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In an emergency evacuation situation what would you do?

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Abstract

This paper explores the responses of train passengers to an open ended question ‘In an emergency evacuation situation what would you do?’ A survey of 796 train passengers shows that respondents are more likely to depend on instructions from train station staff or public announcements rather than being active and evacuating quickly or alerting/inquiring emergency personnel. Male respondents displayed more active behaviors than their female counterparts. Passengers were also willing to assist women, children and elderly in evacuation, therefore displaying cooperative behavior. The findings are consistent with the predictions from some of the theoretical models on emergency evacuation as well as observations from documented crowd disasters, suggesting that questionnaire survey could be a useful method to supplement our understanding of complex and rare events like emergency evacuation. However, some of the observed behaviors in some of the past incidents like ‘pushing’, and ‘overlooking alternative exit’ were not recorded because of social desirability bias or because of their low likelihood, especially in unprompted responses.

Our findings suggest that it would be very important to ensure that all station staff received proper training on emergency evacuation. Their roles and responsibilities regarding the management of the emergency situation in the train station have to be clearly communicated. Further, appropriate campaigns need to be conducted for passengers to make them aware of the importance of being proactive by using red emergency call buttons, calling 000 (emergency services number) to ask for help or going to the assembly area/safe place immediately.

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1. Introduction

Passengers' movement is a major component of the transportation system. Over the past decade, there have been considerable efforts on the development of evacuation management systems and plans to respond effectively to natural disasters, terrorist attacks or other emergencies occurring in the underground train stations (Drury et al., 2009; Fridolf et al., 2013; Shiwakoti et al., 2018). In the recent past, there have been several accidents in major train stations and tunnels that have prompted the evacuation of passengers, resulting in fatalities and injuries (Shi et al., 2012; Fridolf et al., 2013). Therefore, it is essential to understand the behavior of passengers to be able to increase the efficiency and safety of railway station design, and develop better evacuation and crowd management plans (Fridolf et al., 2013; Shiwakoti et al., 2016).

Although existing studies on passengers evacuation have been studied from different perspectives, such as mathematical model/simulation, controlled laboratory experiments, evacuation drills, and socio-psychological studies of documented crowd disasters (Fridolf et al., 2013; Shiwakoti et al., 2008; Shi et al., 2016), limited studies have been conducted on questionnaire survey to gauge the likely behavior of passengers in case of an emergency situation. Due to the complexity and rare nature of emergency evacuation, the existing studies have all examined only some critical aspects of the problem but with some limitations. More research using different approaches such as questionnaire survey is needed to complement and supplement the existing research and advance our understanding of this critical issue (Shiwakoti et al., 2017).

One of the fundamental questions that needs attention is 'To what extent does the results from a questionnaire survey reflect the actual behaviors that have been observed in the documented passenger crowd evacuations or the simulation models' prediction?' Although insightful, the information gathered from survey comprises self-reported behavioral intentions and not actual behaviors. Although self-reported intentions have been found to be reliable and valid for many consumer and driving behaviors, their reliability and validity for rare events have not been demonstrated. Validity and reliability are critical if data on perceptions and beliefs of passengers on evacuation procedure and behavior collected through survey is to be used to develop or verify simulation models, theoretical behavioral models or design solutions for crowd management. In order to address that gap, we examine the likely responses of passengers in case of an emergency evacuation in an underground train station via an open ended question. Particularly, we investigate how the self-reported responses correspond to previous findings from documented passenger crowd evacuations and predictions from theoretical or simulation models.

The structure of the paper is as follows. The next section on literature review describes the findings from the previously documented passengers' crowd evacuation. It is then followed by the description of our survey and research methodology. Key findings and discussion of results are presented next, which is followed by the conclusions.

