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Chemical Laboratory Safety Knowledge, Attitudes And Practices

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Abstract:

Inadequate knowledge, negative attitudes and unsafe practices while handling chemicals can contribute to incidents such as fires, accidents, injuries and fatalities at academic institutions and laboratories. The purpose of this study is to evaluate the knowledge, attitudes, and practices (KAP) of lab personnel towards chemical safety atan academic institution. A cross-sectional study was conducted among 123 laboratory personnel at Makkah using purposive sampling.A self-administered questionnaire was distributed by email to collect data which was analysed using descriptive statistics, a Spearman Correlation Coefficient measures and a Chi-Squared test. In general, the respondents' knowledge and attitudes towards chemical safety were high with median sc[1]ores ranging between 79.2% and 88.9%, respectively. However, their practices were moderate, with a mean score of 74. 1%. There was a weak correlations between attitudes and the level of knowledge ($r_S = 0.38, p < 0.05$) and practices($r_S = 0.19, p < 0.05$). There were significant associations between sociodemographic data (χ^2 value, $p < 0.05$) with knowledge and practice levels. Although the overall scores were satisfactory, some aspects still need improvement, especially with regard to the Globally Harmonised System (GHS) of Classification and Labelling of Chemicals symbols, personal protective equipment (PPE) compliance and emergency response procedures. The practice of eating and drinking in laboratories by lab personnel is an issuethat also requires attention.

Keywords: *Knowledge, attitude, practice, chemical safety.*

Introduction:

Chemicals are an unavoidable aspect of modernlife. They are used to clean, disinfect, run

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equipment, treat diseases and fertilise crops, among other things. While many of the chemicals we use daily have many advantages, they can also be dangerous and pose physical health and environmental risks if they are not handled properly (Walters et al., 2017). Chemicals can have many hazardous properties which include being explosive, quickly oxidising, flammable, corrosive, irritating, radioactive or toxic (Anza et al., 2016). Chemical burns, skin and eye irritations, headaches, organ failure, cancer, and death can result from exposure to these substances (Kavalela et al., 2019). Depending on the intensity, these effects can substantially impact a person's quality of life and ability to work (Abbas et al., 2015).

In academic institutions in Saudi Arabia and many different countries, chemicals are used in laboratory sessions that arepart of the syllabus of students pursuing a degreein the Sciences as part of their formal education.These hands-on classes allow students to delve into theories they have learned and stimulate their interest in the subject (Gudyanga, 2020). Chemistry is one of the subjects in which dangerous substances are frequently employed in lab sessions. As a result, students are exposedto various chemicals during the sessions. Moreover, most universities are trying to improve their standing via research grants that would be good for their branding. This situation has resulted in more research being conducted in laboratories at universities, increasing the useof hazardous chemicals on campus (Campos & Colbourne, 2018).

While safety concerns apply to everyone exposed to potentially dangerous substances, those who work with chemicals regularly such as students and laboratory workers are particularlyvulnerable. Inappropriate practices might lead to accidents (Syed Draman et al., 2010). The deathof Sheri Sangji from the University of California (UCLA) in 2008 due to pyrophoric substances has opened the academic community's attention to the dangers in academic laboratories (Ménard& Trant, 2020). Since 2001, the United States Chemical Safety and Hazard Investigation Board (CSB) has documented 120 events inacademic institutions worldwide, involving 87 evacuations, 96 significant injuries and threedeaths (Mulcahy et al., 2013). Aside from laboratory accidents, infrastructure damage fromchemical-related fires and explosions have been reported frequently as in Malaysian universities, including a fire in a laboratory at the University of Malaya's Department of Chemistry (2001), an engineering laboratory at the Universiti Putra Malaysia (2002) and a laboratory at the Universiti Kebangsaan Malaysia's School of Applied Physics (2005) (Syed Draman et al., 2010).

Previous studies discovered most employeeshad insufficient knowledge, negative attitudes and used unsafe practices when handling chemicals (Walters et al., 2017; Gudyanga, 2020; Leung, 2021). While most students and workers had good levels of awareness regarding hazard identification, some did not accurately match the Globally Harmonised System (GHS) of Classification and Labelling of Chemicalspictograms. Meanwhile, research on studentsat universities in Jordan showed that their attitude towards chemical waste disposal and management of chemical spills was troublesome(Al-Zyoud et al., 2019). Some students believe putting chemical trash down the sink is always safe and that tiny chemical spills are not dangerous. With regards to chemical safety practices, Papadopoli et al. (2020) reported that almost half of the workers stated they eat in thelab and only half of them wear eye protection when handling chemicals.

