Indicators of Organizational Resilience in Critical Sociotechnical Systems: A Qualitative Study for the Refinery Complex

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Abstract

Background: Resilience engineering is a new approach for safety management. The purpose of this paper was to determine indicators constructing organizational resilience as an important part of overall resilience.

Methods: This was a qualitative study. The data collection method was semi-structured interviews as well as the discussion group method. The data were analyzed with conventional qualitative content analysis.

Results: Overall, 232 primary codes were classified in 81 sub-indicators and 11 indicators. Eleven indicators were as follows: management commitment, performance management system, flow of information/communication, involvement culture, error management system, education, preparedness, flexibility, innovation culture, change management, and human resource management.

Conclusions: Refineries and other firms are recommended to evaluate the situation of any identified indicators, therefore, they can promote the level of resilience by improving any indicator.

Keywords: Organizational Resilience, Indicator, Sociotechnical Systems, Refinery, Qualitative Study

1. Background

Due to rapid changes of technology and occupational accidents that impose heavy costs (1, 2), new approaches and improving safety management systems seems absolutely necessary, especially in oil industries, which have a high risk of accidents (3).

Resilience engineering (RE) is a new approach to safety management, which is suitable for high-risk systems with sophisticated features (4). Resilience engineering does not replace all existing safety procedures, yet it is an attitude that can fill some existing gaps (5). Hollnagel defined RE as "the intrinsic ability of a system to adapt its function before, during, or after major mishaps or changes, so that it can continue the operations required under both expected and unexpected conditions" (6). Becker et al. described resilience as "emergent property determined by society's ability to anticipate, recognize, adapt, and learn from variations changes, disturbances, disruptions, and disasters that may cause harm to what human beings value" (7).

Direct measurement of a system's resilience is impossible. Four cornerstones of resilience engineering involve responding, monitoring, prediction, and learning (8). According to various studies, four principles consti-

tuting resilience include: Management commitment, flexibility, learning, and awareness (9, 10). Dinh et al. proposed six principles contributing to resilience, which were flexibility, controllability, early detection, minimization of failure, limitation of effects, and administrative controls/procedures (11). Azadeh et al. proposed a new concept of RE entitled integrated resilience engineering (IRE). They introduced four new factors, including teamwork, redundancy, self-organization, and fault-tolerant (12).

Several studies introduced different indicators for assessment of resilience (13, 14) and mostly considered some indicators, and did not cover all aspects of resilience. In the recent years, organizational components have been considered as the main factor affecting safety in addition to technology and human factors. Organizational factors are considered very important because they can function as an early informant (14). Therefore, it is recommended for appropriate indicators to be determined in separate dimensions, including organizational, technical, and human dimension. As a result, the situation of overall resilience can be measured more accurately while planning and decision making may be better achieved. Therefore, a qualitative study was conducted to determine organizational indicators constructing resilience in a refinery complex as a crit-

Table 1. Demographic Characteristics of the Participants

Feature	Number/Year
Number of participants	23
Gender	Male (15), female (8)
Age	Mean: 40.4 years (28 - 60)
Work experience	Mean: 13 years (3 - 29)
Field of study	Occupational health, safety engineering, industrial engineering, industrial management, mechanical engineering, chemical engineering

ical sociotechnical system.

2. Methods

This qualitative study was part of a large-scale study that was done following consolidated criteria for reporting qualitative research (COREQ) (15). The main method of data collection was semi-structured interviews. Purposeful sampling was used with maximum variance of sampling (16). Sampling and interviews were continued until data saturation (17). Twenty-three interviews were conducted with people from various positions in the refinery complex and universities, as well as three discussion groups. To obtain more information, three interviews were repeated. Interviews were performed by a PhD student, who had practical experience. Characteristics of the participants are available in Table 1. Interviews contained some pre-designed open questions to allow participants to express their details perceptions. For example, participants were asked: "What organizational factors are involved in the prevention of accidents, or returning to normal condition at times of crisis?" Participants were also asked some probe questions such as "What do you mean? Please explain more about it").

