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# Analysis of Workers' Safety Attitude in an Iranian Process Industry

**Mohammad Khandan[a], Shahram Vosoughi*[b]**

[a]Research Center for Environment Pollutants, Qom University of Medical Sciences, Qom, Iran.
[b] Department of Health Sciences, Faculty of Health, Safety and Environment, Shahid Beheshti University of Medical Sciences, Hakimieh, Tehran, Iran.
***Correspondence** should be addressed to Dr. Shahram Vosoughi, **Email**: sh_vosoughi@yahoo.com

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**A-B-S-T-R-A-C-T**

**Background & Aims of the Study:** To prevent lots of work-related accidents in different industries and workplaces, managers should consider macro-factors such as safety culture and its elements like safety climate as the main subject to reflect attitude toward safety . This study aimed at finding the best work shift group in an Iranian process industry by safety attitude/climate analysis conducted in 2010.

**Materials and Methods:** Through a cross-sectional study 151 workers were selected in order to fill the safety climate questionnaires. After gathering safety climate questionnaires, the statistical tests of T-test, ANOVA and Pearson correlation were used through SPSS V16 to analysis data. To find the best work shift group TOPSIS method was also utilized.

**Results**: 134 out of 151 completed questionnaires were valid, making the response rate %88.74. Questionnaire's reliability was assessed by Cronbach's Alpha to be 0.928. The mean score of safety climate was 154.84 while the maximum score could be 245. Furthermore, 68.7% of workers had positive safety climate. A significant relationship was found between age and safety climate ($P< 0.05$).

**Conclusion**: The most effective and least attractive alternatives shift groups for intervention were selected in this company using TOPSIS method. By taking into account variant effects of accidents in process industries in different categories such as personal injuries/death, damage to property, and effects on environment and community, the results showed the importance of attention to safety principles and developing a positive attitude among employees with regard to safety.

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## Background

Macro-factors such as safety culture and its elements like safety climate as the main and reliable factor to reflect workers' safety attitude in the workplaces should be considered by decision makers in different organizations in order to prevent lots of work-related accidents. According to some reports and statistics, more than 2.2 million workers die due to work-related accidents or diseases (1). One of the most important methods to prevent hazards is some leading criteria like safety attitude/climate, or safety culture. Management systems and staff are two vital components of human factors (2). To control accidents and their costs, these elements need to be taken into account in management process. The first official use of the term safety culture dates back to an initial report about the Chernobyl accident (3). Wiegmann et al 2002 formulated a global definition of safety culture (4). In their view, individual and group values, attitudes, perceptions, competencies and patterns of behavior shape safety culture in an organization that determines the commitment to safety, and the life style and proficiency of an

organization's health and safety management. Actually, safety culture is seen as a subset of the overall organizational culture (5). The concept of safety culture has its origin in the social and behavioral psychology of the 1950's and 1960's that came to the fore in the organizational psychology, organizational behavior, and management literature of the 1980's (3). As the safety culture is a sub-facet of organizational culture and a subset of organizational factors, it denotes the extent to which upper level management demonstrates positive and supportive safety values, attitudes and behaviors. It is one of the most stable and substantial forces within organizations, shaping the way members think, behave, and approach their work (6). Zohar (1980) as cited in Yule (3) defines the term safety climate as "…a summary of molar perceptions that employees share about their work environments." Safety climate may reflect the underlying culture of the work-group or organization, although its focus is actually much narrower than safety culture, this is the common point of different definitions about safety climate (3). There are lots of factors such as management and workers' commitment to safety, safety behaviors, and safety knowledge related to safety culture. Despite the fact that higher numbers of assessed factors could help ergonomists to control and limit them, it would cause difficulties in analysis and decision making process. Using decision making models like Multi Criteria Decision Making (MCDM) can solve the problem.

**Aims of the study:**

This study was conducted in functional units of a process industry, located in Iran in 2010.

