

Chemical Risk Perception and Safety Behaviors as Key Factors toward Safer Chemical Industries - A Case Study in Iran

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ABSTRACT

Organization and employees' attitudes towards chemical risks are an important contributing factor for safe and unsafe behaviors. These risks should be controlled to as low as reasonably practicable (ALARP) level. The objective of this study was to assess chemicals risk perception, safety knowledge, attitude and their relationships with safe behavior among chemical workers in Iran. The study was a descriptive-analytical and cross-sectional study. 209 workers from five chemical companies were selected in random and stratified sampling. Vinodkumar questionnaire as a demographic questionnaire and Smith-Jackson questionnaire as a safety behaviour questionnaire was utilized to assess safety knowledge, attitude, and chemicals risk perception. Collected data were analyzed utilizing T, ANOVA, and multiple-linear regression by SPSS V20. Males were in the majority (83.1%). Mean and standard deviation (SD) of age and work experience were 31.75 ± 6.86 and 6.00 ± 5.24 years, respectively. Also, mean and SD of risk perception, safe behavior, knowledge and attitude were 22.33 ± 4.29 , 22.12 ± 2.88 , 24.79 ± 4.79 and 19.18 ± 3.08 , respectively. Gender and education were the most important demographic criteria in the case of difference in four variables. Also, correlation between safety behavior with risk perception and safety attitude was significant ($p<0.05$). According to the findings, development in employees' knowledge and attitude through organizational plans and omission of cultural and organizational barriers against doing safety orders and risk perception enhancement would result in workers' safer behaviors towards chemical risks; leading to occupational accidents and diseases reduction in industries.

Key words: Safety Behavior, Risk Perception, Knowledge, Attitude, Chemical agents

INTRODUCTION

An important way to identify hazards before occurring accidents is to determine "Leading" criteria such as: safety culture or climate, as indication of total safety state [1]. The safety culture was introduced after the Chernobyl accident in 1986 [2]. Safety cultures of various beliefs, values and attitudes in a group [3]. Safety climate has been emerged from safety culture concept that is the appearance of the hidden parts of the safety culture in behavior and expressed attitudes by the employees; besides, safety climate can be assumed as attitudes and perceptions of people about safety conditions in an organization. Safety climate can be considered as the outer layer of safety culture [2]. Considering the current situation of the organization and staff's attitude may help to correct many problems from the base. On the other hand, conditions of the organization and workers' attitude towards this situation would be reflected in their behavior [3]. Safety attitude refers to belief of employees to organizational safety implementation.

Its evaluation is considered as an early warning about safety system's failure [4].

Presence of humanity as one of the important components of a system is one reason for the complexity of decision making in the field of occupational health. It can be said that compared to other areas of research, psychological studies have been obsoleted in occupational health [5]. For example, assessment of the employee's accident proneness in industry, as well as impact of cognitive fields such as: risk perception on behavioral and development of safe and unsafe acts has been growing.

Although, the correct methodologies is required to identify vulnerable groups and individuals, individuals with high potential for exposure to workplace risks should be identified [5]. Safety behavior here means individual behaviors in the realm of chemical safety to control and/or prevent exposure to chemicals [6]. In 1982, an anthropological framework was introduced for

understanding how to interpret risks among humans that became well-known as Cultural Theory [7]. Based on this theory, individual differences as a very important issue were considered, as well as differences between understanding and interpretation of people around the risks and dangers, and how they will act differently while facing various dangers [8]. Different factors have been assessed regarding to perception potential of people while failures occur. Some of these factors were: knowledge (which is dependent on education and experience), the problem solving ability, memory, understanding, and decision-making ability [9]. Safety climate as a quantitative measure of safety status, is closely related to communication in the field of risk.

