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ASSESSMENT OF KNOWLEDGE, ATTITUDES AND PRACTICES OF LABORATORY PERSONNEL TOWARDS CHEMICAL SAFETY IN UNIVERSITI TEKNOLOGI MARA CAMPUSES, MALAYSIA

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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 at an academic institution. A cross-sectional study was conducted among 123 laboratory personnel at Universiti Teknologi Mara (UiTM), Malaysia 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 scores 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 department, campus and training status (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 issue that also requires attention.

Keywords: Knowledge, attitude, practice, chemical safety.

Introduction

Chemicals are an unavoidable aspect of modern life. They are used to clean, disinfect, run 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 Malaysia, chemicals are used in laboratory sessions that are part of the syllabus of students pursuing a degree in 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 exposed to 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 use of 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 particularly vulnerable. Inappropriate practices might lead to accidents (Syed Draman *et al*., 2010). The death of 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 in academic institutions worldwide, involving 87 evacuations, 96 significant injuries and three deaths (Mulcahy *et al*., 2013). Aside from laboratory accidents, infrastructure damage from chemical-related fires and explosions have been reported frequently 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 employees had 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 Chemicals pictograms. Meanwhile, research on students at 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 the lab 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, waste management 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 UiTM in Malaysia, especially in chemical laboratories such as the Institute of Science, Faculty of Health Science, Faculty of Applied Sciences, Faculty of Medicine and Faculty of Chemical Engineering. Data was collected from lab personnel between September 2021 until November 2021. Informed written consent was obtained from all the subjects based on the approved study protocol by the UiTM Research Ethics Committee, Universiti Teknologi MARA, UiTM bearing the following reference number, Ref.: 600-TNCPI(5/1/6) REC/08/2021 (MR/640). The confidentiality of information and anonymity of the respondents was maintained throughout this study.

Sample Size

The sample in this study was selected through a purposive sampling process. From the population size of 172 lab personnel from a chemical lab at UiTM, 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 UiTM. 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 years and fluent in Malay.

Survey Method and Survey Instrument

Due to the feasibility and safety reasons as per the COVID-19 pandemic, the questionnaire was distributed 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 with a Cronbach alpha coefficient of 0.754. Research questions components were divided into four (4) sections marked 'A' through 'D'. Section A 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 chemical safety. 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 frequency counts. 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 variables and 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 respondents is 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 31 and 40 years (74%) and almost half (46.3%) of the lab personnel worked in the institution for 11 to 15 years.

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 recognise the 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 answer for 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 most frequent 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)

Table 1: Demographic background of respondents (N=123)

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
Department		
Faculty of Applied Sciences	34	27.6
College of Engineering	14	11.4
Faculty of Medicine	29	23.6
Hospital UiTM	9	7.3
Others	37	30.1
Campus		
Eastern Region Campus	7	5.7
Central Region Campus	91	74.0
Northern Region Campus	19	15.4
East Malaysia Campus	6	4.9
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

Table 2: Respondents' knowledge of GHS pictograms (N=123)

	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)

and knowledge (comprehensibility-which one acquires 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.

Table 3 shows the respondents' responses to chemical safety knowledge questions. The respondents' knowledge of chemical safety was considered 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 not manage chemical incidents if or when it occurs in the workplace. Further information regarding respondents' responses to chemical safety questions is shown in Table 3.

The percentage of respondents' knowledge of emergency equipment handling is shown in Figure 1. Most lab personnel were familiar with all emergency safety equipment's location and proper use in this study.

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 to the 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 undergraduate students. Undergraduate students usually have less experience with chemicals and the only training they have is before starting an experiment or before the semester begins (Wu *et al*., 2021).

Therefore, based on an analysis of chemical safety knowledge questions among lab personnel in UiTM, 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 how to interpret the oxidiser, health hazard and acute toxicity symbols. Attention should also be given to their insufficient knowledge of chemical spill incidents and the proper way to use chemical spill kits.

Attitudes Towards Chemical Safety

Table 4 shows the respondents' responses to chemical safety attitude questions. Respondents' attitudes towards chemical safety were considered high because more than 75% answered nine questions correctly. However,

Table 3: Distribution of respondents' knowledge of chemical safety (N=123)

	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 was kept 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 for chemicals.	14 (11.4)	**107 (87.0)**	2 (1.6)
8.	Easily oxidized chemicals can be stored with flammable chemicals.	2 (1.6)	**111 (90.2)**	10 (8.2)
9.	I know how to store chemicals that need to have special storage conditions.	**93 (75.6)**	7 (5.7)	23 (18.7)
10.	I know the procedures to follow for chemical waste disposal.	**106 (86.2)**	4 (3.2)	13 (10.6)
11.	I know the location of the emergency safety equipment	**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 knew whom to contact in case of an emergency.	**113 (91.9)**	2 (1.6)	8 (6.5)
14.	I know the emergency response procedure must be 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 gas leak.	**72 (58.5)**	15 (12.2)	36 (29.3)
16.	I know what should be done if any chemicals splash to the eyes.	**116 (94.3)**	2 (1.6)	5 (4.1)
17.	I know how to intervene in case of inhalation or ingestion of any chemicals.	**53 (43.1)**	19 (15.4)	51 (41.5)

*Responses in bold are the correct answers to the appropriate attitudes

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 to chemical safety attitudes questions is shown in Table 4.

