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Original Article

Chemical Safety Knowledge Assessment of Academic Researchers from Brazil During Covid-19 Pandemic

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ABSTRACT

Introduction: Laboratories are inextricably dangerous work environments, as fatal incidents are reported in both academic and non-academic environments worldwide, where poor safety culture has been recognized as the major accident contributor. Workers can be exposed to chemical, biological, physical, or radioactive hazards, in addition to musculoskeletal stresses. In Brazil, hundreds of thousands of workers are employed in laboratories, either in private or public institutions. Although laboratory safety can be governed by local, state, or federal regulations, learning how to identify common laboratory hazards is the first step to preventing accidents in the lab environment.

Methods: The study aimed to assess the degree level of safety culture in an academic population of research laboratories, located in the largest city in Brazil, and their compliance with occupational safety regulations during the COVID-19 outbreak. This study was carried out between October and November 2020. The results were obtained from the standardized questionnaire used to assess 98 researchers working in laboratories during the COVID-19 pandemic.

Results: The majority of respondents (95%) reported being exposed to more than two risks, simultaneously. About two-thirds (66%) of them were not fully aware of the laboratory's risk map. About half of the researchers (50%) were lacking in safety culture, and 57%and 43% were preoccupied with chemical and non-chemical hazards, respectively. Personal protective equipment (PPE) during laboratory work was used by most researchers, but 75% of researchers claim that security awareness learning should be a high priority for admission to laboratories. About 39% of researchers agreed that awareness of security must be improved in their laboratories

Conclusion: The survey proves the lack of information and attitudes about chemical safety, especially among less experienced researchers, even if they use personal protective equipment when necessary.

Keywords: Chemical Hazards, Chemical Safety, Laboratory Risk, Safety and Health

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Introduction

In early 2020, the World Health Organization (WHO, 2020) announced the outbreak of COVID-19 as a pandemic. With the resumption of work in the laboratories, several concerns were raised by researchers related to chemical safety. The perceptions of chemical risk (chemical burns, exposure to chemical vapors, among others) were verified in research laboratories, public institutions, and the largest city in Brazil. Experimental laboratories and researchers are important parts of teaching at academic and research institutes.[1] The drug discovery to treat several pathological conditions as well as the development of vaccines demand an enormous amount of chemical reagents, equipment, and laborious procedures.[2,3,4] In Brazil, academic research is mainly developed by undergraduate and postgraduate students in public universities and research centers.[5] Besides serious accidents involving researchers and technicians in the conduct of their activities which have been reported elsewhere, literature is showing the perception of safety prevention.[6] Evidence showed that undergraduate and postgraduate students are the major individuals affected by chemical agents, as they do not often operate with solid experience based in chemical safety.[7] Ménard and co-workers reviewed fatal accidents registered worldwide between 2008-2018, and showed that for most cases, accidents in the laboratory are identical in the distinct teaching and research institutions.[8] Importantly, the same authors also highlighted the students' poor chemical safety knowledge, thus leaving a marked gap in safety precautions. According to Marin et al., the level of safety is related to the perceptions of risk shared by students, and accidents in university laboratories revealed significant gaps in safety.[9] The study showed that safety behavior may also emerge in informal groups and that improving safety conditions in college laboratories require a more careful analysis of the laboratory users' perceptions of safety that is needed to develop targeted safety interventions.

In addition, in a survey on the use of chemicals in academic research funded by the American Chemical Society, McEwen and co-workers focused on three areas: information, risk assessment, and lessons learned practices.[11] There were 195 Brazilian universities (105 public and 90 private) in 2017 with the main source of public universities in the state of São Paulo. The present work was carried out in an Institute of Health Sciences where approximately 171 laboratories perform experiments in several research fields (infectious diseases, immunology, physiology, cancer, neurosciences, cardiovascular and renal, bioengineering and biotechnology).[12]

This study was carried out anonymously, with one hundred researchers, to assess the degree of safety knowledge among researchers (undergraduate, postgraduate, laboratory technician, post-doctoral and principal investigator) about the risks involved in handling or exposure to product chemicals, the level of perception of actions and decisions on chemical safety and how safety protocols are being applied in the laboratories of the University of the State of São Paulo.

