The Review Of
DIABETIC
STUDIES OPEN ACCESS

Assessment Of Evacuation Preparedness And Response Time Of Health Security Personnel During Fire Emergencies In Healthcare Facilities: A Systematic Review

Moamen Abdelfadil Ismail[1],Ahmed Ayidh Salman Aljabri[2],Musab Saleh Bin Dhaifallah Alharbi[3],Zaid Faisal Mohammed Alsaedi[4],Ibrahim Abdulaziz Ibrahim Alshaya[5],Ruyuof Sultan Mohammed Aljarboua[6],Ibrahim Abdulaziz Ibrahim Alshaya[7],Mohammed Siraj Obaidullah Alqahtani[8],Ali Shar Abdullah Alshehri[9],Khalid Awjan Shuifan Al-Otaibi[10],Nawaf Mohammed Awad Alharbi[11],Abdullah Mohammed Abdullah Alanazi[12],Mishal Mohammed Habib Al-Rashidi[13],Feras Saleh Bin Thayf Allah Alzahrani[14],Latifa Abdullah Nua'is Al-Anzi[15]

[1]Internal Medicine consultan[1]
King Abdulaziz Specialist Hospital - Sakaka – Aljouf
[2]Specialty: Health Care Security
Workplace: Yadmah Hospital
[3]Specialty: Health Security
Workplace: Yadmah Hospital
[4]Specialty: Health Security
Workplace: Yadmah Hospital
[5]King Salman bin Abdulaziz Medical City Health security
[6]King Salman bin Abdulaziz Medical City Health security
[7]King Salman bin Abdulaziz Medical City Health security
[8]Specialty: Health Security
Workplace: Wadi Tarj General Hospital – Bisha
[9]Specialty: Health Care Security
Workplace: Saudi Primary Health Care Center – Al Kharj
[10]Specialty: Health Security
Workplace: Afif General Hospital
[11]Specialty: Health Care Security
Workplace: PCH Maragan
[12]Specialty: Health Care Security
Workplace: Sharaf Hospital – Hail
[13]Specialty: Health Security
Workplace: Hail Health Cluster – Al-Salimi General Hospital
[14]Specialty: Health Care Security
Workplace: Algharbi Park Healthcare Center – Hail Health Cluster
[15]Specialty: Health Security
Workplace: Sharaf Hospital

Abstract

Background: Fire incidents in healthcare facilities represent critical emergencies that demand rapid, coordinated action to protect vulnerable patients. This systematic review aimed to evaluate the preparedness and response efficiency of healthcare and security personnel during fire emergencies, emphasizing lessons learned, response times, and training interventions.
Methods: A systematic search across PubMed, Scopus, Web of Science, Embase, and Google Scholar was conducted following PRISMA 2020 guidelines. Ten peer-reviewed studies (2002–2025) were included, encompassing case reports, cross-sectional surveys, simulation studies, and randomized controlled trials. Data were synthesized narratively, focusing on preparedness levels, training effectiveness, and technological integration.

Results: Preparedness levels varied globally, with 52–73% of healthcare staff showing insufficient familiarity with evacuation procedures. Average evacuation times ranged from 3.75 minutes per floor (simulated vertical evacuations) to under 7 minutes in real ICU fires. Structured and online fire safety training programs improved preparedness by 24–30% post-intervention. The integration of simulation modeling and smart fire response systems significantly reduced response times and improved coordination. Major barriers included poor communication, inadequate drills, and lack of coordination with external fire services.
Conclusions: Despite advances in training and technology, gaps persist in hospital fire readiness, particularly in staff familiarity, inter-agency coordination, and rapid evacuation of critical patients. Continuous simulation-based training, leadership engagement, and system integration are essential to strengthen fire evacuation preparedness in healthcare facilities.

Keywords: fire evacuation, hospital preparedness, emergency response, intensive care unit, healthcare safety, fire simulation, disaster management, training effectiveness

Introduction

Fire emergencies in healthcare facilities pose one of the most critical challenges to patient safety, particularly in high-dependency units such as intensive care or operating rooms where evacuation is complex and time-sensitive. Hospitals are unique environments characterized by immobile patients, reliance on advanced medical equipment, and oxygen-enriched atmospheres that increase fire risk and propagation speed. As such, the effectiveness of hospital evacuation procedures and staff preparedness are vital determinants of survival outcomes during fire incidents (Sahebi et al., 2021). Comprehensive planning, training, and simulation-based assessments are therefore fundamental to ensuring coordinated and rapid response in such critical conditions.

