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Original Article

Biosafety knowledge and perception among medical laboratory students: a cross-sectional study at a medical university in Vietnam

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ABSTRACT

Introduction: Medical students have to deal with biohazards in laboratories during undergraduate studies and intensive practice in hospitals. Unsafe operators can result in an outbreak of biohazardous pathogens to healthcare workers, the community, and the environment. However, the most common risk factors for laboratory accidents are a lack of perception and knowledge of biosafety and laboratory safety management. This study aimed to assess knowledge and factors influencing the biosafety practices of medical students at Hanoi Public Health University, Vietnam

Methods: A cross-sectional study was conducted to assess the biosafety knowledge of all 286 students majoring in a medical laboratory at HUPH from December 2021 to February 2022. Ethical clearance was obtained from the Ethics Committee of Hanoi University of Public Health. The questionnaire has been created based on WHO biosafety guidelines with some modifications according to the local context. The data were collected by face-to-face interviews.

Results: Out of the 286 students invited to complete a biosafety questionnaire, 68.6% of students recognized the fundamental principles of biosafety. Additionally, 76.2% and 91% of students correctly identified risk factors and danger signs in the laboratory, respectively. Furthermore, 79.8% of students provided accurate answers to biosafety laboratory troubleshooting questions. Notably, academic performance, students' year of study, and average scores in biosafety courses had significantly related to the biosafety knowledge. Gender factors and academic performance were related to the rate of obtaining precise knowledge about incident handling and preventing risk factors in the laboratory.

Conclusion: The passed rate of biosafety knowledge among medical laboratory students at the University of Public Health was 68.6%. Factors such as the student's school year, academic performance, average score in the biosafety course number of internships in hospitals significantly affected their biosafety and troubleshooting knowledge in the laboratory.

Keywords: Biosafety, Biosafety education; Hanoi University of Public Health, Vietnam, Medical student

Introduction

Clinical laboratories are indispensable units in hospitals and medical universities. Laboratory scientists are integral parts of healthcare teams. They analyze biological specimens (cells, blood, bodily fluids, specimens…) to support doctors' decisions in diagnosis.[1] In the laboratory environment, risk factors such as pathogens infections, fire, explosion, or toxic chemicals are always exposed to medical staff.[2] Students in medical laboratory programs undertake various

practical sessions, including biochemistry, microbiology, hematology, histology, and parasitology. Therefore, students undertaking such specialties are in direct contact with various hazards, which increases the likelihood of exposure to chemicals or infectious agents, including blood-borne infections, if substantial safety measures are not accurately followed.[3] Biosafety is essential knowledge and skills that should be provided to medical students to learn and become familiar with the professional work.

A compilation of research on laboratory-related infections from 1930 to 2004 showed that there were 5,527 laboratory-associated infections, including 204 deaths.[1] The Belgium Institute of Technology and Biosafety reported 67-82 cases of related laboratory infection from 2007 to 2012.[1] Bio risk and biosafety are realities that cannot be ignored by medical students or medical laboratory workers.[4]

It is estimated that there are 2.5 accidents per week in academic laboratories. A surveillance study, conducted by the CDC, ranked laboratory incidents in educational institutions second among the industries studied, and a large number of injuries were those among students. Studies about safety practices in chemistry, biology, and medical laboratories, in academic institutions worldwide and in the Middle East, indicate a lack of knowledge, and a misunderstanding of safety concepts, emphasizing increasing safety awareness through lectures, training, and other activities.[3] To ensure that medical laboratory students are adequately trained about biological risks and laboratory risks they are likely to face, it is essential to include and emphasize biosafety training as part of the educational curriculum. According to the data collected from 82 medical students and 12 teachers at Oswaldo Cruz Foundation courses in Rio de Janeiro, biosafety in healthcare working environments is in discrepancy with school environment. The research pointed out the necessity of improvement in the teaching processes of biosafety in secondary courses in the health area.[3] Knowledge about biosafety increases according to academic evolution in graduation.[5]

The basic biosafety course is a mandatory subject for medical laboratory students at Hanoi University of Public Health (HUPH). The students must take this course in the first year before continuing their clinical laboratory core subjects such as microbiology, biochemistry, hematology, and clinical practice in hospitals. However, gaining insight into biosafety knowledge requires real-life experience in laboratory situations. This experience is not yet available to first-year medical students and will be added throughout their studies and hospital internship experience. Therefore, it is necessary to evaluate the basic knowledge, knowledge about handling biosafety situations, and factors related to the development of the biosafety capacity of medical students to improve training programs related to biosafety. This study aims to assess biosafety knowledge and analyze some related factors of students majoring in Medical Laboratory Technology at Hanoi University of Public Health, Vietnam.

