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EXPLORATION AND EVALUATION OF THE SAFETY OF UNIVERSITY LABORATORIES: CASE OF THE FACULTY OF TECHNOLOGICAL SCIENCES OF CONSTANTINE 1 UNIVERSITY - ALGERIA

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Research article

Abstract: The risks associated with academic practical work are often perceived to be much lower than the risks inherent in industrial operations. The main objectives of the study are to explore the extent of the application of safety management within the laboratories of the Faculty of Science and Technology of Constantine 1 University, Algeria. A survey questionnaire was distributed to faculty laboratory staff exploring the administration's knowledge, attitudes, and commitment to implementing safety management policies in academic laboratories. The results obtained provided information on the current situation of the laboratory safety management system, in particular the unreasonable layout, the safety risks to which users are exposed as well as the level of adequacy of the systems already in place.

Keywords: University laboratories, management system, risk, safety culture, safety.

Introduction

The term "laboratory" is defined as a research facility with equipment, materials, etc. installed by a university or research institute for activities related to science and technology. The academic laboratory plays a very important role in the learning process, as it provides practical experience and excellent training to develop various skills (AlShammari et al., 2021). It is therefore one of the most important educational tools in university teaching and scientific research. It is an important place to exploit innovative scientific and technological capabilities. Laboratory research or experimentation exposes students, researchers and workers to numerous risks. Because they face various potential dangers, including chemical, biological and physical agents (Ayi and Hon, 2018) present in the work environment. Laboratories are therefore an inherently dangerous working environment and their safety must be a top priority (Hill, 2007; Yang et al., 2019). A safety incident can be defined as an unplanned event within a specific environment caused by various unstable factors, which can temporarily or permanently suspend work and result in injuries, deaths and damage to infrastructure. Laboratory safety is therefore a state in which there is no danger or fear of an accident occurring due to the measures that must be taken to avoid harm to students and researchers. A safe laboratory does not happen naturally; various factors must be taken into account and various efforts must be made to ensure it (Karapantsios et al., 2008). Research demonstrates that academic laboratories are more dangerous than industrial laboratories due to more relaxed safety management/culture and less investment in university safety compared to industrial plants (Marendaz et al., 2013; Schröder et al., 2016; Olewski et al., 2016b; Menard and Trant, 2020). Unfortunately, in recent years, high-profile serious and fatal accidents have occurred in university laboratories Table 1 (Labsafety.org, 2023). According to data from the U.S. Chemical Safety and Hazard Investigation Board (CSB), 120 university research laboratory incidents have been recorded since 2001, resulting in

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87 evacuations, 96 serious injuries and three deaths and these represent only the accidents that universities have been required to report in due to the seriousness of the consequences (CBS, 2011).

Table 1. A partial list of laboratory accidents in academic establishments (2012-2022) (Labsafety.org, 2023)

Year	Institution	Description of the accident
2022	Chemistry Laboratory of Isfahan Industrial University, Iran	One person dead, another injured in chemistry lab fire.
2021	Laboratory of Nanjing University of Aeronautics and Astronautics, China	Two people died in laboratory explosion.
2021	Laboratory of the Institute of Chemistry of the Chinese Academy of Sciences. Beijing, China	A student was killed in the explosion.
2019	INRA laboratory, Versailles, France	In May 2010, a young technician accidentally stuck her thumb in a double pair of latex gloves while working on mouse brain tissue containing mad cow disease proteins. She died of the disease nine years later.
2018	Laboratory at Jiao tong University, Beijing, China	Three students killed in explosion while researching wastewater treatment.
2017	Microbiology laboratory at Premier Service Medical Investments. Harare, Zimbabwe	A student researcher died from burns suffered in a fire.
2015	Tsinghua University. Beijing, China	Postdoctoral researcher dies in hydrogen explosion.
2014	Pathology Laboratory, Delhi, India	Two technicians died in a fire caused by a short-circuited air conditioner.
2012	University, Shanghai, China	A student opened a cylinder of toxic gas and died from inhalation.

