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Original

Safety Culture and Resilience in a Petrochemical Industry

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Abstract

Background: Safety has affected the productivity of many industries, including the nuclear power, oil and gas, and railway industry. Resilience engineering is a new field in safety science. This study investigated the dimensions that contribute to safety culture and resilience and their relevance in petrochemical industry. **Methods:**This is a descriptive-analytical study. At first, a questionnaire was used to assess the level of safety culture in twelve dimensions. Then, a six-factor resilience engineering questionnaire was administered. Data were analyzed in SPSS 19 and EXCEL software programs using statistical tests such as the correlation coefficient. **Results:**The mean safety culture score was 290(43.2). The lowest score was related to the training indicator and incident and near-miss reports. The mean score of the resilience index was 201.5(25). The lowest score was related to the learning and reporting culture index. There was a significant correlation between the safety culture score and resilience engineering score (P=0.003). The results also showed that the score of safety culture and resilience increased with age and experience. **Conclusion:** Safety culture and resilience are correlated directly, implying that individuals and organizations can become more resilient by increasing levels of safety culture.

Keywords: Safety culture; Resilience; Petrochemical industry

Introduction

Accidents in process-based industries such as petrochemical plants can lead to substantial loss of life and assets. Besides, they can be detrimental to the environment.[1] In the heart of accidents are factors such as insufficient education, poor safety culture, and lack of organizational resilience.[2, 3] Studies show that the highest number of work-related deaths in Asia is due to accidents in the working environment.[4] Safety is the most fundamental organizational principle for which management plays an important role, especially in highly complex and extensive organizations that are counted as critical industries.[5] The safety culture involves the application of safety values, effective and useful attitudes, the creation of a healthy and safe working environment, and the administration of laws, systems, and management methods.[6] The safety culture has been considered an active indicator in modern safety literature and an important and fundamental solution to controlling accidents.[7] The ten indicators of safety culture are based on the HSE health and safety climate survey

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questionnaire. They include 1) the status of education and competence, 2) production versus safety preference ratio, 3) communication status, 4) the status of workers' participation, 5) accidents and near-misses, 6) organizational and managerial commitment, 7) status of production line supervisors and managers, 8) status of occupational safety and health rules and regulations, 9) status of neglect of occupational safety and health rules and regulations, and 10) overall attitude.[8, 9]

Resilience means elasticity and flexibility. In the field of safety, resilience denotes an organization's potential and inherent ability to regulate its performance before, during, and after changes or events in the organization so that it can withstand accidents and perform its functions. Highly vulnerable organizations are not resilient and are considered as vulnerable systems.[10] Resilient engineering (RE) is a new organizational approach to measure and maintain safety in complex systems such as process industries, oil and gas industries, and petrochemical plants.[11] Safety management systems must be both forward-looking and passive, which is exactly the case in RE. In fact, an organization must be completely resilient both before and after accidents.[12] To evaluate resilience, six indicators have been proposed by Hollnagel, including management commitment, reporting culture, learning culture, awareness, preparedness, and resilience.[13] Beheshti et al. point to the Connor-Davidson's resilience scale in religious beliefs.[14] Building on a 10-item questionnaire to assess safety culture, a 2007 study by Silva et al. found that unsafe behaviors, accidents, and severity of accidents decrease as safety culture score increases .[15] Rabiee highlighted the relationship between patient safety culture and demographic parameters.[16]

Studies have shown that organizational factors, especially in complex systems, underlie accidents.[17] Since the petrochemical industry is among complex systems, organizational indices such as resilience and safety culture are effective. This study aimed to investigate the organizational safety culture and resilience indicators in the petrochemical industry and the factors affecting resilience. The findings can be used to identify weaknesses, reduce accidents, and improve the organization's safety.

Methods

The present study was conducted descriptively in a petrochemical industry over a period of 18 months. The total number of employees was 538. In this study, the sample comprised industry executive staff, who amounted to 300 people.

