



Effectiveness of a Laboratory Safety Training Program Among Female Students in Medical and Health Colleges: A Pre-Test and Post-Test Study in Saudi Arabia.

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Abstract:

Background: A vital part of medical and health education is laboratory safety, particularly in situations involving potentially dangerous materials and equipment. In this study, female undergraduate students at Saudi Arabian medical and health colleges were asked to rate the efficacy of a laboratory safety training program.

Objective: To determine the effectiveness of a structured laboratory safety training program in improving the knowledge and self-assessed safety practices among female students in medical and health colleges in Saudi Arabia.

Methods: Early in 2024 a Single group pre-and post-test study design was adopted; the participants of the experimental group are not selected with randomization. Participating were 161 female students in their first through fourth years of medical and health colleges. To evaluate knowledge, attitudes, and self-assessed practices related to laboratory safety, a validated questionnaire comprising 25 items was employed. Using lectures, practical exercises, and demonstrations, the training curriculum was presented. Paired t-tests and chi-square tests were used in the statistical analysis to compare the outcomes before and after the intervention.

The results: The overall safety knowledge of the participants improved statistically significantly after the intervention ($p < 0.001$). Understanding chemical danger symbols, emergency response procedures, and proper use of personal protective equipment (PPE) were important areas for improvement. Additionally, self-reported preparedness to deal with crises rose dramatically.

Conclusion: The significance of formal safety education in health-related curriculum was highlighted by the laboratory safety training program, which successfully improved students' knowledge and readiness. To uphold and enhance safety standards, it is advised to implement ongoing safety training.

Key words: laboratory safety, training program, medical education, health colleges, Saudi Arabia, female students

Introduction:

Medical and health college laboratories provide serious threats if safety procedures are not properly followed. Accidents in lab environments can pose major health risks, particularly if students are not aware of the correct handling techniques. [1] Improving the standard of education and safety in educational institutions is becoming progressively more important in Saudi Arabia.

In the recent decades, many severe laboratory accidents including the leakage and infection of pathogenic microorganisms had been reported 1–3. [2] These facts emphasized the pressing need for a more effective training system to educate bio-safety knowledge to related workers. In medical university, the concept of laboratory biosafety should be indoctrinated to undergraduate students before entering the laboratory to perform experiments. We established a laboratory safety training system with online studies for undergraduate students to help them master basic and accurate knowledge effectively. The learning materials in this training system were concise and avoid overloaded interdisciplinary information beyond their understanding or distracting their concentration from the major subjects. [4] (Xunmin Zhu,, et al., 2024)

A fundamental concept, laboratory safety awareness encompasses several important aspects that safeguard the environment and the health of those who work in a laboratory. Exposure to volatile solvents, high-pressure gases, explosive chemicals, hazardous microorganisms, and caustic and toxic materials can all pose concerns in a laboratory. Accidents in laboratories can be prevented with little caution and adherence to established safety protocols. According to the current study's findings, only a few respondents were aware of the safety precautions that should be taken in scientific labs. A new generation of scholars and scientists that are concerned about safety can make important developments in several disciplines. Their efforts can be more safely and responsible to solve global difficulties like healthcare advancements and environmental

problems. [3] (Joy HE, Thomas M.2023)

Objectives

The primary aim of this study was to evaluate the effectiveness of a structured laboratory safety training program in improving the knowledge and self-assessed safety practices among female students in medical and health colleges in Saudi Arabia.

Research Questions

1. Does participation in the laboratory safety training program significantly improve students' knowledge of laboratory safety hazards and procedures?
2. Does the training program lead to improved self-assessment scores in laboratory safety practices among the students?

Hypotheses

- H_0 (Null Hypothesis): There is no statistically significant difference in laboratory safety knowledge and self-assessed safety practices before and after the training program.
- H_1 (Alternative Hypothesis): There is a statistically significant improvement in laboratory safety knowledge and self-assessed safety practices after the training program.

Materials and Methods:

Ethics statement

This was approved by the management of Medical Applied Sciences College-Al-Namas. After meeting the inclusion criteria, the researcher presented the participants to the participants. The researcher received voluntary and informed permission from each participant.

Study design:

Quasi-experimental study designs include Single group pre-and post-test design.

Setting

The study was conducted at Medical Applied Sciences College-Al-names, university of Bisha, KSA, from January to February 2024.

Participants

All female undergraduate students at Bisha University who are enrolled in health and medical colleges and are undergoing training in chemical and medical laboratories in the Asir region of the Namas Governorate and who choose to participate part were selected.

Interventions

Data Collection Tools:

Data were collected by using a semi-structured questionnaire.

Procedure:

The program was created prior to the study's execution, and written consent from administrative authorities was acquired. The study was planned in three stages, which are as follows:

Phase I: Pre-test Assessment phase:

After being made aware of the goals of the study, each participant signed an agreement. All participants were interviewed to collect data regarding the program's content and sociodemographic features.

Phase II: Implementation:

During this phase, A training program that includes awareness lectures and training sessions about how to handle laboratory dangers and how to utilize safety measures in medical laboratories was conducted. The participants were divided into groups within two days, the intervention program workshop delivered.