Methods

A cross-sectional study was carried out from December 2021 to February 2022. The target group of this study included medical laboratory students in HUPH.

The sample size was calculated using the Cochrane formula for estimation of proportion, $n=z^2pq/ d^2$, using a past prevalence of passed biosafety knowledge among medical laboratory students of 68.6%, at a 95% confidence interval (CI) and a 1% margin of error.

The sample size was estimated at 181 students, which was optimized to a total population of 286 undergraduate students. All students who were studying in the medical laboratory program at HUPH were taken for research. Among them, 98 students were in the 1st year (34%), 88 students in the 2nd year (31%), 80 students in the 3rd year (28%), and 20 students in the 4th year (7%). Eight instructors who directly supervised students in hospital practice courses were interviewed to make the findings more comprehensive and objective about knowledge and factors influencing

biosafety.

The questionnaire was generated to survey the participants' information, knowledge, and skills regarding biosafety problems in medical laboratory students. Face-to-face interviews were conducted to collect data. Discussions and short interviews helped to collect information regarding factors influencing students' ability to handle biosafety situations in hospitals. The questionnaire consisted of three sections. Section 1 focused on general information, while sections 2 and 3 evaluated knowledge about biosafety according to Biosafety guidelines of WHO.[6] The survey of biosafety knowledge included recognizing hazards, restricted activities, and knowledge about biosafety troubleshooting in the laboratory. The scoring was done by giving 1 point for each correct answer and 0 points neither for wrong answers nor skipping the questions. Individuals with a knowledge score >=7/10 were considered to pass, while <7/10 were considered to fail.[5]

The data were entered into Epidata 3.1 and analyzed using STATA 15.0 software. Descriptive statistical tools such as frequency, percentage, median, and interquartile range were used to express the results. The Pearson chi-square test was used for bivariate analysis to determine the presence of an association between dependent and independent variables. All tests were performed with a significance level of 5% (p-value <0.05).

The study was ethically approved by the Ethics Committee, Hanoi University of Public Health under decision No 212/2021/YTCC-HD3. The study was conducted with the consent of the University of Public Health's leadership. Research participants were fully explained about the study, assured of confidential information, and could refuse to participate in the study without giving any reason.

Results

A total of 286 students took part in the study. Among them, there were 98 freshmen (34%), followed by sophomores, juniors, and senior students with 31%, 28%, and 7% respectively. Female students accounted for a majority of 223 (78%), while their male counterparts were 63 (22%). All the students have completed the biosafety course and have been involved in medical laboratory practices. Additionally, 3rd and 4th year- students have participated in internship courses in hospitals whereas 1st and 2nd year students have not undergone any internship.

General knowledge of biosafety was assessed based on students' recognition of basic concepts and laboratory risk factors. The assessment of biosafety knowledge is shown in Figure 1. The average rate of students recognizing basic concepts was 68.6%. Most students demonstrated awareness of concepts related to laboratory biosafety knowledge on infectious pathogens, accounting for 81.1% (Figure 1).