Step 1. Safety culture measurement

The Nordic Questionnaire and HSE Standard Questionnaire hold 87 questions (9) in ten main dimensions with validity 0.89, which include: 1- Training, 2- Production preference over safety, 3- Safety communication, 4- Employee safety participation, 5- Management safety commitment and organization, 6-Accidents and near-misses, 7 - The status of supervisors, top managers, and managers of the production line, 8 - The status of ignoring safety rules and regulations, 9 - The status of safety rules and regulations, and 10 - The general attitude of employees to safety. Demographic information concerning age, tenure, history of accidents, and education level, among others, were enquired. The questionnaires were filled out by the workers, and wherever they had difficulty understanding an item, the researcher was present to explain. Also, if the researcher noticed that a respondent had failed to answer an item, he asked him/her to answer the question. The questionnaire was built on a five-point Likert scale to assess the safety culture, ranging from "I completely agree" to "I completely disagree." The following equation was used to use the Safety culture score:

$$M = \frac{5k + k}{2} \quad (1)$$

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M=average
k=number of questionnaire questions

Step 2. Industry resilience measurement

The 60-item Resilient Engineering Questionnaire in six main dimensions with validity 0/92 was employed. The dimensions comprised 1) management commitment, 2) learning culture, 3) knowledge, 4) flexibility, 5) emergency preparedness, and 6) reporting culture.[11] Demographic questions were exactly similar to those of the safety culture questionnaire. Similarly, the way to complete, monitor, and score the items was followed accordingly. After the data were collected, the results were analyzed in SPSS-19 and Excel software using statistical tests, correlation coefficient test, linear regression test, and the independent t-test.

Results

The safety culture score was 290(43.2). The mean score of the resilience index was 201(25.5). There was a significant relationship between safety culture and item Resilient Engineering scores (P = 0.003), meaning that the higher the safety culture score, the higher the resilience score and tolerance. Table 1 displays demographic characteristics and their relationship to safety culture and resilience. Also, the average scores obtained from the ten items of safety culture were mentioned in Table 2.

Findings concerning the relationship between safety culture and age showed that the safety culture score increased with age (correlation coefficient: 0.527, P = 0.004). The results of the independent t-test indicated that Accident history had an impact on the safety culture score (correlation coefficient: 0.635, p = 0.002). The relationship between safety culture and education using the one-way analysis of variance showed that education did not have a significant effect on the safety culture score (P = 0.87). Table 3 lists the average scores obtained from the six cases of resilience.Resilience and age correlated positively and significantly (correlation coefficient: 0.660, P = 0.002).

The results of the independent t-test for those who were involved in an accident indicated that the Accident history affects the resilience score (correlation coefficient: 0.521, P = 0.001). The relationship between safety culture and education using the one-way analysis of variance showed that increased education had a significant effect on the resilience score (correlation coefficient: 0.578, P = 0.003). There was a significant relationship between the safety culture score and resilience engineering score (correlation coefficient: P = 0.951, P = 0.003), meaning that the higher the safety culture, the higher the resilience and tolerance in the organization and individuals.

Table 1. Demographic characteristics and their relationship with safety culture and resilience

	Mean (Standard deviation)	Correlation with safety culture	Safety culture coefficient	*P*-value	Correlation with resilience	Correlation with resilience coefficient	*P*-value
Age(year)	27 (9.37)	Yes	0.527	0.004	Yes	0.660	0.002
Tenure	10 (6.77)	Yes	0.436	0.0005	Yes	0.715	0.006
Education	Primary education to master's	No	-	0.87	Yes	0.578	0.003
Having accidents	1 (4.063)	Yes	0.635	0.002	Yes	0.521	0.001

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Table 2. Mean scores obtained from the ten items of safety culture

Items	Obtained mean scores	Desirable mean scores	Standard deviation	Probability value	Evaluation result
Education	18.02	21	6.69	0.523	Undesirable
Preference for production and safety	16.03	15	5.67	0.000	Desirable
Communications	19.24	18	5.54	1.010	Desirable
Employee participation	17.34	15	4.13	0.036	Desirable
Reporting accidents and near-misses	22.35	24	6.42	0.042	Undesirable
Management commitment	46.74	42	10.42	0.007	Desirable
The commitment of supervisors and managers	22.32	18	4.98	0.002	Desirable
Safety rules and regulations	36.15	24	10.45	0.004	Desirable
Ignoring safety rules	12.49	9	3.53	0.30	Desirable
General staff attitude	80.23	57	7.35	0.001	Desirable

