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Effect of Educational Intervention of Laboratory Technicians' on Work Precautions and nosocomial infections

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ABSTRACT

Background: Laboratory and other health care workers are exposed to a variety of occupational health hazards, particularly laboratory-acquired infections (LAIs), due to inconsistent adherence to universal work precautions (UWP). These precautions are essential in minimizing the risk of exposure to potentially infectious materials. Despite their importance, many laboratory technicians are unaware of the risks involved, which can result in unsafe laboratory practices. This study aimed to evaluate the impact of Educational Intervention of Laboratory Technicians' on Work Precautions and nosocomial infections

Methods: An interventional study was conducted with laboratory technicians at a tertiary care teaching hospital. A pretest-posttest design was used, where participants completed a self-administered questionnaire before and after an educational intervention. The intervention consisted of two 1.5-hour interactive lectures on universal precautions and laboratory biosafety measures. The questionnaire, developed from existing biosafety guidelines, included 60 questions covering demographic information, knowledge, attitudes, and practices. Data were analyzed using statistical tests, including Pearson chi-square and paired t-tests, with a significance level set at $P < .05$.

Results: The results demonstrated a significant improvement in the knowledge, attitudes, and practices of the participants following the educational intervention ($P < .0001$). Before the intervention, 60% of participants had poor knowledge, 82.5% had moderate attitudes, and 60% exhibited poor practices. Post-intervention, 45% of participants showed good knowledge, all participants had good attitudes, and 40% demonstrated good practices. Significant improvements were observed in 14 of the 18 knowledge-related questions, 4 of the 12 attitude-related questions, and 14 of the 19 practice-related questions. The absolute learning gain was high, with a medium class average normalized gain across all sections.

Conclusion: The educational intervention significantly enhanced the knowledge, attitudes, and practices of laboratory technicians concerning universal work precautions. These findings suggest that targeted educational programs are effective in improving laboratory safety practices and reducing the risk of laboratory-acquired infections. Regular training and reinforcement of biosafety measures are essential to ensuring laboratory workers' adherence to safety protocols.

Keywords: improvements, participants, protocols, t-tests.

INTRODUCTION

Laboratory workers are typically exposed to a variety of occupational health hazards, which, if appropriate biosafety practices are not followed, can pose a serious threat to their health and safety. The prevention of

laboratory-acquired infections requires that personnel be thoroughly acquainted with universal work precautions (1).
Most laboratory technicians who are usually exposed to large volumes of clinical specimens are exposed to a myriad of possible pathogens. Unfortunately, most of them are not aware of these risks and may thus not have enough motivation to create consistent universal work precautions. The result of unsafe laboratory behavior encompasses specimen collection, transport, storage, processes, and disposal, which elevate the susceptibility of a technician to infection (2).
According to the recommendations from the CDC, universal work precautions apply to blood, body fluids with visible blood, semen, vaginal secretions, body tissues, and certain other fluids, including cerebrospinal, synovial, pleural, peritoneal, pericardial, and amniotic fluids. They generally do not apply, though, to feces, nasal secretions, sputum, saliva, sweat, tears, urine, and vomit unless those contain visible blood (3).
Universal work precautions emphasize the use of personal protective equipment such as masks, gloves, gowns, aprons, and protective eyewear. These are designed to minimize the risk of exposure to potentially infectious materials. Since explicit barriers for all possible clinical situations are often unrealistic, some judgment must be employed by healthcare professionals in selecting protective action. The need for safe handling of needles, scalpels, and other sharp instruments is important in reducing the rate at which injury may occur during a procedure and also during cleaning and the disposal of such instruments (4).
All clinical material, such as blood or specific body fluids, should be treated as if it were infectious. Laboratory personnel should be completely aware of the hazards around them and informed about biosafety principles that would promote correct safe behaviors for laboratory work, correct usage of containment facilities, and efficient procedures for the disposal of waste (5).
Awareness, perception of threats, beliefs, access to resources, workload, and workplace culture can influence adherence to biosafety practices by a laboratory worker. Laboratory technicians should therefore have the knowledge, attitude, and skills to apply safe practice principles consistently (6). The education intervention may, thus, be one of the effective methods of raising awareness, improving adherence to universal precautions, and bringing behavior change in attitudes and stated practices that may help reduce risk for LAI (7).
This is further corroborated by studies that have established that educational interventions contribute to a reduction in infection rates among health workers. For instance, one review by Safdar and Abad reported drastic declines in the rates of laboratory-associated infections, ranging between 0% and 0.79%, following targeted educational interventions being carried out (8).
Likewise, effective educational programs should take into consideration factors that influence compliance with biosafety among laboratory personnel to identify gaps in knowledge and practice that inform strategies or interventions aimed at reducing the risks of infection (9). These educational strategies should be stringently evaluated for their potential to ensure the required improvement in laboratory safety practice before being formally adopted into institutional policy (10).
In the light of these facts, the present study was a questionnaire-based interventional study that evaluated the efficacy of Educational Intervention of Laboratory Technicians' on Work Precautions and nosocomial infections

