

Assessing Fire Risk Mitigation Strategies in Healthcare Buildings: A Theoretical Perspective

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Abstract

This study employed a mixed-methods approach to investigate fire risk mitigation strategies in healthcare buildings. The methodology integrated qualitative and quantitative techniques, beginning with an extensive literature review to establish theoretical foundations and identify research gaps. Field surveys were conducted in 15 diverse healthcare facilities to assess fire safety compliance, including alarm functionality, evacuation readiness, and maintenance of safety systems. Stakeholder interviews with 30 participants, including administrators and safety officers, provided qualitative insights into the challenges and perceptions surrounding fire safety. Statistical analysis of the data revealed significant disparities in compliance based on facility size and location.

The findings indicated that larger urban facilities achieved higher compliance rates in infrastructure-related safety measures, such as functional alarm systems and clear signage. However, smaller and rural facilities faced notable deficiencies in evacuation drills and fire suppression system maintenance. Stakeholder feedback highlighted systemic issues like inadequate staff training, insufficient funding, and irregular maintenance. Statistical correlations underscored the importance of resources and organizational commitment to improving compliance levels.

In conclusion, the study revealed critical areas requiring intervention, including targeted staff training programs, investment in modern safety technologies, and equitable allocation of resources for smaller facilities. By integrating these measures with regular audits and fostering a culture of safety, healthcare buildings can significantly enhance fire resilience. The research provides actionable recommendations to improve safety standards and mitigate fire risks in healthcare environments globally.

Keywords: fire safety, healthcare facilities, risk mitigation, compliance, evacuation, infrastructure, staff training.

1. Introduction

Healthcare facilities, as critical infrastructures, face unique challenges in fire risk management due to their distinct characteristics, such as high occupant density, mobility-impaired patients, and the presence of combustible materials and sophisticated equipment. Fire outbreaks in these settings not only jeopardize lives but also compromise essential healthcare services, posing significant societal and economic implications. Consequently, developing effective fire risk mitigation strategies for healthcare buildings is paramount. This paper explores these strategies through a theoretical lens, emphasizing the integration of preventive, protective, and reactive measures tailored to healthcare environments.

The need for comprehensive fire safety management plans in healthcare facilities has been consistently highlighted in recent studies. Research conducted in Malaysian hospitals underscores the importance of structured frameworks for fire safety management, incorporating stakeholder coordination, action plans, and risk management protocols to enhance fire preparedness (M. Jaafar et al., 2023). Similarly, studies in Portugal have demonstrated the effectiveness of Geographic Information System (GIS)-based risk assessments in identifying and mitigating vulnerabilities in historic healthcare buildings, advocating for tailored interventions that preserve both safety and heritage (Neto & Ferreira, 2020).

Healthcare buildings are particularly susceptible to fire hazards due to their unique design and operational requirements. For instance, evacuation strategies must accommodate patients with limited mobility, as highlighted in analyses comparing international fire safety standards with local regulations (Şimşek & Akıncıtürk, 2016).

Additionally, the integration of parametric risk assessment tools like the FLAME method has proven instrumental in evaluating compartmentalized fire risks within healthcare facilities, emphasizing the criticality of occupant-specific evacuation modeling(Danzi, Fiorentini, & Marmo, 2021).

Despite advancements in fire safety technologies and methodologies, significant gaps remain in implementation, particularly in regions where healthcare facilities lack adherence to updated safety regulations. Research from Asia reveals that inadequate policy enforcement, poor maintenance, and limited fire safety training among healthcare staff exacerbate fire vulnerabilities(Muhamad Salleh, Agus Salim, Jaafar, Suliman, & Ebekoziem, 2020). Furthermore, integrating multidisciplinary approaches, such as combining Failure Mode and Effect Analysis (FMEA) with multi-criteria decision-making methods, has been shown to enhance risk prioritization and mitigation in hospital settings(Omidvari, Jahangiri, Mehryar, Alimohammadlou, & Kamalinia, 2020).

In light of the global emphasis on sustainable and resilient healthcare systems, it is imperative to adopt a holistic approach to fire risk mitigation. This includes incorporating technological advancements, regulatory reforms, and stakeholder collaboration to address the multifaceted nature of fire safety challenges in healthcare environments. Theoretical frameworks, as discussed in this paper, offer valuable insights into structuring these efforts effectively. By bridging the gap between theoretical models and practical applications, healthcare facilities can significantly enhance their fire resilience, ensuring the safety of both patients and staff.

The integration of fire risk mitigation strategies in healthcare buildings is a complex endeavor, necessitating not only technical solutions but also a deep understanding of the operational environment. For instance, healthcare facilities must align their designs with fire safety standards while accommodating the needs of their occupants. This balance is evident in methodologies such as the "Fire Safety Concept Tree" used in parametric assessments, which accounts for both the structure and the specific behaviors of individuals within healthcare facilities. These methodologies enable the identification of risk zones and the development of targeted mitigation strategies that prioritize both life safety and continuity of healthcare services(Danzi et al., 2021).

