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Proposing an Evacuation Exit Plan for Pilgrims during Accidents from the Shrine of Imam Reza

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Original Article

Abstract

INTRODUCTION: Behavioural patterns of the people can affect the emergency evacuation procedure. The most important issue of crisis management is to evacuate the people from the accident site in the shortest time and with the maximum speed. Pilgrimage destinations attract many pilgrims on religious occasions, and this has highlighted the importance of addressing this issue in these centers. This study aimed to explain and propose an evacuation exit plan for pilgrims during accidents in the most important and prominent religious center of Iran (Shrine of Imam Reza).

METHODS: This descriptive-analytical study was performed using an applied research method. The document-library and field methods were used to collect data. The statistical population includes the managers of the Shrine complex, experts of the crisis management headquarters, consulting engineers in architecture and urban planning, as well as managers and experts in Mashhad Municipality. The sample size was estimated to be 384 cases based on Cochran's formula. The collected data via questionnaires were analyzed by SPSS and Smart PLS software using structural equation modelling.

FINDINGS: According to the results, the presented model includes seven variables (group movement, individual movement, incident management technology tools, perception of the physical environment, physical movement, modelling, and behavioural culture) affecting the pilgrims leaving the incident site in the Shrine of Imam Reza.

CONCLUSION: The results of this study indicated that the presented model with 7 variables and 21 parameters can be used as a suitable model in other places.

Keywords: Crisis Management; Emergency Evacuation; Shrine of Imam Reza (AS); Optimal Model.

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Introduction

Natural and man-made crises are among the challenges encountered by most big cities across the world. Due to the occurrence of natural and man-made crises in recent decades in Iran, it is of utmost importance to have coherent and efficient management in a crisis. Emergency evacuation of those rescued from disasters is one of the general strategies and main activities in managing a crisis caused by unforeseen incidents. In many dangerous situations, the best solution is to move the vulnerable people to safety (1). Urban emergency evacuation concern has been raised as a complicated issue in the real world due to the behavior of people, the effects of environmental factors on the urban space, and the need for emergency evacuation of people from accident-affected areas and moving them to safety, in the shortest possible time and with the least number of injured (2). Therefore, urban planners and managers should come up with optimal solutions for emergency evacuation and predict rescue and relief in urban areas in the pre-crisis phase.

Accordingly, safe emergency road networks

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for the evacuation of injured people should be identified and necessary measures should be taken in order to optimize them (3). The investigation of the behavioral patterns of the people is among the methods that are used to explain and present the optimal model of an emergency evacuation. In fact, the behavioral patterns of the people in an emergency can influence the population evacuation procedure. A complete understanding of these behavioral approaches is a necessity for the designers of crowded urban spaces, such as high-rise buildings, hospitals, public transport stations, sports stadiums, as well as cinema halls and theaters, to predict the behavior and movement of people in dangerous situations and calculate the actual evacuation time and compare it with the necessary standards of evacuation procedures. Managers and space users are also obliged to get familiar with these approaches to manage the emergency efficiently in critical situations, such as earthquakes, fires, bombings, and terrorist operations (4). Religious centers are among places that are potentially exposed to the crisis. These places welcome many pilgrims on religious occasions, and this has increased the importance of addressing this issue in these centers. Therefore, this study aimed to explain and present an evacuation exit plan for pilgrims during accidents in the most important and prominent religious center of Iran (the Shrine of Imam Reza in Mashhad). The spatial arrangement complexity of the courtyards and the presence of a large number of people within the Shrine increase the probability of the population's vulnerability to natural and man-made disasters. Furthermore, the characteristics of the urban texture surrounding the Shrine of Imam Reza (with an area of about 300 hectares), including worn-out texture and fineness, compactness (the texture surrounding the Shrine of Imam Reza has undergone a transition from wearing out to renovation since 1993. This project has been continuing since the end of the 2001s at a fast pace), the residential accommodations on a large scale near the Shrine, a large volume of commercial activities, and especially the construction sites lead to traffic restrictions and congestion in normal conditions, which seem seriously problematic when a crisis occurs. In line with this topic under study, limited research has been conducted in Iran. In a study (5), it was found that emergency evacuation is affected by the interaction of human behavior with space; accordingly, it considers the external environment (environmental and constructional features), as well as psychological and human factors as two important categories in evacuation simulation procedure. In another study (4), after reviewing the previously conducted studies, four behavioral patterns of the people in the emergency included mass panic, dependence, normative, and social identity. Therefore, a gathering of people with behavioral phenomena of mass panic leads to human disasters. It is worth mentioning that humanitarian social behaviors, such as helping strangers and disabled people, do not necessarily reduce evacuation time in an emergency.

