

# Factors Influencing Hospital Emergency Evacuation during Fire: A Systematic Literature Review

## Abstract

**Background:** Although the hospital is known as a safe place for treating patients, due to various reasons, it is prone to several internal hazards, including fire. This study aimed to identify the factors affecting hospital emergency evacuation during fire. **Methods:** This was a systematic review conducted according to the PRISMA guideline. Thematic Content analysis was utilized to analyze and extract results. We found the studies investigating the factors affecting hospital emergency evacuation during fire through a comprehensive search in various data resources (MEDLINE, Web of Science, Google Scholar, Embase, ProQuest, Scopus, IRANMEDEX, SID, ISC, and Magiran) and other sources from the beginning of January 2000 to the end of December 2019. Thematic Content analysis was also employed to analyze. **Results:** At first and based on the initial search, 4484 studies were identified, and 48 articles were finally included in the study. Based on the results; five main themes along with 10 sub-themes were identified. The themes included the incident's characteristics, response measures, hospital preparedness, hospital residents, and hospital building, and the sub-themes were emergency evacuation features, fire characteristics, command, operation, patients' and staff's characteristics, planning, logistics, and structure and design hospital. **Conclusions:** Based on the results of the present study, hospital preparedness as one of the most important factors can reduce the hospital evacuation time. Therefore, hospitals can ensure a timely and more effective response in emergency evacuation during fire by improving their preparedness.

**Keywords:** *Disasters, emergencies, emergency evacuation, fire, hospitals*

## Introduction

Hospitals as one of the most important healthcare institutions have a vital role in providing services under both normal circumstances and emergencies.<sup>[1-3]</sup> Although hospitals are known as a safe place to treat patients, they are prone to internal and external disasters.<sup>[4]</sup> A damage to the hospital structure or the occurrence of a disaster may jeopardize the provision of care services and the health of hospital residents and ultimately lead to the complete evacuation of the hospital.<sup>[1]</sup> The incidence of a disaster in a hospital may be associated with many physical injuries because of the long evacuation time of hospitals. Hospital evacuation is a process with special complexities as they have generally tall and colossal buildings.<sup>[5,6]</sup>

From 2000 to 2017, more than 150 hospitals were emergency evacuated in the United States. Studies showed that 16% of these evacuations were related to man-made

threats, and 13% were due to internal factors from which fires accounted for about 40% of intrahospital threats.<sup>[7]</sup> Hospitals because of using electrical equipment, medical gases, and flammable liquids are susceptible to fire.<sup>[8]</sup> Hospital fire, due to limitations in relocating patients, is a special event that usually associated with high casualties. So, in managing the hospital fire, many challenges including the complex process of transferring of patients are encountered.<sup>[9-11]</sup>

Hospital evacuation while keeping the safety of its residents is a complex process.<sup>[12]</sup> Many hospital residents are those with impaired mobility the transferring of whom to a safe place can be very difficult for staff.<sup>[13]</sup> One of the most important differences between evacuating a hospital and other buildings is that hospitalized patients are often disabled and need the help of other people to relocate.<sup>[14]</sup> Despite all these issues, evacuating a hospital should be fast and safe to prevent harm to the residents, a large number of whom must

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DOI: 10.4103/ijpvm.IJPVM\_653\_20

#### Quick Response Code:



**How to cite this article:** Sahebi A, Jahangiri K, Alibabaei A, Khorasani-Zavareh D. Factors influencing hospital emergency evacuation during fire: A systematic literature review. *Int J Prev Med* 2021;12:147.

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be evacuated within the shortest time.<sup>[15,16]</sup> However, a safe hospital evacuation during fire is time-consuming due to patients' limited mobility.<sup>[17]</sup>

The hospital emergency evacuation is a difficult process due to the insecure translocation of critically ill patients who should be evacuated without any disruption in their treatment.<sup>[18]</sup> So, identifying the factors affecting hospital emergency evacuation can boost the managers' and staff's knowledge and skills and help to design and implement a secure and rapid hospital evacuation program during fire. Therefore, the aim of the present systematic review aimed to characterize these factors.

