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ORIGINAL RESEARCH PAPER

Health Risk Assessment in Building Environments Using Fuzzy Topsis Method

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ABSTRACT

The use of mathematical methods for risk assessment is an important instrument to control health risks. This research is performed to discuss the status of health risks of Larestan city. For this reason, the fuzzy Topsis method was used and firstly, four health risks insights including (safety insight, safety performance, comprehend risk, and evaluation risk) were discussed. According to results due to workers' insight into health risk status which was obtained by experts, four scales are offered which were used to optimize factory risk for effective factors. The results showed that, the threshold value for risk evaluation was estimated as 0.86, 0.726. The most suitable transmission variable is determined as risk evaluation, on the other side; it was a suitable pattern for risk transmission evaluation (t) for mild regression with LFUZZY TOPSIS. The findings help managers of occupations to reduce health potential risks and provide new insights to solve uncertainties in management and control potential risks.

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1. Background

Increasing the development of industries and establishing new working environments need to promote safety levels and prevent events (Gul et al., 2018; Sekhavati et al., 2023). In this regard, each telecommunication activity tolerates on bio environment which shall be a probable risk for the nature of the project and environment. Thus, to prevent events, evaluation, and management of health and environmental risks are imperative (Fataei et al., 2013; Cho et al., 2014; Fataei, 2020; Satiarvand et al., 2022). In industrial environments, there are different dangerous factors and physical factors are important. One of the physical factors is air pollution which is for the industrial society and causes important safety and health risks in workshops and shall be considered to prevent probable risk. Air pollution has resulted in the concentration of pollutants, intensity inversion, air stability, and distribution thermal regime and as a result increases different cardiovascular diseases which are more in cold seasons (Mostofie et al., 2014; Tabari et al., 2021; Khayat and Nasiri, 2023; Towoju et al., 2023; Wungrath et al., 2022). According to the last estimations, the scale of cancerous pollutants due to population and industrial activities is 10 more than Europe union standards in metropolitans like Shiraz and Tehran (Bai et al., 2007; Fataei, 2014; Torfi et al., 2021; Fazeli et al., 2019; Gazijahani et al., 2017; Hadi Bonab et al., 2020; Hosseinzadeh et al., 2013). Risk management aims to establish a systematic and continuous framework to identify, evaluate, delete, control, prevent, and inform risk.

Then, in the risk management process, the decisions are made in terms of comparing results due to risk (Jassbi et al., 2009; Haimes, 2015; Hassanpour Kourandeh and Fataei, 2013). Risk evaluation is based on the necessity of application of control actions to protect human forces (Pinto et al., 2011; Nami et al., 2017; Sekhavati and Jalilzade, 2021). Therefore, as for health risks due to pollution of industries and telecommunications which endanger people, it is necessary to pay attention to optimization of health risks to help air pollution and optimize risk and its necessities. Optimization and maintenance for many engineering, economic, and social systems are necessary to minimize costs and maximize interest and because of the vast in different sciences, it grows more (Kazemi, and Aboutaleb, 2013). The most famous mathematical optimization models are optimization by Fuzzy Topsis which is an efficient model for health risk.

Mahdevari et al., performed research on health and safety risk management in coal mines by fuzzy TOPSIS. In this study, three underground coal mines in Kerman were selected as case samples. This model can perform necessary actions to prevent events (Mahdevari et al., 2014).

Gelabale, prioritized and calculated all effective factors which are environmental, engineering, and economic factors to select equipment for controlling air pollution by designing select model equipment for air pollution control (case study: Cement Sharg Company) by helping fuzzy hierarchical analysis. The results showed that among the main elements, the economic model with a weight of 0.555 is recognized as the most important effective criteria to select air control pollution and environmental and engineering scales are other ranks with weights of 0.286 and 0.159 (Golbabaei et al., 2014). In 2009, a study namely evaluation of transmission companies for dangerous wastes by TOPSIS and AHP methods was performed by Gamas. According to the results, it is difficult to select the most accurate and suitable transport company for producers of dangerous wastes which needs the attention of safety authorities (Gumus, 2009). Groveling and Kapen Haro 2011 performed research as Fuzzy TOPSIS for group decisions, a case study on oil in the sea. They showed that the selection of the best strategy to fight against oil in the sea shall be evaluated by different values for each scale and forms multi scales decision problems (Krohling and Campanharo, 2011).