This study aims to assess laboratory personnel's knowledge, attitudes and practices towards chemical safety in academic institutions. Risk identification, safety control measures, housekeeping, hygiene practices, chemical storage, emergency response, wastemanagement and accident investigation are the components of chemical safety (Walters et al., 2017). Underestimating these elements can increase the risk of explosions, fires, infrastructure damage and injuries or fatalities involving laboratory workers (Lestari et al., 2016).

Materials and Methods

Study Location

This descriptive cross-sectional study was conducted among lab personnel at Makkah, especially in chemical laboratories.Data was collected from lab personnel between September 2022 until November 2022. Informedwritten consent was obtained from all the subjectsbased on the approved study protocol.The confidentiality of information and anonymity of the respondents was maintained throughout this study.

Sample Size

The sample in this study was selected througha purposive sampling process. From the population size of 172 lab personnel, the sample size of this study was determined based on the calculation using the Raosoft Sample Size Calculator. With an indicator percentage of 0.50, a margin of error of 5% and confidence interval (CI) of 95%, the calculated sample size was 120. The selection criterion of the sample in this study was respondents who were lab personnel at Makkah. The lab personnel had more than one year of work experience to ensure optimum knowledge and workplace exposure. In addition,respondents were aged between 18 and 60 yearsand fluent in Malay.

Survey Method and Survey Instrument

the questionnaire wasdistributed to the laboratory personnel using online platforms including email, WhatsApp messenger and the social media platform Facebook. Questionnaires from studies by Walters et al. (2017) and Kavalela et al. (2019) were used as a guideline and adopted in this study as it had good internal consistency witha Cronbach alpha coefficient of 0.754. Researchquestions components were divided into four (4) sections marked 'A' through 'D'. SectionA was related to the demographic background of the lab's personnel. Section B was about the lab personnel's knowledge of chemical safety. The answers in Section B were dichotomous: "Yes", "No" or "Not Sure". Section C was about the attitudes of lab personnel towards chemical safety. The level of agreement was rated through 5-point Likert Scale ranging from 1 being "Strongly Disagree" to 5 being "Strongly Agree". Finally, section D was about the practices of lab personnel towards chemicalsafety. The level of agreement was rated through a scale that was marked with "Never", "Sometimes" and "Always".

Scoring System

For all three knowledge, attitudes and practises (KAP) sections, the correct answer was given a point and the incorrect answer was given no points. Then, the calculated scores for all questions were converted to a percentage. The highest percentage set-up was 100%. The total score for the level of knowledge, attitudes and practices of respondents was classified into two parts: Less than 75% = poor and more than 75% = good, based on a study by Ames et al. (2019).

Data Collection and Analysis

The data obtained in this study was analysed using Statistical Packages for the Social Sciences (SPSS) version 27. Data was collected and analysed using descriptive statistics, including calculating measures of central tendency (means and medians), standard deviation and frequencycounts. Spearman rho correlation was used to assess whether knowledge, attitudes and practice scores were associated with one another.The chi-squared test was used to determine associations between all categorical variablesand levels of knowledge, attitudes and practices. The significance level was set at $p < 0.05$.

Results and Discussion

Demographic Background of Respondents

The demographic background of the respondentsis shown in Table 1. A total of 123 participants completed the survey, with slightly higher numbers of female lab personnel than males. Most of the lab personnel were aged between 31and 40 years (74%) and almost half (46.3%) of the lab personnel worked in the institution for 11 to 15 years.

Characteristics	n (N=123)	Percentage (%)
Age (years)		
20 - 30	7	5.7
31 - 40	91	74.0
> 40	25	20.3
Gender		
Male	59	48.0
Female	64	52.0
Educational level		
SPM	32	26.0
Diploma	40	32.5
Degree and above	51	41.5
Duration of employment (years)		
1 - 5 years	11	8.9
6 - 10 years	21	17.1
10 - 15 years	57	46.3
More than 15 years	34	27.6
Types of laboratory		
Teaching laboratories	102	82.9
Research/service laboratories	21	17.1
Participation in chemical safety training		
Yes	114	92.7
No	9	7.3

Knowledge of Chemical Safety

The respondents' knowledge of GHS pictograms is summarised in Table 2. A total of 117 (95.1%)and 90 (73.2%) personnel were able to recognisethe symbols "toxic to the environment" and "acute toxicity", respectively. However, many respondents could not interpret the "oxidisers" and"health hazards" questions which involved 50(40.7%) and 53 (43.1%) personnel, respectively.The most frequently chosen incorrect answerfor the "oxidisers" symbol was "flammable". Meanwhile, for the "health hazard" symbol, most respondents (43.1%) chose "irritation" and"acute toxicity". For the skull and crossbones pictogramme, which is "acute toxicity", the mostfrequent incorrect answers were "carcinogenic"and "health hazard".