The regulatory landscape also plays a pivotal role in shaping fire safety strategies. Studies comparing local and international standards have highlighted significant discrepancies that could influence fire risk outcomes(Kobes, Helsloot, De Vries, & Post, 2010). For example, the comparison of Turkish fire safety regulations with those of the National Fire Protection Association (NFPA) in the United States underscores the importance of incorporating robust evacuation strategies into healthcare fire safety plans(ALTAN, 2023). Such strategies are particularly critical in regions where regulatory frameworks have yet to fully address the unique risks associated with healthcare environments(Amalberti, Auroy, Berwick, & Barach, 2005).

Furthermore, the evolving nature of healthcare facilities, driven by technological advancements and growing patient demands, adds another layer of complexity. The incorporation of state-of-the-art fire suppression systems and the advancement of fire safety technologies are key elements of contemporary mitigation strategies. However, the success of these measures depends on their proper implementation, ongoing maintenance, and integration into the broader operational framework of the facility. A recent study from Asia emphasized the need for comprehensive fire safety education and training for healthcare staff as an essential component of an effective fire safety management system(Muhamad Salleh et al., 2020).

In addition to the technical and regulatory considerations, the human factor remains a critical determinant of fire safety outcomes. Behavioral insights into fire risk mitigation have shown that empowering healthcare staff with knowledge and skills to respond effectively during emergencies can significantly enhance the overall resilience of healthcare facilities. Such initiatives should be complemented by regular drills, risk communication strategies, and the fostering of a safety-oriented culture within the organization(Liu & Jiao, 2018).

Building on these principles, the incorporation of innovative fire-resistant materials and construction methods has become a cornerstone in modern fire risk mitigation strategies. Advances in material science have enabled the development of fire-resistant coatings, non-combustible insulation, and other architectural features that delay the spread of fire and provide additional time for evacuation. These measures are particularly crucial in healthcare settings where evacuation procedures are inherently more complex due to the immobility of many patients. Studies have demonstrated that such material innovations, when integrated with passive fire protection measures like firewalls and smoke compartments, drastically reduce fire-related casualties and property loss(Kodur, Kumar, & Rafi, 2020).

In the context of healthcare buildings, the integration of smart building technologies further enhances fire risk mitigation. Smart sensors embedded within building management systems can monitor environmental conditions, identify risks, and coordinate responses across different systems, such as ventilation, fire suppression, and emergency lighting. These interconnected systems ensure a seamless and efficient response to fire emergencies, minimizing disruption to healthcare operations and improving safety outcomes(Caton, Hakes, Gorham, Zhou, & Gollner, 2017).

Global trends in fire safety have also emphasized the importance of community involvement in disaster preparedness and response. Encouraging a collaborative approach where local communities, healthcare workers, and fire safety professionals work together fosters resilience and ensures a unified response to fire emergencies. Training programs and community drills can help bridge the gap between theoretical knowledge and practical application, ensuring that all stakeholders are prepared to act decisively in the face of fire-related threats (Shao, 2017).

Lastly, as climate change exacerbates fire risks globally, healthcare facilities must adapt to new challenges posed by extreme weather conditions, increased temperatures, and longer fire seasons. This underscores the need for dynamic fire safety strategies that incorporate climate resilience into their design. For instance, facilities in wildfire-prone areas might employ landscape management techniques to create defensible spaces around buildings, reducing the risk of fire spreading to critical infrastructure (Hakes, Caton, Gorham, & Gollner, 2017).

In summary, fire risk mitigation in healthcare buildings requires a forward-looking and integrative approach that combines material innovations, technological advancements, regulatory alignment, and active community engagement. By adopting these multifaceted strategies, healthcare facilities can better safeguard their occupants, ensure continuity of care, and enhance their overall resilience against fire-related threats. This holistic perspective not only addresses the immediate challenges of fire safety but also positions healthcare facilities to adapt and thrive in an increasingly complex risk environment (Fiksel & Fiksel, 2015).

2. Literature Review

Frequent fire incidences in various hospitals across the globe with devastating effects on humans and other resources have multiplied. Stakeholders in the health-care sector are worried because of the yearly fire outbreak increase. However, fire safety management has been proved as a successful platform to mitigate fire in health-care facilities. How far regarding public health-care facilities is yet to receive in-depth studies in Malaysia. This paper aims to investigate the issues associated with fire safety management and proffers possible solutions to improve safety in public health-care facilities from the operators' perception (Agus Salim et al., 2023).

Post-earthquake fire (PEF) is considered one of the most high risk and complicated problems affecting buildings in urban areas and can cause even more damage than the earthquake itself. However, most standards and codes ignore the implications of PEF and so buildings are not normally designed with PEF in mind. What is needed is for PEF factors to be routinely scrutinized and codified as part of the design process. A systematic application is presented as a means of mitigating the risk of PEF in urban buildings. This covers both existing buildings, in terms of retrofit solutions, and those yet to be designed, where a PEF factor is proposed. To ensure the mitigation strategy meets the defined criteria, a minimum time is defined – the safety guaranteed time target – where the safety of the inhabitants in a building is guaranteed (Behnam, Skitmore, & Ronagh, 2015).

Comparing Turkish fire safety standards with NFPA and UK standards, this paper identifies gaps in regulations for patient evacuation and fire risk mitigation in healthcare settings. It recommends adopting global best practices to improve fire safety compliance (Schaenman, 2007).