Multifaceted decision analysis (MCDA) is a collection of analytic methods which help managers to solve complicated and weak problems and use decision-making knowledge and effective scales to solve them. There are different strategic approaches for MCDA which act successfully for different problems. In a study, the Fuzzy TOPSIS multiple criteria decision-making methods have been used to rank the critical success factors of construction projects. Finally, a comparison of the proposed method and Entropy-based Fuzzy Multi-MOORA has been shown. According to the research results, the level of the effect of each critical factor on the successful execution of Iran's construction projects will be provided (Maghsoodi and Khalilzadeh, 2018).

AHP is an acceptable decision factor that is used to determine relative importance in certain decision-making. One of the most basic steps in each problem is to estimate dependent data. AHP is based on pair comparison which is used to determine relative importance (Sekhavati and Jalilzadeh, 2021; Khajeh Hoseini et al., 2022; Su and Deng, 2023; Mogaji and Atenidegbe, 2023). The fuzzy TOPSIS method is the most applied and famous method to rank options in a fuzzy environment ((Krohling and Campanharo, 2011; Lin et al., 2023). The present study aims to evaluate building health risks using the Fuzzy TOPSIS method. This study was conducted due to the lack of similar studies and the lack of sufficient data at Larestan University of Medical Sciences to improve the safety of construction workers and to reduce health risks and injuries at work.

2. Materials and Methods

Larestan is one of the southern cities in Fars province which had 221,000 populations in the census of persons and housing in 2011 and the population of Lar was 90,000. The shortest path to the sea is 160 km from access to sea which connects it to Pol pot but its distance minimizes to 97km by direct lane. Lar locates north of Hormozgan and south of Fars. Larestan is a strategic region because of military and economic factors and it is one of the entrance exit corridors because of the north-south bridge of the Persian Gulf into the open seas.

From a methodology point of view, this study was combined (descriptive qualitative) and was performed in two steps:

First step: in the first step, a descriptive study was performed on 100 people of sample to identify and evaluate different levels of air pollution, comprehend health risks, safety insight, safety performance, controlling actions, and accurate working methods which data required was collected by field measurement methods and questionnaire. The validity and reliability of the questionnaire were estimated by experts and the alpha Cronbach was 0.72.

Second step: since the subject of research is to optimize occupational health risks due to air pollution in Fuzzy TOPSIS, thus, the second step is in a qualitative field, therefore, in the second step (qualitative step) and after determining worker's status health risks, safety insight, safety performance, controlling actions, and accurate working status, 15 experts were selected by targeted method and structured by field interview method and completed checklist of multifaceted decision and at last, evaluated, prioritized and optimized by Fuzzy TOPSIS method.

The membership function of a trainable fuzzy number is offered as follows:

$$\mu_a(x) = \left\{ \begin{matrix} \frac{x-a1}{a2-a1} & if\ a1 \le x \le a2 \\ \frac{a3-x}{a3-a2} & if\ a2 \le x \le a3 \\ & otherwise \end{matrix} \right\} \quad [1]$$

Which μa˜(x) is by X membership function in the logical region in a for triangle fuzzy number and in another side,

a = (a1, a2, a3)

The fuzzy ranking is offered in Table 1 for dependent variables.