Regarding chemical waste disposal, some lab personnel still disposed chemicals in the sink. Therefore, chemical waste may accumulate in the university's environment or find its way into the nearby stream or drainage, thus, posing

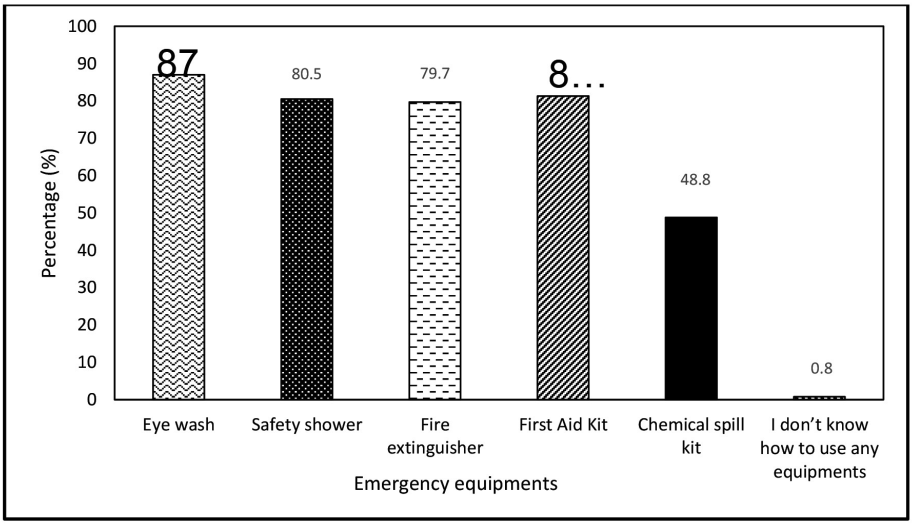

Figure 1: Respondents' knowledge of emergency response equipment

Table 4: Distribution of respondents' attitudes towards chemical safety (N=123)

	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)

*Responses in bold are the correct answers to the appropriate attitudes health risks to the residents (Al-Zyoud *et al*., 2019). This result is similar to that of Al-Zyoud *et 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 are monitored 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 in UiTM, 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 were aware that they should follow general safety procedures such as avoiding drinking and eating in the lab. They also realised the importance of 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.

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 in UiTM is concerning. Training must be conducted periodically and include first-hand activities such as fire drills and exercises that allow laboratory personnel to 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, foam or 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 asked what to do in case of a gas leak or fire, some of them answered "run out of the building", "run to safety" or "run out of area" which are incorrect responses and could lead to issues like trampling. This demonstrated that most workers or students may be indecisive when responding to a fire emergency without proper training.

Overall, most lab personnel showed moderate practice (74.14±12.83) in almost all items for this research question (Table 5). However, less than 50% of the lab personnel

Table 5: Distribution of respondents' practices on chemical safety (N=123)

	Questions	Number of Responses (%)		
		Always	Sometimes	Never
1.	Did you read the safety procedures before an experiment was started?	**89 (72.4)**	33 (26.8)	1 (0.8)
2.	How often do you work alone when doing experiments 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 after removing gloves after handling chemicals?	**122 (99.2)**	1 (0.8)	0 (0)
5.	Did you check the chemical label before using 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 handling chemicals or conducting experiments?	**45 (36.6)**	64 (52.0)	14 (11.4)
8.	How often do you wear complete PPE while handling chemicals in the laboratory?	**60 (48.8)**	63 (51.2)	0 (0)
9.	How often do you check that emergency safety 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)

*Responses in bold are the correct answers to the appropriate practices

consistently wore a complete PPE, especially safety glasses when handling chemicals. Apart from that, some of them admitted that they were always 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).

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.

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. Meanwhile, there were significant relationships between department, campus and training status with knowledge level. Moreover, there were also significant relationships between department and campus at practice level.

Table 7 shows the associations between chemical safety knowledge levels and respondents' department, campus region 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).

Based on the chi-square cross tabulation, the College of Engineering Studies showed the highest number of respondents (85.7%) with good knowledge levels compared to other departments (Table 7). An Occupational Safety and Health (OSH) course was embedded in the syllabus taught to the students in this department. Moreover, this may also be due to the engineering college's status that was accredited with ISO 45001: 2018, Occupational Safety and Health Management System (OSHMS). This is the only department in UiTM that has had this certification since 2019. Under OSHMS, the department must follow strict guidelines such as good safety policy, documentation, implementing hazard identification [using Hazard Identification, Risk Assessment and Risk Control (HIRARC) analysis], and providing good control measures and proper waste management. 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).

