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A study of staff pre-evacuation behaviors in a Malaysian hotel

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Abstract

Simulating fire and evacuation scenarios is crucial for engineers to assess building safety during fire incidents. Accurate simulations require data on occupants' behaviors, particularly during the pre-evacuation phase as these decisions significantly impact evacuation duration. Gathering comprehensive data from diverse regions while considering cultural and regional variations is necessary to understand how occupants' behavior is influenced. Thus, this study focuses on examining the behavior of Malaysian hotel staff during unannounced fire drill to gain insights into factors affecting their behavior during pre-evacuation stage, such as fire experience, fire alarm, drill participation, fire training, and awareness. The study categorizes the actions performed by the hotel staff into sequences and analyses them based on influencing factors. The findings indicate that instead of immediately evacuating in response to emergency notification, the hotel staff engage in various actions. Most staff members initially investigate or ignore the emergency, resulting in longer pre-evacuation times. Moreover, the results suggest that previous drill participation and high awareness levels contribute to shorter pre-evacuation times. Conversely, previous fire experience, fire training, and fire alarm familiarity have no effect on pre-evacuation time.

KEYWORDS
building evacuation, evacuation drill, human behavior, influencing factors

1 | INTRODUCTION

Building fires may cause a significant number of injuries and fatalities due to the large number of people occupying them.[1] Engineers often employ performance-based fire safety design (PBD) evaluations to determine how well intricate or unconventional building designs protect occupants. They use various methods to estimate evacuation times, including basic arithmetic and sophisticated agent-based simulation models. During these assessments, they compare the fire modelling results with estimated evacuation times for specific sections or the entire building to determine if occupants have enough time to evacuate safely.[2,3] Two critical parameters to identify the evacuation process are the Available Safe Escape Time (ASET) and the Required Safe Escape Time (RSET). As such, if the required time exceeds the available time, evacuees cannot safely escape. For a model to generate accurate representations of a simulation process, it must be capable of producing decisions made at three broad levels. The first level involves modelling the primary decisions made before the movement initiation. The most critical aspect of this level is determining the timing prior to the movement. It has been referred to in the literature as pre-evacuation or premovement time.[4] The pre-evacuation time starts when an occupant or group of occupants receive the fire notification and ends when they engage in purposive evacuation movement towards safety within or outside the building.[5] There is no typical quantified duration of pre-evacuation time, and it could range from seconds to many minutes. In fact, the pre-evacuation time depends on several behavioral actions; for instance, when occupants receive a fire warning, it is common for them to gather information to understand what is going on.[6–8] Despite being confident in identifying the threat, occupants engage in extra actions and try to verify and evaluate the potential risks by communicating with others. After investigating the incident, instead of evacuating, individuals perform actions such as shutting down equipment, gathering their personal belongings, and assisting those who may need help. Additionally, pre-evacuation times will depend on several other factors, which may include the level of fire training, whether the individual is awake, experience with previous real-life fire incidents, the type of alarm system present and its susceptibility to false activation, and the occupants' self-confidence.[3–10] Collecting data on various elements of occupants' behavior, such as pre-evacuation time is necessary to develop evacuation simulation models to assist users in identifying sensible input parameters.[11–13] Such data can be collected through questionnaire studies, direct interviews with fire survivors, and evacuation drills.[14] Furthermore, evacuation data can also be used to validate the accuracy of existing evacuation models.[15,16] Several studies present evacuation data from different types of occupancies and buildings such as cinemas,[17,18] shops,[19–21] library buildings,[3,7,22] high-rise buildings,[1,23,24] and hotels.[25–27] Different evacuation databases have been proposed for users of egress simulation tools.[11–13] For instance, Lovreglio et al.[13] addressed the challenges of identifying and employing pre-evacuation data in evacuation modelling and fire safety engineering, by providing a recent database that presents an expanded collection of pre-evacuation times collected from 9 fire incidents and 103 evacuation drills in 16 countries, grouped by the structures' occupancy type. In addition, they highlighted the need for new data for specific occupancies, and non-Western countries. A survey of the literature concludes that most of the available pre-evacuation data were collected in developed or high-income countries.[28] In contrast, more than 95% of fire fatalities and fire-related injuries occurred in low- and middle-income countries, where fire fatality rates are nearly six times higher.[29] The extant literature indicates that there is a lack of comprehensive studies from various regions of the world, including Southeast Asia. While there may be few exceptions, the available studies on this topic remain limited in terms of both scope and number. It is important to acknowledge that economic, demographic, and cultural variations may result in different evacuation patterns.[30] Moreover, cultural differences could influence occupants' behavior and may vary from one country to another as each country has its own building occupants' characteristics. Several previous studies have emphasized the significant influence of culture on evacuation timing, particularly during the pre-evacuation stage. This research question has driven various research projects, with one of the most renowned studies conducted by Galea et al.[31] These variations emphasize an urgent necessity for collecting fire evacuation data from diverse global regions. This paper contributes to the advancement of knowledge regarding the influencing factors on hotel occupants' behavior during the pre-evacuation time. This is achieved in this work by analyzing the behavior of Malaysian hotel staff during an unannounced fire drill. Identifying different behavioral sequences, and analyzing the impact of several factors on the behavioral sequences and pre-evacuation time. This study also provides new findings which will allow the comparison of a new dataset from a country where evacuation studies are rare. Hence, the results would contribute into developing new customized dataset for fire engineers in Malaysia.

2 | BACKGROUND

Pre-evacuation time is a critical aspect of fire safety engineering as it provides crucial information on the time available for occupants to evacuate the building in the event of fire.[32] Efforts have been made to document pre-evacuation times in various settings. However, the data available are inconsistent between building types. For instance, a variety of data collected from announced or unannounced fire evacuation drills in office buildings and apartment complexes are available for use by fire engineers.[13] In contrast, data from other building types, such as hospitals, library buildings, and hotels is not as exhaustive. As such, there is still a need to acquire an understanding of the available data on pre-evacuation time in hotels, alongside the various types of pre-evacuation behaviors exhibited and the factors that influence their performance in hotel buildings.

2.1 | Pre-evacuation times

Incidents analysis has demonstrated that delayed evacuation is strongly associated with a greater number of fire fatalities and injuries, especially in residential buildings and hotels.[33] Several studies[34–37] revealed that the time required to initiate evacuation (pre-evacuation time) is a critical factor that affects the overall escape time more significantly than the time needed to reach a safe location (movement time). Pre-evacuation times can be quantified for various building types using data from both evacuation drills and real emergency situations.[13] For instance, in a study by Bryan,[6] the behavior of 554 guests during the MGM Grand Hotel fire in the United States was examined. The findings revealed that occupants spent varying durations in the pre-evacuation stage, ranging from less than 5–270 min. The study emphasized that the success of the initial evacuation depended on factors such as timing, immediate ability to leave, and location within the building. Another study by Kobes et al.[32] involved unannounced fire drills in both real and virtual hotel environments, evaluating 153 tests across three scenarios. Data were collected through cameras, online and post-test questionnaires, and face-to-face interviews. The average pre-evacuation time across scenarios was 103 s, with a range of 28–878 s. Notably, participants in the real hotel were asleep when the alarm sounded, resulting in longer reaction times compared with participants in the virtual environment. While, in the study by Mossberg et al.,[38] evacuation data were collected from occupants of a high-rise hotel in Sweden using eye-tracking glasses. Participants took part in three evacuation scenarios, where pre-evacuation ranging from 10 to 725 s for awake participants without luggage. Arias et al.[39] conducted similar experiments in Stockholm, Sweden, using Virtual Reality (VR) to simulate evacuation scenarios. Pre-evacuation time analysis showed similarities between physical and VR experiments, suggesting VR's potential for studying human behavior in fire. However, differences in participants' perception of the virtual environment indicate the need for further research to minimize disparities. Lovreglio et al.[13] utilized the mean and standard deviation of the pre-evacuation time from previous studies to propose four evacuation time distributions for hotels. Pre-evacuation averages and standard deviations played a fundamental role in facilitating comparisons between different studies. These statistics are important when presenting evacuation studies results as demonstrated in previous research.[11–13] Regardless of the importance, these two statistics do not provide enough information to identify which distribution the pre-evacuation data is from. However, several attempts have been made to investigate the pre-evacuation stage for hotel occupants using different approaches that span both engineering and explanatory perspectives. In fact, in pre-evacuation studies, explanatory and engineering perspectives provide different but complementary insights. Explanatory digs into the "why," investigating motivations and decision-making through surveys and observations, seeking to understand the behaviors behind the delays, while engineering focuses more on the "how," by analyzing measurable components like movement speed and all behaviors that do not bring the individual closer to the exit. Fire safety engineers have the additional objective of verifying whether safety components (in a broad sense) meet satisfactory levels, and focusing on safety adequacy by asking "is it enough?". As such, pre-evacuation time as a holistic concept is useful for initial planning, while it overlooks the diverse stages and individual differences present in real evacuations, from information processing and social interaction to gathering belongings. The analysis of these factors can help engineers move beyond limitations and design more dynamic and effective evacuation plans that reflect the true complexities of human behavior and its influencing factors in emergencies.

2.2 | Pre-evacuation behavior and influencing factors

In the 1970s, the role of human behavior in fire events became a focal point for researchers, leading to extensive research in fire safety. Wood's[40] study in the United Kingdom on human behavior during house fires, and Bryan's[41] study of residential fire incidents in the United States, both revealed the varied behaviors performed by occupants during fires, including attempts to extinguish the fire, gathering personal belongings, and walking through smoke when evacuating. Nilsson et al.[42] highlighted the impact of social influence during the pre-evacuation stage, where individuals may be influenced by others to follow a particular exit path or may be inhibited by the inactivity of others. Moreover, in the study of 83 evacuation trials in a hotel, Kobes et al.[33] found that smoke, exit signals, and familiarity with the building are significant influencing factors on occupants' behavior. While Liu et al.[43] utilized Interpretive Structure Modelling (ISM) approach to analyze several factors that influence occupants' behavior during the pre-evacuation stage, identifying age, gender, and education level as key factors. Therefore, pre-evacuation behavior, refers to the actions taken by individuals during the pre-evacuation stage, including decision-making, response to emergency alerts and instructions, movement within the environment, and interactions with others.[33] These factors influence how people react to fire, that is, which path in the behavior sequence is followed. Figure 1 illustrates possible sequences of human behavior in fire emergency situations as proposed by Canter et al.[44] This conceptual model has been fundamental over the years to explain how evacuees behave in the early stage of fire evacuation for different types of buildings.[45,46]

Despite that the behavioral sequence concept covers a wide range of aspects, including risk perception, urgency, cognitive, and social factors, Figure 2 proposes an expansion of the behavioral sequence model by Canter et al.[44] as it allows the selection of more actions, and it is iterative as it allows potential multiple actions leading to a variety of behavioral actions that define the behavioral sequence until the evacuee decides to move toward a safe space.

