Original Article

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Safety Measures in Biochemistry Laboratory: Need of the Hour

Biochemistry Section

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ABSTRACT

Introduction: Biochemistry laboratories like any other laboratory contain certain inherent dangers and hazards for the students. Proper guidelines regarding laboratory safety are missing in Biochemistry curriculum. So, skill training about laboratory safety in Biochemistry laboratory will be useful for the MBBS students.

Aim: To train the undergraduate medical students about laboratory safety using "Safety measures in Biochemistry Laboratory" module and to assess their perception about this module.

Materials and Methods: A prospective interventional study was conducted in which 100 students of first year MBBS 2017 batch were included which were divided into study and control groups. In Study Group, 50 students were trained in the topic of laboratory safety using a module on "Safety measures in Biochemistry Laboratory" which included three sessions of didactic lectures and two sessions of hands-on training. In Control Group, 50 students were not given any intervention. Outcome of training was assessed with the help of "Biochemistry Laboratory Safety Index" (BLSI) scores, which was designed by authors and was validated from 10 external subject experts of the Biochemistry Department. Pre-test and post-test marks of study and control group participants were compared using paired t-test for each group. Absolute learning gain (Post-test score-Post-test score) and relative learning gain (Post-test score-Pre-test score/Pre-test score) was calculated.

Results: Absolute learning gain for control and study group was 0.11 and 5.53, respectively, while relative learning gain for control and study group was 0.16 and 89.62 respectively. Pre-test and post-test scores are statistically non-significant ($p>0.05$) in the control group, while Pre-test and post-test scores are statistically significant ($p<0.001$) in the study group. BLSI scores in control group was excellent for 9 (18%), good for 16 (32%), average for 19 (38%) and poor for 06 (12%) students; while in study group it was excellent for 41 (82%), good for 08 (16%) students, average for 01 (02%) students and poor for nil students.

Conclusion: Module of "Safety measures in Biochemistry Laboratory" is significantly effective educational intervention as it improves the knowledge about Laboratory safety and its implication for medical students during Biochemistry practicals. Training about "Safety measures in Biochemistry Laboratory" can be incorporated in the existing undergraduate Curriculum of Biochemistry.

Keywords: Chemical and reagent, Fire, First aid, Personal

INTRODUCTION

Laboratory environment can be hazardous place to work. Biochemistry laboratories like any other Chemistry laboratory contain certain inherent dangers and hazards. All the undergraduate students of MBBS have to perform practicals in the Biochemistry laboratory throughout the first year MBBS. They routinely come in contact with chemicals, reagents, fire and biological samples in the laboratory. Catastrophic accidents occurred in the academic laboratories have drawn the consideration of authorities and media and thus, have highlighted the importance of guidance and implementation of laboratory safety in the academic settings [1-5]. Therefore, all the medical students should learn to work safely in laboratories in order to prevent damage to everyone around.

It is pivotal to develop pure safety culture in research and teaching laboratories in the academic institutions. Medical students must make a constant effort to think about the potential hazards associated with what they are doing and to think about how to work safely to prevent or minimise these hazards as much as possible [4]. But, still there are no proper guidelines in the Medical curriculum regarding laboratory safety. So, skill training about Laboratory safety in Biochemistry laboratory will be useful for the MBBS students. All Medical students must understand laboratory safety and emergency procedures prior to their first laboratory session. So, this study was performed at Department of Biochemistry to train the undergraduate medical students about laboratory safety using "Safety measures in Biochemistry Laboratory" module and to assess their perception about this module.

MATERIALS AND METHODS

A prospective interventional study was conducted from September 2017 to March 2018. Institutional Ethics Committee Clearance for the study was obtained (IEC Letter of Approval Ref. No. DMIMS (DU)/IEC/2017-18/6914 Date: 16/12/2017). Written consent was obtained from all the students. The study population was undergraduate medical students (1st semester MBBS students). A total of 120 students in whole 2017 batch MBBS were included and out of them only 100 could participate in all the activities of the study. Data obtained from remaining 20 students (10 from Study group and 10 from control group) were discarded as they did not attended all the sessions of the training. The response rate was 83.33%. Out of 100 students who participated in this study, 50 (A batch) categorised as study group, whereas other 50 (B batch) were categorised as control group, randomly. This grouping was done using convenience sampling. The students participating in this study were oriented to the purpose of the study and motivated to participate in the study.

