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IMPROVING FIRE RISK MANAGEMENT PRACTICES IN MULTI-STORY BUILDINGS: A CASE STUDY OF KINONDONI DISTRICT, DAR ES SALAAM, TANZANIA

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ABSTRACT
This study investigates fire risk management in high-rise buildings, focusing on fire hazards, preparedness, and safety measures. Data was collected through interviews and questionnaires from occupants and building managers in ten buildings in the Kinondoni District. The results of this study revealed that electrical hazards and cooking activities were identified as the most significant fire risks. Despite the presence of fire safety equipment such as extinguishers, a lack of fire safety awareness and evacuation plans was found to be widespread, with 80% of respondents reporting the absence of an evacuation plan and 72% stating they do not use fire extinguishers. Additionally, about six multi-story buildings lack adequate fire risk management practices, which exacerbate the fire risks. This study highlights the urgent need for improved fire safety awareness, regular drills, and the implementation of comprehensive evacuation strategies. To reduce fire hazards and improve safety, it is essential to implement regular inspections, ensure proper ventilation in kitchens, and enhance training programs on fire extinguisher use. The findings emphasize that enhancing fire preparedness in high-rise buildings is crucial for preventing fire-related fatalities and property damage.

Keywords: Fire risk management, multistory buildings, fire safety practices, risk assessment, emergency preparedness.

INTRODUCTION

Multi-story buildings are widely used worldwide for various purposes, including shopping centers, recreational facilities, offices, and markets (Rihardjo, 2020). The rapid development of both developed and developing countries has led to an increase in life expectancy, which has, in turn, contributed to significant population growth. This growth has resulted in land scarcity for settlement, as well as social and economic challenges (Kodur *et al*., 2020a).

Buildings constitute a major part of built infrastructure and play a crucial role in a country's socioeconomic development. These structures are designed to last for a long time; however, throughout their lifespan, they may be exposed to various hazards, both natural such as earthquakes, hurricanes, and tsunamis and human-induced, such as fires and explosions. These hazards can lead to partial or complete structural collapse (Kodur *et al*., 2020).

Fire hazards in buildings refer to the potential risk of accidental or intentional fires that threaten human life, structural integrity, and property safety (Kodur *et al*., 2020). Due to rapid global development, fire hazards in high-rise buildings have evolved in terms of severity and complexity (Kodur *et al*., 2020). Several factors influence the occurrence of fires in high-rise buildings, including building conditions, the availability of firefighting facilities and equipment, local cultural and geographical factors, climate conditions, unit configurations, production methods, historical records, and past fire incidents (Wang, 2021).

Multi-story buildings present unique fire hazards due to their significant height, large floor areas, high number of floors, extensive use of combustible materials, and consumption across various equipment types (Lei *et al*., 2024). As the height and number of floors increase, so does the density of occupants, making fire evacuation more complex and time-consuming (Yang Siling & Jiang Genmou, 2017).

Fires can occur in everyday settings, including homes and workplaces. In the United States, building fires were responsible for 77% of civilian fire deaths, 88% of civilian fire injuries, and 83% of direct property damage in 2022 (Ma *et al*., 2025). Between 1993 and 2015, a total of 86.4 million fire incidents resulted in millions of fatalities (Brushlinsky *et al*., 2017), with annual global fire-related losses accounting for 1% of the world's GDP (Bulletin, 2024). Additionally, Brushlinsky *et al*. (2019) reported that 3.8 million fires cause approximately 44,300 deaths annually in both developed and developing countries. For example, in Abuja, 444 fire incidents resulted in the deaths of 194 people (Oaikhena & Akande, 2024).

Available statistics suggest that cooking is the leading cause of fires in both residential and non-residential buildings (U.S. Fire Administration, 2016). However, architectural factors such as open designs—including glass partitions, false ceilings, large windows, and poor fire compartmentation—can contribute to rapid fire spread due to increased oxygen supply (Faruque *et al*., 2017; Drysdale, 2011). Current fire protection measures in many buildings fail to adequately address fire hazards, making fire safety a growing concern (Kodur *et al*., 2020).