These actions are based on individuals' perception of the situation, their intention to act, and the considerations involved before these actions are carried out. In essence, behavioral actions are not random; rather, they are influenced by various factors. One of the factors observed in the literature is that people who have experienced a fire before had different behavior during evacuation compared with the ones with no prior experience. Suggesting that people may interpret the cues and information they receive during fire emergency based on their previous experiences.[47–49] For instance, if an individual has previously encountered fire alarms that turned out to be false alarms, they may be less likely to take the alarms seriously in the real situation. Conversely, if an individual has experienced a real fire before, they may take the alarms more seriously and evacuate more promptly.[50] In some cases, individuals may lack awareness of safety precautions, further increasing their dependence on the building's emergency response system. Pauls et al.[51] stated that the level of awareness among building occupants can significantly influence their decision-making process during emergency situations. If occupants have poor situation awareness, they are more likely to respond inadequately or make incorrect decisions during emergencies. Further suggestions have been made for a need to enhance staff fire emergency training in hospitality buildings. These trainings would help to reduce the time taken to identify fire cues and recognize fire situations by training staff to respond to the alarm as if a real fire has occurred. This would improve coping behaviors during emergency situations by instructing staff to utilize all available fire prevention tools.[44] Ultimately, implementing fire drills along with effective fire training would increase preparedness and safety during emergencies. Drills serve as a simulation of emergency evacuations in buildings. Like any model,

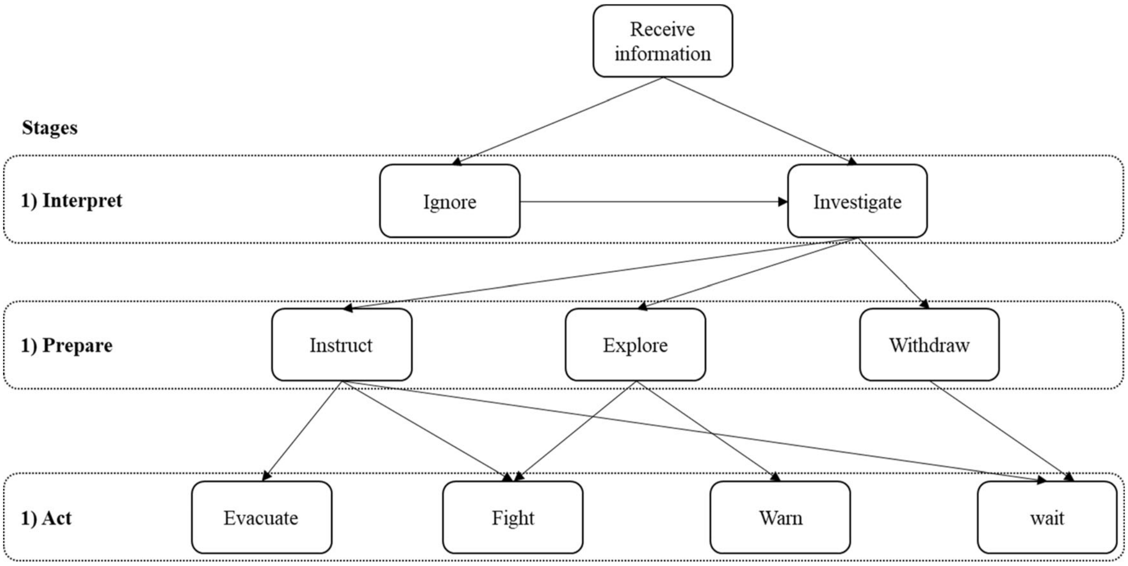

FIGURE 1 Possible sequences of human behavior in fire emergency situations.[44]

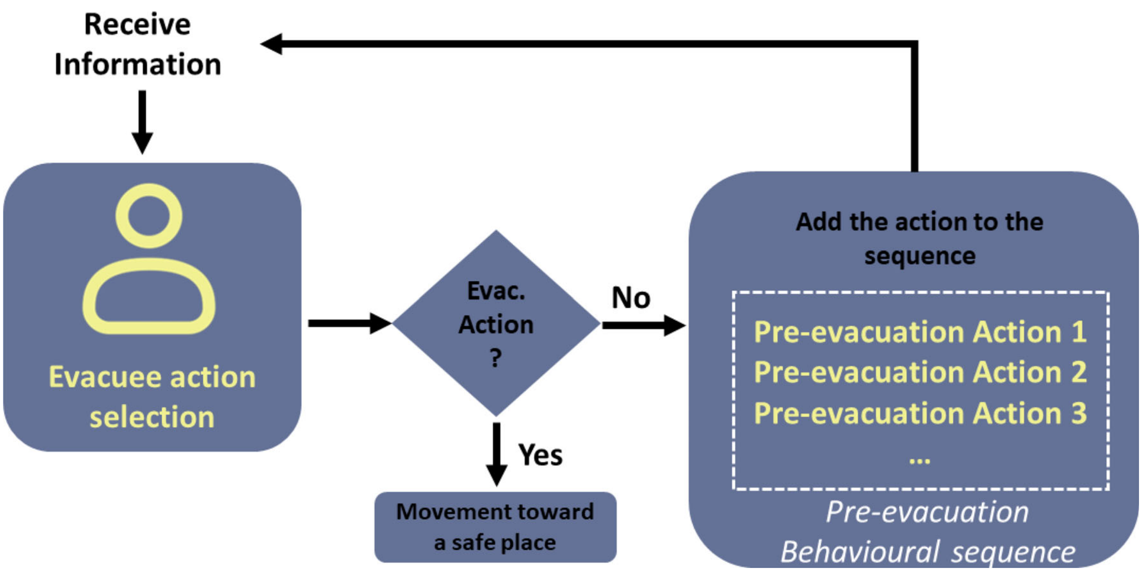

FIGURE 2 Expanded behavioral pre-evacuation sequence model in fire emergency.

drills involve simplifications, and their effectiveness depends on the nature and extent of these simplifications. The ideal scenario for a drill involves the presence of a typical occupant population, safety staff, and procedures that would be expected during real incident. This enhances the similarity between the drill and real-life situations, making it a valuable aspect of the egress drill model. By involving actual members of the target population in their familiar environment, the drill can better represent the conditions that might be encountered by a specific group of evacuees during real emergency.[48] Hospitality buildings aim to provide a relaxed and comfortable environment. This can lead guests to become less alert and more reliant on the staff as they are expected to be well trained and possess a thorough understanding of safety protocols inside the hotel. While previous studies have explored the behavior of hotel guests, there is a lack of documentation and quantification specifically regarding the pre-evacuation behavior of hotel staff. Most existing case studies have predominantly focused on hotel guests, leaving a gap regarding this specific aspect. Thus, it is crucial to understand the behavior of this category of occupants during fire emergencies. Given the unpredictable nature of fire events, conducting unannounced fire drills can serve as a valuable tool for observing staff behavior in a controlled yet realistic environment that closely simulates actual fire scenarios.

3 | METHODS

This part of the study provides information about the methodology used in this paper, starting with the characteristics of the building and occupants where the drill was carried out and the pre-evacuation data was collected (Section 3.1), the drill settings (Section 3.2), the questionnaire design and data collection (Section 3.3), and finally data analysis (Section 3.4).

3.1 | Building and occupants

The study took place in a resort located along the coastal stretch of Port Dickson district in the state of Negeri Sembilan, West Malaysia. The resort opening was in 2009 with a total of 264 rooms, divided between two separated structures, the main tower (hotel), and chalets built over the water (Figure 3).

The unannounced fire drill was carried out in the main tower, which is a multistory building that stands tall with eleven floors, including the ground floor and ten above it. Vertical access is facilitated by two elevators and multiple staircases. The ground floor [C] houses the lobby, Coffee House, and Bar Lounge. Administrative offices are located on the first floor and inaccessible to the public, while the second floor features a ballroom and meeting room. The third floor includes restaurant, spa, game room, and Karaoke room. Parking [A] is available on the fourth, fifth, and sixth floors as shown in Figure 4. Guest units with a size of 56/57/65.5 square meters, each equipped with a private pool, are situated on the seventh, eighth, and nineth floors, with fifteen units per floor [B]. The top level is a terrace.

The building units and corridors are equipped with ceiling fire sprinklers. Each floor has a fire alarm system installed in the corridors with ring-bell alarms that can be activated automatically or manually. Additionally, a sound system, used for playing music and making announcements is used to broadcasts prerecorded messages during fire emergencies. Furthermore, to comply with the Malaysian Department of Occupational Safety and Health (DOSH), a fire drill must be carried out in the hotel at least once, preferably, and not limited to twice a year. After lifting the restrictions imposed on hotels due to the COVID-19 pandemic, the main tower was not open to guests

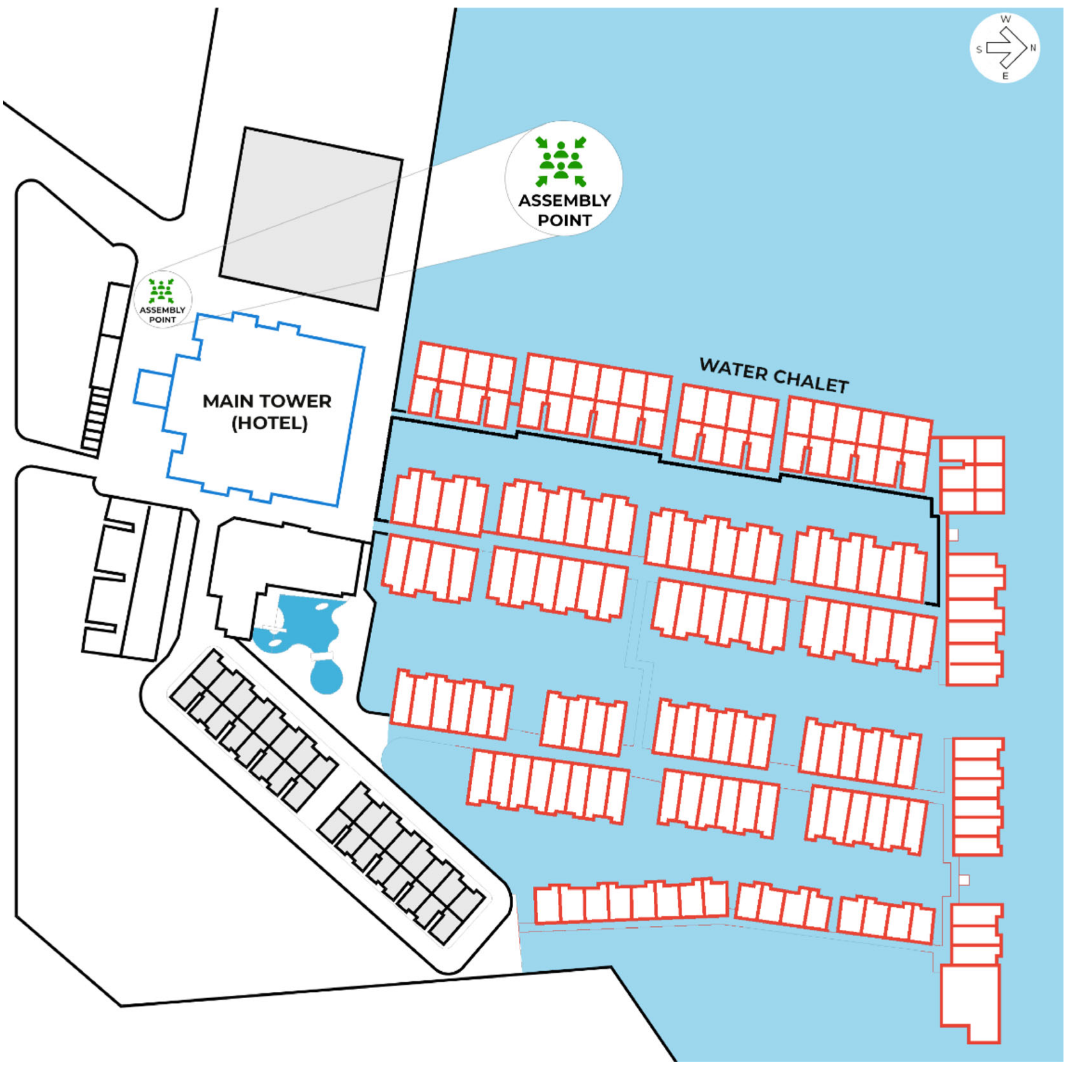

FIGURE 3 Location of the main tower inside the resort (In blue outline).

FIGURE 4 Floor plans of the Main tower (hotel building). (A) Car park plan (*floor 4*, *5*, *6*). (B) Units floor plan (*floor 7*, *8*, *9*). (C) Ground floor plan.

yet; only water chalets were fully operational. The number of staff (age group 18–65 years) on duty depends on shift time and activities within the building. Usually, the highest number of staff is found during the day shift.

3.2 | Drill settings

The fire drill took place in October 2021, on a Wednesday during regular business hours at around 10 am. The drill exclusively involved staff from the main tower (hotel), with no participation of guests or staff members from other buildings of the resort. The drill was led by the resort's Emergency Response Team (ERT) in collaboration with members from the Fire and Rescue Department of Malaysia (FRDM). However, only the ERT and FRDM members were informed about the fire drill, while the hotel staff remained unaware. At the time of the drill, the staff members were located on different floors within the building. As the fire alarm was manually activated inside the building, the voice notification system immediately delivered instructions in the Malay language, emphasizing that the situation is not a drill and urging an immediate evacuation of the premises.

