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Management of occupational safety and health (OSH) in university chemical laboratories: A case study at a University Federal Public service in the interior of Paraná - Brazil

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Abstract*— *The risks associated with academic research are often much lower than those in large-scale process industry operations. While inventories of hazardous materials are lower in the university environment and the number of hazards may be lower, factors such as chemicals used in laboratories and the proximity of researchers to their equipment can equate to a high individual risk for laboratory users. The number of reported laboratory accidents resulting in fatalities, serious injuries, and financial loss demonstrates a need for better risk management practices in academic teaching and experimental research laboratories. Academic and research labs at universities contain various risks, and the associated risks can be significant if not appropriately managed. The misperception that university labs are low risk is partly due to a lack of awareness of the hazards. This paper discusses an approach to applying health and safety practices to chemistry laboratories at a federal university in the interior of Paraná and discusses selected challenges and suggested solutions.

I. INTRODUCTION

Safety and health have been significant issues developing in the social context due to the increased concern with preventing dangerous situations for people everywhere (Li et al., 2015). The point of safety does involve not only industries but also educational institutions that have laboratories whose users are highly exposed to various hazards such as chemical, biological, physical and radioactive hazards and musculoskeletal disorders (Fan et al., 2014). These hazards can be avoided because there are many factors capable of contributing to the safety and health in the laboratory, such as the correct operation of instruments, stress management, handling of chemical or hazardous material, risk assessment, and emergency procedures (Reader et al. ., 2015).

State or federal regulations generally regulate safety and health practices that limit exposure to hazardous substances. Many educational institutions have developed their occupational safety and health programs approved and monitored by a management board (Liu et al., 2015).

However, even an almost perfect system can incur a breach; there is always the possibility that something will not go as planned, exposing specific hazards through accidents and injuries to users. These undesirable possibilities can occur due to certain flaws in safety procedures or even lack of safety culture and awareness, careless attitude, poorly designed laboratories, and overcrowding (Reader et al., 2015). Regulatory bodies have noticed that many higher education institutions have studied workers' attitudes and perceptions of safety in many Western countries (Fan et al., 2014). Of these, the main factors for laboratory accidents stem from the human attitude and the accumulation of information and experiences, which lead individuals to act in a certain way when faced with a particular stimulus (Catino; Patriotta, 2013). Laboratory safety does not just involve strict adherence to regulations; it is also the result of everyone's attitude and commitment (Hajmohammad; Vachon, 2014). Students adhere to the rules only in some situations and may not follow all of them. The biggest challenge in educating students about safety is getting them to understand and recognize hazards rather than just following safety rules (Högström et al., 2010).

For Maksemiv and Michaloski (2016), safety is paramount in science teaching, and it is necessary to improve safety practices and culture in many universities. The importance of laboratory safety must be encouraged in students from the beginning, repeatedly, and must not be forgotten (Catino; Patriotta, 2013). However, universities can and should play a more active role in controlling risks to ensure the safety of students, faculty, staff, and even visitors. Occupational safety and health (OSH) should be practiced to increase awareness among laboratory users (Gonçalves Filho et al., 2013).

Indeed, OSH issues are as important as human rights and should not be considered another privilege (Oliveira et al., 2010; Nordlöf et al., 2015). To meet OSH requirements, universities must ensure that campuses are safe and conducive to these activities. Because of this, the Brazilian Association of Technical Standards (ABNT, 2011) recommends some recommendations for improving security in colleges and universities:

1. isolation, preventing access to personnel who do not work directly with the laboratory;

2. controls to provide a ventilated workspace that typically includes chemical fume hoods, biosafety cabinets for working with hazardous chemicals and pathogens;

3. administrative controls to provide safety training, access to risk information, and laboratory inspections by health and safety institutions to ensure a safe working environment;

4. Personal Protective Equipment (PPE) such as lab coats, eye protection, and gloves provide a direct protective layer for researchers. Depending on the risk, additional equipment is often required.