From the knowledge of GHS pictogram results, it can be concluded that there is a discrepancy between awareness (familiarity) and knowledge (comprehensibility-which oneacquires from specific training). Even though the workers were familiar with the symbols, their comprehension was insufficient. Kavalela et al. (2019) reported that 95% of the staff and students in another institution in Malaysia could correctly match explosive, corrosive, flammable, irritant and oxidizer pictograms, respectively, indicating that they have a very high understanding of laboratory safety signs and symbols. Thus, the university should be assigned as a reference university and educational visits are necessary to understand the university's environment which contributes to the high comprehension levels among their staff and students.

Knowledge Questions		Correct Answer (%)	Wrong Answer (%)
1.	GHS symbol: Oxidisers	73 (59.3)	50 (40.7)
2.	GHS symbol: Health hazard	70 (56.9)	53 (43.1)
3.	GHS symbol: Acute toxicity	90 (73.2)	33 (26.8)
4.	GHS symbol: Toxic to the environment	117 (95.1)	6 (4.9)

Table 3 shows the respondents' responses to chemical safety knowledge questions. The respondents' knowledge of chemical safety wasconsidered satisfactory with more than 75% of respondents answering 13 out of 17 questions correctly. However, on the question regarding the knowledge of preparation of the chemical register, only 78 (63.4%) of the respondents answered "yes" to the question. Besides, only 53 (43.1%) respondents answered "yes" on handling emergency cases related to inhalation and ingestion of toxic chemicals. This result indicated that 50% of the respondents could notmanage chemical incidents if or when it occurs in the workplace. Further information regardingrespondents' responses to chemical safety questions is shown in Table 3.

This study finding is in line with Leung's (2021) study among lab personnel in Hong Kong where the correct responses on the awareness level of GHS symbols and Emergency Response Preparedness (ERP) were 67% and 94.5%, respectively. However, this ran counter tothe findings by Walters et al. (2017) and Al- Zyoud et al. (2019) in which the knowledge level of undergraduate students from multiple institutions was "low". This may suggest that workers' training status and working experience were important factors contributing to the high knowledge levels compared to undergraduatestudents. Undergraduate students usually have less experience with chemicals and theonly training they have is before starting anexperiment or before the semester begins (Wu et al., 2021).

Therefore, based on an analysis of chemical safety knowledge questions among lab personnel, it was shown that the respondents of this study have a high level of knowledge (79.17±15.13). However, the low level of respondents' knowledge of GHS symbols should be noted. There were high numbers of respondents who did not know howto interpret the oxidiser, health hazard and acutetoxicity symbols. Attention should also be givento their insufficient knowledge of chemical spillincidents and the proper way to use chemical spill kits.

	Question	Number of Responses (%)		
		Yes	No	Not Sure
1.	I know how to read Safety Data Sheets.	**101 (82.1)**	8 (6.5)	14 (11.4)
2.	I know the location of the Safety Data Sheet waskept in the laboratory.	**106 (86.2)**	3 (2.4)	14 (11.4)
3.	I know how to fill up chemical registers.	**78 (63.4)**	21 (17.1)	24 (19.5)
4.	All types of gloves give the same level of protection.	1 (0.8)	**120 (97.6)**	2 (1.6)
5.	All types of masks give the same level of protection.	3 (2.4)	**118 (96.0)**	2 (1.6)
6.	I know how to do appropriate donning and doffing PPE procedures.	**100 (81.3)**	10 (8.1)	13 (10.6)

