ORIGINAL ARTICLE

Assessment of Chemical Safety Awareness Among University Laboratory Workers

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ABSTRACT

Introduction: Occupational injuries and diseases due to chemical exposure can occur if the aspect of chemical safety management is neglected at workplaces. This study investigated the chemical safety awareness among university laboratory workers. **Methods:** One hundred and fifty-one laboratory workers were selected randomly from laboratories located in three schools of the Universiti Sains Malaysia Health Campus. A validated questionnaire regarding knowledge and awareness of chemical safety was distributed among the respondents. **Results:** Descriptive analysis showed that the level of chemical safety awareness was moderate. The result found no significant differences between the three schools' knowledge ($p=0.24$) and awareness ($p=0.72$) on chemical safety. Significant correlations were found between the workers' knowledge and awareness of chemical safety ($p<0.05$) for each school. **Conclusion:** Continuous training related to personal protective equipment was recommended to enhance the workers' knowledge of chemical safety and, thus, preserving their awareness level.

Keywords: Chemical safety awareness, Laboratory workers, Knowledge, Attitude

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INTRODUCTION

In the developing world of science and technology, wide use of chemicals in laboratories is usually seen. Chemical hazard is a significant occupational health and safety issue in the workplace these days (1). The worker who handle chemical every day face a more prominent risk than anyone who is not. Furthermore, the chemical commonly used in the laboratory can be harmful, especially when it is not handled correctly, as guided by the standard operating procedures. Chemical safety practices are important measures that could help to reduce accidents, especially those who work in a laboratory (2). Following safe operating procedures, good housekeeping, and continuous safety training are examples of good chemical safety practices (3). Legget (4) once stated that the accident rate in academic chemical laboratories could reach up to 50-fold higher than those in industrial laboratories. Following the laboratory accident that happened in one of the universities in Los Angeles and resulted in a student's death, Langerman (5) concluded that most of the academic laboratories are considered unsafe for either studying or working. In that study, the Chemical Safety and Hazard Investigation Board identified 94 laboratory accident cases and various accidents reported in the news.

Meanwhile, there had been an accident reported in a secondary school in Penang. Thirteen school students had been shown to experience symptoms such as difficulty breathing and coughing after inhaling iodine gas that was reckoned to happen during a science experiment. Further investigation concluded that this accident occurred due to poor ventilation in the school's laboratory (6).

Laboratory accidents have been accounted for several reasons. For instance, the workers take for granted the use of personal protective equipment (PPE), lack of experiences of the person in-charged, chemical mishandlings, and the poor knowledge of the appropriate countermeasures in the presence of an emergency (7). The fire incidences that took place in three local universities in Malaysia were an excellent example of safety issues that happened in the laboratories (8).

Another recent accident had occurred in a school's laboratory where four students were burnt by hot water during an experiment, and they had to receive medical treatment at the hospital (9). On another note, chemical spills in a laboratory also had brought attention to the enforcement of safety practices in the laboratory (10). It was believed that the likelihood of these events occurring could be reduced through continuous safety awareness training among all the workers and the visitor of those particular laboratories.

Chemicals react differently. Some chemicals are potent through inhalation, while some are sensitive to skin absorption. For example, workers who work with unvented furnaces are exposed to specific concentrations of carbon monoxide. Hence, the condition will lead to headaches, nausea, and even death (11). At the same time, skin irritation may occur for accidental spillage of a highly acidic chemical onto the skin due to its corrosive characteristics (12).

All individuals who work in the laboratory need to be taught about chemical safety and be aware of it. Chemical safety is the combination between proper knowledge, a good attitude, and safe practices, with a close observation of every aspect of procedures (13). However, awareness of chemical safety is not something that can be created naturally in every worker. This aspect should be progressively taught and imparted through continuous education and training (14). Due to this, the safety level in the research and teaching institutions can be further improved by implementing safety education strategies with the involvement of all laboratory staff members (15). Therefore, safety awareness training among workers in the laboratories is required to reduce the likelihood of accidents.

