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Original

Introduce a Tool to Assess the Understanding of the Early Warning System in High-Risk Organizations

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Abstract

Background: Although early warning system processes follow precise models and scenarios, the human part is not fully understood. Most people before and during crises, act according to their interpretive plans, sometimes when the situation may not be dangerous, but can lead to dangerous reactions. The purpose of this study was to provide an indicator that can be used to assess people's understanding of early warning systems. **Methods:** This study is a descriptive-analytical study that was conducted in 2019 in a gas refinery in Iran. In the first step, the Perception Index questionnaire was translated into Persian with the help of English language experts. In the next step, the validity and reliability of the questionnaire were assessed. The questionnaires were distributed and completed among 168 refinery personnel. The collected data were analyzed using SPSS software version 24, and Pearson and Spearman correlation coefficients were determined by statistical tests. **Results:** The content validity index was 0.8, and the content validity ratio was 0.66. The general index of perception of the rapid warning system in this industry was 71.74 percent. Pearson correlation test did not show a significant correlation between age and perception index (r = 0.060), and also this test showed a positive correlation between perception index and work experience (r = 0.691). Spearman test was used to examine the relationship between two variables of education level and perception index. The results showed that there was a strong correlation between these two variables (rho = 0.746). **Conclusion:** The results showed that the perception index in this questionnaire has high validity and reliability and can be used in high-risk industries. The general perception index gained in this industry was in good condition, which means that people are more likely to be well aware at the time of an accident and will behave appropriately. However, it is suggested that the managers of the industry understudy hold training classes related to the early warning systems, hold emergency maneuvers, and familiarize the personnel with different scenarios.

Keywords: Perception Index; Risk perception; Emergency; Questionnaire; Early warning.

Introduction

Early warning is the timely and effective provision of information that allows organizations and individuals to prevent and reduce risk and prepare for an effective response.(1) Due to the nature of the disaster, Warning Systems, or Early Warning Systems are provided, WS is limited to

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unpredictable disasters, i.e., conditions where there is no indication of the occurrence of disasters and crisis assessment and population preparation, cannot be interpreted. According to the Public Entity Risk Institute (2010), a complete and effective Early warning system (EWS) consists of four elements:

1. Risk knowledge: Awareness of danger and vulnerability
2. Monitoring and warning equipment: Technical capacity to continuously forecasting of potential hazards and warning issue
3. Publication and communication: publishing understandable warnings with prior preparation information
4. Ability to respond: Awareness of hazards, alarm equipment programs, and appropriate actions for people at risk.[2]

In this link list, each element has two direct links and interacts with each of the other elements, and the failure of any part of the system means the failure of the entire system. Although a significant portion of early warning systems processes follows precise models and scenarios, the human sector is not yet fully understood. It is difficult to measure the ability of individuals to react effectively to work conditions, which vary based on the interactions of complex psychological, social, and environmental factors.[3,4] Most people act before and during crises based on their interpretive plans, which are not always appropriate for dangerous situations and can lead to dangerous reactions.[5] This problem can be considered as a quality issue, which is generally not sufficiently addressed in the design or development stages of the EWS. The human factor, in particular, plays an important role in all four elements of the early warning system.[3,6] People's behavior at the moment the warnings start has a direct impact on the effectiveness of the warnings. Moreover, it is the factor of perception that establishes the connection between external images and ideas and muscle activity. James (1884) and Rebott (1905) explained the term perception in simple terms and based their claim on the foundations of reason and body movement. James suggests that "bodily changes are directly related to the perception of reality," and Reboot says that perception is an intermediate period that connects external images and ideas with muscle activity.[7,8] We usually do not consider quantitative criterion for this concept because the perception is the sum of the separate concepts. However, using a "perception" index allows us to consider this aspect of aggregation because quantitative perception can have certain consequences in decision support systems.

