sciendo

Civil and Environmental Engineering
Vol. 18, Issue 1, 258-268, DOI: 10.2478/cee-2022-0024

FIRE EVACUATION OF ELDERLY IN HIGH-RISE RESIDENTIAL BUILDINGS IN INDIA

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Abstract

The move towards high-rise buildings in metro cities to accommodate an increasing population has various cons. In high-rise buildings, fire is a huge disaster. According to global statistics on fire accidents in high-rise buildings, elderly persons are the most vulnerable, as they are less likely to respond swiftly and evacuate than other inhabitants. To address this concerns, this research will examine the behaviors of older occupants in high-rise buildings during a fire and their perceptions of egress components. The study also inquired the elderly to come up with disaster solutions based on their knowledge and experience. Environmental-behaviour research methods have been used to detect elderly issues in high-rise residential buildings in India. In this study, it was found that their vulnerability is a big factor in their lack of knowledge and awareness about fire, as well as their limited mobility, low vision, hearing loss, insecurities, and behaviour when there is an emergency. The study also revealed that the behaviour of the elderly is different from that of the rest of the people during fire. This entails taking into account the specific needs of the elderly during fire management. This research can further assist policymakers in upgrading fire safety regulations to make them more effective and inclusive.

Keywords:

Fire safety;
High-rise buildings;
Elderly;
Evacuation;
Egress components.

1 Introduction

Urbanization has led to the scarcity of land in major metropolitan cities in India. High-rise development is one of the residential solutions to population growth. Compared with low-rise buildings, high-rise buildings give more advantages in terms of less building cost incurred by an individual, better view, and noise reduction. However, fire safety is a significant concern in high-rise buildings. Therefore, comprehensive fire safety management strategies must be implemented to protect these buildings from fire. As per the Accidental Deaths & Suicides in India (ADSI) report published by National Crime Records Bureau (NCRB) in 2020, 9329 cases of fire accidents were reported in India. Of the reported cases, around 57.6 % were from residential buildings. In recent years, there has been a significant decline in fire incidents due to improvisations in fire management. However, the number of casualties is still above 10,000 per year [1].

It is to be noted that the elderly are the primary fire victims. According to the World Health Organization, the elderly above 60 will double, and the elderly above 80 will triple [2]. Although India is regarded as the youngest country, the elderly population has increased alarmingly. The government categorises the elderly into three groups: 60 - 70-year-olds, 70 - 80-year-olds, and those over 80. While India's overall population would expand by 40 % between 2006 and 2050, people aged 60 and up will climb by 270 %. The fastest-growing segment of the elderly population is the oldest elderly group, which is the most vulnerable due to disabilities, diseases, terminal illness, and dementia [3].

In 2019, there were about 9 million fires and more than a million deaths around the world. In India, the number of reported deaths due to fire was 11,037, with more than 57 % deaths in residential buildings. Though the population of China is more than that of India, the deaths recorded in India due to fire are 2.5 times more than in China [4]. Similarly, in the United States, more than 30 % of deaths

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are reported by the elderly (age above 65 years), even though they constitute 13 % of the population. The physical, cognitive, and emotional capabilities of the human body reduce with age making it difficult for the elderly to respond and act during panic situations. Visual acuity, depth perception, loss of hearing, and sense of smell are a few common problems among the elderly, reducing their ability to respond and react. Dementia and age-related neurological issues, which are very common like Alzheimer's disease, affect memory, thinking, and conduct, rendering the elderly more vulnerable to disasters like fire.

There are three main components to fire safety: the prevention of fire, control of the spread of fire and smoke, and extinguishment of existing fires [5]. Active and passive fire prevention systems are used in fire safety. In general, active fire protection is concerned with detecting and putting out fires, whereas passive fire protection is concerned with preventing fires from spreading. There are three stages of fire evacuation, Phase 1: The fire starts and is identified; Phase 2: The residents are notified about the fire and make an evacuation decision; and Phase 3: The people safely escape from the building. In fire evacuations, these three steps are crucial [6]. The stack effect, or the rising smoke upward, is one of the most challenging fire management and evacuation challenges in high-rise buildings. As a result, it is critical to design the egress system efficiently [7]. Due to the tremendous wind velocity blowing in all directions at such a height, it is impossible to contain the fire. In one of the fire events at Avighna Heights, a 19-story high-rise residential complex in Mumbai, India, it was impossible to control the fire. The most difficult challenge for the elderly during fire evacuations is their incapacity to relocate to a location of safety or refuge [8-10]. Because the elderly are the most vulnerable, there is a need to examine their behaviour and obstacles during the mentioned phases so that essential changes in building standards can make the fire management system more efficient and inclusive.

Along with the egress component of building facilitating evacuation, the fire and rescue department plays an essential role in the efficient evacuation of high-rise buildings. Unfortunately, the lack of a snorkel or a fire ladder in most Indian cities is also a serious concern. Ironically, until 2015, the longest available ladder in India was sole with the Mumbai Fire Department, which is a Hydraulic Ladder 90 meters high adequate to evacuate individuals living in a 30-story high-rise building [11].

