Journal of Human, Environment and Health Promotion. 2018; 4(1): 7-12

Journal of Human, Environment and Health Promotion

Journal homepage: www.zums.ac.ir/jhehp

Development and Validation of an Awareness Assessment Instrument of Safe Work for Laboratory Staff

Fatemeh Ghiasvand [a] | **Shirazeh Arghami** [b,*] | **Manouchehr Mahboubi** [a] | **Javad Bakhtiari** [a] | **Shabnam Mohammadgholoih** [a]

[a] *Zanjan Student Research Center, School of Public Health, Zanjan University of Medical Sciences, Zanjan, Iran.*
[b] *Department of Occupational Health Engineering, School of Public Health, Zanjan University of Medical Sciences, Zanjan, Iran.*

***Corresponding author:** Shirazeh Arghami
Department of Occupational Health Engineering, School of Public Health, Zanjan University of Medical Sciences, Zanjan, Iran, 45157-86349. Tell: +98-9121909978.
E-mail address: arghami@zums.ac.ir

ARTICLE INFO

Article type:
Original Article

Article history:
Received January 4, 2018
Revised February 19, 2018
Accepted February 24, 2018

DOI: 10.29252/jhehp.3.2.65

Keywords:
Chemical Substances
Awareness Assessment
Laboratory
Content validity index
Content validity ratio

ABSTARACT

Background: Chemistry laboratories of universities are dangerous. However, there is no appropriate instrument to assess staffs' awareness. The present study aims at developing a standardized instrument for awareness assessment of laboratory personnel on safe work.
Methods: The present study is a kind of developing instrument methodology. The study was implemented in two phases: (I) generating items based on the review of relevant literature and interviews, and (II) assessment of the content validity according to seven occupational health and laboratory sciences experts. The validity of the tool was determined based on content validity index (CVI) and content validity ratio (CVR).
Results: In the item generation phase, 53 items were developed in four areas including storage of chemical substances, usage of chemical substances, personal protection equipment, and general observations. The value of CVI was in the range of 0.75-0.91, while the CVR was in the range of 0.4 to 1. Based on these values, some items were omitted and, finally, the content validity for the 40-item questionnaire was established.
Conclusion: Since the content validity of this questionnaire was established, it can be used in future studies.

1. Introduction

Industrial developments made human to be exposed to chemical substances. Nowadays, use of chemical substances in our daily life is inevitable. Undoubtedly, use of chemical substances in many fields of life and economy has led to remarkable benefits, revolutionized the quality of life, caused individuals have been exposed to various chemical substances, especially in their workplaces [1]. The evidence and epidemiological studies show unsafe use of chemical substances has caused chemical accidents in the workplace and environmental catastrophes [2].

Some of these chemical substances have a lot of hygiene hazards for health, and exposure to them can have a different Harmful effect on the health of workers and personnel [3].These hazards specifically relate to the production and use of chemical substances in various procedures [4]. Currently, the people are facing 85 thousand types of chemical substances. In addition, more than 500 to 1000 new chemical and recombinant substances are introduced each year, and the personnel's lack of awareness about the characteristics of these substances is threatening their health and work safety [5]. The exposure to chemical substances is very diverse, and it occurs in a wide range of industrial and non-industrial workplaces in different dimensions – from small workshops to largescale industries.

To cite: Ghiasvand F, Arghami Sh, Mahboubi M, Bakhtiari J, Mohammadgholoih Sh. Development and Validation of an Awareness Assessment Instrument of Safe Work for Laboratory Staff. *J Hum Environ Health Promot*. 2018; 4(1): 7-12.

In addition to factories and chemical industries, laboratories are among workplaces where the personnel are exposed to chemical substances and their hazards; and, given the diversity of the job and the workforce, laboratories are highly vulnerable workplaces; therefore, their safety demands a great deal of attention [6].

It is surprising to realize that university laboratories are more dangerous than industrial environments; because the educational organizations' attention toward safety is negligible if not completely nonexistent [7, 8]. Conducted studies indicate that the majority of accidents that take place in laboratories are due to the lack of awareness of personnel about the correct method of using chemical substances [9].

