



FIRE EVACUATION PREPAREDNESS AMONG OLDER RESIDENTS IN AN INDEPENDENT LIVING FACILITY

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Abstract

This study examines fire evacuation preparedness among older residents in an independent living facility, with particular attention to self-reported fire safety knowledge, perceived evacuation cues, and egress-related preparedness. Using the Protective Action Decision Model (PADM) as a guiding framework, a structured survey questionnaire was administered to 137 residents aged 50 years and above at an Independent Living Complex, Temerloh, Pahang of whom 75 provided complete responses for analysis, immediately after an inaugural fire drill conducted at the facility. The questionnaire comprised four sections addressing respondent background, environmental and social cues, protective action decision-making, and fire safety knowledge. Findings indicate that respondents placed strong importance on route-related orientation, place of assembly, and alarm-related cues, while mobility-related considerations remained relevant to perceived evacuation readiness. Given that the survey relied on self-reported responses from a single site immediately after a drill, findings are interpreted as exploratory post-drill perceptions rather than definitive evidence of evacuation performance. Nonetheless, the study offers practical insight for planning and facility design, highlighting the need for clearer wayfinding signage, accessible and redundant alarm communication systems, and structured assisted-evacuation arrangements to strengthen fire preparedness among older residents in independent living settings.

Keywords: Fire safety, Independent Living, Older Residents, Evacuation, Human Behaviour

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INTRODUCTION

Fire safety for independently living older residents is critical due to their heightened vulnerability during emergencies. Physical limitations, cognitive impairments, and comorbidities can hinder swift and safe evacuation (Shah et al., 2023; Taylor et al., 2023; Halbouni et al., 2025), while age-related physiological changes increase the risk of severe injury outcomes (Akashah et al., 2017). Many older residents remain inadequately prepared for emergencies, particularly those living alone or lacking prior emergency experience (Thompson et al., 2024; Khalaf et al., 2023). Personal barriers such as mobility limitations and complex building layouts impede evacuation, whereas facilitators such as family discussion of evacuation plans improve preparedness (Thériault et al., 2024; Thompson et al., 2024). Existing evacuation strategies in senior residences may not adequately address this population's needs, reinforcing calls for tailored, inclusive planning that respects older residents' autonomy (Thériault et al., 2024).

In Malaysia, research on older residents' evacuation preparedness remains limited and largely disconnected from local housing and ageing-in-place policy discourse. Most available evidence originates from simulation studies, general evacuation theory, or institutional care contexts, offering little insight into how older residents in independent living arrangements (Quan & Ahn, 2024; Ahmad Khalid et al., 2020), an increasingly emphasised model under Malaysia's ageing-in-place and housing policy agenda, perceive and respond to real fire drill scenarios. This gap is significant given Malaysia's rapidly ageing population and growing policy interest in enabling older residents to remain in community-based, non-institutional housing. This study addresses this gap by examining post-drill fire evacuation preparedness among residents aged 50 and above (reflecting Malaysia's inclusion of the pre-elderly cohort in ageing-related planning frameworks) at Independent Living Complex, Temerloh, Pahang, guided by the Protective Action Decision Model (PADM).

LITERATURE REVIEW

Evacuation Timeline and Its Relation to Fire Safety

Evacuation timeline directly shapes emergency response effectiveness and occupant survival (Liu et al., 2026). Pre-evacuation time, comprising recognition and response time, is shaped by alarm clarity, environmental conditions, and behavioural response (Liu et al., 2026). Darkness can extend evacuation time by 28.1%, and older residents require roughly 30.4% longer than younger occupants due to age-related limitations (Kinkel et al., 2024). Alarm familiarity and prior training shorten recognition time, while social cues also influence response (Menzemer et al., 2024; Balboa et al., 2023). Reduced visibility can lower walking speed by 43.9% (Yan et al., 2024), and regular drills improve evacuation efficiency by up to 12.87% (Ding et al., 2024). Figure 1 illustrates these phases,

highlighting the critical nature of pre-evacuation time in ensuring occupant safety during a fire.