In India, the fire safety codes followed in buildings vary from state to state. Though the National Building code of India (NBC) 2016 provides detailed guidelines for fire safety in high-rise buildings, the fire safety regulations are state-specific. As per NBC, 2016, a building 15 meters above ground level or has more than three storeys is considered a high-rise building. High-rise buildings must get a certificate of approval from the fire department. The buildings with more than 500 sq. meters of the floor must be provided with two staircases. The staircase shall be of the enclosed type with one of the staircases on the external wall of the buildings. Residential buildings less than 60 meters in height are exempted from the provision of automatic sprinklers and fire staircases. This makes the residential buildings less than 60 meters more vulnerable to fire accidents. The guidelines also lay conditions for a refuge area of around 15 sq. Mts, above 24 meters in height. The residential buildings with balconies less than 60 meters in height are exempted from a provision of refuge area [12].

Though the fire towers are preferred in all high-rise buildings above eight storeys or 24 meters, where one required means of egress shall be through the fire tower, it is not implemented in high-rise buildings. The code also mandates the provision of a fire control room with all communication systems and facilities for receiving messages from every floor for all apartments above 30 meters. The fire control rooms can provide support to the elderly during evacuations. This is also absent in India's major high-rise residential buildings. In addition, one fire lift with an eight-person capacity (545 kg) for a floor area of 1,200 square metres should be available exclusively for firefighting personnel to contain the fire. Solid doors with at least one hour of fire resistance should be installed on lifts.

Though there are guidelines for fire safety, there are severe issues regarding implementing these guidelines. Most of the high-rise residential buildings in India violate the prescribed fire safety guidelines and standards. The state-specific building codes also lack various approaches to be implemented vigorously. Thus, there is a need to relook at the existing fire safety codes in India, which are more inclusive and as per the needs of the elderly occupants[12].

2 Human behaviour in fire evacuations

There has been a surge of research on fire evacuations since 2001 after the World Trade Centre (WTC) fire incident. However, much research has also been carried out regarding fire safety and human behaviour. It was found that there is no definitive way in which humans behave or act in

case of fire; instead, people behave in a not rational manner during such incidence [12, 13]. Actions like re-entering the building once having evacuated and trying to extinguish the fire before attempting to evacuate have also been reported. Further, people's reaction to fire is based on their familiarity with the exit route and their previous experience with fire [5, 15]. It is also seen that people tend to help each other before they start evacuating, which further delays the evacuation from the building. According to Proulx, the various factors which impact human behaviour in a fire are knowledge and awareness, education, and fire safety provisions in the building. He also argues that there is little evidence that people panic in fire situations. In contrast, other factors result in a delay in evacuation [6].

In another study, various egress components were analysed about human behaviour in high-rise buildings using evacuation models [16]. Evacuation models help study the effectiveness of egress components with erratic human behaviour and egress design. Using an evacuation model, a study analysed ventilation parameters in timber apartment buildings [17]. Many types of research were carried out in fire evacuation in high-rise buildings with specific contexts associating psychological and social behaviour. However, through the available literature on fire safety, one can say that there is a shortage of literature on elderly behaviour in high-rise residential buildings in India.

3 Research design

This research aims to understand elderly behavior and associated risks during a fire evacuation. In addition, this study seeks to identify elderly behavior decisions in fire evacuations and investigate the perception and challenges that the elderly face while evacuating the building.

A combination of qualitative and quantitative approaches has been used to conduct the survey. The survey was carried out using environmental-behaviour research methods to identify concerns of the elderly. This method will help understand complex human behaviour to produce descriptive generalizations and hypotheses based on experience. A semi-structured questionnaire was used to carry out the survey. The sample population covered elderly above the age of 60 years living in high-rise residential buildings which are not less than 24 meters. The study is limited to major Indian cities, including Mumbai, Ahmedabad, New Delhi, Bangalore, Indore, Trivandrum, and Calicut. The elderly who suffered significant diseases or were bedridden were excluded from the study.

The questionnaire for the survey was developed using Protective Action Decision Model (PADM) established by Kuligowski in 2013. As seen in Fig. 1, the important part of PADM is its description of the decision-making steps that influence protective actions taken in response to natural and technological disasters, such as perceiving information, paying attention to statements and understanding information, determining the nature of threats, personalising risks, searching for potential protective actions and taking those actions. For more than half a century, researchers have used this model to guide their investigations into hazards and disasters, and it now serves as a guide for emergency response planning [18].

