

Knowledge and Practice of Standard Precautions and Awareness Regarding Laboratory Safety among Undergraduate College Students from Bengaluru, India

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This study aims to evaluate students' understanding of standard precautions and the safe handling of laboratory equipment and materials, identify gaps between knowledge and practical application of these precautions, and explore perceived barriers to adherence. The study involved 130 college students from the 2022, 2023, and 2024 batches from various colleges in Bengaluru, India. Participants completed a self-administered questionnaire assessing their knowledge of standard precautions and safe handling practices for laboratory equipment and materials. The questionnaire also included open-ended questions to examine reasons for non-compliance with standard precautions, along with space for additional comments. Despite demonstrating correct knowledge in areas such as the use of personal protective equipment (PPE) like gloves and goggles, hand hygiene, and the safe handling and disposal of laboratory materials and sharp objects, poor adherence to these practices was observed. Key barriers included difficulties in handling laboratory equipment, discomfort with wearing gloves and aprons, impracticality of regular handwashing, and a lack of adequate supplies. While a significant proportion (84.6%) acknowledged the importance of wearing proper laboratory attire, 32.3% were unaware that certain reagents, such as acrylamide and ethidium bromide, could act as potent neurotoxins and mutagens. Additionally, only 63.8% understood the importance of reporting occupational exposures, and knowledge of appropriate handling and disposal protocols remained insufficient. These findings underscore a significant disconnect between knowledge and practice regarding standard precautions, highlighting the urgent need for continuous training programs, along with active supervision and monitoring, to ensure better adherence among students.

I. Introduction

Laboratory safety is defined as the application of a combination of laboratory practices and procedures, laboratory facilities, and safety equipment when working with potentially harmful agents, biological, chemical, electrical or radioactive to protect the laboratory staff and, through them, the general public. 1. The possible hazards a researcher may face in the laboratory environment may be through exposure to toxic, corrosive, or flammable chemicals, pathogenic microorganisms, cryogenic materials, high-voltage equipment or faulty electrical systems, lasers or radioactive materials and fire related emergencies. 2.

Laboratory safety involves using personal protective equipment (PPE) like gloves, goggles, and lab coats to minimize exposure to hazards. It encompasses safe handling, storage, and disposal of chemicals, biological agents, and laboratory equipment. Regular maintenance ensures equipment functions correctly, and hygiene practices, such as avoiding food and maintaining cleanliness, are essential. Emergency preparedness includes access to fire extinguishers, first aid kits, and eyewash stations. Proper waste management including segregation, labeling, and disposal of hazardous and non-hazardous waste to prevent contamination and environmental harm. Undergraduate students are at a very early stage of their professional career, and have to take a maximum load of laboratory courses in any general college, and because they often lack the necessary knowledge regarding safe laboratory practices or though aware fail to apply the required precautions when needed, fall at a great risk of occupational exposure to all kinds of laboratory hazards as mentioned. It is thus essential to instill in them biosafety practices and risk control methodologies from the very beginning before incorrect practice develops into a habit. The present study was thus conducted with the following objectives: 1) to assess the knowledge of the students on standard precautions and the safe handling of laboratory equipment and materials 2) to identify the gap between knowledge and practice of standard precautions and 3) to determine the perceived barriers against adherence to standard precautions.^{1,2}

II. Materials and Methods

The study was conducted from September 2024 to January 2025 among all the 130 undergraduate students of the 2022, 2023, 2024-batches from diverse college students at in Bengaluru, India. Informed consent was taken from students for participation into the study and anonymity was assured. A self-administered, pre-designed and semi-structured questionnaire was prepared by selecting relevant items from "Safety and Emergency Protocols and Guidelines" published by the Office of Laboratory Safety and Environmental Health, Indian Institute of Science, and modified according to the field experiences of the researcher. The questionnaire was then