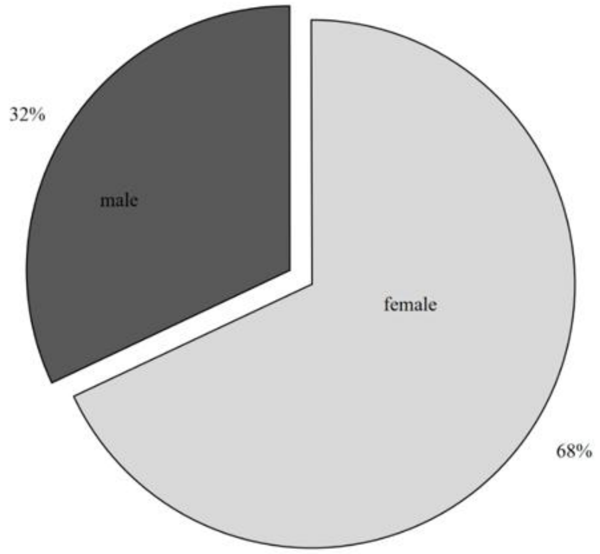
These recommendations may include, for example, relevant guidance on the health of particular groups such as students, faculty, and staff; applicable legislation, such as health surveillance of researchers exposed to animals; and other information, such as the size of universities, the age distribution of university staff and students, and the pattern of employment at universities, which is determined by university funding arrangements (Hirata; Mancini Filho, 2002; Högström et al., 2010).

Taking the scenario presented as a reference, the present is udo addresses and assesses the level of safety and awareness among users of chemical laboratories at a federal public university in Paraná. In addition, the study describes the nature of OSH as a result of the challenges of its integration into university education. The way forward must be to develop an integrated university approach to creating a safe and healthy working and learning environment, combined with the inherent learning risks.