In other words, if an organization identifies risks, communicates the identified risks to workers properly, and provide training so that workers are armed with knowledge of the hazards and how to avoid injury, then the risk communication process is well established in that organization [10]. Risk of exposure to chemical perception is defined as the understanding level of exposure to chemical materials and their dangers [11]. As there is no compiled and holistic study on risk perception and assessment of human awareness through announcement media (e.g. boards, signs, alarms, colors, texts, procedures, instructions, rules), it is difficult to anticipate comprehensive workers' perception regarding risk. Consequently, assessing risk perception effects on unsafe behaviors, accidents, injuries, safety culture and climate is difficult [12]. So, conducting researches to study these critical factors is vital especially in industries such as paint and resin production, pharmaceuticals and petrochemical are among industries that their workers are at risk of exposure to chemicals. A study in Brazil showed that workers in gas stations perceived chemical risks associated with occupational accidents [13]. A study among hairdresser students reported that ones with higher score of knowledge regarding chemicals founded that exposure to certain hairdressing-related chemicals is harmful to human health [14].

It is possible that values and norms of people change gradually over time [15]. Management style is also another crucial factor that has a direct role in above mentioned factors and can limit or emphasize them [16]. Various studies have focused on some aspects such as: perceptual control on workplace, fatalism, optimism, and their influence on control and confidence. Thoughts and beliefs of workers, manner of communication with them, and their communication with each other, cultural variables, job demands, and workplace hazards may affect risk exposure and safety performance of an organization.

Undoubtedly, chemical risks are one of the most important risks in industrial companies [17].

This study has considered a critical topic: Assessment of the relationship of chemical risk perception, knowledge and attitude with safe behavior among operational line workers who expose to chemicals.

MATERIALS AND METHODS

This study utilized a descriptive-analytical and cross-sectional analysis tool. Given the importance of chemicals in small and medium-scale industries challenges the five involved industries were selected. Sample size formula in the case of assessment of relationship between quantitative variables with an alpha of 0.05, power of 0.8 standard deviation of 3.67 (variable with the highest variation) (3), and standard error of the mean as 0.5, was calculated as minimum sample size of 209. As activities were different in terms of risk in studied industries, Stratified sampling method was applied. Based on the industrial type samples have been selected in random based on numbers of their employees.

A researchers-developed questionnaire was used to gather data about demographics factors including age, gender, work experience, shift working, education level, and numbers of safety training courses. Safety knowledge and attitude have been assessed by Vinodkumar' questionnaire [18] that contains 12 questions (seven questions for safety knowledge and five items for safety attitude) with responses in a Likert scale (1 represents strongly disagree and 5 represents strongly agree). The validity and reliability of Vinodkumar's questionnaire has been verified in Iran [19]. Chemical risk perception and safety behavior questionnaire had 15 items (seven questions for Chemicals risk perception and eight ones for safe behavior) and were based on Smith-Jackson *et al* [6]. Each question has responses in five point Likert scales, which are a valid and reliable tool [6]. The questionnaire was translated to Farsi and then back warded to English in order to be considering with local and language barriers in Iran.

After that, its reliability has been tested and verified in a pilot study. Safety knowledge and attitude questionnaires can report a score between 12 and 60 for each case [18]. Furthermore, final score of risk perception and safety behavior questionnaires ranges between 15 and 75. After collecting data, it was analyzed utilizing T, ANOVA, and multiple-linear regression by SPSS V20.

RESULTS

In the first step, a pilot study was conducted to determine the validity and reliability of the tools belong to the risk perception and safety behaviors.

Tools validity was done in terms of face validity via the Backward-Forward procedure. Based on the before-after study, it is recognized that reliability is affected by two questions from the safety behavior questionnaire. Finally, these two questions were eliminated from the questionnaire.

Demographic Variables

The participants of the study were 209 workers of five chemical companies in Iran (Table 1). The majority of workers (83.1% of participants) were male. 78 employees (37.5% of participants) had a high school degree, that where the majority of participants regarding education, on the other hand, 26 employees (12.5% of participants) had associate's degree. Also, 151 employees were married (72.2% of participants). The mean and standard deviation of age and work experiences of workers was equals to

31.75±6.86 in the range of 15-58 years and 6.00±5.24 years, respectively. Additional information related to demographic variables is shown in Table 2. On average, any subjects of the studied population have been participated in only 0.88 training course on occupational safety and health (OSH) (Table 3).