2. Literature Review

Existing studies on passenger crowd evacuation have focused mainly on the development of mathematical model/simulation, (Galea and Galparsoro, 1994; Shiwakoti et al., 2008) because replication of emergency situations in controlled laboratory experiments is difficult due to ethical and safety concerns (Shi et al., 2015). Therefore, most model predictions for crowd behaviors under emergency condition have been verified visually through computer graphics (Shiwakoti et al., 2011; Dias et al., 2014; Shi et al., 2016). Without the verification with complementary data on emergency situation, and thus it is difficult to gauge the reliability of these mathematical models. Socio-psychological studies have looked qualitatively at the human behavior based on previous crowd disasters (Chertikoff 1999; Mawson 2007). However, such studies lack the systematic analyses needed to understand and quantify crowd behaviors under emergency conditions, which is important to develop the appropriate simulation model.

Through the detailed review of the literature, it is observed that there are several recurring debates and uncertainties regarding the likely strategies and behaviors of people under emergency conditions. Those behaviors can be summarised as follow:

2.1 Herding behavior

Several studies of documented crowd disasters have stated that people have the tendency to follow the other people, displaying a herding behavior (Chertkoff & Kushigian, 1999; Helbing et al., 2002; Pelechano & Malkawi, 2008). The most common reactions of people when an emergency event occurs are anxiety (panic) and fear. As such, people cannot make personal decisions, leading them to follow other passengers (Helbing et al., 2002; Pan et al., 2006; Dell'Olio et al., 2013). This behavior may lead them to overcrowd parts of the station or block exits (Dell'Olio et al., 2013). As the evacuation is delayed due to blockage, the desire to get out quickly may lead to pushing behavior, and trampling or stampede can happen at the exit (Helbing et al., 2002; Dell'Olio et al., 2013). Also, herding behavior may lead passengers to overlook alternative exits during emergency situations (Helbing et al., 2002). Computer simulations have shown that neither individualistic nor herding behavior performs well, and that optimal chances of survival are expected for a certain mixture of individualistic and herding behavior (Helbing, 2012).

2.2 Cooperative behavior

Researchers are still equivocal about whether people under emergency situation will display pushing behavior, or cooperative behavior by remaining calm and helping others. While in some crowd disasters and evacuation, pushing behaviors have been observed (Helbing et al., 2002; Schadschneider et al., 2009; Twarogowska, 2014), in other cases people have shown cooperative behavior (Sime, 1995; Chertkoff & Kushigian, 1999; Mawson, 2007; Cocking et al., 2009; Drury et al., 2009). Also, previous studies of behavior during emergencies have noted that social bonds within groups are sustained, with people delaying their individual egress to ensure safe evacuation of the group as a whole (Sime, 1995; Cornwell et al., 2001; Cocking et al., 2009). The affiliative model developed by Sime (1983, 1985) highlights that people are more likely to be drawn to places or people that are familiar to them. Therefore, people avoid unfamiliar escape routes simply because they are unfamiliar (Fridolf et al., 2013).

2.3 Role-rule governed behavior

The role-rule behavioral model, which has been developed with learning from several documented evacuation studies (Fridolf et al., 2013), states that how a specific person responds to a threat (e.g., fire) will depend highly on the role of the person (e.g., if he or she is a staff member or a passenger). For example, awareness of the evacuation procedure in a train station can be associated with the rules linked to the roles of train station staff members. In contrast, passengers may not be aware of the emergency evacuation information tools and procedures as they tend to rely on the instructions from staff members or the relevant authority before seeking additional information during evacuation. This reactive nature of relying on information from station staff or emergency personnel can create negative consequences (Fridolf et al., 2013).

2.4 Active behavior

In several evacuation incidents, rather than waiting for instructions, people were proactive and moved to exits quickly and also used the emergency call buttons once they were aware of the emergency situation (Fridolf et al., 2013). The proactive approach of passengers has been observed not only in underground transportation but also in aircraft evacuation as observed in the China Airlines CI-120 accident (Chang & Yang, 2011).

2.5 Demographics related behavior

Several studies show that demographics characteristics, such as gender and age, have an influence on passengers' behavior during emergency situations. For instance, a study conducted by Enarson (2006) in California concluded that females were more risk averse and seek out information more than males during disasters. Also, the same study found that males tended to disregard evacuation orders. Furthermore, females were found to be more likely than males to follow what other passengers do. This behavior might be due to different risk perception and attitudes. Enarson (2006) believes that males are more risk takers, while females are more risk avoiders. Kanno et al. (2006) reviewed 12 different disasters and found that, compared to younger people, elderly people showed more

reactive behaviors and intended to wait for instruction during an emergency.

