregar valor e favorecerem a educação dos nossos alunos, e o processo de ensino em sala de aula em contexto neurológico de aprendizagem e entendimento pessoal de aprendizagem e o contexto educacional assertivo e proveitoso.

Gráfico 9

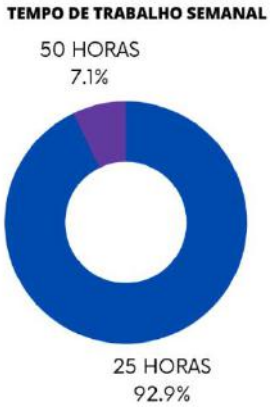


Gráfico 10

A maioria dos nossos profissionais atuam em nossa escola por (25 horas) neste turno matutino, sendo (25 horas) 92,9% dos nossos profissionais. E apenas 7,1% fazem dois turnos de trabalho com 50 horas semanal de trabalho

Evidencio que os profissionais, participantes dessa pesquisa possuem em sua maioria 50%, mais de 20 anos no processo pedagógico da sala de aula, onde conseguem visualizar a necessidade da neurociência no processo de ensino, facilitando a aprendizagem e direcionando o sucesso e construção do conhecimento.

Algumas Reflexões Acerca Das Respostas Das Professora sobre a Neurociência na Escola :

> "Sabe-se que a educação pautada no indivíduo lhe possibilita o alcance de condições favoráveis à sua efetiva participação social¨. (Distrito Federal, 2010, p. 15).

O que você entende por Neurociência aplicada na Educação na Escola?

Professor 1 – Os profissionais da educação compreendem com mais clareza o funcionamento do cérebro e suas ações. Assim, todos os alunos são capazes de aprender algo novo todo dia.

Professor 2 – Ampliar o motivo e comportamento do aluno e suas dificuldades.

Professor 3 – Ajuda na compreensão dos comportamentos de alunos com comprometimento neurológico.

Professor 4 – Entendo como algo que só vem para agregar, propor uma nova compreensão das nossas práticas pedagógicas.

Professor 5 – A Neurociência estuda como o cérebro aprende e que o cérebro tem plasticidade podendo ser moldado adaptado e sempre aprendendo com as experiências quando estimulado.

Professor 6 - estudar como o cérebro aprende, entender como se dão os mecanismos neurais da aprendizagem, memória, raciocínio, atenção etc. para podermos entender a aprendizagem dos nossos alunos.

Professor 7 – A maneira como o cérebro e as estruturas nervosas irão atuar no aprendizado escolar e posterio9r aplicação desse conhecimento.

Professor 8 – Acredito que pode ajudar a aprendizagem dos alunos.

Professor 9 – Aumentar a qualidade do aprendizado.

Professor 10 – Até o momento não tenho conhecimento do assunto.

Você acredita que a Neurociência aplicada a Educação, pode favorecer a aprendizagem dos alunos em sala de aula?

Professor 1 – Sim, na memória, motivação, atenção e emoção dos alunos através dos fatores que são capazes de estimular o sistema nervoso e a capacidade de aprendizado.

Professor 2 – Sim, entender o indivíduo com suas particularidades e trabalhar com ele de maneira peculiar.

Professor 3 – Sim, como os professores não tem formação para lidar com o público com comprometimento neurológico, a neurociência em colaborar para o professor entender melhor o aluno com comprometimento neurológico.

Professor 4 – Sim, como educadores conseguimos compreender com mais clareza como funciona o cérebro e o sistema nervoso. Podendo mudar as nossas práticas para desenvolver melhor os alunos.

Professor 5 – Sim, a neurociência pode favorecer muito a aprendizagem dos alunos, pois ela olha o potencial dos alunos e não justifica suas impossibilidades, pois de acordo com estímulos adequados as crianças conseguem desenvolver.

Professor 6 – Sim, porque a partir do momento que entendemos como funciona a aprendizagem no cérebro, poderemos ajudar nossos alunos com o raciocínio, memória etc., favorecendo a aprendizagem dos nossos alunos.

Professor 7 - Sim, acredito que temos que compreender o funcionamento do sistema nervoso de uma forma individual e assim, trabalhar com essa informação (deficiências ou não) para melhorar a aprendizagem do aluno.

Professor 8 – Sim, quando conseguimos entender o aluno as suas dificuldades poderão ser ajudadas.

Professor 9 – Sim, pelos conhecimentos já constituídos ao longo do tempo, o cérebro pode responder positivamente.

Professor 10 – Sim, devido aumentar potencialmente a qualidade do aprendizado. Através dos conhecimentos constituídos acerca da forma como o cérebro funciona.

Na sua opinião a "Educação Curricular' merece ser acrescida do assunto "Neurociência Aplicada em Sala de Aula", Sim, não e Por que?

Professor 1- Sim, para melhor atendermos os nossos alunos.

Professor 2 – Sim, para trabalhar e atender o aluno de maneira particular.

Professor 3 – Sim, por falta de informação e formação para o professor regente lidar com situações neurológicas ligadas a sala de aula.

Professor 4- Sim, pois criaria oportunidade de mudar o currículo conforme as necessidades dos alunos.

Professor 5 – Sim, pois até mesmo pessoas com lesões cerebrais conseguem se recuperar com estímulos corretos. Crianças com dificuldades também desenvolvem com estímulos adequados.

Professor 6 – Sim, porque o uso da neurociência aplicada em sala de aula pode estimular os alunos, facilitando a aprendizagem dos mesmos.

Professor 7 – Sim, porque acredito que tudo aquilo que pode ser usado á favor da melhor aprendizagem merece um olhar clínico para a possível inclusão no currículo.

Professor 8 – Sim, para podermos ensinar melhor.

Professor 9 – Sim, acredito que seja uma maneira mais significativa e fácil de desenvolver o aprendizado.

Professor 10 – Sim, porque com o estímulo do cérebro ele vai desenvolver mais.

IX. CONSIDERAÇÕES FINAIS

O mercado de trabalho está a todo vapor. Os profissionais estão cada vez mais se especializando e se atualizando para garantir um bom posicionamento. Neste cenário, a formação continuada é uma das principais ferramentas de sucesso.

Antigamente, somente com um diploma de graduação era possível conseguir excelentes cargos. Hoje, a exigência é maior, devido à grande concorrência de mercado. As empresas buscam desesperadamente os melhores profissionais para os cargos de maior impacto.

A educação de qualidade é o caminho certo para o futuro do país. Sendo assim, a formação pedagógica do corpo docente é fundamental para a preparação e desenvolvimento social.

O modo de aprender também está em constante evolução. E atualmente, mais do que nunca, a tecnologia está fazendo parte do aprendizado. Desta maneira, os profissionais educadores também precisam se atualizar cada vez mais.

As necessidades e demandas das escolas do futuro, exigem um processo de melhoria contínua, conhecimentos avançados e metodologias específicas para entregar um trabalho de qualidade que exige o cenário.

Veja abaixo mais alguns benefícios da educação continuada para o corpo docente e como isso pode impactar na educação:

- Planejar e organizar novas metodologias de ensino
- Analisar e identificar os principais obstáculos no ensino de qualidade
- Ampliar o processo de gestão de classe
- Aderir a novas ferramentas de ensino, a exemplo das tecnologias e outras mídias
- Participar da gestão da escola, visando a melhoria na qualidade de ensino
- Criar um processo de ensino mais atrativo e envolvente para os alunos, garantindo maior engajamento das aulas
- Ampliação de conhecimentos em várias áreas e disciplinas

Antes de mais nada, é importante que o educador realize uma auto avaliação, listando suas maiores competências, habilidades e nível de conhecimento. Em paralelo, listar seus maiores objetivos como educador. Isso ajudará na evolução do professor tanto no meio profissional quanto pessoal.

Pudemos perceber que a educação continuada vai além de somente atualização. Quando falamos em educação continuada, temos 4 aspectos que chamam a atenção: A formação de qualidade; O futuro consistente de uma profissão; O auto desenvolvimento; A Ampliação de competências.

Diante de um mercado com cenário cada vez mais veloz, o educador precisa sempre buscar uma formação continuada para evoluir e contribuir cada vez mais no seu campo de trabalho.

Da mesma forma os alunos precisam se atualizar e desenvolver habilidades que o mercado procura. Se lhe restou alguma dúvida, deixe abaixo nos comentários que em breve lhe retornaremos e não esqueça de compartilhar estas informações super importantes.

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Study evaluating the ability of Fe-BDC-PEG to carry and release active ingredient 5-fluorouracil

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***Keywords*— Metal-organic framework, 5 Fluorouracil, drug carrier, ultrasonic method.**

***Abstract*—** *This paper presents the results of 5 fluorouracil carrying-release of iron (III) framework materials with two ligands of 1,4-benzene dicarboxylic acid and polyethylene glycol diacid synthesized by ultrasonic bath method at room temperature. Materials were characterized, and their properties by scanning electron microscopy (SEM) and infrared spectroscopy (FT-IR) techniques showed that the active ingredient was fully adsorbed into the structural framework of the material without changing the shape and size of the material. The evaluation results for the 5-fluorouracil carrying capacity of Fe-BDC-PEG two-ligand Fe-BDC-PEG framework material showed that the drug absorption capacity reached 358.707 mg/g. The slow-release characteristics of the material were also evaluated, indicating that the effective release of the active ingredient came to 94.42% after 7 days, and the maximum after 10 days reached 97.68%. The Fe-BDC-PEG@5-FU drug carrier material system is studied to orient the application of cancer treatment when minimizing side effects based on the slow release of the system.*

I. INTRODUCTION

Metal-organic framework materials (MOFs) are the self-assembly of metal ions as coordination centre and organic ligands as bridges between metal centre [1]. Currently, MOFs have been attracting attention because of their potential applications. In particular, iron(III)-organic framework materials, with advantages such as pore size and large surface area, low toxicity... [2], have been applied in many fields such as catalysis, 3], adsorption [4], sensing [5] and biomedicine [6]. Many methods have been used to synthesize iron(III)-organic framework materials such as hydrothermal, microwave, ultrasonic [6-8] …

5-fluorouracil is a widely used antineoplastic drug treating many malignancies [9]. The mechanism of action of this drug is based on the irreversible inhibition of the enzyme thymidylate synthase and, at the same time, induces incorrect synthesis in cancer cells belonging to the group of anti-metabolites. However, it has the disadvantage of a short half-life and low stability in the biological environment [10], which requires an efficient drug delivery-carrying system to overcome. One of the potential applications of iron(III)-organic framework materials is in drug conduction-carrying-drug delivery due to their biocompatibility and ability to absorb large amounts of drugs. Its capability has been demonstrated with many drugs such as busulfan, doxorubicin, ibuprofen, aspirin, etc. [11-14]

This paper presents research results on the 5-fluorouracil carrying and releasing capacity of iron(III)-organic framework materials with a mixture of 2 ligands, 1,4-benzene dicarboxylic acid (H_2BDC) and polyethylene glycol di-acid synthesized by ultrasonic technique at room temperature, orienting its application in cancer treatment.

II. EXPERIMENTS

- Chemicals: Polyethylene glycol 250 di-acid, 1,4-benzene dicarboxylic, iron (III) chloride, dimethyl-formamide,

ethanol, 5-fluorouracil, phosphate buffered saline, all according to Sigma-Aldrich USP standards.

- Tools and equipment: Ultrasonic tank; Ketong-101 heating cabinet; Hittech high-speed centrifuge (Netherlands); Philip dry air dryer (Taiwan).

- Synthesis of Fe-BDC-PEG materials: Dissolve 1.35 g $FeCl_3.6H_2O$ (5.10^{-3} mol) in 25 ml of DMF in a 200-ml plastic beaker, and stir well; Add 0.42 g of H_2BDC dissolved in 100 ml of DMF, and add 0.5 ml of polyethylene glycol 250 di-acid. Transfer the entire solution to a plastic beaker containing FeCl3, and react in an ultrasonic bath for 2 hours; Centrifuge to remove the solids in the mixture after the reaction. Wash the product with DMF solvent at 50°C after 30 minutes of soaking. Rinse with a water/ethanol mixture solvent (1:1 ratio). Dry the product at 80°C for 6 hours.

- Characterization of materials: Determination of functional groups and material formation through FT-IR infrared spectroscopy on Bruker instrument. Morphology and size of materials through scanning electron microscopy (SEM) imaging. Material surface parameters by N_2 isothermal adsorption method (BET) on TriStar II Plus 2.03 physical adsorption device.

Determination of drug-carrying capacity of the material: 0.01g empty Fe-BDC-PEG was soaked in 10 ml of 5-FU 1 g/l active ingredient solution for 72 hours. A centrifuge separates the material from the solution and determines the concentration of the 5-FU solution after the material has been removed the drug from the solution. On the other hand, soak the material after loading the drug in 10 ml of PBS solution at 37 °C after different times, filter and separate the material and determine the concentration of 5-FU. Measure UV-Vis spectrophotometer for PBS solution immersed in drug carrier at λ_{max} = 265 nm on the Drawell DV-8200 device. The 5-FU standard curve equation built through the dependence of light absorbance on the concentration of the solution at wavelength λ = 265 nm is C = 4.69*Abs + 1.003 (R^2 = 0.9918).

III. RESULT AND DISCUSSION

3.1. Characterization

The morphology of the materials before and after the 5-fluorouracil application, as observed through scanning electron microscopy (SEM) images, is shown in Figure 1 below, indicating that the material before and after the 5-FU application has a small size. The size and morphology are almost unchanged, and the morphology is in the form of long grains with a length between 100-120 nm and a grain diameter of about 15-20 nm. The difference observed through SEM images is that the drug-loaded material tends to cluster together. That may be because, in addition to the bonding force between the crystals of the material, there is also the formation of bonds between the drug molecules and the crystals of the frame material.

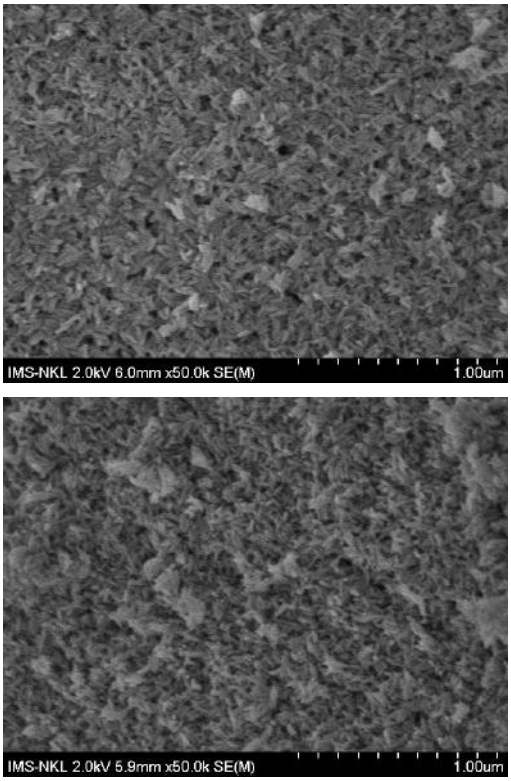

Fig 1. SEM images of Fe-BDC-PEG samples before (left) and after (right) when carrying 5-fluorouracil at 10,000x magnification.

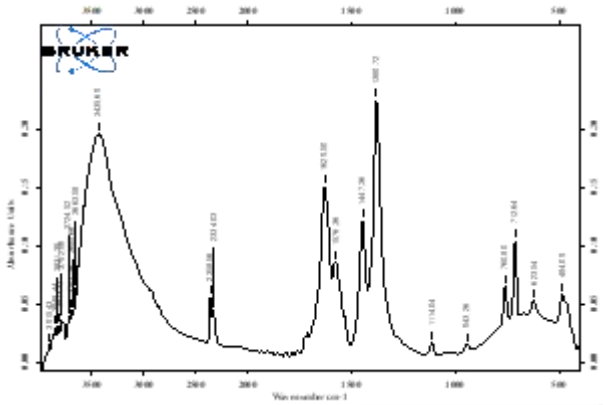

Fig. 2. FT-IR spectra of Fe-BDC-PEG material samples after carrying (adsorption) 5-fluorouracil.

Figure 2 showed the FT-IR spectra of 5-fluorouracil loaded Fe-BDC-PEG in the range of 400-4000 cm^{-1}. The

IR spectrum almost did not show the presence of the 5-FU molecule in the drug-loaded Fe-BDC-PEG except peak at 2358.56 cm^{-1}. However, some small shifts of the peaks can be related to the interaction between Fe-BDC-PEG and 5-FU without participating in forming the bond, only shifting the vibration of the bond. This can be predicted that 5-FU has entered the material's pores; the rest is attached to the surface in small amounts, so there is not enough strength to detect the vibration of the bonds.

The surface characteristics of the materials were evaluated through the N_2 adsorption isotherm method, resulting in the surface area, volume, and pore diameter being 108.967 m^2/g; 0.192 cm^3/g; 7,069 nm, respectively. With this characteristic, the material is promising for carrying high-capacity organic substances.

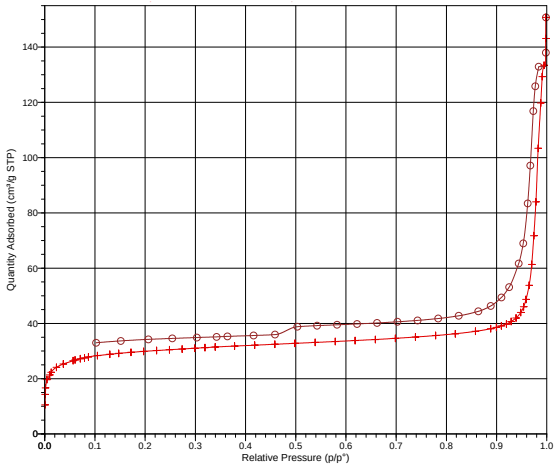

Fig. 3. N_2 isotherm adsorption curve of Fe-BDC-PEG materials.

3.2. The carrying capacity of 5-fluorouracil

The ability to carry the active ingredient 5-FU was assessed through the maximum adsorption capacity after the drug loading process of 72 hours by the UV-Vis photometric method.

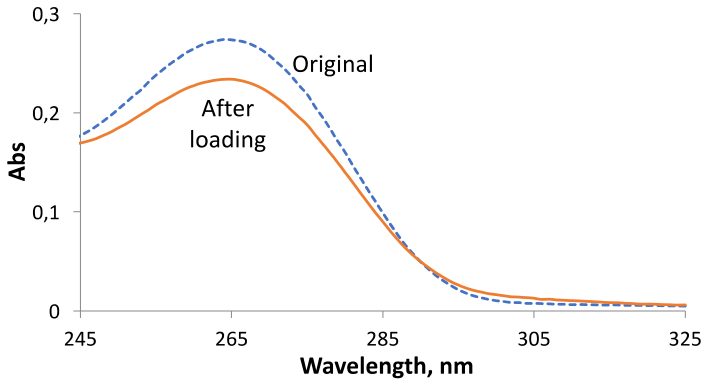

Fig. 4. UV-Vis spectrum of 5-FU solution after drug loading and soaking Fe-BDC-PEG material.

Table 1. UV-Vis photometric results of 5-FU solution after drug loading and soaking Fe-BDC-PEG materials.

	Original solution	Soaking solution
C (dilute 30 times), mg/l	32.599	14.686
C, mg/l	977.984	619.278
q, mg/g	-	358.707

The results of determining the concentration of 5-FU in the dipping solvent of the drug carrier material gave a value of 11.407 mg/l, corresponding to the maximum drug loading capacity of the Fe-BDC-PEG material:

$$Q_{max} = C*V/m_{Fe\text{-}DBC\text{-}PEG} = 358.707\ mg/g.$$

Which in:

- C is the difference in concentration of -FU solution before and after adsorption with Fe-BDC-PEG material, the value determined from the UV-Vis photometric analysis method.

- V is the volume of 5-FU solution used to soak the material: 10 ml ~ 0.01 litter.

- $m_{Fe\text{-}BDC\text{-}PEG}$ is the mass of material used for 5-FU adsorption: 0.01 g.

The results obtained from the determination of the concentration of 5-FU after filtration and separation of materials are much different from the results of soaking, possibly because the concentration of the initial solution is relatively high (1 g/l), so when mixed Dilution with a high coefficient (30 times) for analysis will have a particular error. The solution obtained after letting the adsorbent material shows that Fe-BDC-PEG material can carry the 5-fluorouracil load with relatively high capacity, quite similar to similar material lines like MIL-53(Fe), MIL-88(Fe), MIL-100(Fe) are all capable of carrying 5-fluorouracil with capacities from 160 to 300 mg/g [15]. The results showed that the MIL-53 (Fe), MIL-88 (Fe), and MIL-100 (Fe) are capable of carrying 5-FU with a capacity exceeding 0.131 g/g, 0.28 g/g, and 0.66 g/g.

3.3. Ability to release 5-fluorouracil

Fe-BDC-PEG@5-FU carrier material was immersed in PBS living body simulation solution for different periods at the rate of 0.01g of material in 10 ml of PBS solution. The concentration of 5-FU in the ten times diluted solution was determined by UV-Vis photometric method, giving the results in Table 2 below:

Table 2. *5-FU concentration in PBS solution after different soaking times.*

TT	t, hours	C_t, mg/l	Q, mg/g	Release performance, %
1	1	113.442	113.442	31.63
2	4	114.286	114.286	31.86
3	8	143.035	143.035	39.88
4	12	158.935	158.935	44.31
5	18	168.150	168.150	46.88
6	24	186.150	186.150	51.95
7	72	238.852	238.852	66.59
8	120	291.755	291.755	81.34
9	168	338.702	338.702	94.42
10	240	350.380	350.380	97.68

The survey results on Fe-BDC-PEG's ability to carry and release drugs show that the material can hold and release drugs in a simulated living environment. The active ingredient was removed from the material structure frame after 1 hour, achieved a release efficiency of 31.63%, then continued to release slowly. The drug release rate was relatively fast in the early days, and the drug release efficiency reached 94.42% of the carrier capacity after seven days. However, the drug release rate decreased significantly in the last few days, and the drug release efficiency was 97.68% after ten days. At this time, the amount of medicine left in the material frame is almost gone.

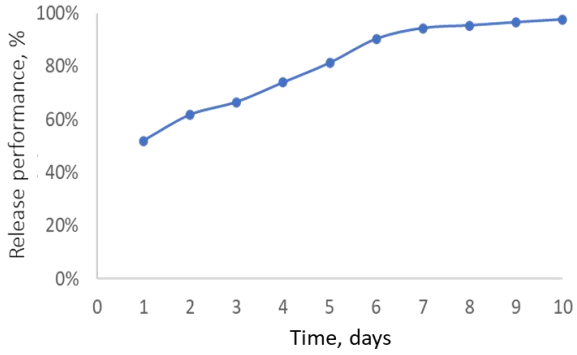

Fig.5. Slow release capacity of 5-FU over time of Fe-BDC-PEG@5-FU carrier material system.

IV. CONCLUSION

Fe-BDC-PEG materials synthesized by ultrasonic method at room temperature have a grain-like morphology with a grain size of about 15-20 nm in diameter and 100-150 nm in length. The material can carry the active ingredient 5-fluorouracil with a carrying capacity of 358.707 mg/g. The effective release of active ingredients reached 94.42% after 7 days, and the maximum after 10 days reached 97.68%. With these results, the Fe-BDC-PEG material is one of the optimal choices for use as a drug carrier for the active ingredient 5-fluorouracil in cancer treatment. The technique of material synthesis and the simple impregnating process of carrying active ingredients from cheap precursors is one of the advantages of choosing this family of compounds for application in therapeutic pharmaceuticals.

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Detection and Control of Bacterial Biofilms

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Abstract— *A biofilm is a clump of bacteria living in a self-produced matrix of extracellular polymeric substances (EPS) linked to a biotic or abiotic surface, indicating that biofilms can exist on a variety of biotic and abiotic surfaces. Abiotic surfaces include floors, walls, drains, equipment, and food-contact surfaces, as well as biotic surfaces like meat, the oral cavity, the intestine, the urogenital tract, and the skin. Humans are a good source of biotic microenvironments for biofilm and bacterial growth, which leads to infectious diseases in most cases. The optimum biotic environment for bacteria to thrive requires a supply of nutrients, humidity, and the right temperature. Biofilms originate on inert surfaces or dead tissue, and they're frequent on medical devices and dead tissue fragments, but they can also form on living tissues. Biofilms' tolerance to harsh environments provides a favorable habitat for microbial populations, allowing for a more efficient flow of chemicals and information amongst microorganisms. As a result, biofilm resistance is a self-protective strategy for microbial development. Bacterial biofilms are detectable by direct and indirect methods and they could be controlled. Bacterial biofilm is a major cause of antimicrobial-resistant bacteria's development and spread, causing severe infections and increased mortality rates.*

I. BACKGROUND TO THE STUDY

Biofilms are complex bacterial communities, which are embedded in a self-produced extracellular matrix (ECM). These biofilms play a crucial role in various fields, including medicine, food, and industry, where they can lead to the development of persistent infections, reduced efficiency in industrial processes, and contamination of food products. Therefore, the detection and control of bacterial biofilms are of utmost importance. This review provides an overview of the latest research on the detection and control of bacterial biofilms.

Detection of bacterial biofilms can be challenging, as they are often hidden and difficult to visualize. However, various techniques have been developed to detect bacterial biofilms, including microscopy, staining, and molecular methods. Microscopy techniques, such as confocal laser scanning microscopy (CLSM), can provide high-resolution images of the biofilm structure, and can also be used to detect the presence of specific bacterial species within the biofilm (Sandeep *et al.*, 2018). Staining techniques, such as crystal violet staining, can also be used to visualize biofilms, but they are less specific than microscopy techniques (Muthuirulandi *et al.*, 2020). Molecular methods, such as polymerase chain reaction (PCR) and fluorescent in situ hybridization (FISH), can be used to detect specific genes or bacterial species within the biofilm (Loo *et al.*, 2020).

The control of bacterial biofilms can be challenging, as they are resistant to conventional antimicrobial treatments. Therefore, alternative strategies have been developed to control bacterial biofilms. One such strategy is the use of

antimicrobial peptides (AMPs). AMPs are small peptides that can penetrate the biofilm matrix and disrupt bacterial cell membranes, leading to cell death (Kim *et al.*, 2019). Another strategy is the use of quorum sensing (QS) inhibitors. QS is a communication mechanism used by bacteria to coordinate gene expression within the biofilm. QS inhibitors can interfere with this communication, preventing the biofilm from forming or reducing its virulence (Alharbi *et al.*, 2020). Additionally, physical methods, such as ultrasonication and photodynamic therapy (PDT), have also been used to disrupt bacterial biofilms (Lebeaux *et al.*, 2014).

The detection and control of bacterial biofilms are important for the prevention of infections, food contamination, and industrial inefficiencies. Various techniques have been developed for the detection of bacterial biofilms, including microscopy, staining, and molecular methods. Alternative strategies, such as the use of AMPs, QS inhibitors, and physical methods, have also been developed for the control of bacterial biofilms. These strategies offer promising avenues for the development of new antimicrobial treatments and the prevention of biofilm-related problems in various fields.

II. DETECTION OF BACTERIA FORMING BIOFILMS

Biofilms generated by bacteria have been detected using a variety of approaches (Boakye *et al.*, 2019).

2.1 Direct observation

Biofilm imaging optical technologies such as light microscopy, SEM, TEM, and CLSM can be used to investigate the complexity and dynamics of biofilms. These methods are used to visualize 3D structures and determine whether or not biofilm exists.

2.1.1 Light microscopy

Light microscopy is the simplest, cheapest, most convenient, and fastest method for quantitatively observing the morphology of microorganisms adhering to surfaces and semi-quantitatively estimating the amount of microorganism adherent on surface (exist, absent, abundant, rare, etc.). Bacteria species such as *Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus epidermidis* have been spotted using a light microscope on acrylic sheets of polymethacrylate films, glass cover slips, and polystyrene petri dishes. To improve the visual clarity of microorganisms, dyes such as epifluorescence and fluorescent can be utilized. Making a smear and centrifuging a sample, respectively, allows researchers to examine the morphologies of sessile and planktonic microorganisms using a light microscope (Kirmusaoglu, 2019).

2.1.2 Transmission electron microscope (TEM)

Due to photons and electrons penetrating cells weakly, thin section of cell cut is stabilized and stained by particular chemicals with the treatment of osmic acid, permanganate, uranium, lanthanum, or lead salts. These stains have a lot of atomic weight. If the exterior structure of cells is being observed, it makes little difference whether the cell section is thin or thick. Water content of biofilm is eliminated by graded dehydration with alcohol. Followed by resin infiltration, then the sample is encased in a gelatin capsule and sent to polymerization. After, thin section taken is post stained with uranyl acetate and lead citrate. At the end of all these stages, the material is examined using TEM ((Kirmusaoglu, 2019).

2.1.3 Scanning electron microscope (SEM)

SEM, a high-resolution technique based on surface scattering and electron absorption, is used to view biofilms because it can detect crucial structural components such as the presence of biofilm matrix (Bossu *et al.*, 2020). SEM is comparable to TEM, in SEM processing, instead of infiltration with resin, embedment in gelatin capsule, and staining with lead citrate and uranyl acetate like in TEM processing, the stage after dehydration is drying and coating the sample with gold. The sample is dried and coated with gold palladium after being dehydrated with graded alcohol. After all of these stages have been completed, the sample is examined using a scanning electron microscope (SEM) (Kirmusaoglu, 2019). However, SEM is a costly technology, and quantifying the biofilm is difficult, especially when researchers are unable to deal with live samples.

2.1.4 Florescent tagging of biofilm

2.1.2 Confocal laser scanning microscopy (CLSM)

CLSM is the most widely utilized approach for studying the 3D morphology of biofilm and it is used to investigate biofilms grown on flow cells with clear surfaces. For confocal microscopy and related methods, biofilm must be fluorescent due to fluorescent molecules such as green fluorescent protein (GFP), a fluorescent protein expressed by biofilm producer microorganisms within biofilm. Deep penetration of excited energy is achieved by scanning laser light across the sample. A 3D digital image is created by the fluorescence of intrinsic fluorophores such as GFP or chlorophyll, or molecules signaled by foreign probes such as fluorescent-labeled antibodies detected by a photomultiplier. CLSM screens the tridimensional shape and physiology of biofilms using a mix of molecular probes and fluorescent proteins that are designed to target and

visualize biofilm components. The majority of fluorescent proteins and probes are made to label cellular organelles and structures (Cruz *et al.*, 2021).

2.1.3 Fluorescent in situ hybridization (FISH)

The probes of the fluorescent in situ hybridization (FISH) technology can be used to identify specific bacteria present in a heterogeneous biofilm ecosystem. FISH can also be used to study fluorescently labeled bacteria within biofilm. Labeled DNA probes hybridize to their complementary nucleic acid targets in FISH. Kirmusaoglu (2019) states that a probe must be constructed to designate only a single species' conserved region. Peptide nucleic acid fluorescence in situ hybridization (PNA FISH) is also used to investigate the structure and composition of biofilms because it allows the use of several fluorescent probe labels that are distinctive of a single microbe. The PNA FISH technique is very useful for CLSM monitoring of mixed biofilms (Cruz *et al.*, 2021).

2.1.5 Nuclear magnetic resonance (NMR) spectroscopy

Nuclear magnetic resonance (NMR) spectroscopy is a technique for examining intractable and complex macromolecular and entire cell systems within biofilms. The NMR signal produced by excitation of the nucleus sample with radio signals is recognized with sensitive radio waves, and the biofilm sample is placed in a magnetic field. Because NMR examination of solids needs a dedicated magic angle spinning machine and may not produce similarly well-resolved spectra, the biofilm sample should preferably be dissolved in a solvent. NMR's timescale is relatively long, making it unsuitable for viewing quick processes, as it only produces an averaged spectrum (Nazir *et al.*, 2019).

2.2 Indirect observation

2.2.1 Roll plate method

On the outside surface of cylindrical materials such as catheters and vascular grafts, the roll plate method is used to detect suspected microbial colonization with the potential to cause indwelling device-associated infection. Microorganisms colonizing the catheter's external surface are discovered using the roll plate approach, rather than microorganisms colonizing the catheter's intraluminal location. (Kirmusaoglu, 2019) Material is touched and rolled on the medium's surface.

2.2.2 Congo red agar (CRA) method

The Congo red agar (CRA) method is a qualitative assay for detecting biofilm producer microorganisms based on the color change of injected colonies on CRA media. Congo red of 0.8 g and 36 g of sucrose are added to 37 g/L Brain heart infusion (BHI) agar to make the CRA medium. The sample to be observed is inoculated on the agar plate and incubated. The morphology of colonies with distinct colors classified as either biofilm producers or not is observed after a 24-hour incubation period at 37 °C. Biofilm producers have black colonies with a dry crystalline consistency, whereas non-biofilm producers have pink colonies (Kirmusaoglu, 2019).

