Predicting Compliance Behaviour During a Flood Disaster Using the Talk-Through Method

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SUMMARY

This study was conducted to explore compliance behaviour during flood evacuation, employing the talk-through approach developed by Lawson (2011), for which participants are required to explain their anticipated actions in response to a hypothetical emergency scenario. The results showed that social cues, as described by the Protective Action Decision Model (PADM) (Lindell & Perry, 2012), were found to be the most effective factor in reducing evacuation delay time and enhancing compliance with evacuation orders. It was also found that in the absence of any routing instructions or specific cues, evacuees ranked familiar and shortest (by distance) routes as more preferable than those taken by neighbours. This study contributes to our understanding of evacuees' delay times and compliance with evacuation instructions, under the influence of different factors, including environmental cues, social cues, warning message contents, and various sources of the warning. It also demonstrated the value of the talk-through as a tool for studying human behaviour in floods without the risks or complications associated with data collection in real flood events.

KEYWORDS

Human factors, flood evacuation planning, compliance behaviour

Introduction

Compliance behaviour is a significant factor contributing to successful evacuation operations (Wang, et al., 2020). Noncompliance with instructions would increase casualties during large-scale movements, specifically in stressful and degraded environments (Daudé, et al., 2019). To help emergency planners and managers create efficient strategies, more empirical research is needed for a more thorough understanding of the factors that contribute to non-compliance (Saha & James, 2017). Additionally, most prior research has focused on how pedestrians respond during a building evacuation; less emphasis has been placed on how people behave while driving a vehicle during evacuation in a large-scale emergency (Bakhshian & Martinez-Pastor, 2023; Aldahlawi, et al., 2024). This work builds upon prior research by addressing evacuees' compliance with instructions during a hypothetical flood scenario. It presents a holistic overview of how people will likely comply in both the traffic network and within buildings, providing valuable insights into behaviour throughout all phases. Overall, this study was conducted to answer the question "What are the key factors influencing evacuees' compliance behaviour with evacuation departure time and routing instructions?", testing the following hypothesis:

H_1: Evacuation delay will vary depending on various influencing factors, including environmental cues, social cues, evacuation distances, levels of congestion, and sources of warning.

H_2: The likelihood of compliance with evacuation departure time will differ across the abovementioned conditions.

H_3: The likelihood of compliance with evacuation routing will differ across the conditions.

Method

Participants

The participants included 26 Saudi citizens (Mean age: 33; range: 23-44) living in areas prone to flooding. Of the total sample, 12 were female and 14 were male. The average household size was 6 members (range: 2-29). Participants reported a median awareness level of flood risks and flood resilience actions in local areas equal to 3 (1=very low, …, 5=very high). Responses show that most participants live in two-story buildings. People with severe health conditions, mental health issues, traumatic experiences of a flood, or lost a close friend or relative in a disaster were excluded from this study. The recruiting process included sending an advertisement via social media.

Materials

The talk-through method developed by Lawson (2011), for which participants are required to explain their anticipated actions in response to a hypothetical emergency scenario, was used to measure the influence of the PADM variables (i.e., environmental and social cues, information sources, and message contents) on compliance behaviour. A questionnaire was developed consisting of 14 Likert-type scale questions to measure participants' likelihood of complying with evacuation orders. Higher scores indicated a higher level of compliance. Rating scales were chosen as they are the most frequently used method in subjective assessment, allowing the participants to express their perceptions (Wilson & Sharples, 2015).

The first section of the talk-through questionnaire focused on demographic and socio-economic information. Demographic information such as age, gender, household size, relationship with the household members, and awareness of flood risks and flood resilience actions in the local area were collected, describing the characteristics of the study sample. Likewise, socioeconomic information involving residence type was acquired. After that, participants were given the time to draw their property layout, as Lawson described (2011). Afterwards, they were presented with a hypothetical flood evacuation scenario and asked to answer several questions. Figure 1 shows the hypothetical flood evacuation scenario.