Effective fire risk management requires implementing key measures such as reliable fire protection systems, strict enforcement of building codes, increased public awareness, and the integration of advanced technology and resources (Kodur *et al*., 2020). Fire risk management is crucial for safeguarding lives and property, particularly in large-scale commercial and high-rise buildings, which are densely populated and play a vital role in economic development (Wang *et al*., 2021). However, current fire safety assessments

rely primarily on manual inspections and professional fire maintenance staff, lacking systematic approaches to evaluating fire safety management. Additionally, much of the data collected is not used for meaningful assessment (Wolski *et al*., 2000).

Fire risk assessment results can contribute to improved safety management practices (Li *et al*., 2018). According to Bryan (2004), although fires are rare occurrences, everyone working in a building must be prepared to respond swiftly in the event of a fire. Other fire safety strategies include regular inspections of electrical installations, taking necessary precautions during renovation work, implementing good housekeeping practices, and providing fire safety education and training to building occupants (Jimal *et al*., 2018). Zou *et al*. (2023) further emphasized the importance of maintaining and protecting fire-fighting equipment, regularly conducting fire safety training and awareness programs, and enforcing strict electrical regulations to prevent fire incidents in high-rise buildings. Olawoyin (2018) highlighted nanotechnology as a potential breakthrough for developing fire-resistant materials, provided it undergoes adequate testing and validation. Additionally, current fire protection measures result in an unquantified level of fire safety, highlighting the need for further research to enhance fire safety in buildings (Kodur *et al*., 2020).

Tanzania has experienced several fire outbreaks in multi-story buildings. Notable incidents include fires at Tanzania Breweries Limited in 2009, Sunset Bungalows and Whitesands Hotel in Zanzibar in 2013, and PPF Towers in 2013 (Willium, 2022). In 2020, a fire incident affected the Kimbi family in Tanga Region. The fires at Sunset Bungalows and Whitesands Hotel resulted in financial losses of over 400 million TZS and 800 million TZS, respectively (Mboma, 2022). Additionally, major commercial areas such as Kariakoo Market (Kondobole, 2023) and Bukoba Central Market (Mulisa, 2023) have faced significant fire risks.Given these challenges, this study aimed to assess the needs and options for improving fire risk management practices in high-rise buildings.

METHODOLOGY

Description of the Case Study Area

Kinondoni Municipality is one of the most predominantly planned areas, with approximately 27.19% of its land developed in a structured manner. This planned development has facilitated the construction of numerous multistory buildings, particularly those with three or more floors. These buildings accommodate a significant population, indicating a high number of people potentially at risk in the event of a fire or other emergencies.

The selection of Kinondoni as the study area was based on several factors. First, its accessibility reduces transportation costs and time, ensuring efficient data collection. Additionally, the study focused on buildings that have been in use for at least two years, as these structures are more likely to be fully occupied, making them suitable for assessing fire risk management practices. Given the density of multistory buildings in the municipality, the area faces a considerable risk of fire hazards, which could have devastating consequences on human life, economic stability, and social well-being if proper emergency preparedness and response plans are not developed and adhered to.

Kinondoni Municipality is geographically located at 6°42’19.08” S and 39°6’45.72” E (Figure 1). It is bordered to the north by Bagamoyo District and Kibaha in the Pwani Region, to the east by the Indian Ocean, to the west by Ubungo District, and to the south by Ilala District.

The municipality experiences a tropical equatorial climate, characterized by warm

and humid conditions throughout the year. The annual average temperature is approximately 29°C, with the hottest months occurring between October and March. The period from May to August has relatively moderate temperatures, averaging 25°C. The area receives an average annual rainfall of 1,300 mm, distributed across two distinct rainy seasons. Humidity levels are notably high, averaging 96% in the morning and decreasing to 67% in the after