The studies on emergency warning systems related to hazards have analyzed the trust or distrust of officials and experts.[9,10] They offer ways to show the exact mechanism and criteria that build people's trust. Properly perception and responding to early warning signs before these signs become apparent (i.e., before a crisis occurs) and become an acute need, is in many cases, more effective and efficient than responding to a disaster after it has occurred.[11] Ideally, early warning systems should initiate appropriate measures to prevent harm to the population at risk, measures such as evacuating, or preparing to respond, such as deploying equipment and deploying respondents. Warning systems are human-centered systems, and so the role and involvement of individuals (people at risk of a particular disaster) are at the core of the system and affect the performance of the system. In fact, the performance of early warning systems decreases if the population does not act properly: For example, he does not understand the announcement warnings or does not take the right actions. This lack of "appropriate action" is sometimes due to the fact that the population has a negative image of the system; for example, they find the system useless, outdated, and incompatible.

This discredits the early warning systems, and negative visibility has destroyed the efficiency of many early warning systems, which in many cases have also been high technology. This negative mentality can certainly be cured, but we need to be aware of this

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"negative" perception of the system. Focusing on individuals and monitoring relevant indicators is very important in the design phase of early warning systems, which can improve the quality of warnings and responses in the event of a crisis.[2,3] As far as we know, there is no perceptual indicator for early warning systems in Persian. Therefore, the purpose of this study was to provide an indicator to help people assess the perception of early warning systems and, after determining the strengths and weaknesses, improve this perception, which in turn increases the efficiency of early warning systems in the industries.

Methods

This descriptive-analytical study was conducted in 2019 in a gas refinery, which is a process industry, in Iran.

Questionnaire translation

In the first step, the Perception Index questionnaire, which is a standard questionnaire in the field of increasing the efficiency of warning systems, was translated into Persian with the help of English language experts and then translated back from Persian into English. In order to identify possible defects and difficulty, the necessary changes and corrections were applied. The questionnaire was developed in 2016 by Arru et al. at the University of Paris-Dauphine in France and was first used in a fire safety study, and its validity and reliability were determined.[8]

Determining content validity and content validity index

After completing the translation of the questionnaire, its content validity was assessed. The purpose of this type of evaluation was to answer the question of whether the content of the tool can measure the defined purpose or not?

In order to assess the validity the judgment of experts in the field was used. Two content validity ratio (CVR) and content validity index (CVI) were used to evaluate content validity quantitatively. To calculate the value of the CVI index, the panel of experts was asked to comment on the relevance of the question to the topic. The number of experts was ten, including four experts from the academic field and six experts from the Department of Occupational Safety and Health of the process industry. There are four options for each question:

1. unrelated
2. Somewhat related
3. Related but need review
4. Completely related

After answering the experts for each question, the number of people who voted for the relevant options "but need to be reviewed" and "completely relevant" was added together and divided by the total number of experts, which is the average CVI and is defined as the CVI index of the questionnaire. Acceptance of each item was based on the following criteria:

If the CVI score is less than 0.70, the item is unacceptable and should be removed. If the CVI score is between 0.70 and 0.79, it is questionable and needs to be revised. Furthermore, if the CVI score is higher than 0.79, the appropriate item is considered, and for the questionnaire, if the CVI score is higher than 0.79, the content validity of the scale is approved. To determine the CVR, the experts were asked to rate each item based on a three-part range: essential; It is useful, but it is not necessary, and it is not necessary, check. Then the answers were calculated according to the following formula (1):

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

In this formula n_E is the number of experts who have responded to the necessary option, and N is the total number of the experts. If the calculated value is greater than the value of Table 1, the content validity of the questionnaire will be accepted.

Table 1. Deciding on CVR[12]

Number of the experts' panel	5	6	7	8	9	10	15	20	25
The minimum amount of validity	0.99	0.99	0.99	0.85	0.78	0.62	0.49	0.42	0.37

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Determining the reliability of the questionnaire

The reliability of the questionnaire is a statistical test that results in a coefficient called Cronbach's alpha, which is used to test the reliability of a questionnaire designed in the form of a Likert scale and the answers to which are multiple-choice. "Cronbach's alpha is used to measure the one-dimensionality of attitudes, judgments, and other categories that are not easy to measure.