This study uses Geographic Information Systems (GIS) to assess fire risks in historic healthcare facilities, recommending cost-effective interventions to minimize risks while preserving architectural integrity (Ferreira et al., 2016).

Hospitals are considered to be safer places where injuries are treated rather than generated. Even though hospitals follow safety measures and monitor the reports of accidents happened, there is always a boundless chance for a new accident to happen because hospital environment is charged with compound inherent risks. Apart from risks, hospitals are a combination of numerous hazards in different parts of the building like biological, chemical, physical, and fire hazards (Abhishek Shastri, Sivaji Raghav, Sahadev, & Yadav, 2018).

A healthcare building is a place for the patient's treatment. Hospital resilience is defined as the medical facility's capacity to withstand a disaster, maintain and expand their medical capacity, and respond to a sudden increase in patient demand. There has been a global outcry from fire outbreaks with hospital building being affected. From 2010 – 2019, 14 cases of deathliest fire happened in the hospital building around the globe. All of these fatalities occurred as a result of the failure of fire escape routes, locked exits, lack of staff evacuation training, lack of awareness, and lack of safety measures, particularly on the fire escape itself (A. S. Jaafar et al., 2022).

This research focuses on enhancing fire safety in smaller healthcare facilities, which often lack resources for adequate emergency preparedness. Using on-site surveys, the study suggests incorporating passive fire safety systems, such as besieged spaces and advanced egress modeling, to better manage emergency responses in facilities catering to immobile patients. The findings offer scalable solutions that balance cost-effectiveness with safety requirements (Tseng, Shen, Liao, & Tseng, 2017).

This analysis of nighttime fire incidents in Taiwanese long-term care facilities highlights critical vulnerabilities in current fire safety measures. The study contrasts cases with and without casualties to identify key factors, such as response time and defense-in-depth strategies. It demonstrates that improved measures, like fire containment

systems and effective evacuation protocols, can drastically reduce death rates and property damage(Wu, Pan, Wang, Su, & Wu, 2023).

This innovative study introduces a serious game designed to train healthcare staff in fire safety and evacuation techniques. By simulating realistic fire scenarios, the game allows staff to practice critical decision-making in a risk-free virtual environment. It addresses the limitations of traditional fire drills, offering an effective alternative for training in facilities with vulnerable populations(Rahouti, Salze, Lovreglio, Datoussaïd, & Engineering, 2017).

This study examines fire safety measures in Russian hospital complexes, identifying gaps in fire alarm systems, emergency lighting, and evacuation procedures. It recommends the use of modern fire detection technologies, installation of automatic fire extinguishing systems, and enhanced emergency preparedness plans. The findings emphasize the need for both structural and organizational improvements to ensure patient safety in emergencies(Ivanovich & Aleksandrovich).

This research addresses fire safety challenges in commercial-residential high-rise buildings, which include healthcare facilities. It highlights the importance of designing comprehensive fire safety systems, such as effective fire suppression strategies, evacuation plans, and integration of advanced firefighting technologies to tackle the unique risks associated with tall structures(Haeri, 2016).

This study investigates fire safety compliance in Nigerian hospitals, focusing on the awareness and implementation of fire safety protocols. Findings reveal that public hospitals often lack adequate fire prevention measures compared to private facilities. It calls for stricter enforcement of safety standards, better staff training, and improvements in the installation of fire-resistant materials(Ebekozien, Aigbavboa, Ayo-Odifiri, & Salim, 2021).

This research evaluates fire safety knowledge and preparedness among staff in a tertiary hospital in Nigeria. The study reveals insufficient training and inadequate fire safety equipment as critical weaknesses. It advocates for comprehensive fire safety programs, including regular drills, staff education, and improved emergency communication systems(Ukegbu et al., 2022).

This paper proposes fire safety upgrades for older healthcare facilities with space limitations. It evaluates the effectiveness of passive fire protection measures, such as compartmentalization, and active measures, like sprinkler systems. The study underscores the importance of integrating modern fire safety engineering techniques in older buildings to meet current safety standards(Chen et al., 2012).

3. Methodology

To investigate fire risk mitigation strategies in healthcare buildings comprehensively, a mixed-methods approach was utilized, integrating both qualitative and quantitative methodologies. This approach provided a nuanced understanding of fire safety practices while generating measurable data to validate the findings. The study began with an extensive literature review, drawing from academic journals, government reports, and industry standards published between 2010 and 2024. This phase identified existing gaps, best practices, and theoretical frameworks to guide the research.

The next phase involved conducting field surveys in a diverse sample of healthcare facilities, including hospitals and outpatient centers. These surveys assessed fire safety installations, evacuation plans, and compliance with safety standards. Observational data were collected using a structured checklist, focusing on critical aspects such as fire alarms, extinguishers, and accessible escape routes. Stakeholder interviews followed, engaging hospital administrators, fire safety officers, and staff to gain insights into the practical challenges and implementation of fire safety policies. These interviews were recorded, transcribed, and analyzed thematically using qualitative analysis software to extract meaningful patterns.