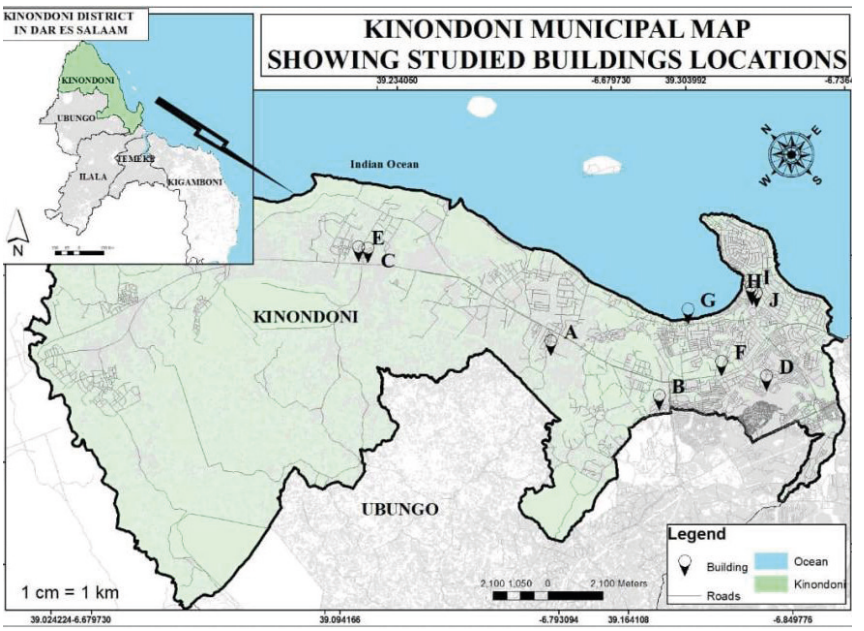

Figure 1: Location of the study areaSource: Kinondoni Municipal Profile 2018

Sampling

This study employed purposive sampling to select multistory buildings within the chosen study area. The sampling criteria considered buildings with three or more floors, particularly those with multiple uses, as these structures pose higher fire risks. Additionally, the selection process factored in the number of floors in the buildings to ensure a representative sample. Buildings that had been in use for at least two years were preferred, as they were more likely to be fully occupied, making them suitable for assessing fire risk management practices.Therefore, this study selected 10 multi-use buildings with multiple floors, classified as multistory buildings.

Data Collection

To ensure the reliability and comprehensiveness of the data, multiple data collection methods were employed, including key informant interviews, questionnaires, and physical observations guided by a checklist.

Physical Observation

This method involved a systematic collection of firsthand data through visual, auditory, and sensory observations. It provided valuable insights into the physical conditions of multistory buildings, fire risks, and existing fire management practices. The observations focused on aspects such as fire safety infrastructure, emergency exits, firefighting

equipment, and general compliance with fire safety regulations. A structured checklist was used to guide the process and ensure consistency in data collection.

Key Informant Interviews

In-depth interviews were conducted with building administrators, fire and rescue officers, and other key stakeholders who possess direct knowledge of fire safety practices in multistory buildings. This qualitative approach allowed for a deeper exploration of fire risk management practices, challenges, and potential areas for improvement. A structured interview guide was used to ensure that all relevant aspects were covered. Interviews were conducted face-to-face to facilitate real-time engagement and clarity. Approximately 12 individuals were interviewed, including building administrators, fire and rescue officers, and other key stakeholders directly involved in fire safety management within multistory buildings. Each interview lasted between 30 and 60 minutes. Participants were selected through purposive sampling, focusing on individuals with direct experience and professional responsibilities in fire safety. The selection criteria included: (1) a minimum of two years' experience in building administration or fire and rescue services; (2) current involvement in fire safety planning, inspection, or emergency response; and (3) willingness and availability to participate in a face-to-face interview.

Questionnaire Survey

A structured questionnaire was designed to collect data on fire risk management practices, awareness, and compliance levels among building occupants and service providers. The questionnaire focused on gathering information about respondents' experiences, knowledge, attitudes, and opinions regarding fire safety measures in multistory buildings. A total of 50 building users participated in the survey. Approximately 38 were occupants (including tenants and property owners), and 12 were service providers, such as building maintenance personnel, security staff, and facility managers. The surveyed participants varied in terms of age, gender, and duration of stay or service within the buildings. Occupants ranged in age from 25 to 60 years, with a mix of both residential and commercial users. The service providers had at least one year of experience in their respective roles. This range of characteristics contributed to a broader understanding of how different user groups perceive and engage with fire safety measures. This method provided quantitative data that complemented the qualitative findings from interviews and observations.

Determination of fire risk level in multistory buildings

To assess fire risk levels in multistory buildings, risk assessment analysis was conducted to identify the most hazardous fire risks and their potential consequences. The Kinney approach was employed to quantify risk levels by analyzing hazard probability, exposure frequency, and impact. The risk rating was analyzed using risk rating formula (Equation1)

Risk Rating [RR] = Probability of occurrence **X** Severity of consequence **eqn 1**

Where Severity = Frequency x impact

The Risk Rating (RR) was calculated by multiplying the assigned probability value by the corresponding severity value, resulting in a quantitative risk score.