Thus, the objective of this study was to determine the level of chemical safety awareness among the laboratory workers. The results obtained can provide an overview of safety concerns that can be ignored by the workers, which could lead to the deterioration of their health and produce severe health effects in the long run. This research could help to identify the loophole in safety issues that occur in the laboratories. This study will also result in the suggestion of the precautionary to reduce the unsafe act and near-miss incidents that may happen in the laboratories, for example, by doing routine check-ups and updates on the labeling of chemicals, inspection on the condition of laboratory equipment's that are used while handling chemicals, assessment on the availability and state of the personal protective equipment and monitoring of the good housekeeping of the laboratory.

METHODS AND MATERIALS

Study Background and Design

A cross-sectional study design was adopted for this study. This research aimed to study the level of chemical safety awareness among laboratory workers in Universiti Sains Malaysia Health Campus (USMKK), Kubang Kerian, Kelantan. This study had obtained approval from The Human Research Ethics Committee (USM/JEPeM/19110730) of Universiti Sains Malaysia. The researcher did a walkthrough survey of each laboratory to conform to the handling of chemicals. Afterward, the name list of workers who work in the selected laboratories was obtained from the department's administration. The number of respondents from three schools in the health campus was calculated using a sampling fraction. The inclusion criteria for this study were the workers who worked in the laboratory and utilized the chemicals, such as the medical laboratory technologists, the science officers and the assistant science officers. Lecturers and students of USMKK were excluded.

Instrumentation

Participants were given a set of questionnaires that were adopted from a previous study (16). The questionnaire was in the English language. A pilot study was conducted among 20 laboratory workers in USM Main Campus to test the validity of the questionnaire. The Cronbach's Alpha showed a good reliability value (α=0.936). The questionnaire consisted of two sections, namely Section A and Section B. The two sections were described as follows:

i. Section A was made up of 11 questions. Seven questions were regarding the respondents' demographic, employment, and workplace information. Another four questions were dichotomous (Yes/No), tested on their current knowledge and information regarding chemicals and chemical safety in the laboratory.

ii. Section B consisted of 49 statements related to chemical safety elements and one question regarding the respondents' suggestions in improving the overall safety of their laboratory. The ten elements of chemical safety included in this study were as follows:

a. Chemical Management (5 questions)
b. Laboratory Management (5 questions)
c. Personal Protective Equipment (PPE) (4 questions)
d. Safe Procedures and Practices (10 questions)
e. Operational Control Methods (5 questions)
f. Training and Education (5 questions)
g. Emergency and First Aid (7 questions)
h. Safety Data Sheet (SDS) (2 questions)
i. Warning Signs (2 questions)
j. Recordkeeping (4 questions)

In this section, knowledge and awareness aspects on chemical safety were measured based on the scale of 1 to 5, where 1 strongly disagrees, 2 disagrees, 3 is indecisive, 4 agrees, and 5 strongly agrees. For the result, the data was presented in mean and standard variation. Meanwhile, a scale of 1 to 5 was used to indicate the

mean value of the chemical safety awareness. The scale of 1 to 2 was recognized as having a low awareness level, a scale of 3 as moderate level, and a scale of 4 to 5 as having a high level of awareness.

Data Collection

This study has been approved by The Human Research Ethics Committee of USM. This data collection was carried out from December 2019 until February 2020. The respondents were recruited using a random sampling method. A total of 151 respondents that were selected randomly had participated in this study, which carried 84.4% of the response rate. Prior to data collection, a short briefing was conducted to describe the purpose of the research and the process of answering the questionnaire booklet. Only those who gave their written consents were selected as the respondents. The respondents were guaranteed that their personal information would not be compromised. The respondents took around 15 minutes to answer the questionnaire booklet and the booklet was collected after its completion.

Data Analysis

The data were analyzed using IBM's Statistical Package for Social Sciences (SPSS) software version 24.0. A scale of '1' to '5' that indicates low, moderate to high, respectively, was used to measure the laboratory workers' level of chemical safety awareness. The correlation between the laboratory workers' knowledge and awareness of chemical safety was tested using Spearman's correlation test. Kruskal-Wallis test was used to find the mean differences of knowledge and awareness on chemical safety between the three schools in USMKK.