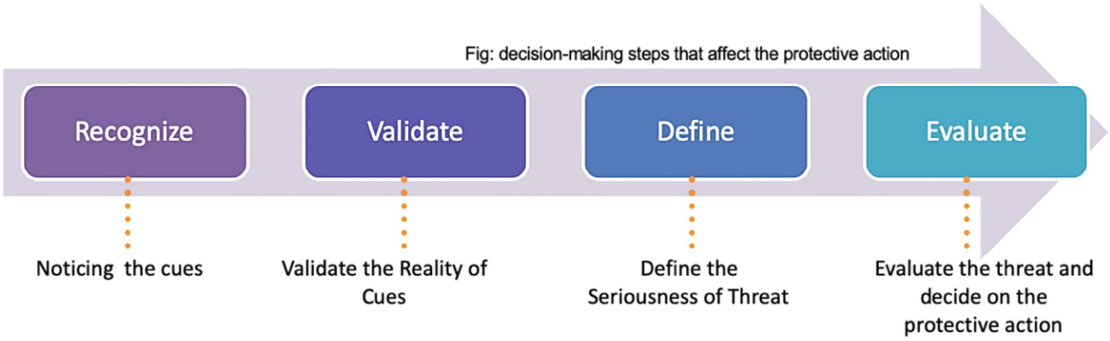


Fig. 1: Decision-making steps as per Passive Action Decision Model – PADM.

To bring more relevance to the questions considered for the survey, a pilot study was conducted with open-ended questions for the elderly who may or may not have witnessed fire incidents to refine the questions to carry out the final survey. Finally, based on the PADM model of fire evacuation, a semi-structured questionnaire was prepared to conduct the last survey. The detailed methodology adopted for the study can be seen in Fig. 2.

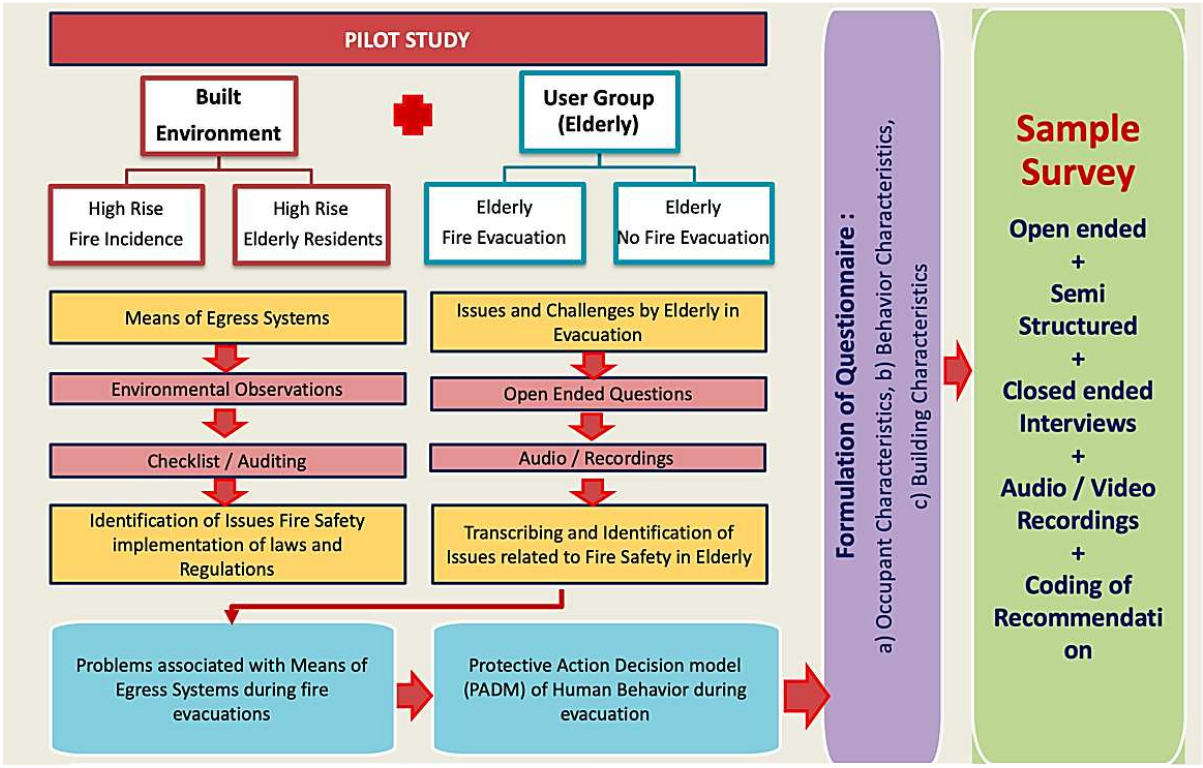


Fig. 2: Methodology adopted for survey.