Table 3. Scores obtained for the six resilience domains

Items	Obtained mean scores	Desirable mean scores	Standard deviation	Probability value	Evaluation result
Learning culture	24.08	30	8.09	0.087	Undesirable
Awareness	32.93	30	4.399	0.000	Desirable
Flexibility	45.33	30	4.08	0.014	Desirable
Preparedness in emergencies	33.94	30	3.78	0.028	Desirable
Management commitment	42.03	30	5.82	0.01	Desirable
Reporting culture	23.38	30	9.21	0.008	Undesirable

Discussion

Petrochemical plants are among the most complex and unpredictable technical industries and systems, where the staff may face many risks as the number of these critical industries increase.[18] Hence, by creating a culture of safety and RE, we can control and reduce the existing risks and accidents.[19] The average scores of the safety culture and resilience of individuals were 290 and 201, respectively, which is evaluated as positive. From the ten dimensions of safety culture, the training and reporting of accidents and near-misses dimensions were lower than the desired levels and are considered undesirable. From the six dimensions of resilience, learning culture, and reporting culture were found undesirable, which can indicate the direct relationship between safety culture and resilience in an organization. In this study, a direct relationship was identified between safety culture and age. Similar findings have been reported regarding the age-dependency of safety attitudes among Hong Kong construction workers. This can also be attributed to the fact that older people have a more positive safety attitude due to more experience and fewer job opportunities.[20] A study by Rabiee et al. showed that there was a significant relationship between safety culture and work experience.[16]

The results of the average safety culture score in this study are evaluated positively. The results of safety studies conducted by Fernández et al. in several factories with less than 50 staff report a positive evaluation. In these studies, the three basic keys to the organization's safety culture were management commitments, workers' participation, and safety management systems. The results of the study showed that if managers have supportive commitments and requirements, the staff is more inclined to safety. These results of the current study are consistent with those of Fernández et al. 's study.[21] A study of the relationship between accident rates and safety culture of 212 coastal workers and divers in the United Kingdom's oil and gas industry, conducted by Ase et al., showed that divers obtained lower safety culture scores than workers, which justified the higher rate of accidents

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for divers. The study also found that there was no significant relationship between safety culture and increased education.[22]

The current study found that learning culture was low and undesirable. Findings from similar research suggest that learning is one of the most important aspects of RE. Therefore, training should be done regularly, internally, and appropriately so that the desired impact can be achieved.[23] In a study, Yousefi et al. noted the psychological resilience ability in the military and civilian industries and used the resilience questionnaire.[24]

Conclusion

Given the novelty of resilience engineering, methods to quantify this approach should be expanded accordingly. Although several methods have been developed for evaluation in recent years, none of these methods have been used in RE to determine the acceptable level of resilience in the process under study Safety culture is also one of the important issues that is mentioned in organizations today. In general, this study measured the safety culture and resilience and showed that safety and resilience culture are directly associated. Accordingly, it is possible to increase the individualistic and organizational resilience by enhancing the level of safety culture. Whenever an organization is turned resilient, it is possible to prevent accidents and its possible consequences in large and complex industries.

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Conflict of interest

There is no conflict of interest to declare in this study.