Table 1: detailed information about selected companies

Name of company*	Staff size	Selected workers	Cumulative Percent
Resin Co.	90	46	22.0
Mahrang Co.	29	2	23.0
Shimi Gostar Co.	55	15	30.1
Refah Shimi Co.	72	27	43.1
Sepahan Co.	240	119	100
Total sample size		209	

* Companies were in the field of Paint/Resin, Paint, Chemicals, and Petrochemicals

Table 2: Data about workers' education level and shift working

Variable (N)	Frequency (%)		
Education level (208)	Up to diploma	40	19.2
	Diploma	78	37.5
	Associate's degree	26	12.5
	Bachelor and higher	64	30.8
Shift Working (209)	Yes	50	23.9
	No	159	76.1

Table 3: description of variables (n=209)

Factors	Unit	Min.	Max.	Mean±SD
Age	Years	15	58	31.75±6.86
Safety Training	Numbers	0	10	0.88±1.28
Work Experience	Years	0.25	28	6.00±5.24
Risk Perception	Score*	10	39	22.33±4.29
Safety Behavior	Score*	12	30	22.12±2.88
Safety Knowledge	Score**	4	35	24.79±4.79
Safety Attitude	Score**	11	25	19.18±3.08

*Smith-Jackson *et al.*'s questionnaire/ **Vinodkumar *et al.*'s questionnaire

Risk Perception Results

According to the results of the study, mean score for perceived risk was 22.33±4.29. Reliability of risk perception questionnaire based on the Cronbach's alpha was assessed and calculated as 0.64. The difference in risk perception between men and women, married and unmarried was not significant statistically ($P>0.05$). However, education levels made a difference. Persons with diploma and bachelor's degree or higher presented a better perception of risk and this difference was significant statistically ($P<0.05$).

Safety Behavior Results

The data show that the mean and standard deviation of the safety behavior, is equal to 22.12±2.88. The results showed that Cronbach's alpha's reliability of the questionnaire was 0.63. The results suggest that the safety behavior between men and women have a

significant difference ($P<0.05$) and women are better educated. In addition, single people have done more safe behaviors than married ($P<0.05$).

Safety Knowledge Results

The average score for safety knowledge variable was reported as 24.79 with the standard deviation of 4.79. The Cronbach's alpha coefficient of the questionnaire was calculated as 0.84. T-test showed a higher safety knowledge for women than men ($P<0.05$), however the marital status was not a factor for different ($P>0.05$).

Safety Attitude Results

The average score for safety attitude factor was reported as 19.18 with the standard deviation of 3.08. Table 3 describes these variables. Cronbach's alpha coefficient of the questionnaire was also calculated as 0.84. Men's attitudes on safety were significantly lower than women ($P<0.05$). Attitude of the single

workers was better than married individuals ($P < 0.05$). The shift work did not cause any significant differences ($P > 0.05$). Regarding education, the difference was significant only in the perception of risk ($P < 0.05$). The Pearson correlation test was recognized that any demographic factors are not associated with the four main variables ($P > 0.05$).

Relations between Variables

Variation Inflation Factor (VIF) was used to test multicollinearity among variable and results showed they were not related. Then, in order to an assessment of the relationship between behavior and safety attitude, risk perception, as well as demographic characteristics, multiple linear regressions at the significant level of 0.05 was utilized. The results of

this test are shown in Table 4. To identify factors related to safety behaviors while working with chemicals, a multiple linear regression model was applied. In this model, demographic variables including age, sex, education level, time shifts, marital status, work experience are considered. Beside these variables, safety training periods were introduced into the model as independent variables. In order to interpret qualitative variables coefficients, one of the classes was considered as the reference category, and the other classes were compared with it. As the results show, variables such as risk perception, gender, and education level of lower than the diploma were correlated significantly in the regression model ($P < 0.05$).