3. Method

Our review of the literature reveals that there are several recurring behaviors of people under emergency conditions. There are also uncertainties regarding the likely strategies of people during evacuation. This study will contribute to the literature by examining several key issues from the evacuee's perspective. If the findings from the survey are consistent with those documented behaviors of people under emergency conditions, data collected from the survey can be a valuable resource to develop simulation models or design solutions for passenger crowd management plans at underground train stations. Rather than a controlled experiment, this survey has been designed to capture respondents' likely responses upon hearing the fire or emergency alarm. So, the responses captured are for an emergency situation that is not very specific and not well controlled nor informed. This scenario is very common in many emergency situations in underground train stations, occurring in the initial period before more information is provided by the authorities (Fridolf et al., 2013), and thus can be used to examine people's initial reactions to the emergency alarm. The passengers often do not know initially whether the situation is a fire drill or a real emergency; or whether it is a fire, hazardous material spill, terror attack or other emergency.

3.1 Passenger survey

An open ended question 'In an emergency evacuation situation what would you do?' was asked to the passengers in an underground train station to investigate the passengers' response during an emergency situation. Melbourne Central Railway Station (MCRS), an underground train station inside a shopping centre in Melbourne, Australia, was selected for the survey. It serves an annual patronage of nearly 16 million. As MCRS is conveniently located with access to many amenities, including universities, hospitals, shopping centres, parks and restaurants, there was an opportunity to get a diverse range of respondents in terms of age and gender. Also, all the major train lines originating from or entering into the Melbourne CBD pass through MCRS. Relevant ethics clearance for the survey was obtained from the University Human Research Ethics Committee.

There were other closed ended Likert scale questions regarding the passengers understanding of the evacuation procedure and way finding. Here we report only the findings from the open ended question. The findings from the closed ended questionnaire have been described in other works (Shiwakoti et al., 2016, Shiwakoti et al., 2017).

3.2 Participants

In total, 796 valid responses were collected for the survey. Of the 796 respondents, 48.4% were males while 51.6% were females. In terms of age distribution, 49.5% of the respondents were in age group 1 (18–25 years), followed by 23.6%, 9.8%, 7.8%, 5.3% and 4.1% respectively for age group 2 (26–35 years), 3 (36–45 years), 4 (46–55 years), 5 (56–65 years) and 6 (above 65 years). This skewness in age distribution of participants could be due to the several universities adjacent to the MCRS attracting a high volume of students through MCRS. Also, Metro Trains' requirement to conduct the survey only from 10 a.m. to 3 p.m. restricted the surveying of peak hour morning and evening commuters.

3.3 Data analysis

We analysed the open ended information using thematic analysis in QSR NVivo software. This software has been widely used for qualitative data analysis (Johnston, 2006). The thematic analysis assists in the identification and exploration of major themes across the recorded information in a systematic manner (Braun and Clarke, 2006). First we generated a word cloud diagram (Fig. 1) using word frequency query. We limited the search for 1000 word frequency with minimum of three character length. This word cloud diagram was very useful in identifying the theme or response category based on the frequency of words used.

As can be seen in Fig. 1, some of the most frequently used words were 'follow' 'instructions', 'emergency', 'exit', 'listen', 'announcement' 'nearest' 'run', 'crowd', 'look', 'staff', 'wait' 'find', 'signs'. Also, there were words

instructions from station staff (43%) as compared to follow other people or the crowd (18%).

The respondents in age group 56-65 and above 65 tend to display more reactive behavior as compared to the other age groups. The age groups 36-45 and 46-55, and particularly males, tend to display active behavior as compared to other age group. Overall, males display more active behavior than female counterparts.