Methods

This descriptive-analytical study was conducted based on an applied research method. The required data were obtained using document-library and field methods. This study mainly aimed to present the evacuation exit plan for pilgrims during accidents in the Shrine of Imam Reza's focusing on its connection with the surrounding texture. Furthermore, this study utilized crisis management approaches to either modify the existing possible strategies or develop new ones for the optimal evacuation of the pilgrims in the Shrine during a possible crisis. This study was conducted using a top-down collaboration approach. Regarding the specialization of crisis management and the urgent need for unified and integrated management, this approach leads to better outcomes during a crisis and prevents chaos/disorder which may be the main factor in reducing the amount of success during an emergency.

The statistical population of this study includes:

1- Managers of the Shrine complex and the Shrine development organization
2- Managers and experts of the crisis management headquarters in Khorasan Razavi Province
3- Architects and civil engineers
4- Managers and experts of the municipality (Samen District)
5- Managers and experts of the fire department

The total population was estimated at 2000 cases; however, using Cochran's formula, 384 people were selected to participate in the study. After reviewing the parameters in Table 1, it was

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recognized that they were somehow close to the topic under investigation; however, the researcher made some modifications to their definitions considering the special conditions of the Shrine and its surroundings. Accordingly, the parameters of the optimal evacuation of the Shrine during an emergency include 7 main variables and 21 sub-variables. It should be mentioned that after monitoring and interviewing competent experts and managers, these measures were reduced to 7 main variables and 17 sub-variables.

Table 1. Variables under study (6)

Row	Variable	Sub-variable	Description
1	Group movement	Imitation of collective behavior	Imitation and following the movement of the crowd
2		Collective information exchange	Analysis of the movement of people and choosing the correct route from the pilgrims' point of view in and around the shrine
3		Movement in the selected path of moving masses	Choosing the busiest route of the crowd
4	Individual movement	The mental image in the pilgrim's mind of the shrine	Each person's mental map of the shrine and the areas surrounding the shrine
5		Search in physical paths	Moving among all the possible movement paths in the courtyards and porticoes of the Shrine and the surroundings to reach a safe place
6		Movement in the cone of vision	A person rushes forward the visible movement path without turning his head/neck
7	Incident management technology tools in closed spaces	Fire announcement and extinguishing	Intelligent fire detection and extinguishing systems
8		Smoke management	Exhaust intelligent systems
9		Immediate access to emergency supplies	Zoning the independent spaces against incidents in the Shrine and its surrounding
10	Perception of the physical environment	Movement toward the signs	Visual signs inside the Shrine and its surroundings (including interior and exterior reference signs)
11		Movement toward the moving nodes	Gathering points inside the shrine in the first stage and its surrounding in the second stage
12		Movement in the dominant traffic lane	The main routes inside the Shrine and the areas with high evacuation capacity and lowest risk surrounding the Shrine
13	Physical movement	Prominent visual elements	What prominent elements and signs in the Shrine and its surroundings form the mental map of the pilgrims?
14		Physical signs	Are the signs effective in exiting from the Shrine?
15		Graphics of the emergency route	Are the graphics of movement routes effective and useful for the emergency exit?
16	Behavioral modeling	Previous training on emergency evacuation	Has a person been trained to take the responsibility of protecting the life or property of other people in the shrine?
17		Responsibility of the person present in the building	Is a person responsible for saving the life or property of other people in the Shrine?
18		Experience of being in similar situations	Has there been any personal experience of being in evacuations in the Shrine before?
19	Behavioral culture	Age	Child - teenager - young - middle-aged – elderly
20		Gender	Male/female
21		Behavioral culture	Religious, cultural, and national behaviors and other values that are the criteria of action in the individual's society

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The mentioned variables are independent variables and the emergency evacuation of the pilgrim in the Shrine is a dependent variable. The required data were collected using a researcher-made open and closed questionnaire, the content validity of which was confirmed by university professors and some experts specializing in tourism, as well as the managers of the Tourism Department of Mashhad, Iran. The research hypotheses were analyzed using the modeling structural equations in SPSS and Smart PLS software. Following that, a graphical structural model was presented in line with the topic under study.