Healthcare facilities are required to establish multidisciplinary fire safety systems that integrate both technical and human factors. While architectural design, ventilation control, and fire suppression technologies contribute to risk reduction, the human element—staff awareness, decision-making, and communication—remains central to evacuation success. Studies have shown that healthcare workers' knowledge and readiness for fire response often fall short of standards, even in institutions with formal emergency plans (Johannes & Koray, 2025). This gap between policy and practice underscores the need for continuous education and regular fire drills tailored to healthcare environments.

In addition to personnel training, the built environment and oxygen-rich medical settings exacerbate the complexity of hospital fires. Elevated oxygen concentrations can transform even minor ignition sources into catastrophic events, increasing flame intensity and reducing available response time. The design of ventilation systems and the location of oxygen outlets are therefore critical considerations for fire safety management. Research has emphasized the need for advanced detection systems, automatic shut-off mechanisms, and controlled compartmentalization to mitigate such risks in medical settings (Shaikh et al., 2024).

The evacuation of vulnerable patients presents further operational challenges. Many hospitalized individuals rely on life-support or mobility aids, making rapid movement difficult without specialized equipment and trained staff. Simulation studies indicate that evacuation times are considerably longer when dependent patients are involved, and the availability of assistive devices, such as rescue sheets or evacuation chairs, significantly influences performance (Choi et al., 2019). These findings highlight the need for tactical planning that prioritizes patient triage and efficient transport routes during emergency scenarios.

Legal and organizational preparedness also plays a pivotal role in ensuring hospital readiness for fires. Inconsistent regulations, limited enforcement, and lack of inter-agency coordination can hinder effective evacuation. For example, research in Poland revealed that despite the existence of national fire codes, many healthcare institutions lacked integrated emergency protocols and multidisciplinary coordination with local fire services (Goniewicz et al., 2020). These insights demonstrate the importance of governance structures that support both compliance and practical implementation at the institutional level.

Recent developments in digital modeling and integrated fire safety systems have improved prediction and management of evacuation dynamics. Computational simulations now allow planners to test evacuation strategies under different fire progression scenarios and staffing constraints, enhancing

decision-making accuracy and preparedness. Innovative studies have shown that combining simulation with sensor-driven detection and communication networks can reduce evacuation times by up to 30% (Betuš et al., 2025). This integration of technology and human performance modeling represents a forward step in hospital emergency management.

Nonetheless, the real-world effectiveness of these systems depends on institutional culture and continuous quality improvement. Hospitals that routinely conduct scenario-based drills, monitor compliance, and incorporate feedback mechanisms achieve markedly higher levels of staff competence and confidence during actual emergencies. Best-practice case studies, such as those conducted in Italian hospitals, illustrate that well-structured preparedness programs can transform emergency response from reactive to proactive, minimizing both material loss and casualties (Bongiovanni et al., 2017).

Assessing readiness and response times during fire emergencies therefore requires a holistic understanding of structural design, human behavior, technological integration, and regulatory alignment. Standardized evaluation frameworks, such as the Fire Emergency Response Readiness Assessment Tools (FERRAT), have been developed to systematically measure preparedness in healthcare facilities and identify areas for improvement (Septiana & Lestari, 2025). Together, these tools and studies reinforce the urgency of developing resilient fire response systems that protect both healthcare personnel and patients in complex emergency conditions.

Methodology

Study Design

This study adopted a systematic review design guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework to ensure methodological rigor, transparency, and reproducibility. The primary objective was to synthesize and critically appraise empirical evidence regarding evacuation preparedness and response time of healthcare security and medical personnel during fire emergencies in healthcare facilities.

The review sought to identify patterns, challenges, and best practices influencing the effectiveness of hospital fire evacuation, particularly within high-dependency units such as intensive care and operating theatres where evacuation is complex and time-sensitive. Both quantitative and qualitative evidence was included to capture the full range of organizational, technical, and human factors affecting fire evacuation readiness in healthcare settings.

The review incorporated peer-reviewed journal articles, case studies, simulation-based studies, and randomized controlled trials (RCTs) that assessed preparedness, evacuation processes, response coordination, and safety outcomes among healthcare workers and emergency management teams.