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum_{1=1}^{k} S_i^2}{S^2}\right) \quad (2)$$

In this formula (2), k is the number of questions or the ratio of the number of variables to the number of questions in the questionnaire (where each set of questions with identical and equal options must be tested separately; for example, questions with 5 answers together and 3 answers together). The order of the items (in terms of question scores) is not important for the Cronbach's coefficient, because this coefficient performs calculations based on variance, in which the number of items, the variance of the sum of each respondent's scores, and the variance of the score, and the variance of the scores are related to item i.

If the Cronbach's alpha coefficient is 0.7 or more, the reliability of the questionnaire is considered to be good. When the Cronbach's alpha coefficient is less than 0.7, the questions which have less correlation with other questions should be determined and eliminated from the set of questions in order to increase the Cronbach's alpha coefficient. However, if the Cronbach's alpha coefficient is between 0.7 and 0.5, the reliability of the questionnaire is evaluated as average. In order to obtain the alpha coefficient, the present questionnaire was distributed among 28 personnel of the process industry.

Gather information in the industry

After measuring the validity and reliability of the questionnaire and its so-called standardization, the questionnaire in this industry process was distributed and completed among 168 personnel in that industry to determine the perception index of the rapid warning systems in this industry. Demographic information such as age, work experience, and level of education was also collected through a questionnaire.

Determine the sample size

The following formula (3) was used to determine the sample size:

$$n = \frac{N * Z_{\frac{\alpha}{2}}^2 * \sigma^2}{\varepsilon^2(N-1) + Z_{\frac{\alpha}{2}}^2 * \sigma^2} \quad (3)$$

According to previous studies [13,14] in the field of early warning systems, the significance level of the test was considered to be 5%. The number of personnel working in the exploitation sector in this process industry was 290, of which 165 were estimated as the sample size, which was finally distributed among 168 questionnaires.

Interpretation of the final score

In order to get an explicit image of the status of the perception index of early warning systems, first, the final score was calculated from zero to one hundred, and then the score was categorized as follows:

Level 1: Score between zero and 50, poor perception of the system, minimal communication, and training efforts required.

Level 2: Score between 50 and 70, people with average perception who are working in the system; they do not think that everything is done for their safety.

Level 3: A score between 70 and 100, people have a good perception of the system, and most likely, people are well aware of the occurrence of events and perform appropriate behaviors.

The collected data were analyzed using SPSS software version 24. For the analyzed data, mean and standard deviation parameters, and Pearson and Spearman correlation coefficients were used.

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Results

The aim of this study was to localize the perception index questionnaire of rapid warning systems in one of the process industries in Iran. First, this questionnaire was translated, and then its validity and reliability were confirmed, the results of which can be seen in Table 2. As can be seen, the content validity index (CVI) is equal to 0.8, which is an acceptable value equal to 0.79, and also the content validity ratio (CVR) is equal to 0.66, which is acceptable according to the number of experts equal to 0.62 which is higher than acceptable in both cases. The reliability of the questionnaire was calculated using Cronbach's alpha coefficient, which is equal to 0.894 Table 2. The alpha coefficient that was obtained through the questionnaire is higher than the minimum acceptable value, which is equal to 0.7. Demographic information about participants such as age, work experience, and level of education is given in Table 3. Gender was not assessed because all subjects were male. The level of education of the employees shows that 39.3% of the people had a university education, 30.4% had a diploma, and the rest were at least literate. The percentage of people who have worked in this industry for less than a year was 23.2%, and the rest of the people, i.e. 76.8%, have been working in this industry for more than a year. The largest number of people in the age group are in the age group of 25 to 40 years, which makes up 46.4% of people.

