Research Paper

Designing and Constructing a Tool for Safety Culture Evaluation in a Processing Industry Based on Factor Analysis

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ABSTRACT

Objectives: This study aims to develop and create a tool based on factor analysis to assess safety culture in the processing industry.

Methods: This study was conducted in the petrochemical industry in 2021. The questionnaires were distributed among 312 employees, supervisors, and managers, and 308 of them were completed. The validity of the questionnaire was assessed by content and construct validity (confirmatory factor analysis), and its reliability was determined by calculating the internal consistency coefficient (Cronbach's α) and conducting a pilot study. Confirmatory factor analysis was used to examine the relationship between the dimensions of safety culture and the dimensions themselves.

Results: The results showed that 62.4% of participants were under 45 years old and 71.2% of them had more than 10 years of work experience. The obtained content validity index (CVI) and content validity ratio (CVR) were 0.88 and 0.91, respectively. The results of exploratory factor analysis (EFA) revealed that six questions were assigned to each dimension of safety culture in the questionnaire. The results of confirmatory factor analysis (CFA) with a P of 0.001 and the overall goodness index of root mean square error of approximation (RMSEA) of 0.07 and the goodness indices of adaptive fit, including good fit index (GFI), comparative fit index (CFI), and normal fit index (NFI) were 0.95, 0.97, and 0.95, respectively.

Discussion: Based on the results, a safety culture assessment instrument was developed, including 10 dimensions and 60 items. The results of factor analysis showed that the built-in instrument is highly useful to assess safety culture. In addition, these results showed that safety culture has the strongest relationship with the priority of focusing on health, safety, and environment (HSE) and the weakest relationship with the dimension of collaboration and involvement.

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Highlights

• A questionnaire with 60 questions in 10 dimensions was designed to evaluate safety culture in the processing industry.

• Based on the results of this study, commitment, and safety support are vital factors in evaluating safety culture.

• Other crucial factors for promoting safety culture are communication, and safety participation, and rewards and fringe benefits as motivating factors.

Plain Language Summary

Safety culture is a set of practices and ways of thinking widely shared by members of the organization. It develops gradually and evolves through interactions among individuals. The term safety culture was first used after the Chernobyl nuclear disaster. Studies have indicated that safety culture has a positive effect on improving safety performance. Evaluating safety culture is a challenge because some aspects of it are invisible. Many types of data collection tools can be used to assess psychological, behavioral, and situational factors. Questionnaires are a standard approach to data collection for safety assessments. In this study conducted in the processing industry, a questionnaire with 60 questions in 10 dimensions was designed by studying various literature, and its validity and reliability were examined. The results of this study have shown that the factors of commitment and safety support, communication and safety participation, and rewards and benefits as motivating factors promote a safety culture the results of this study are similar to the results of the current study.

Introduction

Safety culture is a set of practices and ways of thinking that are widely shared by members of the organization in managing the most critical hazards and similar activities. It develops gradually and evolves through interactions among individuals [1, 2]. The term safety culture was first used after the Chernobyl nuclear disaster. According to Reason in 1987, the Chernobyl disaster was substantially caused by human actions. The conventional criteria for international organizations with good safety culture is 0.12 occupational injuries per 200000 working hours over 5 years, while the same criteria for international organizations with poor safety culture is 50 [3]. Numerous studies have indicated that safety culture has a positive effect on improving safety performance [4, 5]. Many accidents, including the one described, have been subjected to risk assessments, reviews, and analyses revealing that attitudes, behaviors, and human beliefs, as well as organizational variables and equipment deficiencies, can be considered fundamental causes of accidents [6, 7]. Therefore, the critical aspect of an organization's safety management system is its safety culture. It is the most fundamental way to prevent serious accidents, reduce their frequency, and improve safety performance by increasing the quality of safety management [8, 9].

Organizational and individual safety culture is influenced by various factors. Various studies have highlighted numerous aspects of safety culture. The elements of safety culture were identified in Joan Harvey's 2002 study as leadership style and communication, commitment and involvement, risk behavior, job satisfaction, risk avoidance, and risk awareness [10, 11]. In 2009, Vindokumar discussed attitudes, employee involvement, workplace conditions, emergency preparedness, safety priorities, and risk recognition [12].

Evaluating safety culture is a challenge because some aspects of it are invisible. However, many types of quantitative and qualitative data collection tools can be used to assess psychological, behavioral, and situational factors [13]. Evaluating existing safety programs, designing a questionnaire, interviewing some employees, and reviewing safety data are all part of the assessment process [14]. Questionnaires are a standard approach to data collection for safety assessments. This tool contains multiple-choice questions with benefits and drawbacks [15].