Inclusion criteria for cases: The students who were present and attended all the three sessions (135 minutes) of didactic lectures and two sessions (90 minutes) of hands-on training on "Safety measures in Biochemistry Laboratory after Pre-test.

Exclusion criteria for cases: The repeaters were excluded from the study, due to lack of their regular attendance.

Inclusion criteria for controls: Control group were those students who were not given any intervention.

Exclusion criteria for controls: Control group Students who were unable to complete the training session after post-test.

In Study Group, 50 students were trained in the topic of laboratory safety using a module on "Safety measures in Biochemistry Laboratory" which included three sessions (135 minutes) of didactic lectures and two sessions (90 minutes) of hands-on training. Didactic lecture covered the topics like personal safety measures, guidelines for handling of reagents and chemicals, precautionary measures against fire and explosion, laboratory first aid kit and emergency measures and hands-on training included demonstration about personal safety, reagents and chemicals safety, first aid measures and emergency safety in groups of 10 students each while 50 students of control group were not given any intervention.

Knowledge of both the groups was tested with pre-test (annexure 1) on the topic "Safety measures in Biochemistry Laboratory" and Post-test for both the groups was also conducted.

Questions in pre-test and post-test were based on Clinical Laboratory Standards Institute (CLSI) Clinical Laboratory Safety (Approved Guideline) [6] and validated by external subject experts of the Biochemistry department. Content Validity Index for individual items (I-CVI) from 10 subject experts was 0.80. The questionnaire was found to be reliable (Cronbach's alpha: 0.90; intra-class correlation coefficient: (0.98).

Outcome of training was assessed with the help of "Biochemistry Laboratory Safety Index" (BLSI) scores [Annexure 2] which was designed by authors based on CLSI Clinical Laboratory Safety (Approved Guideline) [6] and Safety Standards and Laboratory Procedures for Exposure to Chemicals (Laboratory Medicine) [7]. It was validated from 10 external subject experts of the Biochemistry department. I-CVI from 10 subject experts was 0.90. The questionnaire was found to be reliable (Cronbach's alpha: 0.80; intra-class correlation coefficient: 0.96)

BLSI score depends upon how basic principles of laboratory safety like personal safety, chemicals and reagent safety, fire safety & emergency safety are followed by the medical students while working in Biochemistry Laboratory. Performance of study and control group participants was compared with the help "Biochemistry Laboratory Safety Index" at the end. Control group was exposed to the intervention (didactic lecture and hands-on training) after the study.

Data collection methods: Perceptions were obtained from all of the students i.e., both control and study group using a questionnaire in the form of Feedback form.

STATISTICAL ANALYSIS

Pre-test and post-test marks of study and control group participants were compared using paired t-test for each group. Absolute learning gain (Post-test score-Pre-test score) and relative learning gain (Post-test score-Pre-test score/Pre-test score) was calculated. Effectiveness of intervention was evaluated by Class-average normalised gain (g) = (% Post-test score -% Pre-test score)/(100- % Pre-test score)]. Class-average normalised gain (g) of >0.3 i.e., 30% was considered as significant as per Hake's criteria for effectiveness of an educational intervention [6]. $p<0.05$ is considered as level of significance. Assessment of perceptions obtained using close ended questions was done quantitatively using 5 point likert's scale. Open ended questions were assessed qualitatively.

RESULTS

All the 100 students participated in the study were in the age group 17-22 years and 63 were female, while 37 were males.

From [Table/Fig-1], Absolute learning gain for control and study group was 0.11 and 5.53, respectively; while relative learning gain for control and study group was 0.16 and 89.62, respectively. Pre-test and post-test scores are statistically non-significant ($p>0.05$) in the control group, while Pre-test and post-test scores are statistically significant ($p<0.001$) in the study group.

	Pre-test score	Post-test score	Absolute learning gain	Relative learning gain	p-value
Control group	3.96±1.19	4.07±1.24	0.11±0.05	0.16±0.08	>0.05
Study group	3.83±1.21	9.36±1.31	5.53±0.38	89.62±6.31	<0.001

[Table/Fig-1]: Comparison of Pre-test and post-test scores of study group and control group.
S: Significant; $p<0.05$

From [Table/Fig-2], BLSI scores in control group was excellent for 9 (18%), good for 16 (32%), average for 19 (38%) and poor for 06 (12%) students; while in study group it was excellent for 41 (82%), good for 08 (16%) students, average for 01 (02%) students and poor for nil students.