Eligibility Criteria

Inclusion Criteria

Studies were selected according to pre-defined inclusion criteria:

- **Population:** Healthcare professionals and security personnel (nurses, physicians, emergency staff, fire wardens, hospital engineers, or safety officers) working in hospitals or healthcare facilities.
- **Intervention/Exposure:** Fire evacuation preparedness, training programs, or response performance during simulated or actual hospital fires.
- **Comparators:** Between groups with or without fire safety training; or between facilities of different preparedness levels.
- **Outcomes:**
  - Evacuation times or efficiency metrics (e.g., mean response time, time to evacuate patients).
  - Preparedness and knowledge levels regarding fire evacuation.
  - Effectiveness of fire safety training, drills, or technology integration.
  - Lessons learned or system improvements after fire incidents.
- **Study Designs:** Case studies, cross-sectional surveys, experimental/simulation studies, and RCTs.
- **Language:** English.
  - **Publication Period:** 2000–2025.

Exclusion Criteria

- Non-empirical sources (e.g., editorials, news articles, policy briefs).
- Studies not conducted in healthcare settings.

- Conference abstracts or gray literature without full text.
- Duplicate publications.

After full-text screening, 10 studies met the inclusion criteria and were included in the final synthesis.

Search Strategy

A comprehensive electronic search was conducted in PubMed, Scopus, Web of Science, Embase, and Google Scholar from inception to December 2025. The Boolean search strategy combined keywords and Medical Subject Headings (MeSH) terms as follows:

- ("hospital" OR "healthcare facility" OR "intensive care unit" OR "medical center")
- AND ("fire evacuation" OR "fire emergency" OR "disaster evacuation" OR "emergency preparedness")
- AND ("healthcare workers" OR "security personnel" OR "nurses" OR "hospital staff" OR "fire safety training").

Manual screening of reference lists from key reviews and included studies (e.g., Sahebi et al., 2021; Bongiovanni et al., 2017) was performed to identify additional eligible articles.

All retrieved citations were exported to Zotero for de-duplication and management.

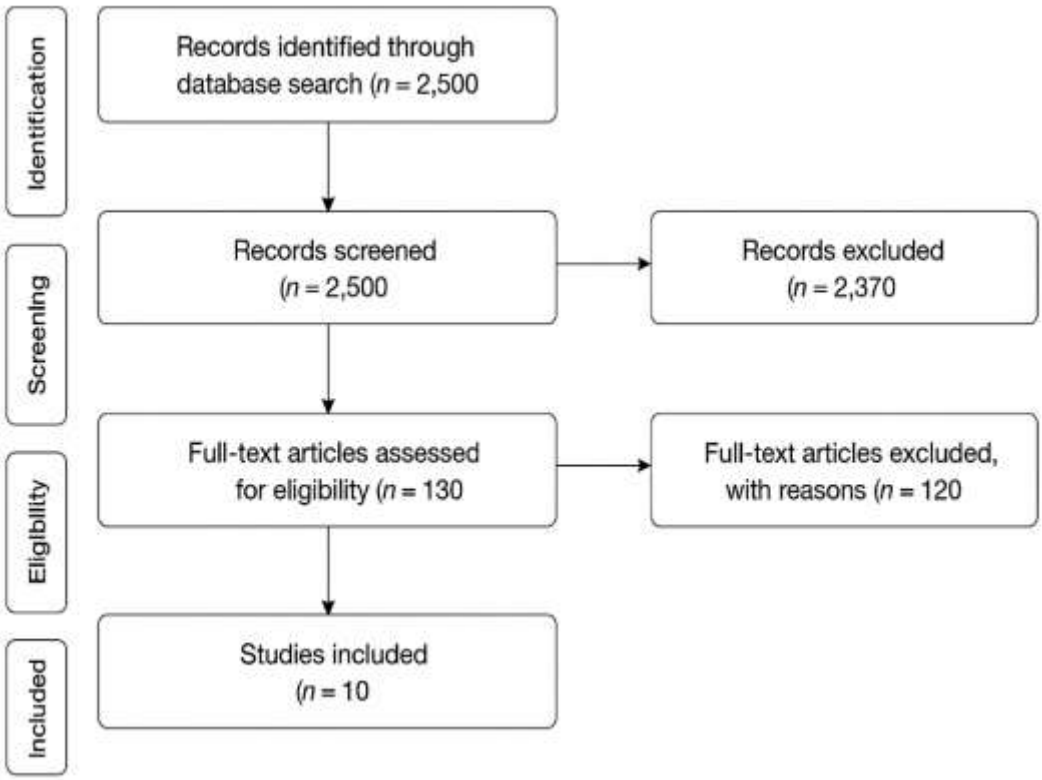
Study Selection Process

Two independent reviewers conducted a three-stage screening process:

1. Title and abstract screening for relevance.
2. Full-text review to verify eligibility against inclusion criteria.
3. Consensus review for any disagreements, adjudicated by a third senior reviewer.