Findings

After developing the research variables, the study sample (n=384) was asked to weigh them. Below is the table including the descriptive statistics of the research parameters.

Structural Model Fit

According to Table 2, the skewness and kurtosis coefficients for all research parameters are in the appropriate range. Considering the skewness and kurtosis coefficients, the assumption of normality of the data for these parameters is confirmed (7, 8).

If the composite reliability value for each factor is higher than 0.7, it indicates suitable internal stability for the models, and values less than 0.6 indicate the absence of reliability. As can be observed in Table 3, Cronbach's alpha coefficients and composite reliability values of all variables in the research model are more than 0.7. Therefore, these variables have the required composite reliability (9, 10).

Fornell and Larcker (1981) introduced the Average Variance Extracted (AVE) criterion to measure convergent validity and stated the critical value as 0.5. According to the values of this criterion in Table 1, it can be observed that all the constructs of the equation model have high convergent validity (11&12). Table 4 tabulates the values related to the correlation coefficients among the parameters along with the Square root values of AVE on the main diagonal. This model has an acceptable divergence if the numbers in the main diagonal are greater than the values below and to the lower right-hand corner of the matrix.

According to Table 2, the AVE square root value of all latent variables is greater than that of the correlation coefficients among them; as a

Table 2. Descriptive statistics of research indicators

Variable	N	Min	Max	Mean	SD	Skewness	Kurtosis
Imitation of collective behavior	384	3	12	8.398	2.594	-0.594	-0.475
Collective information exchange	384	5	16	12.315	3.008	-0.566	-0.655
Movement in the selected path of moving masses	384	9	28	20.714	4.361	-0.552	0.009
Group movement	384	5	12	14.846	2.517	0.706	0.452
Mental image	384	4	16	8.977	3.787	0.169	-0.992
Search in physical paths	384	3	12	6.839	2.283	0.036	-0.607
Individual movement	384	7	14	8.564	4.551	-0.413	-0.816
Fire announcement and extinguishing	384	7	28	15.815	5.374	0.303	-0.603
Smoke management	384	3	12	12.514	4.024	-0.504	-0.912
Immediate access to emergency supplies	384	5	29	19.362	4.604	-0.734	0.565
Incident management technology tools	384	6	12	14.588	2.857	0.886	-0.347
Movement toward the signs	384	3	15	15.371	3.736	0.034	0.247
Movement toward the moving nodes	384	7	18	12.0621	4.449	-0.414	-0.801
Movement in the dominant traffic lane	384	4	27	20.123	2.514	-0.969	-0.455
Perception of the physical environment	384	7	16	10.253	2.612	0.422	0.765
Prominent visual elements	384	5	14	8.328	5.537	0.504	-0.641
Physical signs	384	3	16	14.452	4.870	0.109	0.415
Physical movement	384	6	18	14.765	3.870	-0.258	0.416
Previous training	384	5	12	30.312	4.854	0.2874	0.7001
Similar experience	384	4	15	19.765	2.080	-0.0218	0.753
Behavioral modeling	384	7	14	10.411	2.693	0.941	0.417
Gender behavior segregation	384	4	12	6.594	3.591	0.493	-0.480
Behavioral culture	384	5	14	11.963	2.552	0.910	0.824