Throughout the evacuation process, the ERT refrained from interfering, opting to wait for the staff members at the designated assembly point to avoid any influence on the staff behavior and performance during evacuation. To ensure individual responses and prevent information sharing, questionnaires were distributed to the staff members immediately after they exited the building. This step aimed to gather feedback from each individual separately. Following the completion of answering the questionnaires, the hotel staff participated in a theoretical session on fire safety and the significance of emergency evacuations.

3.3 | Questionnaire design and data collection

The study adopted a cross-sectional questionnaire design. The questionnaire used in this study was inspired by the one published by Kuligowski et al (Appendix S1).[52] It was divided into two sections. The first section has multiple-choice questions to obtain information on occupants' socio-demographics, previous fire experience, trainings, and fire drill participation. While questions in the second section were related to

- The staff location after hearing the alarm
- Their initial thought, their feeling
- Whether they received any instructions
- The time spent before starting the evacuation
- What actions they performed when they got alerted.

When answering regarding the action taken during the pre-evacuation time, the respondents were provided with a list of actions that can be performed during that stage. Helping guests to evacuate was not on the list because no guests were inside the building as mentioned in section (3.1). Respondents were asked to number their actions from what they did first (1) to what they did next and continue to number all actions performed before they started moving to the stairwell/exit. It is worth noting that out of the total 80 respondents, only 62 provided proper rankings for their actions. The remaining respondents either skipped the ranking question or ranked all the actions with the same number. As a result, these incomplete rankings were excluded from the analysis of sequences. The staff actions during the pre-evacuation time were categorized and simplified into a less cumbersome list of actions that could be quantified for everyone.

TABLE 1 List of grouped and simplified actions.

Actions	Grouped actions	Description
Standby	- Waited for instructions - Continued prior activity - Saved my work	To stay in the same spot after the alarm, ignore the warning, continue prior activity or waiting for instructions.
Investigate	- Wondered around - Investigated the fire event - Discussed with coworkers - Looked for information	To evaluate the validity and criticality of the emergency by collecting information about the situation.
Collect belongings	- Collected belongings - Got emergency supplies - Got valuables	To gather personal belongings such as necessities, valuables, and important documents before evacuating.
Follow instructions	- Followed instructions	To follow the instructions provided by the voice notification system and evacuate the building immediately.

Since it is nearly difficult to analyze each action separately, the 12 actions performed by the staff were grouped into four main actions, as listed in Table 1. Kuligowski and Hoskins[52] suggested that actions such as gathering valuables, gathering coats/shoes, and getting dressed fall under the same category. Furthermore, wandering around, investigating the fire event, discussing with coworkers, and looking for information were all grouped under investigation since the investigation action is the time to search for the fire information within an area that the occupant is already familiar with.[9] As for the standby action, waiting or ignoring the alarm means that the occupant did not make any purposeful action towards evacuation. Thus, they waited for instructions, continued prior activity, or saved their work, putting the individual in a standby situation.[53,54] Follow instructions is the action when the occupants decide to follow the instructions from the voice notification system to leave the building immediately. The accurate pre-evacuation time of occupants in a real fire is nearly difficult to predict.[55] Thus, the respondents were asked to estimate the time it took them to perform all actions right after evacuating the building; then, the pre-evacuation time was categorized into four classes: ⩽1 min, 1 to 3 min, 3 to 5 min, and ⩾5 min. It is important to acknowledge that self-reports may be susceptible to recall bias or social desirability bias. To mitigate these biases, respondents were given the questionnaire immediately upon exiting the building, ensuring no interaction between the staff occurred. Additionally, participants were explicitly informed that the questionnaire was not an audit or evaluation of their performance—there are no right or wrong answers. They were assured of the anonymity of their responses, which would not be shared with hotel management. The sample for this study is a convenience sample, containing data from only those staff members who participated in the fire drill. The respondents' participation was voluntary, and no personal details (e.g., name, personal address) were collected. Before answering the questions, a total of 91 respondents from different departments, such as management and finance, food and beverage, housekeeping, maintenance, human resources, and IT participated in the unannounced fire drill that was conducted to simulate a more realistic fire emergency environment. No interns, visitors, or guests participated in the study or the fire drill. Respondents who did not participate in the fire drill or did not answer all the questions were eliminated from the arranged data, resulted in 80 valid responses. The Malay language is respondents' mother tongue, so all the questions were in both languages, English and Malay.

3.4 | Data analysis

This study investigates the influencing factors on the behavior of a Malaysian hotel staff during the pre-evacuation stage. Survey responses were entered into Python (version 3.11), along with pandas[56] and matplotlib.pyplot[57] libraries for data analysis. This statistical tool was employed to compute descriptive statistics, assess correlations, and perform regression analyses on the collected data. The variables found to be influential in the literature (Section 2.2) were applied in correlation coefficient analysis. A contingency table was used to calculate the correlation coefficient between factors with 95% confidence intervals. Categorical variables were tested for statistical significance using Chi-square, with the null hypothesis assuming no relationship exists between the variables. Cramer's V coefficient was selected to examine the correlation between variables of interest that have two or more unique values per category ($R > 2$ and $C > 2$).[58] The purpose of the analysis is to examine the relationship between each influencing factor and its association with other influencing factors, socio-demographic characteristics, and the initial thoughts of the hotel staff when they first received the emergency notification. While correlation does not imply causation, it can still provide insights into potential relationships between variables, how different variables are related, and how they might collectively influence outcomes. In this context, the dependent variables chosen for analysis are the hotel staff's awareness of the evacuation procedure, familiarity with the fire alarm, drill participation, fire training, and experience with previous fire. While the socio-demographic characteristics of the hotel staff (such as gender, age, education level, joining year), their initial thoughts, and influencing factors that are not dependent are considered as independent variables. The analysis also focused on the pre-evacuation duration and the actions performed by the hotel staff. These actions were categorized into 30 sequences; each sequence represents a unique set of actions, varying in both number and order. The primary objective in this part of the analysis is to compare the time taken by the staff to complete each sequence across different groups based on the various influencing factors and to identify any significant differences in the duration of sequences. Combining the actions performed and their corresponding time that the staff estimated makes it challenging to determine the relative significance of each influencing factor. To address this issue and account for the potential nonlinear relationship between the influencing factors and the outcome of interest, the time variables were collapsed into four categories, $\leqslant$1 min, 1 to 3 min, 3 to 5 min, and $\geqslant$5 min. This collapsing transformed the ordered variable into a nominal variable, allowing for larger sample sizes in each category and more statistical power for the application of multinomial regression.[59,60] The dependent variable, pre-evacuation time, was analyzed in relation to various predictor variables (influencing factors), including previous experience with fire, familiarity with fire alarm, participation in drills, fire training, and awareness, to determine the relationships and relative impact of these predictors on pre-evacuation time. To assess the presence of multicollinearity, variance inflation factors (VIFs) were calculated for all variables. The VIF values for each variable found to be <10, indicating no multicollinearity among the independent variables. Regardless of the limitation of the sample size, the proposed model is capable of representing the effect on pre-evacuation times.

4 | RESULTS AND DISCUSSION

4.1 | Experience with fire, drill participation, fire training, and awareness

In this section, the aim is to explore the relationship between pre-evacuation time influencing factors and various characteristics of hotel staff, such as age, gender, education level, and the hotel joining year. Descriptive statistics were generated to gain a better understanding of the joint impact of these factors on the hotel staff's preparedness for fire emergencies.

4.1.1 | Experience with previous fire incidents

The analysis of fire experience among hotel staff ($n = 80$) revealed that 73.8% had no prior fire experience. While female staff reported fire experience at a higher rate (12.5%) compared with males (5.0%) (B), age did not appear to relate with fire experience, with the oldest age groups (46–55 and 56–5) reporting no incidents. Contrary, 10.0% of those aged 26–35 years experienced a fire incident in the hotel and 3.8% in another building (A). Among those who joined in 2015, 11.3% experienced a fire event, while in 2018, 3.8% witnessed one in the hotel (D). The data in Figure 5 do not suggest a clear relation between fire experience and staff characteristics. However, experience with fire incidents is a variable that is beyond individuals' control, this variability is not necessarily influenced by factors such as age or gender because fire emergencies can occur without warning and regardless of individuals preparedness or prior experience. As a result, some individuals may have experience with fire incidents, while others may have none.[61]

FIGURE 5 The hotel staff, ERT, and FRDM members at the assembly point.

4.1.2 | Drill participation

The participation rates in fire drills revealed significant gender disparities, with males showing higher involvement compared with females (B). Additionally, Figure 6 illustrates a noticeable decrease in participation among staff who joined after 2015. Notably, participants with postgraduate degrees showed the highest levels of engagement in fire drills (C), suggesting a potential relation between education level and safety consciousness. Overall, the fact that 85% of staff participated in at least one fire drill, with nearly half engaging in one to three drills and a significant proportion participating in more than three, is considered positive, as the absence or noncommitment of building occupants in fire drills was found as one of the issues related to fire drills participation in Malaysia.[62] Particularly noteworthy is the keen interest shown by staff aged 26–35 years in participating in drills. This higher participation rate among younger staff may be related to their characteristics, such as age and health, as they tend to be more dynamic and walk faster than the elderly.[63] However, it is irrelevant to draw conclusions or compare between participants in terms of age due to the differences in the sample inside each age category.

4.1.3 | Fire training

The analysis of Figure 6 shows that 66.3% of the hotel staff participated in fire trainings. Among those trained, 38.8% received training within the past 12 months. Similar to fire drill, younger staff members (18–25 and 26–35 years age groups) demonstrated higher participation rates in fire training compared with older staff (aged 46–65 years) (A). The data presented in Figure 7B illustrate that a high number of males had never received a fire training before compared with females. This can be due to the idea that men tend to believe in their own ability to verify and attempt to fight the fire, while females prefer seeking help and relying on others to get the information they need.[43] Additionally, staff with postgraduate education demonstrated the highest rates of participation in fire training sessions. This trend aligns with the pattern observed in drill participation, suggesting that individuals with higher education levels are more inclined to participate in training programs as they seek to acquire more information before encountering a real fire situation.[55] However, participants who joined in 2015 showed the most significant participation rates, whereas individuals who joined in 2018 exhibited relatively lower rates of participation (D). These findings suggest that there is still room for improvement in fire trainings within the hotel.

4.1.4 | Awareness

The staff responses presented in Figure 8 indicate high awareness levels of the evacuation procedure. Despite the slight numerical disparities between the two categories, both genders had similar awareness levels (B). Notably, postgraduates show the highest awareness, with only (2.9%) indicating lack of awareness (C). Those who joined in 2014 and 2015 demonstrated full awareness, whereas this was marginally lower for later joiners, who are possibly influenced by nonfamiliarity with the building (D).[43] However, variations in awareness levels could be attributed to various factors such as training, prior