Table 1: Probability rankings for risk assessment

Probabilities	Definition of probability
10	Risk expected to occur
6	Very well possible to occur
3	Rare
1	Improbable but possible
0.5	Conceivable
0.1	Inconceivable

Source: National Fire Protection Association (2016); Akashah *et al*. (2017)

Table 2: Frequency of exposure rankings for risk assessment

Frequency	Exposure times
10	Continuously
6	Regularly
3	Now and then
2	Sometimes
1	Rare
0.5	Very rare

Source: National Fire Protection Association (2016); Akashah *et al*. (2017)

Table 3: Impact ratings for risk assessment

Impact ratings	Extent of damage- definition of impact rate
40	Catastrophic -several deaths
15	Very serious -one death
7	Serious – disability
3	Important -injury with absence
1	Minor – injury without absence

. Source: National Fire Protection Association (2016); Akashah *et al*. (2017)

Table 4 : Risk rating description

Very high risk ≥ 400	Discontinue operation and requires immediate improvement
High risk 200-400	Direct action is required
Substantial risk 70-200	Correction required- short time action is appropriate
Possible risk 20-70	Attention required (regular monitoring)
Acceptable risk ≤20	Risk acceptable but control MUST be maintained

Source: Soltan and Aliabadi (2023)

Data Analysis

Once data was collected and processed, it was analyzed using Statistical Package for Social Sciences (SPSS) version 29 and Microsoft Excel 2021.The analysis involved the use of descriptive statistics to summarize key questionnaires, comparative analysis to identify patterns and correlations in fire risk management practices, and qualitative analysis to interpret key themes from interviews and observations. The integration of both qualitative and quantitative approaches provided a comprehensive understanding of fire risks and management strategies in multistory buildings.

RESULTS AND DISCUSSION

Characterization of potential fire hazards in multi-story buildings

In this study, the types of buildings, number of floors, and main activities conducted were presented in Table 5, detailing all activities from the first to the twentieth floor . Buildings G and F had the highest number of floors, with 13 and 20 floors, respectively. In contrast, the lowest buildings were C, E, I and H, each with only three floors. The findings indicate that certain buildings, particularly those housing apartments, oil shops, and restaurants (D, E, F, G, and H), are at a higher risk of fire hazards due to the nature of their activities (Table 5).

Table 5: Main activities in different multi-story buildings

S/N	Building name	Number of floors	Main activities
1	Building A	6 floors	Bakery, Gym, offices
2	Building B	4 floors	Stationary, offices
3	Building C	3 floors	Financial services, hardware and offices
4	Building D	11 floors	Apartment, boutique, offices and gym
5	Building E	3 floors	Oil shop, Boutique, offices, spare shop

6	Building F	20 floors	Offices and restaurant
7	Building G	13 floors	Apartment, restaurant, gym, shopping mall, gym, hotel, construction activities
8	Building H	3 floors	Hardware, pharmacy, apartment
9	Building I	3 floors	Pharmacy, clinic, butchery
10	Building J	4 floors	Financial offices, tailor shop. Spare shop and apartment

The study further revealed that all ten multistory buildings surveyed (100%) were utilized for a range of economic and social activities, as detailed in Table 5. These activities involve various processes that, if not well managed, could lead to fire emergencies. Notably, buildings A, F, and G house restaurants and bakeries, which pose a significant fire risk due to cooking activities, heat sources, and combustible materials. This aligns with findings by Akeem Wahab (2015), who identified restaurants as potential fire hazards due to the presence of flammable cooking oils, gas cylinders, and electrical equipment. Additionally, according to statistics from the United States Fire Administration (USFA, 2016), cooking-related activities are among the leading causes of fires in both residential and non-residential buildings.

Conversely, buildings B, C and I were observed to have a lower likelihood of fire outbreaks due to the nature of activities conducted within them, which do not involve high-risk fire hazards. The study also found that the buildings accommodate between 30 and 250 people per day, indicating that a significant number of individuals could be at risk in the event of a fire emergency.

A fire hazard comprises factors that can ignite a fire, increase fire severity, hinder fire safety measures, or obstruct evacuation and firefighting efforts. The presence of restaurants in multistory buildings A, F, and G presents a greater fire risk, necessitating strict fire safety measures. Given the potential threats identified, it is crucial for fire safety protocols, such as proper ventilation, fire extinguishers, and regular safety inspections, to be enforced to mitigate fire hazards in these high-risk buildings.

