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Assessment of the State of Knowledge of Chemical Safety and GHS Labelling System in Zahedan Industries (Iran)

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ABSTRACT

Background: The present study aims to evaluate the level of awareness of workers with the Globally Harmonized System (GHS) among workers exposed to chemicals.

Methods: The current study was cross-sectional which was conducted on 80 industrial workers in Zahedan (Iran). Therefore, the Multiple-Choice Question (MCQ) questionnaire according to the GHS international system was used to evaluate general knowledge and the labelling status of chemical substances by designing integrated visual and theoretical questions. Descriptive statistics, and correlation coefficients were also used in data analysis.

Results: The highest awareness of workers was related to explosive (100%) and flammable (96.3%) pictograms. About 72.5% of the participants claimed to have encountered unlabeled chemical packages in their work experience. 86.3% of the workers considered the label on the package "useful to prevent accidents"; about 32% reported that they had never seen "health hazard" pictogram; and about 98.8%, received the necessary training about the dangers of chemicals. Also, the results showed that there was no significant correlation between the age and work history of the participants and their level of awareness ($P>0.05$), but a statistically significant correlation was observed between education and gender and the level of awareness ($P<0.05$).

Conclusions: Analysis of the current state of chemical safety labeling showed that pictograms such as GHS "health hazard" are not familiar to workers. Despite the high level of education, workers could analyse English labels at an average level. Moreover, increasing work records did not have much effect on improving people's awareness.

Keywords: GHS system, Labelling, Awareness, Chemical safety

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Introduction

Humanity has always yearned for a life devoid of peril, where safety and security reign supreme. This innate desire is deeply ingrained in the essence of all individuals, transcending time and generations (1). Today, human life has become closely related to chemicals, so the removal of these substances disrupts human life. On the other hand, the preparation, production, and consumption of these substances contain various risks, especially for the exposed workers (2).

Chemicals are essential materials for various aspects of human life, including industry, agriculture, etc. (3). As the years pass, an increasing number of companies have emerged onto the scene, producing a plethora of chemicals that inundate the market annually. Consequently, more individuals find themselves susceptible to perilous exposure to these hazardous substances as they navigate through various stages of the chemical supply chain (4). Using these materials can improve people's lives and comfort, but along with the benefits of these products, there are adverse effects on people or the environment (5, 6). Therefore, it is very important to observe precautionary principles and control measures when working with these materials to avoid possible harmful effects (7).

Failure to pay attention to the characteristics and types of chemicals and using inappropriate and wrong methods when working with these materials can have unfortunate consequences. The effects and consequences of them, can significantly reduce the ability of people to continue their activities or even reduce their quality of life, based on the severity of the exposures. On the other hand, exposure to these substances can cause respiratory diseases, burns, skin ,and eye complications, headaches, and cancer, and in severe cases, it leads to death (8).

According to Zhao et al.'s (2018) research, 3,974 hazardous chemical casualty incidents occurred in China in the 12 years from 2006 to 2017, resulting in a total of 5,203 deaths (8). In Iran alone, a staggering 9,886 work-related accidents were recorded in 2018 - with 64 incidents attributed to exposure to dangerous chemicals. It becomes evident that raising awareness regarding chemical safety among those employed in production, storage, sales roles as well as occupational health and safety positions holds paramount importance in mitigating risks (4).

Research on identifying the causes of accidents has shown that the main cause of occupational accidents is unsafe acts. Also, studies have shown that people's attitudes and behavior are involved in most occupational accidents that occur due to unsafe behavior (9). Employees lacking adequate education or experience and those unaware of both the immediate and long-term effects associated with these substances find themselves particularly vulnerable when working with chemicals. Thus, scholars stress upon not only acquiring sufficient knowledge but also implementing sound management practices when dealing with such precarious materials (3).

Chemical classification and labeling systems are formulated to indicate the hazards of chemicals and to reduce the associated hazards. In general, the goals of such systems are to systematically identify chemical hazards, alert users to those hazards, and enable them to take appropriate actions to protect themselves (10).

GHS was introduced in 2001 for the classification and labeling of chemicals by the United Nations to unify the classification and labeling of chemicals (10). As such, GHS is a globally harmonized technical system that provides health and safety information on substances and the type of chemical hazard communication. The implementation of GHS is the first step in achieving the correct management of chemicals, considering that all classifications of chemical hazards of harmful substances and dangerous goods are based on the two international systems of the United Nations and the European system. These organizations and international programs are trying to increase the correct management of the safe use of chemicals (11).