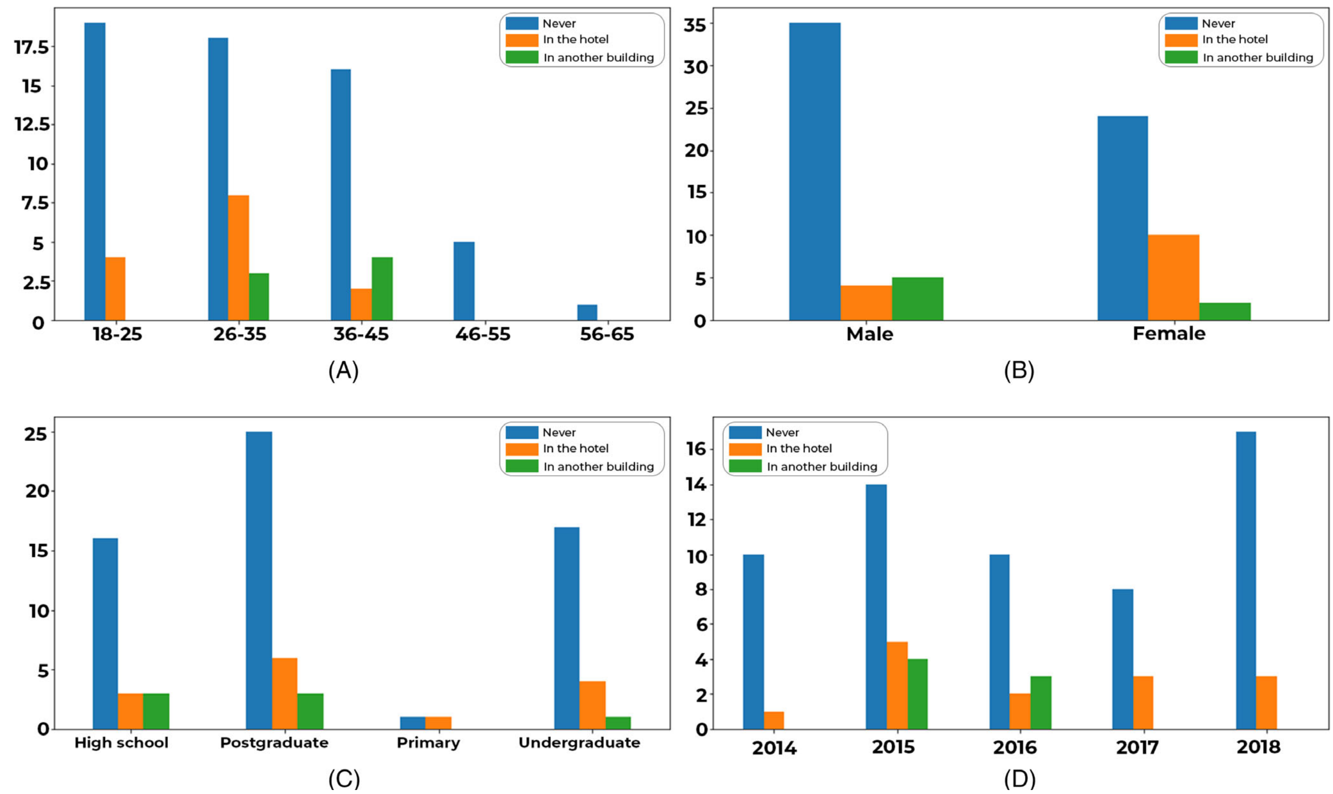

FIGURE 6 Staff characteristics and experience with previous fire incidents. (A) Experience with previous fire by age. (B) Experience with previous fire by gender. (C) Experience with previous fire by education level. (D) Experience with previous fire by joining year.

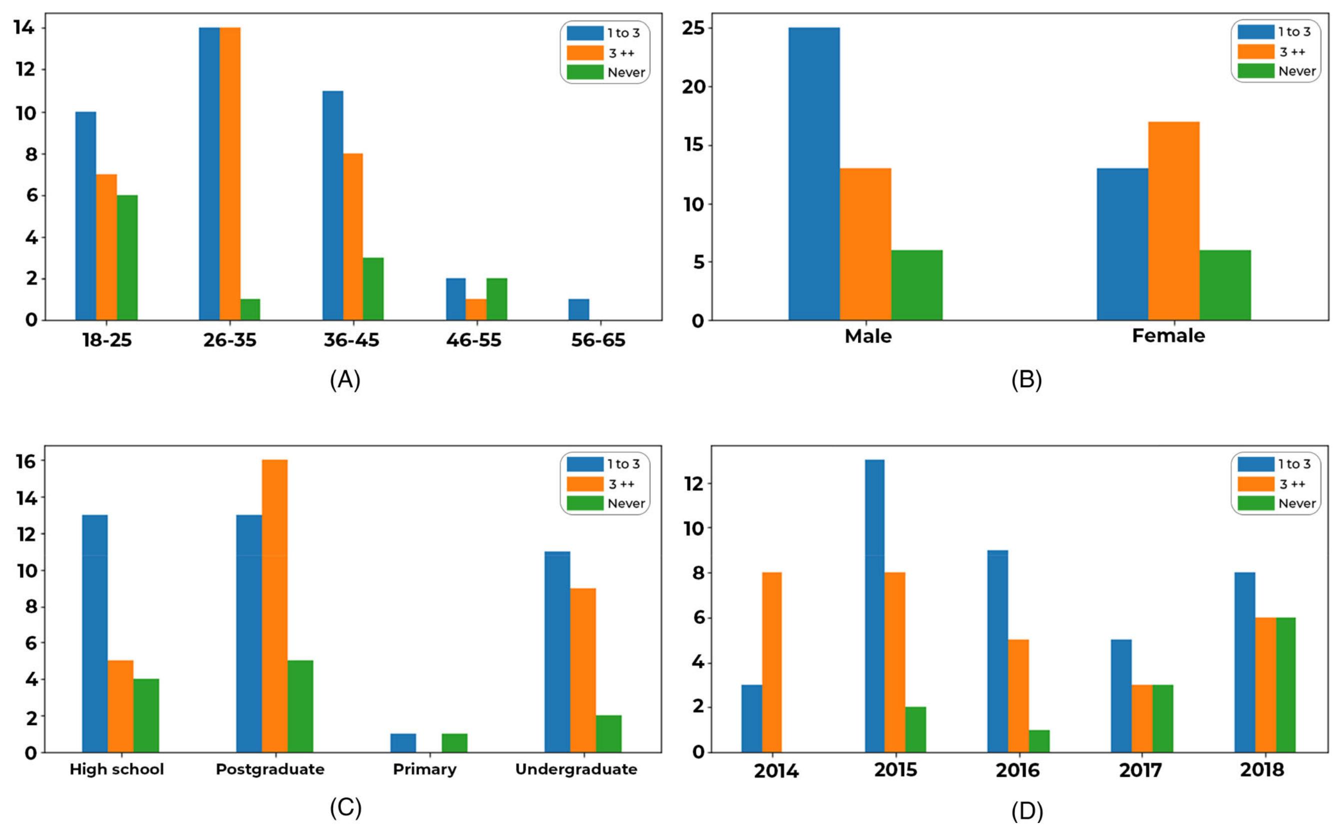

FIGURE 7 Staff characteristics and drill participation. (A) Drill participation by age. (B) Drill participation by gender. (C) Drill participation by education level. (D) Drill participation by joining year.

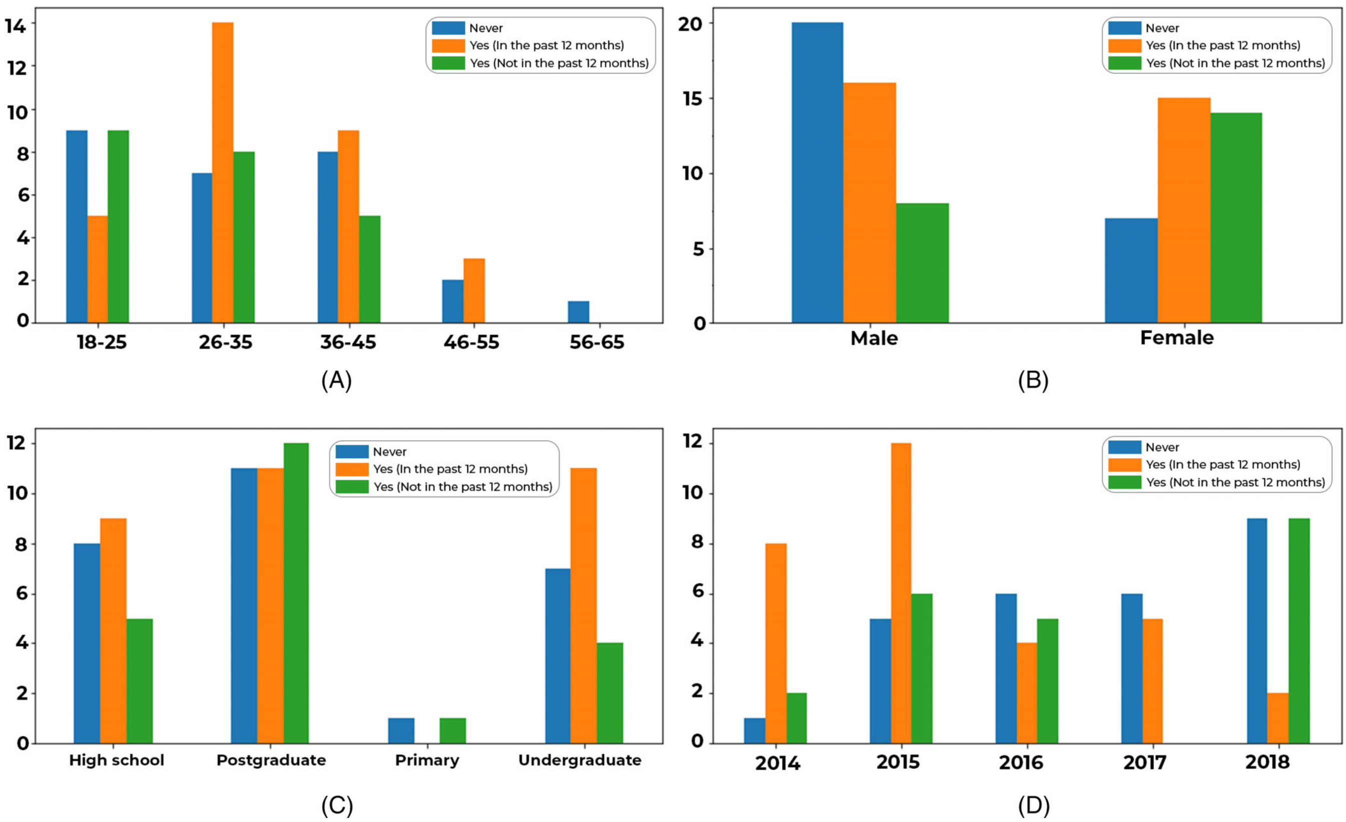

FIGURE 8 Staff characteristics and fire training. (A) Fire training by age. (B) Fire training by gender. (C) Fire training by education level. (D) Fire training by joining year.

experiences with fires, and individual characteristics. Additionally, occupants' awareness may directly influence their emergency decision-making,[64] and it is evaluated by how they react in a real fire event.

4.2 | Correlation coefficient analysis

Chi-square is a statistical test used to determine if there is a significant association between two categorical variables. Table 2 provides the output of a chi-square analysis for the independent variables and their significance with dependent variables (awareness, experience with fire, fire training, drill participation, and fire alarm). The table includes the degrees of freedom (*df*), significance level (*p*), and Cramer's V coefficient for each factor. Cramer's V is a measure of the strength of association for tables larger than 2×2. The heatmap in Figure 10 visualizes the significance (*p*-value) of the influencing factors obtained from the chi-square test. The dependent variables are listed on the x-axis and independent variables on the y-axis. The colour of each cell in the heatmap represents the significance level, with cooler colors (e.g., blue) indicating higher significance and warmer colours (e.g., red) indicating no significance. The annotations within each cell display the actual significance value for the corresponding independent variable and influencing factor on two levels, $^*p < 0.05$, $^{**}p < 0.01$.