2.2.3 Tube method (TM)

Tube method (TM) is a qualitative assay for detecting biofilm producer microorganisms when visible film is present. Isolates are inoculated in polystyrene test tube which contained Tryptic soy broth (TSB) and incubated for 24 hours at 37 °C. Planktonic cells are discharged by rinsing twice with phosphate-buffered saline (PBS) and sessile isolates with biofilms developed on the walls of polystyrene test tubes are stained with safranine for 1 hour. The stain is then removed by rinsing the safranine-stained polystyrene test tube twice with PBS. Visible film lining the walls and the bottom of the tube after the test tube process was air dried will be observed and this suggests biofilm development (Kirmusaoglu, 2019). The tube approach has the benefit of allowing the formation of a large biofilm mass that may be harvested simply by scraping the tube. One use for the technique could be to quantify the effect of antibacterial agents on biofilms by counting colony forming units recovered from tubes before and after treatment with the agents of choice (Nazir *et al.*, 2019).

2.2.4 Micro titer plate assay

The micro titer plate assay is a quantitative approach that uses a microplate reader to detect biofilm production. Bacterial suspension is prepared in Mueller Hinton Broth (MHB) which is supplemented with 1% glucose and adjusted to 0.5 McFarland (1×10^8 CFU/mL). This bacterial solution is diluted 20 times (1/20) to yield 5×10^6 CFU/mL. Then, 180 μL of MHB supplemented with 1% glucose and 20 L of bacterial suspensions are injected into a 96 well flat-bottomed sterile polystyrene microplate to reach a final concentration of 5×10^5 CFU/mL (tenfold dilution (1/10)). At 37 °C, the microplates are incubated for 24 hours. After planktonic cells in wells of microplate are discharged by washing twice with phosphate-buffered saline (PBS) and the wells are dried at 60 °C for 1 hour, sessile isolates with biofilms developed on the walls of wells of microplate are stained with only 150 L of safranine for 15 minutes. After that, the safranine-stained microplate wells are rinsed twice with PBS to remove the safranine stain. The dye of biofilms that lined the walls of the microplate is resolubilized by 150 L of 95 percent ethanol or 33 percent glacial acetic acid or methanol after air drying the wells of the microplate. A microplate reader then measures the microplate spectrophotometrically at 570 nm. The experiments are carried out three times. The blank absorbance readings are used to determine whether or not isolates develop biofilms.

Biofilm producers are isolates with optical density values greater than the blank well (Kirmusaoglu, 2019).

2.2.4 Detection of biofilm-associated genes by polymerase chain reaction (PCR)

PCR techniques are employed not only to identify infections by amplifying species-specific nucleic acid sequences, but also to detect virulence factors by amplifying target virulence genes such as biofilm genes using gene specific primers, even in the presence of an uncultured pathogen. Biofilm-associated gene forward and reverse primers are used. PCR, such as qualitative real-time PCR, multiplex, and conventional PCR, is used to detect whether biofilm-associated gene is present or not in microorganisms. The PCR result is seen on an agarose gel containing a DNA intercalating dye such as ethidium bromide to confirm the presence of amplified gene. The amplicon is only recognized by fluorescence in qualitative real-time PCR employing a pair of particular hybridization probes tagged with fluorescent dye (Kirmusaoglu, 2019).

2.2.5 Tissue culture plate method

Organisms are injected in 10 mL of TSB with 1% glucose after extraction from fresh agar plates. At 37 °C, the broths are incubated for 24 hours. The cultures are then diluted at 1:100 in fresh media. A 200-L portion of the diluted cultures are placed in individual wells of sterile 96-well flat bottom polystyrene tissue culture treatment plates. The organisms in the control group are also incubated, diluted, and added to a tissue culture plate. Inoculated sterile broth serves as the negative control wells. At 37 °C, the plates are incubated for 24 hours. The contents within each well are carefully tapped out after incubation. A 0.2-mL quantity of PBS is used to wash the wells four times. This eliminates the floating microorganisms. The biofilm generated by bacteria adhering to the wells is preserved with 2 % sodium acetate and stained with crystal violet (0.1 percent). The excess stain is washed with deionized water, and the plates is set aside to dry. The optical density (OD) of stained adherent biofilm is measured at 570 nm using a micro ELISA autoreader. The experiment is carried out three times, in duplicate (Hassan *et al.*, 2011).

III. CONTROL/ PREVENTION OF BACTERIAL BIOFILM FORMATION

For the safety of both non-medical and medical regions, a variety of microbial biofilm control approaches involving limited water and nutrient supply, controlled temperature, and well-designed apparatus are necessary. Disinfection and washing of surfaces where bacteria cling are the most common methods for preventing biofilm formation. Acidic chemicals, caustic products, aldehyde-based biocides, hydrogen peroxide, chlorine, iodine, ozone, isothiazolinones, phenolics, peracetic acid, surfactants, and biguanidines are all commonly employed in disinfection procedures. To disinfect and eliminate biofilms, mechanical therapy might be combined with chemical treatments (Tasneem *et al.*, 2018). Another method for preventing biofilm formation is to utilize small molecule biofilm inhibitors. A biofilm inhibitor's antibiofilm characteristics are frequently used to passivate the surface of an implanted medical device or biomaterial. A variety of biofilm inhibitors can be used such as phenols, imidazoles, furanone, indole, bromopyrrole and so on (Verderosa *et al.*, 2019).

Three major strategies for controlling biofilm formation or targeting different stages of biofilm growth have been discovered. The first strategy is to prevent bacteria from adhering to the biofilm-forming surface, the second strategy is to impede biofilm formation during the maturation process and the third strategy is to interfere with the bacterial communication system, also known as the quorum sensing (QS) system, which coordinates biofilm formation and maturation in bacteria (Subhadra *et al.*, 2018). Table 1 summarizes various antibiofilm techniques and agents used.

Table 1: Various strategies for the control of biofilms.

Strategy	Methods/Agents	Examples
Inhibition of initial biofilm attachment	(i) Altering chemical properties of biomaterials	(i) Antibiotics, biocides, iron coatings
	(ii) Changing physical properties of biomaterials	(ii) Use of hydrophilic polymers, super hydrophobic coatings, hydrogel coatings, heparin coatings
Removal of biofilms	(i) Matrix degrading enzymes	(i) Polysaccharide-degrading enzymes (Dispersin B, Endolysins); Nucleases (Deoxyribonuclease I) and Proteases (Proteinase K, trypsin)

	(ii) Surfactants	(ii) Sodium dodecyl sulfate (SDS), cetyltrimethylammonium bromide (CTAB), Tween 20 and Triton X-100, surfactin, rhamnolipids
	(iii) Free fatty acids, amino acids and nitric oxide donors	(iii) Cis-2-decenoic acid, D-amino acids, nitric oxide generators such as sodium nitroprusside (SNP), S-nitroso-L-glutathione (GSNO) and S-nitroso-N-acetylpenicillamine (SNAP)
Biofilm inhibition by quorum quenching	(i) Degradation of QS signals	(i) Lactonases, acylases and oxidoreductases
	(ii) Inhibition of signal synthesis	(ii) Use of analogues of AHL precursor S-adenosyl-methionine (SAM), S-adenosyl-homocysteine (SAH), sinefugin, 5-methylthioadenosine (MTA), butyryl-SAM; SAM biosynthesis inhibitor cycloleucine, AHL synthesis inhibitors such as nickel and cadmium
	(iii) Antagonizing signal molecules	(iii) AHL analogues (bergamottin, dihydroxybergamottin, cyclic sulfur compounds, phenolic compounds including baicalin hydrate and epigallocatechin); AI-2 analogues (ursolic acid and phenyl-DPD); AIP analogues (cyclic peptides such as cyclo (L-Phe-L-Pro) and cyclo(L-Tyr-L-Pro), RNAIII inhibiting peptide (RIP) and its homologues)
	(iv) Inhibition of signal transduction	(iv) Use of halogenated furanone or fimbrolide, cinnamaldehyde, virstatin
	(v) Inhibition of signal transport	(v) Use of copper or silver nanoparticles, Phe-Arg-β-naphthylamide (PAβN)

Source: Subhadra *et al.* (2018)

3.1 Plant-derived antimicrobial compounds

Many medicinal plants have long been used to heal a variety of ailments. Plant-derived chemicals are both safe and cost-effective, with no known negative effects. Monoterpenoids (such as borneol, camphor, carvacrol, eucalyptol, limonene, pinene, thujone), sesquiterpenoids (such as caryophyllene, humulene), and flavonoids (such as cinnamaldehyde and other phenolic acids) make up the majority of plant-based essential oils (Campana *et al.,* 2017). Some of these essential oils have antibacterial and antibiofilm effects (Goel *et al.,* 2021).

3.2 Enzymes

Because enzymes are biodegradable and have a minimal toxicity, they are considered green counter measures against biofilm formation. These characteristics make them an effective biofilm control technique. The generated biofilm is dispersed using enzymes. Examples include: Xylanase, alpha-amylase etc. Xylanase, a cell wall disintegrating enzyme, reduced biofilm development by 70% and dispersed the *Pseudomonas aeruginosa* PAO1 biofilm without impacting planktonic bacteria (Goel *et al.,* 2021).

3.3 Polysaccharides

Polysaccharides can be utilized to prevent the production of biofilms. Most anti-biofilm polysaccharides block biofilms throughout a broad spectrum, whereas others can disperse preformed biofilms. Antibiofilm polysaccharides could be a potential technique for the treatment and prevention of biofilm-related infections due to their non-biocidal mode of

action, biocompatibility, and biodegradability. Antibiofilm polysaccharides are thought to be useful as an adjuvant because they improve antibiotic activity when given combined (Kostakioti *et al.*, 2013).

3.4 Biosurfactants

Biosurfactants are natural chemicals that can change the hydrophobic properties of the bacterial surface. This changes the qualities of adhesion and binding to any given surface. Biosurfactants prevent biofilm development by altering cell adhesion ability through reduced cell surface hydrophobicity, membrane rupture, and inhibition of the electron transport chain which lowers cellular energy demands (Mishra *et al.*, 2020). *Pseudozyma aphidis* DSM 70725, which produces new biosurfactants, produces mannosyl erythritol lipids (MELs). MELs prevents *Staphylococcus aureus* biofilm development by inhibiting bacterial adherence to the surface (Goel *et al.*, 2021).

3.5 Nanoparticles (NP)

The use of nanoparticle coated medicines to dissolve biofilms could result in biofilm eradication. Multidrug-resistant and biofilm-associated illnesses can be treated with nanoparticles instead of antibiotics. The biofilm-NP interaction is a three-step process: (1) NP transport around the biofilm, (2) NP attachment to the biofilm EPS, and (3) NP penetration into the EPS and migration within the biofilm through diffusion, which may be influenced by biofilm pore sizes, charges, hydrophobicity, and the EPS chemical gradient. AuNPs (gold nanoparticles), NO NPs (nitrous oxide-releasing nanoparticles), and drug-delivery NPs with targeting ligands, for example, have the ability to improve closeness between individual biofilm cells within the EPS and the nanocarrier. Because of their versatility, biocompatibility, targeted/triggered release, and ability to integrate lipophilic and hydrophilic medicines, lipid and polymer NPs are gaining popularity (Ekundayo *et al.*, 2021; Shrestha *et al.*, 2022).

3.6 Antibiofilm agents

Antibiofilm agents are a group of substances that can prevent and eliminate the production of biofilms. Antibiofilm substances are mostly derived from natural sources, however chelating agents and synthetic compounds have also been discovered to have antibiofilm action. Plakunov *et al.* (2019) divided the agents into four categories based on their activities at different stages of biofilm development, as shown in Table 2 and Figure 1 below:

Table 2: Classes of antibiofilm agents and their functions.

Antibiofilm agent	Functions
Class I	penetrate the biofilm EPS and decrease the growth of cells
Class II	interfere with the adherence of bacteria and the formation of biofilm phenotype
Class III	controls both the growth of bacteria with biofilm phenotype as well as the EPS synthesis
Class IV	disperse the mature biofilms

Source: Shrestha *et al.* (2022)

3.6.1 Surface attachment inhibitors

Controlling surface attachment has the potential to inhibit the entire biofilm formation process. The suppression of adhesin and EPS molecules can also prevent biofilm development. Surfactants, which reduce the interfacial tension between two substances, are a popular option of antimicrobial agents for limiting bacterial attachment to surfaces. Surfactants are amphiphilic because they have both a hydrophilic and hydrophobic component, and they can be classified as non-ionic, anionic, cationic, or amphoteric. Tween 80 (Polysorbate 80) and Triton X-100 are two commonly used non-ionic, synthetically produced surfactants in laboratories. Microorganisms produce surface-active substances called biosurfactants, which are made up of structurally varied biomolecules (Nitschke *et al.*, 2007).

Quaternary ammonium compounds (QACs) are cationic surfactants that are employed as disinfectants in the food industry and in a variety of medical problems. QACs bind to microorganisms' negatively charged regions causing cell wall stress, lysis, cell death and promote protein denaturation which lowers food intake by affecting cell wall permeability. Several biosurfactants have antibacterial properties, and some even appear to inhibit infections from colonizing surfaces. Rhamnolipid an example of biosurfactant promotes biofilm dispersal in *P. aeruginosa*, *S. aureus*, *Salmonella enteritidis*, and *L. monocytogenes* (Shrestha *et al.*, 2022).

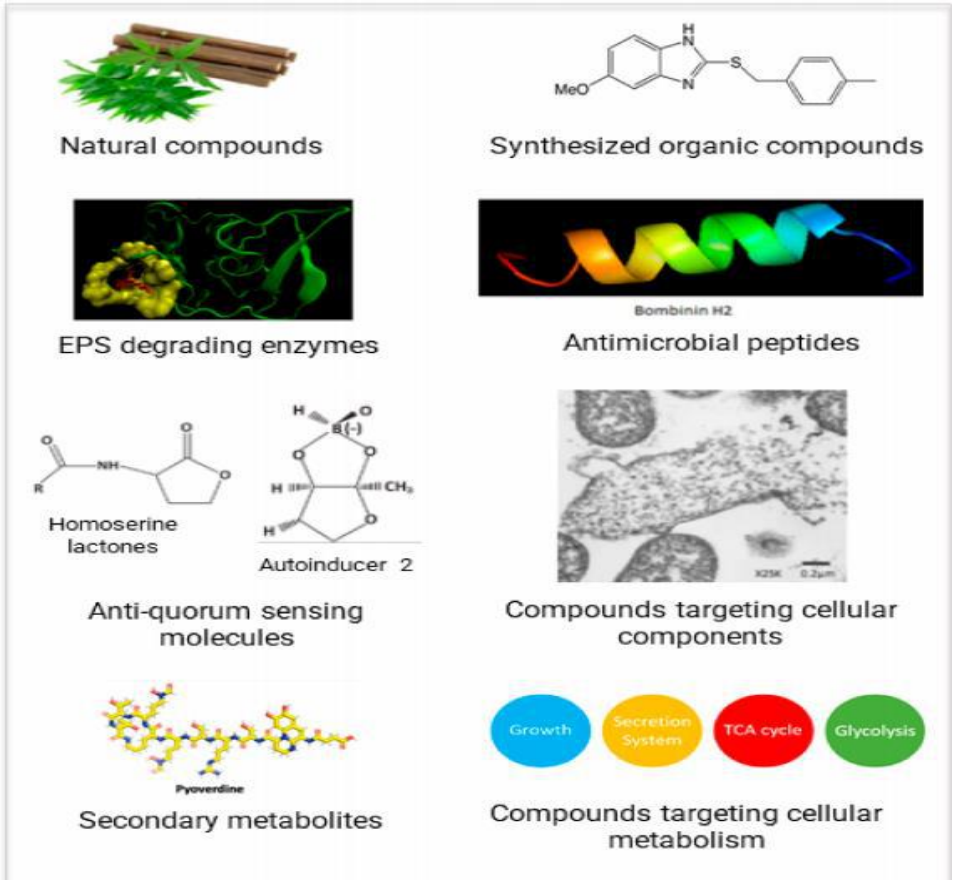

Fig.1: Antibiofilm agents

Source: Shrestha *et al.* (2022)

3.6.2 Compound inducing cell lysis

Biofilm formation may be inhibited by the breakdown of peptidoglycan, which affects the composition of teichoic acids and proteins on the cell wall and also releases signals that regulate genes involved in biofilm formation (Roy *et al.*, 2018). Transglycosylase and peptidoglycan hydrolases (endolysins) are enzymes that breach the cell wall and cause bacterial cell death. Chelating compounds like Ethylene diamine tetra acetic acid (EDTA) can damage cell walls, causing biofilms to break down by sequestering zinc, magnesium, iron, and calcium (Finnegan & Percival, 2015). As a result, bacteria can be combated early in the biofilm growth process by applying such chemicals (Shrestha *et al.*, 2022).

3.6.3 Anti-Quorum Sensing Molecules

Many natural and synthetic chemicals operate as anti-QS molecules, focusing on the QS signaling molecules, this is listed in Table 3. Ichangin and isolimonic acid are potent repressors of biofilm and the type III secretion system, as well as strong regulators of cell-to-cell signaling in bacteria. Cinnamaldehyde, another natural chemical, can decrease swimming motility and change biofilm structure and development especially in *Escherichia coli*. Hordenine, a strong phenylethylamine alkaloid derived from barley can reduce the production of the signaling molecule and impact biofilm development (Zhou *et al.*, 2018). At lower concentrations, plant polyphenols known as quercetin dramatically inhibit biofilm development and other virulence factors (Shrestha *et al.*, 2022).

Table 3: Natural compounds as anti-quorum sensing molecules in biofilm dispersal.

Compound/Molecule	Mode of Action	Effective Against
Garlic extracts	inhibits QS	*Pseudomonas aeruginosa*
Garlic extracts	inhibit LasR and LuxR	*Pseudomonas aeruginosa*
Querentin	decrease LasI/R, RhlI/R expressions	*Pseudomonas aeruginosa*

Isolimonic acid	cell-to-cell signaling	*Escherichia coli*
Isolimonic acid	reduce LuxR DNA binding	*Vibrio* spp.
Cinnamaldehyde	swimming motility	*Escherichia coli*
Hordenine	decrease in signaling molecule, inhibition of QS-related genes	*Pseudomonas aeruginosa*
Autoinducing peptide type I (AIP-I)	inhibit QS	*Staphylococcus aureus*
RNAIII-inhibiting peptide (RIP)	inhibit QS	*Staphylococcus aureus*

Source: Shrestha *et al.* (2022)

3.6.4 Synthetic Small Organic Molecules

The development of synthetic small organic compounds has created a new path for overcoming antibiotic tolerance and disrupting biofilms. Some imidazole and benzimidazole chemicals have the ability to both inhibit and disperse biofilms. By targeting eDNA, polysaccharide intercellular adhesion (PIA), and Protein A (SpA) expression (Shrestha *et al.,* 2016). The biofilm inhibitors indole-3-carboxaldehyde and 3-indolylacetonitrile chemicals reduce biofilm formation by inhibiting curli generation while leaving microbial growth unaffected. Biofilms are reported to be inhibited by brominated furanone derivatives in a variety of bacterial species.

3.6.5 Antimicrobial Peptides (AMP)

Antimicrobial Peptides (AMP) are cationic and hydrophobic residues that contain compounds that can interact with bacteria, fungi, protozoa, and some enveloped viruses. Some AMPs can suppress biofilm in a variety of pathogens at sub-minimal inhibitory concentrations (MICs), hence these peptides are known as antibiofilm peptides (ABPs). Cleavage of peptidoglycan, change of membrane permeabilization or membrane potential, neutralization or disassembly of lipopolysaccharides, inhibition of cell division and cell survival, modulation of adhesion molecule synthesis and function, and repression of the stringent response of bacteria are all antibiofilm effects of antimicrobial peptides (Andrea *et al.,* 2018; Roy *et al.,* 2018). Examples of AMPs are nisin, bovicin HC5, D-enantiomeric protease-resistant peptides, Peptide 1037 and so on. Peptide 1037 can inhibit biofilm formation by reducing swarming and swimming motilities, generating twitching motility, and suppressing numerous biofilm-related genes.

3.6.6 Compounds Targeting Metabolism

This agents or compounds inhibit biofilm formation by modifying it metabolism and affecting the bacterial biofilms genes. Examples are: tea tree oil which have antibacterial and antibiofilm effect against *Staphylococcus aureus*, and it can also modify its metabolism by changing the expression of genes involved in the pyrimidine, purine, glycine, serine, and threonine metabolism pathways, as well as the amino acid biosynthesis route. Exogenous amino acids, such as L-arginine, also inhibits biofilm development by suppressing the genes required for the creation of *Streptococcus mutans* biofilm EPS (Shrestha *et al.,* 2022).

3.6.7 EPS Degrading Enzymes for biofilm Dispersal

The use of EPS degrading enzymes such as amylase, Dispersin B (DspB), and DNase I to break down the EPS is a common antibiofilm approach which reduces biofilm development and degrades mature bacterial biofilms such as *Vibrio cholerae, Staphylococcus aureus* and *Pseudomonas aeruginosa* (Sun *et al.,* 2013). EPS degrading enzymes have the potential to be employed as an antibacterial agent in biofilm dispersal strategies.

3.6.8 Phage Therapy

Bacteriophages, commonly known as phages, are bacterial viruses that are bacteria's natural enemies. Many bacteriophages also produce depolymerases, which destroy the EPS in biofilms, making them excellent for biofilm targeting (Mishra *et al.,* 2020). Phage therapy uses lytic phages, which do not enter a prophage form and so rarely carry or transfer virulence genes, while causing rapid bacterial cell destruction (Kostakioti *et al.,* 2013). Some phages have hydrolytic enzymes on their surface that allow them to infiltrate the biofilm matrix and infect bacteria within biofilms. Bacteriophages have a number of characteristics that make them sensitive to biofilms. Bacteriophages like Sb-1 can boost antibiotic activity against biofilm (Shrestha *et al.,* 2022).

One advantage of phage therapy over antibiotic therapy is that it is considerably more targeted. In contrast to antibiotics, which can kill both harmful and beneficial bacteria in the stomach, a phage adheres to one specific bacterial strain while leaving others intact. At the same time,

the specificity of phage therapy may be a disadvantage because matured and naturally generated biofilms may be resistant to phage therapy (Shrestha *et al.*, 2022). However, there are still some drawbacks to using phages, such as the risk of bacterial resistance to phages, the possibility of unwanted horizontal gene transfers via lysogenic phages to share virulence-related genetic elements across the biofilm community, and phage immunogenicity, which can result in the human host producing neutralizing antibodies, which can lead to inflammatory side effects (Schulze *et al.*, 2021). Multiple bacteriophages can be mixed to generate a super phage mix, also known as a phage cocktail, to increase the action of phage against biofilms. Bacteriophages are extremely promising technologies for controlling or even eradicating bacterial biofilms (Luo *et al.*, 2021).

3.6.9 Photodynamic therapy

It makes use of photosensitizing compounds, which absorb light of a given wavelength and binds to target cellular components such as lipids, proteins, and nucleic acids. It generates reactive oxygen radicals, which in turn form hydrogen peroxide, hydroxyl radicals, and superoxide anion, killing or poisoning the target. For this type of mechanical elimination of biofilms using photodynamic treatment, the photosensitizer and light source used are critical. Methylene blue, toluidine blue, and toluidine blue O are some of the most commonly used photosensitizers (Sadekuzzaman *et al.*, 2015). Methylene blue has a wavelength of 664 nm, while toluidine blue has a wavelength of 638 nm, both of which are in the UV-visible range of 600-1000 nm. It has been discovered that the amount of time spent pre-radiating over the target has an effect on the microorganism's elimination (Srinivasan *et al.*, 2021).

3.6.10 Quorum quenching (QQ)

Quorum quenching (QQ) is the phenomena of the QS system being down-regulated or silenced. Suppression of QS signal molecule formation, signal sequestration, receptor antagonist, and inhibition of targets in the QS signal transduction pathway are all examples of QQ techniques (Srinivasan *et al.*, 2021). Chemistries, antibodies, and specialized enzymes can all be used to sequester signal molecules. For managing bacterial biofilm, peptide-based quorum sensing modulators are being actively explored, and this method looks to be more effective for gram-positive bacteria. Phytochemicals and plant by-products are two forms of anti-QS compounds that are very promising. Anti-QS agents are mechanistically sound, implying a novel class of biofilm-fighting compounds (Luo *et al.*, 2021).

Quorum quenching can be done at multiple levels utilizing different chemicals, such as preventing bacterial adhesion, inhibiting biofilm formation, or causing mature biofilms to disintegrate. Although quorum quenching does not kill germs, it does make them more susceptible to conventional treatments and can be used in conjunction with antibiotics (Schulze *et al.*, 2021). Anti-QS drugs can theoretically disrupt QS signaling and hinder biofilm formation because QS plays such a vital part in biofilm formation signaling. As a result, anti-QS drugs may be able to combat antibiotic resistance brought on by biofilm development (Luo *et al.*, 2021). Resistance to quorum sensing inhibitors (QSIs) can only emerge as a result of mutations that prevent QS-deficient bacteria from producing virulence factors; as a result, the bacteria become nonvirulent (Li *et al.*, 2020). Lactonase, acylase, oxidoreductase, and paraoxonase are all examples of quorum quenching enzymes found in bacteria.

The inactivation of acyl homoserine lactone molecules is the recognized mode of action of QQs (Sadekuzzaman *et al.*, 2015). Furanone, ajoene, naringin, musaceae, and curcumin are some of the natural QSIs that have been shown to suppress bacterial biofilm formation. Furthermore, the presence of a secondary messenger called c-di-GMP in high concentrations encourages bacteria to develop biofilms. As a result, blocking the c-di-GMP pathway could be a good technique to avoid biofilm formation (Muhammad *et al.*, 2020). Quorum quenchers, on the other hand, are usually species specific; thus, to eradicate mixed-species biofilms, a mixture of quenchers is required. In both Gram-negative and Gram-positive bacteria, ajoene, a sulfur-rich compound from garlic, reduces the expression of small regulatory RNAs (sRNAs) (Mishra *et al.*, 2020).

3.6.11 Electrochemical method

The electrochemical approach is one of the most interesting and promising strategies for preventing bacterial biofilm formation. The electrochemical technique, often known as the 'Bioelectric effect,' is the result of combining a lower dose of antibiotics with a mild electric field to disintegrate biofilm development or mature biofilm. The electric potential reduces the antibiotic dosage required to inactivate the biofilm and causes the biofilm organisms to die. The essential principle of the electrochemical method is that under direct current, electrostatic force enhances antimicrobial binding and transport towards the biofilm matrix, hence increasing biofilm detachment efficacy. The media undergoes hydrolysis as a result of the electric field, resulting in the release of charged ions and hyper oxygenation in response to heat stimuli (Srinivasan *et al.*, 2021).

Antibiotics usually have a difficult time penetrating the biofilm matrix. The antimicrobial agents cause the biocide ions to be released under the influence of the electrical field, which is ascribed to a change in biofilm permeability. The

biofilm is inactivated as a result of the entry of biocide ions into the biofilm matrix. Even at low concentrations, it kills bacterial cells by electrophoresis and electro-osmosis. Electrospray is another novel way for eliminating biofilms using the electrochemical technology. A sterile polymer surface devoid of biofilm is obtained by dispersing fluids from a high energy potential (Srinivasan *et al.*, 2021).

IV. BACTERIAL BIOFILM CONTROL IN DRINKING WATER DISTRIBUTION SYSTEM (DWDS)

The following are some strategies for limiting the formation of bacterial biofilms in the drinking water distribution system:

4.1 Pretreatment

This is accomplished by lowering the amount of organic matter entering the distribution system. Microbial growth is controlled by limiting the nutrients required for growth through more appropriate DW treatments (sedimentation, filtration, UV disinfection, ozone, and peroxide), i.e. the formation of biologically stable DW. Microorganisms require a 100: 10: 1 C: N: P (carbon, nitrogen, and phosphorous) ratio, with carbon being the growth-limiting nutrient. As a result, limiting the carbon content reduces the likelihood of microbial growth. Biofilm generation on pipe surfaces can be controlled or delayed using an aqueous suspension of silver nanoparticles as a pre-treatment in water systems prior to the main treatment units, such as membrane filtration (Simoes & Simoes, 2013).

4.2 Material selection

This ensures that the piping and fittings are built from materials that are chemically and biologically stable. The type and stability of the material used in DWDS can have a significant impact on biofilm proliferation. Biofilms develop at varying rates and have varied microbial community structures in different types of pipes. Iron pipes sustain 10 to 45 times greater growth than plastic pipes, and it is also more reactive to disinfectants and quenching their antibacterial properties. As a result, the type of material can have an impact on biofilm disinfectant efficiency. Biofilms grown on copper, Polyvinyl chloride (PVC), and cement lined ductile iron were inactivated with far less free chlorine or mono-chloramine than biofilms grown on unlined iron surfaces (Simoes & Simoes, 2013).

4.3 Hydrodynamics

This refers to the prevention of water stagnation and silt collection in distribution systems. Pipes with long water residence durations and dead-ends are linked to high organic material sedimentation zones and, as a result, profuse biofilm growth. Periods of non-flow or the storage of water in residential pipes or tanks are linked to high bacterial populations. To reduce sediment build-up in DWDS, operation measures such as pre-treatment optimization, minimizing particles in DW entering the network, the application of sufficiently high flow velocities that may result in a self-cleaning network, and regular flushing under specified conditions should be considered (Simoes & Simoes, 2013).

4.4 Chemical disinfection and alternate techniques

This refers to keeping a suitable level of disinfectant throughout the distribution system. Chemical disinfection, primarily with chlorine, and an increase in its residual content throughout the network are the key strategies for controlling biofilm growth in DWDS. Water disinfection is a technique for killing or inactivating microorganisms that have survived the treatment process and ensuring microbiologically safe water through the DWDS. This is accomplished by using excessive disinfectants, notably chlorine, to maintain a disinfectant concentration during water distribution, so preventing microbiological formation in pipelines and tanks (Simoes & Simoes, 2013).

A handful of pathogenic germs, however, are resistant to chlorine. Chloramines (less efficient than free chlorine and produces the same Disinfection byproducts (DBPs) as chlorine but in lesser levels), Ozonation, and UV radiation (electromagnetic energy in the range 250-265 nm) are examples of disinfectants that can be employed in DWDS. Physical (UV light) and chemical (chlorine and chlorine dioxide) treatments in combination are more effective in removing DW biofilms than either treatment alone (Simoes & Simoes, 2013).

4.5 Bacterial biofilm control in food industries

Biofilm generation is controlled in the food industry using a variety of physical means and chemical compounds, including within pipelines and on work surfaces. The prevention of biofilm formation in the industry is a critical step in achieving the goal of a safe and high-quality product. However, it is impossible to completely avoid or eliminate biofilm growth on food and in the food processing environment. In the food sector, bacterial biofilms are treated as follows:

4.5.1 Chemical Treatments

As a biofilm treatment, a variety of concentration- and time-dependent chemical sanitizers can be used. The goal is to lower microbial populations to safe levels for humans, which is known as sanitization. Food processing equipment must be sanitized in order to prevent cross contamination between batches of food. Chlorine-based sanitizers are most commonly employed in the food industry; however, some microorganisms have developed resistance to chlorine

treatments. Aqueous Chlorine dioxide (ClO_2) is the most extensively used sanitizer in the food sector (Nam *et al.*, 2014). In the food industry, quaternary ammonium compounds (such as Metaquats) are frequently employed as sanitizers, including for biofilm eradication. The bacterial cell membrane is disrupted by these positively charged water soluble chemicals, resulting in bacterial lysis (Jennings *et al.*, 2016). The clearance of biofilms generated by these resistant bacteria could be improved with a multi-faceted approach involving a mix of therapies. Other less prevalent sanitizers, such as salicylate-based polyanhydride esters can be used (Galie *et al.*, 2018).

4.5.2 Enzymatic Disruption

Because enzymes are biodegradable and have a minimal toxicity, they are considered green countermeasures against biofilm formation. They are commonly employed in detergents for food industry applications because of these characteristics, which make them an effective tool for biofilm reduction. Pectin methylesterase, for example, is an enzyme which can inhibit biofilm formation in bioreactors. The food industry needs this activity because it can be used as a pre-treatment for various devices and equipment (Galie *et al.*, 2018). Other enzyme activities, such as amylases, cellulases, lyases, glycosidases (such as dispersin B), and DNAses, are often utilized in the food industry as part of industrial detergents to remove biofilms (Galie *et al.*, 2018).

4.5.3 Steel Coatings

Nanoparticles have antibacterial qualities and can be used in a variety of industrial settings by coating n surfaces of equipment colonized by bacterial biofilm. In industry, silver nanoparticles and metal oxide nanoparticles are more widely used. Iron oxide (Fe_3O_4), titanium oxide (TiO_2), zinc oxide (ZnO), copper oxide (CuO), and magnesium oxide (MgO) are some of the examples of nanoparticles (Galie *et al.*, 2018).