Imagine that you and all your household members are currently at home. You receive the following text message from the government: “Immediate evacuation is needed due to upcoming flooding. Your home is in the highest-priority evacuation zone. Use your own vehicle and follow Route 1 immediately. Go to the assigned Shelter A for safety.” The image below is also sent by text message, although it will contain more detailed local area information regarding routes and destinations:

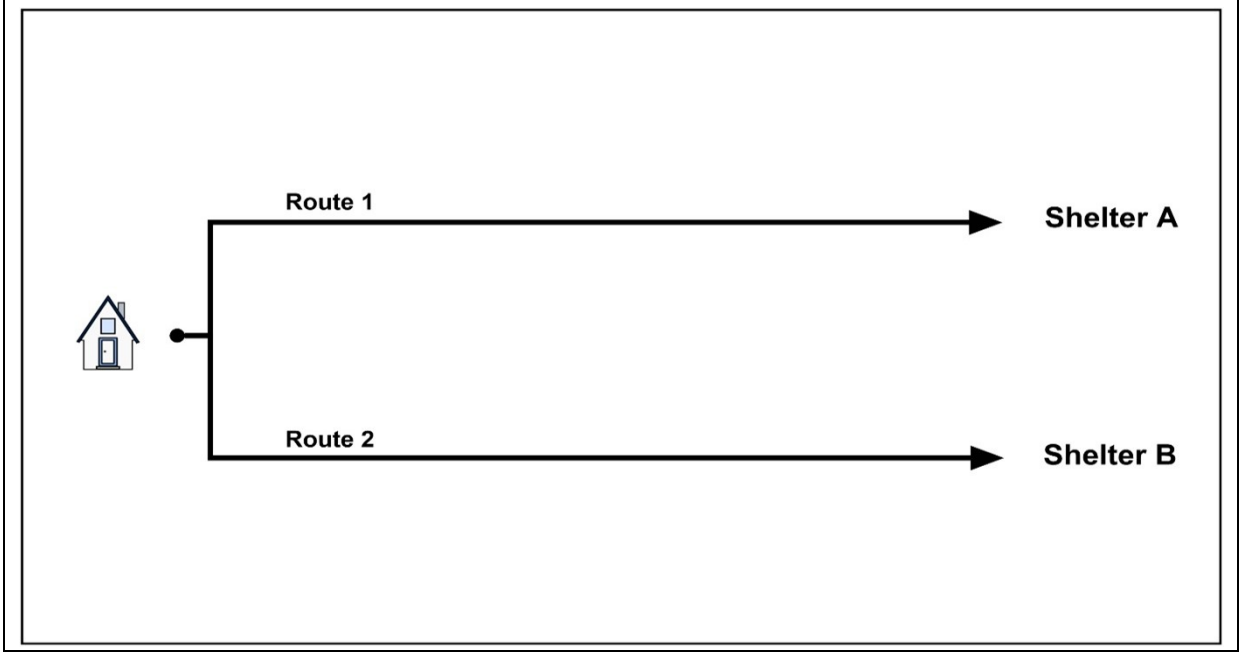

Figure 1: The hypothetical flood evacuation scenario employed in the talk-through questionnaire

The talk-through questions included what actions they would take upon receiving the warning until they reached the shelter, specifying the location of each action. Participants were also asked to predict their expected departure time following the evacuation warning (i.e., control condition for studying the evacuation delay). Then, participants were asked to rate the influence of the PADM variables on their compliance with evacuation departure time, as well as predict their anticipated departure time for each condition. Following that, participants were asked to rank their preferences regarding the evacuation route from six route characteristics, including most familiar, least congested, shortest by distance, on high ground, recommended by Google Maps, and taken by neighbours. Participants were also given the option of stating their preferred (i.e., distinct from the given list) route and ranking it. However, this data was excluded from the analysis, because only four participants reported a preferred route, which was an inadequate number of responses to be considered. At last, participants were asked to rate the influence of the PADM variables on their compliance with evacuation routing instructions.

Procedures

PADM is a theory that can be employed as the foundation for designing a conceptual model of human behaviour and decision-making during the time before evacuation in an emergency (Lindell & Perry, 2012). According to Lindell et al. (2019), PADM is a suitable framework for studying human behaviour during a flood evacuation. Following a within-subject design, this study explored how the different PADM-derived conditions affect evacuation delay time, compliance with evacuation departure time, and compliance with routing instructions. The PADM-derived conditions employed to study evacuation delay and compliance with departure time are as follows:

Condition 1: Noticing heavy rainfall accompanied by gradually rising, visible, flood level.