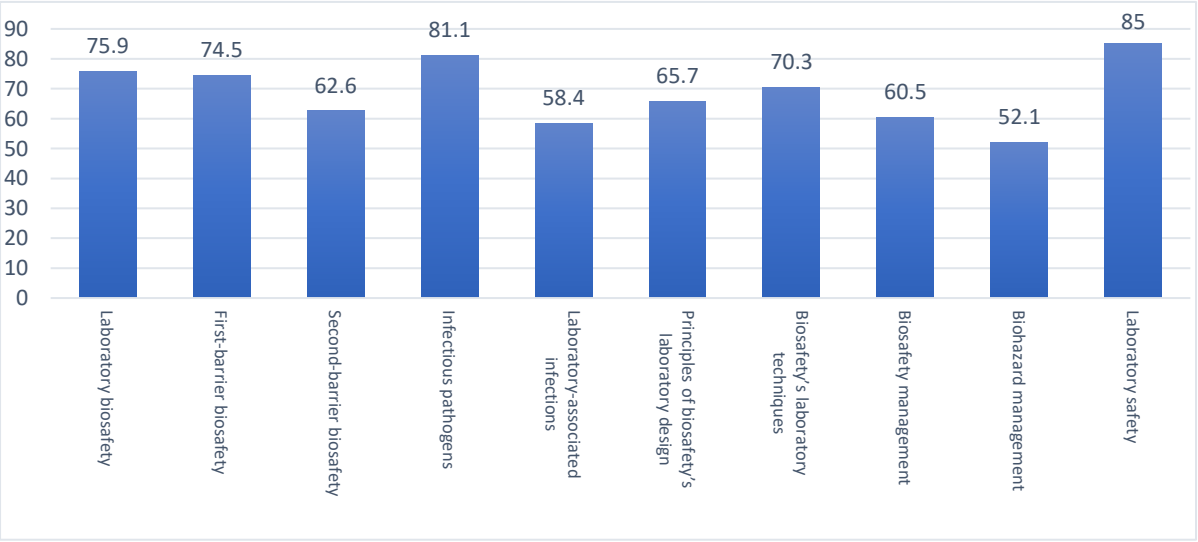

Figure 1: General biosafety knowledge prevalence of the respondents (%)

Risk factors are prevalent in laboratories, and recognizing these factors and assessing their level of danger are important skills for students to protect themselves while working in a laboratory. The assessment of students' identification of laboratory hazards is shown in Table 1. The two most commonly recognized risks were exposure to pathogenic microorganisms (95.1% answered correctly) and exposure to chemicals (91.6%).

Table 1. Students' perceptions of laboratory hazards (n=286)

Laboratory hazard	Correct answer students	Passing rate (%)
Exposure to pathogenic microorganisms	272	95.1
Exposure to chemicals	262	91.6
Exposure to hazards such as fire, electricity, etc	195	68.2
Injuries from dangerous objects	219	76.6

As risks in the laboratory always exist, laboratory workers need to follow safety principles and be able to recognize danger signs to protect themselves during work. Students' perception of common laboratory safety procedures was also evaluated through a questionnaire that assessed their awareness of restricted activities and identification of hazard signs. Appropriate knowledge about prohibited activities in the laboratory ranged from 83.2% to 99.7% (with an average of 94.5%). Nearly all students recognized that playing/eating is prohibited in the laboratory (99.7%). Students' accurate awareness of other prohibited activities in the laboratory was also high (> 90%). The survey findings are presented in Table 2.

Table 2. Student's perceptions about restricted activities and hazard signs (n=286).

Student's perceptions about biosafety practice	Correct answer students	Rate of correct answer (%)
Restricted activities in the laboratory		
Sucking pipette by mouth	278	98.2
Using saliva to attach the tube's barcode	280	97.9
Touching mouth, eyes, phone screening… after exposing to samples	282	98.6
Directly discharge the contaminated solution into the public sewer system	281	98.3
Wearing personal protective clothing out of the laboratory	295	90.6
Wearing lab slippers outside the laboratory	262	91.6
Using shoes, open-toed sandals, and heels in the laboratory	281	98.3
Hanging protective clothing with casual clothes	282	98.6
Reusing medical masks	250	87.4
Playing/eating at the lab	285	99.7
Holding specimen samples without gloves	267	93.4
Storing gloves and masks in a pocket to reuse	273	95.5
Using a pair of gloves for multiple patients	238	83.2
After contact with a patient, still wearing gloves and touching surrounding surfaces	264	92.3
Signs recognition		
Biohazards sign	259	91.2
Radioactive substances sign	241	85.4
Flammable substances sign	277	98.2
Cytotoxicity sign	251	89.1