Table 1. Fuzzy ranking for dependent variables

Weight (QA)	Option evaluation	Fuzzy numbers
Very slight	Very weak	(1,1,3)
Little	Weak	(1,3,5)
Much	Good	(3,5,7)
Very much	Very good	(7,9,9)

If the distance between trainable numbers is considered as a fuzzy number, the distance between them is in terms of relations 2,3.

b = (b1, b2, b3) و a = (a1, a2, a3) [2]

$$d(a,b) = \sqrt{\frac{1}{3}[(a1-b1)^2 + (a2-b2)^2 + (a3-b3)^2]} \quad [3]$$

2.1. Fuzzy TOPSIS model

TOPSIS option insight was selected as the optimal option which has the shortest distance in the positive ideal and the longest distance in the negative ideal. If we suppose that the decision group has k members, the following relationship is true:

x˜kij = (akij, bkij, ckij)

w˜jk = (wjk1, wjk2, wjk3)

i = 1, 2, . . . , m, and j = 1, 2, . . . , n,

˜xij = (aij, bij, cij)

$$a_{ij} = \frac{min}{k}\left\{a_{ij}^{k}\right\}, b_{ij}\frac{1}{k}\sum_{k=1}^{\kappa} b_{ij}^{k}, c_{ij}\frac{max}{k}\{c_{ij}^{k}\} \quad [4]$$

Fuzzy accumulative weight is calculated in terms of the following relationship:

w˜jk = (wj1, wj2, wj3)

$$w_{ij} = \frac{min}{k}\{wjk1\}, w_{j2}\frac{1}{k}\sum_{k=1}^{k} w_{jk2}, w_{j3}\frac{max}{k}\{w_{jk3}\} \quad [5]$$

Fuzzy group multifaceted decision is seen in the following matrix:

$$\bar{D} = \begin{matrix} A1 \\ A2 \\ Am \end{matrix} \begin{bmatrix} C1 & C2 & Cn \\ x_{11} & x_{12} & \cdots x_{1n} \\ x_{21} & x_{22} & \cdots x_{2n} \\ x_{m1} & x_{m2} & \ldots x_{mn} \end{bmatrix} \quad [6]$$

$$\bar{W} = (\overline{w1}, \overline{w2} \ldots, \overline{wn}) \quad [7]$$

xij, vi, j and ˜ wj, i = 1, 2, . . . , m; j = 1, 2, . . . , n

xij = (aij, bij, cij)

˜ wj = (wj1,wj2,wj3) [8]

The normalized fuzzy decision matrix is as follows:

$$\bar{R} = [rij]_{m*n}, i = 1,2, \ldots, n \quad [9]$$

$$\bar{r}ij = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \quad [10]$$

$$c_j^* = \frac{max}{i} c_{ij}\ (benefit\ criteria) \quad [11]$$

$$\bar{r}ij = \left(\frac{a_j}{c_{ij}}, \frac{a_j}{b_{ij}}, \frac{a_j}{a_{ij}}\right) \quad [12]$$

$$a_j^- = \frac{min}{i} a_{ij}\ (cost\ criteria) \quad [13]$$

Normalized fuzzy decision matric is calculated for evaluation of weight for normalized fuzzy matrix:

$$\bar{V} = [\acute{v}_{ij}]m * n, i = 1,2, \ldots, m: j = 1,2, \ldots, n \quad [14]$$

$$v_{ij}^{-} = r_{ij}^{-}(0)w_j^{-} \quad [15]$$

The positive and negative ideal solution is calculated as follows:

$$A^* = (v_1^{-*}, v_2^{-*}, \ldots, v_n^{-*} \quad [16]$$

$$v_j^* = \max_i \{v_{ij3}\}, i = 1,2, \ldots, m: j = 1,2, \ldots, n \quad [17]$$

$$A^- = (v_1^-, v_2^-, \ldots, v_n^{-*} \quad [18]$$

$$v_j^- = \min_i \{v_{ij1}\}, i = 1,2, \ldots, m: j = 1,2, \ldots, n \quad [19]$$

The ideal distance for positive and negative ideal solutions is calculated as follows:

$$d_i^* = \sum_{i=1}^{n} d_v \left(v_{ij} v_{ij}^*\right), i = 1,2, \ldots, m \quad [20]$$

$$(d_i^- = \sum_{i=1}^{n} d_v \left(v_{ij}^- v_{ij}^-\right), i = 1,2, \ldots, m \quad [21]$$

Relative closeness to the ideal solution is calculated as follows:

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*}, i = 1,2, \ldots, m \quad [22]$$

According to results, due to workers' insight into health risk status which was obtained by experts, four scales are offered which were used to optimize factory risk for effective factors. Since the relative importance of different factors is different, the fuzzy TOPSIS method is used to remove the problem. In another step, the relationship among factors is recognized.