## Methods

The present study was conducted via the two methods of systematic review and thematic content analysis. At first, a systematic review was performed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines<sup>[19]</sup> to acquire the articles related to the research purpose. The protocol of this review was registered in the International Prospective Register of Systematic Review (PROSPERO) under the code of CRD42020164943. According to the PRISMA protocol, a search strategy was designed and performed screening, study selection, quality evaluation, and data extraction, respectively. The phases of study selection and qualification and data extraction were independently conducted by two researchers. In the case of any disagreement between these researchers, a final decision was made through group discussion. For thematic content analysis, the six-phase content analysis framework of Braun & Clarke (2006) was used.<sup>[20]</sup> The six steps of content analysis included familiarity with the data, generation of initial codes, searching for themes, reviewing themes, defining themes, and finally writing the draft" replacement with "The six steps of content analysis included data familiarization, generating raw codes, searching for topics (themes), reviewing and defining topics, and finally writing the draft."<sup>[20]</sup>

### Data resources and search strategy

To comprehensive search in this study, data resources including MEDLINE in (PubMed, Web of Science, Google Scholar, Embase, ProQuest, Scopus, IRANMEDEX, SID, ISC, and Magiran, conference and congress papers, key journals (Prehospital and Disaster Medicine, Disaster Medicine and Public Health Preparedness) and reference list of selected articles and systematic reviews were employed. The MeSH terms, consulting with scientific experts, and terms in related articles were used to extract valid keywords. The English keywords and their Persian equivalents used in this study included "Emergency Evacuation", "Urgent Evacuation", Evacuation, "Evacuation Time", "patient Evacuation", "Medical Facility", "Health Center", "Healthcare Center", "Tertiary Referral Center",

"Tertiary Care Center", Hospital, "Health Facility", Fire, Event, Incident, Disaster, and Emergency. At first, the initial search syntax for PubMed by using the operators, keywords and search fields, and then, designed the syntax for other databases based on this structure was written. The number needed to read (NNR) index was used for search syntax evaluation. NNR index is defined as the ratio of the number of retrieved articles to related articles.<sup>[21]</sup> The period of the search was from the beginning of January 2000 to the end of December 2019. Published articles gathered in English and Persian. Examples of the used search strategy have been mentioned in Appendix 1.

### Eligibility criteria

All Persian and English studies about the hospital emergency evacuation during a fire, published from the beginning of January 2000 to the end of December 2019 were included. The studies dealing with the assessment of fire safety in hospitals, emergency evacuation regardless of the type of the incident and disasters, emergency evacuation of buildings other than hospitals, hospital emergency evacuation for reasons other than fire, decision-making during an emergency evacuation, emergency evacuation in hospital external fires, and a general evaluation of hospital emergency evacuation in various incidents and disasters were excluded.

### Study selection

In order to manage search results, all articles were inserted into EndNote X7 software, and after removing duplicates, their titles and abstracts were screened based on the eligibility criteria to identify potentially relevant articles. In the next step, two researchers (AS, KJ) independently studied the full texts of the possibly related articles with details and finally selected qualified articles.

### Quality assessment

At this step, two researchers (AS, KJ) independently evaluated the quality of the selected studies using different tools including the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) for observational studies.<sup>[22]</sup> This tool has 22 items, and each item is scored from 0 to 2 (the minimum and maximum scores are 0 and 44, respectively). Accordingly, the quality of studies was divided into three categories including low (0–15 points), moderate (16–30 points), and high (31–44 points). The Center for Evidence-Based Management (CEMBA) was used for case studies.<sup>[23]</sup> This tool has 10 items, and each item is scored from 0 to 1 (the minimum and maximum scores are between 0 and 10, respectively). The scores of 0-2, 3-6, and 7-10 indicated poor, moderate, and high qualities, respectively. Consolidated Standards of Reporting Trials (CONSORT) was used for trials studies.<sup>[24]</sup> This tool contains 25 items, and each item is scored from 0 to 2 (the minimum and maximum score

is 0 and 50, respectively). The scores of 0-16, 17-33, and 34-50 indicated poor, moderate, and good qualities, respectively. The Modified STROBE was used for the studies that were not assessable by the mentioned standard quality assessment tools [Appendix 2]. This tool contains 9 questions, and each question is scored from 0 and 1 (the minimum and maximum scores are 0 and 9, respectively). The scores of 0-2, 3-6, and 7-9 indicated poor, moderate, and high qualities, respectively.