In the accident analysis report of the Ministry of Science and ICT (MSIT), the number of R&D laboratory accidents in South Korea gradually increased from 166 in 2014 to 203 in 2015 and 204 in 2016. Out of 204 cases in 2016, 164 were university laboratory accidents, 18 were research institute laboratory accidents, and two were corporate laboratory accidents (Yoon, 2021). Most of this research showed that the increase in the number of accidents was due to the absence of safety management policies by laboratories, such as continuous guidance and inspections in the field, and insufficient law enforcement capabilities. It is clear that safety must be a top priority in teaching and academic research laboratories (Cadwallader and Pawelko, 2019; Yi et al., 2020). The strategic status of safety management must therefore be a clearly important priority. Academic laboratory safety is a systematic, time-consuming effort, involving a wide range of complex tasks and relationships, to effectively manage the laboratory (Roukatou and Dretti, 2022). Although safety is a major issue that must be permanently ensured during laboratory activities, some laboratories at our university are old, dating from the 1980s, which have not been fitted out and renewed according to architectural development. Until now, there are laboratories that have not been renovated to fit the actual needs. Up to the academic's knowledge, there are no statistics available on accidents in our university laboratories; however, unfortunately one major accident was highly mediatized about the death of a student in a laboratory, electrocuted during a practical work session in electrical engineering. The victim received a 380-volt mass due to a faulty cable used during this session (Lexpressiondz.com, 2012). In fact, to our knowledge, there is a lack of studies and surveys on safety management in the university environment, which address the situation of academic laboratories in Algeria. This study aims to fill this gap by analyzing the state of safety management in academic laboratories of the Faculty of Science and Technology at Constantine 1 University (FSTUC1).

As the goal is to assess the safety of academic laboratories, we sought to answer the following research questions:

1. What is the level of application of general safety measures in the laboratory?
2. What workplace safety practices are applied in the laboratory?
3. What are participants' attitudes and perceptions toward laboratory safety?
4. What is the degree of commitment of the administration to apply risk management policies?

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Methodology

This case study was carried out in spring 2023, with the aim of examining the knowledge of laboratory staff in terms of safety practices and discovering the application and commitment of the safety management system of educational laboratories of the Faculty of Sciences of Technology at Constantine 1 University in Algeria. A survey questionnaire was administered to supervisors, laboratory managers (technicians and/or engineers) and members of the FSTUC1 teaching staff, to collect relevant data about their knowledge, attitudes, and commitment to implementing safety management policies in academic laboratories.

Data Collection

The main tool of data collection in this study is a survey questionnaire. The target population being laboratory staff; it was distributed to a sample of laboratory supervisors (technicians, engineers) and teaching staff. A total of 65 questionnaires in French language were distributed. The participants received anonymous questionnaires including an opening paragraph explaining the purpose of the study, informing that there was no obligation to complete the questionnaire, and reassuring that the information obtained would remain confidential. Survey responses were recorded and exported to a spreadsheet for further analysis.

Description of Survey Questionnaire

The survey questionnaire was developed based on the literature review of comparable studies (Schröder et al., 2016; Algaralleh, 2014; Ashen et al., 2022) and adapted other questions. It includes two sections. The first focuses on the personal characteristics of the participants; such as gender, age, number of years of laboratory experience and task/role, the level of self-perceived risk in the laboratory and whether the participant has ever suffered an injury of any type since working in the laboratory. The second part included 29 statements. For the rating system, the study adopted the Likert scale for both sections (a) and (d) to answer the reach questions 1 and 4. It is very useful for measuring opinions, attitudes and behaviors (Losby and Wetmore, 2012; Ankur et al., 2015). The score was calculated by assigning a score of 1 for “strongly agree”, 2 for “agree”, 3 for “neutral”, 4 for “disagree”, 5 for “strongly disagree”. The level of response is judged according to the following Table 2.

Table 2. Discretionary scale according to the five-point Likert scale

Response	Interval	Level
Strongly agree	1.00 – 1.79	**Weak**
Agree	1.80 – 2.59	
Neutral	2.60 – 3.39	**Moderate**
Disagree	3.40 – 4.19	**High**
Strongly disagree	4.20 – 5.00	

Data Analysis

The processing and analysis of the collected data was carried out using Microsoft Excel. Participants responded to all items included in the four sections. The percentage for each response was calculated by dividing the number of responses received for a question by the total number of respondents. Additionally, analytical processes were carried out, including the evaluation of frequency, mean and standard deviation. Survey results were measured by category.

Results and discussion

Demographic data

Although 65 questionnaires were distributed, only 40 participants submitted completed questionnaires, representing a response rate of 61.54 %. Figure 1 shows the percentage of respondents by gender, of which 52 % of participants are female and 48 % are male.

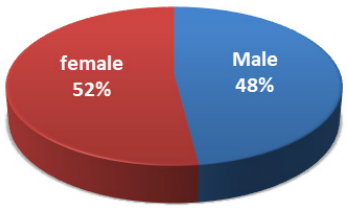

Figure 1. Percentage of respondents by gender

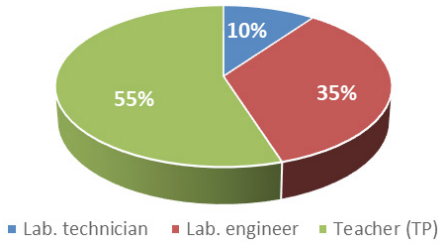

Figure 2. Participant task/role

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Among the respondents (Figure 2): 55 % are teachers (almost all provide practical work), 35 % are laboratory engineers and 10 % technicians. We see in Figure 3 that the age group of 36-45 years is predominant because it represents 58 % of the respondents in the study. This figure is also reflected in the number of years of experience, the groups: less than 5 years and more than 21 years of experience representing 13 % of the study sample and the lowest group was that of 16-20 years of experience representing 5 % of the study sample, while the 5-10 years group represents 38 % followed by the 11-15 years of experience group representing 33 % of the study sample, as shown in Figure 4.