Condition 2: Seeing neighbours staying at home (noncompliance influence).

Condition 3: Seeing neighbours evacuate (compliance influence).

Condition 4: Receiving information on a shorter evacuation distance to the shelter (2.5 km).

Condition 5: Receiving information on a longer evacuation distance to the shelter (5 km).

Condition 6: Receiving information indicates heavy congestion with the warning message.

Condition 7: Receiving information indicates moderate congestion with the warning message.

Condition 8: Receiving the evacuation warning from an official government siren, instead of by text message.

Condition 9: Receiving the evacuation warning from social media instead of receiving it from official government sources.

Similarly, the PADM-derived conditions employed to study compliance with routing instructions are as follows:

Condition 1: Noticing heavy rainfall accompanied by gradually rising, visible, flood level.

Condition 2: Seeing other vehicles take the suggested route per the evacuation instructions (compliance influence).

Condition 3: Seeing other vehicles take a different route to the evacuation instructions (noncompliance influence).

Condition 4: Noticing congestion on the instructed route.

Condition 5: Availability of another evacuation route, distinct from the instructed one, which is more familiar.

Considering that the factors influencing driving behaviour, including route familiarity and traffic conditions (Wu, et al., 2012; Bian, et al., 2023), differ from those associated with pedestrian behaviour, PADM-derived conditions were modified as appropriate. The flood evacuation scenario included receiving an evacuation warning by a text message while at home, hence, multiple warning sources (i.e., social media or official siren), along with being informed about evacuation distances (i.e., shorter or longer distances) and traffic conditions (i.e., moderate or heavy congestion) presented in the warning message, were excluded from studying driver compliance.

The talk-through sessions were conducted online or in person, depending on the participant's preference and availability. A partial counterbalancing strategy was applied, producing two forms in which selected questions were reversed to minimise order effect. To elaborate further, in the “message content” conditions, half of the participants answered the “heavy congestion” condition first and, after that, answered the “moderate congestion” condition, whereas the other half did the opposite. Also, half of the participants answered the “shorter evacuation distance” condition first and, after that, answered the “longer evacuation distance” condition, whereas the other half did the opposite. However, other conditions were not counterbalanced which is considered a limitation to this study. Future studies should apply a more efficient counterbalancing strategy in a within-subject design to control bias. The participants were randomly assigned to one of the forms.

Results

As mentioned, a taxonomy based on the PADM framework was developed to analyse the results.

Evacuation Delay Behaviour

The repeated measures ANOVA showed a significant difference in evacuation delay time between the different conditions (F (1,13) =22.546, p <0.001). Paired samples t-tests showed substantial differences between the control condition, in which participants were told they received a warning by text, but no other influences were mentioned, and both social cues (compliance and noncompliance influence) conditions. The social–compliance influence condition showed a substantial decrease in delay time compared to the control condition (mean difference = 5.65, p = .003). In contrast, the social–noncompliance influence condition showed a substantial increase in delay time compared to the control condition (mean difference = 3.77, p < .001). Figure 2 illustrates the average evacuation delay time (i.e., in minutes) predicted by the participants across the PADM-derived conditions.