### Data extraction and analysis

Two researchers (AS and KJ) extracted the final studies data independently, in the pre-prepared checklist. The checklist included the first authors' name, the record type, year, place, and design, as well as the findings. Thematic content analysis was used to analyze the data. Initially, the first author (AS) studied the results of 48 qualified articles. In thematic content analysis method, in addition to the headings obtained from the studies, the text of the results was also studied and coded accordingly. For coding, all the codes and basic concepts related to the factors affecting hospital emergency evacuation during fire, were extracted. Then they were, carefully studied line by line, several times to identify initial codes. Afterwards, the first and second authors (AS, KJ) examined all the identified codes in terms of similarities and differences, and then similar codes were classified under one category to form a sub-theme. In the next step, the sub-themes that had a similar concept were placed together to form a theme. Finally, a draft of the summarized designed findings was discussed by all the authors, and necessary amendments were applied until reaching an agreement on the draft.

## Results and Discussion

### Search results

Initially, a total of 4484 studies were obtained in the primary search, and after removing duplicates, the titles and abstracts of 2976 studies were screened. After omitting irrelevant articles, the full texts of 147 possibly related studies were reviewed, and finally, 48 articles entered the final phase of the study [Figure 1].

### Descriptive statistics

Among the final studies, 29 were journals, 13 conference papers, four book sections, and two theses. Eight studies had been conducted in the United Kingdom, eight in the United States, eight in China, four in Italy, one in the Netherlands, two in Sweden, two in Iran, five in India, two in Japan, and one in each of Spain, Germany, Canada, Belgium, Russia, Turkey, Portugal, and Taiwan. In terms of study design, most of the studies had been conducted with the simulation method. Regarding the quality assessment results, 23 and 25 studies had medium and good qualities, respectively. The selected studies' characteristics have been shown in Table 1.

### Thematic content analysis

Based on the systematic literature review and thematic content analysis, the factors affecting emergency evacuation during hospital fire were divided into five main themes and 10 sub-themes. The themes included the incident's characteristics, response measures, hospital preparedness, hospital residents, and hospital building, and the sub-themes were emergency evacuation features, fire characteristics, command, operation, patients' and staff's

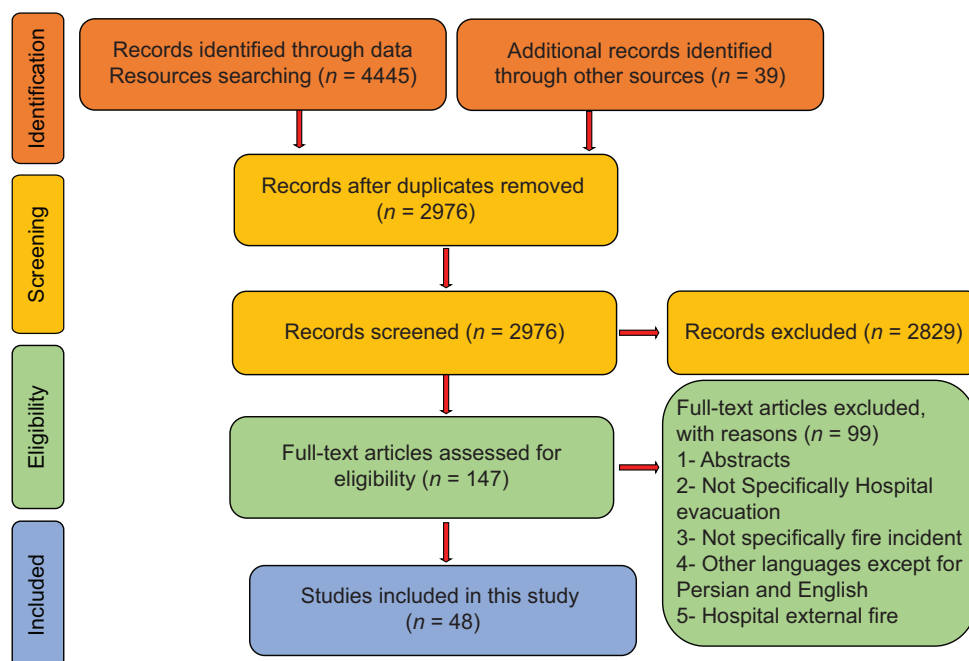


Figure 1: PRISMA Flowchart of systematic literature review of identifying the factors influencing on emergency evacuation in hospital fire

