# A Study Survey of Awareness of Jordanian Chemists about Chemical Hazards

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## Abstract

This study is an attempt to identify the level of awareness of safety measures practiced in the survey was conducted between September and December 2020 among chemists graduated in Jordan in several working sectors (teaching, Laboratory work and in manufactures). A total of 245 eligible subjects were asked to participate in the study. The majority were females (71.0%), their ages ranged from 18 to 40 years, and most of them were between 18-22 (62.9%). As for educational qualifications, 65% were students. 77.1% of them had a good knowledge of chemistry. Most of the accidents were in the laboratory by females (68%), 78% of the accidents were by females in the household. The age of 18-22 (58.9%) caused most of the accidents in the laboratory. Also, the age of 18-22 (69.9%) caused most of the accidents in the household. 55.5% of laboratory accidents were from students. As result females and students were the major reason for chemical accidents. There is no significant difference in the average attitude towards chemical safety by age. There is no significant difference in the average attitude towards chemical safety as per education.

***Keywords—*** *Awareness, chemical safety; safety perceptions; laboratory safety.*

## Introduction

The amount and variety of chemicals used in workplaces, households, and others have led to an increase in chemical accidents. Chemical accidents include fires, explosions, or leaks that can cause illness, injury, disability, or death. These accidents affect the environment, disrupt societies, and the economic burden in many countries. Hazardous chemicals are controlled and managed through relevant laws and regulations to prevent chemical accidents.

A chemical incident is defined as the uncontrolled emission of a toxic material, which results in harming the health and the environment surrounding it. Chemical incidents can occur because of natural activities, or because of accidental or intentional activities. These incidents can be rapid and severe or have a slow onset when there is a 'silent' release of a chemical. Also, they can also range from slight releases to full-scale main crises [(1)]. The term "chemical incident" might refer to anthropogenic or technological events, including:

- an explosion at a place of work that stores or uses chemicals.
- contamination of a chemical with food or water supply.
- an oil spills.
- a leak during transportation from a storage unit.
- deliberate release of chemicals in conflict or terrorism.
- an outbreak of disease that is associated with chemical exposure.

Chemists are dealing with dangerous materials that

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can be irritant, explosive, flammable, radioactive, or a health hazard. Accidents in industrial factories, chemical laboratories & chemical storages, or even in houses have been reported worldwide for several reasons, such as an absence of personal protective equipment (PPE), limited experience, mishandling of chemicals, and lack of knowledge about the proper actions to be taken in emergency cases [1]. A list of chemical incidents illustrated in table 1.

**Table 1 : Chemical Incidents**

| Date | Chemical Incidents |
|---|---|
| December 6, 1917 | Halifax, Canada. The Halifax Explosion. A ship loaded with about 9,000 tons of high explosives destined for France caught fire as a result of a collision in Halifax harbour, and exploded. The explosion killed about 2,000 and injured about 9,000. |
| October 4, 1918 | T. A. Gillespie Company Shell Loading Plant explosion. An ammunition plant in Sayreville, New Jersey exploded, killing approximately 100 people, destroying 300 buildings and causing $18 million in damages. |
| March 1, 1924 | 1924 Nixon Nitration Works disaster. A plant for processing ammonium nitrate in Edison, New Jersey exploded, killing 24 people, injuring 100 and destroying several buildings. |
| July 17, 1944 | Port Chicago Disaster. A munitions explosion that killed 320 people occurred at the Port Chicago Naval Magazine in Port Chicago, California. |
| Nov 27, 1944 | RAF Fauld Explosion. Explosion of between 3500 and 4000 tonnes of ordnance in an underground munitions store that killed 70 people. |
| August 9, 1965 | Little Rock AFB, Searcy, Arkansas. 53 contract workers were killed during a fire at a Titan missile silo. The cause of the fire was determined to be a welding rod damaging a hydraulic hose carrying Aerozine 50 fuel. This allowed the hypergolic fuel vapors to spread throughout the silo, which were then ignited by an open flame. |
| April 13, 1976 | Lapua Cartridge Factory explosion. An explosion in a munitions factory in Lapua, Finland kills 40 workers. |
| May 5, 1983 | “6 Martie” Ammunition Factory in Zărnești, Romania.[1] An explosion in the production facilities inside the factory completely destroyed two buildings, killing 37 people and injuring more than 300. |
| April 10, 1988 | Ojhri Camp, Rawalpindi, Pakistan. A military storage center exploded, killing more than 90 people. |
| July 11, 2011 | Evangelos Florakis Naval Base explosion, Cyprus. The disaster occurred when 98 containers of gunpowder exploded; 13 people were killed, among them the captain of the base, three commanders, twin brothers who were serving there as marines, and six firefighters. 62 people were injured, and the explosion knocked out the island’s power station for days. |