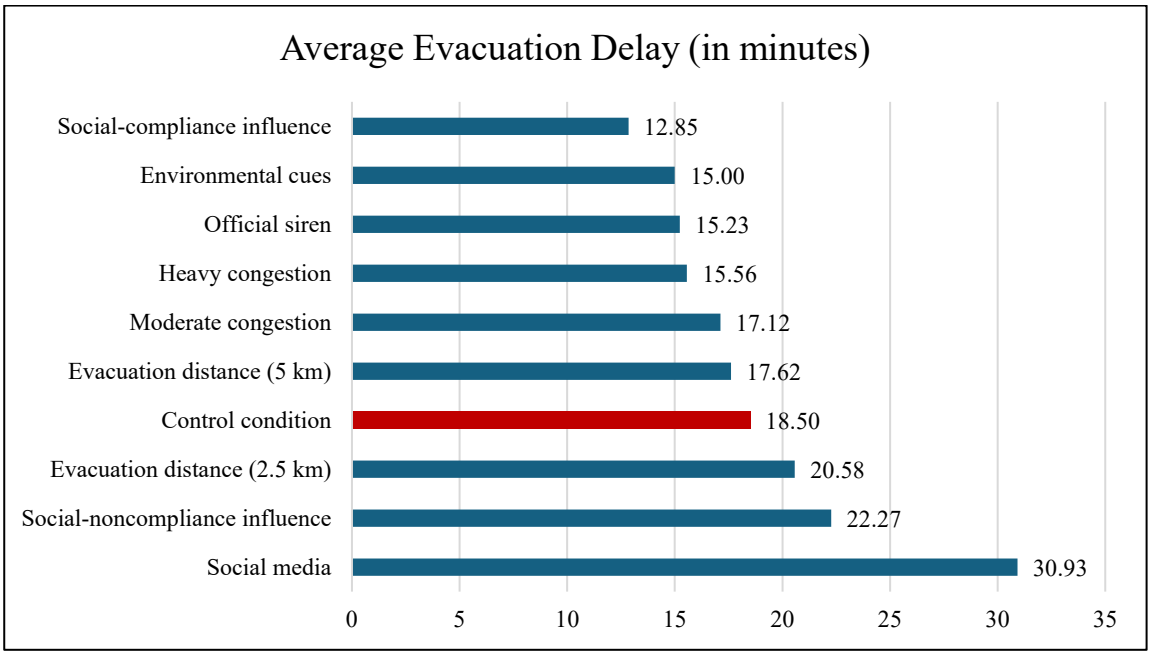

Figure 2: Comparison between the evacuation delay averages in the different conditions

As appeared in Figure 2, the average evacuation delay time was 18.50 minutes in the control condition, highlighted in red. The shortest delay time, reported in the "social-compliance influence" condition, was 12.85 minutes, while the longest anticipated delay time was 30.93 minutes when social media delivered evacuation warnings.

Compliance behaviour

Friedman's tests were employed to evaluate participants' ratings of their anticipated compliance with evacuation departure time and routing instructions across the different conditions. The results indicated significant differences between the conditions in both compliance with departure time ($\chi^2(8) = 87.218$, p<0.001) and routing instructions (χ^2 (4) = 48.877, p<0.001). The Wilcoxon Signed-Rank tests, applying Bonferroni correction, revealed significant differences across many condition comparisons.

For departure time compliance, receiving warnings from social media led to significantly lower compliance compared to social–noncompliance influence (p = 0.001), environmental cues, social–

compliance influence, evacuation distances, and congestion levels (all: $p < 0.001$). Additionally, social-noncompliance led to significantly lower compliance compared to being told about a longer distance to evacuate (5 km), environmental cues (both: $p=0.001$), social-compliance influence, and official siren (both: $p < 0.001$). Finally, being told about a shorter evacuation distance (2.5km) led to significantly lower compliance compared to social-compliance influence and environmental cues (both: $p < 0.001$). Figure 3 illustrates the median values for the rating scores across the PADM-derived conditions.