The reason for creating a tool to evaluate safety culture based on indigenous indicators and components of a community is, theoretically, the shared views, assumptions, and values of organizational safety, such as the anthropological dimension of safety culture, reflect the broader safety culture. At the national level, principles,

attitudes, norms, behaviors, and assumptions could have a direct impact on how employees perceive their organization and, consequently, how they behave regarding safety. Considering this potential direct impact on organizational behavior, it is argued that the effectiveness of various organizational plans and processes, safety management activities, and leadership characteristics (i.e. the normative aspect of safety culture) are influenced by the characteristics of national culture or culture of the organization and its members [16]. Several safety culture assessment tools have been developed, such as the occupational psychology centre safety culture questionnaire (SafeCQ) and rail safety and standards board (RSSB) questionnaires used to assess safety culture in the rail industry and the Secro assurance safety assessment tool used to assess safety culture (attitudes) in the nuclear, rail, and petroleum industries in the UK and Eastern Europe. Parkestani et al. have also assessed the validity and reliability of a safety culture questionnaire [5, 17]. The aforementioned questionnaires have limitations in that they do not cover all aspects of safety culture, apply only to certain countries, such as the nuclear, rail, or petrochemical industries, and are not specific to processing industries, or focus only on safety and do not consider the role of health, safety, and environment (HSE) factors. Therefore, this study was designed and conducted to consider broader aspects of safety culture, focusing also on indices and indigenous components of processing industries due to great importance and the significant social and economic consequences of accidents in them [18].

Materials and Methods

This descriptive and analytical study was conducted on 312 workers in different departments of the petrochemical industry of Tabriz City, Iran in 2021.

A questionnaire is one of the common methods for data collection in research [19]. A safety culture questionnaire with ten dimensions and 60 questions or items was designed and developed by the research team. Data collection in this study was performed by self-completion of the questionnaire by the studied samples. Of course, the main explanations were provided both directly (by the researcher) and indirectly (by HSE experts in the petrochemical industry).

Study population

The study population included 1 100 workers in 6 different departments, including health, safety, environment, and quality (HSEQ), refining, planning and operation, repair and maintenance, laboratory, and administration; therefore random sampling was used to select the study participants. The sample size was 284 people with the Cochran formula and d=0.05. Since some samples were expected to be excluded from the study, 10% were added to this sample number, so that 312 people from 6 departments (20.7% from the repair and maintenance department, 16% from the administration department, 12.4% from the finishing department, 11.9% from the planning and operations department, 11.2% from the laboratory, and 9.4% from the health, safety, environment and quality [HSEQ] department) of this industry were finally included in the study. The inclusion criteria included at least 5 years of work experience, a bachelor's degree or higher, and informed consent to participate in this study. The exclusion criteria included not completing the questionnaire.

Study implementation steps

Designing a specific safety culture questionnaire and determining its validity and reliability: First, numerous dimensions of safety culture were extracted from various sources by examining various literature [5, 20] and consulting experts, and then a bank of preliminary questions was built from these questionnaires. In this study, the method proposed by Lawshe was used to determine content validity [21]. The content validity of the questionnaire was first confirmed by the judgment of experts in the field. The expert group consisted of 10 chemical and HSE engineers with an average age of 45 years, 15 years of experience, and a master's degree or higher. Then, the content validity index (CVI) and the content validity ratio (CVR) were determined, and the questions with CVR and CVI less than 0.62 and 0.79, respectively, were excluded from the questionnaire based on the number of experts. The Cronbach's α parameters of the questionnaire were obtained after conducting a pilot study and collecting 53 questionnaires. According to the designed questionnaire, each question was weighted on a Likert scale from 1 to 5, so that the highest value for safety culture was 300 and the lowest was 60.

Questionnaire distribution and data collection: The questionnaire was issued to 312 employees from various units in the Tabriz petrochemical industry. The options were based on a 5-point Likert scale and 10 dimensions of safety culture.

Analysis method

Factor analysis is a method for analyzing variation among dependent variables based on their description

by a limited number of hidden variables [22]. Factor analysis consists of two types, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The Kaiser-Meyer-Olkin test (KMO) for the sampling adequacy index was performed using SPSS software version 23. A value of 0.7 is acceptable for the adequacy of the questionnaire data. To determine construct validity, exploratory factor analysis with varimax rotation was performed. Factor loadings of the safety culture questionnaire sections greater than 0.4 represent more crucial questions and can be used for the specified factors. Factors with factor loadings greater than 0.5 are more crucial and acceptable, while those with factor loadings of 0.5 and above are of significant importance and more relevant to the desired dimension [23]. Confirmatory factor analysis was conducted to examine the relationship between each dimension and the others. If the factor loading is less than 0.3, the relationship between each dimension and the other dimensions resonates; if it is greater than 0.3, it means that they are significant in other groups. CFA involves first proposing the theory, then deriving the model from it, and finally testing the model for compatibility with the observed data [24]. It is worth noting that the data in this study were analyzed using SPSS software, version 23 and AMOS software, version 23. Goodness-of-fit (GOF) indicator results for this conceptual model were estimated. General GOF indices such as root mean square error of approximation (RMSEA) have acceptable values of 0.05-0.08, whereas adaptive GOF indices, such as comparative fit index (CFI), normal fit index (NFI), and non-normed fit index (NNFI) or Tucker Lewis index (TLI) have acceptable values of 0.95-1 [25, 26].