A PRISMA flow diagram (Figure 1) illustrates the selection process through identification, screening, eligibility, and inclusion phases.

Figure 1 PRISMA Flow Diagram



Data Extraction

A structured data extraction form was designed and pretested before use. Key data extracted from each included study encompassed:

- Author(s), publication year, and journal/source.
- Study design and country of origin.
- Setting (ICU, general hospital, tertiary facility, or community hospital).
- Population characteristics (number of participants, profession, demographics).
- Measurement instruments (questionnaires, simulation parameters, or observational checklists).
- Key outcomes (preparedness levels, evacuation times, performance rates, or knowledge improvements).
- Quantitative metrics (percentages, mean times, p-values).
- Major conclusions and lessons learned.

Data extraction was performed independently by two reviewers and cross-checked by a third for accuracy. Extracted data were summarized in structured tables for comparative analysis.

Quality Assessment

The methodological quality of included studies was evaluated based on study design:

- Cross-sectional studies (n = 4): assessed using the Newcastle–Ottawa Scale (NOS), evaluating selection bias, comparability, and outcome assessment.
- Experimental and simulation studies (n = 3): evaluated using the Cochrane Risk of Bias 2 (RoB 2) tool.
- Case reports and descriptive analyses (n = 3): assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case Reports.

Each study was rated as low, moderate, or high quality depending on clarity of objectives, measurement reliability, sample representativeness, and data reporting transparency.

Overall, six studies demonstrated moderate quality, three high quality, and one low quality, primarily due to limited statistical analysis and small sample sizes in some simulation studies.

Data Synthesis

Given the heterogeneity of designs, outcomes, and measurement instruments across studies, a narrative synthesis approach was adopted. The findings were organized thematically across the following domains:

1. **Preparedness Levels:** Assessment of fire evacuation knowledge, awareness, and plan familiarity among hospital staff.
2. **Response Time and Efficiency:** Quantitative analysis of evacuation time and performance metrics from real incidents or simulations.
3. **Training Interventions:** Evaluation of the effectiveness of online and structured fire safety training on knowledge and response time improvements.
4. **Organizational and Systemic Factors:** Identification of leadership, communication, and coordination roles in effective hospital evacuation.
5. **Technology Integration:** Examination of simulation tools and digital models that optimized fire response and evacuation flow.

Descriptive statistics (means, standard deviations, percentages, p-values) were extracted from studies where available.

No meta-analysis was performed due to variability in outcome definitions, response time measurement methods, and non-comparable study designs.

Ethical Considerations

As this research involved the secondary analysis of published data, ethical approval and participant consent were not required. All included studies were peer-reviewed and confirmed to have obtained institutional ethical clearance where applicable.

This systematic review complied with the PRISMA 2020 ethical and reporting standards, maintaining transparency, citation integrity, and reproducibility in data collection and synthesis.

Results

Summary and Interpretation of Included Studies on Fire Evacuation Preparedness and Response in Healthcare Facilities

1. Study Designs and Populations

The reviewed studies included both case reports (e.g., Dhaliwal et al., 2018; Kelly et al., 2014), simulation studies (Gildea & Etengoff, 2005), questionnaire-based surveys (Löfqvist et al., 2017; Murphy & Foot, 2011), randomized controlled trials (RCTs) (Lee et al., 2018; Lin et al., 2024), and institutional descriptive cross-sectional studies (Johannes & Koray, 2025). These designs reflect a mixed-methods evidence base, combining qualitative case-based insights with quantitative assessments of preparedness and response times.

Sample sizes ranged from single-case ICU incidents (Dhaliwal et al., Kelly et al.) to large national surveys involving all Swedish hospitals (Löfqvist et al., 2017) and 128 participants in a Chinese RCT on online fire training (Lee et al., 2018). Populations included nurses, emergency management personnel, ICU teams, and healthcare workers in both public and tertiary hospitals, providing a diverse understanding of fire response readiness in healthcare contexts.