4.2.1 | Awareness

The results indicate that education level ($V = 0.323$, $p = 0.039$) and fire training ($V = 0.350$, $p = 0.008$) have a statistically significant relationship with staff awareness of the evacuation procedure. In fact, individuals during fire events may find themselves in novel situations where they have limited resources at hand, such as time or information, making the decision to evacuate more challenging.[65] While time can vary upon the emergency situation, the information that contribute to the awareness of the individual can be acquired through different means including education; for instance, occupants with lower levels of education have a tendency to engage in firefighting activities during the pre-evacuation period, while occupants with higher education levels tend to gather more information about the fire and assess the situation before making a decision.[43] This suggests that individuals with lower levels of education may have limited understanding of fire safety procedures or may underestimate the risks involved. As a result, they may take matters into their own hands and attempt to fight the fire without considering the potential risks or the effectiveness of their actions, which can be described as a lack of awareness. In contrast, individuals with higher levels of education are more likely to often possess knowledge about fire safety procedures and a better understanding of the potential hazards involved. They prioritize gathering relevant information about the fire, such as its location, intensity, and potential escape routes.[55] This cautious approach allows

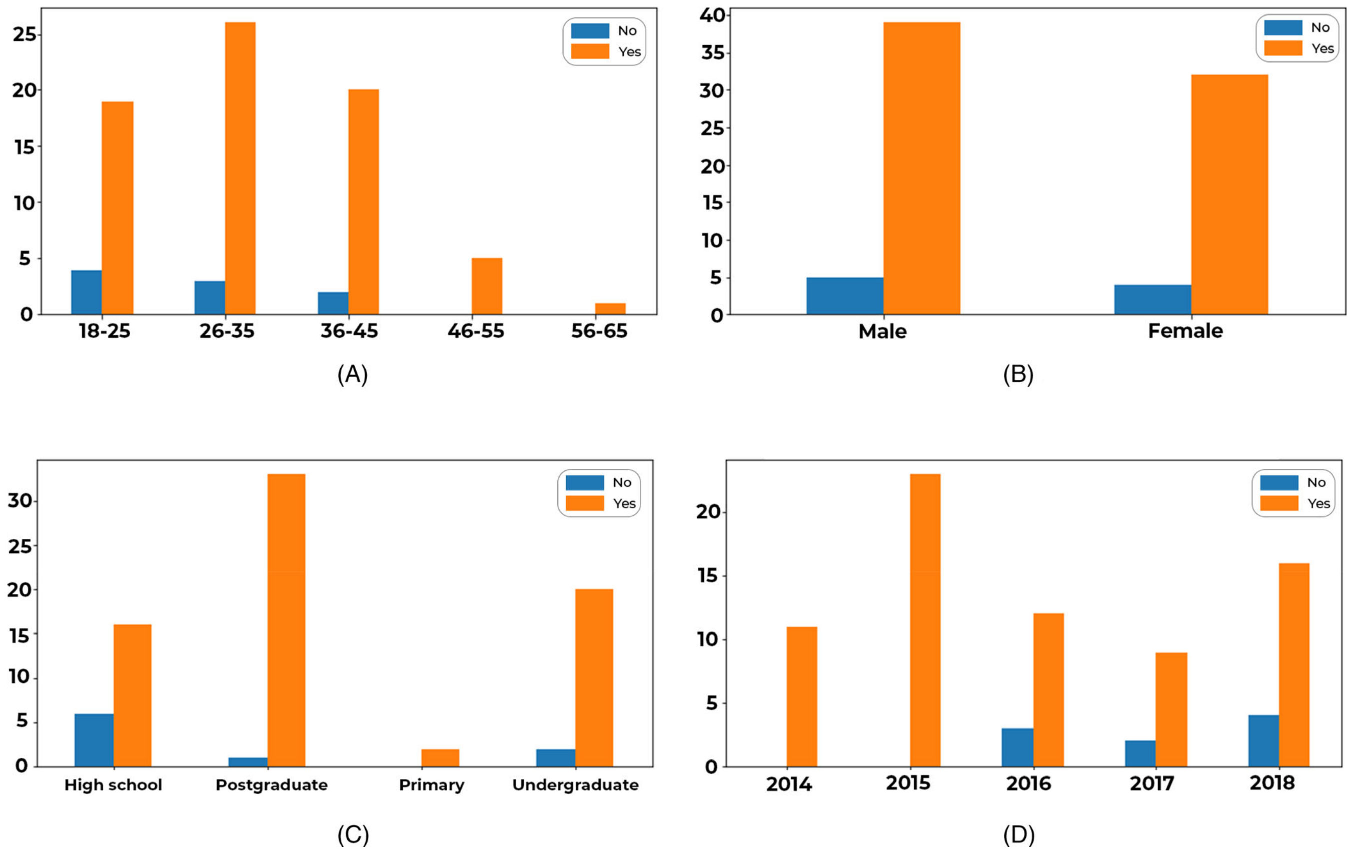

FIGURE 9 Staff characteristics and awareness of the fire evacuation procedure. (A) Awareness of the fire evacuation procedure by age. (B) Awareness of the fire evacuation procedure by gender. (C) Awareness of the fire evacuation procedure by education level. (D) Awareness of the fire evacuation procedure by joining year.

them to assess the situation and make informed decisions based on their evaluation and prior knowledge. While this can be seen as a positive aspect of being aware of the emergency, it may also result in occupants spending more time investigating the event, leading to longer pre-evacuation time. Additionally, fire trainings provide an opportunity to enhance the staffs' knowledge and awareness of potential fire risks within the building. These training programs provide valuable information about fire safety measures, including preventive measures, fire detection, and response protocols.[66] Importantly, fire trainings promote a culture of awareness among hotel staff. However, none of the other independent variables (gender, age, joining year, fire alarm, experience with fire, drill participation, and initial thoughts) were found to have a significant relation with the staff awareness levels.

4.2.2 | Experience with fire

None of the examined independent variables show a statistically significant relationship with fire experience ($p > 0.05$). these findings align with the suggestion made in Section 4.1.1 that experience with fire incidents is a variable that is not influenced by factors such as age or gender. Fire incidents can happen without warning and affect individuals regardless of their age, gender, or other demographic factors. This means that some individuals may have encountered fire incidents in the past, while others may not have any personal experience with such events.

4.2.3 | Fire training and drill participation

When asked about their participation in fire trainings, 66% of the staff reported having taken part in fire training either in the past 12 months or before. Having 66% of the total staff trained can be considered average. However, achieving a higher percentage can also be challenging due to the joining of new employees and the possibility of some individuals missing the training sessions. There was a strong correlation between the length of time staff members had worked at the hotel and their participation in fire trainings ($V = 0.370$, $p = 0.005$). Staff members who had been working in the building for a longer period were more likely to have participated in fire trainings. While participation in fire trainings would elevate the awareness level ($V = 0.350$, $p = 0.008$), it is not the only factor to be considered, it is equally important to consider the quality of the trainings provided.[66,67] To ensure competency and preparedness, it is beneficial to conduct regular and realistic emergency scenarios through fire drills.

TABLE 2 Contingency table of the correlation coefficient between factors.

Influencing factors	Independent variables	Chi-square	*df*	*p*	Cramer's V
Awareness					
	Gender	0.001	1	1.000	0.004
	Age	1.756	4	0.781	0.148
	Education Level	8.364	3	**0.039***	0.323
	Joining year	7.523	4	0.111	0.307
	Fire alarm	5.869	3	0.118	0.271
	Experience with fire	0.323	2	0.851	0.64
	Drill participation	3.020	2	0.221	0.194
	Fire training	9.778	2	**0.008****	0.350
	Initial thoughts	0.534	3	0.911	0.082
Experience with fire					
	Gender	5.160	2	0.076	0.254
	Age	9.828	8	0.277	0.248
	Education level	2.814	6	0.832	0.133
	Joining year	10.712	8	0.219	0.259
	Fire alarm	5.176	6	0.521	0.180
	Initial thoughts	6.767	6	0.343	0.206
	Drill participation	2.871	4	0.580	0.134
	Fire training	2.916	4	0.572	0.135
	Awareness	0.323	2	0.851	0.64
Fire Training					
	Gender	7.801	2	**0.02***	0.312
	Age	8.368	8	0.398	0.229
	Education level	3.050	6	0.803	0.138
	Joining year	21.847	8	**0.005****	0.370
	Fire alarm	8.355	6	0.213	0.229
	Experience with fire	2.916	4	0.572	0.135
	Drill participation	25.847	4	**0.000****	0.402
	Initial thoughts	4.530	6	0.605	0.168
	Awareness	9.778	2	**0.008****	0.350
Drill participation					
	Gender	3.558	2	0.169	0.211
	Age	9.471	8	0.304	0.243
	Education level	6.491	6	0.370	0.201
	Joining year	13.502	8	0.096	0.290
	Fire alarm	15.341	6	**0.018***	0.310
	Experience with fire	2.871	4	0.580	0.134
	Fire training	25.847	4	**0.000****	0.402
	Initial thoughts	5.484	6	0.483	0.185
	Awareness	3.02	2	0.221	0.194
Fire alarm					
	Gender	0.233	3	0.972	0.54
	Age	21.143	12	**0.048***	0.48
	Education level	9.554	9	0.338	0.2
	Joining year	9.695	12	0.643	0.201
	Experience with fire	5.176	6	0.521	0.18

(Continues)

TABLE 2 (Continued)

Influencing factors	Independent variables	Chi-square	*df*	*p*	Cramer's V
	Drill participation	15.341	6	**0.018***	0.310
	Fire training	8.355	6	0.213	0.229
	Initial thoughts	14.450	9	0.107	0.245
	Awareness	5.869	3	0.118	0.271

Note: Bold indicates statistically significant *p*-values.
*$p < 0.05$; **$p < 0.01$.

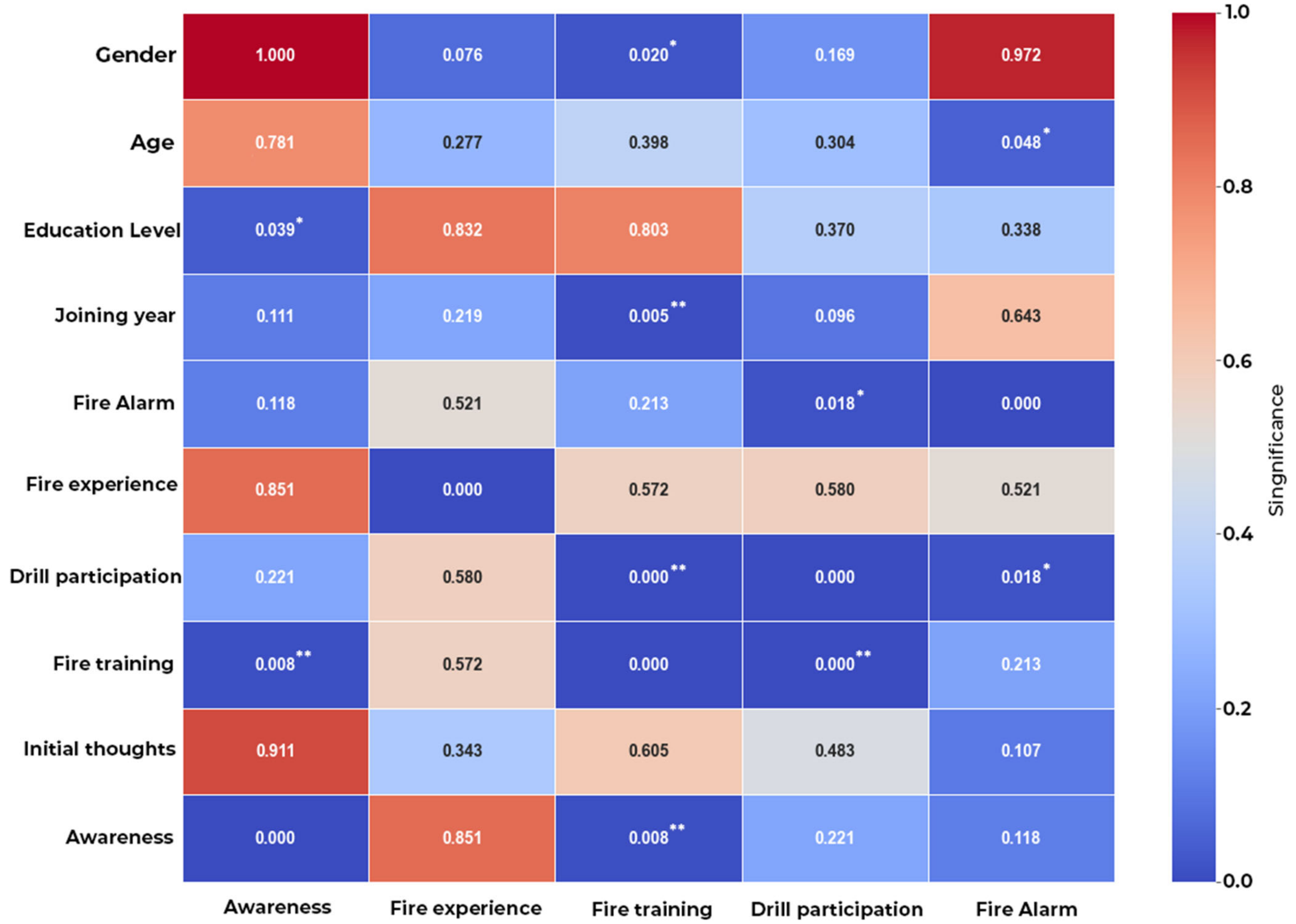

FIGURE 10 Significance heatmap of the influencing factors and staff characteristics.