Potential fire multi-story buildings

This study identified various types of fire hazards, as illustrated in Figure 2. Out of the 70 questionnaires distributed, 50 were completed and returned, yielding a response rate of 71.4%. Based on the responses and follow-up interviews (N = 50), 46% (n = 23) of participants identified electrical faults as the leading cause of fire hazards in buildings. This was followed by cooking-related activities 26% (n = 13), chemical hazards 14% (n =7), smoking 10% (n = 5), and oil spillage 4% (n = 2). These findings highlight that electrical issues pose the greatest fire risk, emphasizing the need for proper wiring, regular maintenance, and adherence to electrical safety standards in buildings.

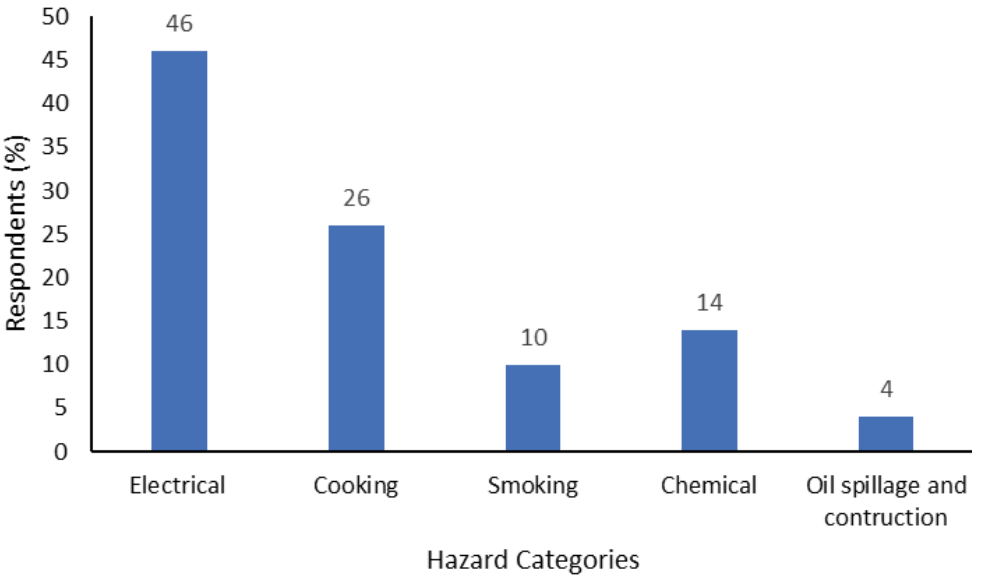

Figure 2: Potential fire hazard categories in the multi-story buildings

As shown in Figure 1, the most significant fire hazard in high-rise buildings is electrical hazards, followed by cooking hazards. These hazards can lead to fire emergencies in various ways, depending on their management and usage. This study identified that electrical hazards primarily stem from poor wiring systems, overuse of electrical outlets, and the use of generators, all of which increase the risk of fire. Meanwhile, cooking hazards are largely associated with restaurants and bakeries that rely on gas supplies for heating, which, when combined with gas leaks and poor ventilation, can lead to temperature buildup and a higher likelihood of fire emergencies.

Findings from the U.S. Fire Administration (2023) support this study's results, indicating that fire outbreaks caused by electrical hazards and cooking activities are among the most prevalent risks in buildings. Additionally, Kodur *et al*. (2020) identified other potential ignition sources, including live flames, heaters, hot surfaces, electrical malfunctions, fireworks, arson, and vandalism.

Given the severity of these hazards, it is crucial to assess the exposure levels of individuals in high-risk buildings to prioritize effective fire hazard control measures. According to Horn *et al*. (2023), fire prevention strategies should focus on minimizing exposure levels to protect those who are most vulnerable to such hazards. Implementing proper fire safety regulations, improved ventilation, regular electrical inspections, and adequate fire suppression systems can significantly reduce the risk of fire emergencies in high-rise buildings.

Fire risks based on fire hazards in multi-story buildings

As shown in Table 6, this study observed that buildings with restaurants and apartments had the highest fire risk levels. The highest fire risk scores were associated with high-temperature areas and smoke accumulation, followed by overheated cooking appliances. However, other activities, such as construction and parking, exhibited minimal fire risk levels.