**Table 1: The extracted articles' specifications in a systematic review on the factors affecting hospital emergency evacuation during fire**

First author's name	Place	Record type	Study design	The findings of the articles
Akincitürk <sup>[17]</sup>	Turkey	Journal article	Mixed method	The location and preparedness of the safe place in each ward, exercise and drill, developing and access to a fire emergency evacuation plan, notification, the design of hospital units, and emergency exit
Alonso-Gutierrez <sup>[25]</sup>	United Kingdom	Journal article	Literature/Simulation	Smoke size, personnel/patient ratio,- work shift, - patients' and staff's safety
Alonso-Gutierrez <sup>[26]</sup>	Spain	Conference proceeding	Literature/Simulation	The time needed to prepare patients, personnel/patient ratio, personnel's movement speed, patients' ability to move , prioritizing patients for relocation, the time needed to reach patients, patients' movement speed
Carey <sup>[27]</sup>	United States	Journal article	Case study	Personnel training, emergency evacuation checklist, triage officer, patient identification tag, exercise and drill, - updating fire emergency evacuation plan, - medical equipment,- necessary drugs, and the number of personnel
Catovic <sup>[28]</sup>	Sweden	Conference proceeding	Cross-sectional	Personnel training, intra-organizational coordination and cooperation, exercise and drill and helping patients in emergency evacuation
De-Ching <sup>[29]</sup>	China	Journal article	Simulation	The width of exit doors, temperature, visibility, prioritizing patients for relocation, and rapid response by personnel
Dhaliwal <sup>[30]</sup>	India	Journal article	Case study	developing a fire emergency evacuation plan, personnel training, exercise and drill, communications, ventilation system, command center, firefighting equipment, and a timely response by hospital
Femino <sup>[31]</sup>	United States	Journal article	Review	The number of personnel, inter-organizational communication, incident command, command center, patient safety, personnel safety, patient transport equipment, necessary drugs, familiarization of personnel with emergency exit routes, and prioritizing patients for relocation
Gildea <sup>[32]</sup>	United States	Journal article	Experimental	The presence of supporting organizations, patients' weight, the width of emergency exit, inter-organizational communication, the number of personnel, patient care and treatment, the number of hospital floors, and the existence of an emergency evacuation team
Gretenkort <sup>[33]</sup>	Germany	Journal article	Experimental	Patients' weight, personnel's physical ability, incident command, the type, and features of patient transport equipment
Hogan <sup>[34]</sup>	Canada	Journal article	Case study	Updating the fire emergency evacuation plan, personnel density, hospital security, medical equipment, incident command, and familiarization of personnel with communication equipment
Hoondert <sup>[35]</sup>	Netherlands	Thesis	Literature/Simulation	The time needed to prepare patients' personnel training, personnel/patient ratio- familiarization of personnel with fire emergency evacuation program, -hospital design, and the type of patients' diseases
Hunt <sup>[36]</sup>	United Kingdom	Journal article	Simulation/experimental	The number and gender distribution of personnel, work shift, the type and features of patient transport equipment, and - personnel's fatigue
Iadanza <sup>[37]</sup>	Italy	Conference proceeding	Simulation	The number, density, and movement speed of patients, and the width of emergency exit
Jafari <sup>[38]</sup>	United States	Book section	Mixed method	Medical equipment, exercise and drill, safe location preparedness, the presence of medical specialists, the number of exit routes and- personnel training
Johnson <sup>[39]</sup>	United Kingdom	Journal article	Case study	Incident command, prioritizing patients for relocation, developing and updating a fire emergency evacuation plan, medical equipment, exercise and drill, emergency exit preparedness, and- personnel training
Kelly <sup>[40]</sup>	United Kingdom	Journal article	Case study	Updating and access to the fire emergency evacuation plan, personnel training, providing psychological services, and familiarization of personnel with emergency exit routes and firefighting
Lee <sup>[41]</sup>	China	Journal article	Trial	Personnel training
Löfqvist <sup>[42]</sup>	Sweden	Journal article	Cross-sectional	The necessity of having a fire emergency evacuation plan, personnel training, - exercise and drill, and familiarization of personnel with emergency evacuation plan