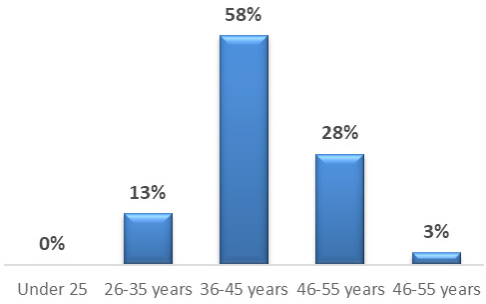

Figure 3. Distribution by age group

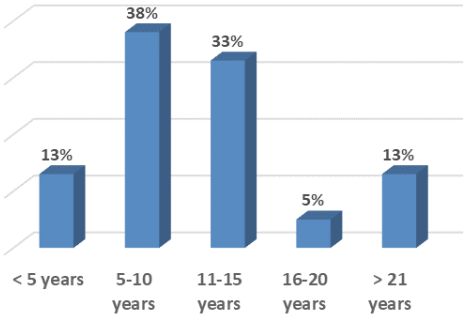

Figure 4. Distribution of years of experience

Meanwhile, the participants answered two questions. They were asked if they had suffered an injury of any type since working in the laboratory. 35 % of study respondents confirmed while 65 % said they had never had an injury, incident or accident at work (Figure 5). The majority (81 %) then declared that they consider the level of risk in the laboratory as "moderate" or "high" and 20 % think that it is "low" (Figure 6).

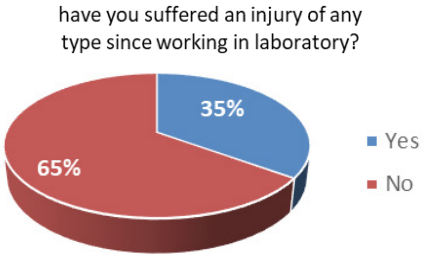

Figure 5. Response rate

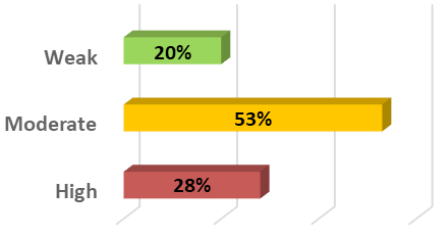

Figure 6. Level of self-risk perceived by respondents

Level of application of general safety measures

For the first area of the study, participants were asked about the level of application of general safety measures in the laboratory. Table 3 shows the means, standard deviations and percentages of respondents' responses to the relevant statements in the first section. From the results, it is clear that the level of application of safety measures is highly unfavorable with an average of 3.72 and an average percentage of 74.35 %. The statements which refer to Q6 and Q12 (there is an alarm system in each laboratory), (The first aid cabinet is equipped with a first aid kit within each laboratory) are ranked first with arithmetic means 4.33 and 4.25 corresponding to standard deviations of 1.07 and 1.13. The statement Q14 which states that "There is a person responsible for risk management within the faculty/university" had a mean of 4.13 and a standard deviation of 1.07 was ranked third, 82.50 % of the respondents did not agree on the existence of a risk manager in the laboratory. On the other hand, "Fire extinguishers are available for each laboratory and periodically examined" obtained the lowest rank with a mean of 2.55 and standard deviation of 1.20. Only 51.00 % of respondents agreed. The rest of the survey results from this area indicate that most respondents disagreed about safety measures in their laboratories. Figure 7 summarizes and clearly shows the classification of statements relating to the level of application of general safety measures.

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Table 3. Assessment of the level of application of general safety measures