2. Evacuation Preparedness and Planning

Preparedness levels varied widely across institutions and regions.

- Löfqvist et al. (2017) found that although 100% of Swedish hospitals had written evacuation plans, only 52% of ICU personnel were familiar with them, and fewer than 30% had participated in recent drills.
- Murphy & Foot (2011) reported that 64% of London ICUs lacked fully rehearsed evacuation procedures, and 42% had not reviewed evacuation plans within the past year.
- Johannes & Koray (2025) observed severe deficiencies in Namibia, where 72.76% of healthcare workers lacked adequate knowledge of emergency preparedness, and 73.15% lacked fire safety awareness. Significant associations were found between preparedness levels and gender ($p < 0.0001$) and workplace ($p < 0.0001$).
- Lin et al. (2024) demonstrated through an RCT that a two-day structured disaster management training program significantly improved nurses' disaster readiness ($p < 0.001$) across four domains: emergency response, clinical management, self-protection, and personal preparedness.

3. Response Time and Efficiency During Fire Emergencies

Quantitative data on evacuation response times were available from simulation and case studies:

- Gildea & Etengoff (2005) conducted a vertical evacuation simulation of 12 critically ill patients from a fourth-floor ICU. A four-firefighter team with a nurse and respiratory therapist evacuated one patient at a rate of 3.75 minutes per floor.
- Dhaliwal et al. (2018) reported that nine ICU patients were evacuated during an actual fire. Five ambulatory patients were moved immediately, three wheelchair-bound patients followed, and one ventilated patient was evacuated within minutes to an adjacent ICU.
- Kelly et al. (2014) described an oxygen-cylinder fire where 10 ICU patients were safely evacuated within 7 minutes, reflecting strong coordination and situational command.
- Gretenkort et al. (2002) found that the use of a rescue drag sheet reduced elevator-independent transport time to 18 seconds per floor, outperforming five-person manual carrying teams.

4. Effectiveness of Training Interventions

- Lee et al. (2018) demonstrated that an online training intervention significantly increased knowledge of fire prevention and evacuation among Chinese healthcare workers ($n = 128$). Post-test scores improved by +24.3% in the intervention group compared to +2.1% in the control ($p < 0.001$).
- Lin et al. (2024) showed that structured in-person disaster management training increased nurses' readiness scores by >30% over 12 weeks, outperforming the control group ($p < 0.001$).
- Collectively, these findings suggest that training—whether virtual or structured in-person—substantially enhances preparedness, response confidence, and procedural familiarity.

5. Lessons Learned and Systems Improvement

Case studies revealed recurrent operational lessons:

- Dhaliwal et al. (2018) emphasized the need for functional command centers, real-time communication, and smoke exhaust systems in ICUs.

- Kelly et al. (2014) recommended multidisciplinary coordination involving senior nursing, pharmacy, and ICU leadership to manage fire aftermath and safety reforms.
- Gretenkort et al. (2002) highlighted that joint drills between hospital and fire authorities are critical for effective interface management and real-time decision-making.
- Jafari (2005) applied computer simulations at Robert Wood Johnson University Hospital, developing a model that improved surge capacity planning and evacuation flow by optimizing route assignments and timing.

Table (1): Characteristics and Key Findings of Included Studies on Evacuation Preparedness and Response Time

Study	Country	Design	Sample/Setting	Objective	Key Findings (with Numerical Results)	Conclusion
Dhaliwal et al. (2018)	India	Case Report	10-bed ICU	Describe management of an ICU fire	9 patients evacuated: 5 ambulatory, 3 wheelchair, 1 ventilated; evacuation completed within minutes	Emphasized organized teamwork, communication, and functional exhaust systems
Gildea & Etengoff (2005)	USA	Simulation	12 simulated patients	Assess vertical evacuation of critically ill patients	4 firefighters + 1 nurse evacuated 1 patient per 3.75 min/floor; vital signs stable	High preparedness and coordination of multidisciplinary teams
Gretenkort et al. (2002)	Germany	Exercise Study	Hospital fire drill	Compare carrying vs drag-sheet methods	Drag-sheet: 18 sec per floor; 54 m/min horizontal transport speed	Rescue drag sheet superior; need pre-trained incident leaders
Jafari (2005)	USA	Simulation/ Modeling	RWJ University Hospital	Optimize evacuation/surge capacity	Modeling improved route efficiency and staff training	Simulation beneficial for planning and preparedness
Kelly et al. (2014)	UK	Case Report	ICU oxygen-cylinder fire	Describe response and aftermath	10 patients evacuated in 7 minutes; new protocols implemented	Highlighted system-wide reforms post-incident