The interviews were conducted in both offline and online modes. The people selected for the survey were above the age of 60 years and lived in high-rise residential buildings in major cities of India. Around 168 respondents participated in the survey. The survey was stopped when there were repetitions in the responses were seen. 150 samples were used for analysis as some of the survey was stopped in between, or some respondents left the survey in between. The sample data were taken from the elderly residing in broadly three categories of high-rise buildings, i.e. 15 m - 24 m (low high rise), 24 m - 39 m (mid high rise), and above 39 m (very high rise). The sample included 42 % in the range of 60 - 65 years, 20 % in 66-70 years, and 21 % in 71 - 75 years. Out of the total samples, 97 were males, and 53 were females. As shown in Fig. 3, the general education of the female elderly was less than males. Around 20 % of the elderly require Mobility aid like wheelchair walking sticks while moving out, and 8 % need the assistance of humans while moving out. About 47 % of the elderly suffer from Non - Mobility Issues like Blood Pressure, Asthma, Heart/Liver/Kidney/ and loss of hearing. Similarly, a significant number of elderly (36 %) also suffered from Mobility issues like Arthritis, Knee Surgeries, Difficulty in climbing, and walking/ loss of vision.

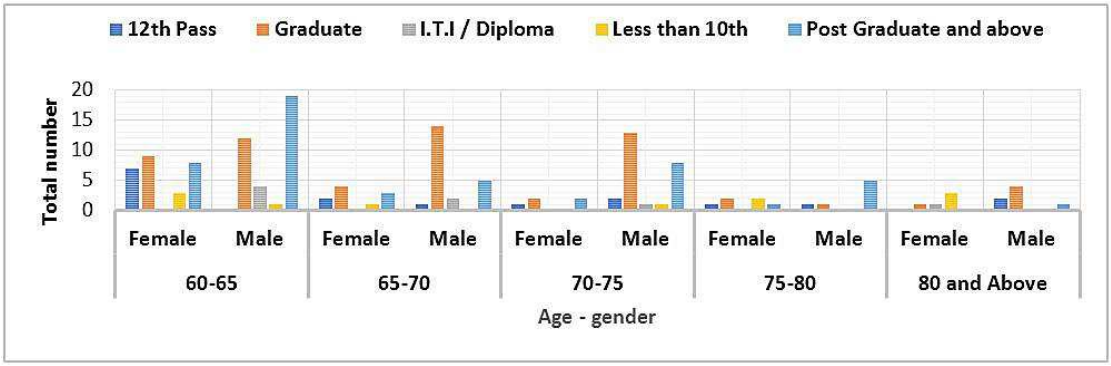


Fig. 3: Education distribution of elderly residents.

The survey participants' considerations were indifferent to whether they had been involved in fire evacuations or mock drills in high-rise buildings. The interviews were conducted from March to October 2020. The interviewers were made aware of the intent of the research, and prior consent was

taken from each respondent to complete the survey. The questionnaire was divided into three parts. The first part explores the occupant's fire safety knowledge and basic information about the fire. The second part explores the behaviour and initial reactions of the elderly during fire evacuations. Finally, the occupant's perception regarding egress components was studied in the last part of the survey. In the end, occupants were asked to suggest recommendations regarding fire safety in high-rise buildings. A digital voice recorder was used to record the interviews. All the recordings were transcribed and coded to gather results based on the content analysis technique. The collected data was imported into Microsoft-excel for qualitative data extraction and analysis. The answers were checked thoroughly to ensure no inputting errors had occurred. The coding was done under various issues and risks which elderly face during fire safety.

The results of the survey are given as graphs depicting the responses of the residents. The replies were analysed using the Relative Importance Index method as shown below:

$$\textit{Relative Importance Index}\ [\%] = \frac{5(n_5)+4\,(n_4)+3(n_3)+2(n_2)+1(n_1)}{5(n_1+n_2+n_3+n_4+n_5)} \times 100, \quad (1)$$

where n_5 = strongly agree, n_4 = agree, n_3 = neutral, n_2 = disagree and n_1 = strongly disagree. The results are presented in the subsequent section. The interviews were conducted through online audio conversations and recorded.

4 Results

The following section elaborates on the different qualitative and quantitative data analysis findings under various subheads.

4.1 Knowledge and preferences

4.1.1 Knowledge of fire evacuation and fire safety

To ensure effective evacuation, all the occupants must be well aware and informed about the fire safety provisions in the building. The elderly were asked about their previous fire experience as part of a mock drill or real-life experience. As seen in Fig. 4*,* only 25 % of the respondents had prior evacuation experience during a fire. The rest, 75 %, had no awareness about fire training (Mock Drills, Short Term Course, etc.), nor were they aware of fire safety equipment. Most of the elderly reported that they had seen fire extinguishers, fire alarms, fire panels, etc., while moving in and out of the building. Still, they were sceptical about their maintenance and its working during real fire situations. Some of the elderly also reported that though they were aware of the mock drills in the buildings, ironically, they were discouraged by concerned authorities to take part in drills considering they would be tired in the whole drill process. Many elderly reported severe issues with the readability of signages and information on a fire evacuation plan. Though the signages and data were available at a few of the buildings studied, it was observed that the visibility of the respondents. Considering India as the second most populated country with an urbanization rate pacing high in metropolitan cities, moving towards high-rise buildings is inevitable, mock drills are a significant part of fire safety management systems, and high-rise occupants not being acquainted with it shows a substantial flaw in the overall management system. This section of the study also raises the concerns that the elderly are unwilling to use the fire safety system and are also not progressively encouraged to learn about them. In Hongkong, a similar study of residents of all ages found that 68.9 % had not received any training on evacuation techniques.[19]. A study in Portugal considering 225 respondents revealed that only 35 % of occupants knew the building's evacuation plan, and the rest were unaware of any fire safety training and knowledge [20].