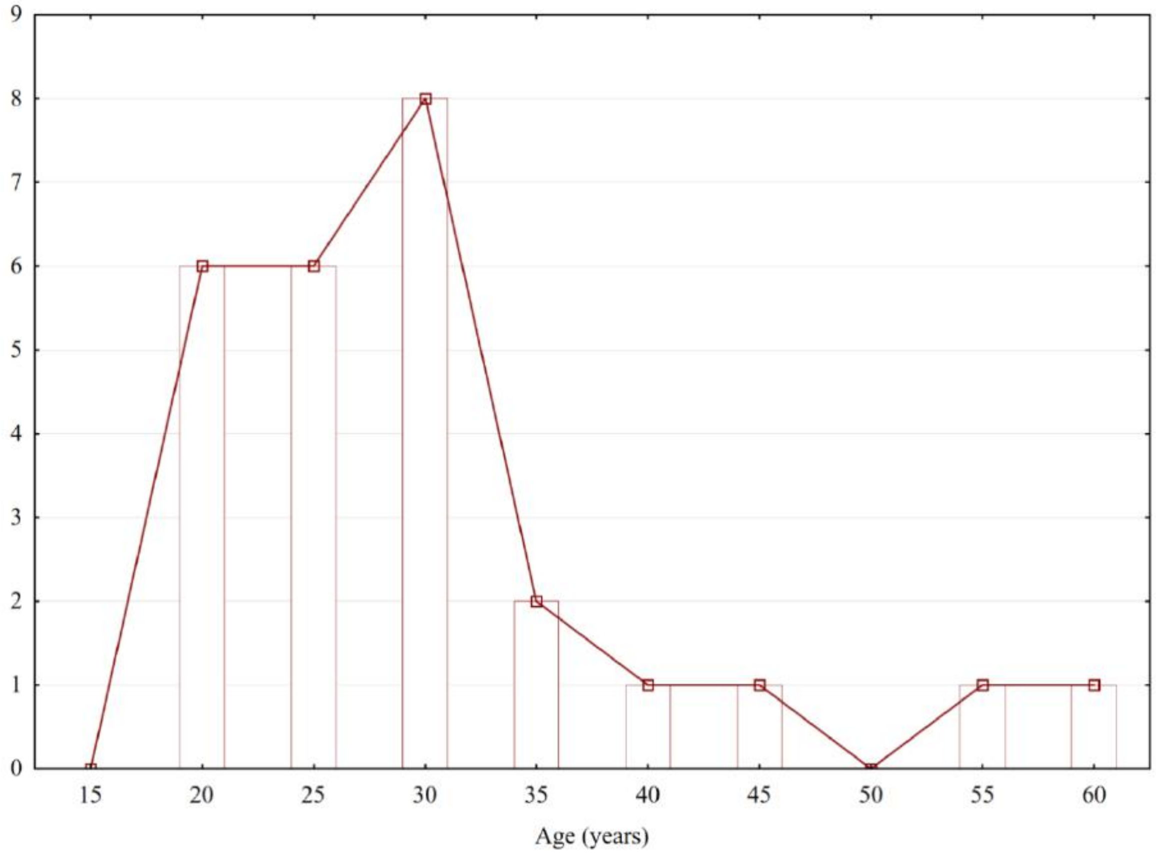
II. METHODOLOGY

The study was carried out between December 2019 and January 2020 in three chemistry laboratories of a federal public institution in the interior of the state of Paraná. A total of 20 master's and doctoral students and five laboratory technicians participated in the study and received the questionnaire to answer. The questionnaire-based on the biosafety manual for chemical laboratories by Hirata and Mancini Filho (2002) was developed and designed in two parts: part A, composed of demographic data, and part B, consisting of 10 questions related to safety awareness in the laboratory and ten inquiries about laboratory safety practice. The questionnaire consisted of closed questions that should meet a Likert scale adapted to four points. Respondents would assign scores to each question if 1 - strongly disagree, 2 - disagree, 3 - agree, or 4 - strongly agree. The collected data were analyzed using the Statistica 10 software and considered Cronbach's Alpha as a reliability criterion (Leontitsis; Pagge, 2007). This section presents the results obtained in the survey with the 25 respondents. Initially, we have the demographic data referring to part A of the questionnaire, that is, sex, age, knowledge about safety standards, and time of experience in laboratories. Figure 1 (a) presents the percentage of respondents by gender and indicates that 32% are male and 68% are female. Figure 1 (b) shows the age of the respondents. It is worth noting that most master's students enter graduate school immediately after completing their undergraduate courses. And the highest age is precisely the technician with the longest time in the institution. Figure 2

(a) shows the percentage of respondents about the safety knowledge of the laboratory, and Figure 2 (b) shows the time they are in direct contact with the laboratories. From the results, it is possible to verify that most of them know safety and health aspects; that is, of the 25 respondents, only one says they do not know.

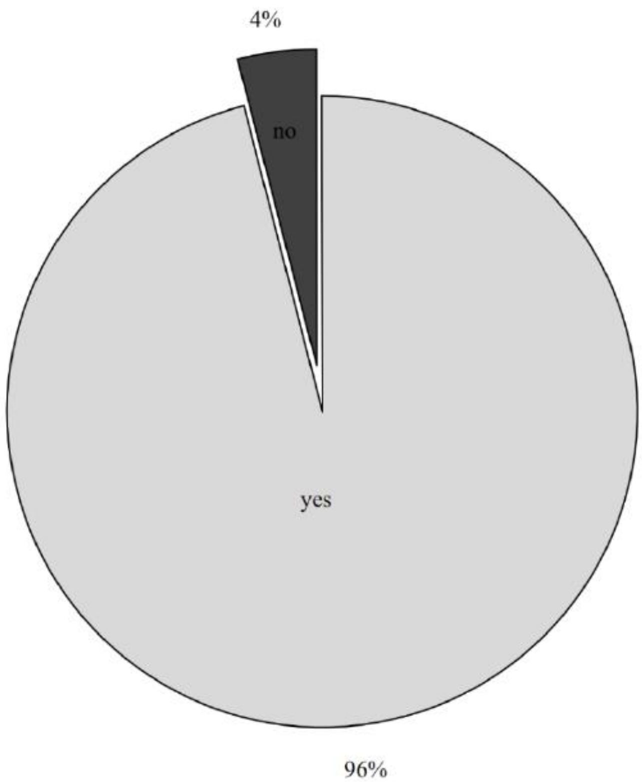


(a)