The likelihood of these events can be minimized if chemicals are used and stored properly and under strict safety regulations and rules. As a result, regulations and laws have been developed by different organizations for using chemicals with potential hazards, through Safety Data Sheets (SDS) or labels. Labels are assigned to each chemical according to the potential hazard it may cause, and chemists should be familiar with the meaning of each label to know how it should be handled. Crucially, the United Nations Conference on the Environment and Development UNCED) has recognized that a Globally Harmonized System (GHS) of classification and labeling of chemicals was needed (1).

Proper comprehension and interpretation of the dangerous chemicals &chemical labels is a very important factor for preventing accidents anywhere. Most of the studies that were conducted were aimed at students of chemistry and related branches of work in chemistry laboratories, chemical laboratory safety among college students in Trinidad and Tobago (1).

Regulatory standards - such as the Process Safety Management (PSM), the Risk Management Plan Rule Standard in the USA, and the Seveso III Directive in Europe - require locations where hazardous chemical products are stored and used to comply with their requirements (2). These regulatory standards should prompt a process safety protocol for any chemical-physical laboratory in industry and academia.

In academic physical and chemical laboratories, where toxic and flammable chemical products are handled, there should be qualified personnel. However, according to Olewski and Snakard (2017) (3), student and research staff turnover is an important reason why compliance with these regulations is difficult in short-term experiments in academic research laboratories. Also, process safety information should be available when performing the routine analysis. However, when research is conducted, process safety information is usually part of the research. This creates a difficult problem from a safety standpoint if poor process safety information procedures are in place during the research. Ultimately, poor information on process safety for short-term experiments can occur due to the high turnover of students and postdoctoral researchers (2)

It is recommendations to the creation of the Chemical Hygiene Plan, involving: i) lab planning and inspections, ii) the creation of safety policies, and iii) training for students and staff (2).

To ensure safety and security in scientific laboratories, the following requirements must be met: (4)

1) Risk management: It is the preventive aspect of laboratory work and aims to prevent or reduce risks to individuals and facilities, reduce losses and avoid recurring accidents.

2) Laboratory practices: It is the practical aspect that includes all practical activities related to the science course. It is imperative that these activities are sound and properly performed according to the instructions regulating them. Failure to perform tasks due to lack of knowledge, carelessness, or haste may cause accidents.

3) First aid: It represents the therapeutic aspect that is no less important than the preventive and practical side of safety procedures in the laboratory. In many cases, good behavior in an emergency and providing first aid to injured people in the laboratory can be critical.

The aim of this work was to evaluate chemist knowledge in workplaces regarding the safe use of chemicals and chemicals products in Jordan.

## Methods

### Study design

The survey was conducted between September and December 2020 among chemists graduated in Jordan in several working sectors (teaching, Laboratory work and in manufactures). A total of 245 questionnaire were conducted.

It is divided into the following secondary questions:

1) What is the level of awareness of safety measures (i.e., laboratory risk management, appropriate laboratory

practices, and first aid for laboratory injuries).

2) Are there statistically significant differences in the degree of awareness of safety procedures used by the participants due to practical experience at ($\alpha \leq 0.05$)?

3) Are there statistically significant differences in the degree of awareness of the safety procedures used by the participants due to the educational level at ($\alpha \leq 0.05$)?

**Survey instruments**

The questionnaire was developed based on the literature reviews of comparable studies. The questionnaire consisted of 20 items distributed into the following five sections: Personal Information, Knowledge of Chemicals, Attitude towards Chemical Laboratory Safety, Chemical Laboratory Safety Practices, Emergency Equipment and Procedures,

Statistical analysis

Statistical analysis was developed using STATA software program, version 16 (Stata Corporation. College Station, Tx).

Data were summarized using frequencies and percentages for categorical data and mean and standard deviations for continuous data. Univariate and stepwise multivariate logistic regression analyses were performed to determine the independent association of explanatory variables.