MATERIALS AND METHODS

It was an interventional study in which self-administered questionnaires were used for assessing the knowledge, attitudes, perceptions, and practices of the laboratory technicians working in a central clinical laboratory of a tertiary care teaching hospital. The purpose was to study the effectiveness of an educational intervention on any gap in education and work practices. Ethical Committee approval from the institutional ethics committee was obtained for the study.
In fact, the respondents had been adequately informed about the nature, content, scope, and purpose of the research. They were promised that their participation was strictly voluntary and their individual answers would be anonymous. Only those volunteers who had given verbal consent were included. For clarity, instructors were also present in case any participant asked questions.
All subjects completed a pretest questionnaire before receiving an educational intervention consisting of two interactive 1.5-hour lectures on the topics of universal precautions and laboratory biosafety measures. Lectures were given by the principal investigator. Participants completed a posttest questionnaire that was identical to that used in the pretest afterwards.
The structured questionnaire was designed in the light of related literature, based on guidelines from the World Health Organization's Laboratory Biosafety Manual and the Centers for Disease Control and Prevention's Perspectives in Disease Prevention and Health Promotion Update. For clarity and relevance, the questions were critically reviewed by senior subject experts and modified where necessary.
This study was conducted in a specific demonstration hall with a seating arrangement that had numbers. Each participant randomly chose a seat, and the questionnaires were distributed according to the seat numbers in order to maintain anonymity. Accordingly, questionnaires were linked with seat numbers only to keep participants' personal data confidential.

The questionnaire contained 60 questions divided into four sections:

1. Demographic information (5 questions)
2. Knowledge assessment (18 questions)
3. Attitudes/perceptions assessment (12 questions)
4. Practices assessment (19 questions)

The knowledge assessment included multiple-choice questions, yes/no items, and enumerative questions. The attitudes/perceptions assessment used a 1- to 5-point Likert scale ranging from strongly agree to strongly disagree. Similarly, the practices assessment used a 1- to 5-point Likert scale, with responses ranging from never to always.

For the scoring system, participants received 1 point for each correct response related to knowledge, positive attitudes/perceptions, and correct practices, and 0 points for incorrect knowledge, negative attitudes/perceptions, or suboptimal practices. Scores of 75% or higher were considered good, 50% to 74% moderate, and less than 50% poor.

Statistical Analysis

Responses were compiled and tabulated using Microsoft Excel 2010 software. Appropriate statistical tests were applied as needed. Pearson chi-square tests were used to calculate p-values for the pretest and posttest responses. Paired t-tests were used to compare pretest and posttest scores, with statistical significance set at $p < .05$.

To assess the effectiveness of the educational intervention, absolute learning gain and class average normalized gain were calculated as follows:

1. **Absolute learning gain**: (posttest score) – (pretest score)
2. **Class average normalized gain (g)** was calculated using Hake's criteria:

- Low gain: 0.1 to 0.29
- Medium gain: 0.3 to 0.69
- High gain: 0.7 to 1.0

RESULTS

Knowledge of Universal Work Precautions

The evaluation of knowledge regarding universal work precautions, measured through pretest and posttest questionnaires, revealed a significant improvement in knowledge following the educational intervention ($P < .00001$).

Prior to the training, the majority of participants (60%) demonstrated poor knowledge, 25% showed moderate knowledge, and only 15% displayed good knowledge. After the training, 45% of participants achieved good knowledge levels, 32.5% exhibited moderate knowledge, and only 22.5% had poor knowledge.

Significant differences were found between pretest and posttest responses for 14 of the 18 knowledge-related questions, highlighting a notable increase in participants' knowledge after the intervention.

Attitudes Regarding Universal Work Precautions

The evaluation of attitudes revealed a statistically significant improvement following the training ($P < .0001$). Before the training, 82.5% of participants had moderate attitudes, while 17.5% showed good attitudes, and none had poor attitudes. After the training, all participants demonstrated good attitudes regarding universal work precautions.