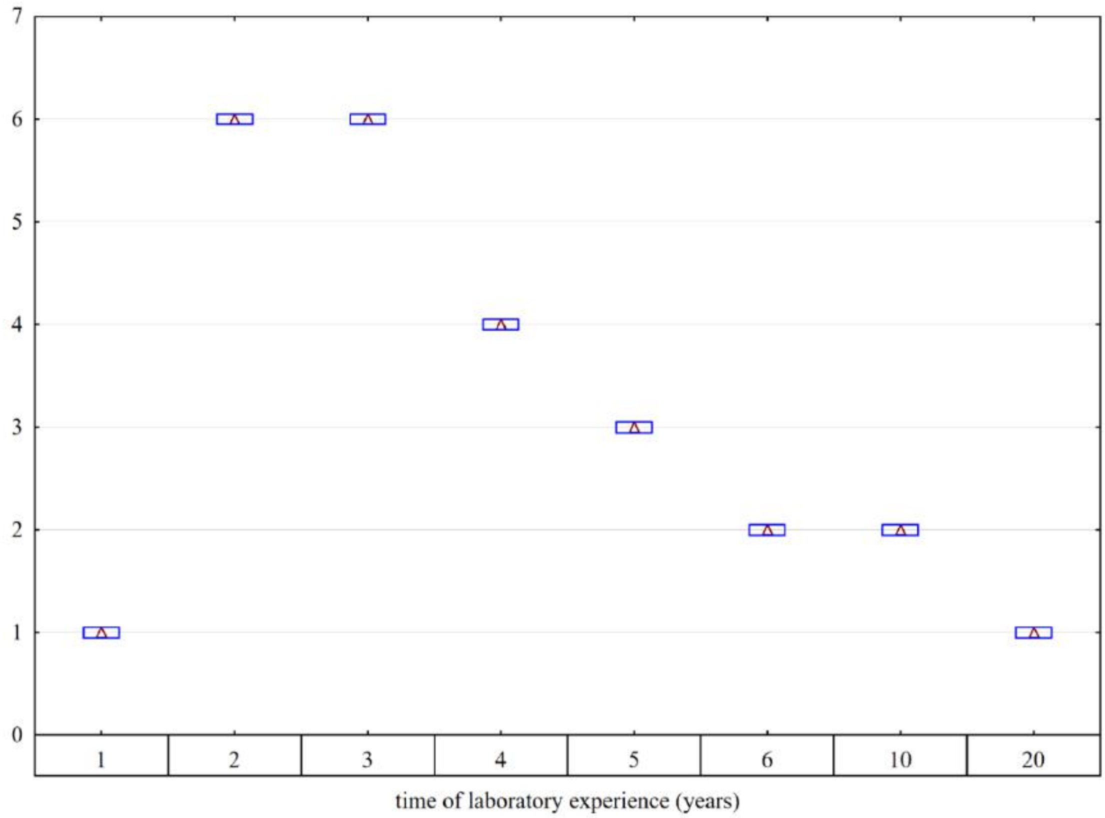


(b)

Fig.1 Percentages of respondents in relation to: (a) sex; (b) to age.



(a)



(b)

Fig.2 Percentages of respondents concerning: (a) knowledge of safety standards;(b) the time of trial.

In addition, Figure 2 (b) presents the percentage of laboratory experience among the respondent users. With the results, it is possible to verify that 8% of the team has ten years of experience and 4% more than 20 years, while the other 4% refers to the respondent who has only one year of experience. These two values refer to the technician with the highest age and the longest time in the institution and the master's student with the lowest age and the least experienced in the laboratory. The rest of the respondents had between 2 and 6 years of experience, accounting for 84%, of which 48% are respondents with 2 and 3 years of laboratory research.

To analyze the second part of the questionnaire (part B), it was necessary to establish a reliability criterion for the data. In the case of using the Likert scale, it is recommended to use Cronbach's Alpha at an acceptable value above 0.80 so that the data are well correlated (Leontitsis; Pagge, 2007). Table 1 provides reliability statistics for the questions used in this study. The result shows that Cronbach's Alpha was 0.82 and 0.87, respectively, for the ten questions related to safety awareness in the laboratory and the ten questions related to the safe practice in the laboratory, which is considered reliable for the data (Leontitsis; Page, 2007). Table 1 also shows the mean and the respective standard deviations for the 20 questions.

Security awareness data among lab users are presented. The average score for each question was between 3 and 4, representing the respondents' agreement with the proposed statements. The most excellent awareness was related to the laboratory being well ventilated and knowledge of safety kits, which reflects the need to help some users if there is a need. Respondents gave it the lowest score regarding cleanliness and organization, representing a problem many universities face. After carrying out experiments, many students do not clean and organize the laboratories as they should. In this case, it is up to the technicians and the guiding teachers to reaffirm the importance of cleaning. It is essential to highlight the number of respondents who agreed with the extent of supervision while performing some practical work in the laboratory.

Appropriate supervision practice helps ensure a safe environment for all academics intheir activities, including laboratory activities (Langerman, 2009).