4.5.4 Biosurfactants

Biosurfactant can be used in food industry surfaces to reduce the adhesion of germs like Methicillin-resistant *Staphylococcus aureus* (50 percent adhesion inhibition at 8.3 g/mL) and other microorganisms. These chemicals operate on the surface of the relevant target microorganism, lowering surface tension and modifying binding capability. Chelating cations are chemicals that attach themselves into the membranes of microbial cells. This impact changes the permeability of the cell membrane, eventually destroying it and resulting in cell enlargement and death (Galie *et al.*, 2018).

4.5.5 Bacteriocins

Bacteriocins are used in the food industry to inhibit biofilm growth on various surfaces. These antimicrobial compounds can also extend a product's expiry date, protect it from changes during refrigeration, reduce food spoiling, limit the transmission of foodborne pathogens, lower chemical preservative concentrations, and reduce the number of temperature treatments. Nisin is the only FDA-approved bacteriocin in the food industry, and when used as a spray on food-processing surfaces, it can prevent *Listeria monocytogenes* adherence and biofilm development (Galie *et al.*, 2018).

4.5.6 Essential oils

Monoterpenoids (such as borneol, camphor, carvacrol, eucalyptol, limonene, pinene, thujone), sesquiterpenoids (such as caryophyllene, humulene), and flavonoids (such as cinnamaldehyde and other phenolic acids) make up the majority of plant-based essential oils (Campana *et al.*, 2017). According to Desai *et al.* (2012), oregano and thyme oils were likewise found to be highly effective at eradicating *Listeria monocytogenes* biofilms on polystyrene and stainless steel surfaces. Carvacrol is also efficient against biofilms formed by *Listeria monocytogenes* and *Staphylococcus aureus* (Galie *et al.*, 2018).

Other methods for inhibiting or preventing bacterial biofilms include high hydrostatic pressure, non-thermal plasma, quorum sensing inhibition, bacteriophages (phage therapy), and photocatalysis (Galie *et al.*, 2018). The control methods and action mechanism is shown in Table 4 below:

Table 4: Biofilm control methods for their use in the food industry

Methodology	Examples	Mechanism of action
Chemical treatments	Sanitizers (NaOCl, peracetic acid, NaOH, H_2O_2)	Cell structures oxidation
Enzymatic disruption	Cellulase Proteases Glycosidases	Extracellular matrix disruption

	DNAses	
Steel coatings	Nanoparticles (Ag^{2+}, Fe_3O_4, TiO_2, ZnO, CuO, MgO)	Alteration of bacterial membrane
	Repelling surfaces (monolayers, hydrogels, modified topography)	Inhibition of bacterial binding
	Functionalized surfaces (with lisozyme or nisin)	Bactericidal
Biosurfactants	Lichenysin	Inhibition of bacterial adhesion
	Surfactin	
Bacteriophages	P100	Cell lysis
Bacteriocins	Nisin	Cell membrane alteration
QS inhibition	Binding of inhibitors to QS receptors (lactic acid)	Down regulation of adhesion and virulence mechanisms
	Enzymatic degradation of QS signals (paroxonases)	
	sRNA post-transcriptional control	
	Inhibition of QS signals biosynthesis	
	Furanones	Motility inhibition
Essential oils	Citral	QS inhibition, motility inhibition
	Carvacrol	Bactericidal
High hydrostatic pressure	H_2O	Bactericidal (also endospores)
Non-thermal plasma	UV plus O_2, N_2, O_3, H_2O and He	Bactericidal
Photocatalysis		Bactericidal

Source: Galie *et al.* (2018)

4.6 Bacterial biofilm control in healthcare facilities

Biofilm formation on medical devices could be avoided by altering the surface qualities of the devices to prevent bacteria from attaching to them. To detach biofilms from tissues or reduce their effect, higher doses of antimicrobial medicines might be utilized.

4.6.1 Use of nanoparticles

Silver nanoparticles are frequently employed for managing biofilms for medical devices. Actually, the charged silver ions aid in the static attraction between the metal and the charged microbe, enhancing absorption and antibacterial activity through the membrane. Silver nanoparticle treatment slows DNA replication, ribosomal and other cellular protein expression, and interferes with microbial Electron transport chain (ETC). This approach has been confined to human tissues due to the potential toxicity of silver ions. The inclusion of chelators/chelating chemicals destabilizes the biofilm architecture. Calcium, magnesium, and iron are well-known for maintaining membrane integrity and, when combined with a tetrazolium EDTA chelator, for fighting biofilms in vitro or on explanted tube tips, as well as for treating catheter-related blood infections (Malhotra *et al.*, 2015).

4.6.2 By Altering the Chemical Properties of Biomaterials

Antibiotics, biocides, and ion coatings are popular chemical approaches for modifying the surface of biomedical devices to avoid biofilm formation. Antibiotic-coated catheters, such as minocycline and rifampin, have been found to reduce the incidence of *Staphylococcus aureus* biofilm-associated bloodstream infection in hospitals (Ramos *et al.*, 2011). Catheters impregnated with various antibiotics, such as nitrofurazone, gentamicin, norfloxacin, and others, are also thought to play a role in reducing biofilm-associated urinary tract infections. Antibacterial agent coatings on medical equipment are often only effective for a short length of time due to the chemical's gradual leaching. Thus, utilizing long, flexible polymeric chains to immobilize antimicrobial chemicals on device surfaces has proven to be

an efficient way to limit biofilm formation in the long run (Subhadra *et al.*, 2018).

4.6.3 Surfactants

Surfactants such as sodium dodecyl sulfate (SDS), cetyltrimethylammonium bromide (CTAB), Tween 20, and Triton X-100 aids biofilm dispersal and detachment. Surfactin, a cyclic lipopeptide generated by *Bacillus subtilis* has been shown to prevent biofilm formation and stimulate biofilm dispersal in *Salmonella typhimurium, Escherichia coli*, and *Proteus mirabilis* (Subhadra *et al.*, 2018). Many bacteria, including *Pseudomonas aeruginosa*, synthesize rhamnolipids, which promote biofilm dispersal in a variety of bacterial strains.

4.6.4 Anti-adhesion Coatings

For the eradication of biofilms on clinical surfaces, there are primarily four chemical cleaning procedures used. Detergent, hydrogen peroxide cleaning, bactericidal/bacteriostatic coatings, and anti-adhesion coatings are examples of these approaches. Anti-adhesion coatings may typically prevent biofilm formation at an early stage, which is preferable in therapeutic settings. Chemical composition and reactivity, hydrophilic/hydrophobic properties, surface textures, and surface charges are all factors to consider when designing an anti-adhesion coating surface. For example, Li *et al.* (2020) found that the modified polyurea antibiofouling coating has a hydrophobic property, that nanotitanium dioxide can generate reactive oxygen species to kill bacteria, and that the riblet surface textures formed by nanotitanium dioxide can improve the drag reduction effect and antibiofouling performance. Furthermore, such coatings have the ability to extend the interval between maintenance and demonstrate their commercial relevance in real-world applications (Li *et al.*, 2020).

Quorum quenching, the utilization of free fatty acids, amino acids, and nitric oxide donors, the use of matrix degrading enzymes, and so on are all examples of other control mechanisms (Subhadra *et al.*, 2018).

V. CONCLUSION AND RECOMMENDATION

Biofilms are surface-attached communities of bacteria held together by self-produced polymer matrixes made mostly of polysaccharides, secreted proteins, and nucleic acids [RNA and extracellular DNA (eDNA)], as well as other components such as water, lipids, extracellular enzymes, and metal ions which poses a severe threat to public health of individuals. The EPS in biofilm allows surface adhesion and serves as a barrier between biofilm cells and the environment which provides nutrients and protect them from desiccation, radiation and other environmental conditions. Biofilm is formed in a variety of ways by various organisms. Bacterial biofilm development takes place in a series of well-ordered steps from initial attachment to surfaces to maturation of the biofilm. Biofilm growth is influenced by a variety of biotic and abiotic variables such as oxygen requirement, pH, nutrients availability and so on. Biofilm-associated bacteria differ from their free-living planktonic type in a number of ways.

To establish a biofilm on any surface, such as implant materials, vessels, pipes, water bodies, food items, textile surfaces, ship hulls, power plants, and so on, a wet or hydrated area with some nutrients is the minimal condition. On the surface, biofilm production is a slow and laborious process that takes years to develop and mature. The chemical composition, surface area, and stability of the substratum colonized by the biofilm microbiota have significant implications for its structure and function, as well as distinguishing its communities within and between habitats, the amount and kind of cells in the biofilm, as well as the external physical environment, are all critical considerations. These parameters have an impact on biofilm production and responsiveness to environmental challenges such as antibiotic or chemical treatment.

Various procedures and approaches have been developed in order to get rid of dangerous biofilms, with the main focus on interfering with bacterial attachment and QS, as well as biofilm matrix degradation. Biofilm generation in various industrial equipment can be treated using a variety of standard mechanical and chemical procedures such as the use of biosurfactants, enzymes, nanoparticles on surfaces and so on. Novel strategies, such as the use of anti-adhesion agents to block a specific biofilm step without killing the bacteria, or the use of natural bacterially produced signals to promote bacterial dispersal are bioavailable treatment strategies for biofilm eradication.

The complexity of biofilm-mediated infections and their increased resistance to antibiotics make them difficult to control. The prevention of their surface colonization to restrict biofilm development is important, as this is the first step in the formation of biofilms. Future strategies to improve biofilm eradication may be developed to encourage the commercial intake of certain biofilm inhibitors like enzymes, AMP, AML, and QS inhibitors. However, in-depth research is required for the clarification of the effect of these biofilm inhibitors during biofilm infection in the host while their applicability to humans should also be proven. It should be noted that biofilm inhibitors may not be responsible for antibiotic resistance; they hold a lot of promise in the future for treatment or management of biofilm-based infections.

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The Psychologist's Role in the Process of Listening to Children Victims of Sexual Violence in Legal Proceedings

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Abstract— *This work presents a set of interpretations made by the psychologist regarding the procedure for listening to children who are victims of sexual violence in legal proceedings based on the Doctrine of Integral Protection of the child. Documental surveys were carried out on the procedures for taking special statements from children in legal proceedings. Under the light of Winnicott's theory of emotional development, based on academic experience and extension activities, a personalized and dynamic qualitative method of investigation, essentially constructive-interpretative, was used to interpret the listening procedures. The result demonstrates that the discussion of the theme is recent in the world and that the biggest obstacle to a consensus regarding a procedure that proposes the non-revictimization of child victims of sexual violence in legal proceedings is to understand and study the limits of psychological science and legal science with a view to the Doctrine of Integral Protection.*

I. INTRODUCTION

The recognition of human rights as participants in the political world with regard to children began in the 19th century, the scientific discoveries reduced the infant mortality rate [1]. Listening to a child involved in a legal process based on conceptual and legal advances consists in considering them as a subject of law, as a desiring social subject whose capacity to desire is often devastated by the actions of adults [2].

Human Rights principles guarantee fundamental freedoms and equality; the child, in this context, has three basic foundations in the Doctrine of Integral Protection in force in Brazil, namely: they are subjects of rights, people in a peculiar condition of development and they have an absolute priority. As subjects of rights, opportunities to be heard in legal proceedings and freedom of expression are ensure.

In accordance with the Convention on the Rights of the Child (1989) in Articles 12 and 13, regarding the Doctrine of integral protection, it is considered the phase of childhood a peculiar developmental condition and absolute priority in the service policy. Those three fundamentals cited before are dynamic and, in terms of sexual abuse against children, reach high levels of complexity, considering the historical-structural, cultural, psychosocial, legal, ethical and political dimensions.

This article consists of a set of interpretations regarding the procedure for listening to child victims of sexual violence in court proceedings in order to carry out documentary surveys of the testimonies of children in legal proceedings around the world. The way of intervention in taking the testimony of child victims of sexual abuse in legal proceedings that is discussed in this work. The non-revictimization is the guarantee that the child will not go through moments of psychological stress in the constitution of evidence during the justice procedures.

II. THE RECOGNITION OF CHILDREN VICTIMS OF SEXUAL VIOLENCE AS SUBJECTS OF SPECIFIC RIGHTS

The international normative basis is based on Human Rights, which historically take the form of a set of events,

dated between May 5, 1789 and November 9, 1799, that changed the political and social framework of France, called the French Revolution. This revolution ranks among the greatest in human history and proclaimed the universal principles of liberty, equality and fraternity. In the struggle to consider fundamental human rights, in the dignity and worth of the human person, on December 10, 1948, the Universal Declaration of Human Rights was promulgated as a guide to common ideals to be achieved by all nations in effecting universal respect for human rights and fundamental freedoms. The recognition of human rights as participants in the political world with regard to children began in the 19th century, with scientific discoveries that reduced the infant mortality rate:

> Because of the abundance of cheap labor, there was less need for children to work. Laws that protected them from long workdays allowed them to spend more time studying, and parents and teachers were more concerned with identifying and meeting children's developmental needs. The new science of psychology taught that people could understand themselves by learning what had influenced them during their childhood. (PAPALIA, 2006, p. 47).

The Children and Adolescents Statute (CAS) materialized the Doctrine of Integral Protection and the principle of absolute priority for children in its Articles 1 and 4:

> Art. 1st This law provides for the full protection of children and adolescents.
>
> Art. 4th It is the duty of the family, the community, society in general and the public authorities to ensure, with absolute priority, the realization of the Rights relating to life, health, food, education, sport, leisure, professionalization, culture, dignity, respect, freedom and family and community coexistence.
>
> The priority guarantee comprises;
>
> a) Priority to receive protection and help in any circumstances;
>
> b) Priority of attendance in public services or services of public relevance;
>
> c) Preference in the formulation and execution of public social policies;
>
> d) Privileged allocation of public resources in areas related to the protection of children and youth. [3].

In guaranteeing the rights of children, based on the Doctrine of Integral Protection, the right to healthy sexual development is a fundamental right. But when this is violated, it is the family's, society's, and state's duty to guarantee specific rights to protect the child.

III. WINNICOTT'S CONTRIBUTIONS TO THE UNDERSTANDING OF CHILD DEVELOPMENT

Reflecting on Winnicott's concepts allows us to understand the child sexuality that safe and pleasant relationships will provide, as external factors, healthy aspects for emotional development. The family plays an essential role in the emotional development of the child.

In the family, the roles that parents play are fundamental for child development. Winnicott describes the “good enough mother” as the one who

> feeds the omnipotence of the infant and to some extent sees sense in it. And it does it repeatedly. A true self begins to come to life through the strength given to the infant's weak ego by the mother's complementation of the infant's expressions of omnipotence.
>
> The mother who is not good enough is not able to supplement the infant's omnipotence, and so repeatedly fails to satisfy the infant's gesture; instead, she replaces it with her own gesture, which must be validated by the infant's submission. This submission on the part of the infant is the initial stage of the false self, and results from the mother's inability to sense the infant's needs [4].

The father, in Winnicott's theory, in very early stages of development is not mentioned, however, he is present and presents himself as a process of differentiation of interaction and interdependence in the early development of the child. The father has the main role at this time to support the mother. But this presence will only be possible according to their emotional maturity, however, according to the mother's emotional maturity and history. The family constitution presents new configurations in the historical context with the entry of women into the labor market and often paternal care in the child's first relationship. It is the caregivers, the family that make the child experience changes that happen due to family expansion and

tribulations. Winnicott (2005) in his text Factors of Integration and Disintegration in Family Life (1957) states that “The existence of the family and the preservation of a family atmosphere result from the relationship between parents within the framework of the social context in which they live” [4]. However, it is necessary to consider parents as individuals who had a history of family creation and conservation of their parents' relationship and update these experiences in their relationship with their children.

In the individual field, for the parents according to Winnicott (2005), there are forces linked to the complex sexual fantasy, not only considering sex in its physical satisfaction, but also as an achievement of emotional growth that happens throughout life from pleasant relationships for the person and society in order to move towards mental health.

IV. PROCEDURES FOR LISTENING TO CHILDREN VICTIMS OF SEXUAL VIOLENCE IN LEGAL PROCEEDINGS

In the legal context of multidisciplinary work, the psychologist is designated by the judge to carry out the procedure of “interrogation” of the child in judicial proceedings. However, inquiring is different from listening for psychological science, in the legislation, which establishes the professional performance of the psychologist, there is no questioning as a practice of psychology.

The obstacle between the boundaries of the legal and psychological sciences consists in: while the Justice System seeks the objective truth of the facts, the psychology seeks the subjective truth. The listening process in psychology consists of a construction that requires special rules of the interpretation method that involves linking the meaning of symbolic objects, in order to understand the subjective truth of language. Listening to a child involved in a legal process based on conceptual and legal advances consists of considering them a subject of law, as a desiring social subject whose capacity to desire is often devastated by the actions of adults [2].

The obligation of the child's testimony at a certain chronological moment in legal proceedings can extinguish the child's desiring capacity in the face of freedom of expression and make more difficult the psychic preparation to expose a traumatic fact. The child's right to be heard guarantees justice the possibility of arriving at the objective truth of the facts, but it does not guarantee the limit between the use of authority, by imposing the child to take a statement, and the use of freedom by respecting time psychic elaboration of a traumatic moment that will be a constituent part of the child's personality in his emotional development. [5].

Listening to children who are victims of violence in legal proceedings has become the focus of intense debates for the category of psychologists after a consultation received by the Federal Council of Psychology in April 2006. The Regional Council of the 7th Region, in Rio Grande do Sul, requested clarification regarding the technology used Children's and Youth Court in Porto Alegre, known as the 'Deposition without Damage' Project.

This project offered subsidies to the Legislative Power for the elaboration of the Complementary Bill 35/2007, which is being discussed in the National Congress and proposes to add Section VII to Chapter II – On Procedures – of Title VI – On Access to Justice – of the Special Part of ECA and provides for other measures, announces in item III of Art. 197-B of Subsection I – Questioning of Witnesses – of Section VII – Special Provisions Relating to the Questioning of Witnesses and Early Production of Evidence in Crimes Against Sexual Dignity with Child or Adolescent Victim or Witness, that the questioning will be mediated by a duly professional designated by the judicial authority, who will transmit the questions of the judge and the parties to the deponent. In the manner that takes place in Rio Grande do Sul, the professional designated by the judicial authority is the psychologist or social worker.

V. REFLECTIONS ON THE SYSTEM OF GUARANTEE OF RIGHTS IN THE COMPLETE PROTECTION OF CHILDREN DURING THE LISTENING PROCEDURE IN JUDICIAL PROCEEDINGS

A conclusion section must be included and should indicate clearly the advantages The Deposition without Damage Project is an advance in the face of authoritarian legal practices where the child in an instruction hearing made the statement through questions prepared by the judge, prosecutor, defense attorney of the defendant who had no care and concern for the internal conditions, psychic, of the child in relation to the trauma. The judge of law from Campo Grande-MS, in a survey carried out during one of the university's extension actions, reported that the procedure as it was carried out worried him, as it did not guarantee the protection of the child and explained that the technology and method used by Rio Grande do Sul when performing the same procedure were innovative.

The prediction of the methodology of testimonials with children as a legal and political advance that guarantees the legitimacy of the method no longer depending on the interpretation of the

> Justice System managers according to Complementary Law Project 35/2007 is justified:
>
> I – to safeguard the physical, psychological and emotional integrity of the deponent, considering his/her peculiar condition as a person in development;
>
> II – due to the age of the deponent, so that the loss of memory of the facts does not come to the detriment of the verification of the real truth;
>
> III – to avoid revictimization of the deponent, with successive inquiries about the same fact, in the criminal, civil and administrative spheres.

Among these guidelines there are principles that consider the integral protection and absolute priority of the child. However, in our academic experience linked to a Child Protection Network service, obtaining the objective truth of the facts, required by law, of a complex phenomenon such as sexual violence against children in order to safeguard the physical, mental and emotional integrity, in addition to avoiding revictimization of the child, it is a complex task.

Discussing the physical, psychic and emotional integrity of the child victim of sexual violence is to consider, according to the basis of Winnicott's psychoanalytic theory, the fundamental role of the environmental holding, of welcoming adults who will have a direct or indirect relationship in the construction of justice for these cases, what the psychologist from Lithuania called rapport. Considering the best interest of the child is to allow the child to be heard, considering him/her as a person in a peculiar condition of development and building, according to Winnicott, a trajectory for the constitution of the true self and, later integration of the ego in the child, that is, the elaboration of the trauma without secondary damage. It is not by imposing in space and time the opportunity for the child to be heard and concentrating power in justice through practices that produce abuse of the common good, doing in excess with damage, according to Sêda (2001), that full protection will be guaranteed and the peculiar developmental condition of the child will be considered

VI. QUESTIONS ABOUT THE PSYCHOLOGIST'S ROLE IN THE PROCESS OF LISTENING TO CHILDREN VICTIMS OF SEXUAL VIOLENCE IN JUDICIAL PROCEEDINGS

Psychology can contribute to multidisciplinary, multi-institutional and multi-professional work, given the provocation in the debate on the guiding principles of listening to child victims of sexual violence in legal proceedings. A starting point is consider the uniqueness of each case and, mainly enabling a holding that facilitates the child to talk about trauma (sexual abuse), from a place of specialized listening and forms of ethical intervention that are integrated with public policies, respecting the Human Rights of Children in favor of Protection Integral.

According to Santos and Gonçalves (2009) survey of the experiences of taking special testimonies of children and adolescents, six countries use psychologists as trained technicians to carry out interviews with children in the judicial process. In Brazil, the 'Testimony without Damage' Project emphasizes the importance of specialized listening for conducting the interview and indicates psychologists and social workers as technicians.

Based on scientific studies of each training, psychology and social service, the provocation in responding about the guarantee of integral protection of the child in the process of listening to child victims and witnesses of sexual violence in the judicial process is necessary in the multidisciplinary work based on the vision holistic-systemic approach to the process.

The performance of the psychologist in the process of listening to children in the judicial process is a recent discussion, in Brazil it began in 2003 with the implementation of the Project 'Testimony without Damage' in Rio Grande do Sul. The actors of the Child Rights Guarantee System, the Child Protection Network and the Federal Council of Psychology pointed out some questions as a way of reflection and ethical improvement of techniques to regulate the psychologist's performance.

VII. LISTENING TO CHILDREN VICTIMS OF VIOLENCE IN LEGAL PROCEEDINGS: A SERVICE POLICY TO GUARANTEE THE COMPLETE PROTECTION OF CHILDREN

A scientific study is needed that aims to understand and interpret the meanings of a psychological nature that child victims of violence have to the fact before, during and after the listening procedure in judicial proceedings. Consider psychological aspects such as the health-disease phenomenon in the constitution of the personality and

comply with the principles of the Code of Ethics as a professional and researcher with a clinical attitude, namely:

It is the posture of acceptance of the emotional existential suffering of the subject of the researcher's studies, assumed by this professional, who thus inclines his listening posture, his gaze and his multiple and interconnected sensibilities, which interacts with his theoretical knowledge of the research methodology in towards that person whom he wants to better know and understand scientifically, systematically undertaking a research of the phenomena as perceived by this individual, and being primitively moved by the desire to help those who suffer. (TURATO, 2010, p. 240)

According to the CFP Resolution No. 010/05 the psychologist has the following duties:

> Art. 1 - The fundamental duties of the psychologist are:
>
> [...]
>
> c) Provide quality psychological services, in dignified working conditions appropriate to the nature of these services, using principles, knowledge and techniques recognized as grounded in psychological science, ethics and professional legislation.
>
> [...]
>
> Art. 8 - In order to provide non-continuous care for a child, adolescent or disabled person, the psychologist must obtain authorization from at least one of their guardians, subject to the provisions of current legislation:
>
> [...]
>
> §2 - The psychologist will be responsible for the referrals that are necessary to guarantee the integral protection of the person assisted.
>
> [...]
>
> Art. 14 - The use of any means of recording and observation of psychological practice will comply with the rules of this code and the professional legislation in force, and the usurer or beneficiary must be informed from the beginning."

Inquiry is not part of the knowledge and techniques based on psychological science, ethics and professional legislation. Providing services in dignified working conditions is not subjecting oneself to the imposition of attitudes that are not consistent with professional practice regulations. When listening to child victims of violence in legal proceedings, the psychologist becomes a facilitator, a professional role that does not match his practice.

In a multidisciplinary attitude, the psychologist provides services to other professionals governed by the Resolution No. 007/2003 of the CFP a Manual for the Elaboration of Written Documents produced by the psychologist, resulting from psychological evaluation. Psychological assessment is a technical-scientific process of data collection, studies and interpretation of information regarding psychological phenomena, which result from the individual's relationship with society, using methods, techniques and instruments validated by the Federal Council of Psychology and the System Assessment of Psychological Tests.

The elaboration of written documents is the psychologist's instrument of interlocution with other professionals and recognized in Resolution 013/2007 of the CFP, making the professional who uses it with bad conduct liable to inspection and responsibility for the professional acts performed. In this regard, there has been progress in the practice of listening to children in legal proceedings carried out in Spain, even though video recording technology is still being used, as a guarantee of reliability and effectiveness that the questions asked by the actors of the Rights Guarantee System were in the right place. sense indicated by each author, without causing double interpretation.

The production of the psychological theoretical framework, which aims at the subjective truth, understands how the child experienced the situation of violence, is compromised when the professional needs to consider a temporal bureaucratic procedure in legal proceedings. The psychological time to understand a given situation differs from the chronological time of legal proceedings. But it is in this area of activity that psychology, in view of its work methodology and scientific knowledge, contributes to the web of institutional relationships to assist legal operators in the integral protection of children.

The psychic time to understand the situation of violence and, fundamentally, the elaboration of the psychic trauma is demonstrated when, in professional practice, the child is not verified as a communicator of violence, since it involves psychological phenomena such as guilt and insecurity that are part of the development process emotional, but who has been brutally offended when sexual abuse occurs.

Therefore, it is not allowed open a psychic wound and not provide the holding for the healing of this wound. The child's silence is a defense that is involved in this web of internal feelings that are providential for their psychic sanity with regard to the health-disease phenomenon. By observing our attitudes, we remain silent when we don't

trust the people around us, when we don't believe that individuals can collaborate to heal psychic wounds.

Why force a child to talk about a trauma - which is similar to the organic part, a wound that most of the time is much greater psychically than physically - without guaranteeing the integral attention of the service, without informing that the report will be presenting will be assisted by several other professionals, including the defendant and that this report is the key, main evidence for the conviction of a person who has intense emotional ties?

What Rights are we guaranteeing when we submit children to talk about a fact that causes them suffering? It cannot be disregarded that the recording of the testimony is an advance on how the testimony was provided. But, according to Nogueira Neto:

> The strict procedures for questioning children and adolescents in the procedural judicial sphere cannot, therefore, be placed as the only ones responsible for proving the materiality of the crimes and the authorship of the indicted/accused/defendant. The search for the truth of the case file and the real truth must be done primarily by other means of proof, such as expert, documentary, testimonial and indicia. The declarations of children and adolescents as victims or witnesses should not be recognized as judicial evidence, but as elements of collaboration. Thus, the ideal is not just to reduce damage in court testimony, replacing them with hybrid forms of social/psychological listening and court testimony (the so-called “deposition without damage”, for example). It is rather to avoid as much as possible that they are held responsible for the production, almost exclusively, of the evidence of materiality and authorship of the crime, taking into account, for example, the legal principle of the prevalence of the “superior interest of the child and the adolescent" [6].

Shouldn't the Child Protection Network be articulated in such a way that the sectors involved in Basic Protection Policies and Basic Social Protection Policy have information about the child and the family? To reach the Rights Guarantee System and to attend the Special Social Protection Policy, the child had the support and guarantee of comprehensive care in the provision of basic services that are gateways for complaints of violation of Rights, therefore, they are indicators, witnesses and can provide, through documentary means, subsidies that indicate facts of sexual violence against the child.

Psychology has the responsibility of discussing, together with the actors of the Rights Guarantee System, the multidisciplinary work methodology in the integral protection of children in cases of sexual violence in judicial proceedings, since it is the sole responsibility of this professional to improve the scientific field of knowledge and practice, but it has as regulation of internal interest of the category resolutions that guide its practice such as the definition of the field of action of the specialist in Legal Psychology, according to Resolution CFP 013/2007, which presents prevention as a practice of the psychologist; assessment; preparation of documents, guidance to children and adolescents, detainees and their families, among others; psychological care and research production.

An assistence policy for child victims of violence in legal proceedings must have materialized in the integral protection of the child, establishing in all institutional care sectors favorable environmental conditions for the elaboration of the trauma, environmental holding, and guaranteeing healthy emotional development. The psychologist in this context needs to have a proactive personal and professional attitude that problematizes, evaluates, debates before acting, but above all, that develops a qualified listening that is only possible from the ability to put oneself in the place of the subject of Law in a peculiar situation of development and being the trusted technician, secure bond and genuine embracement, that is, seeing the child and not the procedure [7].

A conclusion section must be included and should indicate clearly the advantages, limitations, and possible applications of the paper. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

VIII. CONCLUSIONS

This work sought to offer a reflection on the process of listening to children who are victims of sexual violence in legal proceedings, in order to highlight the importance of studying the emotional development of children in the integral protection of the child, based on the specific right to be heard and freedom of expression. guaranteed by the 1989 Convention on the Rights of the Child.

We demonstrate that there are advances in reflection on the theme of child sexuality with regard to non-revictimizing

practices of child victims of sexual violence in legal proceedings around the world. The child is no longer subjected to multiple inquiries, a sensitive mode of intervention on the part of adults is sought, adapting the language to the child's age and an impact on the intervention that values the child's word effectively as evidence in legal proceedings.

In the field of Psychology as a professional practice in the intervention model proposed by the 'Depoimento sem Dano' Project in Rio Grande do Sul, the discussion is recent. Psychology is involved in the multidisciplinary team and, therefore, needs to position itself in relation to its praxis in the legal field.

Winnicott's theory of emotional development emphasizes the importance of the environment in the child's emotional development for the constitution of the personality by having environmental failures as the main etiology of the different psychopathological conditions as a fundamental element. Therefore, if the focus is on the understanding that we want to protect and guarantee the rights of children, psychological science allows us to consider all aspects of child development, guide and correct environmental failures that enable the healthy development of the child.

The process of listening to child victims of sexual violence in court proceedings has quantitative data that prove the guarantee that the child's word is valid as evidence in holding the offender accountable. But there is a limitation in what is discussed as the problem involved for psychology. It is questioned which role the psychologist plays in this context and the guarantee of child protection in the face of revictimization of the same in this procedure.

It is understood that the statements of children in legal proceedings should not be considered as judicial evidence, but as collaboration, since it is possible to prove the materiality of the crime and the authorship of the offender in the records by other means of proof, such as expertise, documents, testimonials.

The child's testimony, as it is being discussed, becomes almost the exclusive instrument for proving the materiality of the authorship of the crime and makes the child responsible for this judicial decision; and, in the case of intrafamilial sexual abuse, this involves great damage since the child becomes responsible for condemning a person with whom he or she had emotional ties.

In Psychology, the discussion of the subject is recent, it is in its infancy phase and involves only external factors such as the number of interviews, the chronological time in judicial proceedings and the intervention model of the public agents involved. But it is necessary to invest in scientific studies that aim to understand and interpret the meanings of a psychological nature that child victims of violence give to the fact before, during and after the listening procedure in judicial proceedings.

The normative and institutional mechanisms for doing so must improve the principles of human rights and not base professional practice exclusively on legal principles, in the search for the objective truth of law and in respect for the chronological time of judicial proceedings.

The difficulty in organizing ideas about the subject is found in this barrier between the limits of psychological and legal sciences. There is no consensus either among professionals of the two sciences or among professionals of science itself about a procedure that guarantees reduction of damage in the method of listening to child victims of violence in legal proceedings.

There is unquestionable progress in studying the subject, especially in the implementation of the Doctrine of Integral Protection in the relationship between citizens-citizens and citizens-actors of the child protection network and guarantee system. But it is necessary to encourage research on the child's subjectivity in the face of the listening procedure in judicial proceedings; this is one of the ways for Psychology to subsidize its work and build guiding parameters of its praxis based on theories of human development. And, above all, to guarantee means so that the child does not have to have his or her testimony representing him or her as being fully responsible for the decision of professionals in legal proceedings.

