



Pedestrian overpass use and its relationships with digital and social distractions, and overpass characteristics



Long T. Truong^{a,*}, Hang T.T. Nguyen^b, Hien D. Nguyen^c, Hung V. Vu^d

^a Department of Engineering, School of Engineering and Mathematical Sciences, La Trobe University, Bundoora, Victoria, 3086, Australia

^b Institute of Construction Engineering, University of Transport and Communications, Hanoi, Viet Nam

^c Department of Mathematics and Statistics, School of Engineering and Mathematical Sciences, La Trobe University, Bundoora, Victoria, 3086, Australia

^d Department of Civil Engineering, University of Transport and Communications, Ho Chi Minh City, Viet Nam

ARTICLE INFO

Keywords:

Design
Distraction
Overpass
Footbridge
Pedestrian

ABSTRACT

Pedestrian deaths and injuries are a major health issue in both developed and developing countries. In Vietnam, pedestrians account for about 10–11% of all road traffic deaths, while their travel distance contributes to approximately 2.4% of the total distance travelled by all modes. This paper aims to explore the use of pedestrian overpasses and identify influencing factors, particularly with regards to social and digital distractions, and overpass characteristics. An observational survey was conducted in Hanoi, Vietnam, in March 2017 at ten pedestrian overpasses. Behaviours of 608 pedestrians, including those who used an overpass to cross and those who illegally crossed, were observed. The rates of overpass usage varied significantly, between 35.9% and 96.5%. Modelling results suggest that pedestrians tended to compensate for the risks of illegal crossing by forming group and avoiding digital and social distractions (i.e., calling, operating a mobile phone's screen, listening to music, or talking to other pedestrians while crossing). In addition, overpass usage decreased with taller overpasses, but increased with wider overpasses. Effects of gender, weather, and illegal crossing speed on overpass use were also discussed.

1. Introduction

Road traffic crashes continue to be a major global health issue. Although some reductions in road traffic deaths have recently been observed in high and middle-income countries, there have been limited improvements in low-income countries (WHO, 2018). Among approximately 1.35 million peoples who die on the world's roads every year, more than half are among vulnerable road users, including pedestrians, cyclists, and motorcyclists (WHO, 2018). Globally, pedestrians make up 23% of all road traffic deaths, suggesting that nearly one in every four victims of road traffic deaths is a pedestrian. In South East Asia, the proportion of pedestrian deaths is 14%, which is lower than the global average (WHO, 2018).

In Vietnam, there were approximately 8100 road traffic deaths in 2018 (NTSC, 2019). Most road traffic deaths were among motorcycle users, i.e. approximately 60% (Ngo et al., 2012; Truong et al., 2016a; NTSC, 2019), since motorcycles are the main transport mode in Vietnam, representing 93% of all registered vehicles in the country (WHO, 2018) and 86% of the traffic flow in major cities, e.g., Hanoi (Bray and Holyoak, 2015). The proportion of pedestrians among road

traffic deaths has been suggested to range between 10%–11% (JICA, 2009; Ngo et al., 2012). For example, Ngo et al. (2012) suggested that pedestrians accounted for 11.2% of road traffic deaths, using data from a sample mortality surveillance system in 16 provinces. The true proportion of pedestrian deaths may be higher, due to under-reported issues that were highlighted in a study of child pedestrians in Vietnam (Brondom and Florian, 2012). Nevertheless, this suggests that there is an over-representation of pedestrians among road traffic deaths in Vietnam, considering that pedestrians account for approximately 2.4% of all distance travelled (iRAP, 2018). Despite the rapid increase in motorisation in Vietnam (NTSC, 2019), walking will continue to be an important mode of transport, particularly for short-distance travel (Nguyen et al., 2017) and access to public transport (Tran et al., 2014). Thus, it is crucial to understand pedestrian safety issues in Vietnam.

Pedestrian overpasses or footbridges are provided to remove pedestrian-vehicle conflicts, thus improving the overall safety as well as traffic flow of the streets under the overpasses. However, evidence from many countries has shown that many pedestrians cross illegally around overpasses. In Ankara, Turkey, Räsänen et al. (2007) observed that the rate of using pedestrian overpasses ranged between 6% and 63%.