3. Results

Figure 2 shows effective factors in the optimization of health risk which has four insights safety insight, safety performance, risk comprehension, and risk evaluation, and subscales are determined for each of them in Figure 1.

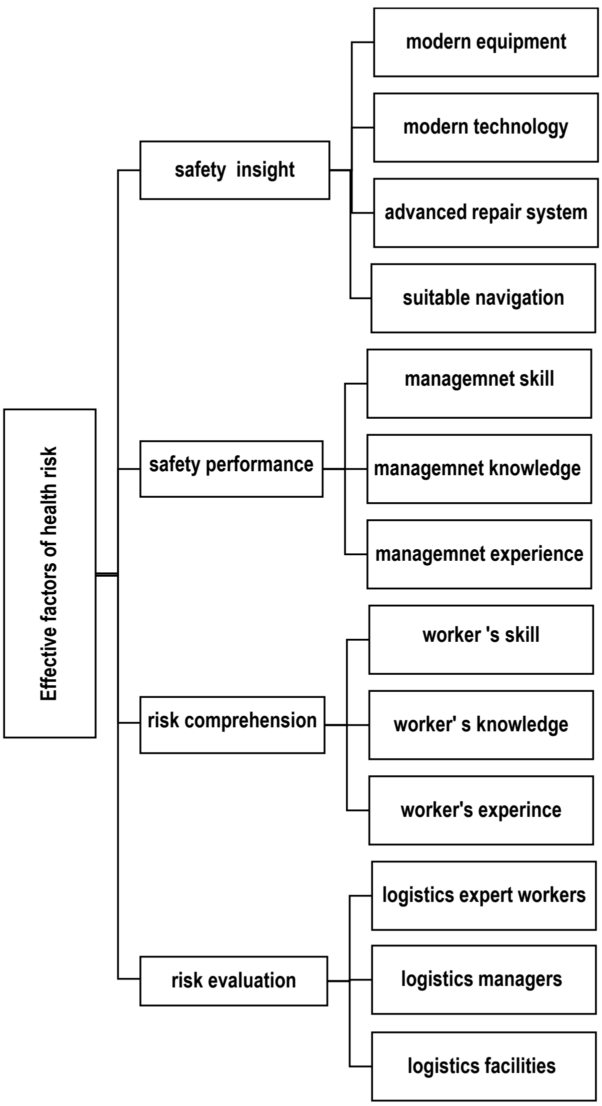

Figure 1. Network model to determine optimization factors for health risk

In another step, the main weighting scales (performed in terms of 9 quantitative hour scales) are determined which are in Table 1 the most weight is for risk comprehension and the lowest scale is safety insight.

In another step, as for network structure, the general super matrix structure or first matrix was recognized (Table 2). This matrix has 13 subscales which show the specifications of the main scales and are selected for the aims of the study. Table 3, shows a pair comparison for the internal dependency of the matrix.

To obtain general prioritizations in a system with interaction effects, vectors of internal priorities are entered into suitable columns in a matrix. As a result, a supermatrix (a divided matrix) is obtained by the relation between two clusters. By replacing the vector of internal priorities and clusters in the supermatrix, an unharmonized supermatrix is obtained.