Hence, the Intergovernmental Forum on Chemical Safety (IFCS) recommended that

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governments around the world adopt the GHS guidelines so that all countries follow the same set of guidelines and practices (12). Implementation of the GHS benefits workers, industries, and the general public by promoting awareness of the hazards of hazardous chemicals, increasing safety, reducing chemical exposure accidents, facilitating domestic and international trade in chemicals, and preparing better for proper response (4).

In light of the absence of a centralized authority in Iran dedicated to compiling and interpreting data on chemical substances and their risks, as well as the dearth of research exploring workers' familiarity with GHS guidelines, this current investigation was undertaken to assess the extent of knowledge pertaining to chemical safety and ascertain the adequacy of workplace labeling practices.

Methods

This study, characterized by its cross-sectional and descriptive-analytical nature, encompassed all employees at Ariashimi and Morwarid Hamon industries located in Zahedan city (Iran).

Data Collection Tools

In light of a lack of suitable survey instruments tailored for evaluating chemical safety comprehension, the researchers opted to utilize the most recent iteration of UN GHS regulations for this purpose (10). Therefore, in this study, the questionnaires of Fayazi et al., whose validity and reliability were confirmed, were used (13).

Questionnaire No. 2 was specifically designed to assess participants' overall knowledge regarding chemical safety and to evaluate the current practices related to chemical labeling within their workplaces. Questionnaire No. 1 included a total of 37 items, comprising 24 multiple-choice questions and 13 image-based questions intended to assess the participants' ability to interpret hazard symbols from the GHS, the Workplace Hazardous Materials Information System (WHMIS), and Chemicals (Hazard Information and Packaging for Supply) Regulations (CHIP) systems. Additionally, this questionnaire collected demographic information, including age, gender, work experience, educational attainment, job, and field of study. Questionnaire No. 2 consisted of 40 items- 25 multiple-choice questions aimed at assessing the state of chemical labeling practices at the workplace, and 15 visual questions focused on determining the frequency with which participants observed hazard pictograms on chemical labels. Furthermore, respondents were asked to identify the geometric shapes in which these symbols were most and least commonly encountered. The target population comprised individuals potentially exposed to hazardous chemicals during routine occupational tasks. Accordingly, participants were drawn from a diverse range of professional roles, including production and packaging line workers, warehouse personnel, drivers, technicians, supervisors, and managerial staff from chemical manufacturing facilities located in Zahedan Industrial Town.

Determination of sample size and data analysis

The first type error (alpha) was equal to 0.5 and the estimation error was 0.5. Also, according to the standard deviation of knowledge, using the MCQ questionnaire and based on the provided references, the sample size was determined to be 82 people. Participation in the study was voluntary and people who did not want to participate in the study were excluded.

Descriptive and analytical statistics were used to analyse the data. Therefore, standard deviation, mean, and percentage were used to report that the descriptive statistics of quantitative variables was used for the advanced analysis of scores.

Results

Demographic information

80 people participated in this study, 64 (80%) were men and only 16 (20%) were women. In addition, 53 people (65%) were from production line and warehouse workers, and 29 people (35%) were supervisors, managers, technicians, and occupational health experts of the industry. Detailed demographic information is shown in Table 1.

Table 1. Description of demographic variables

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Variable		Frequency	Percent
Age (years)	35≤	28	35.0
	40-36	29	36.3
	40>	23	28.7
Gender	Man	64	80.0
	Female	16	20.0
Work experience	5≤	23	28.7
	10-6	20	25.0
	10>	37	46.3
Education	School education	56	70.0
	College education	24	30.0
Job	Production line personnel	46	62.2
	Warehouse personnel	7	9.5
	Driver	2	2.7
	Manager	4	5.4
	Technician	6	8.1
	Facilities	7	9.5
	Professional health and safety expert	2	2.7
	Supervisor	6	7.5

Assessment of knowledge about chemical safety

More than 98% of the respondents correctly answered the question regarding the appropriate response to a chemical spill or splash. In contrast, only 33.85% provided the correct answer to the question concerning the circumstances under which protective eyewear should be used when handling chemicals. The distribution of correct responses to the multiple-choice items in questionnaire 1 is presented in Table 2.