* Corresponding author.

E-mail address: L.Truong@latrobe.edu.au (L.T. Truong).

<https://doi.org/10.1016/j.aap.2019.07.004>

Received 8 February 2019; Received in revised form 20 June 2019; Accepted 9 July 2019

Available online 18 July 2019

0001-4575/ © 2019 Elsevier Ltd. All rights reserved.

Another study conducted in Izmir, Turkey showed that 54% of pedestrians used an overpass to cross the road (Demiroz et al., 2015). In Xian, China, the usage rate of pedestrian overpasses was estimated at 77% (Wu et al., 2014). A study in Tanzania suggested that 58% of pedestrians preferred to cross at the street level, followed by crossing above the street level (26%) (Mfinanga, 2014). In Bogota, Columbia, it was reported that 25% of interviewed pedestrians indicated propensity to use a pedestrian overpass to cross the road (Cantillo et al., 2015). In Malaysia, the usage rate of pedestrian overpasses was observed to be between 19% and 74% (Hasan and Napiyah, 2018). Overall, the usage rate of pedestrian overpasses can vary significantly across different countries and cities. Regarding the behaviours of pedestrians at overpasses in Vietnam, little research has however been conducted, e.g. (Phung and Tran Cuong, 2007).

Factors affecting the use of pedestrian overpasses have been examined in a growing number of studies. For examples, perceived safety of overpass use has been found to be positively associated with overpass use (Räsänen et al., 2007; Sinclair and Zuidgeest, 2016; Oviedo-Trespalacios and Scott-Parker, 2017). Perceived crossing time, time and distance savings, and convenience are also important predictors of overpass use (Moore, 1953; Räsänen et al., 2007; Rankavat and Tiwari, 2016). Effects of demographic factors, e.g., age and gender, on overpass use are also indicated in several studies (Wu et al., 2014; Cantillo et al., 2015). There is mixed evidence regarding the relationships between overpass characteristics and overpass use. Hasan and Napiyah (2018) found that overpass use increases as the number of lanes of the road under the overpass increases, whereas the study by Wu et al. (2014) indicated that overpass use is not affected by characteristics of overpasses and roads under overpasses. Overall, an improved understanding of the relationships between overpass use and characteristics is needed.

The widespread use of electronic devices is likely to increase digital distraction, also known as technological distraction, while walking. Thompson et al. (2013) showed significant impact of technological distraction, i.e., using a mobile phone or listening to music, on increased crossing time and unsafe crossing behaviour at crosswalks. Pešić et al. (2016) observed that pedestrians who used a mobile phone while crossing behaved less safely compared to those who did not use a mobile phone while crossing at unsignalized intersections. Lennon et al. (2017) found that frequent use of a mobile phone may lead to risky crossing habits. Relationships between social distraction, e.g., crossing in group and talking, and unsafe pedestrian crossing behaviour have also been identified (Thompson et al., 2013). While these studies investigated effects of social and digital distraction on pedestrian crossing behaviour, they tended to focus on level crossings. An understanding of digital distraction at overpasses is important since digital distraction would increase the risks of falling on stairs when getting on and off overpasses, or crashes when crossing illegally. Yet, little is understood about the relationships between social and digital distraction and pedestrian crossings at overpass locations.

This paper aims to explore the use of pedestrian overpasses in Hanoi, Vietnam and identify associated factors, particularly with regards to social and digital distractions, and overpass characteristics. The main contributions of this paper are improved understandings of the behaviours of pedestrians around overpasses in Vietnam, the effects of social and digital distraction, and overpass characteristics on overpass use.

2. Method

2.1. Survey

An observational survey was conducted in Hanoi, Vietnam in March 2017. A total of ten pedestrian overpasses were selected for the survey, based on an initial investigation. These pedestrian overpasses were in various areas with varying adjacent attractions (e.g. universities, hospitals, and shopping centres) and characteristics (e.g., overpass height

and width, and road width).