N°	Statements	Average	Stand. Deviation	%	Sample orientation	Rank
Q1	The physical conditions (noise level, lighting, ventilation, temperature) in the laboratories are adequate.	4.05	0.90	81.00	Disagree	4
Q2	The laboratory is designed so that there is no risk of slipping, tripping or falling.	3.43	1.08	68.50	Disagree	11
Q3	All aisles and exits are free of obstructions.	3.25	1.19	65.00	Neutral	13
Q4	Emergency exits are available and in sufficient number.	3.78	1.21	75.50	Disagree	8
Q5	Laboratory space proportional to the number of students.	3.35	1.10	67.00	Neutral	12
Q6	There is an alarm system in each laboratory.	4.33	1.07	86.50	Strongly disagree	1
Q7	Storage areas for chemicals, flammable liquids and gases are properly segregated and kept away from laboratory staff desks.	3.53	0.99	70.50	Disagree	10
Q8	Personal protective equipment available and adapted to the dangers involved, and is located in a well-known location.	3.98	0.95	79.50	Disagree	6
Q9	Hazard warning signs are located in unobstructed locations to indicate any hazards that may be present.	4.00	0.99	80.00	Disagree	5
Q10	Fire extinguishers are available for each laboratory and periodically examined.	2.55	1.20	51.00	Agree	14
Q11	All electrical equipment is periodically tested and labeled with the test date.	3.83	1.11	76.50	Disagree	7
Q12	The first aid cabinet is equipped with a first aid kit in each laboratory.	4.25	1.13	85.00	Strongly disagree	2
Q13	Waste streams are separated as necessary (solid vs. liquid, hazardous vs. non-hazardous, etc.) and are not accumulated for more than 60 days in the laboratory.	3.63	1.15	72.50	Disagree	9
Q14	There is a risk management manager within the faculty/university.	4.13	1.07	82.50	Disagree	3
	Weighted average	**3.72**				
	Average percentage			**74.35**		

In fact, the safety management of Algerian university laboratories has never been evaluated. This study, conducted on the FSTUC1 campus, identified unreasonable laboratory layout and low safety awareness. This is clear from the results that the level of application of general standard safety measures is highly unfavorable. This can be explained by the lack of investment in sufficient and complete safety facilities and equipment; revealing that the laboratories do not have alarm systems or first aid means. Unfortunately, the campus does not have a person responsible for managing laboratory safety. Although many departments and disciplines are involved, laboratory management is carried out collaboratively by the Dean's Office, department heads and the General Resources Office; which leads to dispersed management. The results are in agreement with previous studies (Langerman, 2009; Jianfeng et al., 2022; Mingqi et al., 2022): Most university laboratories were not safe places to work or study, revealing many weaknesses in laboratory safety management. Some studies agree that the lack of training programs, low safety awareness and insufficient safety knowledge among laboratory staff were among the critical factors affecting laboratory safety management (Kong and Yang, 2021; Chao et al., 2023).

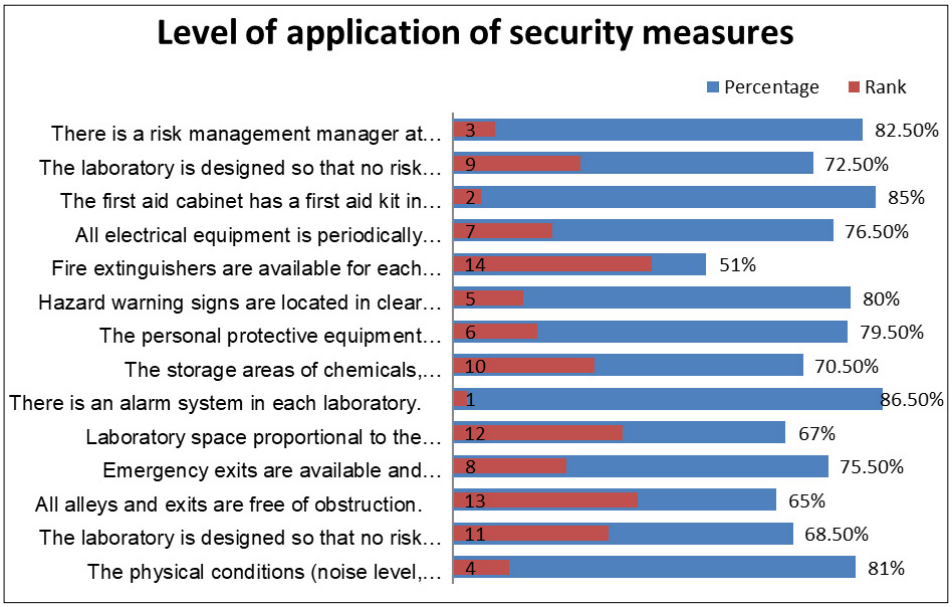

Figure 7. Classification of section A results

Table 4. Opinions of respondents in section B of the survey questionnaire

Statements			N	%
Q15	Appropriate safety measures have been taken in my laboratory to protect against injury.	□ Agree	3	7.50
		□ Disagree	30	75.00
		□ Do not know	7	17.50
Q16	I have received safety training on the specific agent/hazards I work with.	□ Agree	8	20.00
		□ Disagree	29	72.50
		□ Neutral	3	7.50
Q17	Do you know the location and use of safety equipment?	□ Yes	13	32.50
		□ No	27	67.50
Q18	How often are safety inspections carried out in your laboratory?	□ At least a month	0	0
		□ At least a quarter	0	0
		□ At least once a year	15	37.50
		□ Do not know	25	62.50