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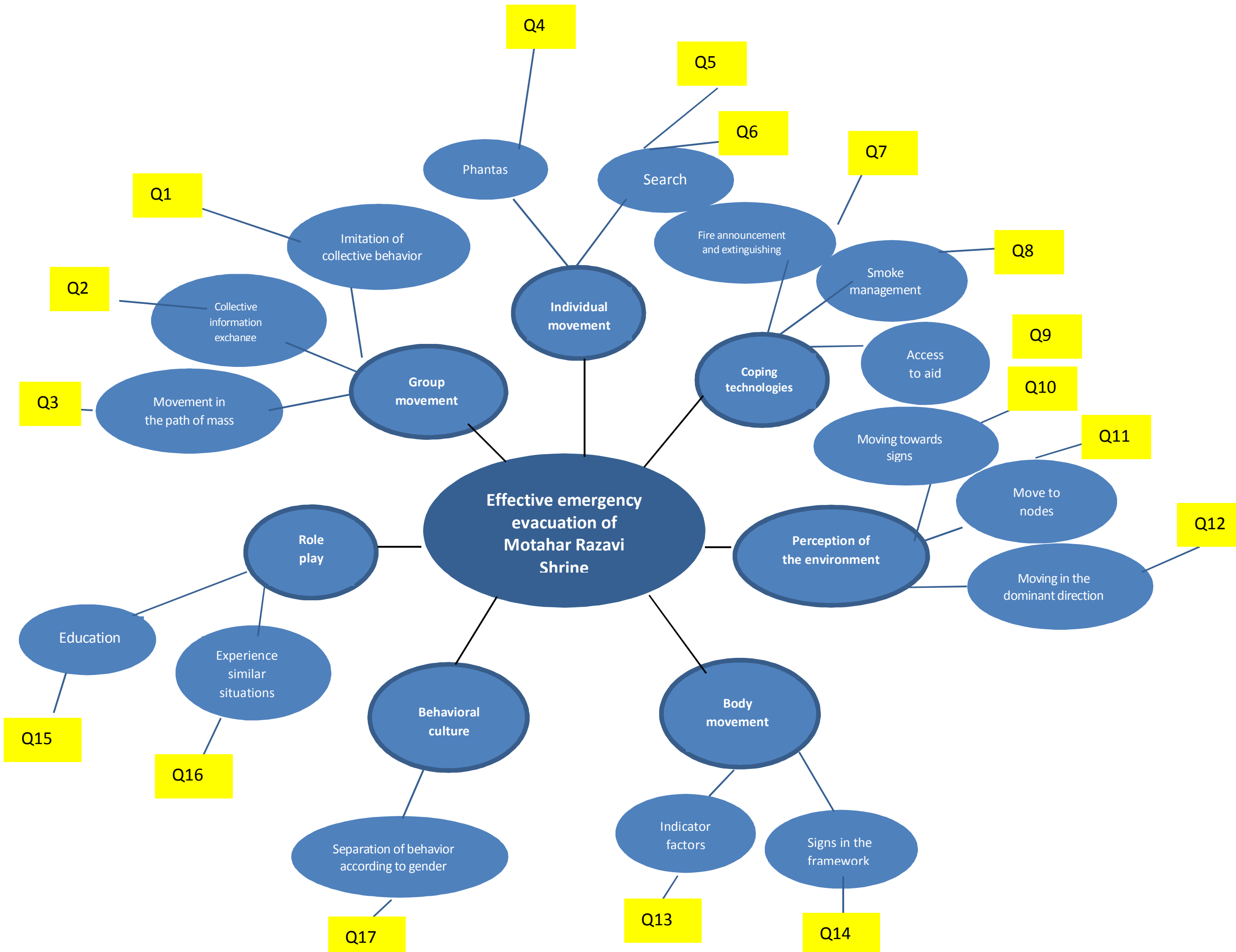

Diagram 1. Fit index of the emergency evacuation model

Table 3. Reliability of the questionnaire

Variable	Cronbach's alpha	Composite reliability	AVE
Imitation of collective behavior	0.791	0.877	0.712
Collective information exchange	0.711	0.83	0.564
Movement in the selected path of moving masses	0.717	0.763	0.617
Group movement	0.958	0.97	0.889
Mental image	0.705	0.844	0.656
Search in physical paths	0.891	0.856	0.75
Individual movement	0.796	0.671	0.54
Fire announcement and extinguishing	0.816	0.680	0.571
Smoke management	0.714	0.850	0.641
Immediate access to emergency supplies	0.810	0.693	0.55
Incident management technology tools	0.923	0.784	0.680
Movement toward the signs	0.702	0.741	0.583
Movement toward the moving nodes	0.754	0.825	0.588
Movement in the dominant traffic lane	0.801	0.880	0.714
Perception of the physical environment	0.784	0.910	0.745
Prominent visual elements	0.832	0.650	0.592