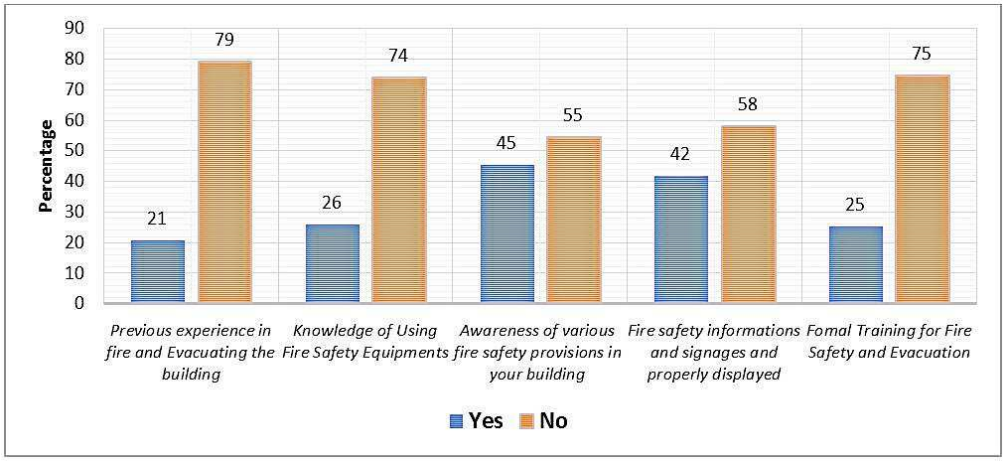


Fig. 4: Knowledge, awareness, and experience of fire safety of respondents.

4.1.2 Preferred mode of evacuation

Two significant aspects impacted the preferred mode for fire evacuation. Firstly, the floor on which the elderly resided—secondly, the health issues related to elderly occupants, as seen in Fig. 5. The elderly who lived on the topmost floors undoubtedly preferred lifts in case of fire. The rest of the elderly on lower floors believed in using a staircase as, according to their notion, lifts cannot be used in a fire. The decision to use a lift and staircase is also influenced by the physical capabilities of the elderly occupants. Many elderly on the higher floors opined taking the stairs to the terrace rather than taking the lift down on the ground floor. Though the elderly with physical mobility issues were aware of the associated risk of using the lift in fire, they preferred staircase or assisted evacuation. Due to a lack of awareness, the elderly were unsure of what should be used as a preferred evacuation mode. Different countries have different takes on whether a lift or staircase should be used during a fire. The Indian building codes favour using a staircase as a route of evacuation, although other countries take a different stance. Education level also seemed to play a significant role in people's choices for evacuating as they preferred the staircase prescribed in the Indian building code. In a similar study, considering all age groups, 444 participants from different countries, more than two-thirds suggested that they would not consider lifts for evacuation [21]. Another comparable study discovered that for occupants living above 40 floors, 50 % of inhabitants would use the lift to evacuate only [22].

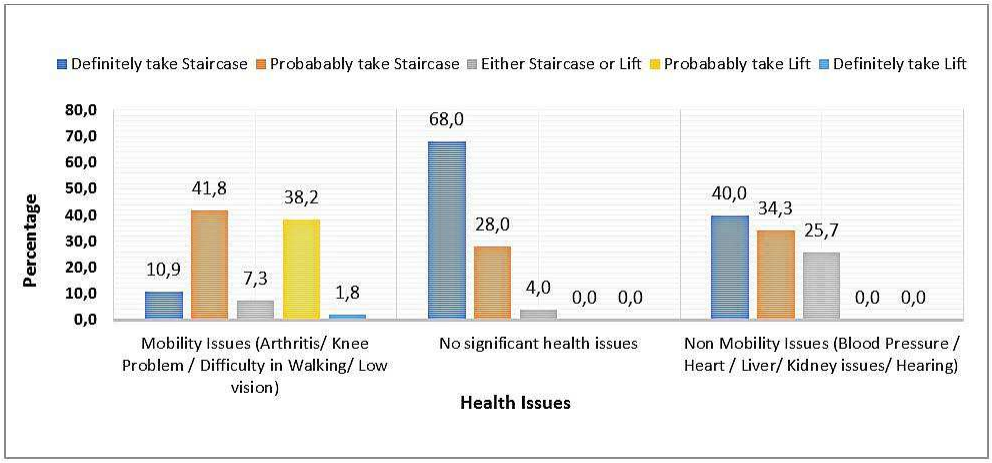


Fig. 5: Comparison of health issues *v/s* preferred mode of evacuation.