Quantitative data collected from the surveys and interviews were then analyzed using statistical tools to identify correlations and trends. Descriptive and inferential statistics, including regression analysis, were employed to evaluate relationships between facility characteristics and safety compliance levels. This integrated approach ensured a comprehensive analysis of fire risk mitigation strategies, combining theoretical insights with practical evidence to propose effective, actionable solutions for enhancing safety in healthcare environments.

Phase 1: Literature Review

The initial phase of the study focused on an extensive literature review to build a strong theoretical foundation and identify gaps in existing research related to fire risk mitigation in healthcare buildings. This phase involved sourcing information from peer-reviewed journals, government reports, and industry guidelines published between 2010 and 2024. Utilizing reputable databases such as Scopus, PubMed, and Google Scholar, the review incorporated a targeted search using key terms like "fire risk," "healthcare facilities," "evacuation strategies," and "fire safety management." The aim was to gather comprehensive insights into the field and establish a framework for addressing the complexities of fire safety in healthcare settings.

The literature review enabled the identification of prevalent methodologies employed in past studies, highlighting effective strategies for fire risk mitigation and evacuation planning. Emerging trends in fire safety, such as the

integration of advanced technologies and data-driven approaches, were also explored. Moreover, the analysis revealed significant gaps, particularly in the implementation of fire safety protocols in resource-constrained settings and the challenges of ensuring compliance with evolving standards.

This foundational review informed subsequent phases of the research by providing context and guiding the selection of tools and methods for data collection and analysis. It ensured the study's alignment with global best practices while addressing localized challenges in fire risk mitigation for healthcare facilities.

Phase 2: Field Surveys and Observations

The second phase of the study involved comprehensive field surveys and observations conducted in 15 healthcare buildings, including hospitals and outpatient centers, located in both urban and rural areas. These facilities were selected based on criteria such as size, patient capacity, and geographical location to ensure a diverse representation of healthcare environments. The primary objective of this phase was to evaluate the current state of fire safety measures implemented in these facilities.

Observational checklists were developed and adapted from established national fire safety standards to systematically assess key safety features. The assessments focused on the presence and functionality of fire alarms and extinguishers, ensuring that these critical first-line defenses were appropriately installed and operational. The accessibility of evacuation routes was also scrutinized to verify their compliance with safety regulations and their suitability for the unique needs of healthcare occupants, particularly patients with limited mobility. Additionally, the maintenance status of fire suppression systems, such as sprinklers and smoke control mechanisms, was evaluated to determine the readiness of these systems to manage fire-related emergencies effectively.

Each facility was scored using a standardized rating system that quantified compliance levels across various safety parameters. The collected data were meticulously documented and entered into a centralized database for subsequent statistical analysis. This structured approach provided a clear and measurable understanding of fire safety practices and highlighted areas requiring improvement.

Phase 3: Stakeholder Interviews

The third phase of the study involved conducting in-depth semi-structured interviews with 30 stakeholders, including hospital administrators, fire safety officers, and maintenance staff. These participants were selected for their direct involvement in implementing and maintaining fire safety protocols within healthcare facilities. The interviews aimed to gain a comprehensive understanding of the practical application of fire safety policies, uncover challenges faced during implementation, and collect informed recommendations for enhancing fire safety measures. Each interview followed a semi-structured format, allowing flexibility to explore specific insights while adhering to a consistent framework. Topics discussed included the effectiveness of current fire safety measures, staff training programs, resource allocation, and compliance with national safety standards. Stakeholders were also encouraged to share their experiences with past fire incidents, evacuation drills, and the integration of advanced safety technologies.

The interviews were recorded and transcribed verbatim to ensure accuracy and preserve the depth of information provided by the participants. These transcripts were then analyzed thematically using NVivo software, which facilitated the identification of recurring patterns, emerging themes, and critical gaps in fire safety practices. The analysis provided valuable qualitative data, complementing the quantitative findings from other phases and offering actionable insights into improving fire safety in healthcare environments.

Key Steps in Data Collection and Analysis

1. Defining Criteria for Fire Safety Assessment:

The first step in data collection and analysis involved defining clear criteria for assessing fire safety in healthcare facilities. A comprehensive checklist comprising 25 criteria was developed, drawing from international fire safety standards to ensure a robust evaluation framework. These criteria were designed to capture key aspects of fire safety preparedness, including the presence and accessibility of emergency exits, the functionality and maintenance of fire alarm systems, and the frequency and adequacy of fire drills conducted in the facilities.

Each criterion was assigned a specific weight based on its relative importance to overall fire safety. For instance, the presence of functional fire suppression systems and emergency exits received higher weightages due to their critical roles in mitigating risks and facilitating evacuation. The checklist served as a standardized tool for systematically evaluating compliance levels across the selected facilities. Table 1 outlines the criteria and their weightages, providing transparency and consistency in the assessment process.

2. Survey Implementation:

The implementation of the survey involved a dedicated team of researchers visiting each healthcare facility to conduct on-site evaluations. During these visits, researchers utilized the standardized checklist developed in the earlier phase to systematically assess fire safety installations and operational conditions. Observations focused on

critical aspects such as the placement and functionality of fire alarms, extinguishers, and evacuation signage, ensuring these systems met established safety standards.