Results

Reliability and validity of the questionnaire

The obtained CVI and CVR were 0.88 and 0.91, respectively. Hence, the questionnaire's content validity was confirmed by the judgment of the HSE and chemical engineers. The Cronbach's α test was used to analyze the questionnaires' reliability after a pilot study was conducted and 53 completed questionnaires were collected. If Cronbach's α coefficient is greater than 0.7, the question is acceptable; otherwise, the questions with the lower coefficient must be eliminated and corrected. In this study, Cronbach's α was first calculated for ten sets of questions, each of which examined a different aspect of culture, and, then the coefficient for the entire questionnaire was determined. The Cronbach's α coefficient for the ten dimensions of the safety culture assessment tool in this study was greater than 0.7, providing statistical confirmation of their reliability (Table 1).

Demographic data of the participants

Descriptive results showed that 62.4% of participants were under 45 years old and 71.2% of them had more than 10 years of work experience. A total of 69.4% of the participants had a bachelor's degree and 30.6% of them had a master's degree or more. All participants were men and 60% of them were married. In addition, the subjects worked in an 8-hour shift.

Exploratory factor analysis (EFA)

To conduct an exploratory factor analysis using the results of the completed questionnaires, the KMO index for sampling adequacy was calculated to determine if the samples were adequate for factor analysis. The KMO index for this questionnaire was calculated as 0.806. The data are adequate according to the allowable value of this index for questionnaire data adequacy (KMO=0.7). EFA was then used to identify the interrelated questions. Only questions with a factor loading of 0.4 or more were accepted in extracting factors (Table 1).

Confirmatory factor analysis (CFA)

Once the factors and their associated questions were identified, a confirmatory factor analysis should be conducted to verify their correctness and factor structure. Therefore, first, the unilateral relationship with safety culture and then the bilateral relationship of each dimension to the other was examined (Figure 1, Table 1). These results showed the strongest correlation between safety culture and the dimensions of priority of work to HSE (factor loading=0.655), motivation to follow HSE principles (factor loading=0.610), and manager and supervisor commitment to HSE (factor loading=0.556) (Figure 1). In addition, the good fit index (GFI) of this model is 0.95 and the AGFI is 0.93, corresponding to the GOF indices of the confirmatory factor analysis model in this study. The NNFI and NFI indices of the model were estimated to be 0.96 and 0.95, respectively, and the CFI index was calculated to be 0.97. The standardized root mean squared residual (SRMR) and RMSEA indices were 0.07 and 0.052, respectively. Hence, according to the standard values of these indicators of acceptance and suitability of the model, all the results of the indicators pointed to the suitability of the model. The significance threshold for these results was also evaluated as less than 0.001 ($P<0.001$) (Table 2).

Table 1. Results of exploratory factor analysis and Cronbach's α coefficient of the safety culture questionnaire

Safety Culture Dimension	Question Title	Factor Loading	Cronbach's α Coefficient
Priority of work over HSE	Q1: Sometimes I have to deviate from HSE principles to complete a task on time.	0.536	0.714
	Q2: Some pressures are preferable to stick to HSE principles.	0.467	
	Q3: HSE is costly and the company's priority is to avoid additional expenses.	0.573	
	Q4: Management believes that HSE stabilizes the company's revenues and profits.	0.572	
	Q5: In most cases, continuing to work is prioritized over health and safety.	0.481	
	Q6: In this company, HSE issues are as important as production.	0.355	
Cooperation and participation in HSE issues	Q7: I have frequently emphasized the necessity of HSE to my coworkers.	0.505	0.728
	Q8: I believe my colleagues are cooperating and exchanging ideas on HSE concerns.	0.582	
	Q9: I can influence HSE status.	0.650	
	Q10: I'm involved in the development and revision of safety regulations and guidelines.	0.495	
	Q11: I have the opportunity to influence managers' decisions in the HSE field.	0.745	
	Q12: The company's management always seeks the active participation of individuals in improving the HSE situation.	0.624	
The commitment of managers and supervisors to HSE	Q13: When it comes to allocating resources and assets, HSE has always been one of the company's top objectives.	0.714	0.854
	Q14: The organization's HSE decisions are always based on preventative and long-term strategies.	0.633	
	Q15: This company's senior management is fully committed to HSE.	0.416	
	Q16: HSE management reports to the company's top executives.	0.687	
	Q17: The company's management has a well-defined and committed HSE policy.	0.435	
	Q18: I am often forced to undertake unsafe acts by my superiors.	0.567	
Self-report (about their unsafe acts and conditions)	Q19: My co-workers report any errors in their work.	0.477	0.714
	Q20: Reporting your unsafe acts and accidents in the company followed by the encouragement of management and the company.	0.446	
	Q21: HSE cases are reported by specific individuals and there is no specific procedure for the general public.	0.648	
	Q22: The company will not take effective action after receiving reports of HSE irregularities.	0.616	
	Q23: The individuals in charge respond quickly when I report unsafe situations.	0.402	
	Q24: It is not a good idea to report my coworkers' errors because it may result in reprimands.	0.598	
HSE regulations awareness	Q25: My co-workers have complete control over their work regulations.	0.530	0.763
	Q26: Workplace changes in HSE regulations are well-informed.	0.556	
	Q27: The instructions are regularly reviewed to improve their effectiveness.	0.435	
	Q28: I have access to all HSE rules and regulations that apply to my task.	0.656	
	Q29: Doing some activities safely and according to HSE instructions is difficult and tedious.	0.516	
	Q30: Written HSE rules and guidelines are complex and incomprehensible.	0.541	