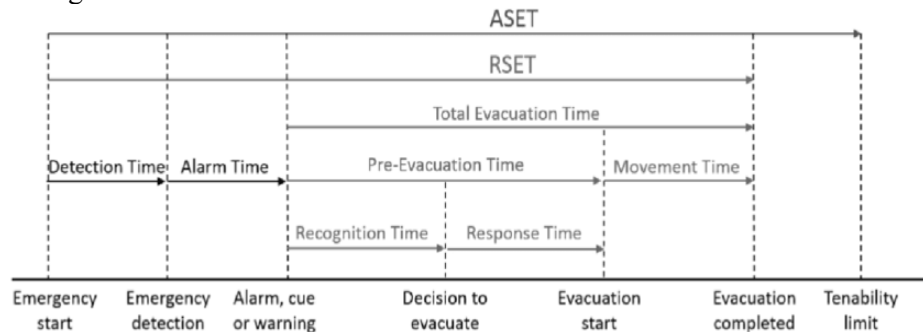


Figure 1: Evacuation timeline
 Source: Satir & Toprakli (2020)

Pre-evacuation Behaviours

Pre-evacuation behaviour encompasses the cognitive and behavioural processes that determine how individuals interpret risk and decide to evacuate (Liu et al., 2026). Fire alarms are frequently perceived as false alerts, delaying protective action, although prior training increases perceived urgency and encourages earlier evacuation (Menzemer et al., 2024). Decision-making is also influenced by environmental familiarity, social conformity, and route-selection preferences (Wang et al., 2024). Emerging technologies, including multi-sensory alarms, mobile applications, and virtual reality training, have demonstrated potential to improve evacuation preparedness (Mao et al., 2024; Yan et al., 2024; Salleh & Mohtar, 2020). These findings reinforce the importance of combining effective warning systems with regular fire drills to strengthen evacuation preparedness among older residents.

Fire Safety among Older Residents

Fire safety presents particular challenges for older residents because age-related changes in mobility, vision, hearing, cognition, and chronic health conditions can delay evacuation and increase vulnerability during emergencies (Priastana et al., 2023; Jia et al., 2023; Ahmad Khalid et al., 2020; Shah et al., 2023). Previous studies have highlighted the importance of individualised evacuation planning, accessible building design, caregiver support, and assistive technologies, such as visual and vibrating alarms, to improve preparedness and support independent evacuation (Thompson et al., 2024; Lian, 2024; Babu et al., 2023; Bhalotia et al., 2023).

Despite these advances, most existing evidence is derived from institutional or residential care settings where evacuation is largely supported by staff, such as healthcare facilities (Lim et al., 2023; Choi et al., 2019; Liu et al.,

2024). Comparatively, independent living facilities have received far less attention, even though residents are expected to rely more on their own decision-making and familiarity with evacuation routes during emergencies. This distinction is particularly relevant in Malaysia, where housing and ageing policies increasingly promote ageing-in-place by enabling older residents to remain in community-based housing rather than institutional care. However, Malaysian fire safety research has yet to generate sufficient empirical evidence to support evacuation planning within these independent living environments. Most local studies continue to emphasise evacuation simulations, building performance, or theoretical modelling (Ahmad et al., 2018; Noumeur et al., 2024; Tan et al., 2014), with limited investigation of residents' post-drill perceptions of evacuation preparedness.

Accordingly, this study addresses this gap by examining post-drill perceptions of fire evacuation preparedness among residents aged 50 years and above in an independent living facility in Temerloh, Pahang. The age threshold was adopted to capture individuals entering later adulthood, when changes in mobility, sensory function, and emergency response may begin to emerge, while reflecting Malaysia's recognition of the pre-elderly population in ageing-related planning. The findings provide context-specific evidence to inform fire safety planning, independent living facility management, and ageing-in-place housing policy in Malaysia.