Each overpass was surveyed on a weekday between 11:30 and 13:00, a period with relatively high pedestrian activities. Although it was not possible to survey traffic volumes on the roads due to limited resources, high traffic volumes at all sites were noted by the survey team. The survey team included four trained surveyors. Two surveyors observed the usage rate of overpasses (one counted the number of pedestrians who used an overpass to cross and one counted the number of pedestrians who did not use an overpass and illegally crossed the road within 40 m, both side of an overpass). The other two surveyors observed pedestrian behaviours (one focused on pedestrians who used an overpass and one focused on those who illegally crossed). It was not possible to observe all pedestrian crossings during the survey period. Thus, a randomised approach was adopted, i.e., observing the behaviours of the first pedestrian to start crossing in one-minute intervals.

Surveyors observed gender and estimated age group for each pedestrian. In addition, they recorded whether the pedestrian was engaged by digital distractions while crossing, including mobile phone call (either handheld or hands free), mobile phone screen operation (text messaging or reading from the screen), or listening to music (either earphones or headphones). Surveyors also observed whether the pedestrian walked alone, silently in a group, or in a group and talking with another pedestrian. Weather conditions during the survey were noted. For pedestrians who illegally crossed, the time for each pedestrian to complete the crossing was also recorded to estimate the average crossing speed.

2.2. Analysis

Data analysis was conducted using R (R Core Team, 2019). The generalized variance inflation factor (GVIF) (Fox and Monette, 1992) was adopted to assess multicollinearity. The GVIF allows for the assessment of both categorical and continuous variables within a unified framework, as oppose to the conventional VIF, which can only handle continuous variables. The GVIF was computed using the *vif* function in *car* package for R (Fox and Weisberg, 2011).

To account for unobserved heterogeneity in traffic safety data, random effect models have often been adopted (Mannering et al., 2016). The modelling of overpass use in this paper was conducted via random effect binary regression to account for unobserved heterogeneity among pedestrians and overpasses, within the generalized linear modelling (GLM) framework (Nelder and Wedderburn, 1972). GLM can be conducted with a number of choices for the link function, including the usual *logit*, which leads to logistic regression. Other link functions include *probit* and *cloglog* (*complementary log log*), which each replaces the use of the logistic distribution function link of the *logit* function, by the standard normal and log-Weibull distribution functions, respectively. The binary regression with the Burr distribution, which has been used in traffic safety analyses (Tay, 2016), was also tested. To select a link function that provide the best-fitted model, the Akaike information criterion (AIC) (Akaike, 1974) was utilised. The AIC is a score that is assigned to the model, which assesses its goodness-of-fit to the data it is fitted to. A lower AIC score indicates a better fit to the data.

3. Results

3.1. Descriptive statistics

Table 1 summarises characteristics of ten overpasses and roads under them. Overpass widths range between 2.5 m and 3.5 m while overpass heights vary between 4.5 m and 5 m. Overpass lengths and road widths under overpasses vary between 21 m and 51 m, and between 15 m and 42 m, respectively. The total number of pedestrians, including those who used an overpass to cross and those who illegally crossed, and the rate of pedestrians using an overpass are also shown in

Table 1
Overpass characteristics and usage rates.

ID	Overpass				Road under overpass Width (m)	Mean illegal crossing speed (m/s)	Overpass use rate	
	Location	Width (m)	Height (m)	Length (m)			n	%
1	Tran Duy Hung	3.5	4.7	45	35	0.87	434	96.5
2	Nguyen Chi Thanh	2.85	4.5	45	31	0.94	319	88.1
3	Lang Ha	3.2	4.7	32	21	1.18	113	75.2
4	Tay Son	3.2	4.5	30.1	21	0.75	140	86.4
5	Nguyen Trai	3.1	4.5	51.4	42	1.48	168	95.2
6	Giai Phong	2.5	4.5	47.5	30	2.00	1358	94.6
7	Hoang Quoc Viet	3.1	5.0	36.4	32	1.81	184	35.9
8	Chua Boc	3.3	4.5	21	15	1.14	202	62.9
9	Xa Dan	3.2	4.5	39	34	2.26	54	79.6
10	Tran Phu	3.1	4.75	46.8	42	2.48	76	88.2

Table 1. The highest usage rate was at overpass 1 (96.5%) whereas the lowest usage rate was at overpass 7 (35.9%), indicating a substantial variation in usage among pedestrian overpasses.