Safety Culture Dimension	Question Title	Factor Loading	Cronbach's α Coefficient
Using personal protection equipment	Q31: I believe the use of HSE equipment will prevent accidents.	0.591	0.713
	Q32: I believe my supervisors are following up enough on the supply of the HSE equipment I require.	0.567	
	Q33: Providing HSE equipment is one of my superior's priorities.	0.587	
	Q34: Using HSE equipment is more crucial for newcomers than skilled people.	0.668	
	Q35: All individuals use personal protective equipment when necessary.	0.559	
	Q36: Using HSE equipment is a nuisance to me.	0.534	
Accidents, incidents, and near-misses	Q37: Here, all accidents and near-misses are always reported.	0.576	0.711
	Q38: After an accident, the major focus is on the personnel, and they are occasionally fired.	0.488	
	Q39: Managers believe the accident is an unavoidable part of the job.	0.701	
	Q40: Incident investigations are conducted to find one person.	0.720	
	Q41: Investigation of accidents and near-misses will prevent their recurrence.	0.455	
	Q42: Investigations are only carried out after a serious incident has occurred on site.	0.555	
Motivation to follow the HSE principles	Q43: In my opinion, compliance with HSE principles has no relevance to my salary.	0.722	0.714
	Q44: The company does not yet understand that a commitment to HSE can be rewarding.	0.435	
	Q45: Despite work shifts and stress, the company's employees have good working conditions and morale.	0.704	
	Q46: Because of my stubbornness toward my superiors, I sometimes disregard HSE principles.	0.553	
	Q47: I disregard HSE principles because I am dissatisfied with my job.	0.591	
	Q48: The type and amount of HSE rewards are appropriate.	0.669	
Teaching and perceiving HSE issues	Q49: Brief training sessions that are held regularly are useful to me.	0.459	0.710
	Q50: Unsafe behavior of employees is reduced by holding training courses.	0.474	
	Q51: Employees in this department have forgotten their job-related HSE training.	0.485	
	Q52: To be promoted, it is necessary to attend training courses in the field of HSE.	0.536	
	Q53: The importance of holding effective training courses across the organization is recognized and actively pursued.	0.467	
	Q54: Individuals receive the necessary HSE training before starting work in this complex.	0.573	
Proper monitoring of HSE	Q55: I feel that if I make an HSE error, it will be revealed one day.	0.580	0.742
	Q56: Managers and supervisors react to ignoring the HSE principles.	0.481	
	Q57: In some circumstances, supervisors ignore employees' violations of HSE guidelines.	0.355	
	Q58: Supervisors rarely monitor their subordinates' safe work.	0.502	
	Q59: My colleagues believe that their behavior in the HSE is monitored.	0.522	
	Q60: I am responsible for monitoring the unsafe behavior of my colleagues.	0.624	

HSE: Health, safety, and environment.

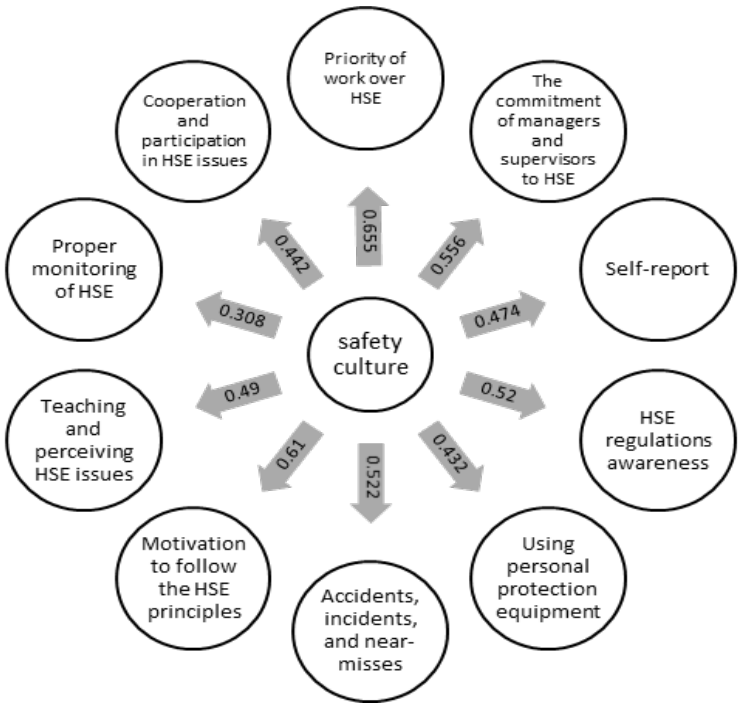

Figure 1. Results of confirmatory factor analysis of the relationship between safety culture and its dimensions