*Contd...*

**Table 1: Contd...**

First author's name	Place	Record type	Study design	The findings of the articles
Manion <sup>[43]</sup>	United States	Journal article	experimental	Personnel experience, personnel/patient ratio, and - patient transportation equipment, the presence of supporting organizations, emergency exit lighting, and patients' clinical condition
McCarthy <sup>[44]</sup>	United States	Journal article	experimental	Familiarization of personnel with fire emergency evacuation plan, developing a fire emergency evacuation plan, and exercise and drill
Murphy <sup>[45]</sup>	United Kingdom	Journal article	Cross-sectional	Exercise and drill, and prioritizing patients for relocation, medical equipment, patient transportation equipment, the necessity for a fire emergency evacuation plan, personnel training, the number of emergency exit routes, the existence of an air ventilation system, and necessary drugs
Rahouti <sup>[46]</sup>	Belgium	Conference proceeding	Descriptive/ Simulation	The number of patients, patients' ability to move, the number of personnel, the time needed for preparing patients, and work shift
Rispoli <sup>[47]</sup>	Italy	Journal article	Case study	The timely arrival of supporting organizations, communication equipment, personnel's physical injuries, and electrical equipment
Samoshin <sup>[48]</sup>	Russian	Conference proceeding	Experimental/ Mathematical	Number of hospital floors, the number and weight of patients, the number, movement speed, and physical ability of personnel, and patients' ability to move
Shafiei <sup>[8]</sup>	Iran	Journal article	Case study	Personnel training, exercise and drill, medical equipment, inter and intra organizational coordination and communication, the existence of fire alarm system, prioritizing patients for relocation, and timely response
Venkateshan <sup>[23]</sup>	India	Journal article	Survey	Prioritizing patients for relocation, medical equipment, the necessity for a fire emergency evacuation plan, and exercise and drill
Tzeng <sup>[49]</sup>	United States	Conference proceeding	Review	Hospital design, the width of emergency exit route, and personnel training
Wei <sup>[50]</sup>	China	Conference proceeding	Survey/ Simulation	The speed of movement of patients and personnel, familiarization of patients and personnel with emergency exit routes
Wigmore <sup>[51]</sup>	United Kingdom	Journal article	Review	The necessity for a fire emergency evacuation plan, personnel training, exercise and drill, prioritizing patients for relocation, medical equipment, intra-organizational communication, inter-organizational coordination, patient care, and necessary drugs
Yokouchi <sup>[52]</sup>	Japan	Conference proceeding	Simulation	work shift, prioritizing patients for relocation, patients' ability to move, and personnel/patients' ratio
Zhang <sup>[53]</sup>	China	Conference proceeding	Mathematical/ Simulation	Transportation distance and prioritizing patients for relocation
Zhang <sup>[54]</sup>	China	Conference proceeding	Case study	Prioritizing patients for relocation, safe location preparedness, personnel training, medical equipment, patient transportation equipment, incident command, and gathering information
Bongiovanni <sup>[55]</sup>	Italy	Journal article	Case study/ qualitative	Personnel training, communication equipment, the provision of psychiatric services, existence of fire alarm system, and familiarization of supporting organizations with the hospital building
Uehara <sup>[56]</sup>	Japan	Journal article	Simulation	Personnel/patients ratio, patients' ability to move type of patient transportation equipment, and transportation distance
Ahmadzadeh <sup>[57]</sup>	Iran	Conference proceeding	descriptive	Patient safety, number of personnel, safe location preparedness patient discharge, medical equipment, necessary drugs, patient care, psychological services, and prioritizing patient for relocation
D'Orazio <sup>[58]</sup>	Italy	Book section	Simulation/ experimental	Emergency exit density, and pre-movement time
GUPTA <sup>[59]</sup>	India	Thesis	Simulation	The position of individuals regarding the emergency exit, and fire location
Gwynne <sup>[60]</sup>	United Kingdom	Journal article	Simulation	Pre-evacuation time and personnel's behavior
Liu <sup>[61]</sup>	China	Book section	Simulation	Number of hospital floors, transportation distance, and the type of emergency exit (elevator, stairs, and so on)
Loria <sup>[62]</sup>	India	Journal article	descriptive	developing, updating, and giving access to fire emergency evacuation plan, personnel training, exercise and drill, and familiarization of personnel with emergency evacuation triage

