Australasian Transport Research Forum 2016 Proceedings
16 – 18 November 2016, Melbourne, Australia
Publication website: http://www.atrf.info

Exploring passengers' behaviour in an underground train station under emergency condition

Nirajan Shiwakoti[1], Richard Tay[2], Peter Stasinopoulos[1], Peter Jarrod Woolley[1]

[1]School of Engineering, RMIT University, Carlton, Victoria, 3053, Australia

[2]School of Business, IT & Logistics, RMIT University, Melbourne, Victoria 3000 Australia

Email for correspondence: nirajan.shiwakoti@rmit.edu.au

Abstract

Passenger crowd behaviours and safety under emergency situation in train stations have been a major challenge in theory and practice. In past, several natural or man-made disasters in major train stations have prompted the mass evacuation of passengers, resulting in fatalities and injuries. This paper explores the behaviours of train passengers in an emergency evacuation and examines two crucial theoretical issues on the passengers' evacuation that includes reactive vs. proactive behaviours and cooperative vs. competitive behaviours. Further, passenger perceived ability to get out safely during an emergency is also examined.

Based on a survey of 1134 train passengers, it was found that respondents were, on average, more likely to be reactive (e.g., wait for instructions over the public address system) than proactive (e.g., use emergency button) in an emergency situation. Interestingly, over 90% of the respondents feel that they can get out safely in case of emergency evacuation. In terms of demographic differences in behaviors, results from the ordered logit models demonstrate that there are significant differences in the evacuation behaviours between males and females but not among the different age groups. Compared to females, males were less likely to use emergency call buttons, call the emergency phone number or wait at the assembly area. Also, males were more likely to display competitive behaviour in the event of an emergency evacuation.

Our findings can assist managers of emergency response in developing appropriate strategies and training, and in designing solutions and education campaigns for efficacious evacuation. Further, the results are valuable resource for developing mathematical models intended to simulate passengers' evacuation in a train station.

1. Introduction

There has been considerable attention on the development of evacuation systems and plans to respond effectively to natural disasters, terrorist attacks or other emergencies occurring in the multi-modal transport (Lambert et al., 2013). In particular, passenger crowd behaviours and safety under emergency situation in train stations are important challenges for transit agencies around the world (Drury et al., 2009; Fridolf et al., 2013). Suburban railways and subway systems are important contributors to the movement of people in many of the world's large cities. For example, Flinders Street Station in Melbourne, Australia, serves an average of 100,000 passengers daily but with significantly higher crowds during special events and unexpected service disruptions (Davies 2008; Pender et al., 2013; Pender et al., 2014; Shiwakoti et al., 2016). These transport hubs pose a significant challenge in the management and security of a large volume of passengers in a confined and complex space (Johnson, 2008; Leurent, 2011; Kim et al., 2015). In the recent past, there have been several natural or man-made disasters that have prompted the evacuation of passengers in major train stations, resulting in fatalities and injuries (Shi et al., 2012; Fridolf et al., 2013).

Existing studies on passenger crowd evacuation have focused mainly on the development of mathematical model/simulation, controlled laboratory experiments, evacuation drills, and socio-psychological studies of documented crowd disasters (Daamen, 2004; Shiwakoti et al., 2008; Fridolf et al., 2013; Shiwakoti et al., 2011; Dias et al., 2012; Dias et al., 2014; Shiwakoti et al., 2015; Shi et al., 2015, 2016). However, controlled laboratory experiments is difficult to replicate emergency situation due to ethical and safety concerns which then have a consequence on the development and verification of mathematical model intended to simulate emergency evacuation. The model's prediction for crowd behavior under emergency condition has been mostly verified visually through computer graphics (Shiwakoti et al., 2008; Shi et al., 2015). Without the verification with complementary data on emergency situation, it is difficult to gauge the reliability of these mathematical models. Socio-psychological studies have looked qualitatively at the human behaviour based on previous crowd disasters. However, such studies lack the systematic quantitative approach on understanding the crowd behaviour under emergency conditions which is important to develop the appropriate model.