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Table 3. Continued

Physical signs	0.956	0.810	0.632
Physical movement	0.763	0.745	0.560
Previous training	0.736	0.792	0.542
Similar experience	0.780	0.815	0.658
Behavioral modeling	0.765	0.920	0.542
Gender behavior segregation	0.921	0.684	0.563
Behavioral culture	0.707	0.787	0.645
Effective emergency evacuation of the Shrine	0.732	0.698	0.710

result, it can be concluded that the divergent validity of the measurement model is confirmed (13, 14).

According to Table 4, the modeling variable with parameters, such as training and similar conditions, had the greatest effect on the emergency evacuation plan (AVE=0.954). Then, incident management technology tool parameters, such as announcing fire extinguishing, smoke management, and access to rescue equipment (AVE=0.943), followed by group movement with parameters, such as imitation of collective behavior, exchange of collective information, and movement in the path of the masses (AVE=0.954), as well as other variables in descending order had an effect on emergency evacuation. The least effective variables were related to individual movement with parameters, such as mental image, and search in the physical path, as well as behavioral culture with parameters, such as gender behavior segregation.

Structural Model Assessment

After investigating the fit index of the measurement models, the fit index of the structural equation model was assessed. The structural model section, unlike measurement models, examines latent variables and the correlations among them regardless of the questions (observed variables).

T-values

Several criteria are used to examine the fit indices of the research model, the first and most prominent of which are t coefficients or t-values. If their value exceeds 1.96, it indicates the correctness of the relationship among the factors, and as a result, the research hypotheses are confirmed at the confidence level of 0.95. (6)

Table 4. Matrix of divergent validity measurement using the Fornell-Larcker method

Variable	Group movement	Individual movement	Incident management technology tools	Perception of the physical environment	Physical movement	Modeling	Behavioral culture
Group movement	0.844						
Individual movement	0.234	0.751					
Incident management technology tools	0.076	0.134	0.943				
Perception of the physical environment	0.043	0.026	0.539	0.810			
Physical movement	0.561	0.624	0.784	0.691	0.831		
Modeling	0.802	0.741	0.697	0.561	0.823	0.954	
Behavioral culture	0.687	0.564	0.55	0.643	0.70	0.698	0.751

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R2 and Q2 Criteria

R2 coefficients are related to endogenous hidden factors of the model (dependent). To check the quality or validity of the model, Cross Validation Redundancy (CV-Red) which is also called Stone-Geisser Q2 was used. These criteria determine the predictive power of the model. If the values of this index are 0.02, 0.15, and 0.35 for one of the endogenous factors, it indicates the weak, medium, and strong predictive power of the factor or its relevant exogenous factors, respectively. (15)

As can be observed in the above table, these criteria are moderate and strong for all endogenous factors indicating the appropriateness of the exogenous (independent) factors in predicting dependent factors and reconfirming the appropriate fit of the structural model.

Table 5 summarizes all relationships; accordingly, all research variables show significant relationships with each other since the t value is more than 1.96 for all parameters. relationships.

General Model Test

The general model includes both measurement and structural model, and by confirming its fit, the fit assessment in one model is completed. The Goodness of Fit (GOF) criterion is related to the general part of the structural models. Accordingly, using this criterion, the researcher can control the fit of the whole model after examining the fit of the measurement and structural models. The GOF was developed by Tenenhaus et al. in 2004.