Table 4: Multiple-linear regression results to identify related factors with safety behaviors

Variable	Parameter	Safety Behaviors		
		P-value	Std. Error	e^{β}
(Intercept)	-	0.000	2.0436	19.162
Age	-	0.163	0.0362	-0.050
Experience	-	0.671	0.0456	-0.019
Safety training	-	0.169	0.1532	0.211
Risk perception	-	0.000	0.0434	0.169
Safety Knowledge	-	0.484	0.0484	-0.034
Safety attitude	-	0.076	0.0711	0.126
Education	Lower diploma	0.014	0.5526	1.363
	Diploma	0.079	0.4678	0.822
	Associate's degree	0.126	0.5920	0.906
	Bachelor or higher degree		Reference	
Gender	Male	0.000	0.4812	-1.786
	Female		Reference	
Marital status	Single	0.289	0.4493	0.476
	Married		Reference	
Shift working	Yes	0.064	0.4531	-0.839
	No		Reference	

DISCUSSION

The majority of industries are small and medium-scale. These industries compared to large industries (with the number of 250 employees or higher), are encountered with greater occupational health and safety challenges [20]. In the small and medium-scale industries, it has been recognized that there are multiple factors resulting in higher numbers of accidents and diseases. Some of these factors are: weakness of financial resources, lack of OSH management skills, lack of management commitment to the implementation of occupational health and safety programs, inadequate cooperation between workers, temporary and contingent workforce, tending to out-sourcing, low-level inspection and tending to use non-formal methods for the prevention of accidents and diseases [21].

Chemicals in the workplaces are one of the major challenges. There is no doubt that in the work environments, there are a large number of chemicals that workers are facing with them while performing their duties [22]. Scientific evidences shows that in the view points of public, working in the jobs such as chemical production have not been considered as a high risk of exposure activity to chemicals (51% and 43% of respondents considered pesticides and chemical fertilizers as a high risk materials respectively. However, 65% of people have been considered smoking as a high-risk behavior) [23]. According to the obtained results of the study that has been shown in Table 3, for OSH training courses for workers among the selected industries, it would be seen by a discrepancy (0-10). The average of these courses for workers is not desirable. Based on this fact, the first step in order to achieve the goal of this

study and increasing the workers safe practices, the number and quality of the OSH training courses should be increased. In a systematic review on the twenty-two studies, it was shown that health and safety training courses were effective that lead to positive behavior in workers [24].

Based on the results of Table 4, the level of education, as one of the statistically significant variables, has been considered in the risk perception ($P < 0.05$). People with lower diploma behaved 1.363 times safer than ones with bachelor or higher. The results in this section are consistent with the results of other researchers [25]. Regarding to the results of other researchers, the younger and less experienced workers, as well as private sector workers employed in small and medium scale industries, are in the lower level of knowledge and hence are in the lower level of risk and hazard perception [26]. In addition, women's safety behavior was 1.786 times higher than men ($p < 0.05$). Increasing one point/score in risk perception would result in safety behavior would experience equals to 0.169 or 16.9% ($p < 0.05$).

Scientific literature has shown that the perception of the risk of exposure to hazardous materials affects accidents and diseases rates and severity of the injuries, strongly [26]. The workers usually have a different perception of risk in their workplaces and this difference is related to work experience and knowledge [27]. On the other hand, workers usually do not estimate occupational risks correctly that leads to unsafe behaviors when handling is appeared [28]. For example, workers who work with a variety of chemicals, in case of the wrong estimation of risk, lead to acute and chronic intoxication and disability or job changes. In one study, based on the measurement of the toxic substances metabolites, it was revealed that workers with less concern about the dangers of pesticides had the higher level of pesticides in their bodies [29]. In jobs that deal with chemicals, especially with less supervision, measures to reduce the risks during activities such as: sign and warning application, simple multimedia training about chemical usages, as well as rules and regulations on buying, distribution and using of chemicals should be used [30].