Phase III: Post-test Assessment phase:

This stage involves gathering post-intervention data. Using the same questionnaire, interviews with all participants were conducted to gather information about sociodemographic traits and program-related details.

Outcomes

- Knowledge of PPE.
- Recognition of chemical hazard symbols.
- Awareness of emergency procedures.

Study size

The sample size was calculated using the following formula for a finite population:

$$n = [N \times Z^2 \times p \times (1 - p)] / [d^2 \times (N - 1) + Z^2 \times p \times (1 - p)]$$

Where:

- n is the required sample size,
- N is the total population size (240 students),
- Z is the Z-score for a 95% confidence level (1.96),
- p is the estimated proportion of the population (0.5),
- d is the margin of error (0.05).

Substituting the values:

$$n = [240 \times (1.96)^2 \times 0.5 \times (1 - 0.5)] / [(0.05)^2 \times (240 - 1) + (1.96)^2 \times 0.5 \times (1 - 0.5)]$$

$$= 230.496 / 1.5579 \approx 148$$

Thus, the minimum required sample size was estimated to be 148 students. To account for potential non-response or incomplete data, a larger sample was targeted during recruitment

Statistical methods

Data analysis was done with SPSS v26. The significance of response variations was assessed using both descriptive (mean, standard deviation) and inferential (paired t-test, McNemar's test) statistics.

Results:

Participants

Table 1. Demographic Characteristics of the Participants (N = 122)

Variable	Category	No. (%)
Age group (years)	18–20	40 (32.8)
	21–23	65 (53.3)
	>23	17 (13.9)
School level	Year 1	15 (12.3)

	Year 2	22 (18.0)
	Year 3	30 (24.6)
	Year 4	37 (30.3)
	Year 5 and above	18 (14.8)

*Data are presented as number (percentage) of respondents. Percentages may not total 100 due to rounding.

240 were the total numbers of students invited to participate

↓

161agreed to participate

↓

161 completed pre-tests

↓

Received laboratory safety training

↓

122 completed post-tests

↓

Data analyzed for all 122 students

Table 2. Pre-Test and Post-Test Knowledge Scores on Laboratory Safety

Knowledge Statement	Pre-test Agree (%)	Post-test Agree (%)	P-value
Laboratories are one of the most dangerous work environments.	74 (60.7)	109 (89.3)	<0.001
Laboratory safety depends on your personal behavior.	65 (53.3)	112 (91.8)	<0.001

About 10% of skin cancers are due to workplace exposure to hazardous substances.	43 (35.2)	102 (83.6)	<0.001
Chemical hazard is determined by substance type and exposure route.	58 (47.5)	108 (88.5)	<0.001

*Data are number (%) of students who agreed with the statement. McNemar’s test was used for pre- vs. post-test comparisons.

Table 2 presents Participants' understanding of important laboratory safety concepts before and after the educational intervention. The percentage of students who agreed with each of the four fundamental safety statements in the pre-test and post-test evaluations is displayed in the table. Significant gains in understanding were noted for every assertion. The pre-test score for the statement "Laboratories are one of the most dangerous work environments" was 60.7%, whereas the post-test score was 89.3% ($p < 0.001$). Understanding that "Laboratory safety depends on your personal behavior" also significantly improved from 53.3% to 91.8% ($p < 0.001$), indicating a change in the perception of personal responsibility.

Only 35.2% of students initially understood the connection between exposure to hazardous substances and skin cancer, indicating a lack of understanding about occupational risks; after training, this percentage increased to 83.6% ($p < 0.001$). Additionally, the percentage of people who knew about chemical dangers considerably rose from 47.5% to 88.5% ($p < 0.001$), according to both substance type and exposure methods. Together, these findings imply that students' safety knowledge was positively impacted by the laboratory safety training program in a statistically significant way. By confirming that the observed differences are unlikely to be the result of chance, McNemar's test strengthens the intervention's efficacy.

Table 3. Self-Assessment of Laboratory Safety Practices (Pre vs. Post)

Item	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	P-value
I am confident in identifying laboratory hazards.	2.8 $\pm$ 0.9	4.1 $\pm$ 0.7	<0.001
I follow proper procedures for handling chemicals.	3.0 $\pm$ 1.0	4.3 $\pm$ 0.6	<0.001
I use PPE consistently during lab work.	2.6 $\pm$ 1.1	4.5 $\pm$ 0.5	<0.001
I know emergency procedures in case of lab accidents.	2.7 $\pm$ 1.2	4.2 $\pm$ 0.6	<0.001

*Mean scores are based on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Paired t-test was used for comparison.

Table 3: Participants' Understanding of Important Laboratory Safety Concepts Before and After the Educational Intervention

Table 3 highlights significant improvements in self-assessed laboratory safety practices following the educational intervention. All four key items demonstrated statistically significant increases in mean scores from pre- to post-test ($p < 0.001$ for all comparisons).