Table 2. Results of confirmatory factor analysis and the two-way relationship between dimensions

Relations of Dimensions With Each Other		Factor Loading Values
Priority of work over HSE	Cooperation and participation in HSE issues	0.131
	The commitment of managers and supervisors to HSE	0.139
	Self-report (about their unsafe acts and conditions)	0.236
	HSE regulations awareness	0.355
	Using personal protection equipment	0.188
	Accidents, incidents, and near-misses	0.166
	Motivation to follow the HSE principles	0.343
	Teaching and perceiving HSE issues	0.106
	Proper monitoring of HSE	0.223
Cooperation and participation in HSE issues	The commitment of managers and supervisors to HSE	0.248
	Self-report (about their unsafe acts and conditions)	0.178
	HSE regulations awareness	0.202
	Using personal protection equipment	0.211
	Accidents, incidents, and near-misses	0.182
	Motivation to follow the HSE principles	0.137
	Teaching and perceiving HSE issues	0.315
	Proper monitoring of HSE	0.264

Relations of Dimensions With Each Other		Factor Loading Values
The commitment of managers and supervisors to HSE	Self-report (about their unsafe acts and conditions)	0.212
	HSE regulations awareness	0.143
	Using personal protection equipment	0.130
	Accidents, incidents, and near-misses	0.290
	Motivation to follow the HSE principles	0.106
	Teaching and perceiving HSE issues	0.272
	Proper monitoring of HSE	0.162
Self-report (about their unsafe acts and conditions)	HSE regulations awareness	0.226
	Using personal protection equipment	0.234
	Accidents, incidents, and near-misses	0.114
	Motivation to follow the HSE principles	0.138
	Teaching and perceiving HSE issues	0.107
	Proper monitoring of HSE	0.187
HSE regulations awareness	Using personal protection equipment	0.152
	Accidents, incidents, and near-misses	0.173
	Motivation to follow the HSE principles	0.141
	Teaching and perceiving HSE issues	0.153
	Proper monitoring of HSE	0.135
Using personal protection equipment	Accidents, incidents, and near-misses	0.159
	Motivation to follow the HSE principles	0.185
	Teaching and perceiving HSE issues	0.161
	Proper monitoring of HSE	0.125
Accidents, incidents, and near-misses	Motivation to follow the HSE principles	0.162
	Teaching and perceiving HSE issues	0.293
	Proper monitoring of HSE	0.133
Motivation to follow the HSE principles	Teaching and perceiving HSE issues	0.184
	Proper monitoring of HSE	0.105
Teaching and perceiving HSE issues	Proper monitoring of HSE	0.134

HSE: Health, safety and environment.

Discussion

This study was conducted to develop a safety culture assessment tool based on indigenous indicators for processing industries. For this purpose, a questionnaire with 60 questions was prepared after studying the relevant literature and sources. The questions covered various aspects of safety culture. As a first step, the content validity and reliability of the questionnaire were confirmed by the judgment of safety experts. After conducting a pilot study and collecting 53 questionnaires, Cronbach's α was determined for the dimensions of safety culture. Cronbach's α was greater than 0.7 in all ten dimensions. Since the minimum acceptable value for α is 0.7 [27], the reliability of the questionnaire was also confirmed. The questionnaire, which included options on a 5-point Likert scale and 10 dimensions of safety culture, was distributed to 312 employees in different departments in the petrochemical industry, and 308 completed questionnaires were collected. The KMO test was conducted using SPSS software. The KMO index was 0.806, indicating that sufficient data were available for factor analysis. To determine the construct validity of the 10 dimensions of safety culture, the method of exploratory factor analysis with varimax rotation was used. Using SPSS software, an exploratory factor analysis was conducted on the data from 308 completed questionnaires to find questions related to each dimension. Then, confirmatory factor analysis was performed to find the relationship between each dimension and the others. If the factor loading is less than 0.3, the relationship between each dimension and the others is significant; if it is greater than 0.3, it means that they are meaningful in other groups [28]. The results showed that the level of factor loading and GOF indices were acceptable and appropriate for this confirmatory factor analysis. The overall GOF index including the RMSEA in this study was 0.052, and the acceptable value of this index for a confirmatory factor analysis model is 0.05 to 0.08, that is, it is in this range, and this model is estimated to be an acceptable analytical model. The adaptive goodness of fit indicators CFI, NFI, NNFI or TLI should also have an acceptable value from 0.95 to 1 [25]. According to the results of this study, the CFI, GFI, NFI, NNFI, or TLI indices were 0.97, 0.95, 0.95, and 0.96, respectively. Consequently, the evaluation results of these comparative indices have shown that the obtained model of confirmatory factor analysis is appropriate and acceptable, based on the comparison of the obtained indices and the acceptable values of these indices.