BLSI	Excellent score above 12	Good score between 9 to 12	Average score between 6 to 9	Poor score below 6
Control group	09	16	19	06
Study group	41	08	01	00

[Table/Fig-2]: "Biochemistry Laboratory Safety Index" scores of study and control group.

From [Table/Fig-3], most of the students agreed that this module is helpful to improve the knowledge about laboratory safety and adds on to the minute procedural details while performing Biochemistry practicals. Most of them also agreed that it improves the confidence, hence helped the students to be more competent in Biochemistry practicals, which will improve their performance in practical examination of Biochemistry. Few of them suggested that it will be more useful, if it is conducted at the start of session.

Sr. No.	Statement	SD	D	N	A	SA
1	This module is helpful to improve the knowledge about safety in Biochemistry Laboratory.	00	02	02	18	78
2	It actually adds on to the minute procedural details while performing biochemistry practicals.	00	04	06	42	48
3	It improves the confidence, hence helped the students to be more competent in biochemistry practicals.	00	04	00	42	54
4	This module taught students about their own and their colleagues' safety in Laboratory as well as how to deal in emergency situations.	00	02	02	36	60
5	This module will improve the performance in practical examination of biochemistry.	00	02	02	42	54
6	It will be more useful if it is conducted at the start of session.	00	02	02	24	72
7	Safety measures in Biochemistry Laboratory model actually is a waste of time.	78	14	06	00	02

[Table/Fig-3]: Feedback from students exposed to laboratory safety on likert scale.
SD: Strongly disagree; D: Disagree; N: Neutral; A: Agree; SA: Strongly agree

From [Table/Fig-4], when students were asked about the advantages under "Safety measures in Biochemistry Laboratory" module, they told that it created awareness and alertness about the laboratory safety guidelines which should be practiced in laboratory and it will decrease the incidents of accidents and injuries in the laboratory. Few students felt that it will make the students more competent and more confident in performing Biochemistry practicals. When asked about improvements in this module, they suggested that it will be more useful if conducted at the start of practicals session. Few students suggested that laboratory personnel should be fully aware of the guidelines and laboratory safety.

DISCUSSION

It is a shared liability of both researcher and an academic institution to administer a safe laboratory environment to their students. Good

Questions	Answers
What are the advantages of "Safety measures in Biochemistry Laboratory" module?	• It created awareness and alertness about the laboratory safety guidelines which should be practiced in laboratory. • It will decrease the incidents of accidents and injuries in the laboratory. • It will make the students more competent and more confident in performing Biochemistry practicals.
Should "Safety measures in Biochemistry Laboratory" module be incorporated in the existing undergraduate Curriculum of Biochemistry? Why?	• Yes. • As it improves the knowledge about Laboratory safety and confidence of students while performing practicals. • It teaches the students about dealing with emergency situations and decreases the incidents of accidents and injuries in the laboratory.
How this module can be improved further?	• It will be more useful if it is conducted at the start of practicals session. • Laboratory personnel should be aware of the guidelines and laboratory safety. • Laboratory should be adequately equipped regarding safety measures.

[Table/Fig-4]: Feedback on open ended questions.

safety practices such as wearing appropriate personal protective equipment should be supplemented with keeping updated safety data sheets, chemical stock and standard operating procedures. People working in the laboratory should be informed about emergency procedures at the time of trouble that includes knowledge of the location and use of fire extinguisher, spill kit, emergency shower, eye wash, first-aid kit, emergency exit routes etc., [8,9].

Generally, researchers obtain a bit of formal training in laboratory safety as authorised by Occupational Safety and Health Standards (OSHA) regulations [10]. However, According to study by Schroder I et al, only 67% of researchers declared that they were trained in the secure use of the specific hazards encountered in their experiments. Also, academic researchers were the least likely to assess risk (only 18% reported doing so) compared to industry (43%) or government (36%) [11].

Widening bay exists between how safety is practiced in industry compared to academic research laboratories. National Research Council has presented a treatise on the subject titled "Safe Science" [12]. The goal of their report is to encourage a better safety environment in non-industrial research laboratories.