Based on the results in Tables 3, safety knowledge score, especially for women, is in good condition. It is documented that knowledge can lead to safe behaviors [31]. In one study, it was shown that 85% of workers had average knowledge, as well as 51% of workers in the field of safety measures application had been in average condition. Also a significant relation has been reported between knowledge scores and safety measures applications [32]. Nowadays knowledge management is considered as an important factor in organizations and industries

performance [20]. A research carried out into the difficulties of industries and organizations faces in developing countries, such as managers are poorly informed and unaware of the scale of safety, ergonomic or occupational health problems, or do not typically interact with OSH specialists [20]. Blame for injuries and errors are often placed on workers in order to avoid criticisms towards owners or policy makers. In this situation, an effective knowledge transfer and a program in the fields of communication enhancement is recommended. Styles of relations, interactions and communication in the work environment, as well as, job motivation, and work self-efficacy are improved with mentioned recommendations, effectively [33].

In line with the findings of other researchers on the relationship of attitudes, knowledge and risk perception of safety behavior, in our study, similar results were obtained. Kumar *et al.* were examined the relationship between safety climate factors, the accidents and attitudes of employees in the chemical industries. The results of their analysis showed that accidents and safety knowledge had the highest value (-0.86) of correlation [18]. Monazzam *et al.* in 2008 conducted a study at a gas refinery located at southern of Iran on the relationship between employee safety attitudes and occupational accidents. They used a questionnaire to assess the safety of workers in attitude. Based on their results, the relationship between safety attitudes and accidents was statistically significant ($P < 0.001$), and with increasing in safety attitude, the number of accidents is reduced [34]. Other work that is designed by Tam and his colleagues was examined the behavior, attitudes and perception of safety among construction workers in Hong Kong. They showed that with increasing in employees' attitude and commitment to safety and reducing obstacles to safe behaviors, workers had a better perception on the accidents [35]. In another study, Brock *et al.* observed a significant relationship between OSH knowledge, attitudes and behaviors [33]. Jahangiry *et al.*, in a study evaluated the risk perception, safety knowledge and attitude among petrochemical industry workers on hearing protection usage rate. This study showed that the relationship between using hearing protection equipment with risk perception and awareness of employees on hearing protection, as well as the relationship between employee attitudes towards safety and hearing risk perception was significant ($p < 0.05$) [36]. In 2010 a study was designed to evaluate the safety climate and estimation of the importance of its factor in a petrochemical complex in southern Iran. according to this research for safety knowledge and safety attitude questionnaire a

Cronbach's alpha coefficient were reported equals to 0.813 and 0.741, respectively [37].

CONCLUSION

Based on the results of this study, safety perception and attitude variables were effective on safety behavior ($P < 0.05$). Safety attitude and risk perception were related to safety knowledge as well. According to the coefficient estimation of each of the three variables entitled knowledge, attitudes and risk perception, it can be interpreted that due to the higher number of safe behaviors of women, the safety behavior score of the men were less than women with the factor equals to 1.786. Besides, by changing the ten points in risk perception variable there will be an 83 percent decline in safety behavior. According to the results, provision of clear information for the risks prevention, systematic implementation of emergency prevention procedures, effective OSH training, conditions of work corresponding to the needs of workers, continuous and systematic check of the health and safety status according to the workplace risks and the developing the necessary safety guarantees for outsourcing and sub-contracting in industries under assessment is recommended.

ETHICAL ISSUES

The Qom University of medical sciences ethics committee approved the study protocol. Also researchers explained all procedures and requirements for participants. They voluntarily approved a consent form before enrolling in the study.

CONFLICT OF INTEREST

There is no conflict of interest to be declared.

AUTHORS' CONTRIBUTIONS

All authors equally help to write this manuscript.

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