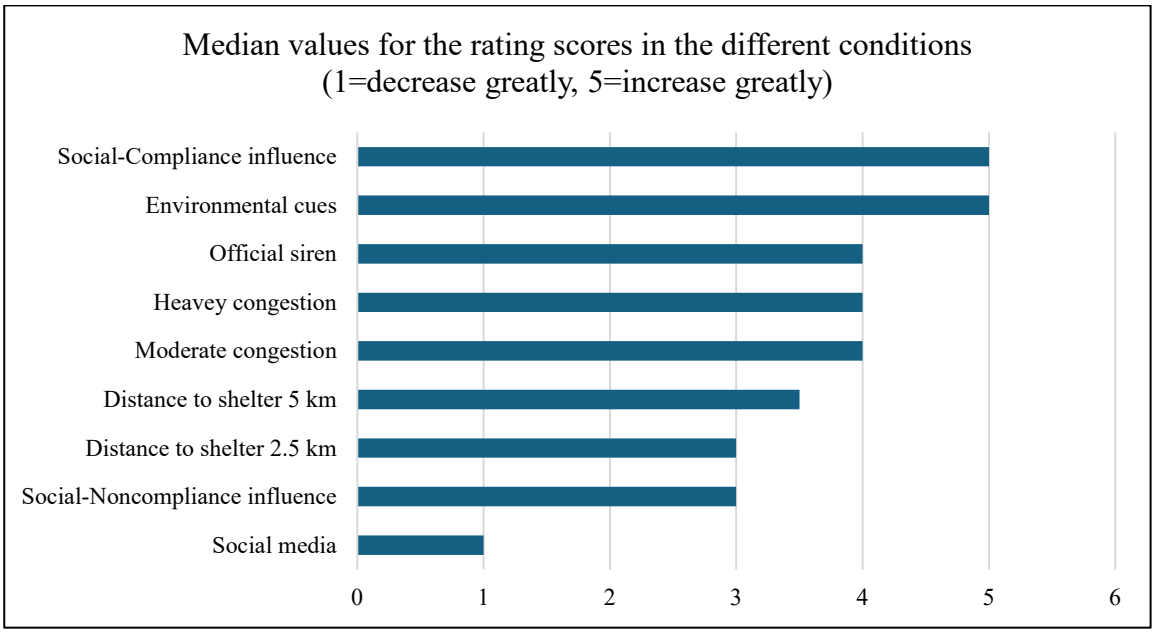

Figure 3: Median values for the rating scores measuring the influence of the PADM variables on compliance with evacuation departure time

For routing instructions compliance, social-compliance influence resulted in greater compliance compared to environmental cues ($p < 0.002$), social-noncompliance influence, congested routes, and familiar routes (all: $p < 0.001$). Furthermore, familiar routes led to a marked reduction in compliance relative to environmental cues ($p < 0.004$). Figure 4 illustrates the median values for the rating scores across the PADM-derived conditions.

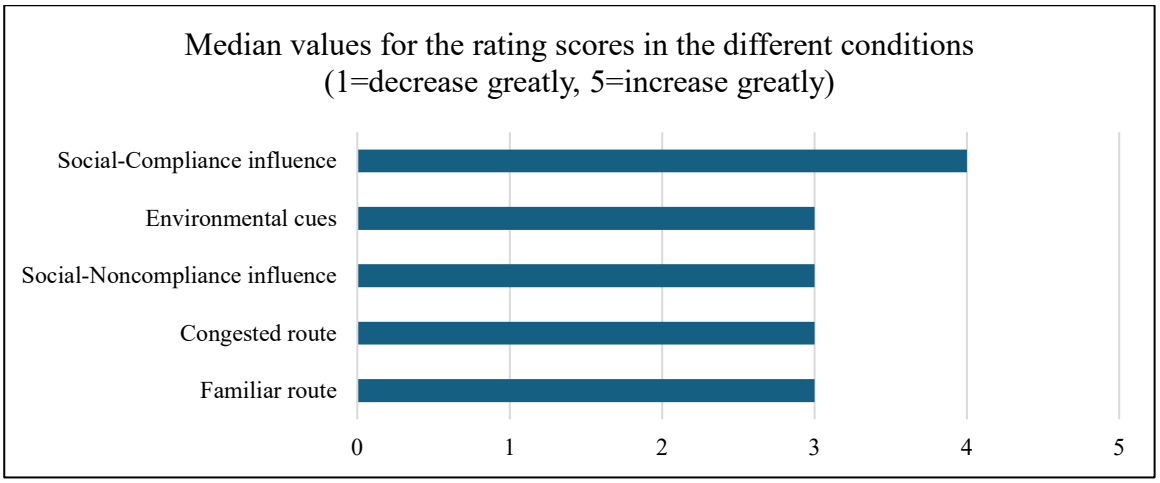

Figure 4: Median values for the rating scores measuring the influence of the PADM-derived variables on compliance with evacuation routing instructions

