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.[1-3] Although hospitals are known as a safe place to treat patients, they are prone to internal and external disasters.[4] 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.[5] 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.[5,6]

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.[7] Hospitals because of using electrical equipment, medical gases, and flammable liquids are susceptible to fire.[8] 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.[9-11]

Hospital evacuation while keeping the safety of its residents is a complex process.[12] Many hospital residents are those with impaired mobility the transferring of whom to a safe place can be very difficult for staff.[13] 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.[14] 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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be evacuated within the shortest time. However, a safe hospital evacuation during fire is time-consuming due to patients’ limited mobility.

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. 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-Analyzes (PRISMA) guidelines 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. 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. 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. 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. 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 (44–points). The Center for Evidence-Based Management (CEMBa) was used for case studies. 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. 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
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                                                                                                                                                                                                                                                                                                                                 |
|---------------------|-----------|-------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Akıncıtürk[17]      | 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[25] | United Kingdom | Journal article | Literature/Simulation | Smoke size, personnel/patient ratio, - work shift, - patients’ and staff’s safety                                                                                                                                                                                                                                                                             |
| Alonso-Gutierrez[26] | 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[27]           | 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[28]         | Sweden    | Conference proceeding | Cross-sectional | Personnel training, intra-organizational coordination and cooperation, exercise and drill and helping patients in emergency evacuation                                                                                                                                                                                                                                    |
| De-Ching[29]        | China     | Journal article | Simulation    | The width of exit doors, temperature, visibility, prioritizing patients for relocation, and rapid response by personnel                                                                                                                                                                                                                                           |
| Dhalìwal[30]        | 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[31]          | 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[32]          | 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                                                                                         |
| Gretenkorf[33]      | Germany   | Journal article | Experimental | Patients’ weight, personnel’s physical ability, incident command, the type, and features of patient transport equipment                                                                                                                                                                                                                                           |
| Hogan[34]           | 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[35]        | 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[36]            | 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[37]         | Italy     | Conference proceeding | Simulation | The number, density, and movement speed of patients, and the width of emergency exit                                                                                                                                                                                                                                                                                                                                 |
| Jafari[38]          | 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[39]         | 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[40]           | 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[41]             | China     | Journal article | Trial         | Personnel training                                                                                                                                                                                                                                                                                                                                                                                                       |
| Löfqvist[42]        | 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...
| First author's name | Place            | Record type | Study design         | The findings of the articles                                                                                                                                 |
|---------------------|------------------|-------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Manion[43]          | 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[44]        | United States    | Journal article | experimental         | Familiarization of personnel with fire emergency evacuation plan, developing a fire emergency evacuation plan, and exercise and drill                            |
| Murphy[45]          | 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, the number of emergency exit routes, the existence of an air ventilation system, and necessary drugs |
| Rahouti[46]         | 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[47]         | Italy            | Journal article | Case study           | The timely arrival of supporting organizations, communication equipment, personnel’s physical injuries, and electrical equipment                          |
| Samoshin[48]        | 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[49]         | 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 |
| Venkataseshan[50]   | India            | Journal article | Survey               | Prioritizing patients for relocation, medical equipment, the necessity for a fire emergency evacuation plan, and exercise and drill                            |
| Tzeng[49]           | United States    | Conference proceeding | Review               | Hospital design, the width of emergency exit route, and personnel training                                                                                   |
| Wei[50]             | China            | Conference proceeding | Survey/ Simulation | The speed of movement of patients and personnel, familiarization of patients and personnel with emergency exit routes                                      |
| Wigmore[51]         | 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[52]        | Japan            | Conference proceeding | Simulation           | Transportation distance and prioritizing patients for relocation                                                                                                                                                      |
| Zhang[53]           | China            | Conference proceeding | Mathematical/ Simulation | Prioritizing patients for relocation, safe location preparedness, personnel training, medical equipment, patient transportation equipment, incident command, and gathering information |
| Zhang[54]           | China            | Conference proceeding | Case study           | Personnel training, communication equipment, the provision of psychiatric services, existence of fire alarm system, and familiarization of supporting organizations with the hospital building |
| Bongiovanni[55]     | Italy            | Journal article | Case study/ qualitative | Patient safety, number of personnel, safe location preparedness patient discharge, medical equipment, necessary drugs, patient care, psychological services, and prioritizing patient for relocation |
| Uehara[56]          | Japan            | Journal article | Simulation           | Personnel/patients ratio, patients’ ability to move type of patient transportation equipment, and transportation distance                                      |
| Ahmadzadeh[57]      | 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[58]        | Italy            | Book section | Simulation/ experimental | Emergency exit density, and pre-movement time                                                                                                                 |
| GUPTA[59]           | India            | Thesis | Simulation               | The position of individuals regarding the emergency exit, and fire location Pre-evacuation time and personnel’s behavior                                |
| Gwynne[60]          | United Kingdom   | Journal article | Simulation           | Number of hospital floors, transportation distance, and the type of emergency exit (elevator, stairs, and so on) developing, updating, and giving access to fire emergency evacuation plan, personnel training, exercise and drill, and familiarization of personnel with emergency evacuation triage |
| Liu[61]             | China            | Book section | Simulation           | Number of hospital floors, transportation distance, and the type of emergency exit (elevator, stairs, and so on) developing, updating, and giving access to fire emergency evacuation plan, personnel training, exercise and drill, and familiarization of personnel with emergency evacuation triage |
| Loria[62]           | India            | Journal article | descriptive         | Number of hospital floors, transportation distance, and the type of emergency exit (elevator, stairs, and so on) developing, updating, and giving access to fire emergency evacuation plan, personnel training, exercise and drill, and familiarization of personnel with emergency evacuation triage |
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. 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. 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. 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. So, using an incident command system (ICS) is important to coordinate activities, optimally use resources, and accomplish a successful emergency evacuation, even in pre-hospital phase. 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. In line with our findings, the results of previous studies emphasize on the role of command in the emergency evacuation of the hospital. 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, and in other hand, people who lose their family members or patients amid emergency evacuation will require psychological consulting. 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 1: Contd...