RESULTS

Sociodemographic Information of the Subjects

Table I showed the sociodemographic data and work-related information for 151 respondents. Twenty-four workers were sampled from the School of Health Sciences (15.9%), 110 workers from the School of Medical Sciences (72.8%), and the rest of the respondents were from the School of Dental Sciences (11.3%). The majority of the respondents were Medical Laboratory Technologists (80.0%), and most of them employed a diploma or equivalent education level (57.6%). Out of 151 respondents, only 1 of them (0.7%) did not seem aware of Safety and Health Policy at their workplace. Besides, 94.2% of the workers reported no accidents in the laboratory in the Year 2019. It was also found that the laboratory committee practiced a regular inspection for the laboratory about one to two times every two months, and the regular inspection for the first aid box was carried out once every six months.

Table I: Sociodemographic distribution and work-related information of respondents

Variable	n	Percentage (%)
Age		
21-30	14	9.3
31-40	92	60.9
41-50	27	17.9
51-60	18	11.9
Gender		
Male	59	39.1
Female	92	60.9
School		
School of Health Sciences	24	15.9
School of Medical Sciences	110	72.8
School of Dental Sciences	17	11.3
Position		
Science Officer	16	10.6
Assistant Science Officer	8	5.3
Medical Laboratory Technologist	121	80.1
Laboratory Assistant	3	2.0
Research Officer	3	2.0
Highest Education Level		
MCE/SPM	4	2.6
Certificate (STPM)/Diploma	87	57.6
Degree/Master	60	39.7
Number of years working in the laboratory		
Less than 1 year	2	1.3
1-10 years	45	29.8
11-20 years	82	54.3
21-30 years	13	8.6
31-40 years	9	6.0
Aware of Safety and Health Policy at workplace		
No	1	0.7
Yes	150	99.3

CONTINUE

Table I: Sociodemographic distribution and work-related information of respondents (CONT.)

Variable	n	Percentage (%)
Number of accidents in the laboratory for the past 1 year (2019)		
0 time	142	94.0
1 to 2 times	7	4.6
More than 2 times	2	1.3
Regular inspection by laboratory committee		
0 time	22	14.6
1 to 2 times in every 2 months	64	42.4
More than 2 times in every 2 months	14	9.3
Regular inspection of first aid box		
0 times	15	9.9
Once in every 6 months	104	68.9
More than once, in every 6 months	7	4.6
Others	25	16.6

N=151
Note: MCE-Malaysian Certificate of Education, SPM-Sijil Pelajaran Malaysia

Elements of Chemical Safety Awareness

Table II shows the overall mean value for the elements of chemical safety awareness. This study assessed ten elements related to the subject of study. The result showed that chemical management showed the highest mean (3.74±0.46), followed by safe procedures and practices. Two elements showed a similar mean value: operational control methods (3.60±0.54) and safety data sheet (3.60±0.53), respectively. Emergency and First Aid (3.55±0.49) and recordkeeping (3.55±0.55) also had a similar mean value. Overall, all elements of chemical safety had about the same scores (~4.00) except for personal protective equipment (3.09±0.57). Whereas, total mean for knowledge and awareness on chemical safety were 3.59±0.43 and 3.49±0.40, respectively.

Table II: Total mean scores for ten elements of chemical safety awareness

No.	Element	Mean	Standard Deviation
1	Chemical Management	3.74	0.46
2	Safe Procedures and Practices	3.67	0.45
3	Safety Data Sheet (SDS)	3.60	0.53
4	Operational Control Methods	3.60	0.54
5	Laboratory Management	3.58	0.52
6	Warning Signs	3.57	0.57
7	Emergency and First Aid	3.55	0.49
8	Recordkeeping	3.55	0.55

CONTINUE

Table II: Total mean scores for ten elements of chemical safety awareness (CONT.)