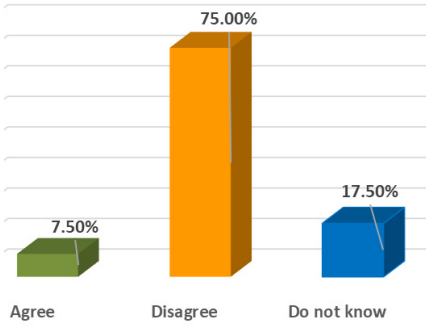

Figure 8. Appropriate safety measures taken in the laboratory

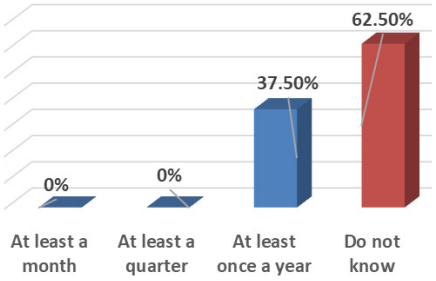

Figure 9. Frequency of safety inspections

Therefore, the authors believe that relevant authorities should pay attention to academic laboratories through the establishment of a regulatory framework for safety management in the future. In addition to formulating a safety management system, university management must also provide technical support and regulations which should include a laboratory safety management accountability system. This will help clarify who is responsible for managing safety at all levels.

Work safety practices applied in laboratories

Tables 4 and 5 show the response percentage for the reach questions 2 and 3. According to the data collected (Q15), 75.00 % of respondents stated that the administration had not taken measures to avoid or minimize accidents in the laboratory. While 62.50 % of respondents (Q18) did not know how often safety inspections are carried out in their laboratories, while 37.50 % indicated that these inspections take place at least once a year. According to question 16, 72.50 % of participants did not receive safety training and 67.50 % did not know the location and use of emergency procedures (Q17).

The fact of stating that the administration had not taken measures to avoid or minimize accidents in the laboratory is questionable and alarming (Figure 8). The lack of education and commitment to safety culture in laboratories is evident when a significant number of participants were unfamiliar with the location and use of safety equipment, and reported that they did not have sufficient training on their laboratory work environment, indicating a significant gap. Additionally, the survey demonstrated that a considerable number of participants did not know how often safety inspections are carried out in their laboratory (Figure 9). These practices reveal that laboratories not only have safety compliance issues, but there is also a lack of a healthy safety culture. Safety culture is made up of beliefs and actions, as well as a leadership responsibility to prioritize safety over goal achievement (Cadwallader and Pawelko, 2019; Mingqi et al., 2022).

It is suggested to promote the improvement and adoption of positive and prudential safety practices. Therefore, it is highly recommended to include safety training to strengthen safety culture through recent technological developments (Schröder et al., 2016; Fan, 2022). Furthermore, laboratory safety rules should be put into practice from time to time and staff should be responsible for accident prevention (Nurul et al., 2017).

Table 5. Opinions of respondents in section C of the survey questionnaire

Statements				**N**	**%**
Q19	How important is safety to you in your laboratory?	□	Very important	21	52.50
		□	Quite important	16	40.00
		□	Moderately important	3	7.50
		□	Not important	0	0
Q20	Impact of inspections on laboratory safety.	□	Safety is greatly improved by inspections	33	82.50
		□	Inspections do not have a significant impact on safety	7	17.50
		□	Safety is slightly compromised by inspections	0	0
		□	Do not know	0	0
Q21	Safety procedures in the laboratory are.	□	Strict	2	5.00
		□	About right	7	17.50
		□	Should be stricter	31	77.50
		□	Do not know	0	0
Q22	Overall safety in my laboratory could be improved in future years.	□	Agree	37	92.50
		□	Disagree	1	2.50
		□	Neither agree nor disagree	2	5.00

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Attitudes and perceptions towards laboratory safety

According to the collected data (Q19), the majority of respondents thought that safety is very important for their laboratory work while 7.50 % considered it to be 'Moderately important'. According to Q20, 82.50 % of respondents supported the fact that 'inspections can have an impact on laboratory safety, while 17.50 % thought that safety is slightly improved by inspections. Only 5 % of participants thought that 'Safety procedures in the laboratory are strict (Q21), while 77.5 % of them say that they should be stricter. According to (Q22), the majority of respondents 92.50 % stated that the overall safety in their laboratory could be improved in future years.

Although it is unfortunate that there are no proper safety practices, it is good to observe that participants believe that safety is very important to their laboratory work (Figure 10) and the majority support the fact that inspections can have a positive impact on safety Q20. This reflects a satisfactory attitude towards safety. The study also found that there are gaps to be filled, participants may be less satisfied with existing safety procedures as a considerable number believed safety should be strict or stricter (Figure 11). Interestingly, the majority of participants said their safety culture could be improved in the future. This perception demonstrates a good will for a change of attitude. The results regarding practices, attitudes and perceptions of laboratory safety are consistent with those of other studies which have shown that understanding safety practices and rules when performing certain laboratory activities is very important. (Jianfeng et al., 2022; Nurul et al., 2017).