These simulations allow building occupants to practice their response to different types of incidents, evaluate their performance, and identify areas that need improvement. This is found in the significance of the staff drill participation (V = 0.402, $p < 0.001$) and fire trainings received. Additionally, regular fire drills, play a significant role in familiarizing occupants with the emergency procedures, evacuation routes, and the fire alarm sound. This familiarity and training can be crucial in the event of a real fire situation, individuals will be better prepared to evacuate safely and quickly.[48] Staff members who had fire training (V = 0.402, $p < 0.001$) and those who were more familiar with fire alarms (V = 0.310, $p = 0.018$) were found to participate more in fire drills. Gender (V = 0.312, $p = 0.02$) also have a significant relation with fire training. It is evident that from all staff members more males (25%) than females (8.8%) were lacking in fire trainings Figure 8 (b). This behavior can be attributed to the tendency of males to rely on their own abilities when fire occurs, leading them to potentially attempt to handle the situation independently. Suggesting that they may possess higher confidence in their firefighting skills and less likely to seek out help or advice from others, including taking fire training. Conversely, females may show a greater willingness to engage in discussions with others to gather information about the fire.[43] A more collaborative approach is observed in female behavior, as they are more likely to seek assistance or advice to make informed decisions regarding their response to the fire regardless of their awareness level. However, even the most well-designed plans can fail if the participants do not understand them or are unaware of their roles during emergencies.[66] Thus, training is a critical factor in establishing effective life safety measures. While the quantity and frequency of training sessions and drills are significant, it is equally significant to emphasize the quality of the training itself.[68]

4.2.4 | Fire alarm

Pre-evacuation process is divided into recognition stage and response stage. Recognition stage begins with the fire alarm or cue and ends with the first response. Human response to fire alarm is complex and influenced by several variables, such as individual characteristics and behaviors, familiarity with alarm sounds, and environmental conditions, all can impact how people respond to fire alarms.[1–69] For the hotel staff, there is a statistically significant association between drill participation, age, and fire alarm. With $p < 0.05$, age have a significant relation with staff response to the fire alarm. This can be explained as younger staff members typically have better physical abilities, allowing them to evacuate the building quickly when they receive the emergency notification. Conversely, older staff members may face physical limitations that make it more challenging for them to evacuate the building. Moreover, age can also shape individuals' perceptions and attitudes towards the fire alarm and emergency procedures. Older staff members may have different thoughts and beliefs about fire safety based on their life experiences or previous encounters with fires. These perspectives can influence their initial thoughts and subsequent actions when responding to the fire alarm.[24,34] The significance of the fire alarm with drill participation ($V = 0.310$, $p = 0.018$) underscores the importance of conducting regular and well-planned evacuation drills. Through such drills, occupants become familiar with the alarm system and evacuation procedures, ensuring a quicker and more efficient response in the event of a real emergency.[48] This was also observed by Reinicke's[70] study, revealing that issues arose during evacuation experiments due to incomplete prerecorded evacuation messages. These incomplete messages resulted in delays as occupants took longer time to receive the necessary information or may have raised doubts about the credibility of the alarm or the seriousness of the situation. Suggesting that if the alarm system had functioned properly and the evacuation messages had been complete, the pre-evacuation time could have been shorter in those experiments.[70]

4.3 | Pre-evacuation time sequences

4.3.1 | Distribution of behavioral sequences based on actions

There was significant variation in how staff members responded to the emergency notification, as evidenced by the different sequences. Figure 11 shows the 30 sequences of actions performed by the hotel staff during the pre-evacuation time. Each sequence has a unique set of actions' order and number that range from 1 to 10 actions; for instance, S1, S2, and S7 are the only sequences where the staff members performed only one action, mainly "Standby", "Investigate", or "Follow instructions". The remaining sequences range from 2 to 10 actions. These variations occur because peoples' actions during an emergency may be influenced by their experiences and psychological state,[55] as well as their activities during the recognition stage, awareness, previous experience with fire, fire trainings and their participation in fire drills.[48,49] The pre-evacuation time starts when occupants recognize the fire situation and ends when they begin moving towards the exit. Thus, all the sequences of actions performed are considered part of the pre-evacuation time. The most common first action across all sequences was "Investigate," appearing in 17 sequences, followed by "Standby" in 10 sequences. However, "Follow instructions" served as the first action in S7 and S26, while "Collect belongings" was only the first action in S30. When examining the second action, "Investigate" followed "Standby" in eight sequences, while "Standby" directly followed the first action in 11 other sequences. The action "Collect belongings" appeared as the second action in sequences S15, S16, S17, S19, and S26, while "Follow instructions" occurred in S9, S13, and S14. Moving to the third action, "Investigate" was performed as the third action mostly in sequences that started with the same action such as (S10, S11, S13, S14, S23, S24, S25, S27) and was performed for the first time in S26. On the other hand, "Standby" served as the third action directly after "Collect belongings" in S15 or "Investigate" in S3. Additionally, "Collect belongings" was the most common third action observed in sequences S4, S8, S9, S12, S20, S21, S28, S39, and S30, while "Follow instructions" occurred only three times in sequences S5, S16, and S22. As for the fourth action, it was consistently either "Standby" or "Collect belongings" across all sequences. "Standby" appeared as the fourth action in sequences S4, S20, and S22, S28, S29, and it was the second occurrence of "Standby" in those sequences. In sequences S9, S13, and S26, "Standby" occurred for the first time as the fourth action. Notably, 68% of all sequences ended at the fourth action, indicating that staff members initiated their movement to safety. In some sequences, staff members repeated the same actions. Specifically, "Standby" and "Investigate" were repeated as the fifth action in sequences S10, S11, S14, S25, and S30. "Collect belongings" was performed for the second time in sequences S21 and S39, while "Follow instruction" was the fifth action in S24. The sixth action shows that staff members returned to "Standby" and "Investigate," while "Collect belongings" was performed for the first time in sequences S10, S11, and S25. In sequence S21, "Follow instructions" occurred for the first time as the seventh action. Only 19% of the sequences have more than six actions. After the seventh action, most staff members went through similar actions, primarily "Investigate," "Standby," or "Collect belongings". Only sequences S11 and S10 consisted of 9 and 10 actions, respectively. Most participants behavioral sequences begin with investigate or standby action, this behavior may be due to the social influence, or indicate the phenomenon known as "herd behavior" or

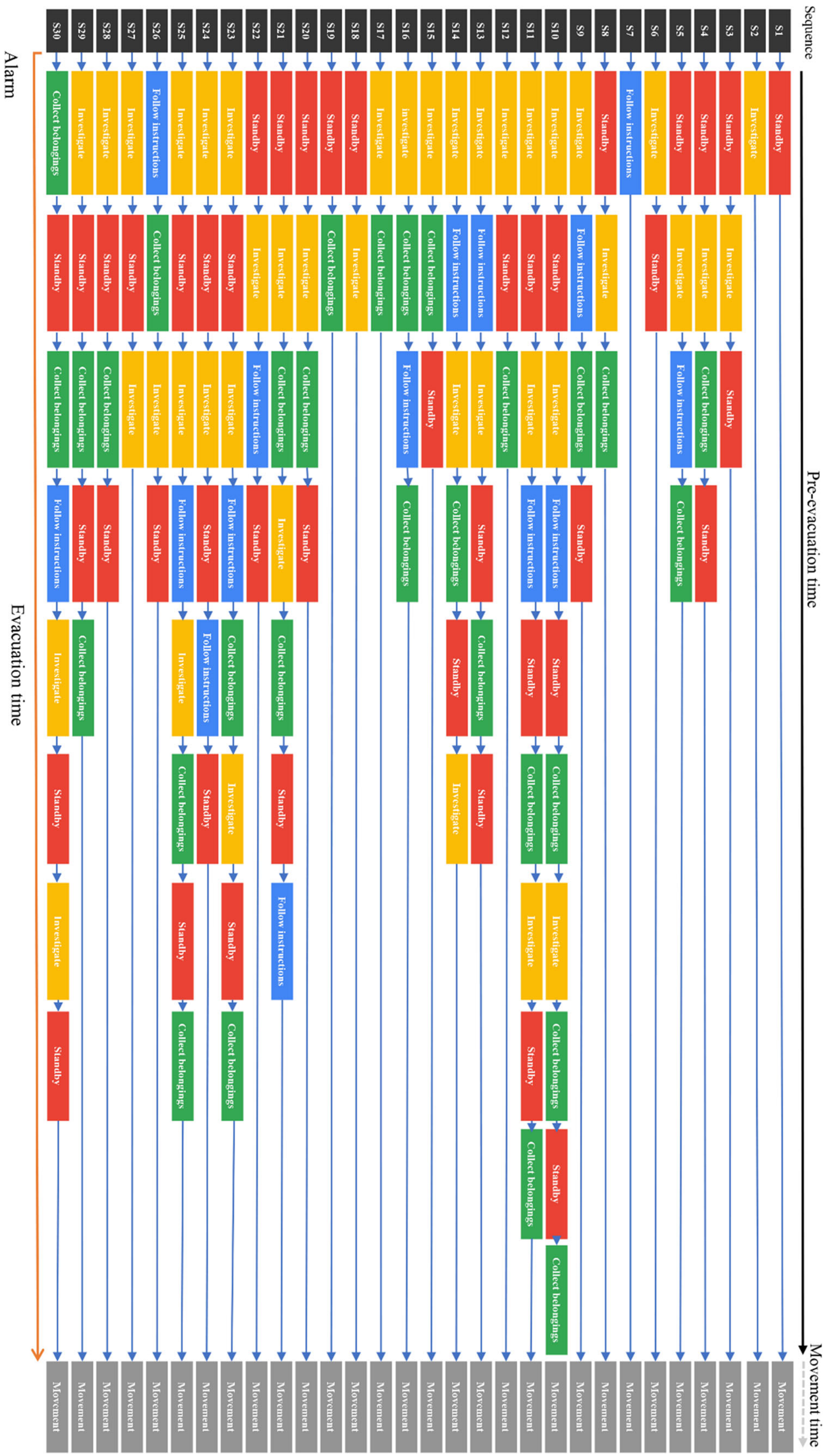

FIGURE 11 Distribution of the pre-evacuation behavioral sequences.

"attachment to people", which refer to the tendency of individuals to feel a sense of belonging to a group and to rely on the actions of others in the group in making decisions.[71] One identified behavior that is thought to be associated with social influence is the observation of others. By observing others and their actions, an individual can gain more information about the emergency. Additionally, observing the behavior of others can help a person conform to social norms and avoid behaviors that may be perceived as foolish or inappropriate.[42]

Similar results were previously found in Sachine et al.[20] study in the United Kingdom, with 60.8% of the staff's initial response to a fire alarm being to wait or seek information. While in Italy, D'Orazio et al.[71] found that some individuals spend time exchanging information with each other rather than immediately evacuating the room. Moreover, a comparison by Eriksson et al.[72] between Swedish and Australian participants in an emergency evacuation highlights that both groups shared a common tendency to seek additional information before deciding to evacuate.[72] The United States MGM Grand Hotel Fire Analysis by Kuligowski[5] revealed that hotel occupants are more likely to take initial actions such as investigating, notifying others, and preparing for evacuation. These behaviors are similar to what is observed in residential fires, and this is likely because hotels and residences have similar living circumstances. In both cases, people are in a contained space and have a general understanding of the layout and potential escape routes. Therefore, when a fire occurs, people may instinctively take similar actions to investigate the situation, warn others, and prepare to evacuate, which may involve getting dressed or gathering essential items.[5] As such, there are no differences in the observed behaviors of Malaysian participants compared with those documented in Western countries. It can be seen in Figure 11 that some staff members proceed to evacuate right after "Standby", "Investigate", or "Follow Instructions" (S1, S2, S7), while the majority engage in the coming-and-going phenomenon, where they return to "Collect belongings", "Standby," or "Investigate" again. Notably, in S10, S11, S23, S25, S26, and S30 staff members engage in extra actions after "Follow Instructions", mainly collect belongings. However, the time spent by an individual on the coming-and-going behavior is considered part of the pre-evacuation time, as movement time starts when the individual makes a purposeful movement towards the exit.[71] Furthermore, it is apparent that the performed sequences display a range of demographic characteristics, including various genders, ages, and education levels. This suggests that the decision of which sequence to follow is not influenced solely by these demographic factors. Several researchers argue that the influence of culture is significant on human behavior during emergencies. However, no significant differences were observed in the hotel staff behavior compared with the presented literature.