References

1. Grote G. Diagnosis of safety culture: A replication and extension towards assessing "safe" organizational change processes. Safety Science. 2008;46(3):450-60.
2. Hollnagel E. Prologue, The Scope of Resilience engineering In, ashgate; editors. Resilience,2011.
3. Halvani G, Ebrahimzade M, Dehghan M, Fallah H, Mortazavi M. Factors affecting safety culture in Yazd steel industry workers. Occupational medicine. 201۲;4(۲-۱):66-72.[Persian]
4. Hämäläinen P, Takala J, Saarela KL. Global estimates of fatal work-related diseases. American Journal of Industrial Medicine. 2007;50(1):28-41.
5. Raees Mohamadi M. Analysis of Indicators Affecting the Faulty Behavior Risk with Fuzzy Multiple. Iran occupational health. 2015;12(4):65-75.[Persian]
6. Rhoades L, Eisenberger R. Perceived organizational support: A review of the literature. Applied psychology. 2002;87(4):698-714.
7. Choudhry RM, Fang D, Mohamed S. The nature of safety culture: A survey of the state-of-the-art. Safety science. 2007;45(10):993-1012.
8. Guillemin F, Bombardier C, Beaton D. Cross-cultural adaptation of health-related quality of life measures: literature review and proposed guidelines. Clinical epidemiology. 1993;46(12):1417-32.
9. HSE. A Guide to Measuring Health and Safety Performance. Health and safety Executive. 2001.
10. Righi AW, Saurin TA, Wachs P. A systematic literature review of resilience engineering: Research areas and a research agenda proposal. Reliability engineering & system safety. 2015;141:142-52
11. Azadeh A, Asadzadeh SM, Tanhaeean M. A consensus-based AHP for improved assessment of resilience engineering in maintenance organizations. Loss prevention in the process industries. 2017;47:151-60.
12. Grecco CHS, Vidal MCR, Santos IJAL, Carvalho PVR. A method to assess safety and resilience in radiopharmaceuticals production process. Work. 2012;41(Supplement1):5839-43.
13. Hollnagel E, Woods DD. Epilogue: Resilience engineering precepts. Resilience Engineering Concepts and Precepts, Ashgate, Aldershot. 2006:347-58.
14. Beheshti E, Zarqam Hajabi M.The Relationship between Resiliency and Practice of Religious Beliefs with Anxiety and Depression among Soldiers. Military medicine. 2018;20(3):333-41.[Persian]
15. Siliva Sharon G ,Human safety and management ,scondedition ,chapter. 2007;(12):363-417
16. Rabiei N, Gholami Fesharaki M, Maleki Sh, Mohamadian M. Relationship between burnout, job satisfaction and demographic factors with the level of patient safety culture in military healthcare staff. Military medicine. 2018;19(6):571-8.[Persian]
17. Omidvar M, Mazlomi A, MohammadFam I, Rahimi Foroushani A, Nirumand F. Development of a framework for assessing organizational performance based on resilience engineering and using fuzzy AHP method-a case study of petrochemical plant. Health and safety at work. 2016;6(3):43-58.[Persian]
18. Habibi EA, Keshavarzi M, Yousefi Rizi HA, Hasanzadeh A. Outcome Analysis of Major Accidents And Determining The Safety Integrity Level Of Processes In Sour Water Stripping Unit Of Gas

[DOI: 10.18502/aoh.v4i4.4513]

Refinery Using Lopa Technique. Health system research. 2011;7(3):301-14.
19. Rajesh R. Technological capabilities and supply chain resilience of firms: A relational analysis using Total Interpretive Structural Modeling (TISM). Technological forecasting and social change. 2017;118:161-9.
20. Siu OL, Phillips DR, Leung TW. Safety climate and safety performance among construction workers in Hong Kong. The role of psychological strains as mediators. Accident analysis & prevention. 2004;36(3):359-66.
21. Fernández-Muñiz B, Montes-peón JM, Vázquez-Ordás CJ. Safety culture: Analysis of the causal relationships between its key dimensions. Safety research. 2007;38(6):627-41.
22. Ek A ,Akselsson R, Arvidsson M, Johansson CR. safety culture in Swedish air traffic control. Safety science. 2007;45(7):791-811.
23. Huber S, Van Wijgerden I, De Witt A, Dekker SWA. Learning from organizational incidents: Resilience engineering for high risk process environments. Process safety progress. 2009;28(1): 90-5.
24 Yousefi R, Toghyani E. Comparison between psychological resiliency and defense mechanisms in the military and ordinary people. Military medicine. 2016;18(2): 207-14.

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