The commitment of the university administration to apply risk management policies

For the fourth section, Table 6 presents the data relating to the administration's commitment to apply risk management policies with a total section average of 3.74 and an average percentage of 74.85 %, which indicates that the respondents did not agree on aspects of management policy. Statement Q27, which states that "laboratory workers are subject to an annual health assessment to examine their exposure to laboratory hazards", ranks first with a mean of 3.98 and standard deviation of 1.00. On the other hand, 77.5 % of respondents did not agree at all on the existence of a service specialized in assessing the risks of the work environment within the campus (Q26) with an average of 3.88 and a standard deviation of 0.88. Statement Q23 "The university administration inspects educational laboratory facilities in order to ensure the application of occupational safety and health rules", occupies the last rank with 71.50 % of respondents who neither agreed nor disagreed. The calculated mean and standard deviation are 3.58 and 1.22 respectively.

Overall, the results in Table 6 demonstrate that the university administration's commitment to implementing risk management policies is highly unfavorable and the current management of laboratory safety has obvious shortcomings. This can be attributed to a lack of clear vision regarding risk assessment and management, and the absence of plans and programs for risk management in academic laboratories. It is clear that the lack of interest in

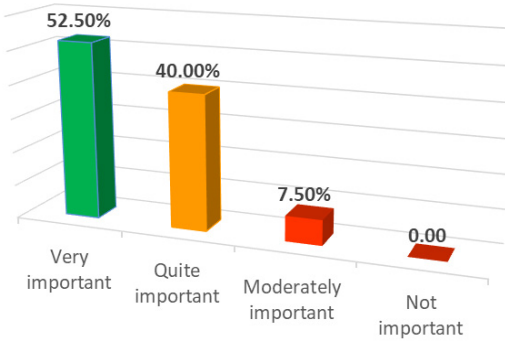

Figure 10. Importance given to safety

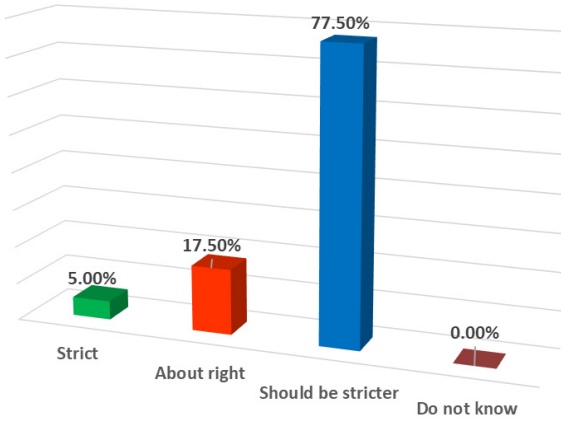

Figure 11. Aspect of safety procedures

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the creation of a professional service specialized in the management of safety risks on campus is a fundamental factor contributing to the emergence of unsafe behaviors and practices, a lack of compliance in safety and poor safety culture.

These results suggest that the role of administration in safety and health management and risk assessment in laboratories is essential. The key to an effective safety management system is the presence of a strong safety culture and a strong safety culture cannot exist without management's commitment to safety (Tomasz et al., 2016). The greater the administration's commitment to safety, the more laboratory safety management is taken into account to ensure a safe campus environment for all academic activities, including laboratory activities. Furthermore, regular and appropriate education and training regarding compliance with safety practices and processes is essential and highly recommended for all laboratory users to increase awareness of risks and will lead to significant improvement of safety culture. Based with previous studies, it has been found that the involvement of university management helps to strengthen the safety culture of an organization (Reniers et al., 2014). Some universities have even made safety training mandatory to maximize training effectiveness (Nurul et al., 2017; Olewski et al., 2016a; Meyer, 2017; Jing and Wu, 2019).

Summary of the results

Overall, these results provide further evidence that the lack of safety compliance and safety culture in academic laboratories is a global phenomenon that deserves urgent attention (Ayi and Hon, 2018). There is no doubt that to improve the safety situation of academic laboratories, the university must pay attention to and invest enough in a scientific management system. The recommendations proposed in this study include and are not limited to the following: an integrated laboratory safety management system within the university be imposed with the strong commitment of university management. This requires legislation, supervision and support from government institutions such as the Ministry of Higher Education. The creation of a risk management and safety department where responsibility is assigned to safety management personnel at all levels will play a key role in strengthening safety awareness. This department must be able to ensure the application of safety and health rules, carry out safety control and inspection of laboratory installations and equipment and must develop plans and programs for monitoring laboratory activities and continuously meet health and safety compliance requirements.