RESEARCH METHODOLOGY

This study employed a quantitative cross-sectional survey design to examine post-drill fire evacuation preparedness among older residents in an independent living facility. It is important to clarify that the study measured self-reported post-drill perceptions of preparedness, evacuation cues, and egress-related awareness, rather than observed or measured actual evacuation behaviour (e.g., evacuation time, route choice, or physical performance). This distinction is central to interpreting the findings as exploratory perceptual data rather than behavioural or performance evidence.

Independent Living Complex, Temerloh, Pahang, is a five-storey residential facility comprising 100 residential units and accommodating 137 older residents. The building is equipped with four emergency staircases (two located on each side of every floor), one lift, and a designated assembly point located at the ground-floor car park near the building. Fire safety provisions include portable fire extinguishers, emergency lighting, and six loud hailer sirens used as a makeshift fire alarm system. The facility was selected because evacuation depends largely on residents' personal awareness and route familiarity rather than continuous staff-led assistance, distinguishing it from institutional care settings.

The survey was administered immediately following the facility's inaugural unannounced fire drill. The drill involved 100% of the residents, with the evacuation coordinated by the building management staff and observed by the Fire and Rescue Department of Malaysia. As described in the Methodology, the evacuation alarm was initiated using the loud hailer sirens, with residents proceeding to the designated assembly point. Questionnaires were distributed to and returned by all 137 residents present during the drill. However, 75 responses (54.7%) were sufficiently complete for inclusion in the analysis. Incomplete responses reflected the limited on-site assistance available relative to the number of residents requiring support, given the physical and sensory needs common among this population. Fire safety awareness activities, including a fire extinguisher demonstration, and a post-drill feedback session led by the Chief of the local Fire and Rescue Department Station and his team, were also conducted. Although evacuation performance data (e.g., evacuation time and observations) were recorded during the drill, these data are beyond the scope of the present study, which focuses on residents' post-drill perceptions of evacuation preparedness. The questionnaire was therefore administered immediately after the drill to capture responses while evacuation cues, route familiarity, and alarm-related awareness remained fresh.

This study adopted a total population (census) sampling approach, targeting all residents aged 50 years and above residing in the facility, rather than a sample drawn from a larger population. This age threshold is consistent with studies that recognise this age group as entering later adulthood, when age-related changes in mobility, sensory perception, and emergency response may begin to emerge, enabling the study to capture early variations in evacuation preparedness before the conventional definition of older age (≥ 60 years).

The questionnaire was developed based on the Protective Action Decision Model (PADM; Lindell, 2017), which explains how individuals perceive risk information, personalise threat, and select protective actions. PADM constructs were operationalised across four sections. Section A captured respondent background (age, gender, tenancy, floor level, prior drill experience). Section B captured environmental and social cues and threat perception (how residents were alerted, and their assumption of the situation). Section C captured protective action decision-making and implementation, including the sequence of pre-evacuation actions, the trigger for beginning evacuation, physical/mobility constraints, and a 13-item scale of perceived evacuation efficacy. Section D captured fire safety knowledge and enabling factors, including awareness of building layout, routes, and equipment, prior training received, and experience with stairs, lifts, and mobility assistance.

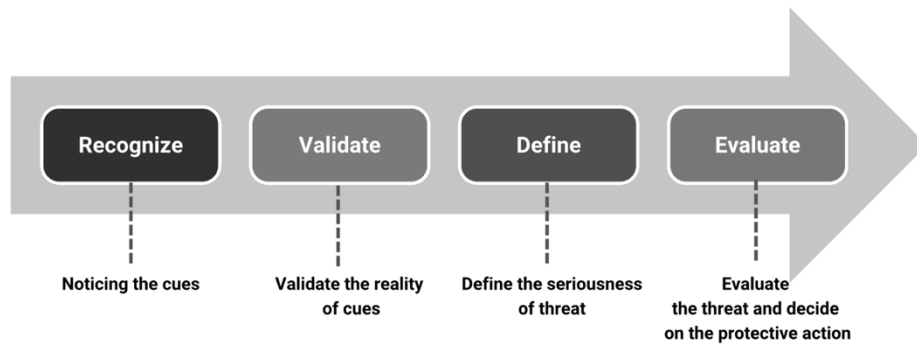


Figure 3: Decision-making stages according to the Protective Action Decision Model (PADM)
 Source: Adapted from Lindell (2017)

Internal consistency was assessed for the multi-item evacuation preparedness scale using Cronbach's alpha. The scale demonstrated good internal consistency ($\alpha = 0.873$), indicating that the items reliably measured the underlying construct of evacuation preparedness. Content validity was established through expert review to ensure the questionnaire items were relevant and appropriate for assessing fire evacuation preparedness among older residents.