Through the detailed review of the literature, it is observed that there are several recurring debates and uncertainties regarding the likely strategies and behaviours of people under emergency conditions. Two important categories are the 'reactive vs. proactive' and 'cooperative vs. competitive' behaviours. Documented case studies of real evacuation in underground transportation systems reveal that different people might be more reactive or more proactive during different emergency situations (Fridolf et al., 2013). In some incidents, people took a reactive approach by not responding to emergency situation even when the emergency alarm went off and evacuated only when the instructions were provided over the public address (PA) system or when they received directions from station staff. Moreover, most people also did not use the emergency call buttons. In other cases, 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.

In terms of 'cooperative vs. competitive' behaviour, previous documented evacuation have demonstrated that people have displayed competitive behaviour like pushing in some cases while in other cases have demonstrated cooperative behaviour by remaining calm and helping others (Chertkoff & Kushigian, 1999; Drury et al., 2009). Several mathematical simulation models have been developed based on the assumption that people will display competitive behaviour during emergency situation (Helbing et al, 2005; Twarogowska et al., 2014). However, researchers are equivocal whether people display competitive or cooperative behaviour under emergency situation.

This paper aims to examine the behaviours of passengers in a train station under emergency evacuation via a questionnaire survey at a major underground train station in Melbourne, Australia. Specifically, we will examine two commonly debated issues in evacuation; namely, proactive vs. reactive and competitive vs. cooperative behaviours. Although questionnaire survey has been popular in transport mode choice analysis (Zheng et al., 2014), behavioural study that has examined the likely behaviour of passengers during emergency evacuation at train stations is limited in literature (Shiwakoti et al., 2017). Due to its complexity, rare and hazardous nature, the existing theoretical, empirical and socio-psychological studies on emergency evacuation 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. The results obtained in this study may be interpreted as likely initial behavioural responses or likely behavioural response under limited or fuzzy information.

The paper is organized as follows. The next section presents the description of the survey. Subsequent sections then describe the data analysis and key results. The final section presents the conclusions and recommendations for future research.

2. Survey

A series of behavioural statements were designed to investigate the passenger's behaviour during emergency situation as well as their perception and ratings of way finding tools at a train station. In this paper, due to space restrictions and scope of the paper, we will present only the results on the passenger's behaviour during emergency situation and not on passengers' ratings of way finding tools.

Melbourne Central Railway Station, an underground train station inside a shopping centre in Melbourne, Australia, was selected for the survey. It serves on average over 55,000 passengers on weekdays. As the station is located right at the centre of Melbourne Central Business District (CBD) with access to many amenities including universities, hospitals, shopping centres, parks and restaurants, there is opportunity to get diverse range of passengers including teenagers, adults and elderly. Further, all the major train lines originating or entering at Melbourne CBD pass through this station.

Permission for the survey was approved from the Metro Trains. Relevant ethics clearance for the survey was sought from the RMIT University Human Research Ethics Committee. Based on Metro Trains suggestion, the survey was conducted in the concourse of MCRS as well as inside the train carriages of different major train lines that pass through the MCRS. Twelve research assistants were deployed for the survey for 6 weekdays starting August 31, 2015. Metro also instructed that the survey was to be conducted between 10 am to 3 pm each day to avoid the peak hour commuters. The participation in the survey was voluntary where the participants self-filled out the anonymous questionnaire. If the participants had questions, research assistant assisted them in clarifying their queries. The survey questionnaire took between 5 to 8 minutes to complete.

To explore the debate on 'reactive vs. proactive' and 'cooperative vs. competitive' behaviours, 10 behavioural statements were developed. The behavioural statements were measured on a 5-point Likert scale: 1 for the very unlikely and 5 for the very likely. Further one behavioural statement on 'get out safely' was also developed to examine passengers perceived likelihood of getting out safely during an emergency situation in a train station. The participant was asked to indicate how likely he/she will do the listed statements when the emergency alarm goes off. Participants were also asked to state their Gender and Age. This survey was designed to capture respondents' likely behaviour upon hearing the fire or emergency alarm and not their responses to very specific and well controlled or informed emergency situation. The scenario is quite common in many real life evacuations where building occupants have little or only fuzzy knowledge of the actual emergency throughout the evacuation process. Table 1 presents the detailed description of the statements, variable name and behavioral classification for 'reactive vs. proactive' and 'cooperative vs. competitive' as used for this study.