Table 2. Pair comparison for main scales as for compatibility coefficient

Criteria	Risk comprehension	Safety performance	Risk evaluation	Safety insight	Normal
Risk comprehension	1	[redacted]			0.31
Safety performance	0.2	1	[redacted]		0.23
Risk evaluation	0.5	0.2	1	[redacted]	0.20
Safety insight	0.33	0.5	0.2	1	0.16

Table 3. Pair comparison for internal dependencies in matrix

Scales	Risk comprehensi on	Safety performanc e	Risk evaluation	Safety insight
Worker' skill	0	0	0	0.16
Worker; knowledge	0	0	0	0.30
Worker' experience	0	0	0	0.08
Management knowledge	0	0	0.47	0
Management experience	0	0	0.16	0
Manager' skill	0	0	0.09	0
Logistics expert workers	0	0.07	0	0
Logistics expert managers	0	0.28	0	0
Logistics expert facilities	0	0.19	0	0
Modern facilities	0.36	0	0	0
Modern technology	0.32	0	0	0
Modern repair system	0.10	0	0	0
Modern navigation	0.06	0	0	0

3.1. Stability test of Variables

The first step in estimation is to discuss the stability of variables. According to the present study, by the PP test, the stability of variables was discussed and its results were in Table 4. As for results, the null hypothesis is rejected in confidence level 99% as for unit root for safety insight, risk comprehension with and without time process. Therefore, these variables are stable, but in risk evaluation, it is stable with width from destination and time process.

Table 4. Results of the PP test for model variables

Variable	In level(to width from destination)	In level(with width from destination and time process)
Safety insight	*(0.00) -21.46	***(0.00) -21.55**
Risk evaluation	(0.10) -2.54	**(0.00) -4.78**
Safety performance	(0.00) -6.01	**(0.00) -6.43**
Risk comprehension	(0.00) -5.05	**(0.00) -6.78**

*Numbers in parentheses show the probable value of the test.

3.2. Determine optimal pause for research Pattern

The first step in the estimation of Fuzzy TOPSIS is to determine the optimal pause for model variables. For each of the variables, pause 8 is considered the highest pause and is the optimal pause of variables. According to it, for safety insight, safety performance, and risk comprehension, two pauses and for risk evaluation, three pauses are considered optimal pauses.

3.3. Nonlinear test and select transport variable

After determining the optimal pause for model variables, the next step is to determine the type of model in terms of the F test in estimating FUZZY TOPSIS which shall be determined in the event of rejection of the null hypothesis on linear and nonlinear and transport variables and the number of regimes for the nonlinear model are determined in terms of F, F2, F3 and F4 test. The results of the research are in Table 5. As for the probable value of the F test, the null hypothesis is rejected for all variables instead of the second pause for a linear model, and the nonlinear hypothesis is accepted for all variables.

To select suitable transport variables among other variables, each potential variable is tested but the priority is on the transport variable which rejected its null hypothesis of F test. According to it, the most suitable transport variable is risk evaluation (t) in Table 5. Selecting a suitable pattern to evaluate risk (t) for F2, F3, and F4 tests is another step in the estimation of the FUZZY TOPSIS model. As for the results in Table 4, the suggested pattern for risk evaluation (t) is a regression model for mild transport with logistic function LFUZZY TOPSIS2.

Table 5. Select the type of model and transport variable

Transport variable	Probable value F	Probable value F4	Probable value F3	Probable value F2	Suggested model
Safety insight(t-1)	0.000	0.132	0.039	0.000	**LFUZZY TOPSIS1**
Safety insight(t-2)	0.425	0.913	0.4	0.038	**Linear**
Risk evaluation(t)*	0.000	0.041	0.000	0.000	**LFUZZY TOPSIS2**
Risk evaluation(t-1)	0.003	0.592	0.032	0.000	**LFUZZY TOPSIS1**
Risk evaluation(t-2)	0.371	0.653	0.927	0.01	**Linear**
Risk evaluation(t-3)	0.023	0.367	0.256	0.001	**LFUZZY TOPSIS1**
Safety performance (t)	0.021	0.039	0.164	0.0206	**LFUZZY TOPSIS1**
Safety performance(t-1)	0.01	0.369	0.003	0.122	**LFUZZY TOPSIS2**
TREND	0.000	0.043	0.000	0.005	**LFUZZY TOPSIS2**