4.1.3 Initial reaction of elderly in fire

The elderly were asked about their initial reaction after seeing fire cues in this part of the study. From Fig. 6, It was found that 35 % of the elderly preferred to collect information about the fire before they decided to evacuate. 21 % of occupants said they would try to call the fire brigade or security to understand what was happening. Few participants preferred to put out the fire by themselves. Also, few said that they would collect valuables like jewellery and money before they evacuated. This shows

that the elderly do not behave as per the sequence prescribed in the fire evacuation plan and save valuables over saving their life. Their decisions are more adorned by insecurities and fear. In a similar study, considering all age groups, it was seen that more than 65 % of the occupant's initial reaction was to find out what was happening before they began to evacuate the building [20]. These results prove that the elderly are reluctant to move out of the building after seeing fire cues.

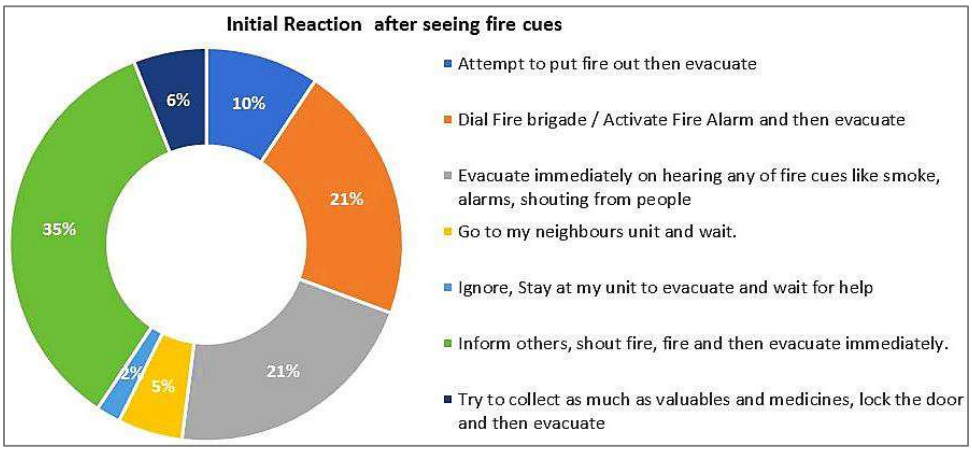


Fig. 6: Initial reaction of elderly on seeing fire cues.

4.2 Perception of elderly

In the second part of the questionnaire, an understanding of the perception of the elderly related to various egress components during a fire has been developed. First, the elderly were asked to rate whether they agree or disagree on a scale of 1 - 5 (Likert Scale) on issues related to fire safety. Then, the results were further analysed using the Relative Importance Index using the formula mentioned above. Finally, questions about staircases, lifts, handrails, exit corridors, fire safety systems, and exit signages were asked to understand the perception of the elderly about the different components.

4.2.1 Lift & Staircase

Table 1: Perception of elderly occupants for using the lift as an evacuation method.

Hazard	Relative importance index	Rank
Fear of using lift due to smoke and fire entering the lift	86.80 %	1
Waiting time is too high, which will lead to panic	86.40 %	2
No knowledge of usage of lift in fire hence avoid using it during fire	82.13 %	3
Being stuck in the lift due to power failure	80.13 %	4

The primary concern which emerged in this part of the study regarding the usage of lifts during the fire was fear of using the lift due to smoke and fire. Another primary concern reported was 'Creation of panic situation while using the lift' as seen in Table 1. As can be seen in Table 2, similar problems were noted by the elderly while using the staircase. A major issue in using the stairs was the fear of slipping and falling during evacuation. The most common concern pointed out was occupants becoming trapped in the staircase due to smoke or fire entering the lobby. It will take a long time to evacuate due to the physical inability of the occupants.

Table 2: Perception of elderly occupants for using the staircase as an evacuation method.

Hazard	Relative importance index	Rank
Fear of smoke and fire entering the staircase	90.93 %	1
Fear of slipping and falling while using stairs	73.73 %	2
Obstruction in the staircase with garbage, waste cartons, flower pots, etc.	69.73 %	3
The problem in climbing down/using the staircase is physical capabilities.	67.07 %	4
Inappropriate dimensions of the staircase will create congestion	64.40 %	5
The difficulty in holding the handrail of the staircase	62.78 %	6

4.2.2 Exit corridor

From Table 3, it is evident that the primary concern regarding the exit corridor by the elderly was uneven surface or the presence of slippery material on the exit corridor. The second primary concern was the presence of obstacles in the corridor like debris, rubbish, etc. Finally, the elderly agreed that people encroach in the corridor by keeping their shoe racks, flowerpots, cycles, and other objects, which can create hindrance during fire evacuations.

Table 3: Perception of elderly occupants for using exit corridors.