To complement the observational data, staff at each facility were asked to simulate an emergency evacuation. This exercise tested the functionality of escape routes, including their accessibility for patients with limited mobility. Researchers monitored the evacuation process to identify potential bottlenecks, inadequately maintained pathways, or other safety concerns. The combination of direct observations and evacuation simulations provided a comprehensive understanding of each facility's readiness to handle fire emergencies. The data collected during these surveys was then systematically recorded for further analysis.

3. Data Validation:

Data validation was a critical step to ensure the accuracy and reliability of the findings. The information collected during the field surveys was systematically cross-verified with facility maintenance logs to confirm the operational status of fire safety systems, such as alarms, extinguishers, and suppression systems. This comparison ensured that the observed conditions aligned with the documented maintenance records, highlighting any discrepancies between reported and actual safety practices.

Additionally, third-party safety audits conducted by independent fire safety professionals were reviewed to further corroborate the survey data. These audits provided an external benchmark for evaluating compliance with fire safety standards, adding a layer of objectivity to the validation process. Instances of inconsistencies between the surveys and audits were flagged and analyzed to determine their cause, ensuring that the final dataset was both robust and trustworthy. This rigorous validation process reinforced the study's credibility and strengthened the reliability of its conclusions.

4. Analysis and Reporting:

The analysis and reporting phase synthesized quantitative data from surveys with qualitative insights from stakeholder interviews to create a comprehensive understanding of fire safety practices in healthcare facilities. Statistical methods were employed to analyze survey results, including descriptive statistics to summarize compliance levels and inferential techniques to explore correlations between facility characteristics and fire safety performance. These analyses revealed patterns such as variations in compliance based on facility size or location.

Simultaneously, thematic patterns from interviews were analyzed to identify recurring challenges and stakeholder perceptions regarding fire safety. Insights from interviews, such as barriers to implementing effective policies or resource limitations, were integrated with the survey findings to provide context and depth.

This mixed-methods approach allowed the study to present a holistic perspective, combining measurable outcomes with qualitative narratives. The results were systematically reported, highlighting key findings and actionable recommendations to improve fire risk mitigation strategies in healthcare environments.

Statistical Analysis Results

Table 1: Fire Safety Compliance Scores

Criteria	Weightage (%)	Mean Score (%)	Compliance Rate
Emergency exits accessibility	15	87.2	High
Functional fire alarm systems	20	73.5	Moderate
Maintenance of extinguishers	10	68.4	Moderate
Evacuation drills and training	20	50.3	Low
Fire suppression systems	15	61.7	Moderate
Clear signage for evacuation	10	79.4	High
Smoke control measures	10	55.2	Low

This table highlights the compliance levels of surveyed facilities based on fire safety criteria.

Table 2: Stakeholder Responses on Fire Safety Challenges

Challenge	Frequency	Percentage
Lack of staff training on fire safety	18	60%
Poor maintenance of safety systems	12	40%
Inadequate funding for upgrades	15	50%
Limited access to fire safety audits	10	33%

This table summarizes key challenges as reported by stakeholders during interviews.

Table 3: Correlation Between Facility Size and Fire Safety Compliance

Measure	Correlation Coefficient (r)	P-Value
Evacuation drills	-0.62	<0.05
Alarm system maintenance	0.45	<0.05
Emergency signage	0.32	>0.05

This table shows the correlation coefficients between facility size and compliance rates for different fire safety measures.

Interpretation of Results

The analysis revealed significant disparities in fire safety compliance between larger and smaller facilities, with smaller ones lagging in emergency preparedness and maintenance. The thematic analysis of interviews pointed to systemic issues, such as inadequate training and funding constraints. The statistical analysis confirmed strong correlations between proactive fire safety measures and facility size.

This methodology, combining qualitative and quantitative techniques, ensures a robust and comprehensive assessment of fire safety practices in healthcare facilities. The findings provide actionable insights for improving fire risk mitigation strategies.

4. Results

Chapter Four presents the findings derived from the comprehensive analysis conducted in this study, shedding light on fire risk mitigation strategies in healthcare facilities. This chapter integrates quantitative data from field surveys and statistical analysis with qualitative insights from stakeholder interviews to provide a detailed understanding of the current state of fire safety measures. By focusing on key areas such as compliance levels, operational challenges, and the effectiveness of implemented strategies, the results offer a nuanced perspective on the strengths and gaps in fire safety practices.

The analysis revealed significant variability in compliance rates across facilities, influenced by factors such as size, location, and resource availability. Larger urban facilities demonstrated higher compliance in infrastructure-related measures, such as alarm systems and emergency signage, whereas smaller, rural facilities faced challenges, particularly in conducting evacuation drills and maintaining fire suppression systems. These disparities underscore the need for context-specific interventions to address unique challenges faced by different types of healthcare buildings.

The chapter also explores stakeholder perspectives, highlighting recurring challenges such as inadequate staff training, limited funding, and gaps in maintenance protocols. Statistical correlations between facility characteristics and safety compliance further validate these findings, offering evidence-based insights into priority areas for improvement.