In this safety culture questionnaire, priority of work over HSE was rated as the most important dimension (factor loading=0.655). One of the vital aspects of the organization's activities and policies is the priority of safety. In addition to safety culture, this component improves productivity and increases production. In addition, part of the safety culture strategy is to understand how safety priorities relate to other strategic initiatives [29]. According to 2015 DiCuccio research, employees believe safety takes precedence over production when production pressures are reduced and safety rules and recommendations are followed [30]. According to a 2013 study conducted by Amini et al., this dimension received the highest score [31] and was rated as one of the crucial items in the Nordic occupational safety climate questionnaire (NOSACQ-50) [20]. Also, in Parkestani et al.'s study, this dimension is considered as a leading factor [5]. In a study conducted by Omidi et al. in 2022, safety priority had the highest score among other dimensions of education, workplace, information exchange, and management commitment [32-34].

The second dimension, motivation to follow HSE principles, is well related to the final index of safety culture (factor loading=0.610). A manager's role in motivating safety compliance is to lead, encourage, and persuade employees to take safety precautions, which often involves money [35]. In a study, Diaz-Cabrera et al. looked at the motivational tendencies of employees [36]. The effect of encouragement on reducing accident rates was examined in a study conducted by Najmabadi [37].

The third dimension (factor loading=0.555) in this questionnaire was management commitment to safety. According to studies, the vital element in developing a safety culture is management commitment, which is at the heart of all efforts. The main characteristic of safety-related actions taken by other employees is the behavior of managers at all levels and the importance they place on safety in their objective decisions [29, 38]. This dimension has been investigated in different types of research, including Shabani Arani, Mohammadfam and Mahmoudi, Fang et al., and Cox and Cheyn, who consider this to be the critical determinant of safety culture due to its effectiveness on other dimensions [39-42].

Compared to the results of other studies, Kao et al. used the International Atomic Energy Agency's (IAEA) modified safety culture model to examine eight dimensions of safety culture, including safety commitment and support, attitude and safety behavior, safety communication and participation, safety training and competence, safety monitoring and audit, and safety and organizational management systems. The results of this study indicated that variables, such as safety commitment and support, communication and involvement in safety, and rewards

and benefits as motivating factors promote a safety culture and that the results of this study are similar to those of the current study [43]. The dimensions as well as the elements developed in this safety culture assessment tool for industrial environments and especially for the chemical industry are an acceptable and practical procedure, as shown by the comparative evaluation of the tool developed in this study, as well as the results of other studies, such as the results of Kalteh et al. and Zwetsloot et al. studies. This comparative analysis and focus on risk factors related to safety culture in the process industry show that considering aspects, such as manager and supervisor commitment to HSE and collaboration and participation in HSE can lead to a correct assessment of safety culture in a processing industry according to the risks of this industry [44, 45]. Although this study had an appropriate design and considered a variety of parameters in developing an appropriate and useful safety culture assessment tool, it also had some limitations that future studies should consider to develop more useful safety culture assessment tools in different work environments. One of the limitations of the study was the lack of involvement of various individuals with extensive expertise and knowledge in the field of safety and organizational culture. It seems that future studies should pay more attention to the involvement of experts in the development of safety culture assessment measures. In addition, the development of an integrated instrument that considers the variables of safety climate, safety behaviors, and safety attitudes could lead to the development of an effective tool in this area.

Conclusion

The results of the confirmatory factor analysis of the safety culture assessment instrument in this study indicate that the 60 items or questions assessed and the 10 dimensions created for it have a strong and effective relationship as a construct or tool. The results of the confirmatory factor analysis show that the relationship between safety culture and the importance of HSE work is the strongest, while the relationship between safety culture and the cooperation and participation dimension is the weakest. These results also show a strong and substantial relationship between the dimensions. The instrument developed in this study appears to be a sound and useful tool for assessing safety culture in the process and related industries so that planning to improve safety culture in an industry can be based on the results of this study to assess the dimensions of safety culture, as well as taking into account the specifics of the design of this instrument (such as the results of all 60 elements assessed). Therefore, it is advisable to implement a plan for continuous improvement of the safety culture in the context of management commitment, employee participation in future studies, and the results of the application of this tool.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the Vice-Chancellor for Research and Technology of Hamadan University of Medical Sciences (Code: IR.UMSHA.REC.1399.940).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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References

[1] Asgarian A, Sadeghi R, Abolhasani F, Mohammadbeigi A, Omidi Oskouei A, Soltanzadeh A. Association between job satisfaction, burnout, and patient safety culture among medical staff of the Qom University of Medical Sciences in 2020, Iran. Journal of Occupational Health and Epidemiology. 2021; 10(2):127-33. [DOI:10.52547/johe.10.2.127]

[2] Khandan M, Maghsoudipour M, Vosoughi S. Ergonomic behavioral and workers' safety perception in Khuzestan petrochemical company. Iranian Rehabilitation Journal. 2012; 10(1):26-30. [Link]

[3] Jiang W, Fu G, Liang CY, Han W. Study on quantitative measurement result of safety culture. Safety Science. 2020; 128:104751. [DOI:10.1016/j.ssci.2020.104751]