7.	Fume hoods can be used as permanent storage forchemicals.	14 (11.4)	**107 (87.0)**	2 (1.6)
8.	Easily oxidized chemicals can be stored withflammable chemicals.	2 (1.6)	**111 (90.2)**	10 (8.2)
9.	I know how to store chemicals that need to havespecial storage conditions.	**93 (75.6)**	7 (5.7)	23 (18.7)
10.	I know the procedures to follow for chemicalwaste disposal.	**106 (86.2)**	4 (3.2)	13 (10.6)
11.	I know the location of the emergency safetyequipment	**109 (88.6)**	13 (10.6)	1 (0.8)
12.	I know how to use emergency safety equipment.	**94 (76.4)**	28 (22.8)	1 (0.8)
13.	When my supervisor was not around, I knewwhom to contact in case of an emergency.	**113 (91.9)**	2 (1.6)	8 (6.5)
14.	I know the emergency response procedure mustbe followed in chemical spills incidents.	**88 (71.6)**	10 (8.1)	25 (20.3)
15.	I know what should be done in the event of a gasleak.	**72 (58.5)**	15 (12.2)	36 (29.3)
16.	I know what should be done if any chemicalssplash to the eyes.	**116 (94.3)**	2 (1.6)	5 (4.1)
17.	I know how to intervene in case of inhalation oringestion of any chemicals.	**53 (43.1)**	19 (15.4)	51 (41.5)

Attitudes Towards Chemical Safety

Table 4 shows the respondents' responses to chemical safety attitude questions. Respondents' attitudes towards chemical safetywere considered high because more than 75% answered nine questions correctly. However, attitudes towards chemical waste disposal and chemical spills were a bit concerning since the percentages of the correct answers were below 80%. For chemical waste disposal, 20.3% of respondents thought it is always safe to dispose of chemical waste by throwing it down the sink. On the other hand, some respondents (22.8%) thought it was unnecessary to report minor chemical spills to a supervisor. Further information regarding respondents' responses tochemical safety attitudes questions is shown in Table 4.

Regarding chemical waste disposal, some lab personnel still disposed chemicals in thesink. Therefore, chemical waste may accumulatein the university's environment or find its way into the nearby stream or drainage, thus, posing health risks to the residents (Al-Zyoud et al., 2019). This result is similar to that of Al-Zyoudet al. (2019) study where 31.6% of the tertiary students were still practising chemical disposal down the sink or drain. In Malaysia, chemical waste packaging, labelling and storage of were promulgated under the Environmental Quality Act 1974 and the Environmental Quality (Scheduled Wastes) Regulations 2005 which aremonitored by the Department of Environment, Environment and Water Ministry (Department of Environment, 2014).

Therefore, based on the analysis of chemical safety knowledge questions among the lab personnel, it was shown that the respondents of this study have very positive attitudes (88.89±13.12) towards all chemical safety components. Most lab personnel wereaware that they should follow general safetyprocedures such as avoiding drinking and eatingin the lab. They also realised the importanceof risk assessment before using any chemicals. Moreover, they followed the correct procedures for chemical disposal and managing, cleaning up chemical spills. Most of them agreed that fume hoods and PPE were essential control measures when handling chemicals. Speaking personally, most lab personnel claim their co-workers were handling the chemicals in accordance with prescribed safety protocols. These findings match those in a study by Walters et al. (2017) where most students at the German Jordanian University had a good attitude towards chemical safety, including chemical waste disposal, accident reporting and the use of PPE.

Questions	**Number of Responses (%)**		
	Agree/ Strongly Agree	**Neutral**	**Disagree/ Strongly Disagree**
1. Eating and drinking in the laboratory are hazardous.	**118 (96.0)**	2 (1.6)	3 (2.4)
2. The skill of interpreting the labels of hazardous chemicals can prevent accidents and injuries in the laboratory.	**122 (99.2)**	1 (0.8)	0 (0)
3. It is very important to handle chemicals in the fume hood.	**117 (95.1)**	5 (4.1)	1 (0.8)
4. Disposing all types of chemical waste into the sink and diluting it with large amounts of water is safe.	11 (9.0)	14 (11.3)	**98 (79.7)**
5. Minor chemical spills are harmless, regardless of the type of chemical spill.	13 (10.6)	8 (6.5)	**102 (82.9)**
6. It is necessary to report even minor chemical spills to a supervisor.	**95 (77.2)**	17 (13.8)	11 (9.0)
7. Chemical safety courses are very important for laboratory staff.	**121 (98.4)**	0 (0)	2 (1.6)
8. Wearing a lab coat at all times is necessary while in the lab.	**115 (93.5)**	4 (3.3)	4 (3.2)
9. My co-workers handle chemicals according to safety procedures (e.g., using a fume hood, complete PPE, etc.).	**111 (90.3)**	9 (7.3)	3 (2.4)

Practices on Chemical Safety

Table 5 shows the participants' responses to chemical safety practices questions. The results showed that 101 (82%) lab personnel confessed that they always or sometimes worked alone during chemical experiments. Moreover, for the question "Have you ever eaten or drunk in the lab area?", there were 32 (26%) respondents admitted they sometimes ate or drank in the lab. Only 60 (48.8%) respondents consistently wore complete PPE such as safety glasses, lab coats, covered shoes and gloves while handling chemicals. In addition, less than half of the respondents (36.6%) claimed they wore safety glasses when handling chemicals or conducting experiments. Further information regarding respondents' responses to chemical safety practices questions are shown in Table 5.