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Humanization in Undergraduate Medical Education: The Brazilian Learner's Perspective

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***Keywords*— Humanization, Medical Humanities, Student, Medical Education.**

***Abstract*—** *The production of humanized health should consider the individual as a whole, taking into account their particularities and perspectives, in order to promote care with ethical, humanistic and clinical quality. The objective of this study is to evaluate, from the perspective of medical students, their perceptions and knowledge regarding humanistic training during medical school. This is a quantitative and qualitative exploratory research in the strict methodological sense of keeping the focus, the object of study, which was made with the students of the Medicine course from the second to the tenth periods of UNIFAMAZ, enrolled in the first semester of 2019. As an instrument of data collection, the structured questionnaire was used, and data obtained transcribed into LibreOffice®, elaborating the corpus for data processing. IRAMUTEQ was used for processing the text corpus. Regarding the absolute frequency of the words within the text corpus, evidence was obtained of the main terms: Patient (frequency of 86), doctor (frequency of 70), care (frequency of 44), empathy (frequency of 48), professional (frequency of 34), important(*

frequency of 35), human (frequency of 33), humanized (frequency of 25), relationship (frequency of 17), physical (frequency of 17), health (frequency of 25), treat (frequency of 15), treatment (frequency of 12), In most of the questionnaires these words considered high frequency, were exposed by the students, correlated with the true meaning for him of a good humanized care. In short, the insertion of the teaching of humanized medicine in the undergraduate course exerts on the student and future professional a reflective, motivational and conductive power about the subsequent medical practices.

I. INTRODUCTION

Humanization is a process that can occur in several areas, however, here the focus will be on health sciences, specifically in the formation and performance of the physician. The term "humanization" is widely discussed in health services and refers to several concepts, historical origins, and even different lines of thought, which allows for several interpretations about it. According to Barros and Passos (2018), for the dictionary of professional education in health: Humanization, in the field of public health policies, refers to the transformation of models of care and management in health services and systems, indicating the necessary construction of new relationships between users and workers and among them.

Humanization in health care is focused mainly on the production of health, observing the subject as a whole, in order to assist him in a very personal way, contemplating not only the disease as a causal factor, but its entire history, with the purpose not only investigative, but in order to promote the desired health, offering the patient or user a service with ethical, humanistic and at the same time, technical quality (BARROS; PASSOS, 2018).

There are many obstacles to the implementation of humanized health care in Brazil. Among them, the precarious conditions of care that both the professional and the patient are exposed to, the lack of material in health units, as well as the long working hours that professionals are subjected to, which makes their work increasingly exhausting, make this process even more difficult. The lack of humanity can be seen from the moment the patient tries to make an appointment, as well as in the long lines that form on the day of the service.

When humanization occurs, it creates better conditions for those who perform health care functions and also for the people who seek care. Observing this, in 2003, the Ministry of Health launched the National Humanization Policy (PNH), with the goal of seeking to put into practice the principles of the Unified Health System (SUS) in the daily lives of health services, producing effects on the ways of serving and caring for people (BRASIL, 2014, p. 10).

The NHP acts by facilitating and stimulating the relationship between managers, workers, and users, decentralizing the hierarchization of competencies with the purpose of inhibiting inhumane activities and practices that may compromise health service users. One of its highlights is the incessant work to combat any kind of violence generated by mistreatment, whether physical or psychological.

Currently, in Brazil, the training of medical students is determined by the National Curriculum Guidelines of the Ministry of Education (BRASIL, 2014, p. 10) and medical schools have introduced in their Pedagogical Projects integrating axes, among them the Medical Humanities, articulated to clinical practice. In the National Curriculum Guidelines for the Undergraduate Course in Medicine (DCNM), it is precisely stated in art. 3 that the physician upon graduation should have the following profile:

> The Medicine graduate will have general, humanistic, critical, reflective and ethical training, with the ability to act at different levels of health care, with actions to promote, prevent, recover and rehabilitate health, at individual and collective levels, with social responsibility and commitment to the defense of citizenship, human dignity, integral health of the human being and having as transversality in its practice, always, the social determination of the health and disease process (BRASIL, 2014, p. 11).

One realizes that in order to transform health, it is necessary to make changes in the construction process of the subjects of these practices. This will only be possible through the necessary qualification of professionals who

become protagonists of this history. The Centro Universitário da Amazônia (UNIFAMAZ), has inserted in its Pedagogical Project of the Medicine Course (PPCM) in its curricular matrix, since its implementation, among others, the axis Medical Humanities, with the objective of forming doctors with a humanistic view and prepared to act in the job market. This axis contemplates a:

> It will be developed by modules organized in themes in the areas of humanities, human rights, cultural diversity, ethics, bioethics, social aspects of health problems, communication of bad news, patient safety, and other themes focusing on respect for the human being and related to the formation of doctors in an interdisciplinary approach, sustained in a process of knowledge construction using active methodologies. The modules take place from the 1st to the 4th period. It is an axis that articulates with the modules of the IESCG, HC, and in the periods. Each module has 02 weekly hours, totaling 40 hours in the period, with relevant themes for the humanistic formation of the medical professional. The definition of the contents is done through meetings and workshops, where the teachers prepare the planning for the period. From there, the objectives of the unit are outlined (BRASIL, 2014, p. 11).

It is necessary to train health professionals for society to act as facilitators of the healing process, ensuring not only the satisfaction of the patient who seeks relief, but above all to see him as a human being.

II. JUSTIFICATION

The humanization of medicine is a very popular subject nowadays; today we seek a medicine based on the person and not only on the disease. Physician Gregorio Marañón was one of the main defenders and systematizers of the so-called *personalist medicine* (1887-1960). He listed the humanities as one of the *five sources of medical knowledge* and classified it as essential for a medicine centered on the person, presenting itself as a facilitator for the physician to enter the patient's personal dimension.

Considering and valuing the findings of science is essential to medicine; however, never before has so much been said about the need to humanize medicine and medical education, but there is still a lack of knowledge about what humanism is and what *humanizing medicine means.*

The implementation of the curricular guidelines for training aims to contribute to the innovation and quality of the pedagogical project, and should guide the curriculum of the Medicine Undergraduate Course towards an academic and professional profile of the graduates consistent with the country's health policies.

In the area of medical training, it is observed that this is a theme that still needs to be scientifically explored. Considering that the institution UNIFAMAZ, presents as a proposal an innovative curriculum, integrative, interdisciplinary with the use of active methodologies and includes in its curriculum an axis of medical humanities. And in its guiding principles, objectives and graduate profile the integrality and humanization of care as a differential in medical training, it is necessary to evaluate from the perspective of the actors to be trained their perceptions of the relevance and effectiveness.

Thus, the scientific relevance of this study theme is justified by the possible contribution to the Higher Education Institution (HEI) in humanistic education in the undergraduate medical course, with special attention to the students' point of view.

III. OBJECTIVES

3.1 GENERAL OBJECTIVE

To evaluate, from the perspective of medical students, their perceptions and knowledge regarding humanistic training during medical school.

3.1 SPECIFIC OBJECTIVES

To interpret how the student considers the relevance of the Medical Humanities axis in the physician's education.

To analyze the degree of knowledge of the students about the humanistic formation of the physician

To identify, from the students' point of view, the importance of humanized health care.

IV. MATERIALS AND METHODS

4.1 TYPE OF STUDY

This is a quantitative and qualitative exploratory research in the strict methodological sense of keeping as its focus, the object of study. The quantitative research is significant because it will help to characterize the intensity and degree of ownership inherent to the object. The qualitative study enables the analysis of individual and collective information, in categories and topics, allowing a broader understanding. For Oliveira (2008, p. 58), these two types of approach are not mutually exclusive, since, in opting for qualitative research, one can resort to quantitative data for a better analysis of the theme or vice-versa.

4.2 UNIVERSE AND SAMPLE

For the development of the research considering its objective was made with the students of the Medical course of UNIFAMAZ, enrolled in the first semester of 2019. Students from the second to tenth periods participated. The choice was intentional to meet the research objective and achieve diverse testimonies, involving students who studied Medical Humanities and students who have advanced and are in practice in health settings.

Chart 1 - The research universe

Participants	Universe	Sample
2	101	20
3	55	10
4	83	16
5	79	14
6	44	08
7	41	08
8	41	08
9	38	06
10	70	14
Total	552	104

Source: Medical course coordination/February/2019

4.3 LOCATION

The research was carried out at the Centro Universitário Metropolitano da Amazônia (UNIFAMAZ), located at Avenida Visconde de Souza Franco, 72, Bairro Reduto, in the city of Belém-PA, 66053-000 (APPENDIX A).

4.4 PERIOD

Data collection was conducted in the month of April 2019.

4.5 DATA COLLECTION INSTRUMENTS

As an instrument of data collection the structured questionnaire was used (APPENDIX B) that made it possible to obtain information about expectations, collect information from a large number of people in a relatively short space. According to Oliveira (2008, p. 83), the application of a questionnaire defined as a technique to obtain information about feelings, beliefs, expectations that the researcher wants to record to meet the objectives of his study, transcribed into the LibreOffice® program, preparing the *corpus* for data processing. The processing of the corpus content was done through the *software* IRAMUTEQ (Interface de R pour analyses Multidimensionnelles de Textes et de Questionneires) version 0.7 alpha2 (CARMAGO; JUSTO, 2013).

Among the possibilities of analysis by IRAMUTEQ, we chose the analysis of similarity and word clouds, since the similarity produces graphics that allow the identification of the distributional principle that concerns the possibility of lexical units occurring in combinations with others. The cloud analysis, on the other hand, starts from the premise of how words are organized and grouped graphically, taking into account their frequency of appearance, originating from the text *corpus.*

The data obtained through the *software* processing were analyzed by the researchers, and were interpreted and discussed in light of the theory of social representations and literature on the subject. The answers were transcribed and submitted to the methodological and theoretical processing of the findings in the light of the referential. The Informed Consent Form (Appendix C) requested permission to record the questionnaires.

4.6 ETHICAL ASPECTS

The research project respected the precepts of the Declaration of Helsinki and the Nuremberg Code, following the determinations of Resolution 466/2012 of the National Health Council and within the limits of the Code of Medical Ethics, and submitted the approval of the Research Ethics Committee (CAAE: 099019.2.0000.5701). It complied with the guidelines described in the Informed Consent Form. The researchers signed a term of commitment (APPENDIX D) as did the teacher responsible for the group's orientation (APPENDIX E). To participate in the research, the students signed an Informed Consent Form that guaranteed the confidentiality of the information and that the informant would not be identified in the final draft of the research report (Appendix C).

V. RESULTS AND DISCUSSION

The examination of the questionnaires generated two categories of analysis: 1) subjective and 2) objective.

5.1 SUBJECTIVE CATEGORY

The main findings in this category, referring to medical humanization, the relevance of the medical humanities axis for the formation of physicians, and relevant topics not covered in the axis, were organized by means of a table that indicates the number of the questionnaire applied to UNIFAMAZ students, and are in their entirety in the work's file bank (Chart 2).

Table 2 - Characterization of the answers to the questionnaires, subjective, applied to students from the 2nd to the 10th period of UNIFAMAZ, in which 104 questionnaires were applied. Legend of the code AL: student, 01: number of the student's questionnaire.

Code	Part of the research participants' reports (text corpus)
AL_01	Good doctor-patient relationship
AL_02	Friendliness. The doctor was very nice. It helps in the spirit. Just to have empathy. To understand the patient's side and not just the professional.
AL_03	It is having empathy for others. Although not so often, there have been doctors who have made me feel welcome and trust them. It directly implies in the patient's adherence to treatment, as well as feeling welcomed. Yes, because we must be human regardless of the conditions we are exposed to. The human being has the ability to change the environment he or she is in, as long as he or she sets out to do so.
AL_04	Treating the neighbor or the patient with a human eye, with empathy, taking a considerate care, being patient with the patient's "agony". The doctor was attentive, patient, and human. The psychological aspect interferes in the evolution of the pathology. It depends only on the doctor's will. It showed us the importance and the relevance of this theme for the formation. How to deal with adverse situations in the day to day routine of a doctor who works in the public health system.
AL_05	It's about having empathy with the patient. I didn't get it. Psychological. Because it depends on the average. It helps to treat people and not of illness. I can't identify.
AL_06	It is empathy. It involves the doctor looking at the patient and not just seeing the disease, but the sick human being. It increases adherence to treatment. Even in an unfavorable environment, empathy must exist. It is important for our training as health professionals. The mental health of medical students.
AL_07	Medical humanization is a broad theme that involves biopsychosocial and environmental characteristics aimed at the care of a human being, where focused care makes the difference in a good doctor-patient relationship. Centered care with a good doctor-patient relationship makes the patient trust the medical conduct more.
AL_08	It is the search for proper medicine.
AL_09	It is medical care that is focused on the person, rather than only on pathology. Indigenous care is important because it presents several situations that are relevant to medical training.
AL_10	Palliative care, elderly care.
AL_11	It is seeing the patient, before the disease. The doctor was concerned about me, not only about the disease, it is not always the physical disease that is making the patient sick. Humanization does not depend on technology, but on character. It is relevant because it reminds the students of their humanity and that of the patients. I have no suggestions
AL_12	It is the service that uses care, well-being, and attention with a biopsychosocial outlook.
AL_13	It's a friendlier interaction towards the patient, not only dealing with the disease, but all their anxieties surrounding the health-illness process. Maximum attention from the doctor towards me. For in most cases the patient just needs a word of comfort for his problem. That is the least that is expected of a consultation. PBL teaching, is giving us the experience that our professors did not have in the academic forefather. Everyone that I thought was important was covered.
AL_14	It is the ability to be sensitive, to deal with other people's illnesses, and to know how to treat and dialogue with the patient in a patient and caring way. Yes, it is extremely necessary to make us exercise from the beginning the

	importance of humanized care and its benefits for patient and professional. Deepening in follow-up, preventive care for the LGBT public
AL_15	It is the perception of the health professional about the intrinsic aspects of the individual, making it possible to provide individualized care that is sensitive to the needs of each individual. It enables reflection and preparation for actions or situations that may occur in the exercise of the medical profession.
AL_16	Medical humanization is patient-centered care. It's turning to the patient and not to the disease. When I was well attended, by a doctor who looked me in the eye. It can help in the good prognosis of patients. This depends on the doctor and his training. It is an axis that teaches us to see the patient with other eyes. There is no theme.
AL_17	It is looking at the patient with sensitivity, ethics and respect, always trying to seek the best and comfort for the family and patient. The doctor was patient, attentive, and looked at me as a whole and not just as what I was looking for. It makes it possible to get to know the patient better and then look for ways to speed up the healing process. Unfavorable environments make humanized care difficult because it consumes the professional. Medical Humanities is relevant for medical students because it allows them to reflect and teach about daily issues in the life of a doctor. Therefore, with medical humanities we can learn about patients' rights, ethics, and get the best management of patients and families. All the main points are covered in medical humanities, so I can't see if there are others so important that have not been covered in the classroom.
AL_18	Medical humanization is the process that all doctors need to use as a basis in their practice, seeking to be as accessible as possible to the patient. The doctors who treated me didn't give me the attention I needed. I believe that humanized care promotes adherence to treatment and ends up influencing the professional's conduct. I believe that contact with the discipline during graduation promotes familiarization and more effective learning.

Source: Part of the data obtained from the questionnaires applied. * The data inserted in the work are not in full, however, all the statements are in a database.

In this category, the similarity analysis and word cloud was performed through IRAMUTEQ, i.e., the set of texts from the transcription of open-ended questions from the questionnaire was analyzed, in which a list of semantically identical words was generated, and their relative frequencies were presented in the text corpus, and a word cloud with central and peripheral terms was generated, with the central and larger ones being the most relevant in the text corpus. The words 'Patient' and 'doctor' were the central terms, while the peripheral terms were 'humanized', 'professional', 'care', 'relationship', and 'form'. The words 'empathy', 'relationship', 'compliance', 'humanization', 'humanity', 'care', 'comfort', 'help', 'respect', and 'treatment' were derived from the central term 'patient'. Derived from the central term 'doctor', the related peripheral terms were 'attend', 'approach', 'medicine', 'social', 'neighbor', 'sick', and 'depend' (Figure 1).

Thus, the good 'doctor-patient' 'relationship' can be built in a 'humanized' and 'empathetic' way, by the 'axis' of Medical Humanities, which promotes the 'formation' in an 'important' way, 'developing' 'skills' in order to influence the 'care' in a 'caring' way, through the 'look' of the 'doctor'. Moreover, the 'patient', in great majority, does not adhere to the 'treatment' against a certain 'disease', thus diminishing the 'health' and the 'importance' of this one, influencing in a negative way the credibility of the medical care coming from a lack of 'condition' to 'influence', 'respect' the 'patient', determining the true form of the humanistic 'process' of care. In the second main derivation of figure 1, in which the word "doctor" is taken as the central secondary word, it is preceded by the word "humanity", since, for the "humanization" to occur, it is necessary the "formation" with information to avoid situations of distancing the doctor from "social" problems, for example**.**

Contemporarily, the doctor-patient relationship has been focused as a key aspect for the improvement of the quality of the health service and unfolds in several components, such as the personalization of the assistance, the humanization of the assistance and the right to information (ARDIGÒ, 1995), treated through themes as the degree of satisfaction of the user of the health service (ATKINSON, 1993; WILLIAMS, 1994; GATTINARA, et al, 1995; DUNFIELD, 1996; ROSENTHAL; SHANNON, 1997), the counselling - the counseling (BERT; QUADRINO, 1989), the doctor-patient communication (BRANCH et al., 1991; WHO, 1993), the suffering of the patient and the purpose of biomedicine (CASSEL, 2007) and the informed consent (SANTOSUOSSO, 1996).

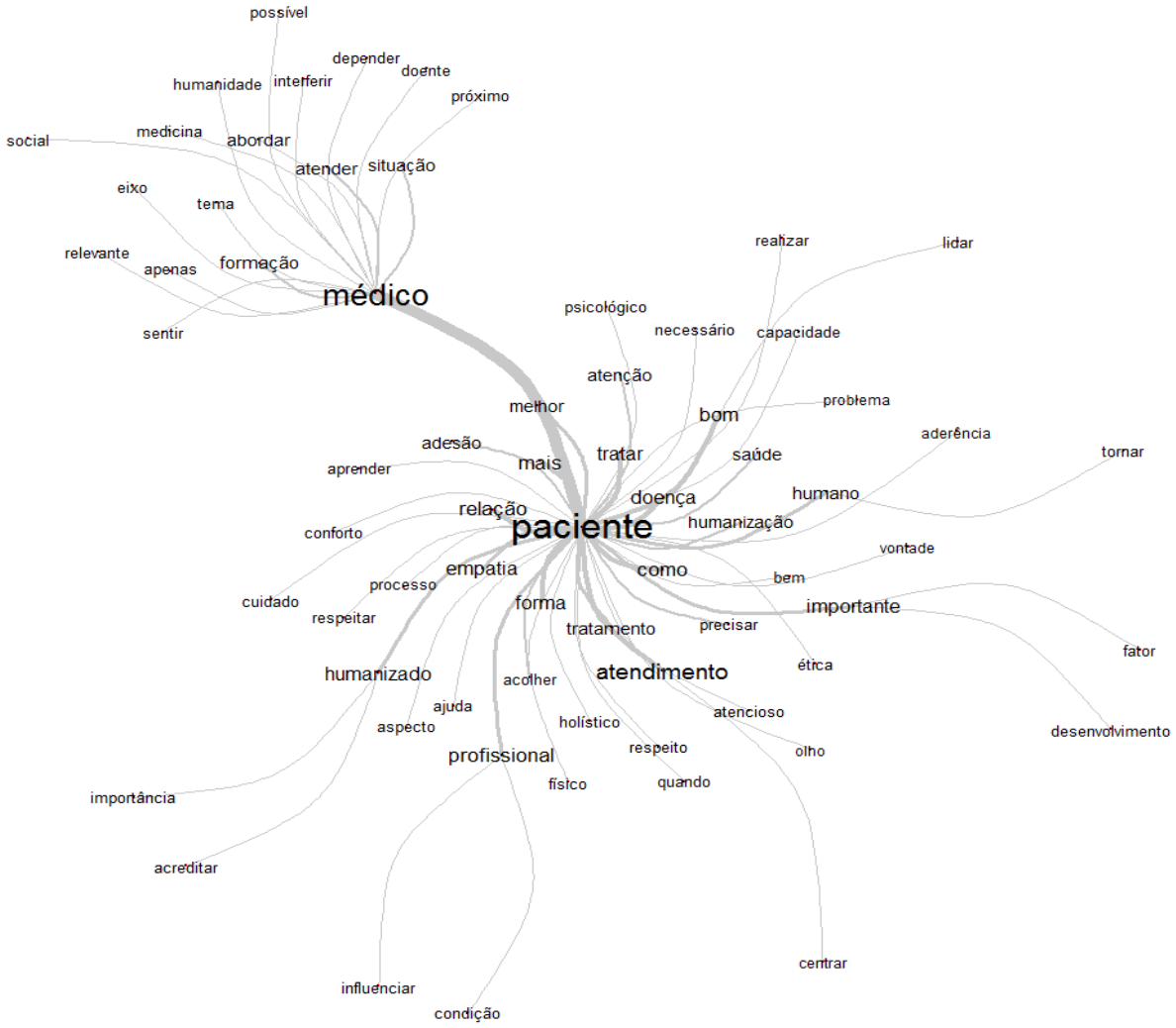


Fig.1 - Similarity analysis between the vocabularies. Belém-Pará-Brazil, 2019.

Source: IRAMUTEQ 0.7 alpha2 data processing.

Another important factor shown in the third branch of the clockwise direction in Figure 1, the word 'disease', 'health' and 'treat', which is interpreted by the biomedical conception as a deviation of biological variables from the norm. This model, based on a mechanistic perspective, considers complex phenomena as constituted by simple principles, i.e., cause-effect relationship, Cartesian distinction between mind and body, analysis of the body as a machine, minimizing social, psychological, and behavioral aspects. If, on the one hand, based on these principles, important transformations have been achieved since the 19th century, such as the birth of the clinic, Pasteur's germ theory, and even the recent successes in genetics, immunology, and biotechnology studies; on the other hand, the human, experiential, psychological, and cultural dimensions of the disease have been neglected. When it comes to verbal and non-verbal communication patterns, as well as the variety of communicational patterns, many problems arise in the doctor-patient relationship: a) the doctor's misunderstanding of the words used by the patient to express pain, suffering; b) the lack or difficulty in transmitting adequate information to the patient; c) the patient's difficulty in adhering to treatment (HELMAN, 1994).

With all of this mentioned, it should be understood that through the analysis of similarity, the real need for the importance of the axis of medical humanities for medical students is evident, which should follow a social and psychological approach, in which the academy is one of the main promoters for the propagation of humanized care.

Although most students and professors recognize that all medical disciplines, in practice, need to refer to humanistic knowledge in order to in fact care for the patient in integrality, the teaching of humanities has been disregarded from the central scope of medicine and meets with resistance (CAPRARA; FRANCO, 1999).

Figure 2 presents the word cloud derived from the text *corpus* obtained in the present investigation, remembering that the vocabulary words were organized according to the frequency they appear in the text processed by IRAMUTEQ (CARMAGO; JUSTO, 2013).

Fig.2 - Word cloud of the text corpus. Belém-Pará-Brazil, 2019.

Source: IRAMUTEQ 0.7 alpha2 data processing.

In what is related to the vocabulary words and their absolute frequencies, within the text corpus of the students' interview, obtained evidence of the main terms: Patient (frequency of 86), physician (frequency of 70), care (frequency of 44), empathy (frequency of 48), professional (frequency of 34), important(frequency of 35), human (frequency of 33), humanized (frequency of 25), relationship (frequency of 17), physical (frequency of 17), health (frequency of 25), treat (frequency of 15), treatment (frequency of 12), In the vast majority of questionnaires these words considered high frequency, such as empathy, doctor and patient, were exposed by students, correlated with the true meaning for him of a good humanized care. A fragment taken from the AL_32 questionnaire, according to Chart 1, makes this premise explicit:

> *"It is the ability of the physician to have empathy and understand the patient, the patient in a biopsychosocial way" (Student 32).*

In addition, another intrinsic component of the semantic words in the questionnaires is the patient as a 'biopsychosocial' being. Given this fact, the "axis" of "medical humanities" is an important vehicle of the real role of the thematic axis in question, the word "care", which is often mentioned in the questionnaires conducted by students. In this context, it is worth demonstrating this view in the questionnaire, AL_34:

> *"The medical humanities axis enables the development of empathy and the training of emotional skills for improved care" (Student 34).*

On the other hand, the word 'holistic' is also focused on, by means of statistical data and through highly cited arguments, and most of them correlate it with humanized care, as in the example of questionnaires AL_38 and AL_42:

> *"Treating the patient well, especially with respect and holistically" (Student 38).*

> *"It's the doctor-patient variation, it's the doctor's way of looking at the patient as a whole, closer" (Student 42).*

As for the checks of holisticity, in face of medical practices, it is founded on philosophical principles that value efficiency, technique, and scientific knowledge, and deny any possibility of a metaphysical knowledge, deploying scientific realism. According to Almeida (1999), when studying the human body, Cartesianism produces a mechanism of forgetfulness that prevents us from mixing and confusing ourselves with the body, it creates the image that the body is a machine.

In fact, to be a doctor who recovers people not only from illness, but also from pain, fear, and helplessness, one must be able to move from intention to gesture that transforms the procedure into a medical act. To train professionals with this level of greatness, it is necessary to develop reason and sensitivity in medical training, the contribution of the humanities to medicine (RIOS; SCHRAIBER, 2014).

It can be stated, as revealed by the word cloud represented by Figure 2, that the term 'Physician' and 'Patient', the most cited and central word, can be considered

the one that best represents the scientific evidence that medical humanity is not centered only on being a physician, but, in fact, doing medicine for people in an integrative way. In the intermediary periphery of Figure 1 and Figure 2, the link between the words ethics and patient was evidenced. Related to the category Physician, which is one of the main links, as already mentioned, for a humanized care, since there is a possibility that medical education leaves the physician as the center and not the patient, and this relationship is based on an ethical conduct, which is the third semantic word that lists this link, as shown and cited by the questionnaire, AL_17:

> *"Medical humanities is relevant for medical students because it allows reflection and teaching about daily issues in the life of a doctor. Therefore, with medical humanities we can learn about patients' rights, ethics, and get the best management of patients and families" (Student 17).*

Thus, the analysis of the importance of the medical humanities axis by the students has been breaking the perspectives of society: from pre-logical, fragmented reasoning, to logical, formal reasoning. This becomes clear in the questionnaire study in question, specifically to the students who had contact with the medical humanities axis, which materializes a thought of the principle and perception of the students before this fact, in this case; the axis. The subject is active in the process of appropriation of objective reality (MOSCOVICI, 1990).

Empathy is the most present characteristic in the students' discourse, both for the definition of humanization and regarding the quality of the doctor-patient relationship in which empathy is a multidimensional construct (in the cognitive, behavioral and affective spheres), which acts as a resource for the regulation of social life, modified by culture and learning (FALCONE, et al., 2018).

> *"It's having empathy with the patient" (Student 5).*

In this way, the conception of representations comprises a set of concepts, statements, and explanations through which the interpretation and even the construction of realities is carried out (JODELET, 1990).

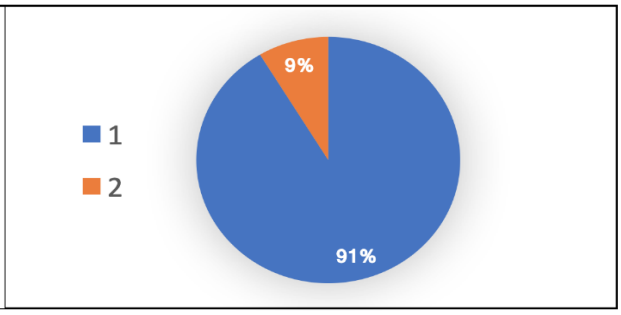
Therefore, it should be understood that medical humanization has an imagetic character and the property of leaving interchangeable sensations, ideas and conceptual games, giving an autonomous and individualistic character, as well as a collective character to each group or individual. As for example in the doctor-patient relationship, in which each group and each individual constructs a relative perception of the subject.

5.2 OBJECTIVE CATEGORY

In addition, objective questions were elaborated in the questionnaire, in which Diagram 1 and Diagram 2 and their respective interpretations of the questions mentioned by the importance of humanization and insertion of humanities curricular units in the curricular structure of medical education in Brazil are outlined. Among them was the question about the perception of the student regarding the medical humanities axis for their training.

Diagram 1 - Diagram of responses to the questionnaire. Belém-Pará-Brazil, 2019.

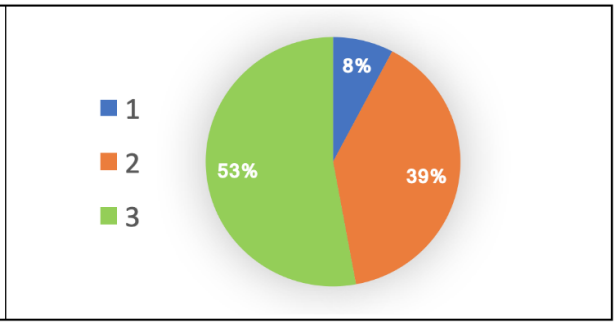
8. VOCÊ ACHA NECESSÁRIO O ENSINO DE HUMANIDADES MÉDICAS PARA A FORMAÇÃO MÉDICA?	
SIM	95
NÃO	9
TOTAL	104



Source: Questionnaires distributed to UNIFAMAZ students.

Diagram 2 - Diagram of responses to the questionnaire. Belém-Pará-Brazil, 2019

9. NA SUA OPINIÃO, O EIXO HUMANIDADES MÉDICAS TROUXE A VOCÊ UMA NOVA PERSPECTIVA QUANTO A HUMANIZAÇÃO MÉDICA?	
NADA	8
POUCO	41
TOTALMENTE	55
TOTAL	104



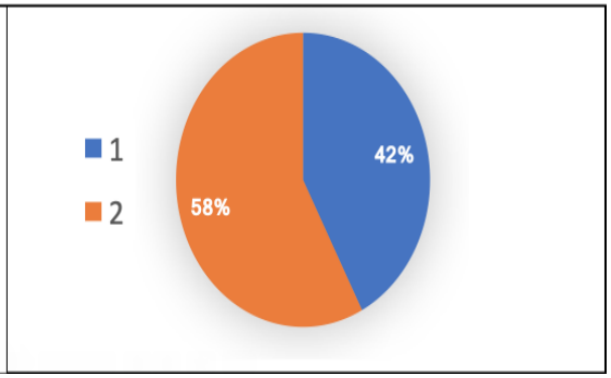
Source: Questionnaires distributed to UNIFAMAZ students

Diagrams 1 and 2 show the relevance of this axis for the students, in which 91% of the answers were "Yes", when asked: "Do you think the teaching of medical humanities is necessary for medical training? The perspective of the students in taking up the idea that the doctor-patient relationship is a key element in health care, humanization would be an element of relational quality, because it proposes a communicational process supported by dialogue. As these are skills that can be taught and learned, its development is recommended in medical schools (CAPRARA; FRANCO, 1999).

However, students often see them as uninteresting and dispensable, in part because, although fundamental to good medical practice, they are often addressed superficially in medical curricula. Diagram 3 shows students' responses when asked about the application of humanized medicine in unfavorable working conditions.

Diagram 3 - Diagram of responses to the questionnaire. Belém-Pará-Brazil, 2019.

5. NO SEU ENTENDER, É POSSÍVEL DESENVOLVER MEDICINA HUMANIZADA EM CONDIÇÕES DESFAVORÁVEIS DE TRABALHO?	
SIM	44
NÃO	60
TOTAL	**104**



Source: Questionnaires distributed to UNIFAMAZ students.

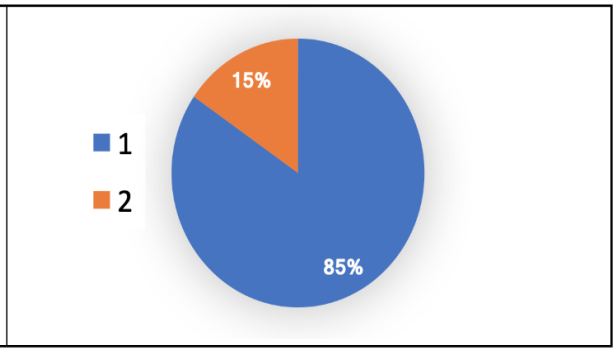
According to Diagram 3, students associate non-humanized practices with the lack of structure of the environment, which should be focused on care. When faced with the precariousness of resources for their work - few beds, few professionals in the health team, fewer technological resources than desirable, among others. Finally, the students were asked about their perception of patient healing and the correlation with humanized medical care.

The humanization of care is part of a larger plan to achieve more efficiency, results, and possibilities for cure in health care facilities. When there is integration and more direct communication between patients and service users, health professionals, and the managers of hospitals, clinics, and medical institutions, a more humanized bond is created among all instances.