The majority (87.5%) of the respondents from other region campuses (east, west and south region campuses) have a high knowledge level (Table 7). However, only 59.3% of respondents from the central region campuses have a good knowledge level. Thus, the results concluded that the location of central region campuses (Shah Alam Main Campus and Selangor Branch Campus) which are in urban areas influences the knowledge level of the lab personnel. This result provides new insights into the association between chemical safety knowledge and the location of the institution, among lab personnel in Malaysia. Non-central region campuses have a small number of employees and can conduct

Table 6: Correlations between level of lab personnel's knowledge, attitudes and practices

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*

*Spearman's rho test with *p*-value < 0.05, N = 123

Table 7: Associations between respondents' demographic background and their chemical safety knowledge level

Variable	Knowledge Level		Total (%) (N=123)	χ^2	*p*-value
	Poor (n=41)	Good (n=82)			
Department					
Faculty of Applied Sciences	6 (17.6)	28 (82.4)	34 (22.6)	16.99	0.002*
College of Engineering	2 (14.3)	12 (85.7)	14 (11.4)		
Faculty of Medicine	16 (55.2)	13 (44.8)	29 (23.6)		
Hospital UiTM	6 (66.7)	3 (33.3)	9 (7.3)		
Others	11 (29.7)	26 (20.3)	37 (30.1)		
Campus					
Central Region	37 (40.7)	54 (59.3)	114 (74.0)	8.45	0.004*
*Others Region	4 (12.5)	28 (87.5)	32 (26.0)		
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)		

*Chi-square test ($p < 0.05$)
*Other region consists of the East, West and South Region Campuses

face-to-face safety training with a small group of workers. Meanwhile, central region campuses, conduct safety training online, to accommodate the higher student numbers. Importantly, researchers found face-to-face training to be more effective than online training as it allowed better engagement between learners and instructors (Martin & Bolliger, 2018; Gherheș *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 safety culture and is widely reported to have a positive impact on workers' safety performance (Siti Fatimah Bahari, 2011; Mashi *et al*., 2016; Lyu *et al*., 2018; Bond *et al.,* 2020; Vallières *et al*., 2021).

Meanwhile, Table 8 shows the associations between respondents' demographic background and their chemical safety practice levels. The Chi-square test of independence indicated significant associations between level of practices and respondents' departments and campus region (χ^2 = 20.59, $p < 0.0001$) (χ^2 = 7.92, $p = 0.007$).

Based on the chi-square cross tabulation data, the Faculty of Applied Sciences showed the highest number of respondents (79.4%) with good practices compared to other departments (Table 8). This might be due to it being the oldest science-based department in UiTM. Thus, habits of safe handling practices have been developed among their workers. Moreover, Occupational Safety and Health (OSH) were taught to students from the Applied Sciences and embedded in the syllabus as was done with students at the College of Engineering Studies. Thus, experts in the departments could convey the chemical safety information to the students and the workers. The Faculty of Applied Sciences also has a chemistry

Table 8: Associations between respondents' demographic background and their chemical safety practice level

Variable	Practice Level		Total (%) (N=123)	χ^2	*p*-value
	Poor (n=57)	Good (n=66)			
Faculty/ Department					
Faculty of Applied Sciences	7 (20.6)	27 (79.4)	34 (27.6)	20.59	<0.0001*
College of Engineering	5 (35.7)	9 (64.3)	14 (11.4)		
Faculty of Medicine	13 (44.8)	16 (55.2)	29 (23.6)		
Hospital UiTM	5 (55.6)	4 (44.4)	9 (7.3)		
Others	27 (73)	10 (27)	37 (30.1)		
Campus/Branch					
Central Region	49 (53.8)	42 (46.2)	91 (74)	7.92	0.007*
Others Region	8 (25)	24 (75)	32 (34)		

*Chi-square test ($p < 0.05$)
*Other region consists of the East, West and South Region Campuses

subunit with a chemist as their instructor or supervisor, contributing to respondents' higher-level of chemical safety practices. Thus, these findings suggest the important role of experts in safety climate development in an organisation, as reported in existing literature (Boelhouwer *et al*., 2013; Cournoyer *et al*., 2016; Schröder *et al*., 2020; Kasmani *et al*., 2021).

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 job position 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, campus location and training status. Besides, their level of chemical safety practices was only related to departments and campus location. Thus, pilot studies should be done at the respective departments as well as at the campus 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 use safe 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 of the lab personnel have similar ages (between 31 and 40 years) and have been working in UiTM 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, high knowledge, attitudes and practices level among lab personnel in UiTM and high participation in chemical safety training demonstrated the importance of safety training.

Conclusion

In summary, it was found that most lab personnel in Universiti Teknologi Mara (UiTM), Malaysia 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 detailed material 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.

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