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**Table 1: Contd...**

First author's name	Place	Record type	Study design	The findings of the articles
Shastri <sup>[63]</sup>	India	Book section	Review	Patients' movement ability, helping patients during evacuation, fire-fighting system, the existence of fire alarm system, number of emergency exit routes, determining a safe location in the ward, the existence of an evacuation plan in the hospital, location of the hospital and rapid response by personnel
Silva <sup>[64]</sup>	Portugal	Conference proceeding	Simulation	Familiarization of personnel with emergency exit route, familiarization of personnel with emergency exit signs, exercise and drill, and personnel's experience
Johnson <sup>[65]</sup>	United Kingdom	Journal article	Simulation	Patients' movement ability, shift work, number of personnel, the time needed for preparing patients, and personnel movement speed
Wei-Wen <sup>[66]</sup>	Taiwan	Journal article	Survey	Determining and the preparedness of the safe location in the ward, designing exit stairs, hospital structure, patients' movement ability, and patients' clinical condition
Jiang <sup>[67]</sup>	China	Journal article	Simulation/experimental	The width of emergency exit, the necessity for the existence of a fire emergency evacuation plan, and speed of patient transportation
Huang <sup>[10]</sup>	China	Conference proceeding	Review	Patients' movement ability, patients' reaction speed, determining a safe location inside and outside the hospital, personnel training, exercise and drill, firefighting equipment, and communication systems
Acar <sup>[68]</sup>	United States	Journal article	Experimental/randomized	Emergency evacuation checklist

characteristics, planning, logistics, and structure and design hospital [Table 2].

Based on our research, various factors such as fire characteristics, command, operation, patients' characteristics, planning, and logistics can have significant roles in emergency hospital evacuation during fire.

The present systematic review showed that fire characteristics such as its location, the extent of the smoke, temperature, and visibility affect hospital emergency evacuation. The results of a study in China showed that items such as fire location, heat, ventilation system, and type of burning materials affect emergency evacuation during fire in metro.<sup>[69]</sup> Following a fire in a hospital, the smoke and, heat rapidly disseminate throughout the building. Inhaling smoke is usually the primary cause of death in this situation.<sup>[70]</sup> On the other hand, smoke reduces visibility so that people cannot track the evacuation routes during the evacuation, and as a result, they encounter obstacles delaying the evacuation.<sup>[71]</sup> In conclusion, fire characteristics (heat, smoke, etc.) affect the emergency evacuation process, and hospitals should appropriately adjust their responses corresponding to such characteristics. So, it seems necessary that hospitals developing their emergency evacuation plans based on possible fire features according to the type of available inflammable materials.

According to the results of this study, the command has an important role in hospital emergency evacuation during fire by coordinating intra-organizational communications. The results of a study in the USA showed that the emergency evacuation of a hospital is a complex process requiring inter and intra organizational coordination and communications.<sup>[43]</sup> So, using an incident command

system (ICS) is important to coordinate activities, optimally use resources, and accomplish a successful emergency evacuation,<sup>[72,73]</sup> even in pre-hospital phase.<sup>[74,75]</sup> Also, we observed that notification as one of the components of command plays an important role in hospital emergency evacuation. Rapidly informing personnel inside the hospital, supportive organizations, and patients' families of the incident are essential. The results of a review in 2015 showed that communication and relationships with society are important factors affecting hospitals' emergency evacuation. Following disasters, emergency evacuation can cause anxiety in all the people involved. Either misinformation or the lack of information exaggerates anxiety and on the other hand delays evacuation.<sup>[76]</sup> In line with our findings, the results of previous studies emphasize on the role of command in the emergency evacuation of the hospital.<sup>[77]</sup> Since evacuating a hospital is a complex process which requires the attendance of other organizations including police, firefighting, and pre-hospital emergency, the presence of a command system through inter and intra organizational coordination and communications can facilitate the evacuation process.