## Results

**Subjects characteristics**

A total of 245 eligible subjects were asked to participate in the study. The majority were females (71.0%), their ages ranged from 18 to 40 years, and most of them were between 18-22 (62.9%). As for educational qualifications, 65% were students. 77.1% of them had a good knowledge of chemistry. 65.0% had good knowledge of hazardous chemicals, for an issue (how many chemical accidents have you been involved in), most of the answers were between 1 to 3 accidents (89.8%).

The frequency and the percent are illustrated in Table 2.

**Table 2 Demographic, professional and knowledge of chemical hazards characteristics of the responders**

| Characteristic | | Frequency | Percent |
|---|---|---|---|
| Gender | male | 71 | 29.0 |
| | female | 174 | 71.0 |
| Age | 18-22 | 154 | 62.9 |
| | 23-30 | 44 | 18.0 |
| | 31-39 | 15 | 6.1 |
| | ABOVE 40 | 32 | 13.1 |
| educational qualification | Currently student | 160 | 65.3 |
| | Post graduate students | 19 | 7.8 |
| | Teachers | 14 | 5.7 |
| | Lab technicians | 12 | 4.9 |
| | Lab managers | 6 | 2.4 |
| | Instructors (master or doctor) | 15 | 6.1 |
| | Others | 19 | 7.8 |

**_Cont..._ Table 2 Demographic, professional and knowledge of chemical hazards characteristics of the responders**

| | | | |
|---|---|---|---|
| Knowledge of chemistry | Minor | 42 | 17.1 |
| | Good | 189 | 77.1 |
| | Expert | 14 | 5.7 |
| Interest in chemical hazardous | YES | 163 | 66.5 |
| | NO | 82 | 33.5 |
| How many chemical accidents where you involved in | 1-3 | 220 | 89.8 |
| | 4-6 | 12 | 4.9 |
| | MORE THAN 6 | 12 | 4.9 |
| | BASICALLY ALWAYS | 1 | 0.4 |

Three questions 7, 8 and 9 were asked, then linked to basic information (age, gender, and education), and a chi-square test was administered to these questions.

Q7-where was most of these accidents?

Q8- what was the type of accident?

Q9- What is the major reason for the chemical accident?

The result shows that:

Most of the accidents were in the laboratory by females (68%), 78% of the accidents were by females in the household. The age of 18-22 (58.9%) caused most of the accidents in the laboratory. Also, the age of 18-22 (69.9%) caused most of the accidents in the household. 55.5% of laboratory accidents were from students. As result females and students were the major reason for chemical accidents. 60% of instructor masters or doctors saw that absence of protection as the main cause for the chemical accident. The persons whose age 18-22 saw that the limited experience as the main cause reason for the chemical accident.

The second part concerns the types of situations that are considered chemical accidents. For them, the answer was agreed or disagree, or neutral, Cronbach's alpha was applied, and it gives a score of 0.671 for these questions. T-tests and analysis of variance were performed on these questions to answer whether there were statistically significant differences in the levels of study structures that could be attributed to age, gender, and education. Table 3 shows the mean, standard deviation, and position of the position elements of chemical safety.

A t-test was performed for independent samples to test that there were no differences in the levels of the study structures that could be attributed to gender, and there was a significant difference in the mean attitude towards chemical safety of males (2.7981) and females (2.3046) $PV = 0.000 < \alpha = 0.05$. An analysis of variance was performed to explore the effect of age on levels of study constructs, Sig. > 0.05 no sig difference. There is no significant difference in the average attitude towards chemical safety by age. There is no significant difference in the average attitude towards chemical safety as per education. Table 3 shows Mean, standard deviation and attitude for items of Attitude Toward Chemical Safety.

**Table 3 Mean, standard deviation and attitude for items of Attitude Toward Chemical Safety**

| | Mean | Std. Deviation | Attitude |
|---|---|---|---|
| 1- Chemical spills are not dangerous, regardless of the spilled chemical | 1.8694 | 1.02793 | disagree |
| 2- It is always safe to dispose of chemical waste by throwing it down the sink and diluting it with large amounts of water | 2.5102 | 1.27592 | disagree |
| 3- Personal Protective Equipment (PPE) is required only when you are using chemicals in the workplace | 2.9633 | 1.28782 | neutral |
| OVERALL | 2.4476 | 0.78557 | disagree |

The third part; Chemical Safety Practices –

Alpha Cronbach (0.787), Table 4 gives the mean, standard deviation and position of the elements of chemical safety practices, a t-test was performed for independent samples to test that there are no differences in study levels that show that can be attributed to gender, there is a large difference in the average practices Chemical integrity of females (2.6494) and males (2.4742) p-value = 0.005 $<\alpha = 0.05$, an analysis of variance was performed to explore the effect of age on levels of study constructs. There is no significant difference in average chemical safety practices by age. There is no significant difference in the average chemical safety practices according to education.