Behaviours of 608 pedestrians, including 413 pedestrians (67.9%) who used an overpass to cross and 195 pedestrians (32.1%) who illegally crossed, were observed across the ten overpasses. The mean illegal crossing speed for each overpass was also presented in Table 1. Overall, the mean speed of illegal crossings was 1.46 m/s with a standard deviation of 0.8 m/s. Pedestrian characteristics are summarised in Table 2. Nearly two thirds (62.5%) of the pedestrians were female. The majority of pedestrians were among the 18–24 age group (60.2%), followed by the 25–44 age group (21.9%) and the 45–64 age group (9.5%). The proportions of pedestrian aged under 18 or above 64 were much lower (5.1% and 3.3% respectively). Most observations were carried out in dry weather (68.6%). Regarding social distraction while crossing, approximately 38.5% of all pedestrians walked in group, either with talking (23.5%) or without talking to another pedestrian (15%). Digital distraction while crossing was observed in more than 10% of all pedestrians. Approximately 2.5% and 3.6% of all pedestrians used a mobile phone for calling or screen operation while crossing, respectively. In addition, approximately 4.4% of all pedestrians listened to music while crossing.

3.2. Relationship between overpass use and digital distraction

The dependence between overpass use and digital distraction was assessed separately from the other potential explanatory variables since these two variables are distinctly connected in the data. This can be seen in Table 3, which shows minimal number of distracted pedestrians

Table 2
Pedestrian characteristics (n = 608).

Characteristics	n	%	
Gender	Male	228	37.5
	Female	380	62.5
Age	< 18	31	5.1
	18-24	366	60.2
	25-44	133	21.9
	45-64	58	9.5
	> 64	20	3.3
Weather	Dry	417	68.6
	Wet	191	31.4
Overpass use	Illegal crossing	195	32.1
	Use pedestrian overpass	413	67.9
Walking behaviour	Alone	374	61.5
	In group, talking	143	23.5
	In group, no talking	91	15.0
Digital distraction while crossing	No	544	89.5
	Mobile phone call	15	2.5
	Mobile phone screen operation	22	3.6
	Listening to music	27	4.4

Table 3
The number of pedestrians by digital distraction and overpass use.

Digital distraction	Illegal crossing	Use pedestrian overpass
No	193	351
Mobile phone call	1	14
Mobile phone screen operation	0	22
Listening to music	1	26
Total	195	413

who chose to illegally cross. Although it is obvious that there is a positive relationship between digital distraction and overpass use, it is still prudent to test such a hypothesis, formally. Since three of the cells of the table have minimal numbers of observations, one cannot perform asymptotic inference via the usual χ -squared test for independence. Instead, a Fisher’s exact test (Agresti, 2019) was performed to provide an exact p-value for necessary test of independence. Results indeed indicated a strong relationship between overpass use and digital distraction, which is significant at $p < 0.001$.

3.3. Modelling the probability of overpass use

It was noted that there were very few digitally distracted individuals who crossed illegally. Given more data, it may be possible to model the propensity to cross with respect to digital distraction with some fidelity. However, the dataset does not allow for the incorporation of this variable, as it is currently measured, into a multivariate model of overpass use.

Before modelling the probability of overpass use, it is important to consider whether there are any redundancies in the data. For example, road width and overpass length may be highly correlated. Thus, remaining variables (i.e. age, gender, weather, walking behaviour, overpass length, overpass height, overpass width, road width, and mean illegal crossing speed) were assessed for multicollinearity. For this assessment, the generalized variance inflation factor (GVIF) (Fox and Monette, 1992) was utilised. Conventionally, one removes a variable from analysis at risk of multicollinearity if $VIF \geq 5$ or equivalently, if $\sqrt{GVIF} \geq 2.236$ (Sheather, 2009). Correspondingly, Fox (2015) suggest that one should interpret the scaled GVIF scores $VIF^{1/df}$ in the same way as one would interpret \sqrt{VIF} . Thus, the variable with the largest scaled GVIF score above the cutoff of 2.236 would be removed. Tay (2017) however suggested against automatic removals of variables with high GVIF scores without careful considerations of parameter estimates. As expected, overpass length had the excessive $VIF^{1/df}$ of 8.691. Furthermore, coefficients for overpass length and road width had different signs, which seemed counter-intuitive. After removing overpass length, there were no longer any variables with scaled GVIF scores that exceed the cutoff threshold.