From the survey, not all lab personnel consistently wore a complete PPE while handling chemicals such as safety glasses, lab coats, covered shoes and gloves. Moreover, safety glasses are not preferred when handling chemicals or conducting experiments. This result is lower than a study conducted in Hong Kong by Leung (2021), where most lab personnel frequently used complete PPE while working with chemicals. Previous studies have shown that the use of PPE varied from 10% to 82% depending on its accessibility, adequacy, affordability, fitness to the user and discomfort (Aluko et al., 2016; Negatu et al., 2016; Asgedom et al., 2019).

Low participation in fire safety training among lab personnel is concerning. Training must be conducted periodically andinclude first-hand activities such as fire drills and exercises that allow laboratory personnelto simulate responses in an emergency. The syllabus must include the class of fire, the proper selection of the type of fire extinguisher (whether ABC powder, carbon dioxide, foamor wet chemical) as well as practices with the Pull-Aim - Squeeze - Sweep (PASS) method with the fire extinguisher (ACS Committee on Chemical Safety, 2017). In a previous study by Walters et al. (2017), when students were askedwhat to do in case of a gas leak or fire, someof them answered “run out of the building”, “run to safety” or “run out of area” which are incorrect responses and could lead to issues liketrampling. This demonstrated that most workersor students may be indecisive when responding to a fire emergency without proper training.

Overall, most lab personnel showedmoderate practice (74.14±12.83) in almostall items for this research question (Table 5). However, less than 50% of the lab personnel consistently wore a complete PPE, especially safety glasses when handling chemicals. Apart from that, some of them admitted that they werealways or sometimes eating or drinking in the lab. Participation in fire safety training and regular medical check-up was also low. These findings were similar to that of other studies which demonstrate the importance of university management intervention (Walters et al., 2017; Ayi & Hon, 2018; Leung, 2021).

Questions		**Number of Responses (%)**		
		Always	**Sometimes**	**Never**
1.	Did you read the safety procedures before anexperiment was started?	**89 (72.4)**	33 (26.8)	1 (0.8)
2.	How often do you work alone when doingexperiments involving chemicals?	48 (39.0)	53 (43.1)	**22 (17.9)**
3.	Have you ever eaten in the lab area?	1 (0.8)	31 (25.2)	**91 (74.0)**
4.	How often do you wash your hands afterremoving gloves after handling chemicals?	**122 (99.2)**	1 (0.8)	0 (0)
5.	Did you check the chemical label beforeusing it?	**111 (90.2)**	12 (9.8)	0 (0)
6.	Before using new or unfamiliar chemicals,do you read the Safety Data Sheet (SDS)?	**68 (55.3)**	48 (39.0)	7 (5.7)
7.	Do you wear safety glasses when handlingchemicals or conducting experiments?	**45 (36.6)**	64 (52.0)	14 (11.4)
8.	How often do you wear complete PPE whilehandling chemicals in the laboratory?	**60 (48.8)**	63 (51.2)	0 (0)
9.	How often do you check that emergencysafety equipment is working or not?	**62 (50.4)**	55 (44.7)	6 (4.9)

10.	How often do you use appropriate ventilation equipment (example: Fume hood)?	**102 (82.9)**	17 (13.8)	4 (3.3)
11.	How often do you participate in fire safety training?	**28 (22.7)**	75 (61.0)	20 (16.3)
12.	Have you ever read and checked emergency routes in your lab?	**61 (49.6)**	55 (44.7)	7 (5.7)
13.	How often do you do health inspections to find out your health status?	**30 (24.4)**	63 (51.2)	30 (24.4)

The Correlations between the Level of Lab Personnel's Knowledge, Attitudes and Practices on Chemical Safety

Spearman's rho correlation coefficient calculation was performed to define the strength of the correlation between the level of knowledge, attitudes, and practices on chemical safety among the 123 respondents. There was a weak relationship between attitudes with the level of knowledge (r_S = 0.38, $p < 0.05$) and practices (r_S = 0.19, $p < 0.05$) (Table 6). However, no statistically significant correlation ($p \geq 0.05$) between knowledge and attitude was observed.