Table 1 Data related to security awareness and practice

Laboratory safety awareness		
	Questions	Mean and standard deviation
Q1	Electrical wires are always arranged in their places.	3.60±0.50
Q2	Electrical equipment is turned off after use.	3.48±0.51
Q3	The laboratory is cleaned and organized after use.	3.24±0.44
Q4	All chemicals are labeled and stored.	3.78±0.51
Q5	The laboratory is well ventilated.	3.88±0.33
Q6	The fire extinguisher works and is in a suitable location.	3.53±0.51
Q7	Lab exits are accessible.	3.72±0.46
Q8	There are first aid kits in the lab.	3.88±0.33
Q9	The safe operating procedure (SOP) is visible on the equipment.	3.40±0.50
Q10	Supervision of laboratory technicians is essential.	3.85±0.50
Cronbach's alpha		0.82
Laboratory safety practice		
	Questions	Mean and standard deviation
Q11	Laboratory users can handle chemicals.	3.40±0.30
Q12	I know the danger I run in working with chemicals.	3.32±0.11
Q13	Laboratory staff knows the material safety data.	2.92±0.23
Q14	Use personal protective equipment (PPE)	3.40±0.62
Q15	I know how to use the fire extinguisher if necessary.	3.28±0.13
Q16	I know the rescue procedures.	3.06±0.45

Q17	I know how to label and classify a chemical.	2.72±0.38
Q18	I can identify hazards and risks in the laboratory.	2.88±0.34
Q19	I can locate the first aid kits.	2.60±0.48
Q20	I know how to give first aid.	2.40±0.49
Cronbach's alpha		0.87

Table 1 also presents data regarding safety practices implemented in the laboratory. As a result, the average score for each question varied between 2 and 3 and between 3 and 4. This means that some users agree, and others disagree with these questions. Behavior also plays a significant role in every organization, and many of the accident-causing factors are driven by individual attitudes towards safety and health issues (Langerman, 2009). If there is bad behavior regarding safety practices, there will not be a good functioning of an educational institution (Hirata; Mancini Filho, 2002; Penna et al., 2010). Based on the results, it is possible to verify that the highest score was given to qualified users to handle chemicals in the laboratory and protective equipment, followed by knowing how to identify the danger and use the extinguisher. The evolution of technological processes has led professionals involved in laboratory teaching activities to be exposed to various biological and chemical risks. According to Hirata and Mancini Filho (2002), the assessment and management of risks are mandatory for the definition of criteria and actions, aiming to minimize the hazards that can affect the health of teachers, technicians, students, and the environment. Regarding personal protective equipment, these are considered primary containment barriers and, together with good laboratory practices, aim to protect individuals and the laboratories themselves (Hirata; Mancini Filho, 2002; Penna et al., 2010). Together, these practices show a good attitude towards creating a safe laboratory environment.

The lowest grade was attributed to knowing how to provide first aid. This is a worrying factor, as several studies advocate that first aid training should be part of the school curriculum (Chima, 2016; Cave et al., 2011). In this way, it is recommended that employees and master's and doctoral students respondents undergo training to know how to act in emergencies. In laboratories, individuals need to be trained in safety and first aid techniques. Each unit must develop its safety manual, identifying risks and operational work procedures, which must be available to all site users (Penna et al., 2010).

III. CONCLUSION

Based on the analysis of the results, it was possible to conclude that some users understand and practice safety and health. In contrast, others do not develop these practices while conducting activities in the laboratory. Unfortunately, this condition contributes to unplanned events to occur. Safety knowledge and exercisearenecessary because they can create a safe workplace environment. For improvement, users must receive safety and health information and training that pay attention to the hazards present in the laboratory. Knowledge about safety practices is essential to avoid or minimize accidents. It is necessary to highlight that the research result was passed on to those responsible for the laboratories of the university participating in this study. They informed that in 2019 the Regulation of the Food, Environmental and Chemical Laboratories of the University was enacted to be implemented in 2020.

Culture must also be created that values health and prevention risks. It is essential to develop a culture of risk and prevention in training programs at all levels of education and in all areas. An educational institution must be a safe and healthy work environment appropriate for education. At the same time, the presence of vulnerable groups (e.g., very young students) and the needs of people with disabilities must be taken into account. The university sector is growing and needs to expose information on hazards and risks and relevant information for planning health provision. This information may include, for example, appropriate guidance on the health of particular groups such as students, faculty, and staff, relevant legislation, health surveillance of researchers exposed to chemicals, and other information such as the size of universities and age group. Of university staff and students.