In this way, more respect and recognition is established between the parties involved, which only tend to reflect in a more effective care to those in need. Humanizing care means considering the existential needs of that person, attending them with solidarity, and being able to comfort them (VENTRIX, 2019).

Diagram 04 - Diagram of responses to the questionnaire. Belém-Pará-Brazil, 2019

4. VOCÊ ACREDITA QUE UM ATENDIMENTO HUMANIZADO PODE INTERFERIR NO PROCESSO DE CURA DO PACIENTE?	
SIM	88
NÃO	16
TOTAL	104



Source: Questionnaires distributed to UNIFAMAZ students

VI. CONCLUSION

In view of what was evidenced by the present study, the insertion of the teaching of humanized medicine in the undergraduate course exerts on the student and future professional a reflective, motivational, and guiding power about the subsequent medical practice.

The construction of the subject is a multifactorial process that receives cultural, social, affective, and sociological influences. Therefore, during medical graduation, students are unique subjects, the result of a series of processes that are not known. Humanized medical education is an addition to the processes of subject formation, who needs to be stimulated to observe the patient from a perspective that is often different from the reality in which he/she lives, making him/her a humanistic, critical, reflective and ethical professional, with the capacity to act at different levels of health care.

Empathy, understood in different ways, according to the view of different authors, stands out as a communicational skill that allows the understanding of the other and the communication of this understanding, was used by most of the students participating in this research to characterize humanized patient care, showing once again that learning this humanized form of medicine is also a tool used in medical practice to see the patient in a transcendent way, taking professional conduct to a sphere that goes beyond the logical and disease-centered thinking.

Given the answers obtained in the application of the questionnaires and already reported in the analysis of the study, it is concluded that the students consider the teaching of medical humanities important for their professional growth and performance, because they believe that the axis led them to reflect on daily issues of medical life, patient care, a differentiated view of illness interfering in the healing process, besides the motivational sense in producing a more humane and ethical medicine.

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Assessment of the Risk of Cardiovascular Diseases and its Relationship with Heart Rate Variability in Physically Active and Sedentary Individuals

Avaliação do Risco de Doenças Cardiovasculares e sua Relação com a Variabilidade da Frequência Cardíaca em Indivíduos Fisicamente Ativos e Sedentários

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***Palavras-chaves*— Comportamento sedentário, Doenças cardiovasculares, Fatores de risco de doenças cardíacas, Frequência cardíaca, Sistema nervoso autônomo.**

***Abstract*—** *Heart rate variability (HRV) is the ability of the heart muscle to adapt to changes imposed on the heart. Therefore, a low baseline HRV may indicate a dysfunction of the autonomic nervous system and lead to the development of cardiovascular diseases (CVD). Thus, the objective of the study was to evaluate and compare HRV with the risk of developing CVD in sedentary and physically active individuals. This is an exploratory, experimental, applied study, with cross-sectional design, under ethical opinion number: 5,581,838. In the sample, 24 individuals of both genders, between 30 and 55 years old, were divided into a sedentary group and another physically active group, excluding those who were not within the inclusion criteria and who had clinically diagnosed cardiovascular or cardiopulmonary diseases. . For data collection, the International Physical Activity Questionnaire and the Cardiovascular Risk Stratification Questionnaire were applied; HRV was verified through the Polar H10 cardiac sensor, blood pressure, weight, height and abdomen-hip circumference. The sedentary group had a higher cardiovascular risk when assessing BMI, waist circumference and waist-hip ratio. Furthermore, the results showed, in sedentary individuals, a significantly higher value of systolic and diastolic blood pressure (124.66±8.91 versus 114.50±9.58 - 84.75±7.02 versus 75.66±6, 38, respectively) and heart rate (74.25±7.96 versus 67.41±7.67) when compared to physically active individuals, which associated with HRV data (42.91±7.54 versus 54.75 ±6.82), time domain and frequency domain, suggest greater sympathetic activity to the detriment of parasympathetic activity in sedentary individuals, reinforcing the cardiac autonomic imbalance in this group.*

***Resumo*—** *A variabilidade da frequência cardíaca (VFC) é a capacidade do músculo cardíaco de se adaptar às mudanças impostas ao coração. Logo, uma baixa VFC, na condição basal, pode indicar uma disfunção do*

sistema nervoso autônomo e levar ao desenvolvimento de doenças cardiovasculares (DCV). Destarte, o objetivo do estudo foi avaliar e comparar a VFC com o risco de desenvolvimento de DCV em indivíduos sedentários e fisicamente ativos. Trata-se de um estudo exploratório, experimental, natureza aplicada, com delineamento transversal, sob número de parecer ético: 5.581.838. Na amostra obteve-se 24 indivíduos de ambos os gêneros, entre 30 a 55 anos, divididos em um grupo de sedentários e outro de ativos fisicamente, sendo excluídos aqueles que não estavam dentro dos critérios de inclusão e que possuíam doenças cardiovasculares ou cardiopulmonares clinicamente diagnosticadas. Para coleta de dados aplicou-se o Questionário Internacional de Atividade Física e o de Estratificação do Risco Cardiovascular; verificou-se a VFC através do sensor cardíaco Polar H10, a pressão arterial, peso, altura e circunferência abdômen-quadril. O grupo dos sedentários apresentou maior risco cardiovascular ao avaliar IMC, circunferência abdominal e relação cintura-quadril. Ademais, os resultados demonstraram, nos sedentários, um valor significativamente maior de pressão arterial sistólica e diastólica (124,66±8,91 versus 114,50±9,58 - 84,75±7,02 versus 75,66±6,38, respectivamente) e da frequência cardíaca (74,25±7,96 versus 67,41±7,67) quando comparados aos indivíduos fisicamente ativos, que associado aos dados da VFC (42,91±7,54 versus 54,75±6,82), domínio do tempo e domínio da frequência, sugerem maior atividade simpática em detrimento da parassimpática nos sedentários, reforçando o desequilíbrio autonômico cardíaco neste grupo.

I. INTRODUÇÃO

As doenças cardiovasculares (DCV) são responsáveis por aproximadamente 30% dos óbitos no Brasil, sendo 50% destes entre 30 e 69 anos. As causas destas doenças incluem fatores de riscos modificáveis biológicos, como hipertensão (IC 95%: 2,2 – 2,7), elevação do colesterol (IC 95%: 1,5 – 1,8) e outros fatores relacionados ao estilo de vida, podendo ser citados obesidade (IC 95%: 1,7 – 2,2), tabagismo (IC 95%: 1,03 – 1,3) e sedentarismo (IC 95%: 1,02 – 2,1)[1,2]. Os fatores de risco não-modificáveis incluem a idade, gênero e hereditariedade[1].

O coração apresenta um mecanismo intrínseco para o controle da frequência cardíaca (FC), de maneira que, ao receber um maior volume de sangue proveniente do retorno venoso, maior será a distensão de suas fibras musculares, processo conhecido por Mecanismo de Frank-Starling[3]. Todavia, o Sistema Nervoso Autônomo (SNA) também desempenha um papel importante na regulação da FC através das ramificações simpáticas e parassimpáticas que agem, a princípio, de maneira contrastante, sendo fundamental para o equilíbrio do organismo[4].

O sistema nervoso simpático, por meio da liberação de noradrenalina, leva ao aumento da FC e da contratilidade do músculo cardíaco (cronotropismo e inotropismo positivo cardíaco), ao passo que o sistema nervoso parassimpático (atividade vagal) promove a diminuição dessas variáveis pela ação da acetilcolina[5].

Em indivíduos saudáveis constata-se a predominância da modulação parassimpática. Por outro lado, em sujeitos com doenças cardiovasculares há a prevalência da modulação simpática, caracterizando uma disfunção autonômica do coração, de maneira que esta alteração está relacionada com a baixa variabilidade da frequência cardíaca (VFC)[6].

A VFC pode ser definida como a capacidade do músculo cardíaco de se adaptar às mudanças impostas ao coração, modificando as oscilações nos intervalos entre os contínuos batimentos cardíacos (denominados intervalos R-R), de acordo com o estímulo oferecido. Por conseguinte, uma baixa VFC, na condição basal, pode indicar uma disfunção do SNA e seus resultados podem levar ao desenvolvimento de doenças cardiovasculares a longo prazo, uma vez que pode repercutir diretamente na FC e, por conseguinte, no débito cardíaco (DC) e na pressão arterial (PA)[7].

No que diz respeito ao sedentarismo, apontado como um importante fator de risco para o desenvolvimento de doenças cardiovasculares, pode ser definido pela ausência da prática de exercício físico regular ou indivíduos que praticam menos de 150 minutos de atividade física moderada ou menos de 75 minutos de atividade física

intensa por semana, e é uma das principais causas de mortalidade no mundo[8]. De acordo com a Pesquisa Nacional de Saúde: 2019, cerca de 40,3% das pessoas em fase adulta não praticam exercício físico dentro das recomendações da Organização Mundial da Saúde[9].

Com relação ao exercício físico, o mesmo pode ser descrito como uma atividade corporal planejada e estruturada de acordo com um objetivo específico[8]. Dessa forma, a Organização Mundial de Saúde preconizou, em sua última diretriz, que caso não haja contraindicações, os indivíduos adultos, para serem considerados fisicamente ativos, necessitam realizar, por semana, atividade física moderada de 150 a 300 minutos ou de 75 a 150 minutos de exercícios intensos[8].

Nesse contexto, conforme a Sociedade Brasileira de Cardiologia, a prática de exercícios físicos e uma dieta balanceada pode caracterizar-se como uma importante forma de prevenção da mortalidade cardiovascular[10], sendo evidente a importância da análise da VFC, dado o seu potencial de promover o desenvolvimento de doenças cardiovasculares em casos de desregulação da modulação autonômica. Sendo assim, o objetivo do presente estudo é avaliar e comparar o controle autonômico da frequência cardíaca, através da análise da VFC, com o risco de desenvolvimento de doenças cardiovasculares em indivíduos sedentários e fisicamente ativos.

II. 2. METODOLOGIA

2.1 Tipo de Estudo e Aspectos Legais da Pesquisa

Trata-se de um estudo do tipo exploratório, experimental, de natureza aplicada, com delineamento transversal, no qual foram realizados questionários validados no Brasil para coleta de dados quantitativos. O projeto foi aprovado pelo Comitê de Ética com número de parecer ético: 5.581.838.

2.2 Amostra

A amostra foi composta por 24 indivíduos de ambos os gêneros, na faixa etária de 30 a 55 anos, integrando toda cor/raça conforme o Instituto Brasileiro de Geografia e Estatística (IBGE)[9], recrutados sem distinção de classes sociais existentes e divididos em dois grupos de 12 integrantes (6 homens e 6 mulheres), sendo um grupo de sedentários e o outro de praticantes de exercício físico tanto aeróbicos como resistidos, com frequência de 3 a 5 vezes por semana e que atinjam, ao menos, 150 minutos de prática há, pelo menos, 6 meses, sendo excluídos aqueles que não estavam dentro dos critérios de inclusão e que possuíam doenças cardiovasculares ou cardiopulmonares clinicamente diagnosticadas.

2.3 Procedimentos Para Coleta de Dados

A coleta de dados foi realizada no período de outubro a novembro de 2022, de segunda a sexta, no turno matutino, na Clínica Escola Integrada de Fisioterapia e Terapia Ocupacional (FISIOCLÍNICA), localizada na Av. Alcindo Cacela, 359 – Umarizal, Belém – PA. Os participantes foram abordados e recrutados a partir do método de recrutamento externo, mediante mídias digitais, como Instagram, Facebook e Whatsapp, em que foi enviado um convite para participação.

A pesquisa seguiu conforme o código de Nuremberg, considerando os aspectos éticos de pesquisa com ser humano e em concordância com a resolução 466/12 do Conselho Nacional de Saúde e todos os participantes deveriam portar o Termo de Consentimento Livre e Esclarecido (TCLE) devidamente assinado.

2.4 Instrumento Para Coleta de Dados

2.4.1 Avaliação do Nível de Aptidão Física

A avaliação da aptidão física foi realizada por intermédio do Questionário Internacional de Atividade Física (IPAQ)- versão curta, proposto pela Organização Mundial de Saúde, o qual tem como objetivo ser um instrumento auxiliador mundial que possa determinar o nível de atividade e/ou exercício físico de um indivíduo[11].

O questionário possui uma linguagem clara e objetiva, com perguntas que abordam o tempo em que os voluntários passam realizando atividade física durante uma semana, seja no trabalho, em casa, como meio de transporte ou por recreação, assim como o tempo gasto sentado, constando de quatro seções de pergunta. Os dados obtidos foram somados para cada domínio de atividade, calculando o total de toda atividade e/ou exercício físico em minutos por semana[12,13].

2.4.2 Estratificação do Risco Cardiovascular

O Escore de Risco de Framingham (ERF) é o instrumento utilizado, à nível mundial, para calcular o risco de evento cardiovascular de acordo com a presença ou não de determinados fatores de risco, avaliando gênero, idade, valores da pressão arterial sistólica, colesterol total, HDL colesterol, tabagismo e diabetes. Atualmente, o ERF é considerado uma forma fidedigna, simples e de baixo custo[14,15,16,17].

O risco cardiovascular dos participantes foi obtido após somar os pontos acumulados dos fatores de risco disponibilizados pelo Ministério da Saúde – Secretaria de Atenção Primária à Saúde[18]. Após isso, com a pontuação total anotada, foi necessário cruzar essas informações para obter a projeção em porcentagem do risco em dez anos. Por último, ao avaliar a projeção do risco em dez anos, obteve-se o grau de risco cardiovascular em baixo (<10%), intermediário (10-20%) ou alto risco (>20%), tendo como

auxílio a calculadora de estratificação do risco, viabilizada pela Diretriz Brasileira de Dislipidemia e Prevenção da Aterosclerose[17,19,20].

2.4.3 Análise Bioquímica

Para o cálculo do Escore de Framingham é necessário obter dados referentes ao colesterol total, LDL colesterol e HDL colesterol[17,18]. Portanto, para reduzir o risco de informações inconclusivas ou erradas do risco cardiovascular, os participantes que não possuíam exames de sangue recentes foram convidados a realizar a coleta, em jejum de 12 horas, na clínica Laboratório Integrado de Diagnóstico, sob responsabilidade dos pesquisadores. Dos 24 participantes da pesquisa, apenas 3 tinham exames atuais e os outros 21 aceitaram fazer a coleta.

2.4.4 Cálculo do Índice de Massa Corporal, Circunferência abdominal e Relação abdômen-Quadril.

Para o cálculo do Índice de Massa Corporal (IMC), utilizou-se uma balança digital da marca Balmak, modelo Slimbasic 200, com capacidade máxima de 200kg e mínimo de 2kg, com graduação a cada 100g, assim como a mensuração da altura do indivíduo por meio da fita métrica inelástica, modelo Vonder, com 1,5 metros[21,22].

Os indivíduos foram pesados sem sapatos e com roupas leves, a fim de minimizar interferências e a altura foi mensurada com o participante ereto, imóvel, com os braços estendidos ao longo do corpo, cabeça na posição neutra, olhando para um ponto fixo na altura dos olhos. Os ombros, as nádegas e os calcanhares permaneceram encostados na parede, sendo a medida mensurada em centímetros, necessitando transformá-la posteriormente em metros para o cálculo do IMC, que consiste em dividir o peso (em kg) pela altura (em m) elevada ao quadrado[21,22].

Todavia, o Índice de Massa Corporal apresenta limitações em virtude da incapacidade de diferenciar a massa magra da gordura[23]. Dessa forma, têm sido propostas outras medidas fidedignas para mensuração da gordura abdominal, como a circunferência abdominal (CA) e relação cintura-quadril (RCQ)[24,25].

Seguindo recomendações, a medição da CA foi realizada ao final da expiração com o indivíduo em pé, com uma fita métrica inelástica, modelo Vonder, com 1,5 metros, posicionada ao redor da região abdominal no ponto médio entre a distância da crista ilíaca e o rebordo costal inferior. Para o cálculo da relação cintura-quadril é necessário, também, medir a área mais larga do quadril, onde há maior protuberância das nádegas. Em seguida, divide-se a medida da cintura pela medida do quadril[21,26,27].

2.4.5 Mensuração da pressão arterial

A medida da pressão arterial (PA) foi realizada através do Monitor de Pressão Automático – Modelo HEM 7113, com o indivíduo sentado, os pés apoiados no chão; o manguito do esfigmomanômetro posicionado ao nível do coração, sobre a artéria braquial do braço esquerdo, sem deixar folgas, de 2 a 3 cm acima da fossa cubital. A seguir, o braço esquerdo, livre de roupas, foi elevado na altura do osso esterno, com a palma da mão voltada para cima, dando início, após 5 minutos de repouso, à coleta e mensurando, a partir disso, a PA sistólica e diastólica[28,29].

2.4.6 Avaliação da Modulação Autonômica da Frequência Cardíaca

Para avaliação da VFC, os participantes foram orientados a não consumir bebidas alcoólicas em até 12 horas antes do teste ou estimulantes (café, chás, chocolate, refrigerante) em até 6 horas e que fizessem refeições leves e não praticassem atividade física extenuante no dia anterior à coleta de dados[30,31]. Durante a coleta, os voluntários foram instruídos a não conversar e não fazer movimentação, sendo os testes realizados em um ambiente controlado – com ar-condicionado e silencioso-, e todos no mesmo período do dia, a fim de prevenir influências do ciclo circadiano[31].

Para a captação da VFC foi utilizado o sensor cardíaco Polar modelo H10 que, por meio de eletrodos ligados à uma cinta elástica posicionada ao redor da região torácica, captura os sinais elétricos constantemente e armazena-os[31,32].

A coleta de dados foi realizada em duas etapas, em que na primeira, os participantes foram mantidos durante 5 minutos em repouso na posição sentada (com 90° de flexão do quadril) e com os pés e coluna apoiados para que a FC alcançasse valores basais. Na segunda etapa, iniciou-se a coleta de dados na posição sentada durante 8 minutos. Foram selecionados os intervalos mais estáveis, utilizando os métodos lineares no Domínio do Tempo: índice rMSSD, SDNN e pNN50 e no Domínio da Frequência: Alta Frequência (HF – 0,15 a 0,4Hz), Baixa Frequência (LF- 0.04 a 0,15Hz) e a relação LF/HF[30,31,32]

Os resultados foram transferidos, via Bluetooth, para o aplicativo Elite HRV instalado no celular, o qual processou as informações coletadas e calculou diretamente os componentes lineares da VFC, assim como forneceu especificamente e diretamente o valor da VFC de cada indivíduo[31,32].

2.4.7 Mensuração da Saturação Periférica de Oxigênio

A oximetria de pulso é considerada uma maneira rápida, prática e não-invasiva de medir indiretamente a porcentagem do transporte de oxigênio na circulação sanguínea, assim como a frequência cardíaca do indivíduo. Para a mensuração da saturação periférica de oxigênio, utilizou-se o oxímetro da marca G-Tech LED, o qual foi

posicionado corretamente na ponta do dedo indicador ou dedo médio de qualquer umas das mãos do indivíduo, por cerca de 1 minuto, permanecendo o segmento parado para que não ocorresse erro na leitura do aparelho. Os valores ideais de saturação compreendem de 95% a 99%[33].

III. ANÁLISE ESTATÍSTICA

Para análise estatística foram elaboradas planilhas através do programa *Microsoft Excel*®, versão 2016, obtendo os valores de todas as variáveis em média e desvio padrão; assim como foi realizada a comparação entre os grupos pelo teste T de Student, sendo considerado o nível alfa de 0,05 para rejeição da hipótese de nulidade.

IV. RESULTADOS

4.1 Idade, peso, estatura e índice de massa corpórea

Os resultados referentes aos itens idade, peso, estatura e índice de massa corpórea estão descritos no QUADRO 1. As médias de altura e peso dos dois grupos não divergiram entre si (Pvalor > 0,05). Já as médias de idade e IMC foram significativamente diferentes entre as duas amostras (Pvalor < 0,05), apontando maiores valores no grupo dos sedentários.

Quadro 1. Comparação física e antropométrica de indivíduos sedentários e fisicamente ativos

Variáveis	Sedentários	Fisicamente ativos	Pvalor
Idade (anos)	47,66 ± 6,24	42,08 ± 7,46	0,035
Altura (m)	1,63 ± 0,12	1,70 ± 0,09	0,076
Peso (kg)	81,02 ± 19,99	71,74 ± 13,51	0,108
IMC (kg/m^2)	29,99 ± 4,59	24,61 ± 3,21	0,002

Os resultados são relatados como média ± desvio padrão. IMC: Índice de Massa corpórea.

4.2 Estado nutricional global classificado pelo IMC

Os resultados relativos ao estado nutricional baseado no índice de massa corporal estão descritos no QUADRO 2. Observa-se que 25% dos sedentários eram eutróficos, 25% com sobrepeso e 50% eram obesos. Já os fisicamente ativos, 8,3 % era baixo peso; 50% eutróficos; 33,3% com sobrepeso e 8,3% obesidade grau I.

Quadro 2. Distribuição dos indivíduos sedentários e fisicamente ativos de acordo com o estado nutricional global classificado pelo IMC

Estado nutricional	Sedentários N(%)	Fisicamente ativos N (%)
Baixo peso	0 (0)	1 (8,3)
Eutrófico	3 (25)	6 (50)
Sobrepeso	3 (25)	4 (33,3)
Obesidade grau I	3 (25)	1 (8,3)
Obesidade grau II	3 (25)	0 (0)
Obesidade grau III	0 (0)	0 (0)

4.3 Risco de doença cardiovascular baseado no IMC

A Distribuição dos indivíduos sedentários e fisicamente ativos de acordo com o risco de doença cardiovascular baseado no IMC está disposto no QUADRO 3. 25% dos sedentários não apresentaram risco cardiovascular; 25% apresentaram risco pouco elevado; 25% risco elevado e 25% risco muito elevado. Já no grupo dos fisicamente ativos, 58% não apresentou risco cardiovascular e apenas 33,3% risco pouco elevado e 8,3% risco elevado.

Quadro 3. Distribuição dos indivíduos sedentários e fisicamente ativos de acordo com risco de doença cardiovascular baseado no IMC

Risco de doença cardiovascular	Sedentários N(%)	Fisicamente ativos N (%)
Normal	3 (25)	7 (58)
Pouco elevado	3 (25)	4 (33,3)
Elevado	3 (25)	1 (8,3)
Muito elevado	3 (25)	0 (0)
Muitíssimo elevado	0 (0)	0 (0)

4.4 Circunferência abdominal, do quadril e relação cintura-quadril de mulheres sedentárias e fisicamente ativas

Os resultados referentes à circunferência abdominal, do quadril e a relação cintura-quadril das mulheres sedentárias e fisicamente ativas estão descritos no QUADRO 4. As médias da circunferência abdominal e a relação cintura-quadril foram significativamente diferentes entre as duas amostras (Pvalor < 0,05), apontando maiores valores no grupo dos sedentários. No entanto, a média da circunferência do quadril não divergiu entre si (Pvalor > 0,05), embora tenha sido maior nos sedentários.

Quadro 4. Comparação da circunferência abdominal, da circunferência do quadril e da relação abdômen-quadril entre mulheres sedentárias e fisicamente ativas

	Sedentárias	Fisicamente ativas	Pvalor
CA (cm)	96,50 ± 7,46	80,00 ± 5,74	0,001
CQ (cm)	105,66 ± 5,91	101,66 ± 5,49	0,147
RCQ	0,91 ± 0,04	0,78 ± 0,03	0

Os resultados são relatados como média ± desvio padrão. IMC: Índice de Massa corpórea. CA: Circunferência Abdominal. CQ: Circunferência do Quadril. RAQ: Relação abdômen-quadril. IMC: Índice de Massa Corporal

4.5 Circunferência abdominal, do quadril e relação cintura-quadril de homens sedentários e fisicamente ativos

Os resultados referentes à circunferência abdominal, do quadril e a relação cintura-quadril dos homens sedentários e fisicamente ativos estão descritos no QUADRO 5. As médias da circunferência abdominal e a relação cintura-quadril foram significativamente diferentes entre as duas amostras (Pvalor < 0,05), apontando maiores valores no grupo dos sedentários. Contudo, a média da circunferência do quadril não divergiu entre si (Pvalor > 0,05), embora tenha sido maior nos sedentários.

Quadro 5. Comparação da circunferência abdominal, da circunferência do quadril e da relação abdômen-quadril entre homens sedentários e fisicamente ativos

	Sedentários	Fisicamente ativos	Pvalor
CA (cm)	104,58 ± 13,34	88,00 ± 7,50	0,018
CQ (cm)	107,41 ± 9,61	98,58 ± 5,48	0,052
RCQ	0,97 ± 0,05	0,89 ± 0,07	0,047

Os resultados são relatados como média ± desvio padrão. IMC: Índice de Massa corpórea. CA: Circunferência Abdominal. CQ: Circunferência do Quadril. RAQ: Relação abdômen-quadril. IMC: Índice de Massa Corporal

4.6 Risco de doença cardiovascular baseado na circunferência abdominal

A Distribuição dos indivíduos sedentários e fisicamente ativos de acordo com risco de doença cardiovascular baseado na circunferência abdominal está disposto no QUADRO 6. 75% dos indivíduos sedentários apresentaram risco muito aumentando e 8,3% risco aumentado para o desenvolvimento de doenças cardiovasculares. Em contrapartida, apenas 8,3% dos fisicamente ativos apresentou risco muito aumentado e 25% risco aumentado, prevalecendo baixo risco de DCV neste grupo, com 66,6%. Já nos sedentários, somente 16,6% apresentaram baixo risco.

Quadro 6. Distribuição dos indivíduos sedentários e fisicamente ativos de acordo com risco de doença cardiovascular baseado na circunferência abdominal

Risco de doença cardiovascular	Sedentários N(%)	Fisicamente ativos N (%)
Baixo	2 (16,6)	8 (66,6)
Aumentado	1 (8,3)	3 (25)
Muito aumentado	9 (75)	1 (8,3)

4.7 Risco de doença cardiovascular baseado na relação cintura-quadril

A Distribuição dos indivíduos sedentários e fisicamente ativos de acordo com risco de doença cardiovascular baseado na relação cintura-quadril está disposto no QUADRO 7. 66,6% dos indivíduos sedentários apresentaram alto risco e 8,3% risco médio para o desenvolvimento de doenças cardiovasculares. Por outro lado, apenas 8,3% dos fisicamente ativos apresentou alto risco e 16,6% risco médio, prevalecendo baixo risco de DCV neste grupo, com 75%. Já nos sedentários, somente 25% apresentaram baixo risco.

Quadro 7. Distribuição dos indivíduos sedentários e fisicamente ativos de acordo com risco de doença cardiovascular baseado na relação abdômen-quadril

Risco de doença baseado na RAQ	Sedentários N(%)	Fisicamente ativos N (%)
Baixo risco	3 (25)	9 (75)
Médio risco	1 (8,3)	2 (16,6)
Alto risco	8 (66,6)	1 (8,3)

4.8 Análise Bioquímica

Os resultados referentes aos dados de colesterol total, HDL e LDL colesterol estão dispostos no QUADRO 8. As médias de colesterol total e LDL dos dois grupos não divergiram entre si (Pvalor > 0,05). Já a média de HDL colesterol foi significativamente diferente entre as duas amostras (Pvalor < 0,05), apontando maiores valores no grupo dos fisicamente ativos.

Quadro 8. Características bioquímicas dos indivíduos sedentários e fisicamente ativos

	Sedentários	Fisicamente ativos	Pvalor
Colesterol total (mg/dL)	191,08 ± 32,55	177,33 ± 35,33	0,176
HDL colesterol (mg/dL)	38,91 ± 4,38	43,25 ± 4,05	0,012
LDL colesterol (mg/dL)	112,08 ± 33,02	111,80 ± 30,44	0,492

Os resultados são relatados como média ± desvio padrão. HDL: High-density lipoproteins; LDL: Low-density lipoproteins

4.9 Níveis de pressão arterial

Os valores de PAS e PAD estão descritos no QUADRO 9. Os resultados demonstraram um valor significativamente maior de PAS e PAD no grupo dos sedentários (Pvalor < 0,05). Dos 12 indivíduos sedentários, 4 apresentaram hipertensão sistólica e 4 hipertensão diastólica, o que corresponde a 33,3 da amostra, respectivamente. Os demais apresentaram valores considerados normotensos. Já no grupo dos fisicamente ativos, 1 apresentou hipotensão sistólica, 1 hipertensão sistólica e 1 hipotensão diastólica. Os demais apresentaram valores considerados normotensos.

Quadro 9. Características bioquímicas dos indivíduos sedentários e fisicamente ativos

	Sedentários	Fisicamente ativos	Pvalor
PAS (mmHg)	124,66 ± 8,91	114,50 ± 9,58	0,009
PAD (mmHg)	84,75 ± 7,02	75,66 ± 6,38	0,002
PAS N %	66,60%	83,30%	
PAD N %	66,60%	91,60%	
PAS B %	0%	8,30%	
PAD B%	0%	8,30%	
PAS A %	33,30%	8,30%	
PAD A %	33,30%	0%	

Os resultados são relatados como média ± desvio padrão. PAS: Pressão arterial sistólica. PAD: Pressão arterial diastólica. PAS N: Pressão arterial sistólica normal. PAS N: Pressão arterial diastólica normal. PAS B: Pressão arterial sistólica baixa. PAD B: Pressão arterial diastólica baixa. PAS A: Pressão arterial sistólica alta. PAS A: Pressão arterial diastólica alta

4.10 Características hemodinâmicas

Os valores de FC e SPO2 estão descritos no QUADRO 10. Os resultados demonstraram um valor significativamente maior de FC no grupo dos sedentários (Pvalor < 0,05). No entanto, os valores de saturação de oxigênio não apresentaram diferença estatística, devido ao Pvalor > 0,05, embora tenha sido maior nos fisicamente ativos.

Quadro 10. Características hemodinâmicas dos indivíduos sedentários e fisicamente ativos

	Sedentários	Fisicamente ativos	Pvalor
FC média (batimentos/min)	74,25 ± 7,96	67,41 ± 7,67	0,026
Spo2 (%)	97,9 ± 0,75	98,33 ± 0,47	0,068

Os resultados são relatados como média ± desvio padrão. FC: Frequência cardíaca. SPO2: Saturação periférica de oxigênio.

4.11 Variabilidade da frequência cardíaca, domínio do tempo e domínio da frequência

Os resultados relativos à variabilidade da frequência cardíaca, domínio do tempo e domínio da frequência estão expressos nos QUADROS 11, 12 e 13, respectivamente. O grupo dos praticantes de exercício físico apresentou uma média da VFC significativamente maior (Pvalor <0,05) comparado ao grupo dos sedentários. Da mesma forma, os índices RMSSD, SDNN e PNN50 demonstraram diferenças significativas entre si (Pvalor < 0,05). Com relação ao domínio da frequência, somente a relação LF/HF teve significância estatística, estando essa variável maior nos sedentários. No entanto, os índices LF e HF não apresentaram diferenças significativas entre os grupos (Pvalor > 0,05).

Quadro 11. Comparação da variabilidade da frequência cardíaca entre indivíduos sedentários e fisicamente ativos

	Sedentários	Fisicamente ativos	Pvalor
VFC	**42,91 ± 7,54**	**54,75 ± 6,82**	**0**

Os resultados são relatados como média ± desvio padrão. VFC: Variabilidade da frequência da cardíaca

Quadro 12. Método linear da análise da variabilidade da frequência cardíaca: Domínio do tempo dos indivíduos sedentários e fisicamente ativos

	Sedentários	Fisicamente ativos	Pvalor
RMSSD (ms)	18,42 ± 9,29	38,86 ± 15,82	0.001
SDNN (ms)	37,84 ± 17,00	57,18 ± 21,50	0.014
PNN50 (%)	3 ± 6,60	20,08 ± 16,26	0.002

Os resultados são relatados como média ± desvio padrão. RMSSD: Raiz quadrada da média do quadrado das diferenças entre intervalos RR normais adjacentes em um intervalo de tempo. SDNN: Desvio padrão de todos os intervalos RR normais gravados em um intervalo de tempo. PNN50: porcentagem dos intervalos RR adjacentes com diferença de duração maior que 50ms.

Quadro 13. Método linear da análise da variabilidade da frequência cardíaca: Domínio da Frequência dos indivíduos sedentários e fisicamente ativos

	Sedentários	Fisicamente ativos	Pvalor
Índice LF (ms^2)	0,07 ± 0,03	0,08 ± 0,02	0,187
Índice HF (ms^2)	0,25 ± 0,05	0,24 ± 0,05	0,388
Relação LF/HF	3,36 ± 2,02	1,56 ± 1,2	0,01

Os resultados são relatados como média ± desvio padrão. LF: Low Frequency. HF: High Frequency

4.12 Pontuação do risco cardiovascular baseado no Escore de Framingham e a classificação do risco em 10 anos

Os resultados referentes à pontuação dos fatores de risco, risco global em 10 anos e a classificação do risco cardiovascular estão dispostos nos QUADROS 14 e 15 e 16, respectivamente. Foi observado que os indivíduos sedentários apresentaram maior pontuação de risco cardiovascular (Pvalor < 0,05) e maior percentual de risco de eventos cardiovasculares em 10 anos (Pvalor < 0,05) comparado aos fisicamente ativos, embora estejam dentro dos valores de normalidade.