This result demonstrated that lab personnel with a high level of knowledge have appropriate chemical handling practices. This also meant that lab personnel with a low level of knowledge had poor chemical handling techniques. This positive association finding is consistent with Walters et al. (2017) study where there is a weak correlation ($r = 0.138$) between what the students know and what they put into practice. As a result, it can be interpreted that the higher a person's knowledge and awareness of a hazard, the more likely they are to take precautionary measures to lower the risk of chemical incidents.

Parameter	r_S	p-value
Knowledge and practices	0.382	<0.000*
Knowledge and attitudes	0.048	0.601
Attitudes and practices	0.193	0.033*

Associations between Demographic Background with Respondents' Level of Knowledge, Attitudes and Practices on Chemical Safety

A Chi-square test was used to identify the association between demographic background and lab personnel's level of chemical safety knowledge, attitude, and practices. Based on the test result, no independent variable has any significant relationship with attitude.

Table 7 shows the associations between chemical safety knowledge levels and respondents' and participation in chemical safety training (χ^2 = 16.99, p = 0.002) (χ^2 = 8.45, p = 0.001) (χ^2 = 13.49, p = 0.001). Thus, this finding suggests that implementing OSHMS could improve OSH performance and promote a safe culture in the workplace, as concluded by previous studies (Psomas, 2011; Vinodkumar & Bhasi, 2011; Petra & Kleinová, 2014; Awang et al., 2019; Nurhazirah et al., 2021).

Chemical safety knowledge among respondents was also associated with their participation in chemical safety training. Of 92.7% of the respondents participating in chemical safety training, 71.1% have a good knowledge level (Table 7). Some 7.3% of the respondents never participated in chemical safety training, the majority (88.9%) have poor knowledge levels.

These results implied chemical safety training strongly affects lab personnel's knowledge. Moreover, a previous study found safety training is a central part of workplace intervention to enhance the safetyculture and is widely reported to have a positiveimpact on workers' safety performance (Siti Fatimah Bahari, 2011; Mashi et al., 2016; Lyu et al., 2018; Bond et al., 2020; Vallières et al., 2021).

Knowledge and practice	**Level**		**Total (%)**	χ^2	**p-value**
	Poor (n=41)	**Good (n=82)**	**(N=123)**		
Participation in chemical safety training					
Yes	33 (28.9)	81 (71.1)	114 (92.7)	13.49	0.001*
No	8 (88.9)	1 (11.1)	9 (7.3)		

To summarise, this study demonstrated that chemical safety knowledge, attitudes and practices were not associated with gender, age, educational level, and duration of employment. This finding is consistent with that of Leung (2021) who proved that gender, age and jobposition did not influence the chemical safety knowledge, attitude and practices of lab workers in universities in Hong Kong. In this study, the chemical safety knowledge of the lab personnel was related to their department, and training status. Thus, pilot studies should be done at the respective departments as well as at the place of work level to determine their safety climate or safety culture Nonetheless, our findings contradict with the study among students in Trinidad in which the scores of safe practices such as reading chemical labels, safety work instructions and wearing protective equipment, differed based on the age and year of study of the respondent's programme (Walters et al., 2017). These associations indicated a higher inclination to usesafe practices in older senior students as they are more mature than younger junior students. This may not be the case for our study as most ofthe lab personnel have similar ages (between 31and 40 years) and have been working in Makkah for more than ten years. Meanwhile, some studies showed that implementing OSHMS in universities improved the safety culture (Njeru, 2014; Nurhazirah et al., 2021). Altogether, highknowledge, attitudes and practices level among lab personnel in Makkah and high participationin chemical safety training demonstrated theimportance of safety training.

Conclusion

In summary, it was found that most labpersonnel in Makkah have a "good" level of chemical safety knowledge and attitudes. Meanwhile, the practice was "moderate", suggesting that inspection must be done regularly to ensure safe chemical handling methods. Although the overall score was satisfactory, some aspects need improvement, especially on GHS symbol interpretations, PPE-use compliance and emergency response procedures. In addition, lab personnel's practice of eating and drinking in laboratories is an issue that requires attention. Moreover, research on chemical safety should be done on specific topics such as hazard identification, risk assessment and control, PPE,fire safety or chemical waste management at academic institutions. Besides, more detailedmaterial and findings such as inspection reports must be compiled to conclude proven evidence of safe work practices. Furthermore, future studies on the impact of the OSH management system in an academic setting are needed to determine the degree of improvement of an institution's safety practices once the system has been implemented.