A significant improvement in attitude was observed in 4 of the 12 attitude-related questions when comparing pretest and posttest responses.

Practices Regarding Universal Work Precautions

The assessment of practices indicated a statistically significant improvement in practice levels after the intervention ($P < .0001$). Before the training, 60% of participants exhibited poor practice levels, 30% had moderate levels, and only 10% had good practices. After the training, 40% of participants demonstrated good practices, 35% exhibited moderate practices, and 25% had poor practices.

A significant difference in practice levels was noted for 14 out of the 20 practice-related questions, indicating substantial improvement after the training.

As shown in the tables, a high absolute learning gain was observed in all three sections. The class average normalized gain, calculated using Hake's criteria, revealed a medium learning gain across all sections. However, the knowledge and practice sections showed comparable and slightly higher learning gains than the attitude section.

Table 1. Knowledge of universal work precautions among laboratory technicians

		Correct responses				
		Before training		After training		
Question/item		n	%	n	%	P value[a]
K1	Are you aware of universal work precautions?	16	40	28	70	.007**
K2	Body fluids to which universal work precautions apply.	18	45	30	75	.01206*
K3	Body fluids to which universal work precautions do not apply.	7	17.5	24	60	.0001**
K4	Are you aware of potential risks of being infected at your workplace?	28	70	36	90	.025347*
K5	Are you aware of prophylactic measures to be taken in the event of injury/exposure?	16	40	25	62.5	.044105*
K6	According to the World Health Organization, how many steps of hand washing do you know?	9	22.5	27	67.5	.00005**
K7	What is the minimum time needed for alcohol-based hand rub to kill most germs on your hands?	8	20	24	60	.00026**
K8	If hands are not visibly soiled/contaminated, which method is most effective for reducing number of pathogenic bacteria on the hands?	6	15	18	45	.0034*
Components of universal precautions						
K9	Avoid injury with sharp	28	70	36	90	.02535*
K10	Barrier precautions	30	75	34	85	NS
K11	Hand hygiene	34	85	39	97.5	.048*
K12	Mention names of various PPE for lab workers	12	30	18	45	NS
K13	How is liquid waste disinfected in labs?	26	65	28	70	NS
K14	How are blood samples discarded after serum preparation?	30	75	34	85	NS
K15	Actions to be taken in case of accidental blood spillage	6	15	17	42.5	.0066*
K16	Actions to be taken in case of needle-stick injury (after exposure prophylaxis)	8	20	19	47.5	.0093*
K17	Actions that are prohibited on laboratory premises	20	50	30	75	.021*
K18	Risk of acquiring HIV infection following needle-stick injury	6	15	20	50	.00083**

[a] Significance was calculated using Pearson chi-square test. NS indicates $P > .05$ (not significant).
* $P < .05$ (significant); ** $P < .001$ (highly significant).

Table 2. Attitudes regarding universal work precautions among laboratory technicians

		Positive attitude				
		Before training		After training		
Question/item		n	%	n	%	P value[a]
A1	Universal precautions should be strictly followed by all health care workers.	30	75	40	100	NS
A2	Do you believe that keeping proper personal hygiene decreases the risk of infection?	25	62.5	36	90	.004*
A3	I have sufficient knowledge to properly follow biosafety precautions.	15	37.5	24	60	NS
A4	Correct hand hygiene practices should be adhered at all times.	27	67.5	32	80	NS
A5	I feel guilty when I omit hand hygiene.	24	60	38	95	.000178
A6	Wearing gloves eliminates the need to wash hands.	17	42.5	28	70	.0132*
A7	Do you believe that overcrowding of the working area increases transmission of infection?	26	65	32	80	NS

A8	Do you think that an increased workload increases the risk of laboratory-acquired infections?	34	85	36	90	NS
A9	Proper biomedical waste management practices is essential.	32	80	38	95	NS
A10	In my opinion, it is important to always use gloves while manipulating human samples.	36	90	40	100	NS
A11	I have the capability to curb poor practices in my workplace.	23	57.5	30	75	NS
A12	Training programs regarding universal precautions should be conducted regularly for laboratory workers.	20	50	37	92.5	.000027**

[a] Significance was calculated using Pearson chi-square test. NS indicates $P > .05$ (not significant).
[*] $P < .05$ (significant); [**] $P < .001$ (highly significant).