Table 2. Distribution of correct answers to MCQ questions to assess chemical safety knowledge

Row	The title of awareness questions	Frequency	Percent
1	Which is the most correct option regarding the effects of dangerous chemicals?	70	87.5
2	What are corrosive chemicals called?	71	88.8
3	What are chemicals with potential acute toxicity called?	60	75.0
4	What information should be on a chemical label?	78	97.5
5	What is the most available and usable source of information to obtain the hazards of a chemical?	59	73.8
6	What does the word *warning* on the chemical label indicate?	49	61.3
7	What does the word * danger* on the chemical label indicate?	63	78.8
8	What do the words *precaution and first aid* on the chemical label indicate?	61	76.3
9	What does the phrase *in case of fire is associated with the risk of explosion* on the label of chemicals?	75	93.8
10	What should be done if the color of the gas cylinder and its label do not match?	76	95.0
11	Which of the following activities is correct in relation to the use of compressed gas cylinders?	74	92.5
12	What action should be taken when faced with a chemical spill or splash?	79	98.8
13	In what case should protective glasses be used when working with chemicals?	27	33.8
14	What is the most important reason for choosing respiratory masks?	77	96.3
15	Which of the following information is in the chemical information sheet?	75	93.8
16	Which option is correct when working with dangerous chemicals?	77	96.3
17	Which of the following statements regarding the maintenance and working with flammable materials is not correct?	72	90.0
18	In which places should an emergency shower and eye wash be installed?	43	53.8
19	Which statement is correct about the transportation of chemicals?	75	93.8

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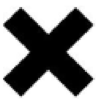
Row	The title of awareness questions	Frequency	Percent
20	Which statement regarding the storage of reactive chemicals is correct?	69	86.3
21	The figure below is the symbol of a chemical substance label. What does arrow number 1 represent?	80	100.0
22	According to the figure above, what does arrow number 2 represent?	79	98.8
23	What does the following rhombus mark indicate?	71	88.8
24	What does the Chemical Analysis Service registration number (CAS No) on chemical labels indicate?	70	87.5

Participants demonstrated varying levels of familiarity with different hazard pictograms. Recognition rates for the symbols representing "toxic and fatal," "environmentally hazardous," "explosive," and "flammable" were 81.3%, 86.3%, 100%, and 96.3%, respectively. In contrast, only 37.5% of the participants correctly identified the meaning of the "corrosive" pictogram. Table 3 provides a detailed frequency distribution of participants' responses to questions evaluating their understanding of these warning symbols.

Table 3. Distribution of correct answers for visual questions of chemical safety knowledge test

Row	Sign	Frequency	Percent	Row	sign	Abundance	Percent
1		73	91.3	8		42	52.5
2		30	37.5	9		68	85.0
3		65	81.3	10		71	88.8
4		69	86.3	11		37	46.3
5		77	96.3	12		65	81.3
6		80	100.0	13		38	47.5
7		62	77.5				

Questionnaire 1 consisted of 37 questions, each contributing one point toward a maximum raw score of 37. To facilitate interpretation of results, scores were normalized to a 100-point scale (approximately 2.75 points per correct response). Based on this scale, knowledge levels were categorized as follows: scores of 0–33 (up to 12 correct answers) indicated poor knowledge; scores of 33.1–66 (13–24 correct answers) indicated moderate knowledge; and scores of 66.1–100 (25–37 correct answers) indicated good knowledge of chemical safety. The mean and standard deviation of participants' total awareness, knowledge of questionnaire items, and recognition of warning symptoms were 0.8132 ± 0.09502, 0.8490 ± 0.08317, and 0.7471 ± 0.16430, respectively.

Factors affecting participants' knowledge scores

The results showed that there is no significant correlation between the age and work experience of the participants and their level of awareness ($P<0.05$). The average score of the participants who had a university education was 10 points

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higher than those with primary education, which indicates a significant relationship between the level of awareness and the level of education of the participants (Table 4). Also, a statistically significant correlation was observed between the level of awareness and gender (P = 0.001)

Table 4. Mean and standard deviation of knowledge of chemical safety signs based on education level

Safety preparation/ Education	Total		Questions		Signs	
	Mean	SD	Mean	SD	Mean	SD
School	0.7872	0.09220	0.8326	0.08161	0.7033	0.16559
University	0.8739	0.07202	0.8872	0.07522	0.8494	0.10755
P- value	0.001		0.006		0.001	

Analysis of the current status of chemical labelling

The relevant questionnaire comprised two sections: dichotomous (yes/no) items addressing topics such as individuals' familiarity with the GHS system, the status of chemical labeling in the workplace, training history, experience with chemical incidents, emergency response measures, and knowledge of chemical safety data sheets; and five-point Likert scale questions assessing aspects such as the method of training, the perceived necessity for instruction on chemical classification and labeling, proficiency in reading English-language labels, ability to utilize safety data sheets (SDS), access to information regarding chemical properties, the condition and legibility of container labeling, and the availability of hazard and transport-related information for chemical substances.