These findings emphasize the importance of implementing fire safety measures, particularly in high-risk areas, to mitigate potential fire hazards in buildings.

Table 6: Risk score and rating for multistory buildings

Building activity	Risk	Score	Risk rating
Restaurants	Electric shock,	24	Possible risk
	High temperature	900	Very high risk
	Overheated cook appliances	126	Substantial risk
	Smoke risk	900	Very high risk
	Ignition of fire (over heated)	18	Acceptable risk
	Hot grease disposal	27	Possible risk
	Gas leaks	18	Acceptable risk
	Improper installations of gas	42	Possible risk
Boutique & tailoring	Electric shock	18	Acceptable risk
	Spread of fire	18	Acceptable risk
Spare & hardware shops	Chemicals e.g., paints, solvents	36	Possible risk
	Electrical hazard	36	Possible risk
	Flammable oils	18	Acceptable risk
Pharmacy & clinic	Electric shock	18	Acceptable risk
	Ignition of fire	18	Acceptable risk
Apartment	Electric shock	18	Acceptable risk
	Cooking fuel leakage	18	Acceptable risk
	Overheated cooking appliance	126	Substantial risk
Parking	Initiate/ spread of outbreak	6	Acceptable risk
	Ignition of fire	14	Acceptable risk
Construction	Initiate outbreak	3	Acceptable risk
Butcheries	Electric shock	18	Acceptable risk
Financial & consultancy offices	Electric shock	42	Possible risk
	Overloading of electrical appliances	18	Acceptable risk

Stationaries	Electric shock	42	Possible risk
	High temperature	84	Substantial risk
Casino	Electric shock	42	Possible risk

In multi-story buildings, fire risk assessment depends on the activities conducted within the buildings. The risk assessment ratings identified cooking activities as the most threatening fire hazard, categorized under both very high risk and substantial risk. This is primarily due to small kitchen spaces with limited ventilation, which contribute to high-temperature buildup in kitchens and, at times, throughout the entire restaurant area. Additionally, in apartment buildings, tenants who fail to follow kitchen safety procedures further increase the risk of fire outbreaks.

On the other hand, activities classified under acceptable risk levels are mainly those where electric shock is the primary fire hazard. These buildings have proper safety measures in place, such as adherence to electrical safety standards, correct usage of electrical appliances, and the installation of circuit breakers for emergencies. However, high power consumption from various equipment in high-rise buildings can also be linked to increased fire risk, as noted by Zou *et al*. (2023).

Fire risk management emergency preparedness level in the multistory buildings

As shown in Table 7, this study identified various fire risk management practices across different buildings. Notably, Building C, which has only three floors, lacked any specific fire risk management measures. The study found that fire extinguishers were the most common fire safety measure implemented in most buildings. Additionally, buildings with a higher number of floors, such as Buildings D, F, and G, had multiple fire risk management practices in place (Table 7).

However, the findings also revealed a low level of fire preparedness among occupants. According to interview responses, only 18% of respondents reported having an evacuation plan (Figure 3). Furthermore, 72% of respondents stated that they did not use fire extinguishers, despite their presence in many buildings. On the other hand, 54% of respondents confirmed the existence of designated assembly points for fire emergencies.

Table 7: Existing fire risk management practices per multi-story building

Buildingname	Number of floors	Existing fire risk management practices
Building A	6 floors	Fire extinguishers, fire alarms, trainings
Building B	4 floors	Fire extinguishers
Building C	3 floors	None
Building D 1	11 floors	Fire extinguishers (carbon and dry powder), smoke detectors, sprinklers system, traceable fire alarm system, fire water pumps, emergency exits and assembly point
D2	11 floors	
Building E	3 floors	Fire extinguishers fire alarms and assembly points

Building F	20 floors	Fire hose reels, fire extinguishers, automatic sprinkler systems, fire alarm system and emergency exits
Building G1	13 floors	Fire extinguishers, automatic fire sprinklers system, fire hose reels, smoke alarm system, fire blankets, warning signs, emergency exits and fire water pumps
G2	13 floors	
G3	13 floors	
G4	13 floors	
Building H	3 floors	Fire extinguishers
Building I	3 floors	Fire extinguishers
Building J	4 floors	Fire extinguishers