Table 6. Results for the last section of the questionnaire

N°	Statements	Average	Stand. Dev.	%	Sample Orientation	Rank
Q23	The university administration inspects educational laboratory facilities to ensure compliance with occupational safety and health rules.	3.58	1.22	71.50	Neutral	7
Q24	There are plans and programs on risk management and there is work to develop safety measures.	3.68	1.10	73.50	Disagree	5
Q25	There is a policy of the faculty/university administration to assess and manage the risks of the working environment in educational laboratories.	3.63	1.17	72.50	Disagree	6
Q26	There is a section specialized in work environment risk assessment within the Faculty/University.	3.88	0.88	77.50	Not agree at all	2
Q27	An annual health assessment of laboratory workers is conducted to examine their exposure to laboratory hazards.	3.98	1.00	79.50	Not agree at all	1
Q28	Technical and financial possibilities are provided for the application of risk assessment and management.	3.78	1.10	75.50	Not agree at all	3
Q29	The university sets up practical training to train laboratory staff to deal with different risks.	3.70	1.32	74.00	Disagree	4
The weighted average		**3.74**				
Average percentage				**74.85**		

Conclusion

This research aims to explore the safety situation of the academic laboratories of the FSTUC1. In fact, there is no safety department dedicated to laboratory safety on the faculty campus and university. We believe this is the first study conducted on academic university laboratory safety in the country. The results revealed an unfavorable state in different aspects of safety. The biggest reason for this is a lack of safety investment and awareness. The study also revealed that the majority of participants have a good will for change, which refers to suggesting an active strengthening of safety awareness to improve safety culture, implementing a laboratory safety evaluation system and the establishment of a professional team to fully implement the laboratory safety responsibility system. Finally, we suggest that future studies be extended to other university laboratories in different faculties. This will enable the promotion of risk management and laboratory safety at the level of university institutions.

References

Algaralleh, A. 2014. Risk evaluation and management in Laboratories of universities: A survey study of Jordanian universities. A Thesis of Master. Mutah University. Jordan.

AlShammari, W., Alhussain, H., Rizk, N.M. 2021. Risk Management Assessments and Recommendations Among Students, Staffs, and Health Care Workers in Educational Biomedical Laboratories. Risk Management and Healthcare Policy, 14: 185-198. DOI: https://doi.org/10.2147/RMHP.S278162

Ankur, J., Saket, K., Satish, C., Dinesh, K.P. 2015. Likert Scale: Explored and Explained. British Journal of Applied Science & Technology, 7(4): 396-403. DOI: 10.9734/BJAST/2015/14975.

Ashen, I.S., Sajani, N., Udaya, K.J. 2022. Analyzing Safety culture in Sri Lankan Industrial Chemical Laboratories. OSHRI. Safety and Health at Work, 13: 86-92. DOI: 10.1016/j.shaw.2021.11.001.

Ayi, H.R., Hon, C.Y. 2018. Safety culture and safety compliance in academic laboratories: a Canadian perspective. J. Chem. Health Saf., 25: 6-12. DOI: 10.1016/j.jchas.2018.05.002.

Cadwallader, L.C., Pawelko, R.J. 2019. Elements of experiment safety in the laboratory. Journal of Chemical Health and Safety, 26 (4-5): 20-25. DOI: https://doi.org/10.1016/j.jchas.2019.01.002

CBS. 2011. Texas Tech University Laboratory Explosion. Washington, DC: Office of Congressional, Public, and Board Affairs.

Chao, X., Lin, G., Kai, W., Tong, Y., Yufeng, F., Haiyan, W., Dan, L., Gui, F. 2023. Current challenges of university laboratory: Characteristics of human factors and safety management system deficiencies based on accident statistics. Journal of Safety Research, 86: 318-335. DOI: 10.1016/j.jsr.2023.07.010.

Fan, W. 2022. Research on Intelligent Management of Laboratory Information Technology. Procedia Computer Science, 208: 184-189. DOI: https://doi.org/10.1016/j.procs.2022.10.027

Hill, R.H.Jr. 2007. The emergence of laboratory safety. J. Chem. Health Saf., 14(3): 14-19. DOI: https://doi.org/10.1016/j.jchas.2006.10.001

Jianfeng, Y., Shenging, X., Yuanhao, H., Xinyong, L., Mingcheng, B., Liangchao, C., Siyun, L., Pengchao, W., Ru, L., Jianwen, Z., Chi-Min, S., Zhan, D. 2022. The framework of safety management on university laboratory. Journal of Loss Prevention in the process Industries, 80. DOI: 10.1016/j.jlp.2022.104871.

Jing, Y.J., Wu, Y. 2019. Investigation and practice on current situation of university students' awareness of laboratory safety. Exp. Technol. Manag., 5: 251-254, 267.