The model with the Burr distribution was not considered further since the shape parameter for Burr distribution was not significant.

Table 4
Results of the cloglog random effect binomial regression model of overpass use.

Variables	Coefficient	Std. Error		Marginal effect
Gender				
Male	Ref			
Female	0.253	0.119	*	0.092
Age				
< 18	Ref			
18–24	–0.209	0.275		–0.076
25–44	–0.577	0.288	*	–0.210
45–64	0.151	0.300		0.055
> 64	–0.637	0.352	^a	–0.232
Walking behaviour				
Alone	Ref			
In group, talking	0.154	0.151		0.056
In group, no talking	–0.371	0.171	*	–0.135
Weather				
Dry	Ref			
Wet	0.629	0.177	***	0.229
Overpass height	–1.259	0.470	**	–0.458
Overpass width	0.617	0.269	*	0.224
Road width	0.053	0.008	***	0.019
Mean illegal crossing speed	–0.626	0.163	***	–0.228
Random effect (intercept)	3.285	1.889	^a	
Standard deviation of parameter distribution	0.011	0.055		
Log likelihood	–342.070			
Log likelihood (restricted)	–572.718			
AIC	712.1			
Number of observations	608			

Note:

^a $p < 0.1$.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Random effect binomial regression models were developed with AIC scores of 716.0, 716.0, and 712.1 for *logit*, *probit*, and *cloglog* link functions, respectively. All of the AIC scores, the *cloglog* link yields the smallest of the AIC values and is thus preferred under the criterion. Results of the *cloglog* random effect binomial regression model are presented in Table 4.

The model was significant at $p < 0.001$. It can be seen that all variables were significant. Marginal effects were also calculated. Results showed that females tend to use an overpass to cross the road (p -value < 0.05). As overpass height increases, pedestrians are less likely to use an overpass (p -value < 0.01). However, the likelihood of using an overpass increases with wider overpasses (p -value < 0.05) or wider roads (p -value < 0.001). In addition, pedestrians tend to use an overpass in wet weather conditions (p -value < 0.001). Furthermore, pedestrians were less likely to use an overpass when the mean illegal crossing speed at this overpass was higher (p -value < 0.001). It can also be observed that at least one category among variables age and walking behaviour were significant (i.e. 25–44 age group and walking in group, not talking respectively). There was also limited evidence for the effect of the > 64 age group (p -value = 0.07).

4. Discussion

Results of this study showed that the usage rates at ten pedestrian overpasses in Hanoi, Vietnam varied between 35.9% and 96.5%. This large variation in the usage rates of overpasses is consistent with statistics reported in Malaysia, e.g. 19%–74% (Hasan and Napiyah, 2018), and in Turkey, e.g. 6%–63% (Räsänen et al., 2007). This suggests that many factors, e.g., overpass, road, and traffic characteristics, can all affect the use of pedestrian overpasses. Despite of the variations, it can be seen that the overpass usage rate in Vietnam is higher compared to that in Malaysia and Turkey. This may be attributed to the perceived

risk of crossing a mixed traffic flow of motorcycles, scooters, and cars travelling at various speeds.

A strong relationship between overpass use and digital distraction was evident in the analysis. More specifically, pedestrians who chose to illegally cross are much less likely to use a mobile phone or listen to music while crossing, compared to those who used an overpass to cross. Given the higher risk of illegally crossing the road, pedestrians who illegally crossed the road would be more cautious and therefore less likely to perform a distracting activity as a risk compensation behaviour. Approximately 10% of all pedestrians were digitally distracted while crossing, i.e., using a mobile phone or listening to music. This is similar compared to Serbia, where 9%–12% of pedestrians used a mobile phone while crossing (Pešić et al., 2016), but much lower compared to Australia, where nearly 27% of pedestrians called, texted, or listened to music while crossing at intersections (Thompson et al., 2013). With the rapid growth of smartphones and connected devices in Vietnam (Nielsen, 2017), the issue of technological or digital distraction while crossing may be increased.