Evacuation routing preferences in floods

Participants were asked to rank their preferred evacuation route from a given list of route characteristics (familiar, least congested, shortest by distance, on high ground, Google Maps, and neighbours take). Ranking scores take values from 1 to 6, in which 1 reflects the most preferred evacuation route. A Friedman's test was employed to evaluate ranking values across the different evacuation routing characteristics. The results indicated a significant difference between the conditions ($\chi^2(5) = 19.125$, $p < 0.002$). The Wilcoxon Signed-Rank tests, with Bonferroni correction employed, showed that evacuees significantly preferred familiar routes and the shortest (by distance) routes over those taken by neighbours ($p = 0.002$ and $p = 0.003$, respectively). Figure 5 illustrates the median values of the rankings of evacuation routing preferences.

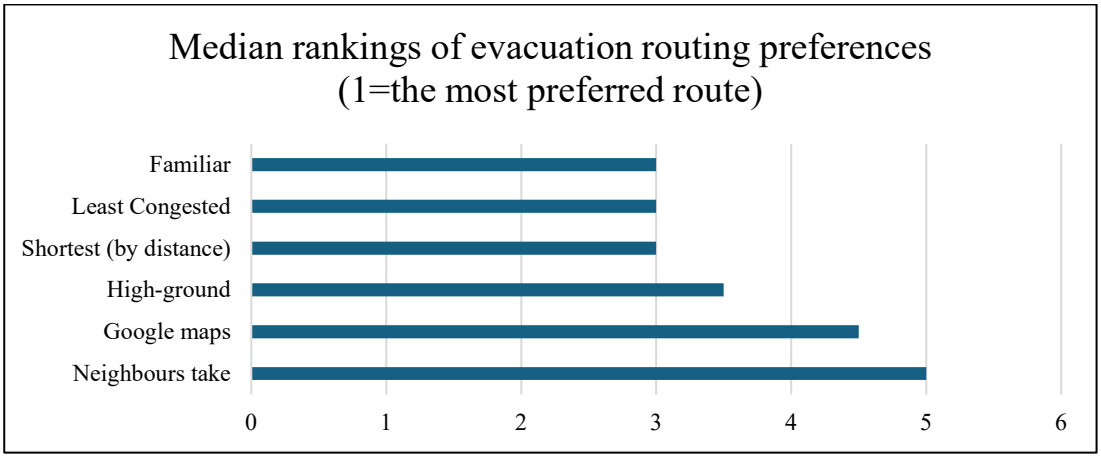

Figure 5: Median values of the rankings of evacuation routing preferences

Remarkably, data analysis suggests that social cues are highly influential on compliance behaviour and time to leave; however, when it comes to preference, evacuees would prefer to take familiar or shortest (by distance) routes. This result is consistent with previous findings, in which route choices are based on the routes located within a short distance or well-known routes (Charnkol et al., 2007; Sadri et al., 2014; Whitehead et al., 2001). Additionally, route familiarity and route choice influence driving compliance greatly, as evacuees tend to follow familiar roads and motorways in emergency evacuation (Chiu & Mirchandani, 2008).

Behavioural pattern in flood evacuation – sequence of acts

Bakeman and Gottman's (1997) approach to analysing the sequential data, which explores behaviour resulting from events as they develop over time, was employed. Notably, no previous study analysed the sequential data during a flood evacuation, representing an additional contribution to this study. Sequential analysis is an efficient approach to identifying behavioural patterns, which offers valuable insights for emergency responders to organise people's responses to a flood evacuation event. It can detect and uncover people's perceptions and decision-making processes under risky situations.

It is essential to compute the transitional probabilities to identify the most probable behavioural pattern in a flood evacuation. Transitional probability is considered one kind of conditional probability, describing the probability of the target event B occurring immediately after event A (Bakeman & Gottman, 1997). Results show that the most probable behavioural pattern in a flood evacuation would include communicating with household members (A), collecting belongings and emergency supplies (D), getting into the car (B), and then heading to the safe point (H), as illustrated in Figure 6.