3.4. Estimation of Research Model

Model estimation consists of two steps. The first step is to select the first values for synchronic parameters variables y and threshold values C1, C2. The second step includes the final estimation of the pattern; the first points for y, C1, and C1 variables are ¼, 0.96, and 2.64 which was offered in another step. Using Newton Raphson's pattern, the parameters of the estimation model and its results were in Table 6. It is worth saying that in linear and nonlinear sections, the variables which were not significant were deleted. According to the results, the majority of coefficients were significant in CI 99%. Another important point is that the adjusted determination coefficient, value was 97%. The final estimation value was 1.31 for the synchronic parameter and it was 0.86 and 2.72 for the threshold value of risk and shall be followed for the transport function:

$$(1.31, \mathrm{c}, \text{risk evaluation}_t) = (1 + \exp\{-1.31(\text{risk evaluation}_t - 2.72)\})^{-1} \quad [23]$$

As for the above points in methodology, in the first and third regimes, G1 and in the second regime G0 is true, and equation == is used to calculate the second equation.

$$\text{optimize health risk}_t = -0.25 - 0.12\ \text{safety insight}_{t-1} + 0.38\ \text{risk comprehension}_t - 1.28\text{safety performance}_t + 0.78\ \text{risk comprehension}_{t-1} + 1.5\ \text{safety performance}_{t-1} + 1.38\ \text{risk comprehension}_{t-2} + 0.32\ \text{risk evaluation}_{t-2} - 0.39 \quad [24]$$

Equation == first and second regime

$$\text{optimization of health risk}_t = -1.07 + 1.9\ \text{safety insight}_{t-1} - 1.13\ \text{safety insight}_{t-2} + 4.5\ safety\ performance + 2.45\ \text{risk evaluation}_t + 3.94\text{risk comprehension}_{t-1} - 2.61\ \text{safety performance}_{t-1} + 0.7\ \text{risk evaluation}_{t-1} - 1.1\ \text{risk evaluation}_{\ t-2} + 3.01\ \text{risk evaluation}_{t-3} + 0.38\ \text{risk comprehension}_t + 1.38\ \text{risk comprehension}_{t-2} \quad [25]$$

In evaluation levels of risk lower than 0.86, first pause for safety insight, safety performance, comprehension of current risk and its first pause, evaluation of current risk and first and third risk and its values with positive effect and risk between 0.86 and 2.72, first pause for safety performance and second pause for risk evaluation and its first pause, current safety performance and third pause for risk evaluation on optimization of health risk had negative effects. The collection of safety insight in two regimes was 0.77 and 0.12 and the sum of risk evaluation and its pauses and intermediate regime were 5.15 and 0.07 and the effect of safety performance on three different regimes was different. The sum of safety performance was 0.77 and 0.12 and the sum of risk evaluation and other variables was 0.22 and side regimes was 1.89.

Table 6. Results of the final estimation model

Linear section	Coefficient(ϕ)	Statistics t	Probable value of t
CONST	-0.25	-4.29	**0.001**
safety insight(t-1)	-0.12	-2.52	**0.014**
risk comprehension (t)	0.38	2.98	**0.004**
safety performance (t)	-1.28	-4.63	**0.000**
Risk comprehension (t-1)	0.78	5.67	**0.000**
Safety performance (t-1)	1.5	4.38	**0.000**
Risk comprehension(t-2)	1.38	9.16	**0.000**
Risk evaluation(t-2)	0.32	8.33	**0.000**
Risk comprehension (t-3)	-0.39	-9.72	**0.000**
Nonlinear section	coefficient (θ)	statistics t	**Probable value of t**
CONST	-0.82	-1.8	**0.076**
Safety insight(t-1)	2.02	2.64	**0.01**
Safety insight (t-2)	-1.13	-1.88	**0.064**
Safety insight(t)	5.78	1.95	**0.056**
risk evaluation (t)	2.45	-2.89	**0.005**
Risk comprehension (t-1)	3.16	2.3	**0.024**
Safety performance(t-1)	-4.11	-2.7	**0.009**
Risk evaluation(t-1)	0.7	1.88	**0.064**
Risk evaluation(t-2)	-1.42	-2.28	**0.003**
Risk evaluation(t-3)	3.4	3.03	**0.003**
		-6.46	**AIC**
		-5.79	**SC**
		-6.20	**HQ**
		97.10%	**R2**
		97.15%	**adjusted R2**