According to the findings, 65% of the participants reported familiarity with the GHS standard (question 1 of questionnaire 2). The questionnaire also examined how participants received training on chemical labeling. The results indicated that a vast majority (98.8%) had received training on chemical hazards, and 91.3% reported that such training had been delivered through educational tools such as posters, brochures, videos, or lectures (Question 9).

A significant proportion of respondents (82.5%) considered chemical labels to be "useful and practical" (question 15), and 86.3% believed that labeling on packaging helps prevent accidents (question 16). Furthermore, 98.8% of the participants stated that label information, when present on containers, was “clear and acceptable,” and 91.3% found the labels to be readable (question 5).

Overall, 72.5% of the respondents reported having encountered chemical containers without labels during their work experience (question 3). In addition, approximately 50% had received or stored damaged containers or containers labeled in unfamiliar languages (question 20). Nonetheless, the majority of respondents rated the overall quality of labeling in their workplace as very high (question 19).

Regarding language accessibility, 37% of the participants reported seeing labels in Farsi, while 26.3% rated their ability to read English-language labels (question 14) as average. Moreover, 98.8% agreed that the placement and positioning of labels on containers were appropriate. Participants were also asked to report how frequently they observed the pictograms listed in Table 5 on chemical packages or containers, choosing from the options: never seen, seen a few times, or seen frequently. The results indicated that the “flammable” and “toxic and fatal” pictograms were the most commonly recognized, whereas the pictograms representing “toxic substances” and “reactive substances” were among the least frequently observed. Additionally, approximately 32% of the respondents indicated they had never encountered the GHS “health hazard” pictogram. These results are summarized in Table 5.

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Table 5. People's familiarity with pictograms

Sign	We have not seen it yet		I have only seen it a few times		I have seen it a lot	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
	13	16.3	27	33.8	40	50
	30	37.5	25	31.3	25	31.3
	7	8.8	15	18.8	58	72.5
	15	18.8	9	11.3	56	70.0
	5	6.3	8	10.0	67	83.8
	12	15.0	23	28.7	45	56.3
	36	45.0	13	16.3	31	38.8
	64	80.0	15	18.8	1	1.3
	32	40.0	25	31.3	23	28.7
	45	56.3	23	28.7	12	15
	35	43.8	20	25.0	25	31.3
	46	57.5	24	30.0	10	12.5
	33	41.3	14	17.5	33	41.3

Discussion

The level of people's awareness of the dangers of chemicals has a very important effect on their performance about the principles of safety of chemicals (14). Controlling the harmful effects of chemical substances is essential to maintain the health of people who are in contact with these substances. Signs and labels engraved on chemicals are one of the ways to exchange information about the risks associated with them. Therefore, a lack of awareness of these labels can cause many fatal diseases and catastrophic accidents (7).

Statistical evaluations of chemical-related incidents in China revealed a significant rise in accident rates from 2012 to 2017. These incidents predominantly occurred during chemical use, transportation, manufacturing, and storage. The substances most frequently implicated were compressed and liquefied gases, as well as flammable liquids. The leading accident types were leaks and explosions, with primary contributing factors including procedural violations and

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insufficient safety training (15). Therefore, GHS has been developed to reduce or control the risks of chemicals due to the extensive global trade of chemicals (16, 17). A study conducted by Peterson in 2010 to evaluate the implementation of GHS in 46 countries showed that regional and global implementation of GHS is mandatory (17).

Given these trends, the present study aimed to assess general knowledge concerning chemical safety among 80 employees in the chemical industry. It also evaluated the status of chemical labeling practices based on GHS and the application of WHMIS and CHIP systems. Findings indicated that participants demonstrated an intermediate level of awareness regarding chemical safety. In a related study, Mehrifar et al. reported that hospital sanitation workers had a correct understanding of only 18% of GHS signs across nine evaluated symbols—substantially below the standard—highlighting their unfamiliarity with GHS (18).

Comparable outcomes were observed by Jahangiri et al., who found that all assessed GHS symbols were recognized below acceptable thresholds among chemical industry workers (19). This alignment is likely due to insufficient training on chemical hazard communication using GHS formats among the target populations (20). However, other studies have found higher levels of symbol recognition. For example, a survey involving 175 chemistry students revealed that 81% of them possessed strong familiarity with laboratory chemical hazard signs. Those with lower comprehension cited neglecting label information and difficulty in recalling or understanding complex symbols as contributing reasons (21). Prior research has consistently demonstrated a robust link between lack of knowledge or training in chemical safety labeling and increased accident occurrence (20, 22, 23).