Interviews lasted 40 to 90 minutes. The interviews were recorded with permition of participants and transcribed verbatim, immediately. To analyze data, conventional content analysis was used. The coding process was done with conventional approaches (18).

To increase the validity and reliability, which is equivalent to truth worthing in qualitative research, four criteria, including credibility, conformability, consistency, and transferability were considered, according to Guba and Lincoln (19). Finally, considering previous researches, indicators and sub-indicators were determined.

3. Results

From all interviews, 232 primary codes were extracted. The codes were classified in 81 sub-indicators and 11 indicators.

According to experts, top management commitment was one of the organizational factors affecting resilience and the main factor in the success of safety programs. Expert 11, academic member: "Role of management is similar to the role of man's brain. If the brain doesn't work properly, the whole body is impaired".

Performance management system was another factor affecting resilience. Expert 3: "If the current state of organization's resilience is not specified by an appropriate performance assessment, we don't know in what situation we are".

Another indicator was education. Expert 4: "Education is like a glowing lamp in the darkness, increases the knowledge and awareness, and improves the attitude of people in various fields".

Another factor affecting organizational resilience was human resources management. Expert 19: "The most important asset of an organization is human resources, and its effective management is the key to organizational success and resilience".

In the case of involvement culture, one of the safety managers believed that: "The participation of all employees leads to the integrity of the organization and reduces conflicts between managers and employees".

Preparedness was another indicator. One participant said: "If simulation, training, and practical exercises for possible events are done, we can react quickly and appropriately so, will have the least damage in occurrence of accidents".

Flow of information/communication allude to the relationships between employees and units that exchange thoughts, feelings and comments. Expert 10: "Effective communication is like blood flowing in the veins of the organization and its absence will disrupt the organization".

In relation to error management system, the participants believed that the organization should provide an appropriate climate for employees to report errors without fear. One expert said: "Organization's climate should be such that staff report errors without any fear. And reported errors should be addressed accurately with appropriate feedback to employees".

The results of interviews showed that flexibility is one of the key factors contributing to resilience. Expert 23: "Individuals should have sufficient authority to make decision and react quickly to unforeseen events".

Change management was one of the factors affecting organizational resilience. The safety officer stated: "Any change can be critical, so change in management has a critical role in controlling risks and ensures continuous improvement in safety and resilience".

The last indicator was innovation culture. One participant said: "Organizations must achieve new ideas, to

increase organization's resilience. Organizational culture has an important role in the creation of innovative ideas".

All the above indicators and their sub indicators are shown in Table 2.

4. Discussion

In this study, the effective indicators and constituents of refinery's resilience were identified in the organizational dimension. Resilience at the organizational level is the dynamics of the organization's structure and policies that make the organization have the capacity to cope with difficulties and hardships (20). One of the proposed indicators was commitment of top management that reflects awareness of problems and opinion about safety and resilience in the enterprise. Management commitment significantly influences safety self-efficacy and safety awareness through teamwork and supervision (21). Some studies recognized management commitment as the most important indicator of resilience (14, 22). Rahimi Pordanjani and Mohammadzade Ebrahimi demonstrated that management commitment to safety and conscientiousness has a direct impact on the performance of safety and safety self-efficacy (23). Commitment of senior managers will ensure the commitment of all employees to the organization's safety programs (24).

Experts noted performance management as a very important factor in resilience, which should be implemented in the form of an integrated system, which is expressed as a performance management system. Performance management helps managers and supervisors assess the level and quality of HSE programs (25). Therefore, appropriate performance indicators should be determined to assess current status of the organization's resilience and ultimately improve it by comparison with the ideal situation (benchmarking).

Today, human resources is the only eternal source, the proper management of which improves organizational resilience. Despite the great attention to human resources as a vital success source of organizations, there is a considerable gap in the field of human resource risks (26). Human resource management includes proper selection of personnel, training, performance evaluation, compensation and etc. (27). Proper management of human resources increases commitment and involvement (28).

Involvement of employees was another important factor, which is a behavior-based approach that creates a sense of responsibility and enhances employees' commitment to the safety goals (29).