Hazard	Relative importance index	Rank
Uneven surface/ slippery material on the exit corridor.	83.87 %	1
Obstacles in the corridor like debris, rubbish	70.80 %	2
Fear of smoke entering the exit corridors and difficulty seeing	66.27 %	3
Congestion in the corridor due to inappropriate width	60.80 %	4
The problem is seen as due to very less illumination	57.73 %	5

4.2.3 Fire safety equipment

This part of the study disclosed no training or awareness sessions for using fire safety equipment and, people were sceptical about the proper functioning of the fire safety equipment. However, though they did not know how to operate the fire safety occupants, this fact did not bother them.

Table 4: Perception of elderly regarding fire safety equipment.

Hazard	Relative importance index	Rank
No training or awareness sessions for the use of fire equipment	86.80 %	1
Fire safety equipment will not work.	85.87 %	2
Non-periodic maintenance of fire safety equipment.	83.47 %	3
Fire alarms not working	83.07 %	4

4.2.4 Exit signages

From Table 5, it is seen that the many buildings did not have signages leading to exit routes. Though the buildings have fire safety equipment, they lack essential information related to fire in terms of an exit plan, do's and don't in fire, and signages in regional languages. Also, the signages in the regional languages were missing making it difficult for the less educated to respond. Most of the elderly agreed that there was the unavailability of accurate information in most of the buildings. The location and legibility of the signages were the other major concerns pointed out by the elderly. Thus, all the signages must be appropriately displayed, and the information regarding the provisions of exit routes should be communicated to all the occupants.

Table 5: Perception of elderly regarding exit signages.

Hazard	Relative importance index	Rank
Non-availability of exit information.	75.20 %	1
The problem in seeing the exit signages	74.00 %	2
The problem in reading of exit signages	64.27 %	3
The location of exit signage is not appropriate	61.73 %	4

5 Discussions

The data collected in the last part was to understand the human behaviour during fire perception related to various egress components. Further, an attempt has been made in the last part of the study to reach recommendations as prescribed by the elderly. All recordings of the interviews were transcribed and coded to identify and categorize solutions defined by the elderly. Before reaching the final list of recommendations, a team of five academicians who were sensitized about accessibility was referred. This process removed biasness and helped better interpret the

categorization of problems, issues, and solutions in the egress system. The following list was developed based on the method mentioned above:

Table 6: Categorization of issues of elderly in fire evacuations.

Sno	Identification of issues	Categorization
1.	• Difficulty in moving around and getting out of the premise, joint pain, bending of knees kidney replacement, arthritis / joint pain • Use of various mobility devices	**Support system for mobility and slow movement**
2	• Low vision and difficulty to orient at the time of evacuation; blur vision due to cataract • Strip lighting; lighting in the corridor and visible lighting during smoke	**Support for better visibility**
3	• Difficulty in perceiving fire alarm • Sceptical on its usage during emergency	**Automatic fire alarm systems**
4	• The problem in opening the doorknob and holding of handrails during evacuation. • Support along the exit routes; support system on both sides of the staircase	**Support system for dexterity**
5	• Living alone, don't have many friends. • Assistance is required while moving out for daily needs and also during evacuation.	**Assistive evacuation management**
6	• Not able to activate the fire alarm; • Training session on use of safety equipment	**Knowledge & awareness**
7	• Slipping and tripping hazard on the exit corridor, exits, and exit discharge • Rough textured tiles and materials on every corridor and staircase	**Non-slippery walking surface**
9	• Public address system with a soothing voice to reduce panic and distress in the building Two-way communication system will reduce panic and fear.	**Emergency panic buttons**
10	• Lock door, take medicines, gold, money, purse, engage in preparatory activities. • No Instruction or awareness about fire safety	**Emergency mock drills**
11	• Not aware of provisions for safe evacuation. • Installation of evacuation plan at every floor; no information about the safety plan	**Fire safety evacuation plan**
12	• Too narrow corridors; not enough ventilation and light in the escape corridors. • Less ventilation in corridors and stairs; encroachment in lobby	**Natural ventilated wide corridors**
13	• Protrusions an on the wall by fire extinguishing system. • Placement of various objects like flower pots, shoe racks, dustbithe ns on the corridor.	**Impediments in the means of egress system**
14	• Sceptical on the effectiveness of the fire extinguishers. • Never seen inspections of fire extinguisher • Most of the fire extinguishers are wither expired on cannot be used.	**Maintenance and regular inspection of safety equipment's**
15	• No readable signage; contrasting signage systems • Height of signages are too high; low visibility due to loss of vision	**Graphical & pictorial signage system**
16	• No provision of dedicated holding points on every floor. • Some mechanism of safe sky bridges connecting it to the main building. • Firebreak lobbies; dedicated provision for bridges to connect two towers.	**Holding points and refuge areas**
17.	• Provision of separate stairs / in corridor space • Separate provision of ramp; A provision of independent means of escape	**Alternate means of exit the problem**
18	• The problem in negotiating levels in corridors • Too long travel distance to reach the nearest exit	**Level difference and travel distance**
19	• Provision of intelligent technologies for evacuation like sliding chutes, evac-chair • Provision of elderly lifts which can be easily operable by elderly themselves • Provision of safety mesh in balconies; PR fire-resistance resistant cloth at every floor	**Alternate evacuation system evacuation**
20	• No signages near fire safety equipment; problem in readability of signages • Most of the signages are in English, which provides a hindrance to readability	**Location & legibility of signage system**
21	• Electrical ducts to be pressurized to avoid the spread to fire to other floors • All the significant ducts are open and may cause fire to spread very fast	**Enclosures and protection of ducts**
22	• No provision for managing fire situations and reducing panic • No provision of manager to control fire safety	**Fire control room management**
23	• Heavy usage of flammable materials in corridors and entrances • No control on what kind of materials should be installed on the corridors and entrances	**Furnishings and rating of materials**
24	• No provision to block one part of the building to other. • No division to block fire in basements also	**Compartmentalization**
25	• Difficulty in operating the fire equipment due to physical disability • No provision of small fire extinguisher to extinguish the small fires	**Portable fire extinguisher system**
26	• No protection to stop the spread of smoke apart from the buildings. • No mechanism to stop the spread of smoke	**Smoke prevention and control**