The score for each question and the overall score of the Perception Index Questionnaire of early warning systems in the studied industry are given in Table 4. As can be seen, the score of question two, which measures the usefulness of the existing early warning system, is 66.96 percent, which is the lowest value among all scores. Question three assesses the level of awareness, and the ability to react at the time of alarm propagation, which is equal to 72.77% in this industry, was obtained through a questionnaire. The level of participation and satisfaction was the highest with a score of 75.45%, sensitivity to false alarms was equal to 72.77%, and finally, public feelings about the level of safety were equal to 70.76%, which in question one and question six, measure this criterion together.

Table 2. Validity and reliability of the questionnaire

Row	Items	CVI	CVR	Cronbach's alpha
1	I feel safe from the dangers in my work environment (such as fire hazards).	0.8	0.6	-
2	The alarm and warning system installed in my work environment is useful and appropriate for my safety.	0.7	0.8	-
3	I know what to do when the alarm system sounds in my work environment.	1	0.6	-
4	I think the hazard warning process and guidelines in order to follow are useful and appropriate information.	0.8	0.8	-
5	I always follow the relevant safety instructions when hearing an alarm sound.	0.8	0.4	-
6	In general, I think the safety in my work environment is satisfactory.	0.7	0.8	-
7	Total	0.8	0.666667	0.894

Table 3. Demographic information of the participants

Level of Education			Work Experience			Age		
Level of Education	Number	Percentage	Level of Education	Number	Percentage	Level of Education	Number	Percentage
Primary education and less	51	30.4	Less than a year	39	23.2	Under 25 years	42	25.0
Diploma	51	30.4	1-5 years	66	39.3	25-40	78	46.4
University	66	39.3	More than 5 years	63	37.5	40-60 years old	42	25.0
--	--	-	--	--	--	More than 60	6	3.6
Total	168	100.0	Total	168	100.0	Total	168	100.0

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Table 4. Scores related to the questionnaire questions

question number	Average	Standard deviation	Percentage
Question Two Score (Utility Assessment)	2.6786	0.849	66.965
Question three score (assessment of awareness level and ability to react)	2.9101	0.953	72.767
Question four score (assessment of participation level and satisfaction)	3.0179	0.957	75.447
Question Five Score (Sensitivity Assessment for False Alarms)	2.9107	0.934	72.767
Questions one and six points (assessment of public feelings about the level of safety)	2.8304	0.890	70.76
General indicator of perception of early warning systems	2.8696	0.770	71.74

Table 5. Pearson and Spearman correlation coefficient

Variable	Average	Standard deviation	Spearman and Pearson Correlation	Sig. (2-tailed)
Age Perception index	2.0714 2.863	0.801 0.770	0.060	0.443
Perception index Work Experience	0.770 0.768	2.863 2.1429	0.691**	0.001
Perception index Level of Education	0.770 -	2.863 -	0.746**	0.001

** The correlation is significant at the level of 0.01 (2-tailed)

The overall index of perception of the early warning system in this industry was equal to 71.74 percent. Pearson and Spearman correlation coefficients were used for statistical analysis. Table 5 shows the results. As can be seen, the Pearson correlation test was used to test the relationship between age and perception index. There was no significant correlation between perceptions and age, and statistically, these two variables are not related to each other (*P*-value = 0.443, n = 168 and r = 0.060). Pearson correlation test showed that there is a positive and strong correlation between perception index and work experience (*P*-value = 0.0001, n = 168 and r = 0.691). The results show that people with longer work experience also have a higher perception index. Spearman test was used to test the relationship between two variables of education level and perception index. theThe results showed that there was a correlation between these two variables (*P*-value = 0.0001, n = 168 and rho = 0.746).