As such, some researchers have pointed out the necessity of a study on this matter, and have taken some steps for the examination and assessment of such environments. For instance, Lestari et al. (2015) compiled a checklist about the conditions of laboratories [10]. Moreover, Mogopodi et al. (2015) examined the safety management in such laboratories [11]. Awareness about the laboratory safety is the first key element for changing the personnel's behavior and preventing accidents in these work settings [12].

Nevertheless, no particular instrument for the awareness assessment of laboratory personnel has been proposed so far. As such, this study was implemented to develop an instrument for the awareness assessment of laboratory personnel about work safety.

2. Materials and Methods

This study was a type of developing tools which was implemented in two phases. The first phase was dedicated to creating items based on the review of relevant texts and also with laboratory experts, and In the second phase, evaluation of face and content validity of those items was done.

Initially, the research team determined that the questions should be provided in four separate areas including chemicals storage, application and use of chemicals, personal protection equipment, and general considerations.

To provide a complete list of required questions in each section, were tried to scrutinize all of the guides, instructions, and even scientific and legal resources in the country (Iran). To being comprehensive the list of questions, a remarkable number of sources were consulted. These sources include collections of occupational safety and health regulations for laboratories, safety books in chemistry and biochemistry laboratories, safety, health and environment academic book, comprehensive guidebooks to working with hazardous chemical substances, labor protection and health regulations, personal protection equipment regulations, journals and publications on safety, hygiene, and environmental protection, laboratory safety and protection, safety and laboratory engineering, and the GHS standard. The questions were extracted aforesaid sources, and a total of 55 questions were obtained by removing common items.

Next, the questionnaire was presented to the experts panel (n = 7), which was composed of specialists in the field of occupational safety and health and laboratory sciences.

Then, content validity was measured based on Lawshe method (1975).

According to his suggestion, the content validity was established of all questions with a minimum content validity ratio (CVR) of 0.99 and a minimum content validity index (CVI) of 0.75 was established. In order to calculate these indexes, the answers of the members were collected in the Likert scale (options included essential, beneficial but inessential, and inessential). Based on the number of votes assigned on the "essential" option the CVR of each question was calculated using Equation 1.

$$\mathbf{CVR} = \frac{n_E - \frac{N}{2}}{\frac{N}{2}} \quad (1)$$

n_E: The number of experts who selected "essential" option

N: The overall number of experts' panel

Based on the number of individuals present in the group of experts, a certain range of values for the CVR will be acceptable. With a larger panel of experts, the acceptable CVR value will decrease; if the panel includes 7 members, the minimum acceptable CVR will be equal to 0.99.

The following criteria have been used to accept or reject questions:

1- The question was instantly accepted if the CVR was equal to or greater than 0.99. This would take place whenever all members of the panel of experts selected the "essential" item.

2- Accept the question if its CVR value is between 0 and 99, Provided that the average value of judgments is equal to or greater than 1.5. In order to calculate the average value of judgments for each question, based on Lawshe's method, options will be replaced with numerical values. So that the "essential" with the number 2, the "necessary but inessential" with the number one, and the "inessential" with the zero value are replaced. This value of CVR shows that more than half the panel members have chosen the "essential" option while the remaining members have chosen the "beneficial" option.

3- A question was rejected when the value of CVR is below zero and the average value of judgment is smaller than 1.5.

A CVR value below zero indicates that less than half of all panel members have chosen the "essential" option and the average value of judgment is closer to the "inessential" option [13]. Items which were accepted in the previous phase, were also examined in terms of their CVI.

The content validity index reflects the comprehensiveness of the judgments about the validity or feasibility of a model,

test, or instrument. To assess the content validity index, all questions should be examined in terms of their simplicity, clarity, and relevance. Each area will be scored from 1 to 4.

The CVI approaches 0.99 as the content validity increases. The content validity index (CVI) can be calculated using equation 2 [13].

$$V_1 = \frac{\frac{Total\ coeefficients\ of\ simplicity}{Number\ of\ panel\ memebers} + \frac{Total\ coeefficients\ of\ clarity}{Number\ of\ panel\ memebers} + \frac{Total\ coeefficients\ of\ relevance}{Number\ of\ panel\ memebers}}{12} \quad (2)$$

3. Results and Discussion

In the item generation phase, 53 items were developed in four areas: storage of chemical substances, usage of chemical substances, personal protection equipment, and general observations. Then, content validity was analyzed according to Lawshe's method and the opinions chosen by the panel of experts.