| First author’s name | Place        | Record type | Study design | The findings of the articles                                                                 |
|---------------------|--------------|-------------|--------------|---------------------------------------------------------------------------------------------|
| Shastri[61]         | 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[64]           | 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[65]         | 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[66]         | 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[67]           | 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[68]           | 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[69]            | United States | Journal article | Experimental/randomized | Emergency evacuation checklist |

characteristics, planning, logistics, and structure and design hospital [Table 2].
slows patient translocation speed and extends the evacuation time. 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. On the other hand, adequate patients’ awareness of the emergency evacuation facilitates personnel’s performance during the process.

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

Table 2: Factors affecting emergency evacuation during hospital fire based on the systematic literature review and thematic content analysis.
Also, the results of other studies have shown that guiding patients by personnel can reduce evacuation time. In overall, in line with other studies, human characteristics, risky behaviors, should take into account. 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. 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.

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. Therefore, employing evacuation plans and strategies by health centers can lead to a safe transfer of patients to other medical organizations. 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. On the other hand, there may be a shortage of transportation equipment for patients with critical conditions as they need special devices to move. 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.

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**Conflicts of interest**

The authors declare that they have no conflict of interest.

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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 Evacuate*) | 11   | 1008           |
| Scopus       | (TITLE-ABS (“Emergency Evacuation”) OR TITLE-ABS (“Immediate evacuation”) OR TITLE-ABS (“Urgent Evacuaion”) 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 ALL (“Hospital” OR “Health Facilit*”)) AND (TITLE-ABS (“Fire”) OR ALL (Event*) OR ALL (incident*) OR ALL (Disaster*) OR ALL (Hazard*) OR ALL (Evacuate*)) | 13   | 1298           |
| Web Of science | (TS= (“Emergency Evacuation”) OR TS= (“Immediate evacuation”) OR TS= (“Urgent Evacuaion”) 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 “Health Facilit*”)) AND (TS= (“Fire”) OR TS= (“Event”) OR TS= (“incident”) OR TS= (“Disaster”) OR TS= (“Hazard”) OR TS= (“Evacuate*)) | 11   | 851            |

*NRR: Number Needed to Read

### Appendix 2: Modified STROBE

| Items                          | Yes | No | N/C* |
|-------------------------------|-----|----|------|
| Introduction                  |     |    |      |
| Has the topic been explained adequately? |     |    |      |
| Have the specific objectives or hypotheses been described? |     |    |      |
| Method                        |     |    |      |
| Is the study design clear?    |     |    |      |
| Has the research location been mentioned? |     |    |      |
| Have methods and data collection been described? |     |    |      |
| Have the statistical methods of data analysis been described? |     |    |      |
| Result and Discussion         |     |    |      |
| Have the findings been described in accordance with goals? |     |    |      |
| Have the results of each target variable been described? |     |    |      |
| Have arguments other than the results been addressed? |     |    |      |

*N/C: Not clear