Table 1. Distribution (%) of behavioral responses by age and gender (M: male, F: female) groups

Age	18-25		26-35		36-45		46-55		56-65		Above 65		Total M	Total F	Total
Gender	M	F	M	F	M	F	M	F	M	F	M	F			
Total number of responses	191	209	85	98	37	41	33	32	22	19	14	15	382	414	796
Response Category															
<u>Active</u>															
a) Move/run to exits or nearest exits or evacuation sign/ assembly area	38	30	36	31	53	25	55	21	30	32	14	7	39	29	34
b) Use emergency button/call 000(emergency services) or police/ask for help	7	5	13	4	1	2	3	3	1	5	1	13	6	4	5
<u>Reactive</u>															
a) Wait/listen for public announcement or station staff instructions	38	41	36	50	39	43	33	61	52	53	71	60	40	46	43
b) Follow other people or crowd	17	24	15	15	8	30	9	15	17	11	14	20	15	21	18

The observations from this study that people will wait for instructions from station staff or the PA supports the role-rule governed behavior proposed in the literature. The passengers perceive that staff or emergency personnel at train station have the role to evacuate them safely as illustrated by some of the typical comments below:

“I would need to have instructions to be given to me by the PA to know what to do. Since I always take the same route and do not know the evacuations plans set up in the station.”

“I imagine there would be staff directing people or a voice over announcement. I would follow the instructions provided.”

“Wait for directions from an authoritative figure/listen out for announcements.”

Risks may increase if the station staffs expect passengers to take necessary actions and follow emergency

procedures; i.e., move quickly to the exit or safe place/assembly area. Any gap in achieving these expectations may create substantial delays in the evacuation process which can result in negative consequences. One particular example that is relevant to this observation is the findings from the study on evacuation of passengers due to fire at King's Cross Underground Station in London in 1987 where thirty one people lost their life in the incident. The study revealed that the passengers' behavior initially changed very little or not at all even though they received cues from the fire. They evacuated only when instructions to evacuate were received from the station staff or until they received very clear evidence about the fire (Fridolf et al., 2013).

It should be acknowledged however that delay in the evacuation process can be due to reasons other than waiting for station staff to give instructions. One key observation that has been noted in the literature is 'task fixation' behavior (Johnson 2005). Some people tend to be so pre-occupied with other tasks (e.g. sending emails/SMS, eating) that they may underestimate the urgency to evacuate unless they receive authoritative instructions from the station staff or observe strong incentives to evacuate (e.g. seeing people running or fire clearly visible).

Also, the literature suggests that different methods of instruction and its effect to passengers' behavior need to be examined to determine the optimum method for communication with the passengers. For example, a study was conducted at the underground Monument Station in the UK to assess the impact of different methods of instruction on passengers' behavior during evacuation (Sime 1999; Proulx and Sime, 1991). The study assessed five evacuation scenarios which involved using different combinations of tools such as an alarm bell, a PA system and station staff. It was observed that when only the alarm bell was used, none of the passengers started evacuation. However, in another scenario, which involved the alarm bell with two station staff members and directive public announcements, was found to be the most effective method to conduct the evacuation. Also, in the case that there was no well-trained staff, the study showed that using the alarm bell with comprehensive messages over the PA system that included explaining the situation plainly such as using the statement "suspected fire", specifying the location of the danger and listing the recommended actions, had bigger impact on passengers' behavior as they dealt with the situation more seriously and followed the instruction promptly (Sime 1999; Proulx and Sime, 1991).

Therefore, our findings suggest that it would be very important to ensure that all station staff received proper training on emergency evacuation. Their roles and responsibilities regarding the management of the emergency situation in the train station have to be clearly communicated. In addition, there is strong need to put in place an appropriate evacuation management plan that considers the clear identification and strategic location of station staff to facilitate the evacuation process. This will minimise the time lost to initiate the evacuation. Further, appropriate campaigns need to be conducted for passengers to make them aware of the importance of being proactive by using red emergency call buttons, calling 000 to ask for help or going to the assembly area/safe place immediately. As pointed out by one of the respondents, this sort of campaigns can occur inside the train carriages:

"I think all carriages should have either a screen or telling people what to do in case of an emergency like all aeroplanes."