pre-tested among 10 post doctoral trainees from different scientific disciplines at the same college and further modifications were incorporated; however, reliability analysis was not performed. On the other hand, the assessment of knowledge of laboratory safety and precautions was done through a mixture of open and closed-ended questions; questions assessing the practices had the options such as "always practiced" and "not always practiced"; however, the Likert scale was not adopted, though it was considered that the self-reporting nature of the responses may contradict the actual practice of laboratory safety. The questionnaire also included open-ended questions regarding reasons for non-adherence to the practice of laboratory safety with an additional space for specific comments. After obtaining informed consent from all the participants, they were asked to fill up this questionnaire within half an hour time. Since all the students were not available at the same place and at the same time, the process was carried out at their different departments at different time intervals. However, most of the students by that time had participated in at least two major laboratory modules. The data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20 and were expressed in simple proportions. Adherence to the correct practice of different components of laboratory safety was assessed by analyzing the responses expressing the correct knowledge. The purpose was to determine whether or not correct knowledge had also been translated into correct practice. Since the number of correct responses relating to laboratory safety was different for its different components, the same statements were kept for presenting the data based on the practices involving those individual components for better understanding. Also, since the study participants, though belonging to different strata of the society but formed a homogeneous group who underwent the same kind of undergraduate training and working in the same environment, no statistical analysis was done based on demographic variables.^{1,3}

III. Results

All the respondents expressed awareness of the proper laboratory practices and possible occupational hazards. The majority of correct knowledge was observed to be related to the use of gloves and aprons, but knowledge relating to the use of goggles was found to be poor (54.6%). Moreover, most of the participants conveyed knowledge of the following; the importance of proper waste disposal, the risk of bending or recapping used needles, fire safety precautions, and safe disposal of chemicals. (Table 1).

Table 1: Knowledge of the respondents regarding Standard Precautions. (n = 130)

Knowledge of laboratory safety	Correct*	Incorrect*
Gloves should be worn every time during handling potentially infectious materials	125 (96.1)	5 (3.9)

Aprons or gowns should always be worn to avoid exposure from splashing	121 (93.1)	9 (6.9)
Goggles should be worn when needed to avoid exposure to the eyes	71 (54.6)	59 (45.4)
Proper grounding and insulation of electrical equipment are essential to prevent electric shocks and potential fires.	80 (61.54)	50 (38.46)
All cryogenic materials, such as liquid nitrogen, should be handled with insulated gloves and face protection to avoid frostbite or burns from extreme cold.	78 (60)	52 (40)
When working with volatile substances, operations should always be conducted in a fume hood to prevent inhalation of harmful vapors.	65 (50)	65 (50)
Proper disposal of biohazardous sharps, such as needles, is critical to avoid injuries and contamination.	117(90)	13(10)
Labs using radioactive materials must enforce strict shielding and dosimetry protocols to minimize exposure risks.	43 (33.08)	87 (66.92)
Emergency exit paths must always remain unobstructed, and fire extinguishers should be regularly inspected to ensure readiness.	115 (88.46)	15 (11.54)

Among the components for which correct knowledge was expressed, practice of always using gloves, aprons/gowns and goggles was reported by only 62.4%, 56.2% and 22.5% of the respondents, respectively. The practice of using fume hoods and eye-wash stations was poor (54.7%) among the participants who had correct knowledge of it; and only 66.3% of respondents who were aware of the proper handling of radioactive materials adhered to its correct practice. Also, only

49.1% of the participants with the correct knowledge of safe disposal of sharp instruments reported to use puncture-proof containers for this purpose (Table 2). The main reasons for non-compliance to the correct practice of laboratory safety were as follows: a) inconvenience in handling needles and sharps when wearing gloves and often no time to wear gloves during rush hours; b) feeling uncomfortable wearing aprons in tropical climate; c) unavailability of goggles for regular use d) regular biowaste disposal not feasible due to huge workload; e) non-availability of functioning eye stations and emergency exits and puncture-proof containers for safe handling and disposal of needles and sharps. (Table 2).

Table 2: Practice of Laboratory Safety among the respondents having correct knowledge and main reasons for non-adherence.

Precaution	Always Practiced (%)	Not Always Practiced (%)	Main Reasons for Non-Adherence
Gloves should be worn every time during handling of potentially infectious materials	78 (62.4%)	47 (37.6%)	Clumsiness and inconvenience in handling needles and sharps
Aprons or gowns should always be worn to avoid direct contact with blood or body fluids	68 (56.2%)	53 (43.8%)	No time due to rush; uncomfortable in tropical climate
Goggles and eye wash stations should be used to prevent exposure to eyes when working with hazardous substances	16 (22.5%)	55 (77.5%)	Not available for regular use
Biowastes should always be disposed of in designated containers to avoid contamination	64 (54.7%)	53 (45.3%)	Not feasible due to the huge workload
Used needles should never be bent or recapped	59 (66.3%)	30 (33.7%)	Non-functioning or non-availability of

			hub-cutter
Puncture-proof containers should always be used for the disposal of sharps	57 (49.1%)	59 (50.9%)	Non-availability of puncture-proof containers at bedside
Emergency exits must remain unobstructed, and researchers should be trained on evacuation protocols	68 (52.3%)	62 (47.7%)	Lack of training or awareness of emergency procedures
Protocols for handling radioactive materials, cryogenic substances, and grounding of electrical instruments should always be followed	75 (57.7%)	55 (42.3%)	Lack of awareness or specialized training