It was found that pedestrians who walked in a group but did not talk were more likely to illegally cross, compared to those who walked alone and those who walked in group and talked. Walking in a group would make pedestrians feel more confident. For example, an increase in unsafe behaviour of pedestrians at intersections has been found to be associated with an increasing number of accompanying pedestrians (Pešić et al., 2016). The fact that pedestrians do not talk to others in the group may suggest either they do not know each other, or they avoid performing a distracting activity. Overall, it can be argued that pedestrians who illegally crossed the road tended to walk in groups and not to talk to another pedestrian as a risk compensation behaviour.

Effects of weather conditions on overpass use were evident in this study. Pedestrians had a higher propensity to use an overpass for crossing in wet weather conditions. At crosswalks, pedestrians would be more likely to engage in unsafe crossing behaviours at inclement weather conditions (Li and Fernie, 2010). However, at overpass locations, overpasses are a preferred option in wet weather conditions as pedestrians can avoid slippery road surfaces and stay drier. This highlights the importance of roofed overpasses in attracting pedestrians.

Results also suggested effects of other overpass characteristics on overpass use, i.e., overpass use decreased with taller overpasses, but increased with wider overpasses. Taller overpasses may be provided to accommodate heavy vehicle traffic, which tends to discourage pedestrians from illegally crossing at the road level. However, pedestrians would be sensitive to height limit signs displayed on overpasses in Hanoi, leading to the significant impact of height on overpass use. Overall, to improve overpass use, it is recommended to adopt the absolute minimum allowable height clearance and avoid narrow widths in the design of overpasses.

Road widths were found to be positively associated with overpass use. As the roads are wider, the difference in distances becomes smaller between overpass and illegal crossings. Thus, illegally crossings might not provide significant distance and time savings compared to crossings using overpasses. Results also showed that pedestrians tend to cross illegally if the mean illegal crossing speed was higher, which is intuitive since pedestrians would save time by illegally crossing with a higher speed. These are consistent with findings of previous research, which indicated distance and time savings are key predictors of overpass use (Moore, 1953; Räsänen et al., 2007). An implication of this finding is that countermeasures, e.g. pedestrian fencing, particularly for narrower roads, may be needed to discourage pedestrians from illegally crossing.

There was evidence that compared to male pedestrians, female pedestrians were more likely to use an overpass. In China, Wu et al. (2014) also reported that female pedestrians have a higher propensity to use an overpass for crossing. In Vietnam, evidence regarding the effects of gender on risky behaviours among road users has been mixed. For example, female motorcycle riders were less likely to wear a helmet (Hung et al., 2006), but less likely to use a mobile phone while riding

(Truong et al., 2016b).

The average illegal crossing speed was 1.46 m/s, which is higher than the average illegal crossing speed (1.21 m/s) at overpass locations reported in Turkey (Demiroz et al., 2015). Compared to pedestrian walking speeds measured at crosswalks in other countries, the average illegal crossing speed identified in this study is within the reported range, e.g. 1.34 m/s in Jordan (Tarawneh, 2001), and 1.49 m/s–1.63 m/s in Australia (Bennett et al., 2001; Truong et al., 2018).

In this study, overpass usage and behaviours of a relatively large number of pedestrians were observed at ten pedestrian overpasses in different locations, with varying characteristics. Nevertheless, several limitations should be acknowledged. First, it was not possible to observe behaviours of all pedestrians during the survey and collect traffic volume data. Future research should employ video data collection and analysis to address these issues. Next, the surveyed sample did not include enough pedestrians with walking disability for analyses. There may be biases with regards to pedestrians' age and gender as they were estimated visually. In addition, observations were only made on weekdays between 11:30 and 13:00, when traffic and pedestrian activities are high. Pedestrian behaviours at overpasses may be different at different times or during the weekend, since traffic and pedestrian populations would be different. Finally, land use characteristics around overpasses, which would affect digital distraction, were not captured in this study.