Reference:

Abbas, M., Zakaria, A., & Balkhyour, M. (2015). Investigation of safety facilities andsafe practices in chemical laboratories of a Saudi University. Journal of Environment and Safety, 7(2), 141-147.

ACS Committee on Chemical Safety. (2017). Safety in Academic Laboratories: Best Practices for First- and Second-Year University Students (8th ed.). American Chemical Society (ACS) Joint Board-Council Committee on Chemical Safety.

Al-Zyoud, W., Qunies, A. M., Walters, A. U. C., & Jalsa, N. K. (2019). Perceptions of chemical safety in laboratories. Safety, 5(2),112-118.

Aluko, O. O., Adebayo, A. E., Adebisi, T. F., Ewegbemi, M. K., Abidoye, A. T., & Popoola, B. F. (2016). Knowledge, attitudes and perceptions of occupational hazards and safety practices in Nigerian healthcare workers. BMC Research Notes, 9, 16-20.

Ames, H., Glenton, C., & Lewin, S. (2019). Purposive sampling in a qualitative evidence synthesis: A worked example from a synthesis on parental perceptions ofvaccination communication. BMC MedicalResearch Methodology, 19(1), 1-9.

Anza, M., Bibiso, M., Kuma, B., & Osuman, K. (2016). Investigation of laboratory and chemical safety in Wolaita Sodo University,Ethiopia. Chemistry and Materials Research, 8(11), 11-15.

Asgedom, A. A., Bråtveit, M., & Moen, B. E. (2019). Knowledge, attitude and practicerelated to chemical hazards and personal protective equipment among particleboard workers in Ethiopia: A cross-sectional study. BMC Public Health, 19(1), 1-10.

Awang, N., Baharudin, M. R., & Saliluddin, S. M. (2019). Occupational Safety and HealthManagement System (OSHMS): Perceptionand safety satisfaction among employeesin certified. International Journal of Education and Research, 7(7), 37-44.

Ayi, H. R., & Hon, C. Y. (2018). Safety cultureand safety compliance in academic laboratories: A Canadian perspective.Journal of Chemical Health and Safety, 25(6), 6-12.

Bahari, S.F. (2011). An Investigation of Safety Training, Safety Climate andSafety Outcomes: A Longitudinal Study in a Malaysian Manufacturing Plant [Doctoral Thesis, The University of Manchester] Proquest Dissertations Publishing. 10029228.

Boelhouwer, E., Davis, J., Franco-Watkins, A., Dorris, N., & Lungu, C. (2013). Comprehension of hazard communication: Effects of pictograms on safety data sheets and labels. Journal of Safety Research, 46, 145-155.

Bond, M. R., Gammie, A. E., & Lorsch, J. R. (2020). Developing a culture of safety in biomedical research training. Molecular Biology of the Cell, 31(22), 2409-2414.

Cournoyer, M. E., Trujillo, S., Lawton, C. M., Land, W. M., & Schreiber, S. B. (2016). Anatomy of an incident. Journal of Chemical Health and Safety, 23(6), 40-48.

Department of Environment (DOE). (2014). Guidelines for packaging, labelling and storage of sceduled waste in Malaysia. http:// www.doe.gov.my/portalv1/en/info-untuk- industri/garis-panduan-buangan-terjadual/ bahasa-english-guidelines-for-packaging- labelling-and-storage-of-scheduled-wastes-in-malaysia/314634

Gherheș, V., Stoian, C. E., Fărcașiu, M. A., & Stanici, M. (2021). E-learning vs. face- to-face learning: Analyzing students' preferences and behaviors. Sustainability (Switzerland), 13(8), 226-227.

Gudyanga, R. (2020). Probing physical sciencesteachers' chemical laboratory safetyawareness in some South African High Schools. African Journal of Research inMathematics, Science and Technology Education, 24(3), 423-434.

Kasmani, N., Shakira, F., Azhar, A., Mazidah, S., Badrul, S., Afrina, A., & Manaf, A. (2021). The delivery of environmental health services in Malaysia: The currentstatus and the way forward. MAEH Journalof Enviromental Health, 3(1), 1-8.

Kavalela, E. N. N., Chelliapan, S., & Kamyab, H.(2019). Evaluation of awareness and safetyamong students and technicians in UTM research chemical laboratories. Journal of Advanced Research in Occupational Safetyand Health, 1(1), 1-8.