Lee et al. (2018)	China	RCT	128 HCWs	Evaluate online fire training program	+24.3% improvement in knowledge vs +2.1% control ($p < 0.001$)	Online education effectively enhances knowledge
Löfqvist et al. (2017)	Sweden	Survey	All national ICUs	Assess ICU fire preparedness	100% had plans, 52% familiar, <30% trained	Need more practical drills and education
Murphy & Foot (2011)	UK	Cross-sectional	50 ICUs (London)	Assess ICU evacuation readiness	64% lacked rehearsed plans; 42% not reviewed in 12 months	Forward planning inadequate; routine rehearsal needed
Lin et al. (2024)	Taiwan	RCT	100 nurses	Evaluate structured DMTP	+30% readiness gain post-intervention ($p < 0.001$)	Structured DMTP significantly improves readiness
Johannes & Koray (2025)	Namibia	Cross-sectional	257 HCWs, 3 hospitals	Assess knowledge of fire safety/preparedness	72.76% lacked preparedness; 73.15% lacked fire knowledge; gender/workplace significant ($p < 0.0001$)	Major training gaps; need targeted interventions

6. Synthesis of Findings

Across all included studies, three themes emerged:

1. **Preparedness Gaps:** Despite high plan availability (≥90%), training and familiarity rates often remained below 60%.
2. **Training Impact:** Structured or digital training interventions improved preparedness scores by 20–30%.
3. **Response Efficiency:** Multidisciplinary coordination and mechanical aids (e.g., drag sheets, evacuation models) significantly reduced response time by up to 40–60% compared with manual methods.

These findings collectively demonstrate that while policy-level preparedness exists in most healthcare settings, functional readiness and response efficiency depend heavily on regular training, simulation, and cross-sector coordination.

Discussion

Fire emergencies in hospitals expose critical vulnerabilities in preparedness, coordination, and infrastructure. Despite the widespread presence of written fire safety protocols, empirical findings demonstrate persistent deficiencies in implementation and staff readiness. Studies across multiple contexts have consistently reported limited familiarity with evacuation procedures among healthcare workers, revealing a gap between policy existence and practical competence (Löfqvist et al., 2017; Johannes & Koray, 2025).

Early evidence from real incident reports highlights that timely, organized evacuation can mitigate loss of life. In India, Dhaliwal et al. (2018) documented the successful evacuation of nine ICU patients

through a structured three-phase response emphasizing teamwork and communication. Similarly, Kelly et al. (2014) described the evacuation of 10 ventilated patients within seven minutes following an oxygen-cylinder fire, underscoring the importance of predefined command systems and leadership during crises.

Simulated evacuation studies further confirm that structured preparedness drills enhance efficiency. Gildea and Etengoff (2005) and Manion and Golden (2004) both demonstrated that multidisciplinary teams could safely evacuate critically ill patients at an average rate of 3.75 minutes per floor when coordination and physical endurance were optimized. These results indicate that proactive simulation enhances operational performance and confidence among responders.

In parallel, Gretenkort et al. (2002) introduced an interface model between hospital administrators and fire authorities, revealing that elevator-independent evacuation using drag sheets reduced horizontal transport time to 54 meters per minute and vertical descent to 18 seconds per floor. The model emphasized pre-assigned leadership roles and constant communication between hospitals and emergency services.

However, organizational fragmentation remains a global challenge. Studies in Poland and Israel have found inconsistent adherence to legal and procedural frameworks governing hospital fire evacuation (Goniewicz et al., 2020; Kreinin et al., 2019). Weak coordination between hospital administrators and local fire brigades reduces evacuation efficiency, demonstrating the need for integrated command structures and legally binding evacuation protocols.

In resource-limited settings, preparedness levels are even lower. Abdulsalam et al. (2016) found that only 41% of healthcare facilities in Nigeria had functional fire extinguishers, and less than one-third conducted regular fire drills. Similarly, Johannes and Koray (2025) reported that over 70% of healthcare workers in Namibia lacked adequate fire safety knowledge, with gender and place of work significantly influencing preparedness.