**Table 4 Mean, standard deviation, and attitude for items of Chemical Safety Practices**

| | Mean | Std. Deviation | ATTITUDE |
|---|---|---|---|
| 1-Before using a new chemical, how often do you read the MSDS (Material safety data sheet | 2.5347 | 0.59006 | ALWAYS |
| 2- How often do you wear appropriate PPE, (including a lab. coat, gloves, eye goggles, closed shoes) when you are working in the lab.? | 2.6694 | 0.54405 | ALWAYS |
| 3- How often do you use appropriate ventilation such as lab. chemical hoods when working with hazardous chemicals | 2.5918 | 0.59086 | ALWAYS |
| OVERALL | 2.5986 | 0.44955 | ALWAYS |

It is well known that preventing or reducing accidents in laboratories is a collective responsibility that requires efforts on the part of staff and users. That is, everyone is responsible for reducing the occurrence of the accident, especially those who conducted the experiment. Accidents usually occur due to negligence, lack of common sense, failure to implement instructions, or errors in conducting experiments.

Prevention of laboratory accidents requires a range of measures including the application of safety awareness requirements after appropriate training, the use of personal safety tools such as wearing glasses and a lab coat during the laboratory period, the use of the least amount of chemicals possible, and experimentation with non-hazardous or less hazardous materials. Whenever possible, anticipate the sequence of events in action. Sources of safety awareness include university courses, faculty, laboratory safety guides, and websites [(4)]

Correct laboratory practices were significantly more likely in researchers who recognized that their exposure to chemicals was low, but who had significant exposure to biological hazards, who agreed with the statement that colleagues handled chemicals by following safety procedures, and who recognized that they had received adequate training in accident management and first aid. Our results showed large gaps in knowledge and a paucity of preparedness in adhering to safety processes to prevent and contain risks related to the use of chemical compounds in research laboratories [(5)].

Residents' awareness of Personal Protective Equipment (PPE) against chemical accidents. Overall, 88% of the population indicated that they need to be prepared to use PPE for chemical accidents, while only a small portion (9%) of respondents answered otherwise, which means that PPE is absolutely necessary for chemical accidents [(6)].

The online safety training available is usually not standardized or accredited courses and is a general limitation. Conversely, similar scores across all demographic workshop groups that have received cross-curricular training indicate chemical laboratory safety, or have attended a bachelor's degree, indicate that these resources are effective in improving students' attitude toward chemical laboratory safety [(1)].

## Conclusion

This result can be explained by the fact that strict rules apply to students enrolled in chemistry laboratories. Students are not allowed to enter chemistry labs without wearing personal protective equipment. Chemicals are kept in fume hoods, so students are not allowed to take them to their seats.

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## References

1. Al-Zyoud W, Qunies AM, Walters AUC, Jalsa NK. Perceptions of chemical safety in laboratories. Safety. 2019;5(2).
2. Stocco da Silva LH, Abreu Rodrigues LC de, Nunes Diogenes A, Tedeschi Gomes Abrantes AC, Baptista A, de Araújo Ponte H. A risk reduction approach for academic research labs: A case study on naphthenic corrosion. J Loss Prev Process Ind [Internet]. 2020;64(March 2019):104061. Available from: https://doi.org/10.1016/j.jlp.2020.104061
3. Olewski T, Snakard M. Challenges in applying process safety management at university laboratories. J Loss Prev Process Ind [Internet]. 2017;49:209–14. Available from: http://dx.doi.org/10.1016/j.jlp.2017.06.013
4. Fagihi YA. The Level of Awareness of Safety Measures Practiced in School Laboratories among Pre-Service Science Teachers at Najran University. J Educ Issues. 2018;4(1):107.

5. Papadopoli R, Nobile CGA, Trovato A, Pileggi C, Pavia M, Pavia M. Chemical risk and safety awareness, perception, and practices among research laboratories workers in Italy. J Occup Med Toxicol. 2020;15(1):1–11.

6. Han DH, Park MS. Survey of awareness about hazardous chemicals of residents living near chemical plants in South Korea. Ind Health. 2018;56(4):285–91.