6 Conclusion

The current study emphasizes the need to broaden the domain of fire safety by acknowledging the specific needs of the elderly during a fire. The qualitative and quantitative approach used in the study has highlighted specific issues existing in the fire safety systems. The present system lacks inclusiveness as it seems to neglect the challenges and problems of the elderly, who are among the significant vulnerable population during disasters like fire. There are specific fire safety provisions in codes that are being poorly implemented. The evidence in the study proves that though regular mock drills are mandatory for high-rise buildings, it is not regularly conducted and lacks the active participation of elderly residents. As was found in the interviews, out of empathy, the instructors of the mock fire drills discourage the elderly from taking part in the mock drills considering their health and reduced physical mobility. This scenario is a significant concern as it shows that the instructors and elderly do not understand the significance of the mock fire drill, which plays a vital role in the overall fire evacuation strategy. It is also seen that most elderly occupants were not aware of how to use fire safety equipment and were also sceptical about the proper functioning of the equipment in times of need. The fire safety equipment is installed in high-rise buildings, but this does not ensure fair usage during a fire. Also, the elderly do not follow the sequence in the fire evacuation plan. The findings of the first part of the study attest to the need to sensitize the elderly towards knowledge and importance of fire safety and emphasize the need to conduct regular mock drills assuring elderly participation.

Another point is that most elderly appeared uninformed about the proper choice to be made during a fire using an elevator or a staircase. The residing floor and health were two significant aspects determining which choice the elderly would make for the escape route. According to the study's findings, educated elderly appeared to make sensible decisions during fire evacuations. Most elderly occupants would not flee immediately upon seeing the fire cues but would instead try to determine the cause and spend time telling others before beginning their evacuation. When the elderly perceive fire cues, they go into shock and lose the ability to make sound decisions. The study revealed that the elderly also fear losing things such as money, gold, and other items, causing the evacuation procedure to be delayed, making the elderly more susceptible.

The second part of the study brought forth various perceptions and notions regarding the different egress components in the high-rise buildings. The most prominent fear of the elderly during the fire was the usage of lift and staircase. Other obstacles that seemed to bother the elderly were uneven and slippery surfaces in the exit corridor and unpreparedness to use fire safety equipment.

In the last part of the study, the elderly discussed other issues and challenges they could face during a fire. They were also asked about the probable solutions from their end to improve the egress design. Most of the elderly thought that the current design of egress components, i.e., stairs and exit corridors, did not accommodate their needs. One of the significant recommendations was the provision of holding points/refuge areas on every floor so that people with mobility impairment can reach a safe place rather than attempting to evacuate the building. The majority of the elderly also feel that there should be a dedicated separate exit for vulnerable populations in the high-rise buildings. There were also suggestions to bring innovative solutions like 'sky bridges,' 'helipads,' 'sliding chutes,' 'evacuation ladder,' evac-chairs, enabling the elderly to evacuate independently without any assistance. The elderly also believe that the height of the riser and tread in the staircase design is inappropriate, posing a slipping and tripping hazard while evacuating, often due to non-compliance with building codes. Finally, improving the legibility of signages was among the significant recommendations.

Thus, this research proved a significant need to improve the design of egress components for the safe evacuation of the elderly. The survey also revealed that aging-related problems like physical, cognitive, low vision and loss of hearing play a significant role in safe evacuation. These problems should be considered while designing the evacuation routes by designers and architects. This study demonstrates the necessity of including the perspective of the elderly into the development of building codes in India. The challenges, issues, and solutions identified in the current study can aid in framing dedicated guidelines for the fire safety of the elderly. This study also calls for further research on other disabilities and their consideration in building codes for combating disasters in a better way.

Acknowledgment

We want to thank the Institute of Architecture and Planning, Nirma University, Ahmedabad, for assisting in the survey’s data collection. Also, we would like to thank Professors from the School of

Planning and Architecture, Bhopal, for their constant support in the research process as a part of the Doctoral program.

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