## Materials & Methods

Through a cross-sectional study, safety climate among 151 workers of all functional units of an Iranian process industry were analyzed by using safety climate questionnaire (SCQ), and TOPSIS method to find the best work shift work group. Workers of the company were divided into 5 work shift groups (working day or No, A, B, C, D). Working day group works all of weekdays during 8-17 o'clock but work shift groups (A, B, C, D) work three times/shifts a week (from 6 until 14, 14-22, and 22-6) rotationally. Their jobs are identical.

In addition, researchers applied statistical tests of T-test, ANOVA and Pearson correlation (SPSS 16) to examine the relationship between safety climate and employees' demographic characteristics such as age, education, job experience, number of training and marital status. Safety climate questionnaire presented by Vinodkumar and M. Bhasi (8) on a 1–5 Likert scale, ranging from strongly disagree to strongly agree was also used. In addition, a demographic questionnaire was utilized in order to gather general data.

SCQ is made up of six categories and contains 49 questions. Categories are 1) Management commitment and actions for safety (F1), 2) Workers' knowledge and compliance with safety (F2), 3) Workers' attitudes towards safety (F3), 4)Workers' participation and commitment to safety (F4), 5)Safeness of work environment (F5), and 6)Emergency preparedness in the organization (F6).

**The TOPSIS method:**

Technique for Order-Preference by Similarity to Ideal Solution (TOPSIS) method is a technique for order preference by similarity to ideal solution proposed by Hwang and Yoon (9). The ideal solution (also called positive ideal solution) is a solution that maximizes the benefit criteria/attributes and minimizes the cost criteria/attributes, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria. The so-called benefit criteria are those for maximization, while the cost criteria are those for minimization. The best alternative is the one which is closest to the ideal solution and farthest from the negative ideal solution.

Suppose a MCDM problem has n alternatives, A1,.,Am, and m decision criteria, X1,.,Xn. Each alternative is evaluated with respect to the m criteria. All the values/ratings assigned to the alternatives with respect to each criterion form a decision matrix (table 1) denoted by decision maker. Let W= (w1,.,wm) be the relative weight vector about the criteria.

**Table 1) Decision matrix (DM)**

| | $X_1$ | $X_2$ | …. | $X_n$ |
|---|---|---|---|---|
| $A_1$ | $r_{11}$ | $r_{12}$ | …. | $r_{1n}$ |
| $A_2$ | $r_{21}$ | $r_{22}$ | …. | $r_{2n}$ |
| ⋮ | ⋮ | ⋮ | | ⋮ |
| $A_m$ | $r_{m1}$ | $r_{m2}$ | …. | $r_{mn}$ |

Then the TOPSIS method can be summarized as follows (Ying Ming Wang, 2006):

1) Normalize the decision matrix X using the eq.1.

$$n_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^{m} r^2{}_{ij}}} \qquad (1)$$

Where $r_{ij}$ is the normalized criteria/attribute value/rating.

2) Calculate the weighted normalized decision matrix. Make use of the known weights vector and normalized decision matrix.

$$W = \{w_1, w_2, \dots, w_n\}$$

$$\approx (\text{consider as a duty of Decision Maker})$$

$$\text{weighted normalized decision matrix} = V$$

$$= N_D . W_{n\times n}$$

$$= \begin{vmatrix} V_{11,\dots} & V_{1j,\dots} & V_{1n} \\ \vdots & \vdots & \vdots \\ V_{m1,\dots} & V_{mj,\dots} & V_{mn} \end{vmatrix}$$

3) Determine the ideal and negative-ideal solutions:

$$\text{Ideal Solutions} = A^+ = \{(\max V_{ij} \mid j \in J), (\min V_{ij} \mid j \in J') \mid i = 1,2,\dots,m\} = \{V_1{}^+, V_2{}^+, \dots, V_j{}^+, \dots, V_n{}^+,\}$$

$$\text{Negative} - \text{Ideal Solutions} = A^- = \{(\min V_{ij} \mid j \in J), (\max V_{ij} \mid j \in J') \mid i = 1,2,\dots,m\} = \{V_1{}^-, V_2{}^-, \dots, V_j{}^-, \dots, V_n{}^-,\}$$

Where J and J′ are the sets of benefit criteria and cost criteria, respectively.