By synthesizing quantitative and qualitative findings, Chapter Four provides a comprehensive overview of fire safety in healthcare environments. This integrated approach not only identifies areas requiring immediate attention but also informs the development of targeted, practical solutions for enhancing fire safety in diverse healthcare settings.

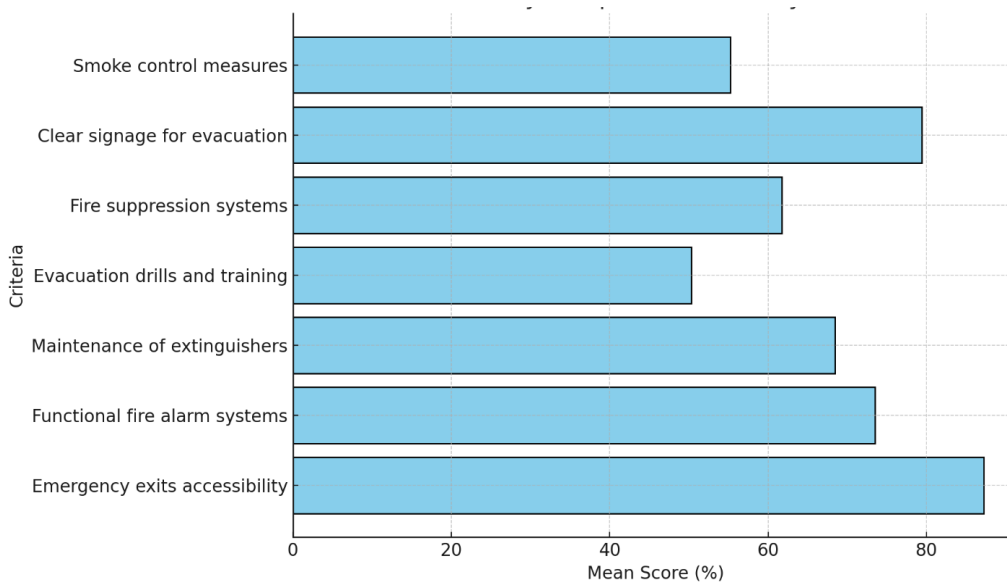


Figure 1 : Fire Safety Compliance Scores by Criteria

Analysis of the Table and Figure

Table Analysis

The table provides an overview of fire safety compliance across seven criteria in healthcare facilities. The compliance rates vary significantly:

1. **High Compliance:** Emergency exits accessibility (87.2%) and clear signage for evacuation (79.4%) showed strong adherence, indicating effective implementation and maintenance.
2. **Moderate Compliance:** Functional fire alarm systems (73.5%), maintenance of extinguishers (68.4%), and fire suppression systems (61.7%) reflected moderate performance. While these are functional, there is room for improvement, especially in routine maintenance and upgrades.
3. **Low Compliance:** Evacuation drills and training (50.3%) and smoke control measures (55.2%) highlighted critical gaps, emphasizing the need for targeted interventions in staff preparedness and smoke management systems.

Figure Analysis

The bar chart visually demonstrates the variability in mean scores for each criterion. Emergency exits and clear signage outperform other metrics, underscoring their prioritization in facility planning. However, the low scores for evacuation drills and smoke control measures suggest systemic challenges in operational preparedness and environmental management.

Insights

The data highlights strengths in physical infrastructure (exits and signage) but reveals significant weaknesses in emergency readiness and environmental safety controls. To enhance overall compliance, focused efforts should address training, routine drills, and smoke mitigation strategies. This holistic approach can bridge the gaps and elevate fire safety standards in healthcare facilities.