4. Discussion

Understanding the various factors that affect work-related injuries and deaths in the industry can help develop prevention strategies, improve safety performance and reduce accidents (Abbasinia and Mohammadfam, 2022). Optimization aims to measure and control risks in terms of different indicators including scale of effect and probable event. The ranking of risks is regarded as the key section. Because risk ranking is a prioritization process and can be planned on the devotion of resources (Yazdi, 2018; Koulinas et al., 2019). On one side, the important action and recognize the risk of each occupation and prioritize controlling actions. Alternatively, a fuzzy technique for Order Performance by Similarity to Ideal Solution (TOPSIS) model was used to evaluate the performance of companies and rank them according to their safety performance (Basahel and Taylan, 2016). The fuzzy-TOPSIS approach is capable of considering not only the uncertainty related to qualitative judgments but also the uncertainty that may reside in the measurement of quantitative or qualitative parameters that exist within the safety, health, and environment risks assessment (Rahim et al., 2021). The health risk of building environments was evaluated by the Fuzzy TOPSIS method (Jassbi ET AL., 2009). To determine effectiveness, LFUZZY TOPSIS was determined as the optimal pattern, Gul et al. performed a study on the comparative map of health risk and occupational risk in terms of FTOPSIS which most important indicator for risk evaluation (Gul and Ak, 2018). According to the results of LFUZZY TOPSIS, the threshold value of risk evaluation was estimated at 0.86 and 2.72. As for the estimated value, 1.31 is for synchronic transport parameter between regimes as smoothly, different variables coefficients are shown in different regimes which confirm the effectiveness of variables on optimization of health risk. In evaluation risk lower than 0.86 and higher than 2.72, the first pause for safety insight, safety performance, evaluation of current risk, and first and third risk had negative effects. The sum of safety insight in side effects and intermediate regimes was 0.77 and 0.12 which emphasize the negative effect. The sum of risk evaluation and pause values in side and intermediate regimes were 5.15 and 0.07 and shows that risk evaluation had a positive and significant effect on health risk so that in intermediate level, this effect is negative and insignificant. In a study, the results indicate that in addition to organizational factors, individual factors, and environmental factors, the government must also play a role in legislation, law enforcement, implementation, and organization of safety training programs Abbasinia and Mohammadfam, 2022). The results of Gul et al. study show that the most important risks have happened during construction and the risks are due to lacking access to a safety belt, falling from panic height, and lacking immediate response to emergency conditions (Gul et al., 2018). The effect of safety performance was positive in three regimes and the sum of the coefficients was 0.22 and in side regimes was 1.89 and which confirms that in high and low evaluation risk, safety performance has more effects than intermediate level on optimization of current health risk. The variety of activities and the exposure time of workers to PMs were among other limitations that may affect the accuracy of some results. Conducting clinical studies on workers who are exposed to suspended particles can complement the present research.

5. Conclusion

In this study, four insights are offered to discuss the situation of Larestan construction workshop which are risk comprehension, safety insight, safety performance, and risk evaluation. In the management of construction projects, evaluation of safety risk is regarded as an important step to identify dangers and value damages. In summary, as for the results, we can say that risk evaluation has a nonlinear effect on the optimization of health risk and safety performance can be effective on risk comprehension and safety performance. On the other side, the speed of transport between regimes is mild and different effectiveness confirms that risk evaluation results in optimization of health risk but it is different during time as if it can be negative. Risk evaluation has different effects on the optimization of health risks.

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