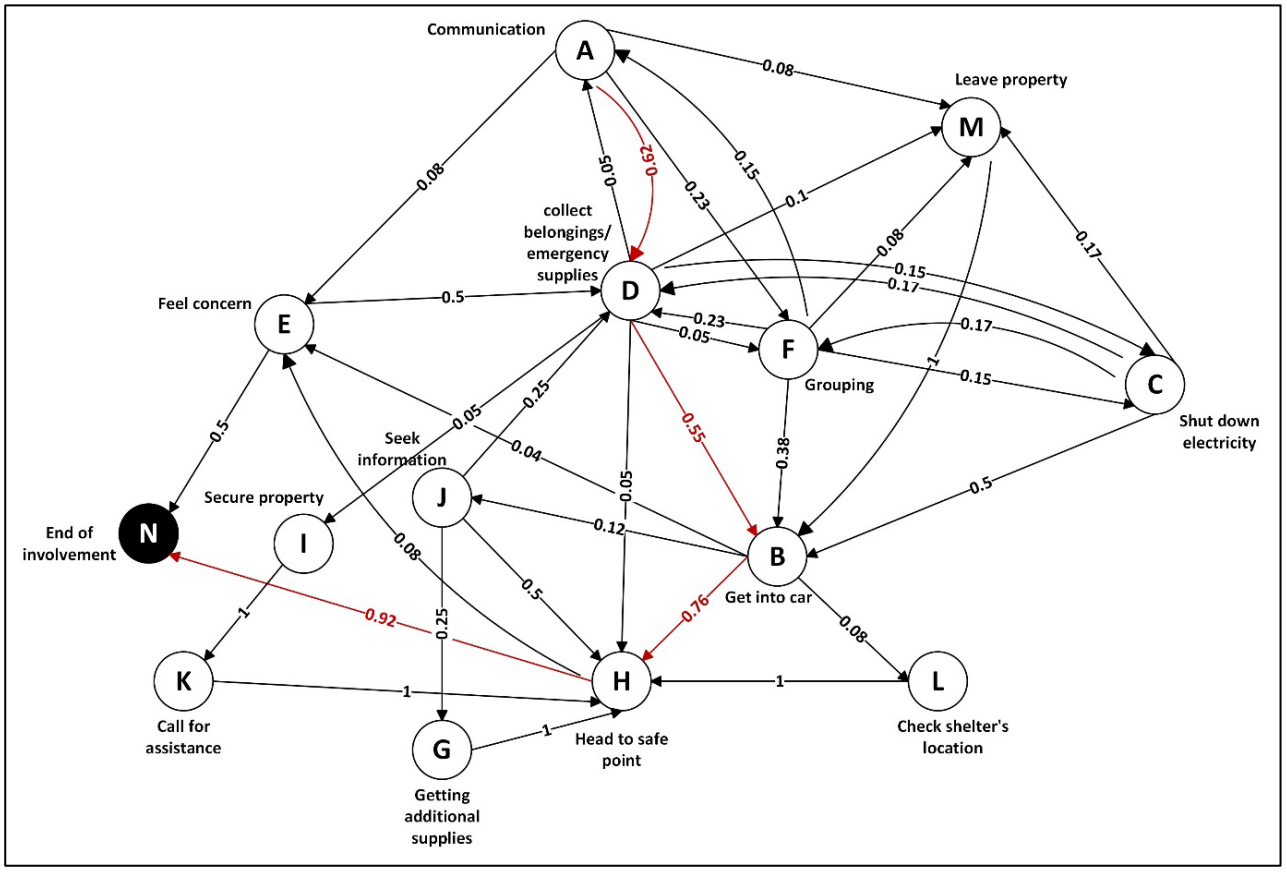

Figure 6: State transition diagram

Conclusions

This research has established the likely compliance behaviour concerning evacuation time and route choice, under different influences based on the PADM framework. Social cues, specifically noticing others complying, were the most effective factor in reducing evacuation delay time and enhancing compliance with evacuation orders. This was followed by environmental cues, specifically heavy rainfall and rising flood water. However, without any routing instructions or specific cues, evacuees ranked familiar and shortest (by distance) routes as more preferable than those taken by neighbours. No significant differences were seen for least congested, on high ground or recommended by Google Maps routes. This work highlighted the need for further research to study drivers' compliance, addressing route choice under multiple information sources and message content influences while travelling.

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