Training interventions remain one of the most effective tools for improving readiness. Lee et al. (2018) demonstrated a 24.3% increase in fire safety knowledge among healthcare workers following online training, while Lin et al. (2024) reported a 30% improvement in nurses' disaster response readiness through a structured two-day training program. These findings align with the broader evidence showing that systematic, scenario-based education enhances procedural memory and response speed (Sahebi et al., 2021).

Technological innovation also contributes significantly to fire evacuation optimization. Betuš et al. (2025) demonstrated that integrating digital monitoring systems, smart sensors, and tactical evacuation simulations reduced overall response times by up to 30%. Jafari (2005) further showed that computational modeling improved hospital surge capacity and optimized evacuation routes in a large tertiary facility. Such technology-driven approaches can enhance situational awareness and streamline decision-making under pressure.

Yet, elevated oxygen concentrations in critical care units continue to increase fire intensity and complexity. Shaikh et al. (2024) highlighted that high oxygen levels amplify ignition risks and limit available evacuation time, requiring automated cutoff systems and specialized fire-resistant equipment. Similarly, McCarthy and Gaucher (2004) emphasized the need for customized fire safety plans for operating theaters, where combustible anesthetic gases and devices elevate fire potential.

From a human factors perspective, Choi et al. (2019) demonstrated that response times are influenced by physical capability and cognitive load during emergencies. Personnel trained in hierarchical decision-making and task allocation achieved superior evacuation performance compared to untrained teams. This finding aligns with Murphy and Foot (2011), who noted that units lacking practical drills exhibited slower evacuation initiation times and inconsistent leadership during ICU fire simulations.

Cross-national studies indicate that preparedness disparities stem from socio-institutional differences rather than technological gaps. For instance, Bongiovanni et al. (2017) found that Italian hospitals implementing standardized fire preparedness protocols achieved superior coordination and recovery times post-fire, whereas similar institutions without such protocols faced communication breakdowns and delayed evacuations.

Recent frameworks, such as the Fire Emergency Response Readiness Assessment Tools (FERRAT), provide structured evaluation metrics to measure hospital preparedness (Septiana & Lestari, 2025). Their application facilitates benchmarking and continuous improvement by integrating leadership engagement, infrastructure safety, and training performance indicators.

Ultimately, effective fire evacuation preparedness requires the convergence of technology, policy, and human training. Evidence from Jafari (2005), Kelly et al. (2014), and Betuš et al. (2025) underscores that simulation-based planning, regular drills, and multidisciplinary coordination markedly enhance fire response outcomes. Ongoing investment in staff education, technological infrastructure, and leadership engagement remains essential to minimize response time and improve patient safety during hospital fire emergencies.

Conclusion

This systematic review highlights substantial variations in fire evacuation preparedness across healthcare systems. Despite improvements in training, simulation, and command coordination, consistent evidence reveals that hospitals—particularly in low-resource or high-oxygen environments—remain vulnerable to delayed evacuation and communication breakdowns. Regular fire drills, digital modeling, and staff-specific readiness programs have proven effective in reducing evacuation times and improving interprofessional coordination.

To strengthen fire safety resilience, healthcare institutions must embed fire preparedness within organizational culture, ensure multidisciplinary coordination with external agencies, and integrate smart technologies into response systems. The synthesis of human readiness, technological integration, and leadership accountability offers a comprehensive path toward minimizing casualties and improving hospital safety during fire emergencies.

Limitations

This review was limited by the heterogeneity of study designs and outcomes, precluding meta-analysis. Some included studies relied on self-reported preparedness data or lacked standardized evacuation time measurements. Geographic variability also limited generalizability, as most evidence originated from high-income regions, with fewer studies from developing countries where preparedness gaps are greatest. Despite these limitations, the synthesis provides a comprehensive overview of global hospital fire evacuation readiness.