In total, 1271 responses were collected. However, some respondents did not fill out several questions. In some cases, respondents chose multiple options. All these cases were considered invalid for the data analysis. Hence, a total of 1134 valid responses were considered for the data analysis. In terms of gender distribution, 48.4% of the respondents were male while 51.6% were female. In terms of age distribution, 49.5 % of the respondents were of age group 1 (i.e. 18-25) followed by 23.6%, 9.8%, 7.8%, 5.3% and 4.1% respectively for age group 2, 3, 4, 5 and 6. This skewness in age distribution of participants (age group 1) could be due to the fact there are several universities adjacent to the MCRS and hence high volume of students travel through MCRS. Also, Metro's requirement to conduct survey only from 10 am to 3 pm restricted surveying peak hour morning and evening commuters.

Table 1: Main variables used in this study

Description	**Variable Name**	**Comments**	**Behavioural classification**
Gender	Gender	Male(M) or Female(F): 1=M; 2=F	
Age	Age	The age group of the respondents. 1: 18-25 years; 2: 26-35 years; 3: 36-45 years; 4: 46-55 years; 5: 56- 65 years; 6: Above 65	
Wait for instructions over the PA (public address) system	Wait For PA	Ranged from 1-5; 1 for very unlikely; 5 for very likely.	Reactive
Wait for directions from station staff	Wait For Station Staff	Ranged from 1-5; 1 for very unlikely; 5 for very likely.	Reactive
Wait at the assembly area until further instructions are given	Wait At Assembly	Ranged from 1-5; 1 for very unlikely; 5 for very likely.	Reactive
Move to the exits immediately	Move To Exits	Ranged from 1-5; 1 for very unlikely; 5 for very likely.	Proactive
Use the red emergency call buttons to ask for help	Use Red Button	Ranged from 1-5; 1 for very unlikely; 5 for very likely.	Proactive
Call 000	Call 000	Ranged from 1-5; 1 for very unlikely; 5 for very likely.	Proactive
Go to the assembly area immediately	Go To Assembly	Ranged from 1-5; 1 for very unlikely; 5 for very likely.	Proactive
Help other people who may have difficulties getting out	Help Other	Ranged from 1-5; 1 for very unlikely; 5 for very likely.	Cooperative
Push or shove other passengers if necessary to get out quickly	Push Passengers	Ranged from 1-5; 1 for very unlikely; 5 for very likely.	Competitive
Get out Safely	Get Out Safely	Ranged from 1-5; 1 for very unlikely; 5 for very likely.	Perceived likelihood of getting out safely

3. Data analysis

In this paper, we present some preliminary analysis of the data from the survey. More detailed statistical analysis of the data is currently underway.

3.1 Descriptive analysis

The collected data were analysed using IBM SPSS Statistics Data Editor which is widely used software for statistical analysis. Figure 1 shows the box- and-whisker plots of the distribution of the responses for each behavioural statement. The cumulative percentage of rating for different variables is presented in Table 2 while the mean, median and mode along with standard error and variance are presented in Table 3.

One thing that is apparent from the box- and-whisker plot is the extent to which the data is located near the median or near the extremes. It is interesting to note that the distribution of scores for variables ‘help other’ and ‘move to exit’ is entirely above 3 (neutral). On the other hand, responses for some items, such as “Call 000”, ‘Use red button’ were quite uniformly distributed. Hence, not only were the responses of individuals in the sample to any likely behaviour not homogenous, the distributions of the responses for different behaviours were also not homogeneous.

As can be seen from the Table 2 and Table 3, the top five most likely behaviours of the respondents were to “Help other people who may have difficulty getting out”, “Move to the exits immediately”, “Wait for the directions from station staff”, “Wait for instructions over the PA system” and “Use red button” respectively. These results indicate that respondents were split on proactive and reactive behaviours with respondents perceive to be more reactive than proactive in emergency situation (more dependent on directions from station staff and instructions over PA system).

Likewise, the highest rating to ‘help other’ and lower rating to ‘push or shove other passengers’ suggest respondents are likely to be co-operative rather than competitive in emergency situation. Further, it can be seen that respondents were confident that they were able to get out safely in emergency situation (over 90% respondents rated likely and very likely). It seems people tend to underestimate the negative consequences of emergency evacuation as they may not have been exposed to real evacuation scenario before. This further supports the previous theories on human cognition ability in disaster. For example, humans have been reported to display both “*abnormalcy bias*” and “*normalcy bias*” (Omer and Alon, 1994). Under this bias, people tend to underestimate the ability of people to function adequately when faced with disaster (referred as *abnormalcy bias*) or people tend to underestimate the probability of disaster (referred as *normalcy bias*).