Data were imported into SPSS and screened for accuracy prior to analysis. Spearman rank correlation was selected because several study variables were measured on ordinal Likert scales and were not normally distributed, making this non-parametric test appropriate for assessing the strength and direction of association between ranked variables. One-tailed significance tests ($p < 0.05$) were applied based on the directional hypotheses. The Relative Importance Index (RII) was used to rank preparedness factors by perceived importance, as it is well suited to converting ordinal survey responses into a standardised index for comparative prioritisation, calculated using the below formula, which facilitated the prioritization of key safety factors based on the residents' responses.

$$\text{Relative Importance Index (RII)} = \frac{\sum W}{A \times N}$$

Where:

- WW is the weighting given to each factor by the respondents,
- A is the highest weight (e.g., 5 for a Likert scale of 1-5),
- N is the total number of respondents.

These analyses provide insights into preparedness-related factors, evacuation perceptions, and perceived priorities among older residents, and

helped identify practical areas for improving fire safety planning and support in similar residential settings.

RESULTS AND DISCUSSION

Demographic, Preparedness and Evacuation Preferences

Based on Table 1, older residents in the higher age brackets (66–80 and 81+) and who have lived longer in the building (37–72 months) show stronger and more consistent participation in fire drills than younger and newer residents, suggesting greater familiarity with and commitment to fire safety procedures. The majority prefer emergency stairs (78.7%) and individual evacuation (69.3%), indicating a strong emphasis on autonomy and accepted stair use, while a small group rely on lifts or group evacuation, highlighting mobility constraints and the need for supportive measures such as designated helpers, evacuation chairs, or protected evacuation lifts. These patterns imply that evacuation planning should simultaneously strengthen routine drill engagement for newer residents and incorporate assisted-evacuation provisions for those with reduced mobility.

An important strength of the study is that the survey was administered immediately after an inaugural fire drill conducted at the facility. This provided a more grounded basis for respondents to reflect on evacuation cues, route familiarity, assemble procedures, and egress-related concerns than would have been possible in a purely hypothetical survey setting. In this sense, the findings reflect preparedness perceptions formed in close temporal relation to an actual evacuation exercise.

At the same time, the post-drill timing may have influenced respondents' answers. Participation in the drill could have heightened immediate awareness of fire safety issues, increased the prominence of evacuation routes and alarm cues, and shaped responses in socially desirable ways. The findings should therefore be interpreted as post-drill perceptions rather than a baseline preparedness entirely unaffected by recent intervention.

Fire Safety Knowledge

Table 1 summarises respondents' self-reported fire safety knowledge captured immediately after the drill. Most respondents (73%) reported awareness of the building's evacuation procedures, and the general alarm was overwhelmingly identified as both the primary informing cue (83.6%) and the dominant trigger for action (89%), consistent with PADM's emphasis on environmental cues as the starting point of protective decision-making (Lindell, 2017). However, only 52% assumed the cue signalled a real fire, while nearly a third either interpreted it as a scheduled drill or remained uncertain, a pattern that echoes findings elsewhere that fire alarms are frequently first read as false alerts or tests rather than genuine threats, delaying recognition (Menzemer et al., 2024). This is reinforced by the

reported first action: most respondents looked around to assess the situation before moving towards exits, mirroring the social-cue-seeking behaviour documented in prior evacuation research (Balboa et al., 2023). Together, these results suggest that while procedural awareness is reasonably strong, the recognition stage of the PADM process, distinguishing a genuine emergency from routine or ambiguous cues, remains a bottleneck, pointing to a need for alarm systems and drills that shorten this appraisal delay rather than only reinforcing route familiarity.