No.	Element	Mean	Standard Deviation
9	Training and Education	3.47	0.50
10	Personal Protective Equipment (PPE)	3.09	0.57
	Knowledge	3.59	0.43
	Awareness	3.49	0.40

N=151

The majority of the respondents are shown to have a moderate awareness level towards chemical safety (92.72%) (Table III). At the same time, 6.62% of them had a high awareness level related to the subject of interest.

Table III Chemical safety awareness level among respondents

Awareness Level	n	Percentage (%)
Low	1	0.66
Medium	140	92.72
High	10	6.62

N=151

Differences between knowledge and awareness towards chemical safety

Table IV shows no significant differences in knowledge ($p = 0.24$) and awareness ($p = 0.27$) towards chemical safety between respondents from the School of Health Sciences, School of Medical Sciences, and School of Dental Sciences. Mean scores of knowledge and awareness on chemical safety for each school were almost at the same value.

Table IV: Difference of knowledge and awareness on chemical safety among schools

Variables	SHS	SMS	SDS	p-value
Knowledge	3.69	3.59	3.49	0.24
Awareness	3.56	3.47	3.45	0.72

Note: SHS-School of Health Sciences, SMS-School of Medical Sciences, SDS-School of Dental Sciences
*significant at $p<0.05$

Relationship between knowledge and awareness towards chemical safety

Table V shows that there were strong correlations between knowledge and awareness of chemical safety among respondents from the School of Medical Sciences ($r = 0.819$, $p<0.05$) and the School of Dental Sciences ($r = 0.870$, $p<0.05$). At the same time, knowledge and awareness of chemical safety were moderately correlated ($r = 0.524$, $p<0.05$) among respondents from the School of Health Sciences.

Table V Relationship between knowledge and awareness towards chemical safety

School	r	p-value
SHS	0.524	0.009*
SMS	0.819	<0.001*
SDS	0.870	<0.001*

Note: SHS-School of Health Sciences, SMS-School of Medical Sciences, SDS-School of Dental Sciences
*significant at p<0.001

DISCUSSION

The overall level of chemical safety awareness among laboratory workers in USMKK was moderate. Results found that the element chemical management has the highest mean score, 3.74 (SD=0.46). Most of the respondents knew that chemicals should be located according to their toxicity level, and special chambers should be present when there were experiments using hazardous chemicals. In addition, the respondents also noticed that a chemical register was available in the laboratory. This condition proved that they knew and were aware of the presence of the chemicals that were available in the laboratory. Besides, the respondents also agreed that inspection on ventilation in the laboratory should be done regularly and assign an experienced person in charge of the management of chemicals. This proved that the respondents' knowledge of chemical management was acceptable (16).

On the contrary, Personal Protective Equipment (PPE) had the lowest mean score, 3.09 (SD=0.57). This was probably because some laboratory workers felt that PPE was not needed to be used (14). Even though most of them were provided with PPE, particularly for those handling the chemicals, most of them also strongly agreed that PPE was not necessary to use in specific experiments. Due to this given situation, it was best believed that this element had the lowest score because their practices did not match their knowledge. In contrast, a previous study by Patma (16) found that element PPE had the highest total mean score among laboratory staff.

The overall level of chemical safety awareness among laboratory workers in USMKK was moderate. Around 92.7% of the respondents scored a moderate awareness level, 6.6% of the respondents achieved a high awareness level on chemical safety, and only 0.7% of the respondent scored a low level on chemical safety awareness.

The majority of respondents (29.8%) have been working in the laboratory for one to ten years, and they might not be fully trained in chemical safety management compared to experienced workers (6.0%) that have worked in the laboratory for 31 to 41 years. This resulted in a moderate level of awareness on chemical safety among the laboratory workers because a longer length of employment will lead to a higher level of knowledge regarding chemical safety in the laboratory (17).

Besides, the majority of respondents were adults with higher educational levels (18). 60.9% of the laboratory workers were 31 to 41 years old and were diploma holders (57.6%), followed by degree and Master's holders (39.7%). A previous study found a significant relationship between awareness and the workers' ages, employment years, and educational level (17). the study concluded that workers with high academic status and a long period of employment would eventually have an increase in awareness.