The documented case study of a fire accident at King’s Cross underground station in London, UK, found that the passengers’ behaviour initially changed very little during the evacuation even though they received cues from the fire and only started evacuating when they were instructed by the ticket collector to evacuate (Fridolf et al., 2013). However, some of the existing mathematical models would calculate the evacuation time without considering the time that might be lost due to the reactive nature of people during emergency situation. The results from this study provided some support for the position taken by some studies on the importance of considering this initial time lost during evacuation in any mathematical or simulation models.

Further, the observation that respondents perceive to be more reactive than proactive in emergency situation support the role-rule model as stated in the socio-psychological literature (Fridolf et al., 2013). The role-rule model states that how a specific person responds to a threat (e.g., fire) will depend highly on the role of the person i.e. whether the person 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 these emergency evacuation information tools and procedure as they tend to rely on the instructions from staff members or the relevant authority before seeking additional information during evacuation. Hence it is quite important that the station staffs receive training on emergency evacuation. Further, clearer roles and responsibilities regarding the management of the emergency situation in the train station should be provided to the station staffs.

The other important issue to investigate is whether there are any differences in the behavior during emergency situation by gender or age. This will be explored by using the logit model as described in the next sub-section.

Figure 1: Box plots showing the likert rating (1 for very unlikely; 5 for very likely) for the different variables