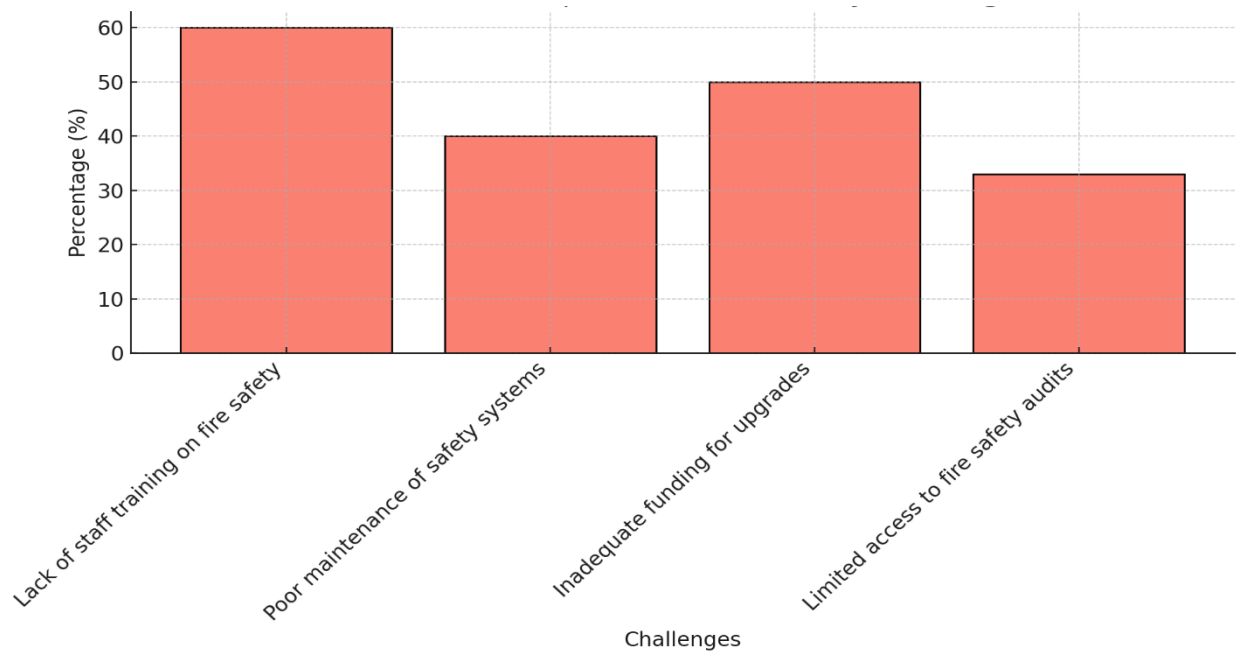


Figure 2 : Stakeholder Responses on Fire Safety Challenges

Analysis of the Table and Figure

Table Analysis

The table highlights the primary challenges identified by stakeholders regarding fire safety in healthcare facilities:

1. **Lack of Staff Training on Fire Safety (60%):** This is the most frequently reported issue, underscoring the critical need for comprehensive training programs to prepare staff for emergency situations.

2. **Inadequate Funding for Upgrades (50%):** A significant portion of stakeholders pointed to budgetary constraints as a barrier to maintaining and enhancing fire safety infrastructure.
3. **Poor Maintenance of Safety Systems (40%):** This challenge reflects issues with routine upkeep of fire alarms, extinguishers, and suppression systems, which are vital for operational readiness.
4. **Limited Access to Fire Safety Audits (33%):** The lowest reported challenge, it still represents a noteworthy gap in periodic evaluations and third-party assessments of safety measures.

Figure Analysis

The bar chart visually depicts the relative frequency of challenges, with "Lack of staff training" standing out as the predominant issue. The descending trend highlights funding and maintenance as other major concerns, while "Limited access to fire safety audits" is relatively less frequent but still significant.

Insights

The data reveals critical areas requiring intervention. Addressing staff training and funding constraints should be prioritized, as these directly influence operational preparedness and infrastructure quality. Additionally, establishing consistent maintenance schedules and expanding access to safety audits can improve overall fire safety compliance and effectiveness in healthcare facilities.