Incidents in the laboratory pose potential dangers that every student and medical personnel working in laboratory environments must be prepared to face. Being fully equipped with troubleshooting knowledge helps students or laboratory workers confidently and calmly handle incidents, ensuring safety for themselves, equipment, facilities, laboratory materials, and the overall environment. The results of assessing students' knowledge of troubleshooting in biosafety laboratories for common situations are presented in Figure 2. Notably, the majority of students (87.8%-89.2%) had knowledge about cleaning spilled pathogenic solutions in safety cabinets, handling centrifuge incidents, and informing colleagues when being stabbed by a needle. However, for more complicated incidents such as spilling pathogenic solutions outside the safety cabinet; flammable chemical spill incidents, and self-troubleshoot of being stabbed by a needle, only 52.8% - 69.6% of students knew to properly handle.

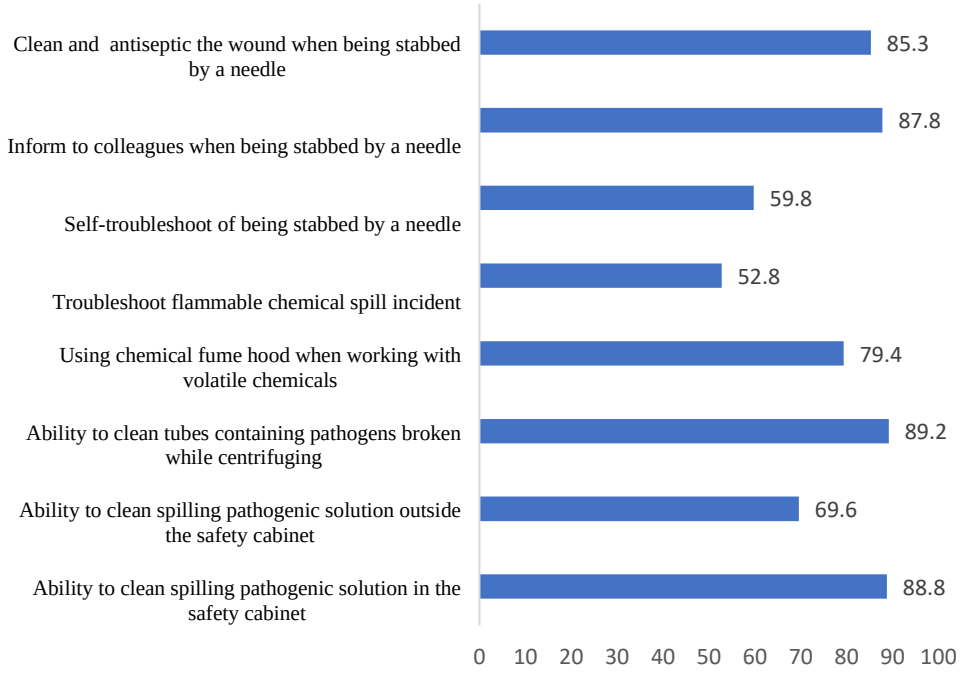

Figure 2: Biosafety troubleshooting knowledge level of the respondents (%)

The percentages of students with basic biosafety knowledge in the 1styear, 2ndyear, 3rdyear, and 4thyear were 70.4%, 58%, 70%, and 90%, respectively ($p<0.05$). In which, students with good and very good academic performance were 71.8% and 88.9%, which was significantly higher than those with average and poor academic performance (50.7%). Gender factors, previous biosafety incidents, and participation in an internship program at the hospital also influenced students' general awareness of biosafety. (Table 3).

Regarding troubleshooting knowledge in the laboratory, gender and academic ability were factors related to the rate of gaining such knowledge. Accordingly, female students demonstrated a higher level of knowledge (82.1%) compared to their male counterparts (69.8%), $p<0.05$. Additionally, 82.1% and 88.9% of students with good and distinction academic performance, respectively, demonstrated proficiency in troubleshooting knowledge, whereas the average group accounted for 67.8%,$p<0.05$. (Table 4).