Quadro 14. Pontuação dos fatores de risco baseado no Escore de Framingham

	Sedentários	Fisicamente ativos	Pvalor
Pontuação	9,75 ± 4,72	4,25 ± 4,41	0,005

Os resultados são relatados como média ± desvio padrão.

Quadro 15. Risco global em 10 anos baseado no Escore de Framingham.

	Sedentários	Fisicamente ativos	Pvalor
Pontuação	9,06 ± 6,52	4,52 ± 5,44	0,045

Os resultados são relatados como média ± desvio padrão.

Quadro 16. Classificação do risco cardiovascular (estudo de Framingham)

Classificação do risco	Sedentários N(%)	Fisicamente ativos N (%)
Baixo (<10%)	9 (66,6)	11 (91,6)
Intermediário (10-20%)	3 (25)	0 (0)
Alto (>20%)	1 (8,3)	1 (8,3)

V. DISCUSSÃO

No Brasil, as doenças cardiovasculares mantêm-se como a principal causa de mortalidade, sendo que um terço dos óbitos por DCV's ocorrem precocemente em adultos na faixa etária de 35 a 64 anos. Neste intervalo de idade, os principais fatores de risco que influenciam no alto índice são: hipertensão arterial sistêmica, dislipidemia, sedentarismo, diabetes mellitus, tabagismo e obesidade[29,34,35].

Nesse contexto, uns dos principais fatores de risco para DCV's que têm se tornado prevalente nos últimos anos é a obesidade e o sedentarismo[36]. Estudos apontam que indivíduos com excesso de peso têm 3,5 vezes maior probabilidade de desenvolver hipertensão, de maneira que 60% da pressão alta está relacionada ao excedente de células adiposas no organismo[37,38]. No presente estudo, os indivíduos sedentários apresentaram a média de colesterol total e LDL superior aos fisicamente ativos, embora não significativamente divergente entre si devido ao Pvalor > 0,05. Já a média de HDL colesterol foi significativamente maior nos praticantes de exercício físico (Pvalor < 0,05).

A World Health Organization (2000) classificou a obesidade de acordo com o índice de massa corporal, sendo o IMC ≥ 30-34,9 obesidade grau I e risco elevado para doenças cardiovasculares; IMC ≥ 35-39,9 obesidade grau II e risco muito elevado e IMC ≥ 40 obesidade grau III e risco muitíssimo elevado[21].

Observou-se nos resultados que os indivíduos sedentários apresentaram maiores valores de IMC, com média de 29,99 ± 4,59 *versus* 24,61 ± 3,21 dos fisicamente ativos (Pvalor < 0,05). De modo que 25% dos sedentários eram eutróficos, 25% com sobrepeso, 25% com obesidade grau I e 25% com obesidade grau II. Já os fisicamente ativos, 8,3 % era baixo peso; 50% eutróficos; 33,3% com sobrepeso e 8,3% obesidade grau I, sendo importante

enfatizar que, dos indivíduos com sobrepeso, metade deles foi decorrente à hipertrofia muscular.

Sendo assim, vale ressaltar que o IMC não distingue a massa gordurosa da massa magra[23]. Logo, para maior precisão do conteúdo de gordura visceral, é indicado aferir a circunferência abdominal e a relação cintura-quadril. Estudos sugerem que as medidas desses três métodos sejam realizadas em conjunto para melhor avaliação do risco cardiovascular[24,27,35].

À vista disso, a Federação Internacional de Diabetes estabeleceu como elevado risco cardiovascular valores da circunferência abdominal ≥ 94 centímetros em homens e ≥ 80 centímetros em mulheres. Já o National Cholesterol Education Program – Adult Treatment Panel III preconizou que a circunferência abdominal ≥ 102 centímetros em homens e ≥ 88 centímetros em mulheres configura-se como risco muito elevado para doenças do sistema cardiovascular[26].

Para o cálculo da relação cintura-quadril, a Organização Mundial de Saúde definiu que RCQ < 0,95 em homens e < 0,80 em mulheres baixo risco cardiovascular; RCQ entre 0,96 a 1 em homens e entre 0,81 a 0,85 em mulheres moderado risco e RCQ > 1 em homens e > 0,86 em mulheres alto risco cardiovascular[27].

Observou-se nos resultados que tanto o grupo de mulheres quanto o de homens sedentários apresentaram maiores valores nos três itens avaliados (CA, CQ e RCQ) comparado ao grupo dos fisicamente ativos, com diferença significativa devido ao Pvalor < 0,05 em todos os pontos analisados. Sendo assim, é importante enfatizar que, do ponto de vista antropométrico, o grupo de sedentários do estudo possui maior risco cardiovascular ao correlacioná-lo com o dos praticantes de atividade física.

Ademais, outra forma de mensurar o risco de desenvolvimento de doenças cardiovasculares é avaliando o Sistema Nervoso Autônomo, o qual apresenta duas ramificações: simpática e parassimpática que agem, a princípio, de maneira contrastante e apresentam um papel fundamental na regulação da frequência cardíaca, estando o simpático relacionado ao cronotropismo e inotropismo positivo cardíaco, ao passo que o parassimpático promove a diminuição dessas variáveis[39].

Em indivíduos saudáveis e/ou praticantes de exercício físico, constata-se a predominância da modulação parassimpática em virtude da redução da sensibilidade dos receptores beta adrenérgicos, atenuando, assim, o cronotropismo e inotropismo positivo cardíaco, o que leva a um maior equilíbrio elétrico do coração. Em contrapartida, a prevalência da atividade simpática caracteriza uma disfunção autonômica cardíaca, aumentado sua vulnerabilidade e o risco de eventos cardiovasculares[40,6].

Dentre as diversas técnicas usadas para avaliar o controle autonômico cardíaco, a VFC tem emergido como uma medida simples e não-invasiva, que através de métodos lineares e não-lineares mensura a atividade simpática e parassimpática[5,6]. Os métodos lineares são divididos em dois tipos: análise no domínio do tempo e análise no domínio da frequência.

Por meio do domínio do tempo mensura-se cada intervalo RR normal durante determinado intervalo de tempo e, então, conforme métodos estatísticos ou geométricos, calcula-se os índices tradutores de flutuações ao longo dos batimentos cardíacos[30,41]. Os índices estatísticos no domínio do tempo avaliados no presente estudo foram: SDNN - Desvio padrão de todos os intervalos RR normais gravados em um intervalo de tempo; rMSSD - Raiz quadrada da média do quadrado das diferenças entre intervalos RR normais adjacentes em um intervalo de tempo e pNN50 - Porcentagem dos intervalos RR adjacentes com diferença de duração maior que 50ms.

O índice SDNN reflete a atividade simpática e parassimpática, no entanto não permite distinguir quando as alterações da VFC são decorrentes à retirada do tônus vagal ou aumento do tônus simpático. Já os índices rMSSD e pNN50 representam a atividade parassimpática (vagal), pois são encontrados a partir da análise de intervalos RR adjacentes. Logo, quanto maiores os valores de rMSSD e pNN50, maior a atividade vagal[42,43,44,45]

De acordo com Maia, valores inferiores a 30 ms do índice rMSSD e inferiores a 4% do índice pNN50 refletem um fator de risco para o desenvolvimento de arritmias[42]. No presente estudo foi constatado que os indivíduos sedentários apresentaram menores valores do índice rMSSD e pNN50, sendo a média dos valores do índice rMSSD abaixo de 30 ms (18,42 ms ± 9,29) (Pvalor < 0,05) e abaixo de 4% (3% ± 6,6) no índice PNN50 (Pvalor < 0,05), sugerindo, portanto, menor atividade parassimpática neste grupo.

Já os fisicamente ativos apresentaram média de 38,86 ms ± 15,82 (Pvalor < 0,05) no índice rMSSD e 20,08% ± 16,26 no índice pNN50, corroborando com estudos os quais demonstram que o controle autonômico parassimpático é mais predominante em indivíduos praticantes de atividade física, apresentando, portanto, menor risco para o desenvolvimento de doenças cardiovasculares[40,6].

Ademais, ao refletir tanto a atividade simpática como a parassimpática, o índice SDNN acaba por representar a VFC de forma global[5,6]. Logo, valores elevados de SDNN indicam uma variabilidade da frequência cardíaca mais

alta. Nesse contexto, vale destacar que os indivíduos fisicamente ativos apresentaram valores superiores de SDNN, com média de 57,18 ± 21,50 *versus* 37,84 ± 17,00 dos sedentários (Pvalor < 0,05).

Já no domínio da frequência, a VFC foi avaliada através de componentes oscilatórios, sendo eles: Alta frequência (High Frequency - HF), que corresponde à atuação parassimpática sobre o coração; Baixa Frequência (Low Frequency - LF), a qual reflete a ação conjunta dos componentes parassimpático e simpático sobre o coração, com predominância do simpático e a relação LF/HF, que representa o balanço simpato-vagal[46,47].

Avaliando o domínio da frequência, tanto os sedentários como os fisicamente ativos obtiveram, sem significância estatística devido ao Pvalor > 0,05, predominância parassimpática, o que contradiz com os valores observados no domínio do tempo, no qual os sedentários apresentaram atuação parassimpática significativamente mais baixas (Pvalor < 0,05), com risco ao desenvolvimento de doenças cardiovasculares

No tocante à relação LF/HF, não é possível analisá-la de forma isolada uma vez que representa o equilíbrio simpático-vagal[6]. Logo, foi necessário associá-la com os índices do domínio do tempo (RMSSD e PNN50) para obter resultados mais precisos. No grupo dos sedentários, a relação LF/HF apresentou um média de 3,36 ± 2,02 *versus* 1,56 ± 1,28 dos fisicamente ativos. Ao associar isso com os valores de RMSSD e PNN50, chega-se à conclusão de que, nos sedentários, há a retirada vagal, com predomínio do simpático, o que acaba por elevar os valores da relação LF/HF.

Tais resultados corroboram com uma revisão de literatura, na qual foi observado que, nos pacientes com epilepsia, houve redução da VFC decorrente da diminuição de HF, rMSSD, pNN50 e aumento da relação LF/HF, refletindo a redução do tônus vagal cardíaco e aumento da atuação simpática[48].

Além disso, contatou-se que, apesar da média da PAS e PAD dos sedentários estar dentro dos valores de normalidade (122/84 ± 8,91/7,02, respectivamente), a PAS e PAD nos fisicamente ativos foi significativamente menor (114/75 ± 9,58/6,38, respectivamente) (Pvalor < 0,05). Nesse contexto, é importante ressaltar que valores elevados da PAS e PAD podem refletir o aumento da atividade simpática, o que pode ser explicado pela influência dos impulsos simpáticos centrais na estimulação da liberação de catecolaminas, as quais desencadeiam uma vasoconstrição periférica com aumento da resistência vascular[49].

Ainda nesse cenário, é válido dizer que indivíduos sedentários apresentaram valores significativamente maiores da FC média de repouso (74,25 ± 7,96) quando comparados aos praticantes de atividade física (67,41 ± 7,67) (Pvalor < 0,05), corroborando com estudos os quais afirmam que há, nos sedentários, maior predominância da modulação simpática e menor modulação parassimpática, uma vez que o sistema nervoso simpático está diretamente relacionado com o aumento da FC. Ademais, o coração do ativo fisicamente é bem mais "treinado e forte", portanto, bombeia mais sangue com menor esforço[5,50].

Com relação aos valores da VFC, observou-se que o grupo dos sedentários apresentou uma média significativamente menor (42,91 ± 7,54) comparado ao grupo dos praticantes de exercício físico (54,75 ± 6,82) (Pvalor < 0,05). Estudos indicam que uma baixa variabilidade, na condição basal, pode ser indicadora de um irregular funcionamento e adaptação do SNA e seus resultados podem levar ao mau desempenho fisiológico do indivíduo e ao desenvolvimento de doenças cardiovasculares a longo prazo. Por conseguinte, uma alta VFC pode refletir uma boa adaptação, com mecanismos autonômicos eficazes[51,52,4].

Wulsin, L.R., *et al* (2015), em um estudo de análise secundária de dados prospectivos de participantes do Offspring Cohort (N 1882) no Framinham Heart Study (FHS), ao avaliar indivíduos com mais de 18 anos e que apresentavam dados a respeito da FC de repouso, VFC e cinco medidas de risco metabólico (PA elevada, hiperglicemia, triglicerídeos elevados, HDL e IMC alto), chegou à conclusão de que a disfunção autonômica (baixa VFC) está associada a maus resultados metabólicos, riscos de doenças cardiovasculares, diabetes e mortalidade precoce, validando, dessa maneira, os resultados encontrados no presente estudo, visto que 50% dos sedentários apresentaram IMC acima de 30kg/m^2; 33,3% colesterol total acima do 200 mg/dL; 25% HDL abaixo de 30 mg/dL, assim como menor VFC[53].

Já Fang, S.C., *et al* (2020) realizou uma revisão sistemática e uma meta-análise de estudo de coorte a fim de avaliar a VFC como marcador para predizer morte por todas as causas e eventos cardiovasculares em pacientes com DCV's. Os achados do estudo mostraram que, ao comparar os pacientes com doenças cardiovasculares, mas que apresentavam alta VFC, com aqueles os quais tinham baixa VFC, estes últimos tiveram um maior risco de mortalidade – de 121% e 46% por todas as causas e eventos cardiovasculares, respectivamente, durante um seguimento de pelo menos 1 ano, correlacionando-se ao estudo de coorte de base populacional de Lopez et al (2015), o qual revelou que uma VFC mais baixa no início do estudo está associada a um maior risco de doença cardíaca e mortalidade[54,55].

Nessa perspectiva, o Escore de Risco de Framingham tem sido a estratificação mais empregada e recomendada pela Sociedade Brasileira de Cardiologia para avaliar o risco cardiovascular e morte por eventos cardíacos[19,17]. No presente trabalho foi observado que os indivíduos sedentários apresentaram pontuação significativamente maior do fator de risco cardiovascular, com média de 9,75 ± 4,72 *versus* 4,25 ± 4,41 dos fisicamente ativos (Pvalor < 0,05) e maior percentual de risco de eventos cardiovasculares em 10 anos, com média de 9,06 ± 6,52 *versus* 4,52 ± 5,44 dos ativos fisicamente (Pvalor < 0,05).

À vista disso, tomando por base a porcentagem do risco cardiovascular em 10 anos, obteve-se que 25% dos sedentários apresentaram médio risco e 8,3% alto risco. Por outro lado, apenas 8,3% dos ativos fisicamente apresentaram alto risco, prevalecendo baixo risco neste grupo, com média de 91,6%, já nos sedentários, somente 66,6% apresentaram baixo risco.

Por fim, contrapondo aos estudos citados e aos resultados obtidos no presente trabalho, na revisão sistemática e meta-análise de Alansare, A.B., *et al* (2021), a qual avaliou a existência da associação entre o sedentarismo e a variabilidade da frequência cardíaca, foi presumido que um maior tempo sedentário estaria relacionado a valores mais baixos dos índices SDNN, RMSSD e HF. Todavia, não se obteve associações significativas entre os itens supracitados, demonstrando que o tempo sedentário maior pode não estar associado ao comprometimento autonômico cardíaco[56].

Vale dizer, porém, que a qualidade dos estudos observados pela meta-análise foi baixa, atendendo, em média, apenas seis dos treze critérios de qualidade, além de fontes potenciais de heterogeneidade encontradas, ao considerar as características dos participantes, assim como instrumento, duração e postura da medição da VFC, os quais podem ter impactado nos resultados[56].

VI. CONCLUSÃO

O presente estudo possibilitou avaliar e comparar o controle autonômico da frequência cardíaca, através da análise da VFC, com o risco de desenvolvimento de doenças cardiovasculares em indivíduos sedentários e fisicamente ativos. E ratificando a hipótese de que indivíduos sedentários apresentavam desregulação do controle autonômico cardíaco, devido à baixa VFC, e maior risco cardiovascular, os resultados demonstraram que os inativos fisicamente apresentaram significativamente maiores valores de IMC, de circunferência abdominal e da relação cintura-quadril, assim como menor VFC comparado ao grupo dos praticantes de exercício físico, com redução da atuação parassimpática ao obter menores valores dos índices rMSSD e pNN50, com predomínio simpático, evidenciado pela maior FC, PAS E PAD, bem como maior valor na relação LF/HF. No entanto, ao avaliar o domínio da frequência, tanto o grupo dos sedentários como o dos fisicamente ativos apresentaram maior influência parassimpática, porém, estes valores não foram significativos estatisticamente.

Para mais, corroborando com esses resultados, foi observado que os indivíduos inativos fisicamente apresentaram maior pontuação de risco cardiovascular no Escore de Risco de Framingham e elevado percentual de ter algum evento cardiovascular nos próximos 10 anos. Portanto, é evidente que o estilo de vida sedentário torna os indivíduos mais vulneráveis ao desenvolvimento de doenças cardiovasculares e até morte.

Por fim, faz-se necessário estudos futuros com um N amostral maior, os quais possam investigar as associações entre a disfunção autonômica da frequência cardíaca com o risco de desenvolvimento de DCV's e morte em indivíduos sedentários e fisicamente ativos, a fim de confirmar os resultados encontrados no presente trabalho.

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Does Blended Learning Approach Affect Madrasa Students English Writing Errors? A Comparative Study

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***Keywords*— Madrasa students, blended learning approach, error analysis, English writing, ESL.**

***Abstract*—** *Previous studies analyzed errors in English as a second language writing in school or university; no work has been conducted on Indian Madrasa (Islamic institution) students' errors in English writing. The current study analyzes Madrasa students' English writing errors. The students were grouped into an experimental group (EG) and control group (CG) and engaged for twenty-eight days, where only EG learners received blended learning (BL) treatment. The investigation used a pre-and post-test purposive design across all the groups. The errors were spotted from their write-ups belonging to morphological, syntactical, and orthographical categories. Next, errors were analyzed both quantitatively and qualitatively. Though the results revealed that both groups committed errors in all seven categories: morphological (article and preposition), syntactical (tense and word order), and orthographic (capitalization, spelling, and punctuation) types, EG's errors were fewer than CG's. This implies that BL can lead to effective remedial writing in Madrasa classrooms. In addition, EG's pre-test scores were also greater than post-test scores, which has implications for adopting BL at different Madaris in India.*

I. INTRODUCTION

Previous studies on writing errors have helped language teachers figure out which errors English learners make pretty often when they write in English (Riyaz, 2020; Jinny, 2019; Dhar, 2016; Saikia, 2016; Farooqi, 2015; Rupinder, 2014; Fakhar, 2013; Vijayalakshmi, 2008; Mathai, 2007; Lalitha, 2011 and Obeid, 2000; Ahmad, 1996; Parasher, 1977). These findings play a crucial role in designing effective writing syllabi. Following this trend, the study sheds light on the common error types committed by Alim students (certificate equivalent to senior secondary) English learners at a public Madrasa in India. However, to our knowledge, no study has explored English writing errors committed by Madrasa students, especially from a blended learning perspective. The findings of this study will provide educators with the classroom reality, demonstrating what needs to be taught and which techniques can be employed to teach English effectively. In order to examine Madrasa students' English writing errors, the authors of this study asked students to produce a small essay writing in English. Following it, frequent errors were identified and classified morphologically, syntactically, and orthographically. Also, the sources and causes of errors were looked into, and strategies for improving writing were given to both teachers and students. The analysis further provides insights into areas like English advancement in order to eliminate writing inaccuracies among EFL learners. As a result, the primary objective of this work is to ascertain the most prevalent types of writing errors made by Madrasa students in English. In this regard, our study's findings indicated that students who received BL treatment improved writing significantly and made fewer errors. This has implications for reducing English writing errors among Madrasa students in India.

Muslims and Madrasa Education Board in India

Muslims have been identified as a minority in India (National Commission for Minorities Act, 1992). The census report 2011 further notes that the minority population is 18.64% of the Indian population. Of these, more than 14% of the total minorities in India are Muslims. Moreover, 72.92 percent of minorities are the most marginalized and deprived communities in India regarding literacy, economic, and health indices. In a few cases, the share of Muslims in education is comparatively lower than other minorities in India. The Indian State constitution defines Muslims as a minority community with the freedom to set up minority and autonomous academic institutions, including Madrasa. The Indian Constitution guarantees minority languages, scripts, and cultures protection and grants them the right to establish and govern religious, and educational institutions of their choice.

Madaris (plural of Madrasa) in the Indian educational system plays a significant role in history, where Islamic theology, sciences, literary, and philosophical subjects are taught. The central objective of Madrasa education is to instil Islamic beliefs and practices among Muslim learners and to educate them to follow the Quran (Muslim's holy book) and the teachings of the Prophet (Alam, 2020; Moosa, 2015). Here, they mainly teach Urdu, Persian, Arabic literature, and the fundamental philosophies of Islam (Pedersen et. al., 2019). They are well-known for promoting literary and philosophical teaching. The courses run by Madrasa are as follows (level-wise) (Reetz, 2010):

- Hafiz – Recitation of Quran only (traditional madaris have been offering this degree)
- Tahtania - equivalent to primary (1-5th standard)
- Munshi - upper primary (6-8th standard)
- Maulvi – higher secondary (9-10th standard)
- Alim - senior secondary (11-12th standard)
- Fazil - equivalent to graduate (Bachelor's degree)

Recent studies have revealed that students have not yet fully benefited from the government's qualitative educational schemes designed to modernization the Madrasa (Pandey, 2019 & 2017; Wani, 2012; Akhtar and Narula, 2010), including English language skills improvement (Hussain, 2017; Sultana, 2017). There is no connection between what Madaris syllabi offer and what students need, hindering them from improving their knowledge acquisition from modern perspectives (Pandey, 2019). Consequently, the key objective of this work remains to explore the main reasons for the low accuracy in English writing among Indian Madrasa students.

Underpinning Blended Learning in English Writing

The Blended Learning Approach (BL) is perceived as a framework for conducting teaching-learning activities that incorporate both face-to-face (F2F) and online learning (OL) formats (Boelens et al., 2015; Graham et al., 2013; Ferdig et al., 2012; Horn and Staker, 2011; Larson and Sung, 2009; Doering 2006; Garrison and Kanuka, 2004). In other words, BL is also quite often explained as a blend of both physical classroom teaching and OL sessions through the internet to provide optimum education (Chao et al., 2021; Stain and Graham, 2014; Moskal et al., 2013; Bersin 2004; Garrison and Kanuka 2004). The combination of F2F and internet-based OL sessions is employed pedagogically in the BL approach (Stain and Graham 2014). The BL can be utilized to address specific student requirements like enthusiasm, educational preference, and capabilities (Smith and Hill, 2019; Williams & Chinn (2009). In this way, it improves student-teacher and student-student communications and develops a more dynamic and collaborative learning atmosphere, leading to increased participation in the classroom (Donnelly 2010). Previous research on writing assessment, in particular, revealed that when using BL, students' writing skills improved significantly (El-Maghraby, 2021; Vu et al., 2020; Rahman et al., 2020; Mabuan and Ebron, 2017; Adas and Bakir, 2013; Keshta and Harb, 2013). The BL approach enhances the long-term retention of knowledge for upgraded cognitive learning outcomes. Consequently, this study uses the word "blended learning." In this respect, it can be argued that adopting the BL in teaching and learning will be advantageous in attaining better output and an enhanced learning experience in Madrasa.

Background of Error Analysis

In language learning, the occurrences of mistakes are said to be "failures in performance", whereas errors are learners' "failures incompetence" (Camargo, 2020; James, 2013; Iseni, 2011; Corder, 1982; Dušková, 1969). It is not advisable to rely on the frequency of errors to identify whether learners have committed an error or a mistake. However, this is still not enough on certain occasions, so we need to go deeper and investigate their sources and reasons to provide a remedial solution. It is possible to unearth the causes of errors into two major groups, intra- and inter-lingual errors (Dušková, 1969; Richards, 1971; Corder, 1975; Touchie, 1986; James, 2013; Keshavarz, 2015). Inter-lingual errors result from the first language's rules being transferred to the second language's grammar. On the contrary, intralingual transitions are attributable to the negative effect of second language structure in the same language. Intralingual errors show learners' inadequate L2 awareness. In their studies, James, 2013; Corder (1971), and Richards (1974) have categorized six

intralingual errors: incorrect categorization, rule ignorance, hyperextension, false analogy, and overgeneralization.

Before the inception of Error Analysis (EA), learners produced errors that needed prompt correction. Unlike EA, Contrastive Analysis (CA) successfully identified learners' errors, including their origins, and noted that errors in the second language (L2) occurred chiefly because of first language (L1) interference. CA concentrated mainly on teaching techniques and materials intending to minimize the effects of L1 interference on L2 (Fisiak, 1985). It was assumed that the similarity between the L2 and the L1 bears a positive impact and encouraged learning. The CA argued that the two-language variations cause issues in second language learning that could be expected compared to L1 and L2.

During the 1950s and 1960s, CA was influenced by Structuralist and Behaviourist ideas of language acquisition (LA). In Behaviourists' opinion, LA happens mainly through stimulus, response elicitation, and repetition of successful behavior (Brown, 2007). Nevertheless, soon after the Chomskyan theory of innateness emerged in 1959, the CA was declared incompetent in forecasting the vast majority of errors, as it only compared the structure of two languages. According to Chomsky (1959), humans are born with a universal grammar that hard-wires intrinsic language ability in the human brain, contrary to the behaviorist theory of LA. However, in the 1970s, the audio-lingual method came with remarkable results soon after, which significantly helped learners avoid errors in L2 writing. This technique encourages learners to avoid errors through complete repetition and chunked language memorization.

Moreover, the idea of EA lies in generative and cognitive linguistics theories of second language acquisition. However, the error is not an indicator of learners' insufficiency but requires immediate elimination (Ellis & Barkhuizen, 2005). Errors are a potential factor in second language learning, which offers learners inputs to validate and change hypotheses about the target language (Keshavarz, 2015). Teachers get insights through the description of errors to recognize language's distinctiveness that causes language learning difficulties (Ellis, 1994). By following several LA techniques, EA shows how learners deal with the process of learning. It is a vital aspect of learning that provides teachers with insights into the development of languages and allows them to monitor the learners' learning progress. In brief, recognizing and explaining errors from a linguistic standpoint encourages learners to self-correct (Macaro, 2010).

EA provides comprehensive coverage of the difficulties faced by language learners during learning (Corder, 1967). In a study, Lightbown and Spada (2006) argue that EA is a critical component of language learning and a vital source of information about students' learning progress. Hence, EA has emerged to respond to CA. Two types of EA processes have been considered. First, describing errors requires applying linguistic theory to incorrect utterances. Second, as analysts identify and linguistically explain errors and point out the psychological explanations for their existence, interpretations of errors exist. In addition, EA is an Applied Linguistics branch that has two features: a) theoretical EA defines the awareness of learners in the second language, and b) functional EA overcomes any barrier between the learner's awareness and the context.

Notably, Corder (1982) proposes five steps of EA: collecting data from learners' language, highlighting, explaining, and evaluating errors. Additionally, Kashavarz (2015) introduced a five-way linguistic classification of errors: orthographic, phonological, lexical, morphological, and syntactic. Such groups are further subdivided to provide a detailed understanding of errors.

Previous Studies on L2 Writing Errors in India

Prior studies have focused on Hindi native speakers' English writing errors mainly from the two most frequent errors perspectives, such as morphological (article, preposition) and syntactic (verb tense and word order) rather than orthographic (spelling, capitalization, punctuation) (Ahmad, 1996; Farooqi, 2015; Fakhar 2013; Parasher, 1977). In this line, Ahmad (1996) examined the errors in eighty essays written in English and found that article, preposition, verb tense, and word order were the most frequently committed errors. The most common causes of grammatical errors were interlingual and intralingual errors.

Additionally, the errors were explored for their contributing origins, with the findings that 39.7% were interlingual and 51.3% were developmental and intralingual errors, respectively. Another study analyzed the written errors committed by 32 participants in senior secondary school (Parasher, 1977). He found that seven of the most common committed errors by Hindi speakers were articles (39%), prepositions (31%), verb tense (22%), and word order (8%). The results further revealed that most writing errors occurred due to the L1 influence and culture-related negative transfers in L2. Farooqi (2015) observed the English written errors of junior high school learners. The findings noted that morphological and syntactical errors were higher than orthographic errors. The nature of the errors was interlanguage.

Furthermore, Fakhar (2013) looked at grammatical errors among 179 essays. The findings distinguished between errors, wrong article usage, and incorrect use of prepositions. The quantitative analysis revealed the negative impact of the native language that resulted in such errors. The author recommended that CA would help teachers provide evidence about both the commonness and the differences between L1 and L2.

Aims of the Study

The work was carried out to identify descriptive writing errors in English among Madrasa students in India. This study aims to achieve two objectives: firstly, an investigation of Madrasa students' English writing errors; and secondly, a comparison of morphological, syntactical, and orthographical errors to capture variation between the two groups (EG and CG), if any. In this line, this work attempts to answer the following three research questions (RQs):

i) When Madrasa English students write in English, what mistakes do they often make?

ii) What are the factors causing such errors?

iii) Are there any significant differences in these errors between the groups exposed to BL and those who are not?

II. METHODOLOGY

The study used a blended learning method to analyze Madrasa students' English writing errors using quantitative and qualitative techniques. The data for this study was gathered from four public Madaris in India. A step-wise description of the methodological procedures has been outlined in the following sub-sections.

Participants and Sampling

Using purposive sampling, the participants for this study were selected. The number of regular students at Madrasa has decreased significantly due to the current COVID-19 situation. Therefore, the experiment was conducted at the four public Madaris. In this study, 100 students participated in Alim's final course (equal to senior secondary). At Madrasa, English was offered as a mandatory subject, and participants were required to attend three hours of English lectures per week. Each lecture session lasted 30 minutes, for a total of 180 minutes per week. To ensure compliance with ethical standards, the study's authors first obtained consent from all students by having them sign a consent form. Notably, participants in this study were only males, as Madrasa does not have a co-educational system. Those aged between 18 and 22 years were equitably split into experimental (N=50) and control (N=50) groups. Each ground was further subdivided into two, i.e., pre and post-test groups. The EG and CG groups had reported that they had been studying English as a subject through Urdu instructions since they were admitted to the Munshi/Maulvi course. All participants were natives of Urdu and functionally bi-multilingual and had lived all of their lives in the same language region (Sitapur, Uttar Pradesh, India). The students who participated in the study belonged to a semi-urban background.

Experimental Group

The experimental group (BL group) of learners received treatment from an experienced teacher using a blended learning approach for learning English grammar. Students received English lectures by the teacher for 60 min. The teacher explained and discussed the rules of English grammar face-to-face with the students for 30 minutes. The students spent the remaining time (e.g., the last 30 minutes) working online on assignments and activities on the laptop using the internet. If they needed assistance, the teacher was on hand to provide it. Students were seated in a smart classroom, enabling them to communicate with one another and the lecturer.

Control Group

All fifty students were given 45 minutes to write an essay on the same topic "Introducing India to Foreigners," for both the pre-and post-tests.

Data Collection and Analysis Procedure

A pre-and post-experimental design were employed for this study, including two groups: the control group received a traditional teaching approach, and the experimental group received a blended learning approach. A pre-experiment questionnaire was distributed between both groups to collect context information about them, including gender, age, and years of English study. Then, the authors of this study distributed the topic 'Introducing India to Foreigners' (Hamid, 2007) among both groups, and students were instructed to write on a sheet of paper for 45 minutes. After task completion, they were given a chance to read their written sentences carefully and correct any mistakes, if any. The same task was redone after the lecture, and they were asked to rewrite the essay on the same topic as they had done earlier, and the same procedure was applied as that utilized for pre-intervention.

The current study utilizes Corder's (1974) methods of EA, which consists of three stages: collecting the data (recognition of errors), describing the errors (accounting for the errors), and explaining learners' written errors (description of errors). Following that, we used Dulay et al.'s (1982) classification of linguistic errors. Additionally, the study delves into the three types of errors: omission, addition, and misformation. Later, a checklist was

employed to record the committed errors and their frequency in learners' writing. Finally, the English language teacher looked at all the written sheets (made by L2 students) to ensure they were correct and valid for further analysis.

Using repeated measures ANOVAs, the error frequency for each student was measured and arranged through variables using the SPSS software package (version 22). Significant (a =.05) differences were identified and noted for interpreting the findings in a series of repeated ANOVA using between and within-subject variables of each group (experimental and control) and pre and post-tests.