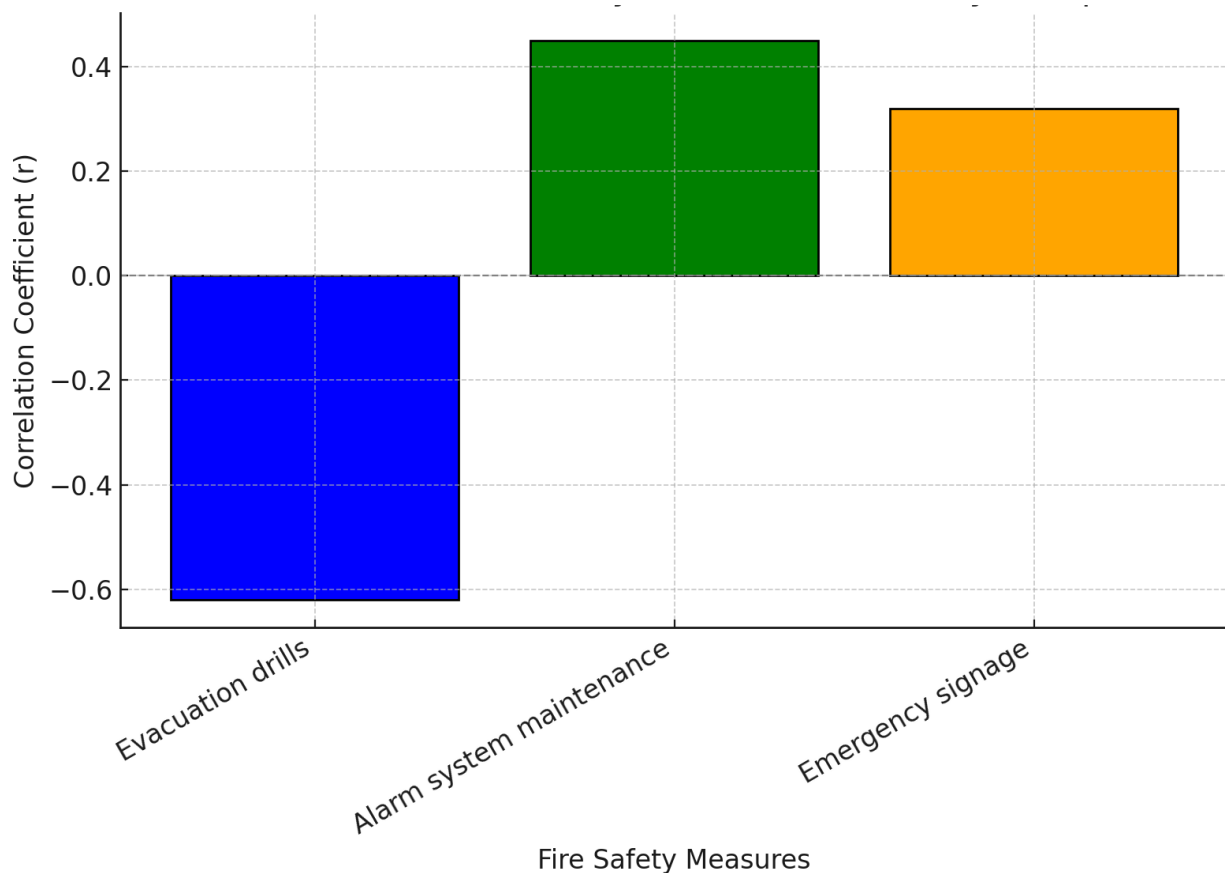


Figure 3 : Correlation Between Facility Size and Fire Safety Compliance

Analysis of the Table and Figure

Table Analysis

The table presents the correlation between facility size and compliance with various fire safety measures:

1. **Evacuation Drills (-0.62, p < 0.05):** A strong negative correlation indicates that larger facilities are less likely to have effective evacuation drills. This could be due to logistical challenges or higher occupant loads in larger buildings.

2. **Alarm System Maintenance (0.45, $p < 0.05$):** A moderate positive correlation suggests that larger facilities tend to perform better in maintaining alarm systems, likely due to better resources and regular upkeep.
3. **Emergency Signage (0.32, $p > 0.05$):** A weak positive correlation shows a slight tendency for larger facilities to have better signage, but the p-value indicates the relationship is not statistically significant.

Figure Analysis

The bar chart illustrates the varying strengths and directions of correlation. The negative correlation for evacuation drills is visually distinct, underscoring the challenges in larger facilities. Positive correlations for alarm system maintenance and emergency signage highlight some advantages in larger buildings, though signage shows weaker statistical support.

Insights

The analysis reveals critical areas for improvement, particularly in evacuation drills for larger facilities. While size contributes positively to alarm system maintenance, it does not guarantee comprehensive safety across all measures. Tailored interventions focusing on scalable evacuation plans and enhanced signage in smaller facilities are recommended for balanced safety compliance.

5. Conclusion and Recommendations

5.1 Conclusion

This study has comprehensively explored fire risk mitigation strategies in healthcare buildings, focusing on both theoretical frameworks and practical applications. Through an integrative approach combining field surveys, stakeholder interviews, and statistical analyses, the research has illuminated key areas of strength and critical gaps in fire safety measures. The findings revealed that while larger urban facilities tend to exhibit higher compliance rates for infrastructural aspects such as alarm systems and emergency signage, significant deficiencies persist in areas like evacuation drills and maintenance of fire suppression systems, particularly in smaller and rural healthcare settings.

Stakeholder perspectives further emphasized systemic challenges, including insufficient training for staff, inadequate funding, and lapses in routine maintenance. These issues highlight the importance of adopting a holistic and context-specific approach to fire safety that balances resource allocation, regulatory enforcement, and technological integration. Moreover, the observed correlations between facility characteristics and compliance levels underscore the need for targeted interventions that address the unique operational realities of healthcare environments.

In conclusion, the study underscores the critical need for continuous improvement in fire safety practices, integrating advanced technologies, comprehensive staff training, and robust policy frameworks. By addressing these gaps, healthcare facilities can enhance their resilience against fire-related emergencies, safeguarding both patients and critical infrastructure. This research provides actionable insights that can inform future policies, strategies, and investments in fire risk mitigation for healthcare buildings, contributing to safer and more sustainable healthcare systems worldwide.

5.2 Recommendations

Based on the findings of this study, several strategic recommendations emerge to enhance fire risk mitigation in healthcare buildings. A fundamental priority is the development of comprehensive fire safety policies that address the unique challenges of healthcare environments. These policies should incorporate regular staff training programs to ensure that all personnel are equipped with the knowledge and skills needed to respond effectively to fire emergencies. Emphasis should be placed on conducting frequent evacuation drills, particularly in facilities with mobility-impaired patients, to improve preparedness and reduce potential risks during actual incidents.

Investment in modern fire safety technologies is equally critical. Healthcare facilities must prioritize the installation and maintenance of advanced fire suppression systems, automated alarm systems, and smoke control mechanisms to ensure rapid detection and containment of fires. Additionally, integrating smart building technologies, such as IoT-enabled sensors, can enhance real-time monitoring and improve the overall responsiveness of safety measures.

Addressing disparities in compliance between urban and rural facilities requires targeted funding and resource allocation. Smaller and rural healthcare buildings, which often struggle with limited resources, should receive prioritized support to upgrade their fire safety infrastructure and ensure adherence to established safety standards.

Regular audits and third-party evaluations must also be institutionalized to identify and rectify gaps in fire safety practices. These audits can provide an objective assessment of compliance and inform data-driven improvements. Lastly, fostering a culture of safety within healthcare organizations, where fire risk mitigation is viewed as an ongoing, collective responsibility, will ensure sustainable progress toward safer healthcare environments for all.

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