- Confidence in identifying laboratory hazards increased from 2.8 ± 0.9 to 4.1 ± 0.7 .
- Proper handling of chemicals improved from 3.0 ± 1.0 to 4.3 ± 0.6 .
- Consistent use of personal protective equipm

ent (PPE) rose markedly from 2.6 ± 1.1 to 4.5 ± 0.5 .

- Knowledge of emergency procedures also increased from 2.7 ± 1.2 to 4.2 ± 0.6 . These findings reflect a strong positive impact of the training program on participants' awareness and self-confidence regarding laboratory safety practices.

Table 4. Participants' Confidence in Emergency Laboratory Skills Before and After the Educational Intervention

Skill Area	Pre-test High Confidence (%)	Post-test High Confidence (%)	P-value
Understanding chemical risk symbols	34%	75%	<0.001
Using an emergency shower	34%	72%	<0.001
Using emergency equipment overall	34%	70%	<0.001

*Values represent the percentage of participants who reported high confidence in each skill area. Pre- and post-test comparisons were analyzed using McNemar's test. A p-value of <0.05 was considered statistically significant.

The pre-test findings showed a lack of knowledge in areas like comprehending chemical risk symbols and using an emergency shower (only 34% rated high confidence). Correct answers dramatically increased after training. Over 70% of students now report feeling very confident when using emergency equipment. Statistically significant improvements were noted in:

- Knowledge of PPE use ($p < 0.001$)
- Recognition of chemical hazard symbols ($p < 0.001$)

- Awareness of emergency procedures ($p < 0.001$)

Discussion:

The results validate the efficacy of focused training initiatives in raising awareness of laboratory safety. Positive results after safety interventions have been reported in similar trials [5] (Al Ghamdi et al., 2020; Khan et al., 2021 [6]. Our research supports these conclusions and indicates that including these programs in curricula can lead to long-lasting gains.

The purpose of this study was to assess how well a laboratory safety training program affected the knowledge and behaviors of medical and health college students. Following the intervention, the results showed a considerable improvement in both dimensions, suggesting that organized safety education can produce major benefits. According to a 2022 study, regular training on laboratory safety preventive measures is essential to ensuring the efficacy of occupational health and safety in scientific laboratories. [7] These findings support the goals of the study and imply that the training course was effective in raising awareness of laboratory safety. Safety education is essential to prevent accidents and casualties in modern society [8] [9].

These results should be viewed cautiously, though. Potential bias is introduced by the lack of a control group and the use of self-assessment, especially social desirability or overestimation of expertise. Although a number of factors were considered, the study's primary focus was on the immediate post-intervention results; as a result, long-term knowledge retention was not evaluated. A 2020 study revealed that It should be mentioned that creating a standard approach is necessary to enhance their practice, knowledge, and attitude [10].

Comparison with Previous Studies

Our results are in line with earlier research that shown that specific interventions in academic contexts led to an improvement in safety awareness (e.g., Al-Mousa et al., 2020; El-Setouhy et al., 2021). [11] [12]Notably, our

findings also support global research showing that prior to formal education, children frequently lack basic safety training. Our sample was all female, in contrast to previous research, which could affect comparative interpretations based on contextual gender-related safety perceptions in laboratory work.

Limitations

There are a few limits to be aware of. The study's single-group pre-test/post-test design, which lacked a control group, made it difficult to describe differences to the intervention alone. Second, the study used self-reported data, which is biased by response and recollection. Furthermore, the study was only carried out in one area of Saudi Arabia, which would have limited participant diversity and introduced location-based bias. These biases may have a moderate amplitude, but their direction probably favors overestimating the efficacy of training.

Generalizability

The results may be applicable in comparable contexts throughout the Middle East and beyond, notwithstanding the local peculiarity. This organized method to safety training can be modified by medical and health educators for use in their own institutions, especially in settings where laboratory training is frequently disregarded. However, before broad generalization can be made, replication in larger and more varied populations is required.

Suggestions

Randomized controlled trials should be a part of future studies in order to better isolate the intervention's effects. Additionally, longitudinal studies are advised for evaluating knowledge retention over time. From an educational perspective, effective practices might be institutionalized by including laboratory safety courses in undergraduate curriculum. Additionally, creating safety products that are culturally appropriate could improve effect and receptivity.

Conclusion:

laboratory safety training program greatly enhances students' understanding and practices in laboratory settings, according to the current study. The idea that focused educational interventions can close safety awareness gaps among medical and health students is supported by these findings. The findings emphasize the need for safety education as a crucial aspect of academic preparation, especially in fields that require a lot of clinical and laboratory work. This study shows how beneficial structured laboratory safety training is. Increasing students' confidence and understanding can result in safer lab procedures. These results have a significant impact on attempts to evaluate education with the goal of enhancing safety culture in health education settings. Future programs must be expanded to incorporate frequent refresher courses and mandated for all institutions.

Declarations

Artificial intelligence tools (e.g., ChatGPT by OpenAI) were used to support language editing and structure improvement during the preparation of this manuscript. All content was critically reviewed and approved by the author in accordance with ethical standards.

Ethics approval and consent to participate: The study protocol was approved by the institutional research ethics board.

Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare no competing interests.

Acknowledgments: The authors thank all the students who participated in this study.

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