III. RESULTS

Statistical Analysis of Errors

A three-way ANOVA analysis on the mean with 3 types of errors (morphological, syntactic, and orthographical) × 2 groups × 2 tests showed the main effect on error types, F (1, 49) =67.915, P=.001, η^2p = .739, revealing a higher mean for morphological errors, which outperformed syntactic and orthographic writing errors (Fig. 1 a). Furthermore, the findings show a statistically significant difference in errors between the groups, F (1, 49) =14.355, P=.001, η^2p = .227, revealing the result that the mean of the errors was higher for CG as compared to EG (Fig. 1 b). The primary effect of the tests was F (1, 49) =16.451, P=.001, η^2p = .251, revealing the result that the mean of errors was higher for the pre-test than the post-test (Fig. 1 c). Further, the interaction between groups (CG and EG) × tests (pre and post-test) was also significant, F (1, 49) =9.616, P=.003, η^2p = .164, entailing the result that there was no difference across test (pre & post) for the CG (Fig. 1 d). Contrastively, EG group learners committed higher errors in pre-test than post-test (Fig. 1 d). Remaining two-way interaction between types of errors × groups (p> .131), types of error × test (p > .579) and three-way interaction between the types of errors × group × test (p> .129) were all non-significant.

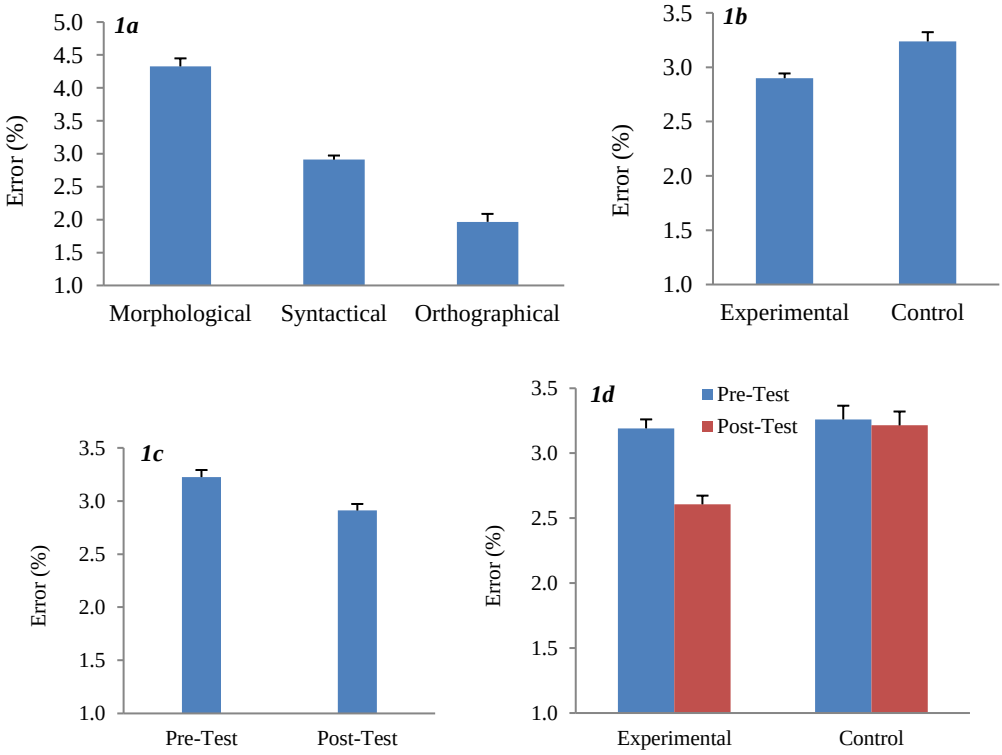

Fig.1. Showing the differences in morphological, syntactical, and orthographical errors between groups and tests in writing (a) the mean of morphological, syntactical, and orthographical errors; (b) the mean of errors for groups; (c) the mean of errors for tests; (d) the mean of errors in tests for groups.

Morphological Analysis of Errors

Quantitative Analysis

This study used two-way ANOVA on the mean of errors between two groups × two tests analysis to illustrate a main-effect on groups, F (1, 49) =8.079, P=.007, η^2p = .142, revealing the higher mean of morphological errors in

CG essays than in EG. This indicates that the CG group learners committed more errors than the EG group (Fig. 1 a). Additionally, the analysis further captured the main effect of tests, (1, 49) =4.218, P=.045, η^2p = .079, revealing the higher mean of morphological errors in writing for pre-test than post-test (Fig. 1 b). The two-way interaction between groups (CG and EG) × tests (pre and post), F (1, 49) = 7.468, P=.009, η^2p = .133, indicates that there is no variation in errors in the CG group across pre and post-test (Fig. 1 c). However, the EG's pre-and post-test results show a statistical error difference. This indicates that the BL approach intervention helped EG learners overcome writing errors (Fig. 1 c). After the meaningful lecture through the BL approach, the learners of the EG group enhanced their writing skills and reduced their errors compared to the CG group learners who received a non-BL learning approach.

Figure 2

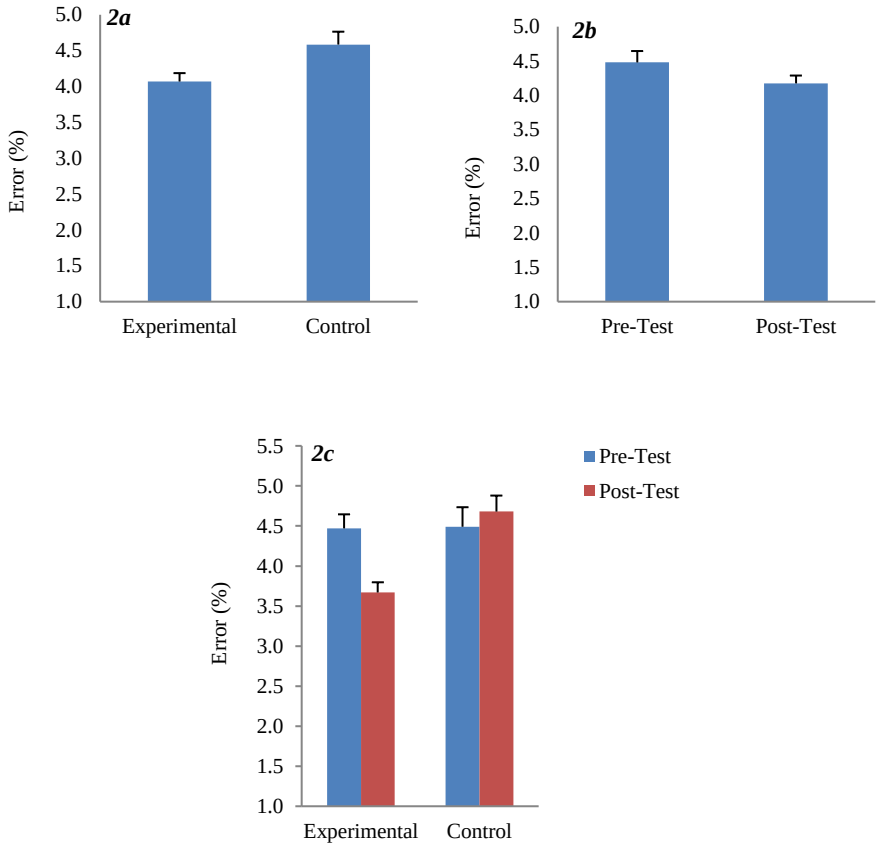

Fig.2. Showing the differences in morphological errors between groups and tests (a): the mean of errors for groups; (a) the means of errors for tests; (c) the mean of errors for tests for groups.

Qualitative Analysis

Errors in article and prepositions were committed in the morphological category, which is given below and indicated with an asterisk*:

Errors in Article

1. Experimental Group (EG) Omission of the definite article: *Taj Mahal was built in *Mughal period by Shah Jahan in *****17th century. (**The** Taj Mahal was built in **the** Mughal period by Shah Jahan in **the** 17th century.)*

2. Control Group (CG) Omission of the definite article: *Taj Mahal is *seventh wonder in India. (Taj Mahal is **the** seventh wonder in India.)*

***3. EG Addition of indefinite article: ****A foreigners stayed in a hotel for one night. (Foreigners stayed in a hotel for one night.)*

4. CG Addition and misuse of indefinite article: *A* India is a* biggest and great county because people of all religion live together. (India is **the** biggest and great country because people of all religions live together.)*

5. EG Misuse of indefinite article: *India has a* most beautiful thing * Himalaya. (India has **the** most beautiful thing, the Himalayas)*

6. CG Misuse of indefinite article: *Dholavira is a* oldest building in India. (Dholavira is* ***the*** *oldest building in India.)*

Errors in Preposition

7. EG Misuse of preposition: Peoples in villages wake in the early morning and sleep *in early night. (People in villages wake up in the early morning and sleep early **at** night.)

8. CG Omission and misuse of prepositions: We reached 5 o'clock on* taj mahal entrance gate. (We reached **at** 5 o'clock **at** the entrance of the Taj Mahal.)

Syntactical Analysis of Errors

Quantitative Analysis

A two-way ANOVA on the mean of error with 2 groups × 2 tests, revealed a significant main effect of groups, F (1, 49) =5.864, P=.019, η^2p = .107, proving the higher mean of errors for CG than EG (Fig. 2 a). This implies that the learners of English have used English prepositions correctly in EG. It implies that learners could comprehend the preposition rules in English writing. The interaction between tests was found to be insignificant (p<.677). In addition, the two-way interaction between groups × tests, F (1, 49) =7.079, P=.011, η^2p = .126, indicated a slight difference in the mean of prepositional errors between CG's pre-and post-test, but the significant mean difference was found in EG's pre and post-test due to the intervention of the BL approach (Fig. 2 b).

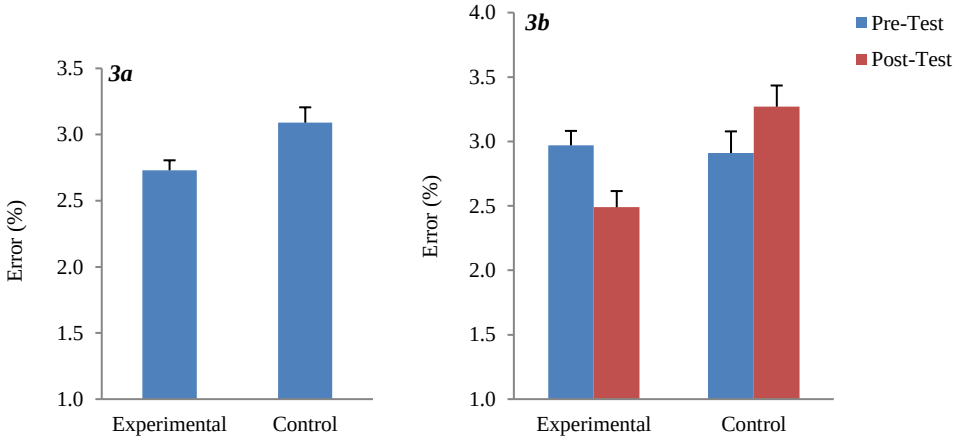

Fig.3. indicates the difference in syntactical errors between groups and tests (a): the mean of errors for both groups; (b) the mean of pre and post errors for both groups.

Qualitative Analysis

The examples presented below reveal that learners make errors in tense and word order. Errors are marked with an asterisk*:

Errors in Verb Tense

9. EG Present continuous instead of Simple Present: *Some Indian are* living* in village and some are living in very big cities. (Some Indians* ***live*** *in villages and some* ***live*** *in very big cities.)*

10. CG Present continuous instead of Simple Present: *Mostly foreigners are* going* to temple mosque and historical place but less people going* to village and small place of India. (Most foreigners* ***go*** *to temples, mosques, and historical places, but fewer people* ***go*** *to the villages and small places in India.)*

11. EG Present continuous instead of Present Perfect Continuous: *Many foreigners are* living* in India from* childhood. (Many foreigners* ***have been*** *living in India* ***since*** *childhood.)*

12. CG Present continuous instead of Present Perfect Continuous: *All Indian are* living* in India with freedom from* 1947. (All Indians* ***have been*** *living in India with freedom* ***since*** *1947.)*

13. EG Present Perfect instead of Past Perfect: *When a foreigner was in Taj Mahal then he has* pointed out a river. (When a foreigner was in* ***the*** *Taj Mahal, he pointed out a river.)*

14. CG Present Perfect instead of Past Perfect: *When I have* gone sudden flight came. (When I had gone, a sudden flight came.)*

Errors in Word Order

15. EG: We tajmahal seeing to field. (We are/were seeing the Taj Mahal from the field.)

16. CG: Some foreigners tell we love live India in. (Some foreigners said that we love to live in India.)

Orthographical Analysis of Errors

Quantitative Analysis

In this study, two-way ANOVA was used on the mean scores of errors with two groups × 2 tests. The analysis reveals the main effect on groups, F (1, 49) =4.447, P=.040, η^2p = .083, revealing the higher score of errors in L2 writing for CG than EG. This infers that the CG learners committed more significant errors than EG (Fig. 3 a). Further, the results also showed a significant effect of tests (pre and post-test), (1, 49) =7.299, P=.009, η^2p = .130, revealing the higher mean of errors in L2 writing for pre-test than post-test (Fig. 3 b). However, the two-way interaction between groups tests, F (1, 49) = 11.980, P=.001, η^2p = .196 which indicated no statistical variation in CG's pre- and post-test results, but EG's pre- and post-test results show a statistical difference, which is due to the intervention of the BL approach (Fig. 3 c). This implies that meaningful-lecture through the BL approach helped EG learners enhance their writing skills, which reduced their writing errors compared to those with the non-BL approach, i.e., CG.

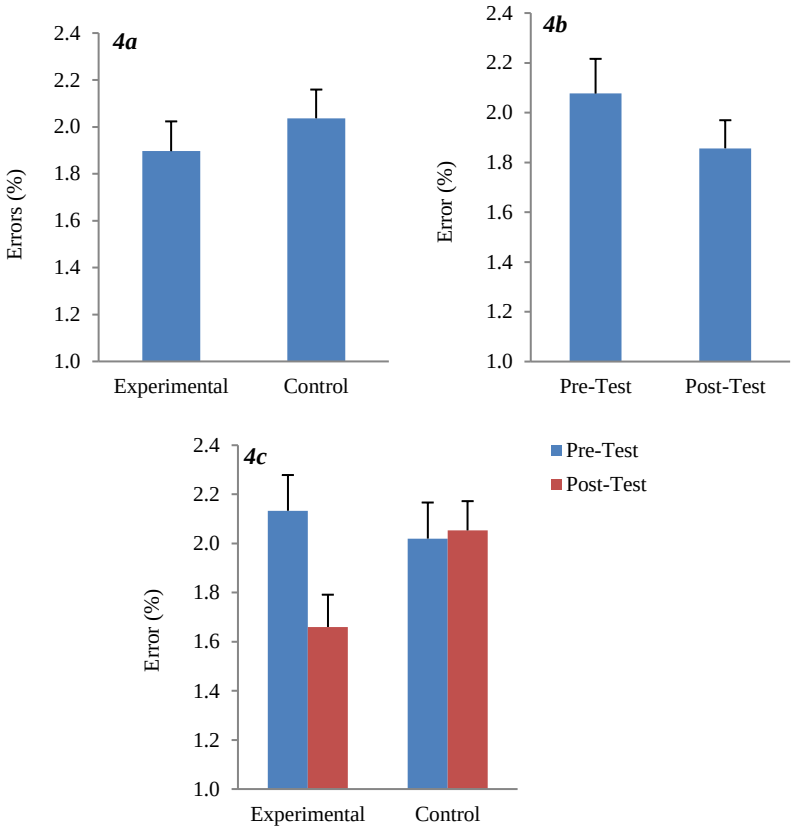

Fig.4. shows the differences in orthographical errors between the groups and tests (a): mean of errors for two groups; (b) means of errors for tests; (c) the mean of errors for tests and groups.

Qualitative Analysis

Errors concerning incorrect spelling, capitalization, and punctuation are marked with an asterisk* below:

17. EG Spelling: *Many* ***forners**** *come India see historical place. (Many* ***foreigners*** *come to India* ***to*** *see historical places.)*

18. CG Spelling: *In India animal* ***laife**** *is also matter. (Animals' lives matter in India.)*

19. EG Capitalization & Punctuation: *Hindu* m*uslim* s*ikh c*hristian we all are live in same society. (****Hindu, Muslim, Sikh, and Christian,*** *we all live in* ***the*** *same society.)*

20. CG Capitalization & Punctuation: *Tajm*ahal* j*ama m*asjid* l*al k*ila* Qutub m*inar India g*ate is famous in our country. (The Taj Mahal, Jama Masjid, Lal Qila (Red Fort), Qutub Minar, and India Gate are famous in our country.)*

IV. DISCUSSION

The main objective of this work was to compare frequent morphological, syntactic, and orthographical errors in the English writing produced by the two groups in the

classroom of Madaris in India. This study has transformed one group into a control and another group into experimental with pre and post-test designs. The errors committed by both groups were compared to capture variation in error patterns. Next, a pre and post-test were also employed to determine significant variation between tests regarding L2 writing errors. It was found that Madrasa students committed morphological, syntactic, and orthographical errors in their writing (RQ 1) due to interlingual and intralingual interference (RQ 2). It was also found that CG and EG committed significantly differently, wherein CG committed more errors than EG (RQ 3). We found that Madrasa students committed morphological which outperformed syntactic and orthographical errors in their writings. These results correspond with Riyaz (2020); Jinny (2019); Dhar (2016); Saikia (2016); Rupinder (2014); Vijayalakshmi (2008); Mathai (2007); Lalitha, N. (2011) and Obeid (2000) studies reported morphological, syntactic and orthographic errors as the most frequent errors committed by Kashmiri, Panjabi, Assamese, Marathi, Bengali, Malayalam, Kannada and Tamil learners in English. In the following sub-sections, each type of error has been discussed in detail.

Morphological Errors in Writing

Morphological errors are the prime category of errors in English writing by learners. This demonstrates a significant difference between EG and CG. It was discovered that students in CG made more errors than those in EG at Madrasa. The students were troubled to place the correct articles and prepositions. The current investigation found that interlingual and intralingual transfers were both groups' primary sources of errors. The current study's findings also contradict Pondra's (2015) findings, which affirmed that article and preposition errors made by Telugu students were primarily due to mother tongue influence. However, the outcomes of the current study revealed that both groups committed interlingual and intralingual errors in English writing. However, our findings were identical to Farooqi's (2015) results, where he reported articles and prepositions as the most common errors among learners.

Errors in Article

Madrasa students' writings (see examples 1, 2, 5 & 6) also show omission and incorrect usage of the definite article, which could be due to the L1 influence, as the definite article is not used in Hindi (Agnihotri (2013), Koul (2008), Jain (2007, 1995) and Kellogg (1972). In addition, the errors in examples 2 and 3 suggest students overgeneralized indefinite article use prior to all the nouns. Due to their incorrect hypothesis regarding using indefinite articles, EG and CG made intralingual errors. The usage of the indefinite article with plural nouns could have been due to the incomplete application of the rules. Also, students formed an ungrammatical structure based on their learning experience when they overgeneralized the indefinite article preceding a noun in the target language (TL).

Errors in Preposition

The two sentences in examples (7 and 8) above demonstrate that learners use incorrect prepositions. These prepositions "in, on, and at" were used interchangeably in their L1 that's why both the EG and CG had trouble employing the correct prepositions (Agnihotri (2013), Koul (2008), Jain (2007, 1995) and Kellogg (1972). The findings of Ahmad, 1996; Farooqi, 2015; Fakhar 2013; Ahmad, 1996; Parasher; 1977 study also support our findings that Hindi learners made errors due to L1 transfer in TL. Such an error occurred due to the negative L1 transfer.

Syntactic Errors in Writing

The second category of errors made by students in English writing was syntactical ones. But the findings revealed significant variation between EG and CG errors, wherein EG made fewer errors than CG. In this line, Farooqi's (2015) findings revealed that students had made frequent errors in verb tense and word order categories but could not provide the reasons for the errors. In this regard, the current study offers the sources of errors among Madrasa students' writing as interlingual and intralingual errors but contradicts previous findings (Rupinder; 2014; Dhar; 2016 and Lalitha; 2001).

Errors in Verb Tense

Madrasa students substituted the Present Continuous instead of the Simple Present, the Present continuous instead of the Present Perfect Continuous, and the Present Perfect instead of the Past Perfect (see examples from 9 to 14). The errors in writing related to verb tense resulted from intralingual and developmental issues between CG and EG. The findings further report verb-tense errors, mainly analogous to Ahmad's (1996) study, and frequent errors in previous studies (Farooqi, 2015 & Ahmad, 1996).

Errors in Word Order

As Hindi is a verb-final language (see e. g., 15 and 16); consequently, the mother tongue's influence could be seen in both groups' writings by their incorrect word order (Agnihotri, 2013; Koul, 2008; Jain, 2007, 1995 and Kellogg, 1972).

Orthographic Errors

The subsequent examples (17, 18, 19, and 20) present the orthographic capitalization errors caused mainly by L1

interference. In this line, previous studies reported that there is a high probability of such errors (capitalization) among L2 learners learning English as a second language. The leading cause of such errors is that languages like Hindi and Urdu do not use the capitalization system. The first word and proper name start with a small letter, while the English language follows the opposite. Moreover, Shaughnessy (1977) indicated that non-advanced writers make errors in punctuation mainly because they believe that the use of spoken language can be transferred to writing without any change.

V. CONCLUSION

To our knowledge, no study has examined second language writing errors from Madrasa students' perspective. Therefore, this is the first study to compare the frequency of common errors committed in English writing by Alim course students at Madrasa belonging to EG and CG. The findings of this study demonstrate that there was a difference between the two groups over time. Further, it was also found that both the groups committed common errors, but EG's post-test scores were significantly higher than their pre-test scores, indicating the usefulness of BL in remedial writing instruction and providing a paradigm shift for successful BL adoption at Madrasa in India. Overall, the findings justify using BL as a teaching approach at various Madrasa. On a broader scale, BL could be a practical approach for improvising English writing skills. Finally, the authors of this study say that the long-term effects of the new BL approach in Madrasa education need to be studied in more detail, taking into account things like different age groups, gender, previous educational background, and more this study may have ignored.

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Mining and its Impacts on Environment and Health with Special Reference to Ballari District, Karnataka, India

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***Abstract*—** *Mining has played a significant role in the development of a country. The financial progress of various nations depends on the production and use of minerals which leads to the expansion of mining activities. Ballari district has rich mineral resources and is known for iron ore deposits. As iron ore is an essential raw material for the iron and steel industry, many Iron and Steel plants are established in Ballari district. In this study, the impacts of iron ore mining on environmental issues such as air, water, soil, and health on the population are reviewed. The review reports that the concentrations of NO_2, SO_2, PM_{10} and $PM_{2.5}$ are greater in the core zone of Subbarayanahalli iron ore mine located in Hospet-Ballari sector. The PM_{10} level exceeds the NAAQS limits of 100 µg/m^3 at different locations of 10kms radius of Ballari city. The surface water bodies around Sandur, Torangallu and Taranagar are silted and contaminated by mining waste. The airborne dust produced during mining activities decreased crop productivity and affected human health. The main conclusion from the review is that more research should be needed to assess the environmental impacts and emphasize sustainable mining operations in association with Government and mining research activities.*

I. INTRODUCTION

Mineral resources play an essential role in the economic development of a nation. This is vital, particularly for developing countries like India. These resources are base for increased industrialization and generate many employment opportunities for the people of the mining regions [1]. The increase in mining activities results from the fact that the financial progress of various nations is dependent on the production and use of minerals, including fuel minerals [2].

With the rapid industrialization due to mining, society also gets the benefits such as the establishment of schools, hospitals, hotels, construction, transportation, communication, and other infrastructure facilities. In India, mining activities bring huge revenues to the State Governments and thus enable the Governments to use the revenue for the welfare and well-being of people in the society [1].

Thus, minerals are an indispensable part of the economy of a nation. Fortunately, India is blessed with huge deposits of mineral resources. It is estimated that more than 0.8 million hectares of land are under mining, however, a major portion lies in the forest area. There are 20,000 known mineral deposits in India and as many as 89 minerals (4 fuel, 10 metallics, 22 non-metallic and 55 minor minerals. As per the annual report of the Ministry of Mines, 2021-22, the 1st Advanced Estimate of Gross Value Added (GVA) of the mining and quarrying sector during 2021-22 at 2011-12 prices is Rs. 336859 crore, which shows a growth of 14.33% as compared to a provisional estimate of GVA during 2020-21 at Rs. 294644 crores. The States which have indicated a major

increase in the value of mineral production are Orissa (93%), Jharkhand (87%) and Karnataka (65%) [3].

II. METHODOLOGY

The Study is based on secondary data published in journals and magazines in the form of articles. It also covers the information provided by the Annual Reports of the Ministry of Mines, Indian Bureau of Mines, Central Pollution Control Board, and other Government organisations. In this study, the impacts of mining iron ore particularly resulting from open-cast mining are covered with special reference to environmental issues (such as Air, Water, Soil), and health hazards on the population of the mining region. The Study area is confined to the Ballari District of Karnataka State.

III. ABOUT BALLARI

The state of Karnataka is abundant in mineral resources. It is said to be one of the most mineral-rich states of India. The mineral belt covers an area of 1.92 lakhs sq. km including 29 districts of the state. Karnataka is also endowed with the green stone belt with valuable mineral resources such as gold, silver, copper, iron ore, manganese, limestone, dolomite, asbestos, bauxite, chromite, kaolin, and granite rock. The Ballari district is enriched with a wide variety of Major and Minor minerals. Major minerals include Iron ore, Manganese, Red Ochre, and Yellow Ochre (as per schedules 11 of MM(RD)1957 and minor mineral includes Building stone such as Granitic gneiss, Gneises and steatite (soapstone), Quartz and Granite. Ballari District has 125 Mining leases of Major minerals of which 30 leases are working and 92 quarry leases of minor minerals [4].

3.1 Iron Ore

The Geological Survey of India (GSI) has estimated a reserve of about 1876 million tonnes of iron ore with about 63% of total iron in the Sandur belt. Large deposits of lateritoid haematitic iron ore in association with manganese ore are from prominent ridges of the Sandur schist belt. There are six ranges carrying iron ore deposits viz., Donimalai, Kumaraswamy, Ramandurga, Yeshavanthanagar, Devagiri and Thimmappanagudi. The Ramandurg deposit is about 10,400 m long and 150 m wide with 62.3 to 62.6% Fe. In Donimalai, six ore bodies with sizeable reserves of 65.2% Fe have been estimated. In Kumaraswamy, the Geological Survey of India has estimated iron ore over a strike length of 2.5 km and width of 465 m [4].

3.2 Manganese Ore

The bimetallic (Fe-Mn) low-phosphorus manganese ore deposits as discontinuous bodies occur all along the western and southern margin of the Sandur schist belt over a strike length of about 40 km with an average width of about 500m. The deposits in Deogiri hill are the largest. The manganese horizon is stratigraphically confined to Deogiri Formation whose thickness varies from 975 to 1000 m consisting of metagreywacke, carbonates with minor interbeds of quartzites, arkose, meta-chert, basic and acid volcanic rocks.

Exploration by large-scale mapping and drilling carried out by GSI has identified three distinct manganese horizons over a strike length of 15 km viz., (i) top lateritoid horizon (ii) middle reef-like manganese ore and (iii) bottom clay mixed zone. Pyrolusite, cryptomelane, and psilomelane are the principal ore minerals. Hausmanite, hollandite and mangano-magnetite have also been recorded. The probable reserves of manganese ore in the entire belt are estimated to be 107.36 million tonnes [4].

IV. SIGNIFICANCE OF IRON ORE MINING AND ITS OPERATIONS

Iron ore is an essential raw material for the Iron and Steel Industry. It is significant among all mining activities and influences largely the economic status of the country. India is one of the leading producers of iron ore with a total reserve of over 33.276 billion tonnes of haematite (Fe_2O_3) and magnetite (Fe_3O_4). About 79% of haematite ore deposits are found in Assam, Bihar, Chhattisgarh, Jharkhand, Odisha and UP and 93% of magnetite ore deposits occur in Andhra Pradesh, Goa, Karnataka, Kerala, and Tamil Nadu. Interestingly, Karnataka alone contributes 72% of the magnetite deposit in India.

The production of iron ore constituting lumps, fines and concentrates was 246.08 million tonnes in the year 2019-20 and is given in table-1.

Table 1: State-wise Production of Iron Ore

Sl.No.	State	Production (in million tonnes)	Percentage
1.	Odisha	146.77	59.64
2.	Chhattisgarh	34.72	14.11
3.	Karnataka	31.40	12.76
4.	Jharkhand	26.89	10.92
5.	Other States	6.30	2.57
	Total	246.08	100.00

Source: Indian Minerals Year Book 2020

From the above table, it is evident that Karnataka stands in third place in terms of the production of iron ore with 12.76 per cent of the total production in the country. The other states in the above table include Andhra Pradesh, Goa, Madhya Pradesh, and Telangana [5].

4.1 Iron ore operations

Depending on the mode of extraction of minerals, mines can be surface mines, underground mines, or a combination of both [6]. Iron ore mining is carried out by open cast method through manual, semi-mechanised and mechanised operations. Generally, mining is done by digging the ore with pick axes, crowbars, chisel, and spades. The mined material is screened manually to separate +10mm float ore which is stacked separately. The waste is backfilled into the pits. In some cases, 150-200 gm of gunpowder or special gelatine cartridges are filled and blasted. The blast tonnage per kg of gunpowder is 2.5 to 3 tonnes. On the other hand, in the case of mechanised mining, hydraulic excavators, Ripper Dozers, Shovels, Dumpers and heavy machines are used. They also use explosives such as Ammonium nitrate–fuel oil (ANFO), Site Mixed Slurry (SMS) and emulsion explosions for blasting the mines.

However, the processing of iron ore involves crushing, screening, washing and in some cases beneficiation and agglomeration. Dry and Wet grinding is also carried and this processed ore is mainly used for manufacturing pig iron, sponge iron and steel and is also used in cement, coal washers, ferro alloys, foundry, vanaspati and glass industries [5]. In the present day, nearly all industrial establishments consume at least one of the minerals in their process of production. This speaks about the significance of mines and minerals in the world [7]. Rapid industrialisation has led to an ever-increasing demand for iron ore resources. The unabated exploitation of iron ore resources led to the ecological imbalance in the natural ecosystem and has caused environmental deterioration [8].

There are 266 iron ore mines in Karnataka, out of which 134 are in forest areas. In the Bellary District, 148 mines (out of which 98 are in forest areas) cover 10,598 hectares of land. The Indian Bureau of Mines in 2005 estimated the total iron ore mineral reserves to be about 1148 million tonnes [9]. The Supreme Court Central Empowered Committee has assessed that even at conservative estimates, at the present rate reserves in the State will be exhausted in about 20 years. Iron ore mining in Bellary took off in 1999, paved by the 1993 National Mineral Policy that began encouraging private players to participate in iron ore mining [10,11]. It received a further push when the Karnataka State Mining Policy in the year 2000 outlined a policy of “Export Oriented Development”. Finally, in March 2003, the state government de-reserved 11,620 square km for private mining that was formerly marked for mining by state entities alone [12]. The changes in mining policy went hand in hand with increasing demand from China due to the Beijing Olympics which caused iron ore prices to soar from around Rs. 1,300 per tonne in 2000 it crossed Rs. 4,500 per tonne in 2005-06 [13].

V. IMPACTS OF IRON ORE MINING

Mineral resource extraction and mining often have a significant negative influence on the environment, including the land, water, air, and biological resources as well as the socioeconomic situation of the local population [14]. The degree of impact depends on the methods, scale, and concentration of mining activities, as well as the geological and geomorphological environment [15].

Mining activities certainly affect all the components of the environment. The ill effects may be permanent or temporary, beneficial, or harmful, repairable, and sometimes go irreparable. In this paper, the study area is chosen as the Ballari District of Karnataka State. In recent years, there has been increased production of iron ore due to the usage of heavy machinery and equipment, particularly in open-cast mining. This open-cast mining results in the dumping of a huge volume of unmined land in addition to a pit-scarred landscape.

The major problem of iron ore mining is the disposal of tailings and other deleterious silica minerals and phosphorus. The mining regions are highly prone to the siltation of agricultural fields, nallahs, riverbeds, and creeks due to the wash off from iron ore dumps in rainy seasons. Apart from loss in crop yield and reduction in fish population in streams are caused by silting. It also results in dust concentration (suspended particulate matter) which poses environmental problems.