REFERENCES

[1] ABNT. Norma 18.801/2011. Sistema de gestão da segurança e saúde no trabalho - Requisitos. ABNT, 2011.

[2] CATINO, M.; PATRIOTTA, G. Learning from errors: cognition, emotions and safety culture in the Italian air force. **Organization Studies**, 2013, v. 34, n. 4, p. 437-467.

[3] CAVE, D. M.; AUFDERHEIDE, T. P.; BEESON, J.; ELLISON, A.; GREGORY, A.; HAZINSKI, M. F.;

HIRATZKA, L. F.; LURIE, K. G.; MORRISON, L. J.; MOSESSO, V. N.; NADKARNI, V.; POTTS, J.; SAMSON, R. A.; SAYRE, M. R.; SCHEXNAYDER, S. M. C. Importance and implementation of training in cardiopulmonary resuscitation and automated external defibrillation in schools. **The American Heart Association Science Advisory**, 2011, v. 123, n. 6, p. 691-706.

[4] CHIMA, S. U. Improving school safety climate in public schools through supervision at 1st and 2nd tiers of Nigerian educational system. **Journal of Research & Method in Education**, 2016, v. 6, n. 5, p. 12-17.

[5] FAN, D.; LO, C.K.Y.; CHING, V.; KAN, C.W. Occupational health and safety issues in operations management: a systematic and citation network analysis review. **InternationalJournalProductionEconomics**, 2014, v. 158, p. 334-344.

[6] GONÇALVES FILHO, A. P.; ANDRADE, J. C. S.; MARINHO, M. M. O. Modelo para a gestão da cultura de segurança do trabalho em organizações industriais. **Produção**, 2013, v. 23, n. 1, p. 178-188.

[7] HAJMOHAMMAD, S.; VACHON, S. Safety culture: a catalyst for sustainable development. **Journal of Business Ethics**, 2014, v. 123, n. 2, p. 263-281.

[8] HIRATA, M. H.; MANCINI FILHO, J. B. **Manual de biossegurança**. Barueri, SP: Manole, 2002. 495p.

[9] HÖGSTRÖM, P.; OTTANDER, C.; BENCKERT, S. Lab work and learning in secondary school chemistry: The importance of teacher and student interaction. **Research in Science Education**, 2010, v. 40, p. 505-523.

[10] LANGERMAN, N. Laboratory safety? **Journal of Chemical Health and Safety**, 2009, v. 6, n. 3, p. 49-50.

[11] LEONTITSIS, A.; PAGGE, J. A simulation approach on Cronbach's alpha statistical significance. **Mathematics and Computers in Simulation**. 2007, v. 73, p. 336-340.

[12] LI, W.; LIANG, W.; ZHANG, L.; TANG, Q. Performance assessment system of health, safety and environment based on experts' weights and fuzzy comprehensive evaluation. **Journal of Loss Prevention in the Process Industries**, 2015, v. 35, p. 95-103.

[13] LIU, X.; HUANG, G.; HUANG, H.; WANG, S.; XIAO, Y.; CHEN, W. Safety climate, safety behavior, and worker injuries in the Chinese manufacturing industry. **Safety Science**, 2015, v. 78, p. 173-178.

[14] MAKSEMIV, C.; MICHALOSKI, A. O. Diretrizes para implementação de um sistema de gestão da saúde e segurança do trabalho segundo a OHSAS 18001: estudo de caso em uma indústria química.**Espacios**, 2016, v. 37, n. 14, p. 11.

[15] NORDLÖF, H.; WIITAVAARA, B.; WINBLAD, U.; WIJK, K.; WESTERLING, R. Safety culture and reasons for risk-taking at a large steel-manufacturing company: Investigating the worker perspective. **Safety Science**, 2015, v. 73, p. 126-135.

[16] OLIVEIRA, J. O.; OLIVEIRA, A. B.; ALMEIDA, R. A. Gestão da segurança e saúde no trabalho em empresas produtoras de baterias automotivas: um estudo para identificar boas práticas. **Produção**, 2010, v. 20, n. 3, p. 481-490.

[17] PENNA, P.M.M. Biossegurança: uma revisão. **Arquivos do Instituto Biológico**, v.77, n.3, p.555-465, 2010.

[18] READER, T. W.; NOORT, M. C.; SHORROCK, S. Safety sans frontières: an international safety culture model. **Society for Risk Analysis**, 2015, v. 35, n. 5, p. 34-56.