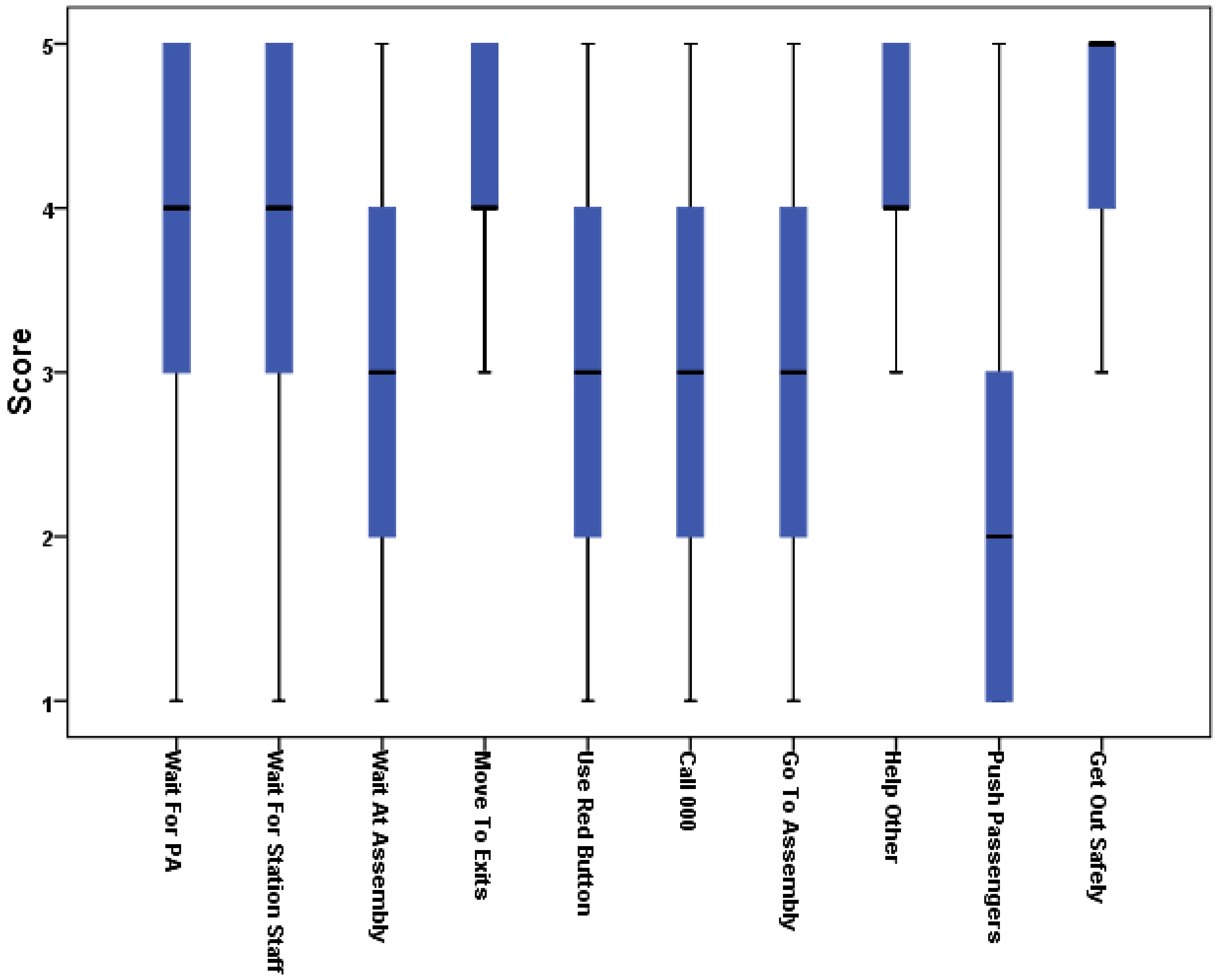

Table 2: Cumulative percentage of rating for different variables

Rating	Wait For PA	Wait For Station Staff	Wait At Assembly	Move To Exits	Use Red Button	Call 000	Go To Assembly	Help Other	Push Passengers	Get Out Safely
	Cumulative %	Cumulative %	Cumulative %	Cumulative %	Cumulative %	Cumulative %	Cumulative %	Cumulative %	Cumulative %	Cumulative %
Very Unlikely	3.2	2.8	12.2	2.3	8.3	11.8	10.3	2.6	48.7	1.5
Unlikely	11.0	10.6	30.9	8.0	26.7	31.4	31.7	6.0	73.5	2.6
Neutral	30.2	27.5	57.9	22.5	51.0	56.1	61.0	22.1	86.8	8.4
Likely	70.1	69.4	82.8	66.8	80.2	79.9	86.1	67.8	95.2	40.5
Very Likely	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100

Table 3: Mean, median and mode of likert score for 'reactive' and 'proactive' variables

Variables	Mean	Standard Error of Mean	Median	Mode	Variance
Wait For PA	3.85	.03	4	4.00	1.07
Wait For Station Staff	3.89	.03	4	4.00	1.03
Wait At Assembly	3.16	.03	3	3.00	1.59
Move To Exits	4.00	.02	4	4.00	0.91
Use Red Button	3.33	.03	3	4.00	1.49
Call 000	3.20	.03	3	3.00	1.67
Go To Assembly	3.10	.03	3	3.00	1.42
Help Other	4.01	.02	4	4.00	0.86
Push Passengers	1.95	.03	2	1.00	1.39

3.2 Gender and age analysis

In this section, we examine the differences in the behaviour during emergency evacuation by gender or age. The likert-type questions as used in this study are measured at ordinal scales where a clear ordering of the category exists and the absolute distances among different category are unknown and not observable. As such methods to model ordinal dependent variables through ordered logistic models have emerged in the literature (Greene & Hensher, 2009; Rifaat et al., 2012; Yasmin et al., 2014).

The logit model that considers the the event of interest in observing a particular score (j) or less is given by Equation 1

$$log(\alpha_j) = \theta_j + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n = \theta_j + \beta X \quad \text{Equation 1}$$

Where,

$\alpha_{j} = P(score \leq j)/(1 - P(score \leq j))$

j=1,…, k-1; k is the total number of categories;
$X_1, X_2, \ldots, X_n$ are *n* explanatory variables;
$\beta_1, \beta_2, \ldots, \beta_n$ are corresponding coefficients.

If we want to indicate that larger coefficients has an association with larger scores (as in this study), we can re-write equation 2 (by changing the sign) for a single independent variable as

$$log(\alpha_j) = \theta_j - \beta X \quad \text{Equation 2}$$

An association with higher scores as in equation 2 suggests smaller cumulative probabilities for lower scores, since they are less likely to occur. A positive coefficient will suggest higher cumulative score are more likely while a negative coefficient will suggest lower cumulative scores are more likely.

Table 4 shows the results from the *logit* model on the gender differences (with Female parameter as redundant for analysis) regarding the likely behavior during emergency evacuation. We could not infer substantial differences in the behavior in terms of age distribution and thus has not been provided. Table 4 only shows the dependent variables that have statistically significant coefficients along with odds ratio.