The iron ore mining activities in Ballari District threaten severe impact on the community and environment in one of the highly exploited iron ore belts of Karnataka State i.e., Sandur-Hospect-Ballari Belt [16]. Sandur -Hospet region has abundant reserves of Iron ores from which many fines are generated during mining, crushing, and screening processes. Nearly 50-60% of the total burden removed from the surface is below 10mm in size and these fines are dumped at mine sites as waste. During the rainy seasons, these fines, carried by runoff water, spread to the surrounding agricultural land thereby reducing the fertility of the soil and productivity of the pedosphere and leading to deforestation. The dissolved constituents from the mining process pollute the surface and groundwater of the region [17].

5.1 Air Pollution

The deterioration of air quality is a significant problem in mining areas [18,19,20]. The primary causes of air pollution in mining regions include drilling, blasting, loading, and unloading of minerals, transportation, as well as dust generation by wind at stockyards. Many meteorological factors such as wind speed, wind direction, temperature, amount of rainfall, and atmospheric stability in mining areas have a great impact on the environment [21]**.** The National Ambient Air Quality Standard was developed in India in 1994 to evaluate and compare the degree of air pollution in various places (CPCB, 1998) **[**14]**.** Particulate matter is one of the major pollutants released during different operations (drilling, blasting, loading, transporting, and unloading of ore) in open-cast mining [22,23]. The levels of NO_2 and SO_2 produced due to mining activities generally remain within the standard limit. Thus, controlling dust emission is crucial for every mining location, as it contains free silica and respirable particulate matter that can lead to respiratory illnesses [21].

Jaswanth Gowda (2016) reported that the activities of the Subbarayanahalli iron ore mine located in Hospet-Ballari sector contribute to air pollution in and around the mine areas. The pollutant concentrations, namely Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Suspended Particles (PM_{10}), and Respirable Suspended Particulate Matter ($PM_{2.5}$), observed in the mining region are greater in the core zone and within the National Air Quality Standards in the buffer zone. Due to variations in rainfall, humidity, temperature, wind speed and direction, the values are quite high in the summer and very low in the rainy season [24].

The particulate matter released at the mining site is carried from their place of production to a long distance by winds and upper-level circulation in the atmosphere. Patel et al. (2017) studied the impact of mining and associated industries on the Air Quality of the Bellary region. The study reported that the PM_{10} levels exceed the National Ambient Air Quality Standards (NAAQS) limits of 100µg/m^3 at different locations of 10kms radius of Bellary city. This was due to the transportation of vehicles on unpaved roads and the contribution from industries [25].

5.2 Water Pollution

Over 98% of the fresh water on the earth lies below its surface. The remaining 2% is what we see in lakes, rivers, streams and reservoirs. Of the freshwater below the surface, about 90% satisfies the description of "groundwater". This groundwater contamination is generally irreversible i.e., once contaminated, it is difficult to restore the original water quality. Unfortunately, the mining operations result in wastes containing oil, grease, and toxic metals, and are run-offs during the rainy season which causes pollution in the ground water . The residual material of mines is dumped into water bodies and as a result of which the colour of the water bodies becomes reddish and the depth of water bodies decreases [26].

Nayak (2016), measured the colour and siltation of water bodies which are located within a radius of 5 and 10km of mining area which lies in the part of Bellary, Hospet and Sandur taluks. The study reported that the impact on any components decreases with an increase in distance from the mining area. The area of the water bodies got silted within a radius of 10 km [27].

Kumar et al. (2012) studied the surface and groundwater quality in the parts of the Sandur Schist belt, Bellary district. The study reported that nitrate, fluoride, magnesium, sodium, and total hardness are high in Narihalla Stream and are polluted and not suitable for drinking or agriculture. Most of the surface water bodies around Sandur, Torangallu and Taranagar are silted and contaminated by the mining waste [28].

5.3 Soil Pollution

Life on earth relies directly on the soil and aquatic ecosystem of rivers. Food would not grow, objects would not decompose, and nutrients would not be recycled if there was no fertile soil and microbial fauna to occupy it. Without fertile soil and microbial fauna that inhabit it, food would not grow, dead things would not decay and nutrients would not be recycled. A significant contributing cause to soil pollution is the disposal of industrial waste as a result of mining operations. The chemical and biological characteristics of soil are affected by these pollutants. The sludges resulting from surface mining which contains several toxic chemicals if untreated pollute the soil. Near the mining region, soil fertility has been negatively impacted. In a few instances, agricultural yield also falls [26].

There have been devastating environmental consequences of the unbridled iron ore mining in Bellary – the largest hit being to agriculture, with once-fertile lands turning red with iron ore silt and bore wells drying up across the entire region. The Supreme Court CEC report also states that nearly 45% of the forest cover in the region has been lost to mining – "As a result of mining and associated activities, what was once an area with green, scenic, undulating hilly terrain, today presents a barren and dismal picture akin to a war-ravaged zone with huge ugly scars" [29].

Suresh Kumar et al. (2017) assessed the soil Loss in Sandur Taluk due to Mining Activities in and Around Bellary district. They adopted Geographical Information System (GIS) based on the Revised Universal Soil Loss

Equation (RUSLE) to study the parameters like Land use, Land cover, Soil, Geomorphology, and catchment boundary. The study found that the areas of Ramgad Forest Block, Devagiri Hills, Northern Donimalai Village, North Eastern Block Hills, and Middle Eastern Taluk encompassing Taranagar Village and Bommagatta Village have considerable soil loss. Due to the ongoing sediment deposition in these places, the water tanks are severely affected [30].

Srinivasa Sasdhar Ponnaluru(2019) did an empirical analysis of the impacts of mining dust on crop productivity in the Bellary district in India. The study found that ore transportation and mining produce airborne dust that has an impact on agricultural productivity. It adopted a change in crop productivity modelled by regressing crop productivity on fertilizer consumption, amount of rainfall, and on mining activity over the study period. The study found that mining drastically decreased crop productivity and this decline in crop yield may be due to airborne dusts [31].

Nayak et al. (2015) evaluated the spatial variation in soil contamination by iron ore Mining of Bellary district using linear discriminate analysis and partial correlation analysis. The study reported that different types of acidic chemicals are concentrated in agricultural soil and affected areas of the Bellary district; simultaneously mining eruption damaged the fertility of the soil [32].

5.4 Noise Pollution

Noise has come to be regarded as a major urban pollutant capable of causing annoying hearing loss, and sometimes even adverse physiological and psychological effects. The unwanted sound emanating from the blasting, crushing, and processing of plants in the mining areas results in either temporary or permanent hearing loss. Due to this noise, the workers get tired and the quality of efficiency will come down. Noise also results in an unnecessary interruption in the communication process. Above all, the high incidence of sound invariably causes circulating problems, irregularities in heart rates, lack of concentration, nausea, headache, loss of appetite etc. [33].

5.5 Health Effect

The particulate matter produced during mining activities is of different sizes and is harmful to human health and the environment. The particles of size 30 µm and above (also known as total suspended particulate matter, TSPM) will settle down quickly near the source of emission. The particles between 30 and 10 µm in size are suspended in the air for a short time and they pose no health risk because when they are swallowed after becoming stuck in the mouth or nostrils. The particles of size less than 10 µm (PM_{10}) enter the respiratory tract when inhaled and the particles less than 2.5 µm in size (PM2.5) enter deep into the lungs and results in adverse health effect. The increased level of particulate matter results in diseases such as asthma, black lung disease and cardiovascular diseases. Thus, the study on PM_{10} and $PM_{2.5}$ emissions in the mining area is of more importance as it poses severe health problems [34,35,36].

Veerendra Kumar et al. (2020) studied the health status of mining labourers in the Bellary district by collecting data from the Primary Health Centre (PHC) of Bellary, Hospet and Sandur taluks. The study reported the number of patients treated or registered for diarrhoea, respiratory infections and other diseases [37].

VI. CONCLUSION

India is the leading producer of iron ore in the world. Apart from the basic Iron and Steel industry, sponge iron, pig iron, the ferrous industry and even the cement industry are also considered the major consumer of iron ore. Therefore, a long-term policy is needed to preserve and conserve iron ore deposits for the country's long-term consumption. The Indian steel sector is set to achieve a global benchmark in terms of quality, standard and technology. This requires huge demand for iron ore. To augment this demand, intensive and deeper exploration needs to be promoted. The underground mining techniques with optimum utilisation of iron ore deposits should be eco-friendly. The main conclusion of the review is that further research is required to assess environmental impacts of iron ore mining activities. Thus, the emphasis should be placed on sustainable mining operations in association with Government and mining research institutes.

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Modeling of Geological and Geophysical Data, Onshore Field of Potiguar basin, northeastern Brazil

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Abstract*—*This work presents the results of 3D Geological Modeling with a focus on the onshore field, in the context of the Potiguar Basin. Therefore, the object of study is the silisiclastic reservoirs of the Açu Formation, unit 3, which correspond to the Albian/Cenomanian fluvial sandstones, in which hydrocarbon accumulations are housed. In this way, a better understanding of the reservoirs of a part of the field was sought through the integration of geological and geophysical information in the Leapfrog software. Where the gamma rays (GR), density (ROHB) and neutron porosity (NPHI) profiles were used to identify regions of reservoir rocks and sealants or non-reservoir. And the microresistivity profiles (MSFL), to determine the water saturation in the formation, and from that the oil saturation in the respective intervals. Through modeling, it was found that the highest relative oil saturation is accumulated in the upper portion of the sequence, in reservoir R1, where the average is 45%. In reservoir R2, intermediate, the average is 30% and in reservoir R3, in the lower part, 38%. And a total volume of hydrocarbons of the order of 1.17 MM3 was estimated for the three reservoirs. From this integration, despite the stage of production categorizing the field as mature, it appears that there are still significant volumes to be exploited.

I. INTRODUCTION

Several studies show the application of software for three-dimensional 3D modeling, treatment and interpretation of geophysical geological data from wells. Among the various ways of representing data such as maps and profiles, geological models in three dimensions have become increasingly present and important in decision-making, such as in the mining sector, exploitation of hydrocarbons, among others. In this work, the Leapfrog software was applied in the analysis and modeling of data from geophysical profiles of hydrocarbon producing wells in an earth field in the Potiguar basin (Figure 01).

Like other basins on the equatorial and eastern margins of Brazil, the Potiguar basin had its origin related to the breakup of the supercontinent Gondwana. In this basin, the source rocks and reservoirs are related to the tectonics of the rift and drift phases, which were responsible for its evolution [1] (Matos, R.M.D. 1992).

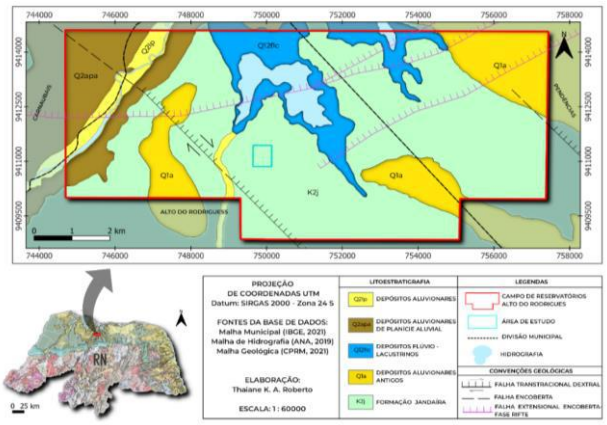

Fig. 1: Geological map and location of the study area.

Oil fields are located along the Carnaubais trend, controlled by the effects of the evolution of this geotectonic segment, which culminated in the implementation of the Potiguar basin (Figure 01). The structure of the field analyzed in this work, which controls the accumulation, configures an asymmetric anticline, defined by the interaction between the layers that dip to the north and the Carnaubais Fault to the south. This structure partly developed from features inherited from the basement [2] (Siqueira, J.B. 2005), which project into the sedimentary filling represented by the Pendência, Alagamar, Açu, Jandaira and Barreiras Formations.

The reservoir rock sequence is composed of sandstones of fluvial origin, and sealing shales of Albian/Cenomanian age. Which belong to Unit 3 of the Açu Formation [3] Conceição et al. (1984) [4] Nolla, F.R. (1992). The source rocks are related to the Alagamar Formation, and the hydrocarbon accumulations are housed in the siliciclastic reservoirs of the Açu Formation.

II. MATERIAL AND METHODS

Currently the representation of data made in a simple and direct way is extremely important in all area of geology, where the 3D models obtained stand out. Successors of block diagrams, and can be classified into two types: explicit and implicit modeling [5] Garcia, L.M. & Gonçalves, I.G. (2021).

Explicit modeling is essentially similar to an engineering drawing process. The modeler defines geological structures such as veins and faults by explicitly drawing them in regularly spaced sections and joining them together. However, geology does not come in boxes, triangles, straight lines or even fancy curves, they are just ways of representing geology on a computer. Implicit modeling is algorithmically generated directly from a combination of measured data and user interpretation. This modeling requires the vision of a geologist, but it is done in the form of trends, stratigraphic sequences and other geologically significant terms [6] Lane, R. (2015). This approach is faster, more flexible and fundamentally better suited for geological modeling.

In figure 2 the two sections look similar, however, the upper explicit section is created by manually joining the contact points, while the lower implicit section is created directly from the geological data. Then, geostatistical methods are used to interpolate the drilling data and thus seek the geological behavior of the solid to be modeled, optimizing the process.

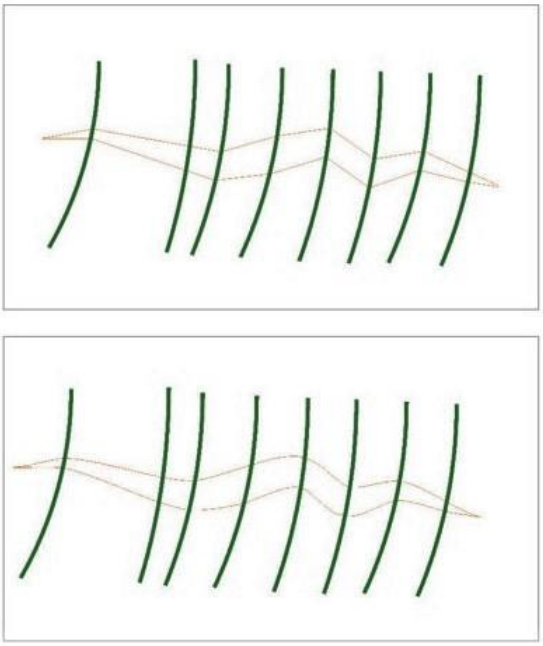

Fig. 02: Upper section generated by manually joining the points. Bottom section generated directly from the data. Source: [6] Lane, R. (2015).

Applying this foundation of implicit modeling, and with the support of the Leapfrog Geo software with Edge extension, this work sought to analyze and associate the physical properties of the lithological types using as input data the information from the geophysical profiles of wells, obtained from the readings every 20.0 cm in the profiling operation.

The modeling was carried out based on four main steps: creation of the topography of the land surface of the study area, import of drilling data (database containing geological and geophysical information of the wells in the study area), creation of intervals (selecting the subdivision of the lithotypes), creating the contact surfaces and generating volumes (Figure 03).

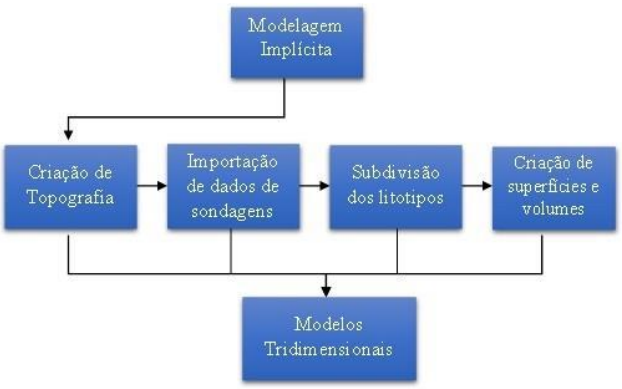

Fig. 03: Flowchart of the modeling steps in Leapfrog.

III. RESULTS

With the information generated in the previous steps that supported the 3D three-dimensional geological model, the numerical modeling step was carried out, which involved a statistical and geostatistical approach as described and illustrated below.

Both reservoir and non-reservoir rocks, whether in the category of seals or intercalations, and other parameters that are duly identified through the profiles, are specialized and analyzed. This understanding is essential, as it provides proper support along with fluid saturation in the numerical modeling stage and obtaining volume estimates. In the case of the subject under analysis, which is hydrocarbons, categorized here as oil. From the steps developed according to the implicit modeling flow of Leapfrog, the 3D geological model of the study area was obtained as a result (Figure 04).

In this model, the profile data obtained in the geophysics of the well, corresponding to the electrofacies (EFAC), which in the input table are represented by the numbers 1, 2, 3 and 4, were regrouped with the label FLAG (0, 1), to separate the intervals of non-reservoir rocks, of the intervals of permoporous reservoir rocks, respectively. Therefore, the data in the table now called FLAG, with their respective attributes, which originated from the electrofacies, are finally used to support numerical modeling in obtaining an estimate of fluid volumes. The final product of the 3D geological modeling is represented by three important reservoir zones (Figure 04).

Here these reservoirs, which are permoporous siliciclastic rocks, from member 3 of the Açu Formation [7] Vasconcelos, E.P. & Lima Neto, F. & Roos, S. (1990), are called reservoirs R1, R2 and R3, from top to bottom. Which are the permoporous rocks, in which hydrocarbon accumulations are lodged. And separated by important seals, called S1, S2 and S3. Which are very low to zero permeability rocks, which are responsible for retaining and maintaining the accumulation of hydrocarbons in the field (Figure 04).

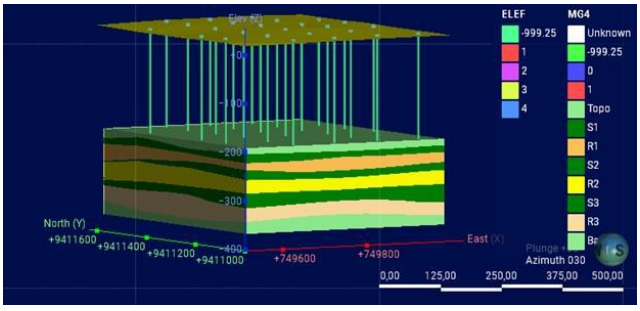

Fig. 04: Geological model (Topography, Electrofacies, Flag, Reservoirs and Seals).

Data statistics and geostatistics

From the 3D geological model, a statistical analysis of the information from the geophysics of the well was carried out, to see the distribution of values in reservoirs R1, R2, R3 and respective oil saturation (So). In this step, with the purpose of relating the information contained in the geophysics profiles of the well with the geology and other properties, the Merged table was combined. According to the statistical analysis, the R1 reservoirs have an average oil saturation (So) of 45%, R2 30% and R3 38%. In addition, in the statistical analysis, the Box plot alternative was explored to verify the relationships between fluid saturations and lithologies that make up reservoirs R1, R2 and R3. Where it appears that the highest relative oil saturation (So) is in the reservoir R1 upper portion, and R3 in the lower portion. And an overlapping of values in the intermediate reservoir R2 (Table 01 and Figure 05).

Table 01: Statistics by reservoir.

Name	Mean	Std. dv	Coef. Var.	Variance	Minimum	Quartile inf.	Mediana	Upper quart.	Maximu
Reservoir R1									
GR_ENVCORR	78,04	19,25	0,25	370,61	41,39	64,46	73,35	86,78	211,76
MSFL	9,20	10,99	1,19	120,72	1,00	4,51	7,46	10,74	314,25
NPHI_ENVCORR	0,25	0,05	0,22	0,00	0,06	0,22	0,25	0,28	0,47
PHID66	0,22	0,05	0,21	0,00	0,06	0,18	0,22	0,25	0,34
RHOB_ENVCORR	2,30	0,08	0,03	0,01	2,09	2,24	2,29	2,36	2,57
So	0,45	0,25	0,55	0,06	0,00	0,35	0,51	0,63	0,80
Vsh	0,17	0,11	0,67	0,01	0,00	0,09	0,14	0,23	0,66
Reservoir R2									
GR_ENVCORR	75,06	15,14	0,20	229,34	46,36	63,87	72,33	83,33	156,45
MSFL	4,28	3,08	0,72	9,46	1,00	2,13	3,80	5,74	46,75
NPHI_ENVCORR	0,26	0,03	0,13	0,00	0,15	0,24	0,26	0,28	0,44
PHID66	0,24	0,03	0,13	0,00	0,12	0,23	0,25	0,27	0,37
RHOB_ENVCORR	2,25	0,05	0,02	0,00	2,05	2,22	2,25	2,28	2,46
So	0,30	0,22	0,73	0,05	0,00	0,07	0,31	0,48	0,80
Vsh	0,13	0,10	0,73	0,01	0,00	0,07	0,11	0,17	0,68
Reservoir R3									
GR_ENVCORR	78,55	18,77	0,24	352,44	43,94	65,59	73,54	87,65	215,60
MSFL	5,51	3,87	0,70	14,97	1,00	2,90	5,01	7,39	48,06
NPHI_ENVCORR	0,26	0,04	0,15	0,00	0,13	0,24	0,26	0,28	0,44
PHID66	0,24	0,03	0,11	0,00	0,11	0,22	0,24	0,26	0,32
RHOB_ENVCORR	2,26	0,04	0,02	0,00	2,13	2,23	2,26	2,29	2,49
So	0,38	0,24	0,63	0,06	0,00	0,20	0,43	0,57	0,80
Vsh	0,15	0,11	0,77	0,01	0,00	0,07	0,12	0,18	0,70

From this verification of the consistency of the data, a careful analysis of the geostatistical parameters was carried out, starting with the search for the appropriate variogram for numerical modeling of the data on the X, Y and Z axes of the search ellipsoid in the estimation of hydrocarbon saturation, here called oil saturation. This procedure was initiated for the reservoirs in the upper zone R1 of the model defined in the geological modeling stage, and a similar routine was applied to the other R2 and R3, from top to bottom, in their specific zones.

Variography of the reservoir R1

It is gathered in the upper region of the field under the denomination R1 reservoir, the sequence of permoporous rocks and respective saturations of hydrocarbons. In this region, we tried to establish the adjustment parameters of the variogram that supported the search ellipsoid in estimating oil saturation in reservoir R1 (Figure 06).

Variography of the reservoir R2

In the middle region of the field, the sequence of permoporous rocks and their hydrocarbon saturation are grouped under the name R2 reservoir. In this region, as in the previous one, an attempt was made to establish the adjustment parameters of the variogram that supported the search ellipsoid in estimating oil saturation in reservoir R2 (Figure 07).

Variography of the reservoir R3

It is gathered in the lower region of the field under the denomination R3 reservoir, the sequence of permoporous rocks and respective hydrocarbon saturations. Figure 08 shows the adjustment parameters of the variogram that supported the search ellipsoid in estimating oil saturation in reservoir R3.

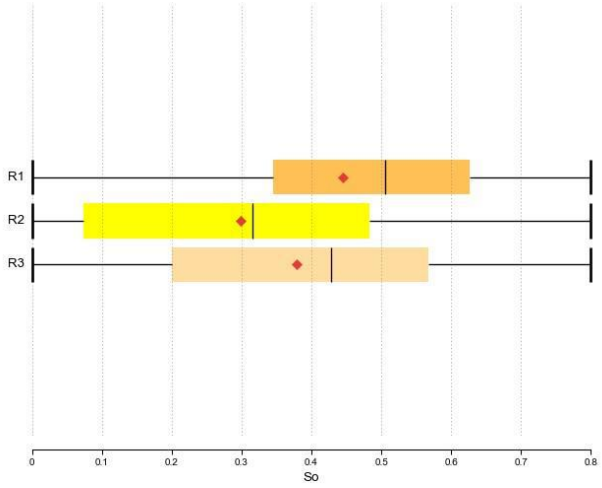

Fig. 05: Distribution of percentage oil saturation (So) in reservoirs R1, R2 and R3.

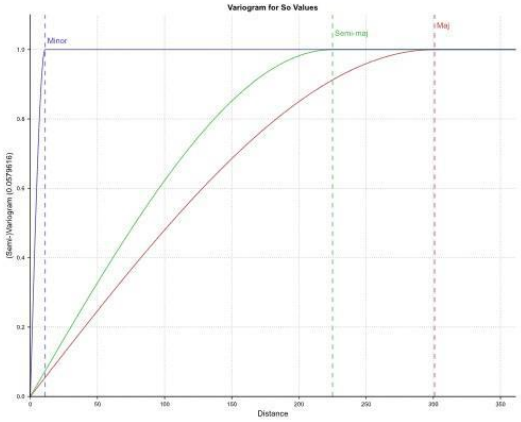

Fig. 06: Parameters and characteristics of the variogram applied to reservoir R1.

Table 02: Estimated volume of the study area by type of reservoir.

Reservoir R1				
Interval %	Vol. for Interval (i	*So mean aprox	Vol. por int.*'	Vol. for int.*So*phi
< 0,38	1.336.783,12	0,38	507.977,58	91.435,97
0,38-0,50	875.655,78	0,44	385.288,54	69.351,94
0,50-0,60	1.064.063,53	0,55	585.234,94	105.342,29
> 0,60	267.297,57	0,60	160.378,54	28.868,14
Total R1:			1.638.880,00	294.998,33
Reservoir R2				
Interval %	Vol. for Interval (i	*So mean aprox	Vol. por int.*'	Vol. for int.*So*phi
< 0,38	3.166.795,25	0,38	1.203.382,20	216.608,80
0,38-0,50	2.350.379,01	0,44	1.034.166,76	186.150,02
0,50-0,60	791.134,74	0,55	435.124,11	78.322,34
> 0,60	94.890,99	0,60	56.934,60	10.248,23
Total R2:			2.729.608,00	491.329,38
Reservoir R3				
Interval %	Vol. for Interval (i	*So mean aprox	Vol. por int.*'	Vol. for int.*So*phi
< 0,38	2.905.130,29	0,38	1.103.949,51	198.710,91
0,38-0,50	1.371.834,38	0,44	603.607,13	108.649,28
0,50-0,60	604.070,30	0,55	332.238,66	59.802,96
> 0,60	119.765,04	0,60	71.859,02	12.934,62
Total R3:			2.111.654,00	380.097,78
Final Volume :				1.166.425,49

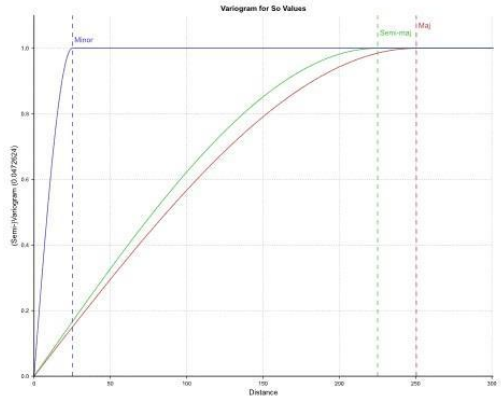

Fig. 07: Parameters and characteristics of the variogram applied to reservoir R2.

Volume estimation

After completing these steps of 3D and numerical geological modeling, considering the fluid saturation at the time the profiles were acquired, hydrocarbon volumes of the order of 0, 29MM3, and respective percentages of saturations per interval.

For reservoir R2 of the intermediate sequence 0.49MM^3, and R3 of the lower sequence 0.38MM^3. And a total volume of hydrocarbons of the order of 1.17MM^3 for the three reservoirs (Table 02).

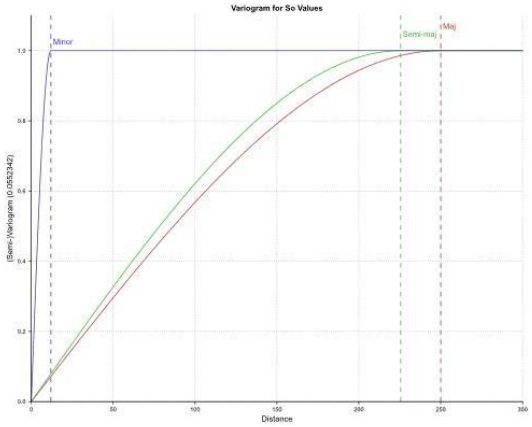

Fig. 08: Parameters and characteristics of the variogram applied to reservoir R3.

IV. CONCLUSION

Based on the observations made, it can be seen that the reservoirs in which the main accumulations of hydrocarbons in the study area are housed are made up of siliciclastic from the Açu Formation, member 3, composed of fluvial sandstones.

The highest relative oil saturations, are accumulated in the upper portion of the sequence, in reservoir R1. Where the average saturation is around 45%. In reservoir R2, intermediate sequence, the average saturation is 30% and in reservoir R3 in the lower part 38%. Through modeling, volumes of hydrocarbons of around 0.29 MM^3 were estimated for reservoir R1, for reservoir R2 0.49 MM^3 and for reservoir R3 0.38 MM^3. And a total hydrocarbon volume of around 1.17MM^3 for the three reservoirs.

Due to the current stage of exploitation, this area is part of a field classified as mature. Therefore, a way to optimize the use of these resources is through a better understanding of the reservoirs, as shown in this research, to verify the regions to be drained, and with that optimize the exploitation of the hydrocarbons that still exist.

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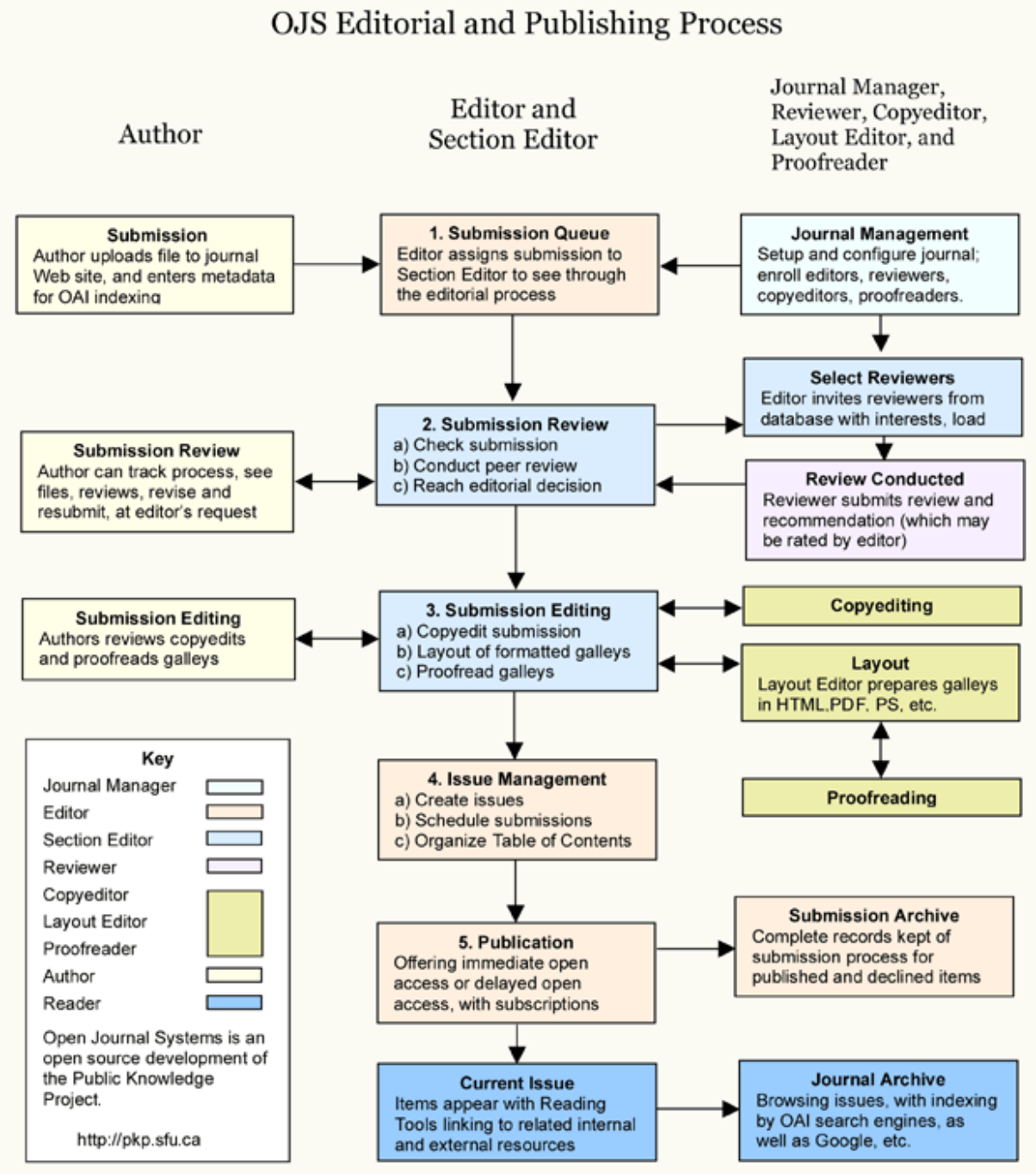

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