Discussion

The main purpose of this study was to provide a tool to assess people's perception of early warning systems in the workplace. First, the Perception Index questionnaire was translated from English to Persian, and then its validity and reliability were calculated. The content validity index (CVI) was equal to 0.8, and also content validity ratio (CVR) was equal to 0.66, which in both cases is higher than the acceptable level, that means this tool can measure people's perception of early warning systems. [15] The reliability of the questionnaire was calculated using Cronbach's alpha coefficient, which was equal to 0.894, i.e., if the test is repeated, stable and reliable answers will be obtained.[16] In a 2016 study conducted in France by Arru et al., the same questionnaire was used with a reliability of 0.816.[8] In this study, in order to evaluate the validity and reliability of the questionnaire, help was sought from academic and industrial experts.

In the past, the validity and reliability of measurement tools were usually determined outside of the industrial environment and by students and in universities.[17] Also, the response scale of the questionnaire used in this study is the 5-point Likert scale, which facilitates the answering process due to having a wider range of answers and considering the phrase "I have no opinion".[18] Self-assessment is the most common and cost-effective way to be aware of the situation of people in a particular subject, which is suitable to provide feedback on the professional performance of people. It is also superior to other methods because it allows people to improve their

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strengths and weaknesses clearly.[19] Therefore, in this study, this approach was also adopted. Based on the opinion of the participating personnel, the usefulness of the rapid alert system was 66.96%, the level of awareness and reaction ability was 72.77%, the level of participation and satisfaction was 75.45%, the sensitivity to false alarms was equal to 72.77%, and the general feeling about The level of safety in the industry was equal to 70.76%. The overall perception index of the rapid warning system in this industry was 71.74%, which is in a good range, but still, there is another 28.26% vacuum to reach the ideal level of 100%. Given that the lowest score is related to people's understanding of the usefulness of the early warning system, this is the best place for industry executives to invest. Implementing measures such as conducting emergency maneuvers and training classes on early warning systems in the workplace and informing staff can be helpful. Pearson correlation test did not show a significant correlation between perception index and age (*P*-value = 0.443, n = 168 and r = 0.060). Pearson correlation test showed that there was a correlation between perception index and work experience (*P*-value = 0.0001, n = 168 and r = 0.691).

However, in the study by Maude Arru et al., conducted at a university in France, there was a correlation between age and perception of early warning systems, which can be attributed to the difference in the place of study. The difference between the present study and the study conducted in France is that this study was conducted in an industrial environment, a place where personnel do not acquire much information and knowledge with age. However, in the university, this is the opposite, i.e., as people get older, their knowledge and awareness increase, and, of course, their perception index also increases. The relationship between perception index and work experience is positive, which means that the longer people work, and the more people have work experience, the more they understand about early warning systems. According to Patrick Scuber's study, the obtained correlation intensity is relatively strong.[20]

Spearman test was used to test the relationship between two variables of education level and perception index (20), and the results showed that there was a strong correlation between these two variables (*P*-value=0.0001 , n=168 , rho=0.746), that is mean, with the increase in the level of education, the level of people's understanding of rapid warning systems also increases. The gender variable was not studied because all participants were male.

Conclusion

The indicator presented in this study measures the perception of on-site early warning systems (EWS). This indicator allows decision-makers and experts to find out how much people perception about existing warning systems. This feedback can start operational progress, hold training classes, change the communication process, and promote warning systems.This index has high validity and reliability and can be used in high-risk industries. The general perception index obtained in this industry was in good condition, which indicates that people have a good understanding of the early warning system in their workplace, and most likely, people have good awareness at the time of accidents and will behave appropriately.

However, the level of understanding of the usefulness of the existing rapid warning system in this industry was moderate, which requires managers and decision-makers in the industry to hold training classes related to the existing early warning system, emergency maneuvers, familiarize personnel with various scenarios, and represent control measures taken, and inform their staff to take action. A significant and positive correlation was reported between the two variables of work experience and education level with the general perception index, but the age variable did not have a significant correlation with the general perception index. It is suggested that

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due to not considering the gender variable in this study, in future studies, the perception index between women and men should be compared.

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