As can be seen from Table 4, there were significant differences in male and female responses for six dependent variables suggesting the behavior of male and female is likely to be different in emergency evacuation. Also the odds ratio is either bigger than 1 or less than 1 suggesting that male and female are not likely to give the equal ratings for the considered dependent variables.

Compared to female respondents, male respondents in the sample were more likely to adopt a competitive strategy but less likely to wait for instructions from the PA systems or station staff, or wait at the assembly area. Interestingly, female respondents were more likely than male respondents to adopt both a reactive and a proactive strategy. Relative to male passengers, female passengers were more likely to use the red emergency button, call 000, wait for instructions from station staff or PA and wait at assembly area. This result was expected as men had been found to be less likely to ask for direction (Venkatesh & Morris, 2000).

Table 4: Outputs from the *logit* model for gender differences

Dependent Variables	Ordered-logit coefficient* β	Significance (*p-value*)	Odds ratio (*exp* (-β))
Use Red Button	-0.277	0.009	1.32
Call 000	-0.299	0.005	1.35
Wait ForPA	-0.454	<0.001	1.57
Wait For Station Staff	-0.433	<0.001	1.54
Wait At Assembly	-0.21	0.047	1.23
Push Passengers	0.228	0.039	0.80

*Note: * The coefficient are for Male (M=1). Female (F=2) is chosen as redundant and thus the parameter is set to zero for analysis.*

4. Conclusion

Passenger crowd behaviours and safety under emergency situation in train stations have been a major challenge in theory and practice. Previous theoretical and empirical studies have examined some aspects of the likely behaviours of passengers during an emergency evacuation in a train station. Two important categories are the ‘reactive vs. proactive’ and ‘cooperative vs. competitive’ behaviours.

To examine these critical debates, this study conducted a questionnaire survey on the likely behaviours of passengers when the emergency alarm was set off in a major underground train station. Our results showed that respondents were, on average, more likely to be reactive rather than proactive and more likely to be cooperative than competitive. Interestingly, over 90% of the respondents feel that they can get out safely in case of emergency evacuation which perhaps suggests people tend to underestimate the probability of disaster and their negative consequences.

Also, compared to females, males were less likely to use emergency call buttons, call the emergency phone number or wait at the assembly area. Also, as expected, they were more likely to display competitive behaviour in the event of an emergency evacuation.

The results obtained in this study may be interpreted as likely initial behavioural responses or likely behavioural response under limited or fuzzy information. The scenario is also quite common in real life evacuations where building occupants have little or only fuzzy knowledge of the actual emergency throughout the evacuation process. Although the actual behaviours of people may differ when confronted with a real emergency situation, the insights obtained from this study are valuable resources in understanding passengers’ likely behaviours, and developing and verifying mathematical models intended to simulate passengers evacuation in a complex environment like a train station. Further, the findings can assist planners or managers of emergency response in developing appropriate strategies, training, design solutions and education campaigns for effective evacuation.

Acknowledgements

The first author would like to thank RMIT University for Emerging Researcher SEH/SAMME Seed Fund for this project. The authors would also like to thank Metro Trains for the generous support to conduct the survey. The efforts of twelve research assistants in conducting the survey are also appreciated.

References

Chertkoff, J M, Kushigian, H R (1999) *Don't panic: the psychology of emergency egress and ingress* (first ed) Connecticut: Praeger Publishers

Davies, J. (2008) *Beyond the façade: Flinders Street, more than just a railway station*. Publishing Solutions.

Dias, C, Sarvi, M and Shiwakoti, N, and Burd, M (2012) Turning angle effect on emergency egress: experimental evidence and pedestrian crowd simulation *Transportation Research Record 2312*, 120-127

Dias, C., Ejtemai, O., Sarvi, M. and Shiwakoti, N (2014) Pedestrian walking characteristics through angled corridors: An experimental study. *Transportation Research Record: Journal of the Transportation Research Board* 2421, 41-50

Drury, J, Cocking, C and Reicher, S, (2009) The nature of collective resilience: survivor reactions to the 2005 London Bombings. *International Journal of Mass Emergencies and Disasters 27*, 66-95.

Fridolf, K, Nilsson, D and Frantzich, H. (2013) Fire Evacuation in Underground Transportation Systems. *Fire Technology 49*, 451-475.