Table 1: Summary of Respondents' Self-Reported Fire Safety Knowledge (Post-Drill)

Indicator	Finding
Awareness of building evacuation procedures	73% aware
Medium informing need to evacuate	Fire alarm 83.6%; voice announcement 30.1%; management instruction 9.6%
Assumed nature of the evacuation cue	Real fire 52%; scheduled drill 21.7%; uncertain 11%
Main cue prompting evacuation action	General alarm 89%; management/warden instruction 25%; neighbour/friend prompt 19%
First action taken after the cue	Looked around; moved to stairs/exits; followed instructions; alerted others

Source: Author's work

Fire Cues for Evacuation

The predominance of the general alarm as the primary evacuation cue highlights the importance of clear warning systems in initiating protective action among older residents, consistent with previous studies that identify alarms as the main trigger for evacuation. However, the reliance on instructions from building management or wardens suggests that many residents seek confirmation from trusted authorities before acting, reflecting the decision-making process described in the PADM. While this may increase confidence, it could also prolong pre-evacuation time if communication is delayed. The limited influence of social cues indicates that evacuation decisions in this setting are driven more by formal warning systems than by observing others. These findings suggest that effective evacuation planning should integrate reliable alarm systems with timely staff communication, supported by visual and voice alarms, particularly for residents with hearing impairments. Regular fire drills should also reinforce prompt evacuation behaviour and reduce dependence on management instructions during emergencies.

Mobility, Correlation, and Preparedness (RII)

Spearman's rho analysis (Table 2) revealed statistically significant but weak positive correlations between physical mobility problems and fire alarm audibility ($\rho = 0.285$, $p = 0.007$), ease of movement ($\rho = 0.233$, $p = 0.022$), and

movement speed ($\rho = 0.221$, $p = 0.029$). Correlation strength was classified using Evans's (1996) guideline, in which coefficients of 0.20–0.39 denote a weak association. As the effect sizes are weak, these results are interpreted with caution: significance suggests a detectable association, though it does not confirm that mobility limitations directly influence evacuation readiness. Other factors, such as evacuation knowledge, procedural familiarity, and decision-making confidence, may also play a role and merit further examination. In terms of fire safety knowledge, most respondents were able to identify evacuation routes and alarm cues, reflecting a reasonable level of procedural awareness, while continued training may help reinforce practical readiness.

Table 2: Spearman's Rho Correlations Between Physical Mobility Problems and Evacuation-Related Factors

Variable	Spearman's rho	p-value	Interpretation
Fire alarm audibility	0.285	0.007	Significant
Ease of evacuation	0.078	0.253	Not significant
Speed of evacuation	0.04	0.368	Not significant
Ease of movement under good physical condition	0.233	0.022	Significant
Movement speed under good physical condition	0.221	0.029	Significant
Fatigue during evacuation	-0.004	0.486	Not significant
Fatigue after evacuation	0.002	0.493	Not significant
Need for assistance	0.126	0.14	Not significant
Need for mobility aids	0.171	0.071	Not significant
Confidence in evacuation decision-making	0.07	0.275	Not significant
Familiarity with evacuation procedures	0.127	0.138	Not significant
Awareness of evacuation routes	0.053	0.324	Not significant
Overall evacuation preparedness	-0.015	0.448	Not significant

Source: Author's work

Table 3 shows that respondents ranked location of assembly ($RII = 0.808$), building layout (0.800), and emergency route (0.773) highest, while fire extinguishers (0.616) and emergency assistance (0.621) ranked lowest. This pattern suggests that older residents' preparedness is anchored more in spatial and procedural awareness than in equipment operation or active help-seeking, consistent with the broader evacuation literature indicating that wayfinding confidence, rather than technical competence, drives perceived readiness among older populations (Liao & Hu, 2025; Lim et al., 2023). The comparatively low ranking of emergency assistance is notable, as it may reflect reliance on management-led instructions and public address systems during drills rather than independent decision-making, a pattern documented in studies of building-dependent evacuation behaviour among older residents (Choi et al., 2019; Lim et al., 2023). This reliance carries implications for redundancy: if verbal or centralised instructions fail during an actual emergency, residents lacking

confidence in self-directed evacuation routes may be disproportionately disadvantaged, underscoring the need for multi-modal, redundant communication systems such as visual signage, tactile cues, and haptic alerts.