As it can be seen in Table 1, the CVI of all questions is acceptable and no questions were omitted in this phase. But the study of the content validity ratio showed that some of the questions were not accepted by the members of experts panel (Table 2). In this stage, content validity of 40 questions was established.

Trusting the awareness of those who are working as experts is always a concerning matter, and such a concern can be due to various reasons. Sometimes, the problem arises from the fact that the specialized training programs in universities do not necessarily match the requirements of the job. In other cases, individuals' careers have been so long that what they had learned during their education has become outdated and incompatible with modern science.

Also, there may be none of these modes, but the staff may have become so accustomed to their routine methods that they have forgotten the correct implementation principles of the job. In any case, regardless of the main cause, lack of appropriate awareness among the personnel about their job have an adverse effect on the quality of the final product or service. Therefore, it is essential to assess the awareness of the personnel every once in a while.

Many studies have been conducted around the world on the personnel's awareness about the basic principles of a job and its potential dangers. For instance, Drekonja et al. (2013) studied physician's knowledge about the management of infectious diseases' treatment. They assessed the awareness of 280 physicians working in hospitals in Miami and Minnesota using the patient management questionnaire based on clinical images [14].

In Iran, assessment of personnel's awareness about the basic principles of a profession and potential dangers is uncommon, and if such an assessment is carried out, there is rarely an appropriate instrument available. Rahimdzadeh et al. (2012) studied bakers' awareness about the effects of using sodium bicarbonate in their breads. The instrument used in their study was a questionnaire whose validity and consistency is unclear [15]. In addition, Kashi and Pourkabiri (2013) attempted to study the effectiveness of training programs which attempt to raise students' awareness about safety in organic chemistry laboratories. The study was conducted on 120 students using a 48-item questionnaire to assess students' awareness about the safety of the organic chemistry laboratory [16]. However, there is no information regarding how to confirm the validity and reliability of this questionnaire. The present study was carried out to offer an appropriate methodology. In this study, using a scientific approach, a questionnaire was designed to measure the knowledge of the laboratory personnel about how to work safely with chemicals. For this purpose first a list of items relevant to safety measures for working with chemical substances was prepared based on the literature, scientific resources, and laboratory safety guides; and, a 53-item questionnaire was designed which encompassed four areas i.e. storage of chemical substances, usage of chemical substances, personal protection equipment, and general observations. It appears that the method employed in the present study for the generation of the initial items is a reliable method as Hulla et al. (2015) used a similar method for the generation of knowledge standards for practitioners within the field of toxicology [17].

Other scholars such as Yaghmai (2003) have regarded the use of content validity procedures sufficient for the standardization of research instruments [18]. In this study, based on Lawshe's method and using the validity and reliability ratio, the items were reviewed and revised down to 40 items. Therefore, the content validity of the developed instrument is established.