In 2012, the University of California Center for Laboratory Safety combined with the Nature Publishing Group and BioRAFT, a developer of university laboratory management software and directed one of the largest surveys of lab safety culture to date [13]. Almost 2,400 respondents participated; 90 percent of which were from academic research laboratories. Although most of the participants (85 percent) agreed with this statement-"appropriate safety measures in my lab have been taken to protect employees from injury"-a deep-seated review hints that this may not be true.

One study showed that only 10% of students, post-doctoral fellows, faculty and staff felt that their safety training had prepared them to assist others and to intervene when others engaged in unsafe behaviours [2]. In a study conducted in academic laboratory, out of 85 participants, 47% of participants did not know how often safety inspections were performed in their labs, 35% did not have access to data or records regarding their lab's safety and whether or not it complied with legislated requirements and 9% did not know how to handle an emergency such as a fire or a spill [14].

All Medical students must understand laboratory safety and emergency procedures prior to their first laboratory session. But, still there are not proper guidelines in the Medical curriculum regarding laboratory safety. So, most of the students suggested about the incorporation of "Safety measures in Biochemistry Laboratory" module in the existing undergraduate Curriculum of Biochemistry.

Development of a "culture of safety" with accountability will result in safe and healthy laboratories. Laboratory personnel should realise that the welfare and safety of each individual depends on clearly defined attitudes of teamwork and personal responsibility and laboratory safety is not merely a substance of materials and apparatus but also of processes and behaviours.

Limitation(s)

Sample size of the study was very small as the intake capacity for first MBBS in the concerned college was 120 for batch 2017. A larger study with a more stratified population size will be required to bridge this gap.

CONCLUSION(S)

The importance of laboratory safety practices needs to be reinforced in academic laboratories, particularly in laboratories dealing with corrosives and poisonous chemicals. So, training of undergraduate medical students about laboratory safety needs to be reinforced which can elude painful incidences of accidents in laboratory. So, such laboratory safety training may be incorporated in the existing undergraduate curriculum of Biochemistry in initial phases of academics.

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Annexure 1

Pre-test/Post-test

Q. 1: Answer the following Questions:

1. What is PPE? (1)

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2. Enumerate any two PPE. (2)

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3. What is OSHA? (1)

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4. What is MSDS? (1)

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5. What is Eyewash station? (1)

Que. 2: Answer as True or False: (4)

1. All chemicals should be returned to their bottles after the work is over. _____
2. For taking any reagent, mouth pipetting is preferable. _____
3. Always add acid slowly into the water. _____
4. Water can be used in case of organic solvents fire. _____

Annexure 2: BLSI

Department of Biochemistry

Biochemistry Laboratory Safety Index (BLSI)

Depending upon how the basic principles about Laboratory Safety are understood and followed, we can judge the knowledge of the student about Laboratory safety.

Tick the correct response for the given principle.

Name of the Student:

Date:

Principles of laboratory safety	Followed	Partially followed	Not followed
Scores given	01	0.5	00
Personal safety:			
1. Long hair or loose clothes should be tied back or confined in the laboratory area.			
2. Eating and drinking should be avoided in Laboratory area and eatables should not be kept on the working floor.			
3. Hands should be washed with soap and water if contaminated and also before leaving the laboratory.			
Chemicals and reagent safety:			
4. Chemicals should never be returned to reagent bottles.			
5. Avoid keeping reagent bottles on the floor from where they can be kicked over.			
6. Mouth pipetting should be avoided.			
7. Water should never be added into concentrated acid. Pour acid slowly into water, stirring constantly.			
8. In case of spillage of acid/alkali, exposed area should be washed with water and medical advice should be obtained immediately.			
Fire safety:			
9. Test tubes containing reaction mixtures, when they are being heated should be pointed away from the people.			
10. Open flames, when not in use, should be switched off.			
11. Water should not be used in case of electrical fire and organic solvents fire.			
12. Location and use of a bucket of sand with scoop and fire extinguisher should be known.			
Emergency/First aid safety:			
13. All breakages and spills should be reported to the supervisor and dealt with immediately			
14. Location and proper use of eyewash station and first aid kit should be known.			
15. Emergency evacuation route should be known.			
Biochemistry Laboratory Safety Index (BLSI) score	Total Score:		

Interpretation about knowledge of Laboratory Safety:

BLSI Score above 12: Excellent

BLSI Score between 9 to 12: Good

BLSI Score between 6 to 9: Average

BLSI Score below 6: Poor