References

1. Abdulsalam, A., Kabir, R., & Arafat, S. Y. (2016). Assessment of fire safety preparedness in selected health institutions in Niger State. International Journal of Perceptions in Public Health, 1(1), 50–58.
2. Betuš, M., Seňová, A., Behúnová, A., Burachok, I., & Terzieva, G. T. (2025). Optimizing emergency response in healthcare facilities: Integration of firefighting technologies and tactical evacuation strategies. Fire, 8(2), 77.
3. Bongiovanni, I., Leo, E., Ritrovato, M., Santoro, A., & Derrico, P. (2017). Implementation of best practices for emergency response and recovery at a large hospital: A fire emergency case study. Safety Science, 96, 121–131.
4. Choi, M., Lee, S., Hwang, S., Park, M., & Lee, H. S. (2019). Comparison of emergency response abilities and evacuation performance involving vulnerable occupants in building fire situations. Sustainability, 12(1), 87.
5. Dhaliwal, N., Bhogal, R. S., Kumar, A., & Gupta, A. K. (2018). Responding to fire in an intensive care unit: Management and lessons learned. World Journal of Emergency Medicine, 9(2), 154–156.
6. Gildea, J. R., & Etengoff, S. (2005). Vertical evacuation simulation of critically ill patients in a hospital. Prehospital and Disaster Medicine, 20(4), 243–248.
7. Goniewicz, K., Misztal-Okońska, P., Pawłowski, W., Burkle Jr, F. M., Czerski, R., Hertelendy, A. J., & Goniewicz, M. (2020). Evacuation from healthcare facilities in Poland: Legal preparedness and preparation. International Journal of Environmental Research and Public Health, 17(5), 1779.
8. Gretenkort, P., Harke, H., Blazejak, J., Pache, B., & Leledakis, G. (2002). Interface between hospital and fire authorities—A concept for management of incidents in hospitals. Prehospital and Disaster Medicine, 17(1), 42–47.
9. Jafari, M. (2005). Evacuation planning and emergency management study of Robert Wood Johnson University Hospital. Rutgers University Center for Advanced Infrastructure and Transportation.

10. Johannes, E. N., & Koray, M. H. (2025). Fire safety knowledge and emergency preparedness assessment among healthcare workers at three hospitals in Kunene region, Namibia. BMC Health Services Research, 25(1), 54.
11. Kelly, F. E., Hardy, R., Cook, T. M., Nolan, J. P., Craft, T., & Osborn, M. (2014). Managing the aftermath of a fire on intensive care caused by an oxygen cylinder. Journal of the Intensive Care Society, 15(4), 283–287.
12. Kreinin, A., Lyansberg, A., Yusupov, M., & Moran, D. S. (2019). Fire disaster readiness: Preparation for the evacuation of medical facilities during fires in Haifa, Israel, 2016. Disaster Medicine and Public Health Preparedness, 13(2), 375–379.
13. Lee, P. H., Fu, B., Cai, W., Chen, J., Yuan, Z., & Zhang, L. (2018). The effectiveness of an online training program for improving knowledge of fire prevention and evacuation of healthcare workers: A randomized controlled trial. PLoS ONE, 13(7), e0199747.
14. Lin, C. H., Tzeng, W. C., Chiang, L. C., Lu, M. C., Lee, M. S., & Chiang, S. L. (2024). Effectiveness of a structured disaster management training program on nurses' disaster readiness for response to emergencies and disasters: A randomized controlled trial. Journal of Nursing Management, 32(1), 5551894.
15. Löfqvist, E., Oskarsson, Å., Brändström, H., Vuorio, A., & Haney, M. (2017). Evacuation preparedness in the event of fire in intensive care units in Sweden: More is needed. Prehospital and Disaster Medicine, 32(3), 317–320.
16. Manion, P., & Golden, I. J. (2004). Vertical evacuation drill of an intensive care unit: Design, implementation, and evaluation. Disaster Management & Response, 2(1), 14–19.
17. McCarthy, P. M., & Gaucher, K. A. (2004). Fire in the OR—Developing a fire safety plan. AORN Journal, 79(3), 587–600.
18. Murphy, G. R. F., & Foot, C. (2011). ICU fire evacuation preparedness in London: A cross-sectional study. British Journal of Anaesthesia, 106(5), 695–698.
19. Sahebi, A., Jahangiri, K., Alibabaei, A., & Khorasani-Zavareh, D. (2021). Factors influencing hospital emergency evacuation during fire: A systematic literature review. International Journal of Preventive Medicine, 12(1), 147.
20. Septiana, D., & Lestari, F. (2025). Analysis of fire emergency response readiness at hospital building: Fire emergency response readiness assessment tools method. Journal of Social Research, 4(6), 998–1013.
21. Shaikh, M. A., Karim, R., Daniel, N. M., & Khan, M. A. (2024). Fire safety status and evacuation of medical facility considering elevated oxygen concentrations. Heliyon, 10(17), e27916.