Methods

This study was conducted with the approval of the Human Research Ethics Committee (CEPSH 26427219.1.0000.5467). The study included 98 participants with female and male academic researchers, ranging from 19 to 70 years old, comprising undergraduate and postgraduate students (MSc., PhD), postdoctoral, technician, and principal investigators working remotely from home and locally in the different departments of a local Academic Research Institute during the COVID-19 pandemic in São Paulo-SP, Brazil. The study was conducted online, involving more than fifty laboratories and only 98 participants responded to the online survey. All 98 responses were included in further analysis. To understand how safety culture is considered in an academic environment, a total of 35 questions (Supplemental material) focused on aspects of laboratory safety behavior particularly on personal protective equipment (PPE), safety tools to help identify risks, hazards, and control measures, communication of hazards, practical application of safety measures in the routine of the laboratory, laboratory waste, risk assessment and perception of risks. The questionnaire was conducted to ensure anonymity and was divided into 2 sections: 1) knowledge of safety and support tools in the identification of risks, hazards, and control measures, and 2) practical application of safety measures in the laboratory routine.

Respondents were recruited from October to November 2020 through emails containing a link to a questionnaire (35 questions), and a text explaining the objectives of the study and the respondents' rights in which the anonymity and confidentiality of data were highlighted. During the survey using the Google form platform, respondents were asked to answer some questions "yes" or "no". The total number of selected answers to the 35 questions was used to measure answers and plot graphs. At the end of the data collection, a data summary of the questionnaire was sent to the Director.

Data were presented as the mean of absolute values or percentages. The data processing and visualization tool for the presentation of results was Tableau Software LLC (Salesforce, Seattle, USA). This tool is suitable for data analysis and visualization applications, which allows users to publish interactive data on the web.

Results

The sociodemographic and occupational information of the participants are shown below (Table 1). The study group was composed of professors and graduate students and laboratory technicians. The profile of those surveyed described in table 1 represented the preponderance of risks of this population, in which a portion reported having no training in chemical safety.

Table 1. Socio-demographic profile of respondents (n=98)

Profile of informants interviewed		**n = 98**	**%**
Level of Research			
	Undergraduate	9	9.2
	Master's degree	15	15.3
	Doctoral degree	26	26.5
	Postdoctoral	5	5.1
	Technician	17	17.3
	Researcher professor	26	26.5
Lab experience in years			
	< 1 year	3	3.1
	1 to 3 years	12	12.2
	3 to 5 years	13	13.3
	> 5 years	70	71.4
Biosafety level (BSL)			
	BSL-1	68	69.4
	BSL-2	24	24.5
	BSL-3	2	2
	Unaware of the danger they were in	4	4.1
Laboratory safety training			
	Undergraduate	14	14.3
	Postgraduate	47	48
	Never	15	15.3
	Others	22	22.4

Researchers are subject to several risks simultaneously. For example, most respondents, above 80%, are subject to chemical, physical and ergonomic risks.

Multiple risk exposures in the laboratory

More than two-thirds (70%) of the interviewed population were exposed daily to more than two risk factors, with a predominance of chemical risk, followed by ergometric and biological risks (Figure 1A). More than three-fourths (75%) were subjected to risk level NB1. The research involved agents with the least degree of risk to laboratory personnel and the environment. In this case, the laboratory is not separated from the other premises of the building. Work was generally carried out on a bench (Figure 1B).

Perception degrees of potential risk exposures in the laboratory and safety equipment

According to figure 2, most respondents (70%) have access to information on chemical safety in their laboratories. On the other hand, more than half (60%) of undergraduate students were unaware of and did not access chemical safety information. Regarding the degree of perception and concern regarding exposure to risk in the laboratory, half of the interviewees showed to be aware and concerned about exposure to potential risks inherent to the work, especially chemical risks. More than two-thirds of the study population (70%) expressed concern about additional risks in the laboratory environment, such as physical, biological and ergometric risks.

Knowledge assessment of mandatory use of Personal Protective Equipment (PPE) in the workplace

According to Figure 3A, most respondents consider it important and necessary to use some PPE (gloves, masks, protective glasses and apron). When PPE is available, they use it frequently (figure 3B).