[4] Mahdinia M, Mohammadfam I, Soltanzadeh A, Aliabadi MM, Aghaei H. A fuzzy bayesian network DEMATEL model for predicting safety behavior. International Journal of Occupational Safety and Ergonomics. 2023; 29(1):36-43. [DOI:10.1080/10803548.2021.2015741] [PMID]

[5] Parkestani HN, Alimohammadi I, Arghami S, Ghohari MR, Farshad AA. [Assessment of reliability and validity of a new safety culture questionnaire (Persian)]. Iran Occupational Health. 2010; 7(1):18-25. [Link]

[6] Maleki A, Darvishi E, Moradi A. [Safety culture assessment and its relationship with the accidents in a dam construction project (Persian)]. Journal of Health and Safety at Work. 2015; 4(4):59-68. [Link]

[7] Azadeh A, Fam IM, Garakani MM. A total ergonomic design approach to enhance the productivity in a complicated control system. Information Technology Journal. 2007; 6(7):1036-42. [DOI:10.3923/itj.2007.1036.1042]

[8] He A, Xu S, Fu G. Study on the basic problems of safety culture. Procedia Engineering. 2012; 43:245-9. [DOI:10.1016/j.proeng.2012.08.042]

[9] Azadeh MA, Keramati A, Mohammadfam I, Jamshidnedjad B. Enhancing the availability and reliability of power plants through macroergonomics approach. Journal of Scientific & Industrial Research. 2006; 65(11):873-8. [Link]

[10] Harvey J, Erdos G, Bolam H, Cox MA, Kennedy JN, Gregory DT. An analysis of safety culture attitudes in a highly regulated environment. Work & Stress. 2002; 16(1):18-36. [DOI:10.1080/02678370110113226]

[11] Ghasemi F, Kalatpour O, Moghimbeigi A, Mohammadfam I. Selecting strategies to reduce high-risk unsafe work behaviors using the safety behavior sampling technique and bayesian network analysis. Journal of Research in Health Sciences. 2017; 17(1):372. [PMCID]

[12] Vinodkumar MN, Bhasi M. Safety climate factors and its relationship with accidents and personal attributes in the chemical industry. Safety Science. 2009; 47(5):659-67. [DOI:10.1016/j.ssci.2008.09.004]

[13] Cooper MD. Towards a model of safety culture. Safety Science. 2000; 36(2):111-36. [DOI:10.1016/S0925-7535(00)00035-7]

[14] Mathis TL, Galloway SM. Steps to safety culture excellence. Hoboken: John Wiley & Sons, Inc; 2013. [DOI:10.1002/9781118530276]

[15] Guldenmund FW. The nature of safety culture: A review of theory and research. Safety Science. 2000; 34(1-3):215-57. [DOI:10.1016/S0925-7535(00)00014-X]

[16] Yorio PL, Edwards J, Hoeneveld D. Safety culture across cultures. Safety Science. 2019; 120:402-10. [DOI:10.1016/j.ssci.2019.07.021] [PMID]

[17] Health and Safety Executive, Human Engineering Limited. A review of safety culture and safety climate literature for the development of the safety culture Inspection. Norwich: HSE Books; 2005. [Link]

[18] Fam IM, Azadeh A, Faridan M, Mahjub H. Safety behaviors assessment in process industry: A case study in gas refinery. Journal of the Chinese Institute of Industrial Engineers. 2008; 25(4):298-305. [DOI:10.1080/10170660809509093]

[19] Rattray J, Jones MC. Essential elements of questionnaire design and development. Journal of Clinical Nursing. 2007; 16(2):234-43. [DOI:10.1111/j.1365-2702.2006.01573.x] [PMID]

[20] Eeckelaert L, Starren A, Scheppingen AV, Fox D, Brück C. Occupational safety and health culture assessment-a review of main approaches and selected tools. Bilbao: European Agency for Safety and Health at Work; 2011. [Link]

[21] Lawshe CH. A quantitative approach to content validity. Personnel Psychology. 1975; 28(4):563-75. [DOI:10.1111/j.1744-6570.1975.tb01393.x]

[22] Schumacker RE, Lomax RG. A beginner's guide to structural equation modeling. New York: Psychology Press; 2004. [DOI:10.4324/9781410610904]

[23] Tanjani PT, Azadbakht M, Garmaroudi G, Sahaf R, Fekrizadeh Z. Validity and reliability of health promoting lifestyle profile II in the Iranian elderly. International Journal of Preventive Medicine. 2016; 7:74. [DOI:10.4103/2008-7802.182731] [PMID]

[24] Farahbod H, Ghiyasi S, Soltanzadeh A. Association of non-organizational factors and occupational accidents: A field study based on structural equation modeling. Journal of Occupational Health and Epidemiology. 2021; 10(1):31-8. [DOI:10.52547/johe.10.1.31]

[25] Ximénez C, Maydeu-Olivares A, Shi D, Revuelta J. Assessing cutoff values of SEM fit indices: Advantages of the unbiased SRMR index and its cutoff criterion based on communality. Structural Equation Modeling. 2022; 29(3):368-80. [DOI:10.1080/10705511.2021.1992596]