The other observation that we could infer from the responses was that respondents tend to underestimate the consequences of the emergency evacuation. Although the respondents mention that they would follow other people (herding behavior), there was hardly any response as to whether they would look for alternative exits if the main exit is crowded. Previously documented crowd disasters have shown that such herding behavior delays the evacuation process as people overlook the alternative exits. The delays make evacuees impatient leading to pushing behavior and ultimately deadly consequences like stampede (Helbing et al., 2002). One of the reasons why respondents do not perceive the negative consequences could be the lack of exposure to the emergency evacuation in the past as emergency evacuation is a rare event, as expressed by some respondents:

"I have never thought about a safety evacuation, especially not at Melbourne Central, so I have no clue (that freaks me out)."

"I haven't experienced any emergency situation at the train station. When this happens, I guess I will probably follow other passengers or try to find staff working at the station"

“I have no idea. I haven't been through that situation yet.”

“Never had thought about this but most probably would try to listen for the instructions by management”

Although there is a debate on whether people display competitive behavior (pushing) or cooperative behavior (helping others) in emergency evacuation (Shiwakoti et al., 2017), some of the responses from the survey tend to align with cooperative behavior where the respondents mention that they will remain calm and help others:

“First figure out what need to be done, where we need to go then help women, children and the elderly get out first”

“Be calm, help the elderly and children. Wait for instructions.”

“Try to evacuate the safely making sure to help elderly/children”

“Look to staff for guidance and assistance and try to assist elderly people”

The cooperative behavior has been observed in several emergency evacuations in the past. For example, one study that examined the London underground train bombings mentioned that people's behavior during the incident was to a large extent orderly and calm, and no evidence of selfish and uncooperative behavior was observed (Cocking et al., 2009). In another study that looked into evacuation from the 9/11 World Trade Centre, it was found that mobility-impaired occupants were carried down many flights of stairs by other occupants (Johnson, 2005).

Interestingly, the danger of pushing behavior at the exit was not mentioned by any respondent in this study. This result may be due to social desirability bias on the part of the respondents, the low likelihood associated with such behaviors, or a combination of both reasons, especially in unprompted responses.

The observation that male respondents displayed more active behavior than female counterparts supports the previous theory of different risk perception and attitudes among males and females. Past studies on disasters have shown that males are more likely to be risk takers, while females are more likely to be risk avoiders (Enarson, 2006). Therefore, as risk takers, males may be engaged in active behavior (Kanno et al., 2006). Hence, the implementation of education campaigns targeted to each gender may be an effective strategy towards achieving efficient evacuation process.

5. Conclusions

The responses from our survey align with the findings from some of the theoretical models (e.g. role-rule model, active/reactive behavior, cooperative behavior) on emergency evacuation as well as documented crowd disasters. Therefore, the questionnaire survey can be a useful method to supplement our understanding of complex and rare events like emergency evacuation.

It was found that passengers tend to display more reactive behavior by depending on the instructions from the station staff and PA announcement rather than evacuating quickly or alerting emergency personnel. Therefore, appropriate training of station staff to handle the emergency evacuation process and education campaigns for the passengers to follow the emergency evacuation procedure should be conducted to minimise the evacuation delays and improve the efficiency of the evacuation process.

Further, the respondents are more likely to undertake cooperative behavior by helping others. There are also certain observations which we could not capture through the survey. We found that people tended to underestimate the likelihood and consequences of the evacuation, and observations like ‘pushing behavior’ and ‘overlooking the alternative exit’ which led to stampede in some evacuation incidents in the past could not be noted in our survey. This result may be due to social desirability bias on the part of the respondents, the low likelihood associated with such behaviors.

It should be noted that the survey questions did not specify a particular threat. Instead, passengers were asked in general about their likely behaviors in case of emergency. Hence, in future work, it is suggested to specify the type of threat as passengers might have different reactions depending on the type of threat. Also, due to the limitation of self-report questionnaire, the responses of passengers in the survey may not fully reflect their actual behavior during

real life emergency situation as human behavior may vary under stress. Furthermore, the likely behavior of people with limited mobility during emergency was not specifically addressed in the research. Future studies should consider such behaviors in order to develop sound evacuation plans. Finally, the research was conducted mainly based on data collected from the survey of Melbourne Central train station. In future, data from other geographic regions may increase confidence in our findings.

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