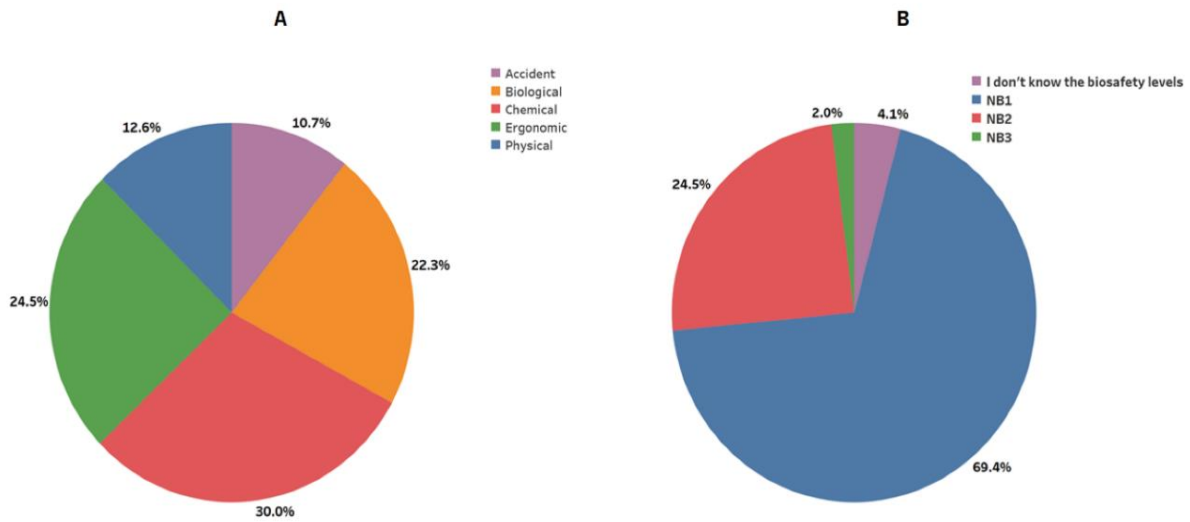

Figure 1. Risks in the laboratory. A) Categories of risks existing in the laboratory and B) Classification of the biosafety level of laboratories

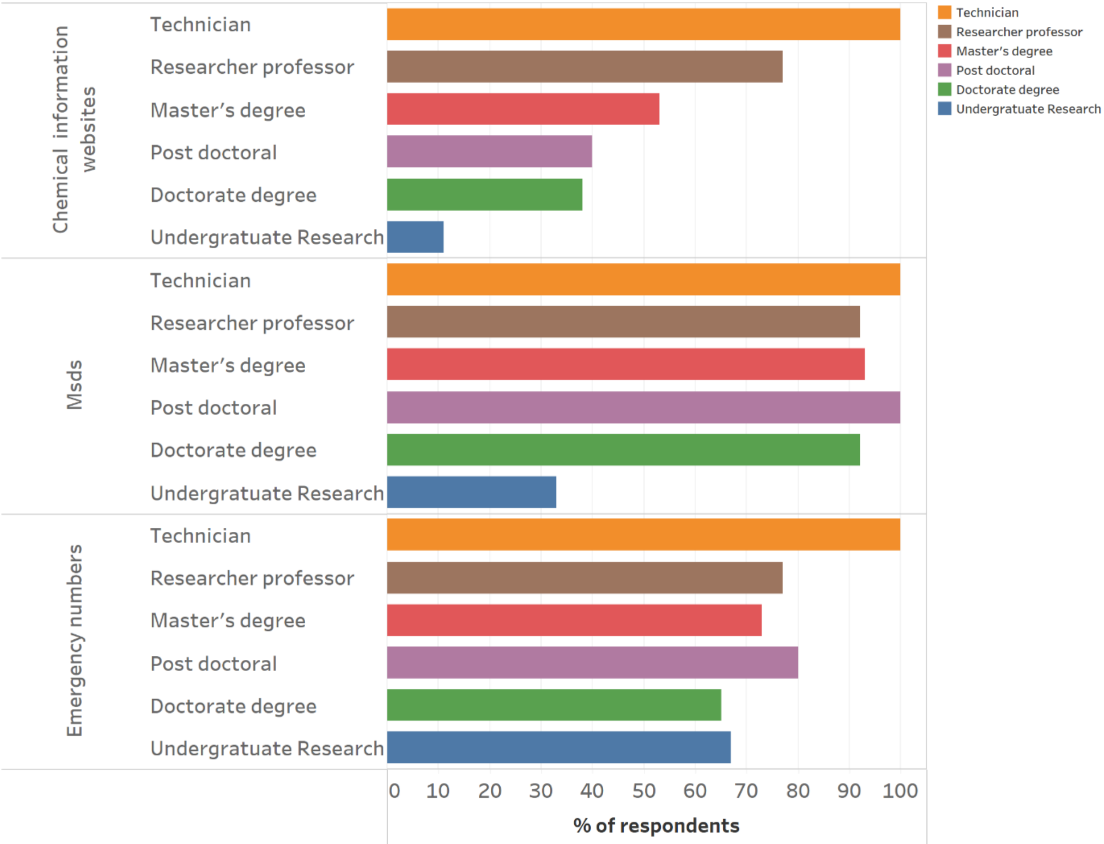

Figure 2. Lab safety education according to research level. Assessment of participants' knowledge about chemical information websites, Safety Data Sheets (SDS), labeling, GHS system and emergency numbers.