Furthermore, findings from the present study indicated a statistically significant correlation between gender and education level and participants' chemical safety knowledge and GHS symbol recognition. Similar conclusions were reached by Jahangiri et al., who also reported that perception of GHS symbols was significantly associated with demographic variables such as gender and education level (19). Also, in Mehrifar et al.'s research, the results of simple linear regression analysis showed that age and work experience are two influential factors in employees' general understanding of GHS symptoms. Therefore, with the increase of these factors, employees' understanding of GHS symptoms increased, while there is no significant relationship between people's age and work experience and their awareness and familiarity scores (18). Consequently, it is crucial to incorporate socio-demographic considerations—including age, work experience, and educational attainment—into the design and implementation of training programs. Providing systematic and recurring instruction on chemical safety symbols may effectively enhance workers' hazard recognition skills.

A study conducted by Boelhouwer et al., in 2013, showed that the danger and preventive pictorial signs in the safety information sheet and labels are more effective (24). The results showed that around half of the people answered the questions about the use of protective glasses when working with materials and the location of the eyewash/emergency showers correctly. Furthermore, less than 50% of the participants answered questions 11 (definition of toxic and infectious substances) and 13 (stimulating substances) correctly. The analysis also revealed that participants across all occupational groups demonstrated limited understanding of key safety concepts, such as recognition of toxic and infectious agents, irritants, use of emergency showers and eye wash stations, and the necessity of protective eyewear. These knowledge gaps strongly suggest that chemical safety education programs in Iran require comprehensive revision and strengthening (25).

In the second phase of the study, participants' views on the current state of chemical labeling at their respective workplaces were examined. Despite generally positive perceptions of chemical labels as informative and beneficial tools, several obstacles limited their practical effectiveness. Common issues included damaged or illegible labels, foreign-

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language text, very small font sizes, and a lack of labeling on secondary containers. Field observations confirmed that original labels were often damaged or missing due to improper transportation, storage, or handling practices. Additionally, secondary containers were seldom labeled at the worksite (26).

Existing literature emphasizes that clear and proper labeling can significantly reduce the risk of accidents and enhance emergency preparedness (27, 28). While workers often rely on experiential knowledge for chemical safety, improper handling and insufficient labeling continue to elevate the risk of hazardous incidents. These findings underline the urgent need for structured training focused on GHS implementation, as well as the replacement of outdated systems such as WHMIS and CHIP. Furthermore, employees must be educated on how to interpret chemical catalogs and consult Safety Data Sheets (SDS) for accurate information.

Conclusions

This study found that while most workers in Zahedan's industries correctly recognized the GHS pictograms for "explosive" and "flammable" substances, there was less clarity regarding "corrosive" and "compressed gas" symbols. Education was identified as a key factor in improving understanding. Additionally, demographic factors—particularly education level and gender—were significantly linked to unsafe behaviors. Conducting a training needs assessment, implementing training, and evaluating its effectiveness through pre-test and post-test tests are among the suggested measures to increase personnel awareness about chemicals.

To enhance chemical safety, a comprehensive strategy is recommended, including risk assessment, stronger regulations, modern technologies, targeted education, and fostering a safety culture. Specific actions to raise awareness of chemical labeling include developing level-appropriate training programs, informing workers about chemical hazards, and assessing training needs related to product labels and SDSs.

Limitations

One limitation of this study is that it was conducted solely within industries in Zahedan, which may limit the generalizability of the findings to other regions or industrial settings with different safety cultures. Additionally, the reliance on self-reported data through questionnaires introduces the possibility of response bias, such as social desirability, which could affect the accuracy of the reported knowledge and behaviors.

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Conflict of interests

The authors declared no conflicts of interest.

Ethical Statement

The protocol of study was approved by the Committee on Research Ethics at Zahedan University of Medical Sciences with the ethics code: IR.ZAUMS.REC.1400.286.

Code of ethics

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Authors' contributions

M. H & F. L, were involved in conception and design; M. H, F. L, F. D, and M. A, collected data; M. H, F. L, did analysis and interpretation of data; M. H, F. L, F. D, & M. A, drafted the manuscript; M. H & F. L, did statistical analysis; M. H & F. L, were involved in administrative, technical, or material support; M. H & F. L, conducted the supervision.

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