Karapantsios, T.D., Boutskou, E.I., Touliopoulou, E., Mavros, P. 2008. Evaluation of chemical laboratory safety based on student comprehension of chemicals labelling. Education for Chemical Engineers, 3(1): 66-73. DOI: 10.1016/j.ece.2008.02.001.

Kong, S., Yang P. 2021. Analysis of Characteristics of Safety Accidents in University Laboratory and Research on the causes of accidents. E3S Web of Conferences, 257. DOI: https://doi.org/10.1016/j.jlp.2022.104871

L'université de tous les dangers [on-line]. Lexpressiondz.com, 2012 [cit. 2012-04-26]. Available at: https://www.lexpressiondz.com/index.php/nationale/luniversite-de-tous-les-dangers-152672

Laboratory Fatalities [on-line]. Labsafety.org, 2023 [cit. 2023-03-22]. Available at: https://www.labsafety.org/memorial-wall

Langerman, N. 2009. Laboratory safety? Journal of chemical Health and safety, 16(3): 49-50. DOI: 10.1016/j.jchas.2009.03.004.

Using Likert Scales in Evaluation Survey work [online]. Stacks.cdc.gov, 2012 [cit. 2012-06-20]. Available at: https://stacks.cdc.gov/view/cdc/136903

Marendaz, J.L., Suard, J.C., Meyer, T. 2020. A systematic tool for Assessment and Classification of Hazards in Laboratories (ACHiL). Safety Science, 53: 168-176. DOI: https://doi.org/10.1016/j.ssci.2012.10.001

Menard, A.D., Trant, J.F. 2020. A review and critique of academic lab safety research. Nature Chemistry, 12: 17-25. DOI: 10.1038/s41557-019-0375-x.

Meyer, T. 2017. Towards the implementation of a safety education program in a teaching and research institution. Educ. Chem. Eng., 18: 2-10. DOI: https://doi.org/10.1016/j.ece.2015.06.003

Mingqi, B., Yi, L., Meng, Q., Nitin, R., Chi-Min, S., Faisal, K., Dongfeng, Z. 2022. Current status, challenges, and future directions of university laboratory safety in China. Journal of Loss Prevention in the Process Industries, 74. DOI: 10.1016/j.jlp.2021.104671.

Nurul, H.C.H., Ahmad, R.I., Nor, K.M., Muhammad, A.S., Noor, S.S., Noor, A.H. 2017. Safety and health practice among laboratory staff in Malaysian education sector. IOP Conference Series: Materials Science and Engineering, 257. DOI: 10.1088/1757-899X/257/1/012004.

Olewski, T., Ahammad, M., Quraishy, S., Gan, N., Vechot, L. 2016a. Building process safety culture at Texas A&M University at Qatar: a case study on experimental research. J. Loss Prev. Process. Ind., 44: 642-652. DOI: 10.1016/j.jlp.2016.08.022.

Reniers, G.L.L., Ponnet, K., Kempeneers, A. 2020. Higher education chemical lab safety interventions: Efficacious or ineffective? Journal of Chemical Health and Safety, 21(1): 4-8. DOI: 10.1016/j.jchas.2013.09.001.

Roukatou, A., Dretti, D. 2022. Analysis of the Determinants of the Effectiveness of the Board of Directors in Family Businesses in Cameroon. Open Journal of Business and Management, 10: 1160-1166. DOI: 10.4236/ojbm.2022.105134.

Schröder, I., Huang, D.Y.Q., Ellis, O., Gibson, J.H., Wayne, N.L. 2016. Laboratory safety attitudes and practices: a comparison of academic, government, and industry researchers. Journal of Chemical Health and Safety 23(1): 12-23. DOI: 10.1016/j.jchas.2015.03.001.

Olewski, T., Snakard, M., Vechot, L. 2016b. Challenges in applying Process Safety Management at a University Laboratories. In Mary Kay O'Connor Process Safety Center; Texas &M University. Libraries. 19th annual International Symposium, October 25-27, 2016. College Station, Texas.

Yang, Y., Reniers, G., Chen, G., Goerlandt, F. 2019. A Bibliometric review of laboratory safety in universities. Safety Science, 120: 14-24. DOI: 10.1016/j.ssci.2019.06.022.

Yi, Z., Peng, M., Hongyang, L., Yuxin, X., Dan, Y., Hui, L., Wei, H., Jingfeng, Y. 2020. Assessing the Safety Risks of Civil Engineering Laboratories Based on Lab Criticity Index: A Case Study in Jiangsu Province. Int. J. Environ. Res. Public Health, 17(17): 6244. DOI: https://doi.org/10.3390/ijerph17176244

Yoon, D. 2021. Operational Process for R&D Laboratory Safety. Sage Journals, SAGE Open, 11(1). DOI: 10.1177/2158244020988853.