In this study, we demonstrated that operation was one of the most important and necessary measures in hospitals' responses to emergency evacuation. A study in the United States showed that many patients need constant medical care during relocation,<sup>[78]</sup> and in other hand, people who lose their family members or patients amid emergency evacuation will require psychological consulting.<sup>[55]</sup> Another study showed that one of the most essential elements of response measures is to prioritize patients for translocation. The results of a study in Japan showed that an inappropriate prioritization can lead to overcrowding in the evacuation route, which

**Table 2: Factors affecting emergency evacuation during hospital fire based on the systematic literature review and thematic content analysis**

Themes	Sub-themes	Examples of codes
Incident characteristics	Fire characteristics	Temperature
		Visibility
Response measures	Emergency evacuation features	Location
		Smoke size
	Command	Pre-evacuation time
		Work shift
	Operation	Coordination
		Notification
		Incident commander
		Communications
		Safety
		Prioritizing patients for relocation
Hospital residents	Patients' characteristics	Patient care and treatment
		Helping patients during emergency evacuation
		Hospital security
		Number
		Weight
	Personnel's characteristics	Type of disease
		Being familiar with emergency exit route
		The ratio of personnel to patients
		Gender
		Being familiar with fire emergency evacuation plan
Hospital preparedness	Planning	Previous experience
		Exercise and drill
		Personnel training
		Existence of an emergency evacuation team
		Fire emergency evacuation plan
	Logistic	Medical equipment
		Firefighting equipment
		Patient transportation devices
		Communication equipment
		The width of emergency exit
Hospital building	Hospital design	The design of emergency exit
		Transportation distance
		The design of hospital wards
		Safe location
		The existence of ventilation system
	Hospital Structure	The number of hospital floors
		The number of emergency exit routes

slows patient translocation speed and extends the evacuation time.<sup>[52]</sup> So, it can be said that although the primary goal of hospital emergency evacuation is to relocate as many people as possible within the shortest time, adequate attention should be paid to the healthcare and treatment of the patients who may need such measures during evacuation.

Among other factors influencing hospital emergency evacuation during fire were patients' characteristics which

determine the number of required personnel and the equipment necessary for translocation. We here found that patients' familiarization with emergency exit routes affected evacuation time. Another study in China noted patients' insufficient awareness of emergency exit routes delayed evacuation and reduced their speed.<sup>[50]</sup> On the other hand, adequate patients' awareness of the emergency evacuation facilitates personnel's performance during the process.<sup>[28]</sup>

Also, the results of other studies have shown that guiding patients by personnel can reduce evacuation time.<sup>[79]</sup> In overall, in line with other studies, human characteristics, risky behaviors, should take into account.<sup>[80]</sup> Overall, these results indicate that the familiarity of patients with hospital emergency evacuation facilitates the process. So, it is recommended that hospitals provide patient education along with staff training programs, which both are important factors in emergency evacuation planning.

The present review proved hospitals need to develop an evacuation plan with the incorporation of important components such as exercise and training, for emergency evacuation during fire. A case study about a fire in an operation room in India found that holding fire drills could improve hospitals' response to fire, minimize the incidence of potentially fatal problems, and create a more secure environment for patients and personnel.<sup>[81]</sup> Other studies have also emphasized on educating personnel about fire safety plans, firefighting, evacuation of patients based on triage, and identification of vulnerable patients to boost. The knowledge and performance of hospital personnel in managing fire and ensure patients' and staff's safety.<sup>[62,82]</sup> Most of the studies reviewed here emphasized on the need for having an emergency hospital evacuation plan during fire. The results of other studies have shown that a successful emergency evacuation depends on previous planning. Therefore, healthcare centers, especially hospitals, should develop operational emergency evacuation plans and make sure that these plans are readily available and regularly exercised and updated.<sup>[83,84]</sup> Therefore, employing evacuation plans and strategies by health centers can lead to a safe transfer of patients to other medical organizations.<sup>[85]</sup> In line with the results of other studies, our findings highlighted the role of planning in hospital emergency evacuation, and therefore, it seems necessary for hospitals to developing required emergency evacuation plans. As these plans are developed based on available standards, it is possible to achieve appropriate planning by continuous monitoring and implementing these standards.

This study showed the necessity of the logistics, both medical and non-medical equipment, during the emergency evacuation of the hospital after a fire. Other studies have shown that most patients faces many challenges, especially patients in critical care units are unable to move and vertical evacuating.<sup>[4]</sup> On the other hand, there may be a shortage of transportation equipment for patients with critical conditions as they need special devices to move.<sup>[86]</sup> Similar to the results of previous studies, we highlighted the role of equipment, especially transportation equipment, in the emergency evacuation of hospitals. This is because most patients are not able to evacuate alone and require devices such as wheelchairs and trolleys. As hospital buildings have a complicated design and structure, it is necessary for hospitals to adequately provide a variety of

patient transportation equipment with different applications based on the number of patients and the type of their diseases.