IV. Discussions

The present study focused on investigating how far the correct knowledge of "Laboratory Procedures" translates into correct practice in practical settings. The study subjects, during their undergraduate course, attended theoretical classes on safe laboratory practices, handling hazardous materials, and emergency response protocols. They were also given practical demonstrations on essential laboratory safety measures and proper disposal of laboratory waste. However, the results of this study revealed poor adherence to the main components of laboratory safety, such as using personal protective equipment, hand hygiene, safe handling of laboratory equipment, and proper disposal of waste, even among students who expressed correct knowledge of these protocols. The main reasons for non-adherence to correct safety practices were reported to include: clumsiness in handling equipment while wearing gloves, lack of time during high workloads, discomfort in wearing aprons, unavailability of safety goggles and eyewash stations for regular use, the infeasibility of frequent hand-washing due to workload, and the lack of functional puncture-proof containers for disposal of sharp objects. Comments like "It is easier to handle equipment with bare hands rather than wearing gloves," "Aprons are unbearable in this heat," "With such a huge workload, hand washing after every experiment isn't feasible," and "There's no puncture-proof container available, so I improvise" further highlight the reasons for non-

compliance. In a similar study conducted in a tertiary care institute in India, by Dubey A et al, with knowledge and practices of biosafety precautions showed that highest mean score of knowledge among the consultant doctors was 75.1 and practice score was 64.3. While 90% of respondents reported proper disposal of sharps, only 60% refrained from unsafe practices like bending or recapping needles. Perceived barriers to the use of personal protective equipment (PPE) included being too busy, discomfort in usage, and colleagues not adhering to protocols themselves. In a similar study conducted in a tertiary care institute in India, by Dubey A et al, with knowledge and practices of biosafety precautions showed that highest mean score of knowledge among the consultant doctors was 75.1% and the practice score was 64.3%. While 90% of respondents reported proper disposal of sharps, only 60% refrained from unsafe practices like bending or recapping needles. Perceived barriers to the use of personal protective equipment (PPE) included being too busy, discomfort in usage, and colleagues not adhering to protocols themselves. Another study from medical biology laboratories in Togo, showed 49.1% had good knowledge and good attitude and 77.1 % had good practices respectively. Although the results show the respondents with prior training had a greater knowledge score in the respective areas, but training had no effect on practice or attitude score. Regional differences in practice scores were highlighted and several gaps were identified through this study. In Karachi, researchers reported that the regular use of PPE was considered impractical and time-consuming due to unavailability and busy schedules. Studies from Indonesia and Saudi Arabia similarly reported poor adherence to safety protocols, despite a high level of theoretical knowledge, with common barriers being a lack of resources and inadequate awareness. A study conducted in 2020 in Congo, found that 91% of laboratories did not apply proper biosafety measures. Wurtz et al; in 2016 following an international survey also noted that 78% of laboratory-borne infections were a result of human error. A study in London reported that while many participants were familiar with basic safety protocols, only a minority could correctly name the emergency equipment available or provide details on how to handle specific incidents. Similar findings were reported in South Africa, where the majority lacked knowledge of the appropriate duration and correct steps to take in emergency scenarios. The researchers

emphasized the importance of consistent onsite training to bridge the gap between knowledge and practice. Furthermore, ensuring the adequate supply of safety equipment—such as eyewash stations, puncture-proof containers, and functional PPE—is critical for improving adherence to laboratory safety procedures.^{3,4,5,6}

V. Conclusions

The study reveals a significant gap between knowledge and practice of laboratory safety procedures. This underlines the necessity for continuous training, supportive supervision, and active monitoring of compliance in the laboratory setting. Moreover, addressing resource availability issues and fostering a culture of accountability and collaboration are imperative to improve adherence to safe practices in laboratories

VI. References

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