Table 3. Practices regarding universal work precautions among laboratory technicians

		Correct practices				
		Before training		After training		
Question/item		n	%	n	%	P value[a]
P1	Do you wash your hands with soap and water after taking a sample?	20	50	30	75	.02*
P2	Do you wash your hands immediately when you come into contact with blood, body fluids, or contaminated items?	26	65	35	87.5	.02*
P3	Do you routinely use alcohol-based hand rub for hand hygiene?	18	45	27	67.5	.04*
P4	Do you wear gloves and apron during work?	27	67.5	36	90	.014*
P5	Do you wear gloves and apron outside the workplace?	30	75	37	92.5	.034*
P6	Do you wear a mask during sputum sample collection and processing?	32	80	40	100	.013*
P7	Do you recap needles before disposal?	26	65	12	30	.002*
P8	Do you discard disposable needles and other sharps into puncture-resistant containers?	20	50	30	75	.02*
P9	Do you cover wounds and cuts on your skin before you start your work?	36	90	40	100	NS
P10	Do you eat or drink in your work area?	32	80	37	92.5	NS
P11	Do you cover spills of blood or body fluids with 1% freshly prepared sodium hypochlorite for 10 minutes and then mop dry?	15	37.5	33	82.5	.0071*
P12	Do you always wash hands or use hand rub after removing gloves?	27	67.5	34	85	NS
P13	Do you dispose biomedical waste in appropriate color-coded containers?	30	75	38	95	.01*
P14	Do you take off gloves when working on the computer?	32	80	39	97.5	.01*
P15	Do you take off your gloves while using a phone?	27	67.5	36	90	.014*
P16	Do you take a shower immediately after laboratory work?	12	30	23	57.5	.0132*
P17	Do you cover the sample prior to centrifugation?	27	67.5	33	82.5	NS
P18	Are high-risk samples received in leak-proof containers?	30	75	34	85	NS
P19	Are workstations decontaminated on a regular basis?	32	80	37	92.5	NS

[a] Significance was calculated using Pearson chi-square test. NS indicates $P > .05$ (not significant).
[*] $P < .05$ (significant).

Table 4. Comparison of mean pretest and posttest knowledge, attitude, and practice scores

	Mean test score + SD		Absolute learning gain	Class average normalized gain (g)			
	Pretest	Posttest			df	t value	P value[a]

Knowledge	7.68 ± 4.72	12.13 ± 3.86	4.45	0.6	39	12.49	<.001*
Attitude	7.7 ± 1.07	10.2 ± 0.72	2.50	0.43	39	13.44	<.0001**
Practice	12.08 ± 3.21	16.2 ± 2.00	4.13	0.6	39	10.06	<.0001**

[a] Significance was calculated using paired *t* test.
* $P < .001$ (significant); ** $P < .0001$ (highly significant).

DISCUSSION

In this study, we observed that over 70% of laboratory technicians had poor knowledge regarding universal work precautions before the training program, a result consistent with previous research. For instance, Zaveri and Karia (2) found that only 20.8% of their study subjects had awareness of universal work precautions, with the majority not even familiar with the term. Similar findings were reported by Omokhodion (11), Alam (12), Odusanya (13), Ejilemele and Ojule (14), Suchitra et al. (15), and El Gilany et al. (1), who all documented low knowledge, attitudes, and practices related to universal work precautions. These results highlight the general lack of awareness and the need for education and training in this area.

However, contrasting results were found in the studies by Goswami et al. (16) and Gurubacharya et al. (17), who reported high levels of knowledge, attitude, and practice regarding universal work precautions among their study populations. These discrepancies may be attributed to differences in training programs, institutional support, and regional factors, which may vary across settings. In our study, the significant improvement in knowledge after the training is consistent with these studies, which highlight the value of educational interventions in improving the understanding and implementation of universal work precautions.

In terms of knowledge assessment, our study asked 18 questions, with 14 showing a significant increase in correct responses after the training intervention. This indicates that the training was effective in improving the technicians' understanding of universal work precautions. However, certain questions related to barrier precautions, personal protective equipment (PPE), liquid waste disinfection, and the method of discarding blood samples did not show a significant improvement. This lack of improvement can be attributed to the fact that the pretest results for these areas already demonstrated a relatively high level of knowledge, leaving less room for enhancement. In particular, knowledge about PPE remained relatively low even after the intervention, which suggests that further training and emphasis on these areas may be needed.