Table 3: Older Residents' Knowledge of Core Factors in Fire Evacuation Preparedness

No.	Factor	RII means	Rank
1	Building layout	0.80000	2
2	Location/place of assembly	0.80800	1
3	Emergency route	0.77333	3
4	Fire alarm location	0.67467	6
5	Fire extinguishers	0.61600	9
6	Emergency assistance	0.62133	8
7	Awareness in aspects of fire safety	0.72800	5
8	Fire drills	0.75733	4
9	Written evacuation procedures	0.65867	7

Source: Author's work

Several limitations should be acknowledged. The study was limited to one independent living facility, restricting generalisability to other settings and populations. Future studies could extend this evacuation-preparedness framework to other vulnerable populations in institutional settings, such as healthcare facilities (Liu et al., 2024). Results relied on self-reported responses, reflecting perceived preparedness and stated readiness rather than directly observed evacuation performance. The survey was also administered immediately after an inaugural drill, which likely heightened awareness of cues and procedures. Findings should therefore be interpreted as exploratory post-drill perceptions rather than baseline preparedness unaffected by recent intervention.

Overall, the findings indicate that older and longer-term residents were more engaged in fire drills, most preferred autonomous stair-based evacuation, and alarms together with management instructions served as the primary evacuation cues. Mobility limitations were associated with greater emphasis on spatial orientation than on independent use of fire safety equipment. These findings suggest that evacuation planning should prioritise age-friendly wayfinding, clearly marked assembly areas, visual and auditory alarm systems, evacuation chairs, protected refuge areas, buddy systems, and staff-assisted evacuation procedures. Regular fire drills tailored to residents with different mobility needs should also be incorporated to strengthen preparedness and support safer emergency evacuation in independent living facilities.

CONCLUSION

In conclusion, this study examined post-drill perceptions of fire evacuation preparedness among older residents in an independent living facility. The

findings indicate that respondents considered route orientation, assembly-point familiarity, and alarm-related cues as the most important factors influencing perceived evacuation preparedness, while mobility-related considerations also remained relevant. As the questionnaire was administered immediately after a fire drill and relied on self-reported responses from a single facility, the findings should be interpreted as exploratory evidence of post-drill perceptions rather than direct measures of actual evacuation performance.

From a theoretical perspective, this study demonstrates the applicability of the PADM in examining post-drill perceptions of evacuation preparedness among older adults. It contributes to the limited literature on post-drill behavioural assessment within independent living facilities in the Malaysian context and provides evidence on how environmental cues and perceived mobility constraints influence evacuation decision-making.

From a planning and design perspective, the findings have practical implications for planners, housing managers, and building designers. The identified preparedness factors support the need for age-friendly evacuation planning through intuitive wayfinding, clearly designated assembly areas, accessible escape routes, effective visual and auditory alarm systems, and evacuation strategies that accommodate residents with mobility limitations. The recommendations presented in the Results and Discussion section further emphasise the importance of regular fire drills, staff-assisted evacuation procedures, buddy systems, and inclusive emergency management practices. Collectively, these findings provide practical evidence to inform the design, management, and fire safety planning of independent living facilities, thereby supporting safer and more resilient environments for ageing populations.

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Consent to Participate

This study was conducted with the informed consent of all participants. Prior to data collection, participants were provided with detailed information about the study's purpose, procedures, and their rights, including the assurance of confidentiality and voluntary participation. Written consent was obtained from all participants, and the study adhered to ethical guidelines throughout the research process.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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