Unintended errors or mistakes are undeniable components of activities (30). In the present study, error management at the organizational level was applied using the concept of culture because optimal errors management requires building a culture, in which errors are considered inevitable. Error management culture includes organizational practices related to rapid identification of errors, adoption, analysis, effective handling, and feedback (31).

Flow of information and communication refers to sending and receiving messages that create and maintain a system of consciously coordinated actions. This concept is an important factor in organizational behavior that can lead to integration and organizational resilience. Effective communication is an important factor to organizational success. Therefore, communication should be placed in the strategic planning process (32). Communication is one of the most important factors that facilitates learning of occurred errors (33).

Education is widely considered as an important component of the occupational safety program and resilience. Education is the process, by which employees gain knowledge, learn about new skills or obtain motivation to do things in a certain way. McDonald et al. argued that training programs increase self-confidence, self-awareness, skills to resolve conflicts, communication, as well as personal resilience (34).

Pursuant to experts, one of the important factors in organizational resilience, was preparedness. Preparedness is the prediction of problems and preparing for them (35). Resilient organizations must predict adverse events, and facilities and resources should be organized as well as frequent monitoring to improve the readiness of the organization. Several studies have considered preparedness as one of the indicators affecting resilience (36, 37).

According to the results, flexibility was another main indicator of resilience. Flexibility allows organizations to adapt to changes, according to their resources and makes organizations be more responsive to changes. Flexibility is a basic requirement and empowers organizations to manage their threats properly (38).

Many participants emphasized that organizations need innovation because of complexity and uncertainty. Nusair et al. demonstrated that leadership as a critical element can have a crucial role in innovation (39). There is a positive and effective relationship between innovation and organizational flexibility (40).

Change is a dynamic and permanent process, which requires awareness, participation, and assistance. Change management is a good procedure to ensure that safety risks are controlled (41). Change management should include all dimensions of organizational structure, decision-making, and planning. Shirali et al. determined change management as one of the factors contributing to buffering capacity (42).

Table 2. Indicators and Sub Indicators of Organizational Resilience Team

Indicator	Sub Indicator
Management commitment	Allocation of sufficient funds, safety priority on the production, development of new policies for safety, evaluation and selection of contractors, active participation in safety meetings, delegation, audit and inspection.
Performance management system	Policies and documentation, employee participation in criterion setting, training, performance evaluation, benchmarking, feedback, continuous improvement.
Flow of information /communication	Climate of communication, relationship with superiors, notification, media quality, horizontal communication, external organizational interaction, conflict management.
Involvement culture	Employee involvement in decision-making, knowledge sharing, empowerment, organizational integration, team working-cooperation between units, active participation in meetings, reporting errors and unsafe acts and conditions
Error management culture	Recording and reporting system, communications, awareness, early detection and analysis, learning, aid in error condition, no blame, and effective handling of error.
Education	Determining training needs, planning, functional and practicality of training, continuity, qualification of trainers, assessment, and feedback.
Preparedness	Policy, updated guidelines, assessment of harmful agents, risk assessment, resource management, document management, internal and external communications, scenario, simulation and practical training, assessment and feedback, planning emergency response.
Flexibility	Capabilities development, access to resources, freedom to act, awareness, opacity, authority, and interactions
Innovation culture	Organizational learning, Knowledge management, climate of creativity, management support, encouraging creative people, holding sublimity tour.
Change management	Prediction of possible changes, change analysis, determine the expected behavior and training, formal approval, change leadership teams, assessment.
Human resource management	Meritocracy, designing and analysis of jobs, well-being and job satisfaction, job evaluation, guidelines, organizational justice and equal opportunities of promotion.

4.1. Conclusion

Organizational resilience is an essential component of organization's ability to plan for, react to, and retrieve from accidents and crisis. This ability requires understanding weaknesses and strengths of resilience. This study identified indicators affecting refinery resilience in the organizational dimension, using expert opinion and literature review. Indicators of technical and human resilience must also be determined. Oil refineries are a critical sociotechnical system and consequences of accidents will have adverse effects in economic, social, and environmental aspects of this system. Therefore, research should evaluate and improve the situation of organizational resilience as an important dimension of overall resilience, using the abovementioned indicators.

Acknowledgments

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