Leung, A. H.-H. (2021). Laboratory safety awareness, practice, attitude, and perception of tertiary laboratory workers in Hong Kong: A pilot study. ACS Chemical Health& Safety, 28(4), 250-259.

Lyu, S., Hon, C. K. H., Chan, A. P. C., Wong, F. K. W., & Javed, A. A. (2018). Relationshipsamong safety climate, safety behavior, and safety outcomes for ethnic minorityconstruction workers. International Journalof Environmental Research and Public Health, 15(3), 1-16.

Martin, F., & Bolliger, D. U. (2018).Engagement matters: Student perceptionson the importance of engagement strategiesin the online learning environment. Online Learning Journal, 22(1), 205-222.

Mashi, M. S., Subramaniam, C., & Johari, J. (2016). The effect of safety training and workers involvement on healthcare workers safety behavior: The moderating role of consideration of future safety consequences. International Journal of Business Management, 1(2), 46-81.

Ménard, A. D., & Trant, J. F. (2020). A review and critique of academic lab safety research,Nature Chemistry, 12(1), 17-25.

Mulcahy, M. B., Young, A., Gibson, J., Hildreth,C., Ashbrook, P., Izzo, R., & Backus, B. (2013). College and university sectorresponse to the U.S. chemical safety board Texas Tech incident report and UCLA laboratory fatality. Journal of Chemical Health and Safety, 20(2), 6-13.

Negatu, B., Kromhout, H., Mekonnen, Y., & Vermeulen, R. (2016). Use of chemical pesticides in Ethiopia: A cross-sectional comparative study on knowledge, attitude and practice of farmers and farm workersin three farming systems. Annals of Occupational Hygiene, 60(5), 551-566.

Njeru, D. K. (2014). Factors that influence implementation of occupational safety and health management system at public universities in Kenya-A case study of Egerton University. International Journal of Current Research, 6(5), 6602-6609.

Nurhazirah, W., Harun, W., & Harun, R. (2021). Evaluation of Occupational Health and Safety Management System (OHSMS) performance and awareness among the employees in the faculty of engineering,Universiti Putra Malaysia (UPM). Journalof Occupational Safety and Health, 18(1), 1-10.

Papadopoli, R., Nobile, C. G. A., Trovato, A., Pileggi, C., Pavia, M., & Pavia, M. (2020).Chemical risk and safety awareness, perception, and practices among research laboratories workers in Italy. Journal ofOccupational Medicine and Toxicology, 15(1), 25-29.

Petra, S., & Kleinová, R. (2014). The new healthand safety standard iso 45001:2016 and its planned changes. International Journal of Interdisciplinarity in Theory and Practice, 43-47.

Psomas, E. L. (2011). Motives, difficulties and benefits in implementing the ISO 14001environmental management system. Management of Environmental Quality: AnInternational Journal, 22(1), 120-126.

Schröder, I., Czornyj, E., Blayney, M. B., Wayne, N. L., & Merlic, C. A. (2020). Proceedings of the 2018 Laboratory Safety Workshop: Hazard and Risk Management in the Laboratory. ACS Chemical Health& Safety, 27(2), 96-104. https://dx.doi. org/10.1021/acs.chas.0c00012

Syed Draman, S. F., Daik, R., & Abdullah, M. L. (2010). Globally harmonized system: A study on understanding and attitude towards chemical labeling amongst students of secondary school. CSSR 2010 - 2010International Conference on Science and Social Research, CSSR, 1305-1308.

Vallières, F., Mubiri, P., Agyemang, S. A., Amon, S., Gerold, J., Martineau, T., Nolan,A., O’Byrne, T., Sanudi, L., Sengooba, F., & Prytherch, H. (2021). Determinantsof safety climate at primary care level in Ghana, Malawi and Uganda: A cross- sectional study across 138 selected primary healthcare facilities. Human Resources for Health, 19(1), 1-11.

Vinodkumar, M. N., & Bhasi, M. (2011). A study on the impact of management systemcertification on safety management. Safety Science, 49(3), 498-507.

Walters, A. U. C., Lawrence, W., & Jalsa, N. K. (2017). Chemical laboratory safetyawareness, attitudes and practices of tertiarystudents. Safety Science, 96, 161-171.

Wu, K., Jin, X., & Wang, X. (2021). DeterminingUniversity Students' Familiarity and Understanding of Laboratory Safety Knowledge-A Case Study. Journal of Chemical Education, 98(2), 434-438.