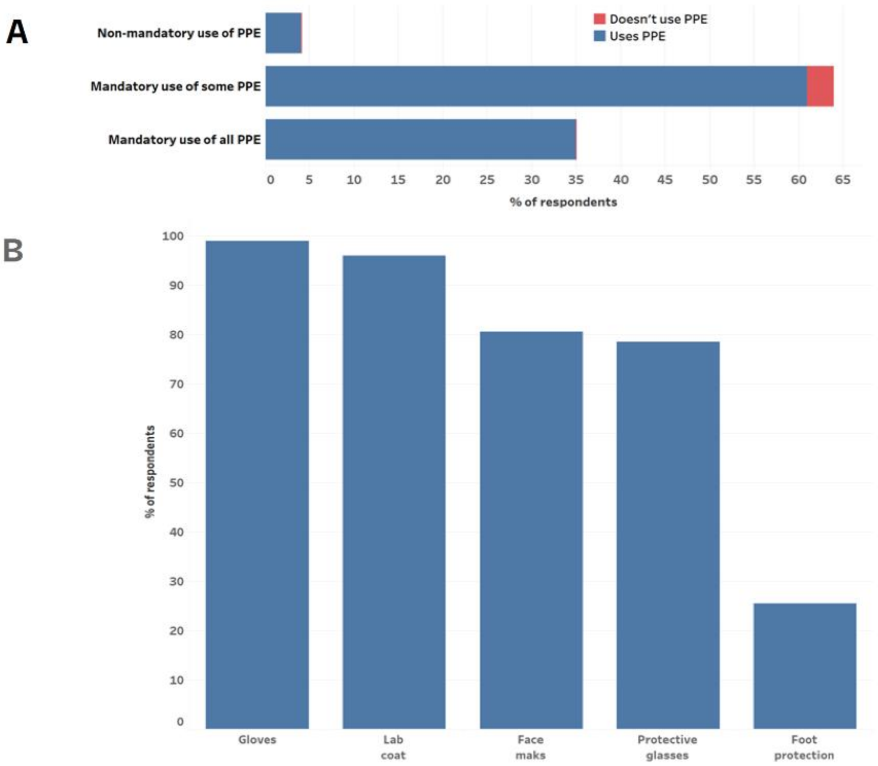

Figure 3. Use of personal protective equipment. A) Use of PPE according to mandatory use B) Frequency of use of different types of PPE.

Familiarity with chemical products handling, storage, and disposal

Most respondents (>70%) access the information and are familiar with the various systems for the disposal and storage of residual chemicals from the research developed (Figure 4). In practice, these residues accumulated in inappropriate places and were not inertized or recycled correctly. The researchers reported that there was a committee on chemical waste. However, it had difficulties in the treatment of chemical residues generated.

In response to the questionnaire, the researchers reported having little familiarity with the database and websites specialized in chemical safety and with the safety data sheets. About 42% of the researchers answered that they had no familiarity or experience in relation to the use of databases and safety information sheets on the use of chemical products, used in their research work. About 25% of the researchers reported knowing sites and databases on chemical safety, such as the American Chemical Society (ACS), PubChem, and CAMEO Chemicals.