Table 1: CVI Results

Item	CVI	Accepted/Rejected
1. Where is the best place for the storage of containers with flammable substances?	0.89	Accepted
2. Where is the best place for the storage of containers of corrosive liquids (e.g. acids and alkaloids)?	0.86	Accepted
3. Compressed and oxidative gasses should be kept away from which of the following materials?	0.82	Accepted
4. Oxidative acids should be kept away from which of the following substances?	0.80	Accepted
5. Acids should be kept away from which of the following substances?	0.78	Accepted
6. Where is the best place for the storage of non-reactive solids?	0.90	Accepted
7. Fine metal powders should be stored away from which of the following materials?	0.85	Accepted
8. How should capsules containing compressed gases be carried?	0.90	Accepted
9. What is the upper limit for filling the test tubes?	0.83	Accepted
10. Liquid oxygen should be kept away from which of the following substances?	0.85	Accepted
11. Reactive metals cannot be kept in which of the following liquids?	0.85	Accepted
12. Which one is the procedure for the dilution of acids and alkaloids?	0.89	Accepted
13. Which types of containers should not be used for the dilution of acids?	0.88	Accepted
14. While working with unstable chemical substances which state of matter should be used?	0.75	Accepted
15. How should oxidative agents be heated?	0.88	Accepted
16. Which of the following items are main concerns when working with ethers?	0.84	Accepted
17. Which of the following measures should be taken when washing glass containers of alkaloids?	0.88	Accepted
18. Fume hoods (which are used to limit the operator's exposure to hazardous chemicals) are not necessary for working with which substances?	0.83	Accepted
19. Which steps should be taken before using new glass equipment for the first time?	0.86	Accepted
20. Which substance is appropriate for the neutralization of strong alkaloids which have leaked?	0.82	Accepted
21. Which substance is appropriate for the neutralization of strong acids which have leaked?	0.82	Accepted
22. Which gloves are appropriate for working with hot objects?	0.88	Accepted
23. Which gloves are appropriate for washing of glass equipment or disinfecting them?	0.88	Accepted
24. Which gloves are not appropriate for working with organic solvents?	0.85	Accepted
25. Which gloves are appropriate for working with corrosive liquids (e.g. acids, alkaloids, etc.)?	0.88	Accepted
26. Which shoes are appropriate for working with corrosive liquids (e.g. acids, alkaloids, etc.)?	0.88	Accepted
27. Which protective apron is appropriate for working with corrosive liquids (e.g. acids, alkaloids, etc.)?	0.88	Accepted
28. For working with which of the following substances bullet filters are not necessarily required?	0.57	Accepted
29. What is the most typical way for the penetration of chemical substances into the body?	0.79	Accepted
30. The majority of typical accidents in laboratories are related to which of the following objects?	0.88	Accepted
31. Which of the following types of waste is considered as to be general and regular waste?	0.85	Accepted
32. Which of the following types of waste is considered as to be special waste?	0.85	Accepted
33. What is the first step for cleaning any substance which is spilled on the laboratory floor?	0.85	Accepted
34. What is indicated by the first sign on a label?	0.79	Accepted
35. In order to absorb and recollect the chemical substances which have leaked or spilled over, using which of the following items is essential after using the leakage kit?	0.84	Accepted
36. Which of the following meanings is indicated by this sign? 	0.91	Accepted
37. Which of the following meanings is indicated by this sign? 	0.91	Accepted
38. Which of the following meanings is indicated by this sign? 	0.91	Accepted
39. Which of the following meanings is indicated by this sign? 	0.90	Accepted
40. Which of the following meanings is indicated by this sign? 	0.91	Accepted