Table 3. Factors influencing knowledge of biosafety

Student's characteristic		**Basic knowledge of biosafety**	
		Pass (%)	**p-value**
Gender	Male	58.7	p >0.05
	Female	70.4	

Year of Study	1st	70.4	**p <0.05**
	2nd	58.0	
	3rd	70.0	
	4th	90.0	
Academic performance	Below good	50.7	**p <0.05**
	Good	71.6	
	Very good	88.9	
Used to get biosafety trouble	Yes	76.4	p >0.05
	No	65.8	
Average biosafety score	Above 7	65.1	**p <0.001**
	Below 7	32.4	
Number of internship courses at the hospital	1	0.0	**p <0.005**
	2	33.3	
	3	72.5	
	4	60.0	
	5	87.5	

Table 4. Factors influencing knowledge of troubleshooting in the laboratory

Student's characteristic		**Knowledge about troubleshooting in the laboratory**	
		Passed (%)	**P**
Gender	Male	69.8	**p <0.05**
	Female	82.1	
Year of Study	1st	77.6	p >0.05
	2nd	80.7	
	3rd	75.0	
	4th	100.0	
Academic performance	Below good	68.7	**p <0.05**
	Good	82.1	
	Distinction or above	88.9	
Used to get biosafety trouble	Yes	85.5	p >0.05
	No	77.9	
Average biosafety score	Above 7	79.4	p >0.05
	Below 7	73.5	
Number of internship courses at the hospital	1	0.0	p >0.05
	2	66.7	
	3	76.3	
	4	100.0	
	5	100.0	

Discussion

Research results show that the general knowledge of biosafety and identification of risk factors among medical laboratory students has a passing rate of 68.6%. This rate is higher than the findings of Nguyen Dinh Minh Man's survey of medical students at Hue University of Medicine and Pharmacy in 2019, which scored 24.1% [5], and the research conducted by Nazia Chaudry and Sania Arif on undergraduate and postgraduate medical students in Pakistan, which scored 59.5%.[7] The difference may be attributed to the fact that the research subjects in this study specifically focused on medical laboratory students who were being trained to work in medical laboratories in the future. According to research conducted by Withanage N.D. on 229 students at universities in Sri Lanka in 2016, there was a statistically significant difference related to laboratory safety knowledge between study programs, but no significant difference was observed among students in the same study program.[8] The aforementioned differences can be attributed to variations in the educational environment and

educational background across different countries.

The ability to recognize danger signs is an important knowledge in biosafety. In this study, we recorded the ability of students to recognize hazard signs as 98.2%, 89.1%, and 85.3%. These percentages are higher than those reported in Nguyen Dinh Minh Man's survey at Hue University of Medicine and Pharmacy on identifying signs of flammable, cytotoxic, and radioactive substances, which recorded pass rates of 81.8%, 60.6%, and 47.7% respectively.[5] This could be the difference between the group of medical laboratory students that we surveyed and other groups of medical students such as nurses, doctors, and orthodontists in their study at Hue University of Medicine and Pharmacy. These (HUPH) students have to gain biosafety courses in 1st year. The corresponding differences in biosafety perceptions between groups of healthcare workers have also been noted in many studies.[4]

Medical laboratory students will become clinical technicians at healthcare facilities. According to research conducted in 2011, the general biosafety knowledge of healthcare workers in Vietnam was 60%[9], which was lower than in Nigeria (73.15 %).[4] This phenomenon can be explained by the fact that biosafety course was introduced relatively late in medical schools. Many barriers to biosafety and biosecurity training in health-related organizations in Africa, the Middle East, and Central Asia have been reported, including inadequate dissemination of guidelines, lack of financial resources, insufficient personnel, lack of equipped laboratories, and lack of instructional material.[10]

In 2021, our study showed a slight improvement in the biosafety knowledge of medical students at HUPH, reaching 68.6%. Most of the prohibited activities were correctly recognized (>90%). However, there were still some improper activities such as reusing medical masks (87.4%) and using a pair of gloves for multiple patients (83.2%). Records from some instructors have shown that when knowledge is incorrect will likely lead to wrong practices: "Many errors occur such as reused gloves, reused masks, wear gloves to touch phone screening after contacting the samples or patients". This may be due to students' limited awareness of risk factors. Consequently, these improper habits can pose potential risks, which are eventually difficult to deter from. Such actions can escalate the risk of laboratory-acquired infections(LAIs) in medical laboratories[11]. This may be the result of students' poor awareness of biohazard management and laboratory-associated infections (52.1%, 58.4%). Over the years, lab safety education has been diminishing as many instructors are not properly trained in its implementation. This can result in students who are not well-educated in safety, nor understand the importance of safety guidelines existence, potentially placing them in dangerous situations.[12] The risks of exposure to biosafety incidents are mostly related to patient specimens from collection to completion of testing in the laboratory, also referred as "the specimen management chain".[13]