The results of this study underscore the positive impact of educational interventions on the knowledge, attitudes, and practices of laboratory technicians regarding universal work precautions. After the training, the majority of technicians showed significant improvements in these areas. Our findings align with several previous studies, such as those conducted by Suchitra et al. (15), Goswami et al. (16), Malgaonkar and Kartikeyan (18), El-Gilany et al. (1), and Gaikwad et al. (6,7). These studies also reported improvements in laboratory workers' understanding and adherence to universal work precautions following training interventions. Notably, El-Gilany et al. (1) emphasized the importance of conducting regular, repeated training sessions to reinforce safe laboratory practices, an approach that could potentially enhance the retention of knowledge over time.

One of the most concerning practices we identified in our study was the routine recapping of needles, reported by 65% of the laboratory technicians prior to the training. Recapping needles is a high-risk behavior that increases the likelihood of needle-stick injuries, a leading cause of laboratory-acquired infections. This practice is explicitly discouraged in biosafety guidelines, such as those in the "Biosafety in Microbiological and Biological Laboratories" (19). The results from our study are consistent with those of Nasim et al. (20), who found that 50% of laboratory technicians engaged in the risky practice of recapping needles. However, after the educational intervention, most of the participants in our study discontinued this unsafe practice, highlighting the effectiveness of the training in addressing hazardous behaviors. This finding underscores the importance of ongoing education to reduce risky practices and improve safety in laboratory environments.

Another unsafe practice we assessed was the reuse of disposable syringes, which was reported by 24% of healthcare providers in a study by Kamal and Khan (21). This practice is problematic as it exposes healthcare workers to potential bloodborne pathogens. In our study, we found similar concerns regarding improper syringe disposal. Nasim et al. (20) found that 43% of public sector workers disposed of used syringes inappropriately, such as by throwing them into regular trash bins without proper safeguards. Similarly, Habibullah and Afsar (22) reported that only 35% of healthcare facilities properly disposed of needles by cutting them before disposal. Following our training program, we observed a marked improvement in syringe disposal practices, as the majority of technicians were found to be adhering to the correct disposal methods. This change further emphasizes the positive impact of training on laboratory safety practices.

Centrifuge machines were another area of concern in our study. Centrifuges can be a significant source of aerosol dispersal in laboratories, and improper use can lead to the inhalation of potentially infectious aerosols. The US Department of Health and Human Services, the Centers for Disease Control and Prevention, and the National Institutes of Health recommend capping tubes and ensuring that centrifuges are closed during operation to avoid exposure to these aerosols (18). Our study found that more than 65% of technicians followed the correct practice of closing centrifuge machines before use, and this practice improved to 87.5% after the training. These results suggest that the training was effective in changing practices related to the use of centrifuges, which is a critical area for reducing laboratory-acquired infections.

The retention of knowledge and practices over time remains a challenge, as highlighted by Suchitra et al. (15), whose study showed that respondents' performance declined in subsequent posttests. Similarly, Wagner et al. (24) observed that knowledge retention can decrease over time if training is not reinforced. This underscores the need for repeated and ongoing training sessions to ensure that laboratory technicians continue to adhere to safety practices and that knowledge retention is sustained over the long term. Regular training sessions, as recommended by El-Gilany et al. (1), could be a key factor in improving knowledge retention and ensuring that laboratory technicians consistently follow universal work precautions.

In conclusion, this study demonstrated a statistically significant improvement in laboratory technicians' knowledge, attitudes, and practices related to universal work precautions following the educational intervention. The results support the effectiveness of the training program but also indicate that there is still room for improvement. To address the issues of persistently low levels of knowledge and practices, further refinement of training modules and a more targeted approach, particularly for lower-performing individuals, are necessary. Future studies should explore the integration of additional factors, such as institutional support, work culture, and workload, which may influence the adoption of safe laboratory practices.

While self-administered questionnaires were used to assess the levels of practice in this study, it is important to note that this method may introduce reporting bias, as respondents may tend to over-report their adherence to safe practices. Direct observation of practices through checklist-based assessments would provide more accurate data on the effectiveness of educational interventions in changing actual behavior. This could be an important avenue for future research to validate the findings of this study and ensure that training programs lead to measurable improvements in laboratory safety.

The findings from this study, along with those of previous research such as Safdar and Abad (6), who reviewed 26 studies on healthcare worker training programs, emphasize the importance of educational interventions in reducing laboratory-acquired infections. However, improving laboratory practices requires a multifaceted approach, addressing not only knowledge but also factors such as institutional policies, available resources, and staff motivation. Future studies should continue to investigate these factors to assess the long-term impact of educational interventions on laboratory safety and adherence to universal work precautions.

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