Greene,H.W and Hensher, A. D (2009) Modeling Ordered Choices: A Primer. Cambridge University Press

Helbing, D., Buzna, L., Johansson, A., and Werner, T (2005) Self-Organized Pedestrian Crowd Dynamics: Experiments, Simulations, and Design Solutions. *Transportation Science 39*, 1–24.

Johnson, W. C (2008) Using evacuation simulations for contingency planning to enhance the security and safety of the 2012 Olympic venues *Safety Science 46*, 302-322

Kim, M., K., Hong, S-P., Ko, S-J. and Kim, D. (2015) Does crowding affect the path choice of metro passengers? *Transportation Research Part A: Policy and Practice 77*, 292-304

Lambert,H.J., Parlak, I.A., Zhou,Q., Miller,S.J., Fontaine,D.M., Guterbock,M.T., Clements,L.,J. and Thekdi,A.,S.(2013) Understanding and managing disaster evacuation on a transportation network Accident Analysis & Prevention 50, 645-658

Leurent, F. (2011) Transport capacity constraints on the mass transit system: a systemic analysis. *European Transport Research Review 3*, 11-21

Omer, H and Alon, N (1994) The continuity principle: a unified approach to disaster and trauma, *American Journal of Community Psychology 22 (2)*, 273–287

Pender, B., Currie, G., Delbosc, A., Shiwakoti, N., 2013. Disruption Recovery in Passenger Railways: International Survey. *Transportation Research Record 2353*, 22-32

Pender, B., Currie, G., Delbosc, A. and Shiwakoti, N., 2014. Social media use during unplanned transit network disruptions: A review of literature.*Transport Reviews 34*(4), 501-521

Rifaat S., Tay R. and de Barros A. (2012) Severity of motorcycle crashes in Calgary *Accident Analysis and Prevention* 49, 44-49.

Shi, C., Zhong, M., Nong, X., He, L., Shi, J and Feng, G. (2012) Modeling and safety strategy of passenger evacuation in a metro station in China *Safety Science 50*, 1319-1332.

Shiwakoti N, Sarvi, M and Rose, G (2008) Modelling pedestrian behavior under emergency conditions – State-of-the-art and future directions, Papers of the Australasian Transport Research Forum 31 Gold Coast : ATRF

Shiwakoti, N, Sarvi, M, Rose, G and Burd, M (2011) Consequence of turning movements during emergency crowd egress *Transportation Research Record 2234*, 97-104

Shiwakoti, N, Sarvi, M, and Burd, M (2014) Using non-human biological entities to understand pedestrian crowd behaviour under emergency conditions *Safety Science 66, 1-8*

Shi, X., Ye, Z., Shiwakoti, N. and Li, Z (2015) A review of experimental studies on complex pedestrian movement behaviors. In CICTP 2015: Efficient, Safe, and Green Multimodal Transportation, 1081-1096

Shiwakoti, N, Gong, Y, Shi, X and Ye, Z (2015) Examining influence of merging architectural features on pedestrian crowd movement *Safety Science 75*, 15-22

Shi, X, Ye, Z, Shiwakoti, N., Tang, D, Wang, C, Wang, W (2016). Empirical investigation on safety constraints of merging pedestrian crowd through macroscopic and microscopic analysis, *Accident Analysis & Prevention 95*, 405-416

Shiwakoti, N, Tay, R, Stasinopoulos, P, Woolley, J.P. (2016) Passengers' awareness and perceptions of way finding tools in a train station *Safety Science* 87, 179-185

Shiwakoti, N., Tay, R., Stasinopoulos, P. and Woolley, P.J. (2017) Likely behaviours of passengers under emergency evacuation in train station. *Safety science* 91, 40-48.

Twarogowska, M., Goatin, P., Duvigneau, R (2014) Macroscopic modeling and simulations of room evacuation *Applied Mathematical Modelling 38*, 5781-5795.

Venkatesh, V. and Morris, M (2000) Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior *MIS Quarterly 24(1)*, 115-139

Yasmin, S., Eluru, N., Bhat, C. and Tay, R (2014) A latent segmentation based generalized ordered logit model to examine factors influencing driver injury severity *Analytic Methods in Accident Research 1(1)*, 23-38

Zheng, Z., Liu, Z., Liu, C. and Shiwakoti, N (2014) Understanding public response to a congestion charge: A random-effects ordered logit approach. *Transportation Research Part A: Policy and Practice 70,* 117-134.