4) Calculate the Euclidean distances of each alternative from the ideal solution and the negative-ideal solution, (2 and 3) respectively.

$$D_{i^+} = \left\{\sum_{j=1}^{n}(V_{ij} - V_j{}^+)^2\right\}^{0.5} \; ; \; i = 1,2,\dots,m \qquad (2)$$

$$d_{i^-} = \left\{\sum_{j=1}^{n}(V_{ij} - V_j{}^-)^2\right\}^{0.5} \; ; \; i = 1,2,\dots,m \qquad (3)$$

5) Calculate the relative closeness of each alternative to the ideal solution. The relative closeness of the alternative $A_i$ with respect to A is defined as eq.4.

$$Cl_{i^+} = \frac{d_{i^-}}{(d_{i^+} + d_{i^-})} \; ;$$

$$0 \le cl_{i^+} \le 1 \; ; \; i = 1,2,\dots,m \qquad (4)$$

6) Rank the alternatives according to the relative closeness to the ideal solution. The bigger the $Cl_{i^+}$, the better the alternative $A_i$. The best alternative is the one with the greatest relative closeness to the ideal solution.

## Results

Out of 151 - which were returned -134 were valid, therefore, the response rate in the present study was %88.74. All workers were male. The mean age of employees' age was (30.95±5.298) years old. Furthermore, 63.6% of the employees were married and the rest were single. Regarding the education, 38.8% of employees had an education level of high school diploma or less with the largest proportion among different groups of education. The employees with M.Sc. or higher level educations were allocated to the least proportion with 3.7%. The results also signified that the mean work experience was (6.57±4.44). Every worker attended five safety training courses in average. Furthermore, %73.1 of studied workers were located in the operating unit, while only 6% of them were in storage unit. Maintenance and Technical services are two other units. In addition, while %29.9 of workers worked daily, 20.1, 17.9, 16.4 and 15.7 percentage of staff were at C, D, B and A shift work groups, respectively.

Safety climate score

Firstly, questionnaire's reliability was found to be 0.928 using Cronbach's Alpha. The results showed the mean score of safety climate was 154.84 (154.64±19.72) while the maximum score could be 245. Table 2 shows average score for components of safety climate.

**Table 2) Cronbach's Alpha and Descriptive of each SCQ factors**

| Factor | F1 | F2 | F3 | F4 | F5 | F6 |
|---|---|---|---|---|---|---|
| **Alpha** | 0.925 | 0.813 | 0.741 | 0.728 | 0.821 | 0.663 |
| **Average** | 12.14 | 4.46 | 19.88 | 21.56 | 25.97 | 71.52 |
| **Standard Deviation** | 2.59 | 1.842 | 5.60 | 2.36 | 3.67 | 14.451 |

Based on the mean score of safety climate which was more than 147 (as middle score), safety climate was positive in the company. In other words, 31.3% of workers had negative safety climate and 68.7% had a positive one. The relationship between safety climate score and age is significant ($p<0.05$) by Pearson correlation, which means safety climate improves with an increase in the age of employees. Nonetheless, results didn't indicate any other significant relationship between safety climate score and other demographic characteristics.

Results based on applying TOPSIS method

TOPSIS method has been used to find the best group of shift workers in the case of safety attitude. In this study, six factors of safety climate in five shift work groups were assessed. Decision making matrix is shown in table 3 which contains total score of safety climate factors for each work shift groups.

**Table 3) Decision matrix based on safety attitude data**

| ND= | F1 | F2 | F3 | F4 | F5 | F6 |
|---|---|---|---|---|---|---|
| **D** | 0.352 | 0.364 | 0.370 | 0.356 | 0.355 | 0.387 |
| **B** | 0.363 | 0.372 | 0.366 | 0.356 | 0.312 | 0.339 |
| **C** | 0.422 | 0.429 | 0.440 | 0.464 | 0.426 | 0.458 |
| **A** | 0.343 | 0.338 | 0.334 | 0.326 | 0.369 | 0.346 |
| **No** | 0.669 | 0.656 | 0.651 | 0.652 | 0.677 | 0.638 |

To conduct TOPSIS method, each safety climate factors needs to be weighted as an input of the method. Researchers used Entropy method to calculate weights: Management commitment and actions for safety was 0.174, Workers' knowledge and compliance to safety 0.159, Workers' attitudes towards safety 0.152, Workers' participation and commitment to safety 0.174, Safeness of work environment 0.197 and Emergency preparedness in the organization was 0.144. Normalizing and

tabulating Numbers was the next stage as shown in table 4.