### Strengths and limitations

This study systematically evaluated all factors affecting hospital emergency evacuation during fire, and this was a strength and unique feature in our research. From the limitations of this review was different methodologies of the selected studies, which due to their importance and relevance to the topic, it was not possible to exclude them. Another limitation was the unavailability of the full texts of three articles that were excluded from the study.

### Conclusion

The results of the present review study showed that a variety of factors including the incident characteristics, response measures, hospital preparedness, hospital residents' features, and the hospital building were effective on hospital emergency evacuation during fire. Data synthesis revealed that hospital preparedness was one of the main factors in hospital emergency evacuation during fire, addressed by the most reviewed studies. As a vital parameter, it is critical to improve the level of hospital preparedness to shorten emergency evacuation time. In conclusion, hospitals can use the results of this review study to be prepared and perform a prompt and effective emergency evacuation in case of fire.

### Acknowledgments

This article is part of a PhD thesis with the Ethical approval and study permission with ID of IR.SBMU.PHNS.REC.1398.170 approved by Shahid Beheshti University of Medical Sciences.

### Financial support and sponsorship

The study was financially supported by Shahid Beheshti University of Medical Sciences, Tehran.

### Conflicts of interest

The authors declare that they have no conflict of interest.

**Received:** 24 Oct 20 **Accepted:** 08 Jan 21

**Published:** 26 Oct 21

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**Appendix 1: Search syntax for systematic review on the factors affecting hospital emergency evacuation during fire**

Data bases	Syntax	NNR*	Records Number
PubMed	("Emergency Evacuation"[tiab] OR "Immediate evacuation"[tiab] OR "Urgent Evacuaion"[tiab] OR Evacuation OR "Evacuation Time"[tiab] OR "patien* Evacuation"[tiab]) AND ("Medical Facilit*" OR "Healthcare facilit*" OR "Health cente*" OR "Healthcare Cente*" OR "Tertiary Referral Cente*" OR "Tertiary Care Cente*" OR Hospital[tiab] OR "Health Facilit*") AND (Fire*[tiab] OR Event* OR Incident* OR Disaster* OR Hazard* OR Emerge*)	11	1008
Scopus	(TITLE-ABS ("Emergency Evacuation") OR TITLE-ABS("Immediate evacuation") OR TITLE-ABS("Urgent Evacuaion") OR TITLE-ABS (Evacuation) OR TITLE-ABS ("Evacuation Time") OR TITLE-ABS ("patien* Evacuation")) AND (ALL ("Medical Facilit*") OR ALL("Healthcare facilit*") OR ALL("Health cente*") OR ALL("Healthcare Cente*") OR ALL ("Tertiary Referral Cente*") OR ALL ("Tertiary Care Cente*") OR TITLE-ABS (Hospital) OR ALL ("Health Facilit*")) AND (TITLE-ABS (Fire*) OR ALL (Event*) OR ALL (incident*) OR ALL (Disaster*) OR ALL (Hazard*) OR ALL (Emerge*))	13	1298
Web Of science	(TS= ("Emergency Evacuation") OR TS= ("Immediate evacuation") OR TS= ("Urgent Evacuaion") OR TS= ( Evacuation) OR TS= ("Evacuation Time") OR TS= ("patien* Evacuation")) AND (TS= ("Medical Facilit*") OR TS= ("Healthcare facilit*") OR TS= ("Health cente*") OR TS= ("Healthcare Cente*") OR TS= ("Tertiary Referral Cente*") OR TS= ("Tertiary Care Cente*") OR TS= (Hospital) OR TS= ("Health Facilit*")) AND (TS= (Fire*) OR TS= (Event*) OR TS= (incident*) OR TS= (Disaster*) OR TS= (Hazard*) OR TS= (Emerge*))	11	851

\*NNR: Number Needed to Read

**Appendix 2: Modified STROBE**

Items	Yes	No	N/C*
Introduction			
Method			
Result and Discussion			

\*N/C: Not clear