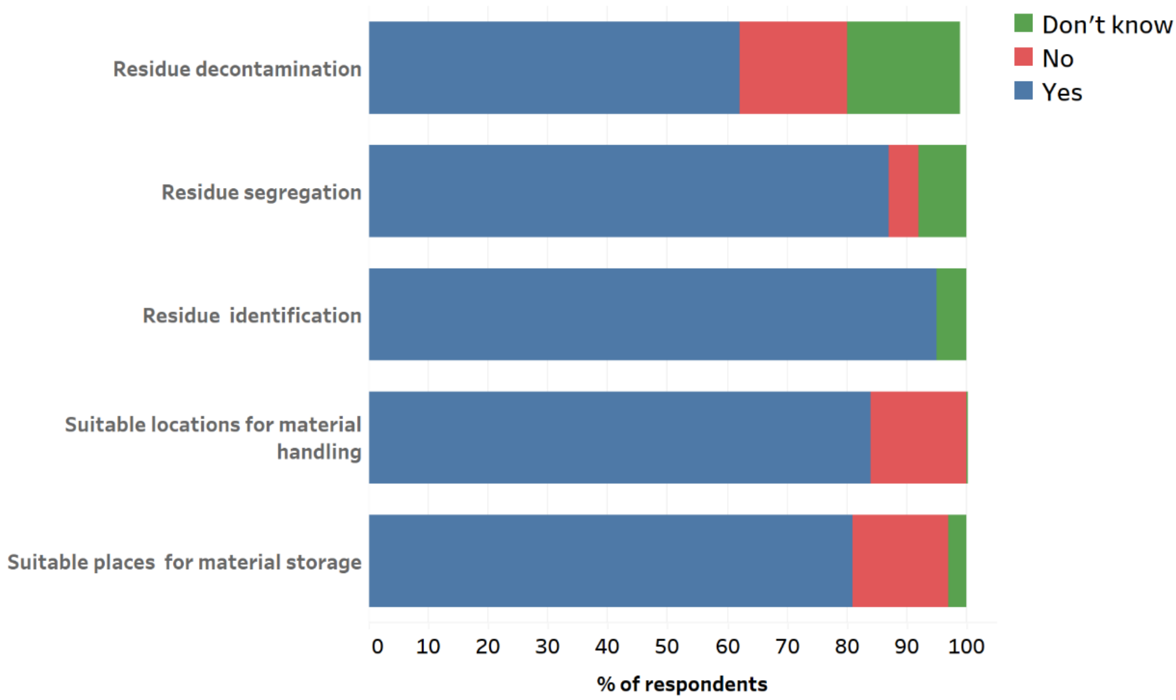

Figure 4. Familiarity with various aspects of material handling, storage and disposal.

Knowledge of the system of labeling and global harmonizes system (GHS) classification of chemical products routinely used in the research laboratory

More than half (58%) of the researchers knew and used the Classification and Labeling System (GHS), officially adopted in Brazil, while 16% of the interviewed people partially knew and 26% had no knowledge (Figure 5).

Regarding the knowledge of the labeling (pictograms) of chemical products used in the research laboratory by the interviewed researchers, figure 5B illustrated that more than half (56%) of the interviewees did not have this knowledge, while 41% knew partially and only 3% have this knowledge.

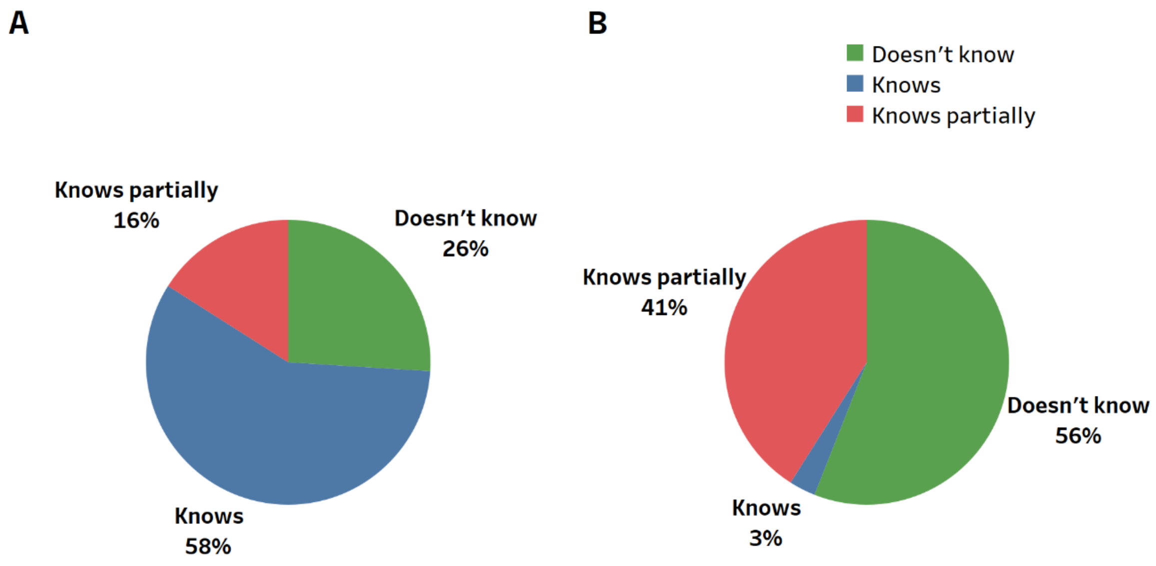

Figure 5. Chemical safety information. A) the percentage of respondents that check Global Harmonized System (GHS) classification when performing an experiment and B) knowledge of labeling system (pictograms) for chemical products

Perception regarding implementation of chemical safety training

More than 60% of the participants agreed that chemical safety training courses should be offered for all categories, and 28% partially agreed with this. Around 10% disagreed with the need for training on chemical safety. More than half of the population (56%) disagreed with the installation of frequent chemical safety meetings, while 31% thought partially in need of it. Only 8% fully agreed that training chemical safety meetings should be more frequent and up to date.