The influence of gender, year of study; academic performance, previous experience with biosafety incidents, average biosafety score, and the number of internship courses at hospitals on basic biosafety knowledge and troubleshooting skills were assessed. Factors such as year of study, average biosafety score, and the number of internship courses at hospitals were found to be correlated with the level of basic biosafety knowledge. A similar trend was also observed in medical students at the Hue Medicine and Pharmacy University, Vietnam in 2019 and UPSJB dentistry students in 2023.[5,14] However, in our study, the pass rate of the HUPH students was higher compared to that of Hue Medicine and Pharmacy. The results of our study differ from those of other authors, such as the study by Nazia Chaudry and Sania Arif in 2013 on undergraduate and graduate students, where no significant difference was found between the results of our study and those of undergraduate and graduate students.[7]

There is a statistically significant difference between student performance and biosafety

knowledge. Students with good and very good academic performance were 71.8% and 88.9%, respectively, which were much higher than students with average and poor academic performance. Students who achieved an average score in a biosafety course >7 had better general knowledge about biosafety than students with an average course score of <7. Similarly, Nguyen Dinh Minh Man's results conducted in 2019 have shown that the percentage of students with lower academic achievement was 8.8% and the percentage of students with good or higher was 29.2%. From the above results, it can be seen that students with good academic performance seem to have more interest, investment, and attention in learning, thereby improving grades and cognitive abilities. Statistically significant differences were not found when examining the relationship between gender, previous biosafety incidents, and biosafety knowledge.

The majority of students knew about handling troubleshooting, with an average rate of 76.6%. About 87.8%-89.2% of students exhibit knowledge about handling simple accidents in laboratories, such as cleaning spilled pathogenic solutions in a safety cabinet or centrifuge, and informing colleagues when being stabbed by a needle. However, only 52.8% - 69.6% of students knew how to handle more complicated incidents, such as clean spilled pathogenic solutions outside the safety cabinet, or a flammable chemical spill incident. This indicates that the students might not be adequately prepared to deal with high-risk situations. The gender factor is related to the rate of gaining knowledge about troubleshooting in the laboratory, with female students (82.1%) outperforming male students (69.8%). Medical laboratory students' knowledge of troubleshooting is also affected by academic performance: students who have good and very good academic performance demonstrate higher percentages of knowledge regarding troubleshooting (82.1% and 88.9%), compared to the average group with 68.7%.

Even though the study revealed significant findings, it is not free from limitations. The study's limitations include a small sample size of participants. The questionnaire only focused on knowledge of general biosafety, laboratory-restricted activities, hazard signs, and biosafety troubleshooting. Finally, the current study only assessed knowledge gain and not the impact of the education module on students' actual practices. Evaluating the effectiveness of the training would require a follow-up study so that medical schools can come up with appropriate interventions.

In medical education universities, laboratory biosafety should be designed as a compulsory course. The institutions should survey the factors in promoting the perception and practice of biohazardous handling to minimize the risk of personal, community, and environmental exposure. Practical training, continuous education, and intensive laboratory practice during undergraduate studies play a significant role in developing a biosafety culture, biosafety knowledge, and practice among students. Therefore, students should be trained throughout their academic careers, given their potential future roles as laboratory workers and researchers. These considerations should be critically considered by medical education institutions.

Conclusions

This study has initially assessed the current status of biosafety knowledge in the laboratory among Medical laboratory students at the University of Public Health. Out of 286 participants who took part in the study, 68.6% of them provided correct answers to the questionnaire. This pass rate is notably higher compared to other medical students in Vietnam.

Several factors have been identified as influencing basic biosafety knowledge, including the student's school year; Academic performance; Average score of biosafety; and the number of internship courses completed in hospitals. Additionally, gender and academic performance are also linked to the rate of gaining knowledge about troubleshooting in the laboratory.

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