4.3.2 | Pre-evacuation sequences duration

Although some staff members followed the same sequence of actions, they took notably various times to complete them. The heatmap in Figure 12 illustrates the pre-evacuation times for each of the 30 sequences (S1–S30) and how many staff members completed the sequence within a specific time interval.

Pre-evacuation sequence refers to the series of actions taken by occupants before they start to evacuate the building in response to emergency. According to Figure 12, from the total of 30 sequences there were 15 observed within the time interval of ⩽1 minute. Among these sequences, S1 had the highest frequency, occurring four times, S2 occurred three times, and S14 appeared twice. Other sequences such as S3, S7, S8, S10, S29, and S30 were also observed within this time range but with lower frequencies. Moving on to the 1–3 min time interval, a total of 26 sequences were recorded. S2 had the highest frequency with five occurrences, followed by S1 with three occurrences. S4, S13, and S16 each appeared twice. Sequences like S5, S6, S7, S8, S9, S15, S17, S22, S23, S25, S26, and S28 were also present within this time interval, but with lower frequencies. Within the 3–5 min time interval, 13 sequences were identified. S1 and S2 appeared twice within this category. Lastly, the time interval of ⩾5 min included eight sequences. Among these, S1 had the highest frequency, occurring twice. The rest of sequences in this time category were present with lower frequencies. Overall, most staff took from 1 to 3 min to complete most of the sequences. In fact, there are no clear patterns observed between the staff across sequences or time categories. For instance, the ones who performed S1 which involves only one action ("Standby"), completed the sequence through all time categories (⩽1 min, 1–3 min, 3–5 min, and ⩾5 min). Several other sequences that were performed within 3 to 5 or ⩾5 min include the reoccurrence of the actions "Investigate" and/or "Standby", this suggests that the staff did not relay in their decision-making on the information acquired from the trainings received, instead they engage in information-seeking activities to confirm the threat and potential risks, showing that they are unsure of what is going on. However, it can be also related to the idea that the training quality was not efficient to provide them with the experience they need. On the one hand, if the staff have some level of confidence about the source of the threat and how to respond, they may still engage in actions such as discussing with others or searching for additional information to gain a better understanding of the situation.[3] The trainings would not eliminate these behavioral actions, instead shortening the time it takes to perform them. The more experienced an individual being in a particular situation, the more likely to rely on heuristics. These heuristics serve as efficient and effective decision-making tools, allowing individuals to make judgments and choices quickly based on their prior knowledge and experiences rather than seeking information from other staff members.[65] Overall, the time required to complete pre-evacuation sequences vary depending on the way actions are performed and characteristics of the occupants performing them. Certain actions, such as waiting, investigating, and collecting belongings, may all contribute to the increase of the pre-evacuation time duration on an individual scale.[5–52] Additionally, age, gender, or role may also influence the performance from a behavioral perspective.[1–68] This influence may vary between individuals and result in different timings even when performing the exact same action.

4.4 | Influencing factors on pre-evacuation time

A Multinomial regression model was estimated to assess the influence of each predictor variable on the outcome variable. The influencing factors, such as experience with fire, fire alarm, drill participation, fire

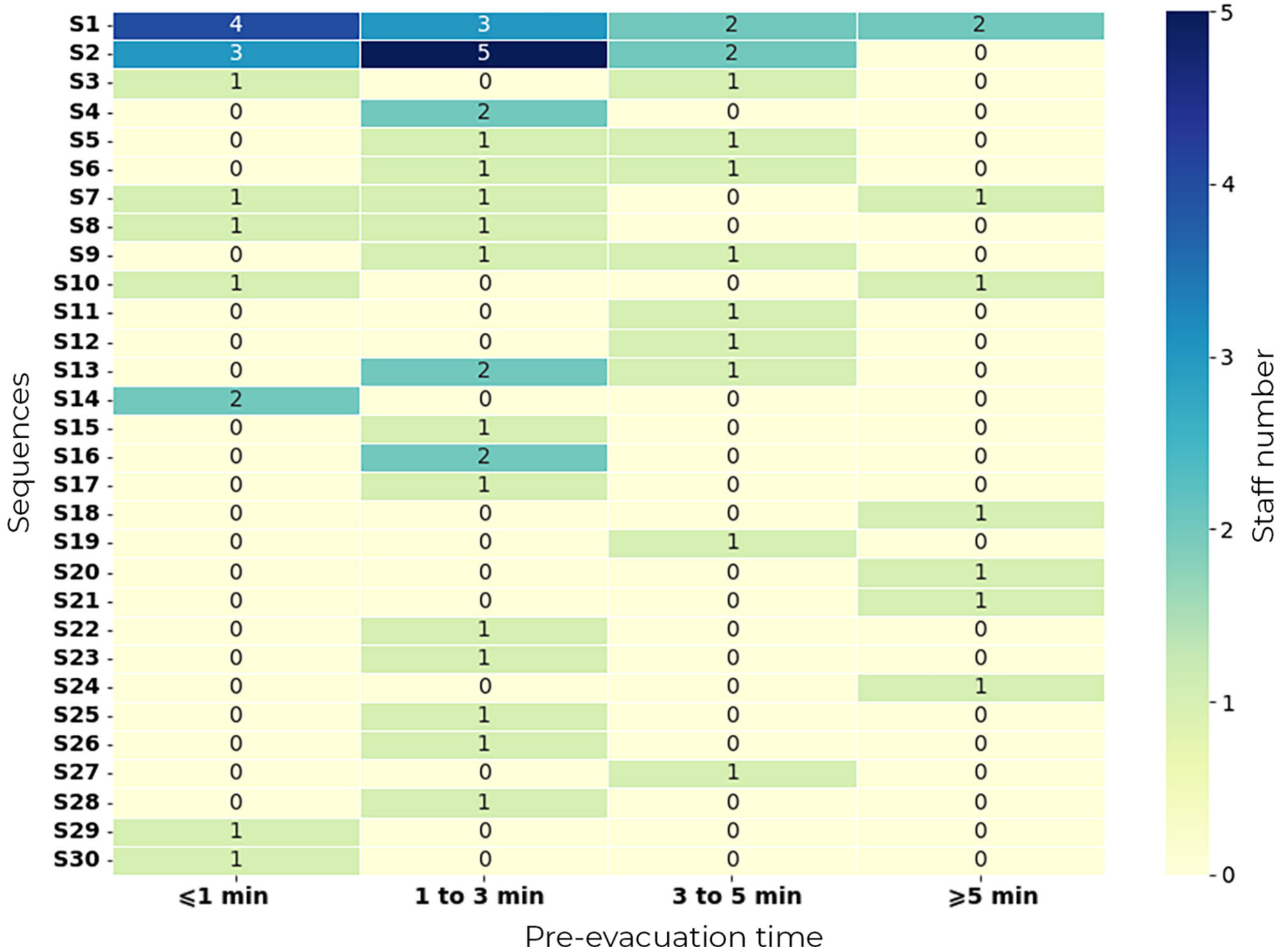

FIGURE 12 Distribution of the staff based on the completion time of each sequence.

training, and awareness, were analysed as predictor variables of the outcome variable (pre-evacuation time). The reference category (base outcome) for the outcome variable was defined as ⩽1 as it is the shortest pre-evacuation time. Table 3 provides the following information:

B: the regression coefficient estimates for the predictor variable.

Std. Error: the standard error of the regression coefficient estimate.

P: the significance level (*p*-value) associated with the Wald statistic.

Exp(B): the exponentiated regression coefficient, which represents the odds ratio for the predictor variable.

The significance level (*p*) determines the statistical significance of each predictor variable in predicting the pre-evacuation time, with a threshold of $p < 0.05$. A predictor variable is considered statistically significant if its p-value is less than 0.05. Conversely, if a predictor variable has a p-value greater than 0.05, it means that there is no significance. The odds ratio (OR) with confidence intervals (CIs) for each independent variable in the model were presented in the forest plot (Figure 14), to illustrate the variables appearing to be more associated with the dependent variable than others. The error bar chart was generated to allow the comparison of the size and variability of the regression coefficient estimates across time frames and influencing factors. The data frame included values for three time categories: '1 to 3 min', '3 to 5 min', and '⩾5 min', representing different influencing factors such as 'Experience with fire', 'Fire alarm', 'Drill participation', 'Fire training', and 'Awareness'. The x-axis represented the variable names, while the y-axis displayed the regression coefficient estimates (B values) for the predictor variable. Each data point was represented by a marker shape (circle 'o', square 's', or triangle '^') corresponding to its category. Random colors were assigned to each time category, with blue for '1 to 3 min', orange for '3 to 5 min', and green for '⩾5 min'. The error bars on each data point represented the standard deviation of the B values for each category, as illustrated in Figure 13.

The forest plot in Figure 14 illustrates the odds ratios (OR) and their corresponding 95% confidence intervals (CI) for each independent variable using markers and error bars. The odds ratios are represented by markers (dots), and the error bars indicate the confidence intervals around each odds ratio estimate. Fire drills refer to the process of simulating and practicing emergency evacuations in a controlled setting.[48]

TABLE 3 Results of the multinomial regression.

Parameter estimates					
Pre-evacuation time	**Influencing factors**	***B***	***Std. Error***	***p***	***Exp(B)***
⩽1 min	(Base outcome)				
1–to 3 min	Experience with fire	0.582	0.665	0.382	1.789
	Fire alarm	0.005	0.351	0.988	1.005
	Drill participation	−1.325	0.486	**0.006****	0.266
	Fire training	0.456	0.459	0.320	1.577
	Awareness	2.173	1.082	**0.044***	8.789
	constant	−2.675	2.389	0.263	
3–5 min	Experience with fire	0.474	0.711	0.505	1.607
	Fire alarm	−0.228	0.381	0.549	0.796
	Drill participation	−0.394	0.483	0.415	0.675
	Fire training	0.407	0.488	0.404	1.503
	Awareness	2.164	1.254	0.084	8.709
	constant	−4.049	2.766	0.143	
⩾5 min	Experience with fire	1.260	0.737	0.087	3.527
	Fire alarm	0.533	0.421	0.205	1.704
	Drill participation	−0.954	0.654	0.145	0.385
	Fire training	1.306	0.691	0.059	3.693
	Awareness	0.133	1.218	0.913	1.142
	constant	−4.868	2.787	0.081	

*$p < 0.05$; **$p < 0.01$.