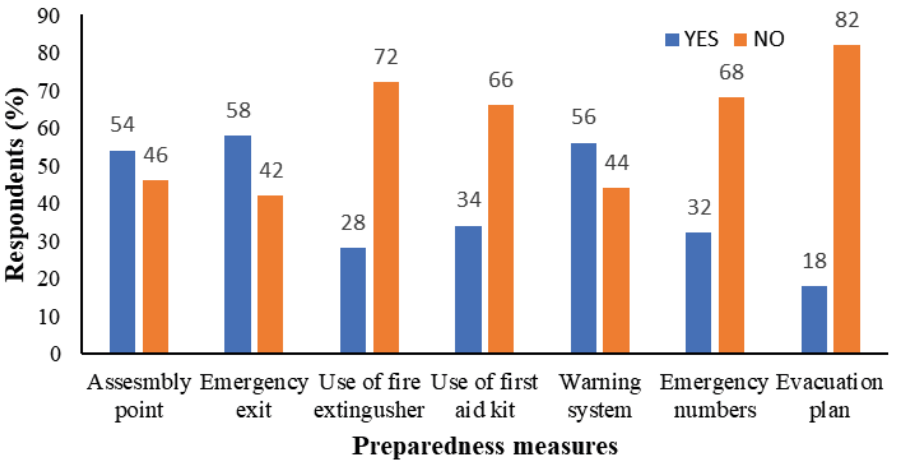

Figure 3: Measure of awareness on preparedness plan

This study revealed that most fire preparedness plans in multistory buildings are inadequate to ensure the safety of human life. For example, when respondents were asked about the existence of an evacuation plan, 80% reported that no such plan was in place. Implementing phased evacuation strategies in high-rise buildings can significantly reduce fire-related fatalities and property damage by up to 80% (Wang *et al*., 2024). Additionally, the study found that awareness of fire extinguisher use was very low. As shown in Figure 4, only 28% of respondents knew how to use a fire extinguisher. This result aligns with a study by Kikwasi (2015), which also found that only 28% of individuals were familiar with using firefighting equipment. To improve fire safety awareness, regular fire safety competitions, fire safety cultural activities, and targeted public training programs should be implemented (Zou *et al*., 2023).

Furthermore, when asked about their understanding of emergency preparedness plans, 60% of respondents stated they had no knowledge of such plans. This finding underscores the lack of effective fire risk management practices in high-rise buildings.

According to Wang *et al*. (2021), reducing fire risk incidents in high-rise buildings

requires the implementation of several key strategies:Developing detailed firefighting plans, including clear escape routes and fire hydrant locations; Conducting firefighting drills monthly or seasonally, ensuring that all relevant staff participate in hands-on training; Regularly inspecting electrical circuits and protecting combustible materials with non-flammable alternatives; Cleaning kitchen flues at least once every six months, with documented records; Carrying out annual electrical inspections and submitting reports to local fire control authorities within three working days of receiving the inspection results; Keeping evacuation passageways and emergency exits clear and regularly maintaining evacuation facilities.

These findings highlight the urgent need for comprehensive fire safety measures, awareness programs, and strict enforcement of fire preparedness protocols to enhance fire risk management in high-rise buildings.

CONCLUSION

This study highlights significant fire risks in multistory buildings, primarily due to electrical hazards and cooking activities, with poor fire preparedness worsening the situation. The findings of this study reveal a significant gap in fire safety preparedness among the surveyed buildings. Specifically, 80% of respondents confirmed the absence of formal evacuation plans in their respective buildings. Additionally, fire extinguisher awareness is low, as only 28% of respondents reported knowing how to use them.The study also revealed that high power consumption, and non-compliance with safety procedures in apartments contribute to increased fire hazards. Although fire safety equipment such as extinguishers was installed in 9 out of the 10 buildings surveyed, their effectiveness remains limited due to insufficient training and awareness among occupants. While approximately 72% of respondents indicated they knew how to use a fire extinguisher, the lack of regular training and practical drills suggests that actual preparedness in the event of a fire may still be inadequate .To mitigate these risks, the study emphasizes the need for comprehensive fire safety strategies, including implementation of detailed evacuation plans and regular fire drills to improve preparedness. Routine electrical and kitchen inspections to prevent fire hazards. Fire safety training programs to enhance awareness and proper use of firefighting equipment.Overall, fire risk management in high-rise buildings remains inadequate, requiring urgent policy enforcement, improved safety protocols, and community awareness programs to enhance fire prevention and emergency response efforts.

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