5. Conclusion

Overall, this paper has explored pedestrian behaviour around pedestrian overpasses in Hanoi, Vietnam, where pedestrian safety has often been overlooked. It has suggested pedestrians tended to compensate for the risks of illegal crossing by forming group and avoiding technological and social distractions (e.g., using a mobile phone, listening to music, or talking to other pedestrians). Nevertheless, many pedestrians still crossed illegally rather than using an overpass. In addition to education and enforcement, engineering solutions, e.g. overpass design, should be considered to address this issue. Several practical recommendations for improving overpass use have been identified with regards to overpass height, width, roof, and pedestrian fencing, particularly on narrow roads.

Declaration of Competing Interest

None.

Acknowledgement

The authors would like to thank the three anonymous reviewers for their constructive comments. Hien D. Nguyen is funded by the Australian Research Council grants DE170101134 and DP180101192.

References

- Agresti, A., 2019. *An Introduction to Categorical Data Analysis*. Wiley, Hoboken.
- Akaike, H., 1974. A new look at the statistical model identification. *IEEE Trans. Automat. Contr.* 19, 716–723.
- Bennett, S., Felton, A., Akçelik, R., 2001. Pedestrian movement characteristics at signalised intersections. 23rd Conference of Australian Institutes of Transport Research (CAITR 2001).
- Bray, D., Holyoak, N., 2015. Motorcycles in developing Asian cities: a case study of Hanoi. 37th Australasian Transport Research Forum (ATRF 2015).
- Brondom, L., Florian, M., 2012. Under-reported: child pedestrian road traffic injuries in Vietnam. *Inj. Prev.* 18 (Suppl 1), A219.
- Cantillo, V., Arellana, J., Rolong, M., 2015. Modelling pedestrian crossing behaviour in urban roads: a latent variable approach. *Transp. Res. Part F Traffic Psychol. Behav.* 32, 56–67.
- Demiroz, Y.I., Onelcin, P., Alver, Y., 2015. Illegal road crossing behavior of pedestrians at overpass locations: factors affecting gap acceptance, crossing times and overpass use. *Accid. Anal. Prev.* 80, 220–228.
- Fox, J., 2015. *Applied Regression Analysis and Generalized Linear Models*. Sage, Thousand Oaks.
- Fox, J., Monette, G., 1992. Generalized collinearity diagnostics. *J. Am. Stat. Assoc.* 87 (417), 178–183.
- Fox, J., Weisberg, S., 2011. *An R Companion to Applied Regression*. Sage, Thousand Oaks.
- Hasan, R., Napiah, M., 2018. The perception of Malaysian pedestrians toward the use of footbridges. *Traffic Inj. Prev.* 19 (3), 292–297.
- Hung, D.V., Stevenson, M.R., Ivers, R.Q., 2006. Prevalence of helmet use among motorcycle riders in Vietnam. *Inj. Prev.* 12 (6), 409–413.
- iRAP, 2018. *Vaccines for Roads IV*. International Road Assessment Programme, London, United Kingdom.
- JICA, 2009. *Research Master Plan for Road Safety in Viet Nam*. Japan International Cooperation Agency, Hanoi.
- Lennon, A., Oviedo-Trespalacios, O., Matthews, S., 2017. Pedestrian self-reported use of smart phones: positive attitudes and high exposure influence intentions to cross the road while distracted. *Accid. Anal. Prev.* 98, 338–347.
- Li, Y., Fernie, G., 2010. Pedestrian behavior and safety on a two-stage crossing with a center refuge island and the effect of winter weather on pedestrian compliance rate. *Accid. Anal. Prev.* 42 (4), 1156–1163.
- Mannering, F.L., Shankar, V., Bhat, C.R., 2016. Unobserved heterogeneity and the statistical analysis of highway accident data. *Anal. Methods Accid. Res.* 11, 1–16.