**Table 4) Normalized matrix of safety attitude data**

| Factors / Shift work | F1 | F2 | F3 | F4 | F5 | F6 |
|---|---|---|---|---|---|---|
| **D** | 1570 | 587 | 494 | 441 | 99 | 291 |
| **B** | 1619 | 600 | 489 | 440 | 87 | 253 |
| **C** | 1881 | 692 | 588 | 574 | 119 | 344 |
| **A** | 1530 | 544 | 447 | 403 | 103 | 260 |
| **No** | 2984 | 1057 | 871 | 806 | 189 | 479 |

Then, ideal positive alternative and ideal negative alternative were evaluated. According to the acquired data, maximum and minimum values are selected.

$$A^{+} = \{0.116\ , 0.104, 0.099, 0.113, 0.133, 0.092\}$$
$$A^{-} = \{0.06, 0.054, 0.051, 0.057, 0.061, 0.049\}$$

And then:

$$D^{+} = 0.122 \quad , \quad B^{+} = 0.128,\ C^{+} = 0.091,\ A^{+} = 0.128,\ No^{+} = 0$$
$$D^{-} = 0.014 \quad , \quad B^{-} = 0.0092,\ C^{-} = 0.045,\ A^{-} = 0.012,\ No^{-} = 0.164$$

Finally, relative similarity to ideal of the compared alternatives is determined:

$Cl_D$=0.103, $Cl_B$=0.067, $Cl_C$=0.331, $Cl_A$=0.086, $Cl_{No}$=1

By doing priority queue according to Kbit,i values ,it becomes clear that working day group is the most effective and working shift group of B is the least attractive alternative for selection. Hence, working day, C, D, A, and B group are at the first, second, third, fourth and fifth rank of importance, respectively.

## Discussion

We used TOPSIS method to list groups based on intervention need to get better safety climate. This technique has roots in operational research and mathematics whose function is under control of one or more decision maker(s) in addition to its being objective (10,11).
This method has been proven in huge amounts of studies all around the world and applied in different fields of studies (10).
However, it is really hard to find publications that have utilized MCDM methods like TOPSIS and ELECTRE in the realm of occupational health and safety; while it can be practically helpful for managers and decision makers in these fields. Generally, workers' attitude toward safety is higher than middle score and acceptable. However, there is about one third of employees with negative safety climate , which is alarming.

By taking into account variant effects of accidents in process industries in different categories such as personal injuries/death, damage to property, and effects on environment and community, the results showed the importance of attention to safety principles and developing a positive attitude among employees regard to safety. Focusing on factors of management commitment and actions for safety, workers' participation and commitment to safety and safeness of work environment will help managers to have some success in the case of safety climate and safety culture enhancement. Scores of mentioned factors are lower than their middle scores and consequently are at higher levels of priorities depending on results of Entropy method. Sustainable improvement in safety climate of the company will be achieved by more attention to those factors. Moreover, results of TOPSIS method make us be aware that the priority of correct actions should be carried out on groups with lower importance. As such, B, A, and D groups must be at the top of the agenda. There are huge amounts of past studies that demonstrate the causal link between safety climate and workers' behavior at the workplace (12-14). It can be deduced that improvement in safety climate will lead to safer worker behavior, consequently slowing down the related accidents and injuries.

## Conclusion

All together, findings depict that TOPSIS can successfully help to handle challenges in occupational safety. It could be said that taking into account safety climate as a macro issue at organizations (14,16), some macro solutions for improvement are required, including work system assessment, work organization review, reward system establishment, with regard to organizational structure to assess, and evaluate function allocation.

## Footnotes

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**Conflict of Interest:**

The authors declared no conflict of interest.

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