Table 5. Relationships within the structural model

Relationships within the structural model of the research	Standard coefficients	Standard error	T-Value	R2	Q2
Group movement → crowd behavior imitation	0.757	0.036	20.909	0.573	0.395
Group movement → crowd information exchange	0.813	0.028	29.129	0.66	0.333
Group movement → movement in the main route of the moving mass	0.952	0.004	258.006	0.907	0.757
Individual movement → mental image	0.77	0.03	25.484	0.593	0.392
Individual movement → search in the physical path	0.840	0.003	21.365	0.845	0.463
Incident management technology tools → fire announcement and extinguishing	0.963	0.021	25.256	0.893	0.802
Incident management technology tools → smoke management	0.782	0.025	29.304	0.698	0.689
Incident management technology tools → access to emergency supplies	0.902	0.039	7.512	0.645	0.870
Perception of the physical environment → movement toward the reference signs	0.725	0.036	13.120	0.763	0.589
Perception of the physical environment → movement toward the moving nodes	0.961	0.024	8.82	0.802	0.707
Perception of the physical environment movement in the dominant path	0.862	0.005	10.93	0.671	0.609
Physical movement → prominent elements	0.741	0.124	4.451	0.591	0.353
Physical movement → physical signs	0.985	0.111	21.441	0.512	0.532
Behavioral modeling → training	0.561	0.0028	12.41	0.609	0.346
Behavioral modeling → experience of being in similar situations	0.639	0.031	15.636	0.825	0.068
Behavioral modeling → gender behavior segregation	0.816	0.005	24.254	0.556	0.58
Physical movement → escape	0.729	0.022	16.115	0.779	0.06
Effective emergency evacuation → group movement	0.415	0.124	3.336	0.172	0.062
Effective emergency evacuation → individual movement	0.953	0.023	41.685	0.908	0.572
Effective emergency evacuation → incident management technology tools	0.515	0.0026	25.256	0.809	0.387
Effective emergency evacuation → perception of the physical environment	0.780	0.023	12.810	0.784	0.423
Effective emergency evacuation → physical movement	0.651	0.110	10.456	0.655	0.369
Effective emergency evacuation → behavioral modeling	0.796	0.033	14.155	0.963	0.335
Effective emergency evacuation → behavioral culture	0.925	0.157	09.23	0.805	0.321

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GOF formula is as follows:

$$GOF = \sqrt{\overline{R^2} \times \overline{\text{Communality}}}$$

Communality is obtained from the average square root factor loadings of each factor.

$\overline{R^2}$=Is the average value of the R square of the endogenous factors of the model.

The values of 0.01, 0.25, and 0.36 indicate weak, medium, and strong values of GOF, respectively, and the fit index for the model was reported as GOF=0.675; accordingly, it shows a strong fitting for the research model. In general, considering the obtained results, and according to the steps that were taken to confirm the measurement model, construct validity and diagnostic calculations, followed by the assessment of the relationships among the research constructs, the model presented by the researcher is approved. Furthermore, 17 parameters that have been determined according to the opinions of the relevant experts were regarded as the independent variables that were effective in an emergency evacuation of the pilgrims in the Shrine of Imam Reza (16, 13).

Discussion and Conclusion

This study mainly aimed to investigate the effect of emergency evacuation parameters on the evacuation exit plan of pilgrims during accidents in the Shrine of Imam Reza, Mashhad, Iran, focusing on its connection with the surrounding texture. According to the model proposed based on the emergency evacuation parameters, the results obtained from the questionnaire using the factor analysis model reveal that the exogenous (independent) factors are appropriate in predicting the dependent factors of the research; moreover, they confirm the appropriate fit of the structural model. Based on the results in Tables 3, 4, and 5, the proposed model includes 7 main variables (modeling, incident management technology tools, group movement, physical movement, perception of the physical environment, behavioral culture, and individual movement) and 17 sub-variables (imitation of collective behavior, exchange of collective information, movement in the path of the masses, group movement, mental image, search in the physical path, individual movement, fire announcement and extinguishing, smoke management, access to rescue equipment, incident management technology tools, movement towards signs, movement towards nodes, movement along with the dominant path, perception of the physical environment, visual signs, physical signs, physical movement, previous training, experience in similar situations, behavioral modeling, gender behavior segregation, behavioral culture, and the effective emergency evacuation of the Shrine) that were confirmed according to the opinions of the relevant experts and the conducted assessments. As a result, while considering environmental factors and the interaction of human behavior with the environment, the proposed model finds the shortest path to reach safety. Therefore, it can be effectively used for emergency evacuation. The findings of the present study are in line with the results of studies conducted by Arzhanagi (2018), Rismanian and Zarghami (2014), as well as Moghaddas and Bina (2021).

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Conflict of Interests

The authors declare that there is no conflict of interest in this study.

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