From Table 3, it can be seen that staff drill participation has a negative regression coefficient estimate for all three time categories (1–3 min, 3–5 min, and ⩾5 min), with the strongest negative coefficient estimate in the ⩾5 min category as illustrated in Figure 13. However, the drill participation has only a significant impact on the pre-evacuation time in the 1–3 min category. The negative coefficient value of −1.325 and a *p*-value of 0.006 indicate that there is a strong negative relationship between the two variables. This means that increasing drill participation has a considerable effect on reducing the pre-evacuation time. The odds ratio of drill participation is 0.266, which implies that for every unit increase in drill participation, the odds of having a pre-evacuation time in the range of 1–3 min category decrease by a factor of 0.266, holding all other variables constant. In other words, the probability of having a pre-evacuation time that falls in the category of 1–3 min is about 26.6% lower for those who had frequent drill participation compared with those who have occasional/no participation, the confidence interval of [0.10, 0.69] supports this finding and indicates a statistically significant effect. Overall, the purpose of fire drills is to improve the efficiency and effectiveness of evacuation procedures, as well as to assess and measure the performance of individuals and teams during emergency situations. By regularly conducting fire drills, individuals can become more familiar with the evacuation process and develop a greater understanding of their roles and responsibilities during an emergency,[48] which reflects the findings. On the other hand, awareness shows a statistical significance effect on the pre-evacuation time with a positive coefficient of 2.173 and a p-value of 0.044. These results illustrate that increasing awareness is associated with higher odds of a shorter pre-evacuation time for the hotel staff. The 8.789 odds ratio of awareness suggests that the probability of staff spending a shorter pre-evacuation time in the range of 1–3 min increases by a factor of 8.789 for every unit increase in awareness. Conversely, with an estimate of 2.164, *p*-value of 0.084 and estimate of 0.133, *p*-value of 0.913, awareness has no significance for the category 3–5 min and ⩾5 min, respectively. Even though 88.8% of the staff claim that they are aware of the evacuation procedure (Figure 9), the findings suggest that the effect of awareness diminishes as the pre-evacuation time becomes more prolonged. It can be concluded that awareness is not merely a theoretical concept that depends on individual beliefs about being aware or not. Rather, it can be objectively observed in situations such as real-life fire emergencies and drills. Analyzing how awareness impacts evacuation performance can provide valuable insights into how people react, behave, and contribute to the improvement of the evacuation procedure. For instance, previous analyses highlighted the need for special messaging strategies with enhanced voice communication systems and additional zoning to provide real-time situational awareness.[50,73] Previous experience with fire has a *p*-value ≥0.1 in "1 to 3 min" and "3 to 5 min" time categories which indicates insufficient evidence of any relationship. While ppvalue of 0.087 ($p < 0.1$) indicate weak evidence of any relationship between the previous experience with fire and pre-evacuation time ⩾5 min. This result may seem counterintuitive at first, as individuals that have had an experience with fire are expected to respond more quickly during emergencies as suggested in the literature. The finding could be explained by

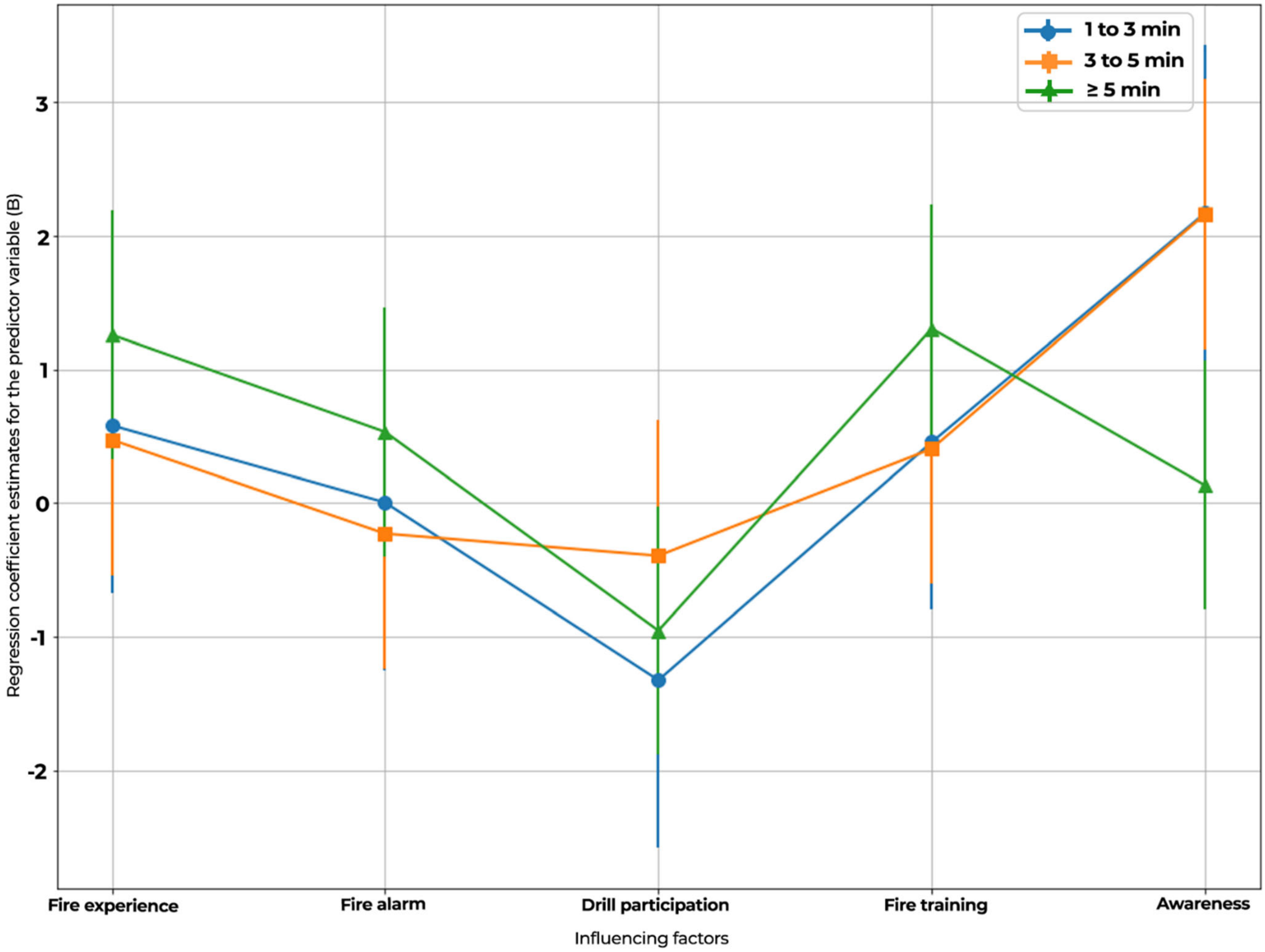

FIGURE 13 Error bars chart of the pre-evacuation time categories and predictor variables.

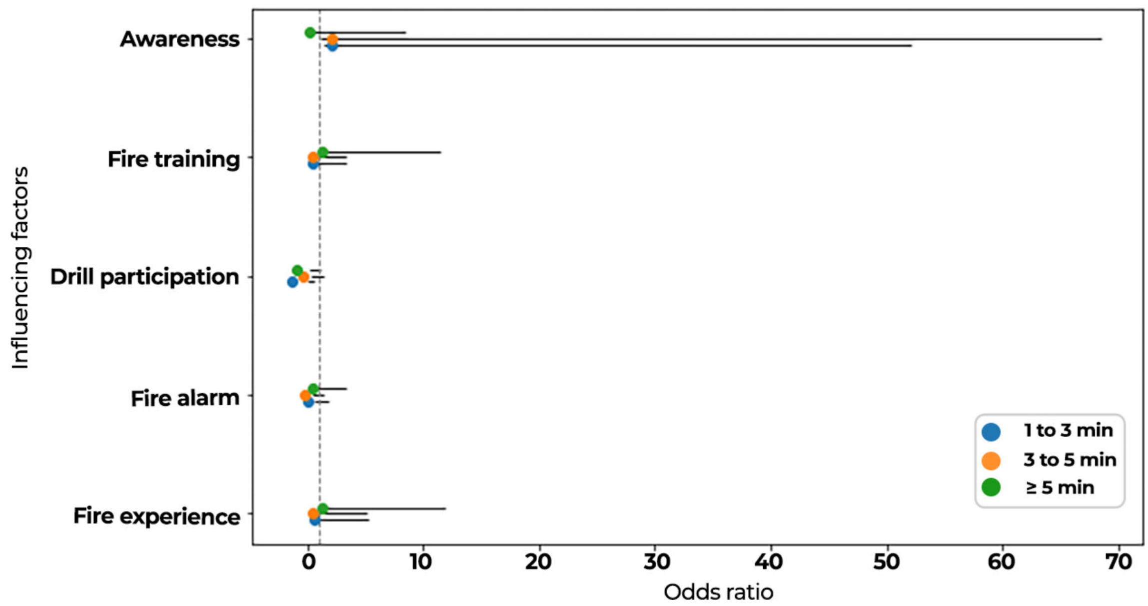

FIGURE 14 Odds ratios and confidence intervals (95%).

the fact that staff members with previous fire experience may be more likely to assess the situation before taking an action. This assessment could involve verifying the source of the alarm, which is supported by the insignificance of the fire alarm ($p = 0.205$) within all time categories, or identifying the safest exit route, which can be translated to the lack of familiarity with the building that can be avoided by effective fire training.[68] It also can be due to the idea that people with more experience may have a false sense of confidence or lack of urgency when responding to fire, resulting in longer reaction times and slower evacuation.[74] Previous research also suggests that there is a variation in the influence of previous fire experiences; for instance, Cohn et al.[47] stated that the effect of previous experience with fire on evacuation behavior varied among participants in the study sample. While some individuals were motivated to evacuate immediately, others delayed their evacuation, and some even decided not to evacuate at all, perceiving the situation as not requiring urgent action.[47] These results highlight the need for a nuanced understanding of the role of previous fire experience in shaping evacuation behavior and underscore the importance of considering individual differences.[49] The results also show that fire training has no significant effect on the pre-evacuation time. With a positive coefficient of 1.306 and a *p*-value of 0.059. Noting that the finding leads to questions on the quality of training that the staff received especially with 66.3% of hotel staff participated in fire trainings before (Figure 8). However, it was found in the study by Yasemin et al.[74] on the World Trade Center evacuation that 60% of the sample studied believed that the fire safety training received did not prepare them in any way to evacuate the building. Suggesting that having a well-trained and knowledgeable group of occupants can greatly reduce the time needed for occupants to evacuate a building in the event of fire. In fact, there may be variability in the way training are conducted, and there must be room for improvement in terms of the consistency and detail of these practices, by ensuring that training and assessment practices are rigorous, thorough, and consistent to achieve optimal performance in real emergency situations.[48] Among the factors examined, fire drills and awareness appear to have the most significant impact on reducing the hotel staff pre-evacuation time. Fire drills, through regular participation, contribute to improving efficiency and familiarity with evacuation procedures, resulting in a considerable decrease in pre-evacuation time. Similarly, increased awareness is associated with shorter pre-evacuation times, emphasizing the importance of hotel staff understanding of their roles and responsibilities during emergencies. On the other hand, none of the other predictors are significant with the pre-evacuation time categories.

5 | LIMITATIONS AND RECOMMENDATIONS

To enhance modelling capabilities in the field of fire engineering, it is recommended to shift the emphasis from solely quantifying observed behavior to a more comprehensive analysis of the factors that influence it. By understanding and incorporating these underlying factors into the modelling process, researchers and practitioners can improve the accuracy and effectiveness of their models. This shift in approach will lead to better predictions and insights into pre-evacuation time behaviors, ultimately contributing to the advancement of fire safety practices and strategies in Malaysia and worldwide. However, the presented results in this study are more indicative than definitive since the study used a convenience sampling technique. Therefore, it is inappropriate to generalize these findings to other hotel populations. In addition to the efforts made to minimize biases in the self-reported data, it is important to acknowledge that the hotel staff's responses regarding their estimation of pre-evacuation time and the actions performed may be susceptible to recall bias or social desirability bias. These biases could potentially impact the accuracy of the data collected. To our knowledge, few studies have been hitherto available on hotel staff pre-evacuation time immediately after unannounced evacuation drill. Therefore, the major originality of the present study is to focus on the factors that influence the pre-evacuation behavior. Hence, despite the limitations discussed above, the present study provides new insights into the behavior of a Malaysian hotel staff, which will contribute towards the development of a customized dataset for fire engineers in Malaysia.

6 | CONCLUSION

The study revealed a variety of behaviors performed by hotel staff during the pre-evacuation stage, characterized by unique combination, number, and order of actions. However, these actions did not demonstrate observable patterns that would directly impact pre-evacuation time. These behavioral variations are likely influenced by other factors. Commonly observed initial actions included investigation and standby, with most staff completing their sequences within 1 to 5 min. The results indicate that (a) drill participation has a significant impact on reducing pre-evacuation time duration, indicating that increased participation in fire drills leads to shorter pre-evacuation times; (b) awareness also plays a crucial role, with higher levels of awareness associated with shorter pre-evacuation times; (c) previous fire experience, fire training, and familiarity with fire alarm found to be a nonsignificant predictors of the pre-evacuation time; (d) age and initial thoughts have a strong relation with staff response to fire alarms. The findings of this study are from an unannounced fire drill conducted in Malaysian hotel. Further studies are still required to collect data from future evacuations to enhance the study's conclusions.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data is available upon request.

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