Table 2: CVR Results

Item	CVR	Average	Accepted/Rejected
1. Where is the best place for the storage of containers with flammable substances?	1	2	Accepted
2. Where is the best place for the storage of containers of corrosive liquids (e.g. acids and alkaloids)?	1	2	Accepted
3. Compressed and oxidative gasses should be kept away from which of the following materials?	1	2	Accepted
4. Oxidative acids should be kept away from which of the following substances?	0.7	1.82	Accepted
5. Acids should be kept away from which of the following substances?	1	1.2	Accepted
6. Where is the best place for the storage of non-reactive solids?	0.43	1.53	Accepted
7. Fine metal powders should be stored away from which of the following materials?	1	2	Accepted
8. How should capsules containing compressed gases be carried?	0.7	1.8	Accepted
9. What is the upper limit for filling the test tubes?	0.7	1.8	Accepted
10. What materials should containers of oxidative agents be made of?	0.14	1.2	Rejected
11. Liquid oxygen should be kept away from which of the following substances?	1	2	Accepted
12. Reactive metals cannot be kept in which of the following liquids?	1	2	Accepted
13. What material should laboratory test tubes (Erlenmeyer flasks, beakers, etc.) be made of?	-0.14	-	Rejected
14. What is procedure for diluting acids and alkaloids?	1	2	Accepted
15. What should be used to the dilution of dense acids and alkaloids?	0.14	1.2	Rejected
16. Which types of containers should not be used for the dilution of acids?	1	2	Accepted
17. While working with unstable chemical substances which state of matter should be used?	1	2	Accepted
18. How should oxidative agents be heated?	1	2	Accepted
19. To which of the following categories do hydrates and oxidative agents belong?	-0.43	-	Rejected
20. Which of the following are main concerns when working with ethers?	1	2	Accepted
21. Which of the following measures should be taken when washing glass containers of alkaloids?	1	2	Accepted
22. Fume hoods (which are used to limit the operator's exposure to hazardous chemicals) are not necessary for working with which substances?	0.7	1.8	Accepted
23. Which steps should be taken before using new glass equipment for the first time?	0.7	1.8	Accepted
24. Which chemical substances can make their way to the blood circulation after touch?	-0.14	-	Rejected
25 Touching which of the following materials causes only local symptoms?	0.14	1.2	Rejected
26. Which substance is appropriate for the neutralization of strong alkaloids which have leaked?	0.7	1.8	Accepted
27. Which substance is appropriate for the neutralization of strong acids which have leaked?	1	2	Accepted
28. Which substance is not appropriate for rinsing chemical substances?	-0.14	-	Rejected
29. Which gloves are appropriate for working with hot objects?	0.7	1.8	Accepted
30. Which gloves are appropriate for washing of glass equipment or disinfecting them?	0.7	1.8	Accepted
31. Which gloves are not appropriate for working with organic solvents?	1	2	Accepted
32. Which gloves are appropriate for working with corrosive liquids (e.g. acids, alkaloids, etc.)?	1	2	Accepted
33. Which shoes are appropriate for working with corrosive liquids (e.g. acids, alkaloids, etc.)?	1	2	Accepted
34. Which protective apron is appropriate for working with corrosive liquids (e.g. acids, alkaloids, etc.)?	1	2	Accepted
35. What substance is used for ensuring the correct functioning of emergency showers?	0.42	1.47	Rejected
36. Which protective instrument should not be changed while working in the lab?	0.14	1.2	Rejected
37. For working with which of the following substances bullet filters are not necessarily required?	1	2	Accepted
38. Which of the following materials is most appropriate for the safety labels of substances present in the laboratory?	0.42	1.47	Rejected
39. Which chemical state is considered to be the most important one in the laboratory?	0.14	1.2	Rejected
40. What is the most typical way for the penetration of chemical substances into the body?	1	2	Accepted
41. The majority of typical accidents in laboratories are related to which of the following objects?	0.7	1.8	Accepted
42. Which of the following materials are stable in the air?	-0.14	-	Rejected
43. Which of the following types of waste is considered as to be general and regular waste?	0.43	1.53	Accepted
44. Which of the following types of waste is considered as to be special waste?	0.7	1.8	Accepted
45. On what basis is the toxicity of chemical substances determined?	0.14	1.2	Rejected
46. What is the first step for cleaning any substance which is spilled on the laboratory floor?	1	2	Accepted
47. What is indicated by the first sign on a label?	0.7	1.8	Accepted
48. In order to absorb and recollect the chemical substances which have leaked or spilled over, using which of the following items is essential after using the leakage kit?	1	2	Accepted
49. Which of the following meanings is indicated by this sign? 	1	2	Accepted
50. Which of the following meanings is indicated by this sign? 	1	2	Accepted
51. Which of the following meanings is indicated by this sign? 	1	2	Accepted
52. Which of the following meanings is indicated by this sign? 	1	2	Accepted
53. Which of the following meanings is indicated by this sign? 	1	2	Accepted

4. Conclusion

The developed instrument is reliable to be used for the assessment of the laboratory personnel's awareness about work safety, and its results can be used for the following purposes:

1- Identification of performance weaknesses which can potentially result in accidents.

2- Determining the educational needs in different parts of laboratories.

3- Providing the necessary educational materials (e.g. guide books, brushers, workshops, etc.) for raising the personnel's awareness**.**

Authors' Contributions

F.Gh., conducted the field work and wrote the manuscript; Sh.A., designed the study, analyzed the data and wrote the manuscript; M.M., conducted the field work; J.B., conducted the field work; Sh.Gh. conducted the field work. All authors revised and approved the final manuscript.