[26] Brown TA. Confirmatory factor analysis for applied research. New York: The Guilford Press; 2015. [Link]

[27] Ansari S, Ghazi AS, Varmazyar S. [Evaluation of the reliability and validity of a questionnaire gauging students' satisfaction with training chairs (Persian)]. Journal of Occupational Hygiene Engineering Volume. 2017; 4(2):1-6. [DOI:10.21859/johe.4.2.1]

[28] Koyuncu I, Kilic AF. The use of exploratory and confirmatory factor analyses: A document analysis. Egitim Ve Bilim-Education And Science. 2019; 44(198):361-88. [DOI:10.15390/EB.2019.7665]

[29] Besnard D, Boissieres I, Daniellou F, Villena J. Safety culture: From understanding to action. Toulouse: Institute for an Industrial Safety Culture; 2018. [Link]

[30] DiCuccio MH. The relationship between patient safety culture and patient outcomes: A systematic review. Journal of Patient Safety. 2015; 11(3):135-42. [DOI:10.1097/PTS.0000000000000058] [PMID]

[31] Amini M, Alimohammadi I, Jahani Hashemi H, Yakkefallah D. [The relationship between the prevalence of accidents and safety culture in two detergents and cleaners companies in 1391 (Persian)]. Iran Occupational Health. 2013; 10(6):93-105. [Link]

[32] Omidi MR, Jafari Eskandari M, Omidi N. Investigating the components of safety culture among employees working in the operational areas of South Zagros Oil and Gas Production Company. Health in Emergencies and Disasters Quarterly. 2022; 7(4):171-6. [DOI:10.32598/hdq.7.4.222.12]

[33] Azadeh A, Rouhollah F, Davoudpour F, Mohammadfam I. Fuzzy modelling and simulation of an emergency department for improvement of nursing schedules with noisy and uncertain inputs. International Journal of Services and Operations Management. 2013; 15(1):58-77. [DOI:10.1504/IJSOM.2013.053255]

[34] Aliabadi MM, Pourhasan A, Mohammadfam I. Risk modelling of a hydrogen gasholder using Fuzzy Bayesian Network (FBN). International Journal of Hydrogen Energy. 2020; 45(1):1177-86. [DOI:10.1016/j.ijhydene.2019.10.198]

[35] McKinnon RC. Changing the workplace safety culture. Boca Raton: Crc Press; 2013. [DOI:10.1201/b15265]

[36] Díaz-Cabrera D, Hernández-Fernaud E, Isla-Díaz R. An evaluation of a new instrument to measure organisational safety culture values and practices. Accident; Analysis and Prevention. 2007; 39(6):1202-11. [DOI:10.1016/j.aap.2007.03.005] [PMID]

[37] Najmabadi H, Halvani G, Esmaeili A, Mihanpour H. Survey of safety culture and its relation to work-related accidents in a city train project. Occupational Hygiene and Health Promotion Journal. 2018; 1(3):164-75. [Link]

[38] Crutchfield N, Roughton J. Safety Culture,an innovative leadership approach. Amsterdam: Elsevier Science; 2013. [Link]

[39] Shabani Arani M, Tabatabaei S, Mansouri N. [Prediction of safety culture based on of dimensions of just culture in of one of the industrial sections of Tehran (Persian)]. Iranian Journal of Ergonomics. 2019; 7(1):63-72. [Link]

[40] Cox SJ, Cheyne AJT. Assessing safety culture in offshore environments. Safety Science. 2000; 34(1-3):111-29. [DOI:10.1016/S0925-7535(00)00009-6]

[41] Mohammadfam I, Mahmoudi S. [Evaluation of HSE culture between Mapna group personnel's (Persian)]. Paper presented at: 1st Congeress on Thermal Station Industry. 31 October 2008; Tehran, Iran. [Link]

[42] Fung IWH, Tam CM, Tung KCF, Man ASK. Safety cultural divergences among management, supervisory and worker groups in Hong Kong construction industry. International Journal of Project Management. 2005; 23(7):504-12. [DOI:10.1016/j.ijproman.2005.03.009]

[43] Kao CS, Lai WH, Chuang TF, Lee JC. Safety culture factors, group differences, and risk perception in five petrochemical plants. Process Safety Progress. 2008; 27(2):145-52. [DOI:10.1002/prs.10246]

[44] Zwetsloot GIJM, van Middelaar J, van der Beek D. Repeated assessment of process safety culture in major hazard industries in the Rotterdam region (Netherlands). Journal of Cleaner Production. 2020; 257:120540. [DOI:10.1016/j.jclepro.2020.120540]

[45] Kalteh HO, Mortazavi SB, Mohammadi E, Salesi M. The relationship between safety culture and safety climate and safety performance: A systematic review. International Journal of Occupational Safety and Ergonomic. 2021; 27(1):206-16. [DOI:10.1080/10803548.2018.1556976] [PMID]