Assessment of the interviewee's safety profile in terms of isolated work and food consumption in the workplace:

The majority of respondents (87%) did not agree with the ingestion of food and beverages in the laboratory, while a small percentage (13%) agreed partially or didn't think there was a problem. Similarly, 27% of the same interviewees disagreed with solitary work in the laboratory, whilst 40% agreed partially or didn't see any problem with working by themselves.

Discussion

The respondents varied from undergraduates (with little or no laboratory experience) to senior researchers with more than five years of laboratory experience. Approximately 70% of respondents have five or more years of experience working in NBI security-level labs.

Researchers reported being exposed to different types of risks (chemical, physical and biological) in research laboratories (Figure 1). However, approximately one-third of researchers reported not knowing their laboratory's risk map, as well as not being concerned about chemical or non-chemical risks (Figure 2). Still, most researchers, about 60%, did not know about the content (or even the existence) of the laboratory safety manual (Figure 3). Approximately 50% of researchers were unaware of emergency contacts.

Most researchers considered chemical safety training necessary (Figure 4). However, they did not consider the periodic meetings on chemical safety important, so only 8% report having frequent meetings to discuss the topic. Half of the researchers do not consult chemical safety information sites. The Safety Data Sheets (SDS), although available to researchers, were rarely consulted before carrying out experiments with chemicals. About half of the researchers reported knowing the preventive labeling of chemical products, such as danger phrases, pictograms and warning words, but only 26% knew the GHS system (Globally Harmonized System).[13,14]

Personal Protective Equipment (PPE) was used, when necessary, and collective protection equipment was also used in most experiments (90% of researchers claim total or partial use of this equipment). Regarding undesirable practices in laboratories, most researchers reported consuming food and beverages within the laboratory environment. They even reported being alone in carrying out most of the experiments.

Peres and collaborators identified this problem in the construction of Good Laboratory Practice procedures in the academy.[16] Approximately 50% of researchers were unaware of emergency contacts. This lack of safety information was related to fewer years of research experience.

Most researchers considered chemical safety training to be necessary (Figure 4). However, they did not consider periodic meetings on chemical safety to be important so only 8% reported holding frequent meetings to discuss the topic.

Personal protective equipment (PPE) was used, when necessary, and collective protective equipment seemed to be used (90% of researchers stated the total or partial use of this equipment). Regarding undesirable practices in laboratories, most researchers reported consuming food and drinks within the research environment.

Ayi and co-workers conducted an online survey of Canadian academic laboratory workers on the lab safety culture. They showed a significant gap between how security is perceived and managed at universities.[10]

Perception of potential risks of the respondents

The interviewed population with knowledge about the safety manual showed that researchers with more experience were the ones who were more involved, as well as had more information about emergency contacts. Apart from the length of experience, a large percentage (above 75%) of the interviewed individuals with research time greater than three years did not know or had neither accessed the chemical safety manual, nor knowledge of emergency contacts in the case of events. The initial spread of COVID-19 brought a partial halt to some public academic institutions. The teaching staff was forced to take on new multiple tasks. The reopening was gradual and limited.[15]

Although laboratories faced stressful situations and many challenges daily, some lessons have been learned. The establishment of new leaders and individual actions, in the laboratories, in terms of safety.

Conclusion

The research showed a lack of information on chemical safety, especially among less experienced researchers, and personal protective equipment was used, when necessary.

All people who perform tasks in laboratory environments where chemical reagents are used must receive regular training (in the form of courses) to better understand the relevant aspects of chemical safety, which includes obtaining the correct information (directed to the reagents used in the activity performed), as well as taking a positive and preventive posture in the face of potential risks to which they are exposed. Finally, the results presented indicated that this scenario reflected the chemical safety conditions in the laboratories of most public universities in Brazil.

Recommendations:

Based on the results presented, this study recommends: each laboratory needs to adopt a code of conduct as per good chemical safety practices and it is necessary to overcome cultural barriers to implement safer laboratory practices in public universities.

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