Conflict of Interest

The authors report no conflict of interest.

Acknowledgments

The authors are eager to express their heartfelt gratitude to Zanjan University of Medical Science, which provided funding for the project as well as the members of the panel of experts who participated in the study.

References

1. Schenk L, Hansson SO, Rudén C, Gilek M. Occupational Exposure Limits: A Comparative Study. *Regul Toxicol Pharmacol*. 2008; 50(2): 261-70.

2. Bahrami A, Rastkar N, Bakand S, Modiri F, Sadeghi F, Talaati H, et al. A Guide to Use of Hazardous Chemical Material. *Environ Occupt Health Center*. Available from: URL: behdasht.gov.ir/uploads/mavad.pdf. [In Persian].

3. Herber RF, Duffus JH, Christensen JM, Olsen E, Park MV. Risk Assessment for Occupational Exposure to Chemicals: A Review of Current Methodology (IUPAC Technical Report). *Pure Appl Chem*. 2001; 73(6): 993-1031.

4. Money C, Margary S. Improved Use of Workplace Exposure data in the Regulatory Risk Assessment of Chemicals within Europe. *Ann Occup Hyg.* 2002; 46(3): 279-85.

5. Alizadeh A, Alizadeh H. Safety in the Laboratory. *J Vet Laboratory Res*. 2012; 4(1), special issue for The 2nd National Congress of Veterinary Laboratory Sciences: 108. Available from: URL: jvlr.journals.semnan.ac.ir/article_977_4aa6aee4394026d2999b011da9170c35.pdf. [In Persian].

6. Adl J. Dangers and Failures in Academic Labs. *Tehran University Medical Science: TUMS Publication*. 2004; 62 (6): 518-25. [In Persian].

7. Peplow M, Marris E. How Dangerous is Chemistry? *Nature*. 2006; 441(7093): 560-1.

8. Langerman N. Laboratory Safety? *J Chem Health Saf*. 2009; 16(3): 49-50.

9. Nicol AM, Hurrell AC, Wahyuni D, McDowall W, Chu W. Accuracy, Comprehensibility, and Use of Material Safety data Sheets: A Review. *Am J Ind Med*. 2008; 51(11): 861-6.

10. Lestari F, Kurniawidjaja ML, Hartono B. Baseline Survey on the Implementation of Laboratory Chemical Safety, Health and Security within Health Faculties Laboratories at Universitas Indonesia. *J Chem Health Saf*. 2016; 3(4): 38-43.

11. Mogopodi D, Paphane B, Petros S. Assessment of Chemical Management Practices and Safety in Junior Secondary School Laboratories in Gaborone. *J Chem Health Saf*. 2015; 22(5): 17-27.

12. National Research Council Committee on Prudent Practices in the Laboratory. Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards. *Washington: DC*; 2011.

13. Lawshe CH. A Quantitative Approach to Content Validity. *Pers Psychol*. 1975; 28(4): 563-75.

14. Drekonja DM, Abbo LM, Kuskowski MA, Gnadt C, Shukla B, Johnson JR. A Survey of Resident Physicians' Knowledge Regarding Urine Testing and Subsequent Antimicrobial Treatment. *Am J Infect Control*. 2013; 41(10): 892-6.

15. Rahimzadeh H, Mansourian M, Karegar M, Ghorbani M, Beyrami S, Shafyian Z. The Knowledge, Attitude, and Performance of the Bakers Regarding the Use of Sodium Bicarbonate in Bread. Payesh. 2012; 11 (2): 279-83. [In Persian].

16. Kashi G, Pourkabiri B. Examining the Effect of Training on Islamic Azad University's Awarness about Security in Organic Chemistry Laboratory in Tehran. *The 8th Seminar on Chemistry of Iran: University of Semnan*; 2013.

17. Hulla JE, Kinter LB, Kelman B. A Standard of Knowledge for the Professional Practice of Toxicology. *Environ Health Persp*. 2015; 123(8): 743.

18. Yaghmaie F. Content Validity and Its Estimation. *J Med Educ*. 2003; 3(1): 25-7.