It was discovered that laboratory workers' knowledge and awareness levels between the three schools of USMKK did not significantly differ. This is due to the centralized training conducted by the higher management, which led to standardized safety operating procedures for workers to follow. Laboratory workers from each school also received an equal source of information from the frequent amount of training that has been given to them. The workers also reported sharing the same recommendations regarding chemical safety in the laboratory during the audit and inspection session. In summary, these factors could influence the insignificant differences between knowledge and awareness on chemical safety between the three schools.

Knowledge and awareness of chemical safety among the laboratory workers were significantly associated ($p<0.05$). 94.0% of the respondents reported that no accident occurred in the laboratory related to chemicals in 2019. This demonstrated that the laboratory workers at the workplace applied safe practices on chemical safety. The periodic inspection of the laboratory conducted by the laboratory committee also helped reduce and prevent the accident from occurring. In USMKK, laboratory inspection was conducted every two months, either one to two times (42.4%) or more than two times (9.3%). Laboratories should be inspected regularly to establish the safety and health environment of everyone at the workplace (18). The respondents performed good housekeeping practices, as 97.4% agreed that they keep the workspace clean before and after an experiment. It was also discovered that 94.0% of the respondents always drained the sinks and cleaned them after every laboratory session. According to National Research Council (19), there was a correlation between systematization in a laboratory and its level of safety. A regular pattern of safety practices performed by the workers describes the safety culture perceived by them. Therefore, a good attitude and safe practices that the laboratory workers implement in managing their work will result in an organized and clean laboratory (2). This further proved the significant correlation between the workers' knowledge and awareness of chemical safety. Kandel, Neupane, and Giri (20) stated that the storage of chemicals needed to have a separate room and not be

easily accessible to other people. Most of the respondents indicated that they have the information on this matter as 87.4% of them strongly agreed and agreed that the location of the chemical storage area must be isolated from the experimental area. In addition, regarding this issue, 99.3% of the respondents also strongly agreed that the chemical storage area must be thoroughly ventilated. The components of knowledge, attitudes, and practices were all interrelated with one another. Thus these components should be managed and nurtured into the worker's continuous or refresher training module to ensure all employees are well prepared in their work (2). In this context, it can be seen that knowledge and awareness correlated when 98.0% of the respondents stated that they had been given training on chemical safety. 94.7% of the respondents had also participated in training on emergency procedures. 94.0% of the respondents strongly agreed and agreed that a training program on chemical safety should be done at least once every two years. de Genaro Chiroli et al. (21) stated that it was essential to train and educate the workers. This was to ensure that the laboratory workers were familiar with the fundamental of safety at the workplace and knew how to implement the practices in conjunction to keep a safe environment in the laboratory.

Overall, knowledge and awareness on each element of chemical safety were correlated with one another. Therefore, the higher the level of knowledge on chemical safety, the better the practice and this could indirectly increase the awareness of chemical safety among the laboratory workers.

The strength of this study was that this study utilized a validated and reliable questionnaire; hence it can provide a good study result. However, this study can be further improved if it can achieve a 100% response rate. Nevertheless, this study has provided robust baseline data for future research. The result of this study was also able to help the campus management determine the flaw and strength of the chemical safety aspect.

CONCLUSION

This study concluded that the laboratory workers in USMKK had a moderate level of chemical safety awareness. It was found that Chemical Management is the most acknowledgeable element in this study. In spite of being the most recognizable element, laboratory workers should never neglect the knowledge that they had regarding this matter. They must keep on implementing the correct and safe attitude when it comes to managing chemicals and other elements. This study also showed no significant difference between knowledge and awareness among the laboratory workers from the three schools on the health campus. The respondents had shown a significant correlation between knowledge and awareness of chemical safety. Additional training and education on the proper use and maintenance of PPE should be given to the laboratory workers. Cooperation between laboratory workers and the management is also needed to improve the situation further.

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