- Mfinanga, D.A., 2014. Implication of pedestrians' stated preference of certain attributes of crosswalks. *Transp. Policy (Oxf)* 32, 156–164.
- Moore, R.L., 1953. Pedestrian choice and judgment. *OR* 4 (1), 3–10.
- Nelder, J., Wedderburn, R., 1972. Generalized linear models. *J. R. Stat. Soc. Ser. A* 135, 370–384.
- Ngo, A.D., Rao, C., Phuong Hoa, N., Hoy, D.G., Thi Quynh Trang, K., Hill, P.S., 2012. Road traffic related mortality in Vietnam: evidence for policy from a national sample mortality surveillance system. *BMC Public Health* 12 (1), 1–9.
- Nguyen, H.T.A., Chikaraishi, M., Fujiwara, A., Zhang, J., 2017. Mediation effects of income on travel mode choice: analysis of short-distance trips based on path analysis with multiple discrete outcomes. *Transp. Res. Rec.* 2664 (1), 23–30.
- Nielsen, 2017. *Vietnam Smartphone Insights Report*.
- NTSC, 2019. *Traffic Safety Annual Report*. National Transportation Safety Committee of Vietnam, Hanoi, Vietnam.
- Oviedo-Trespalacios, O., Scott-Parker, B., 2017. Footbridge usage in high-traffic flow highways: The intersection of safety and security in pedestrian decision-making. *Transp. Res. Part F Traffic Psychol. Behav.* 49, 177–187.
- Pešić, D., Antić, B., Glavić, D., Milenković, M., 2016. The effects of mobile phone use on pedestrian crossing behaviour at unsignalized intersections – models for predicting unsafe pedestrians behaviour. *Saf. Sci.* 82, 1–8.
- Phung, M.T., Tran Cuong, B.D., 2007. Urban planning for location of pedestrian bridge in Hochiminh city, Vietnam. *Proceedings of the Eastern Asia Society for Transportation Studies* 6, pp. 212–221.
- R Core Team, 2019. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.
- Rankavat, S., Tiwari, G., 2016. Pedestrians perceptions for utilization of pedestrian facilities – Delhi, India. *Transp. Res. Part F Traffic Psychol. Behav.* 42, 495–499.
- Räsänen, M., Lajunen, T., Alticafarbay, F., Aydin, C., 2007. Pedestrian self-reports of factors influencing the use of pedestrian bridges. *Accid. Anal. Prev.* 39 (5), 969–973.
- Sheather, S.J., 2009. *A Modern Approach to Regression with R*. Springer, New York.
- Sinclair, M., Zuidgeest, M., 2016. Investigations into pedestrian crossing choices on Cape Town freeways. *Transp. Res. Part F Traffic Psychol. Behav.* 42, 479–494.
- Tarawneh, M.S., 2001. Evaluation of pedestrian speed in Jordan with investigation of some contributing factors. *J. Safety Res.* 32 (2), 229–236.
- Tay, R., 2016. Comparison of the binary logistic and skewed logistic (Scobit) models of injury severity in motor vehicle collisions. *Accid. Anal. Prev.* 88, 52–55.
- Tay, R., 2017. Correlation, variance inflation and multicollinearity in regression model. *J. Eastern Asia Society Trans. Studies* 12, 2006–2015.
- Thompson, L.L., Rivara, F.P., Ayyagari, R.C., Ebel, B.E., 2013. Impact of social and technological distraction on pedestrian crossing behaviour: an observational study. *Inj. Prev.* 19 (4), 232–237.
- Tran, M.T., Zhang, J., Fujiwara, A., 2014. Can We Reduce the Access by Motorcycles to Mass Transit Systems in Future Hanoi? *Procedia - Soc. Behav. Sci.* 138, 623–631.
- Truong, L.T., Kieu, L.-M., Vu, T.A., 2016a. Spatiotemporal and random parameter panel data models of traffic crash fatalities in Vietnam. *Accid. Anal. Prev.* 94, 153–161.
- Truong, L.T., Kutadinata, R., Espada, I., Robinson, T., Burdan, J., Costa, F., Eason, L., 2018. Walking speeds for timing of pedestrian walk and clearance intervals. 40th Australasian Transport Research Forum (ATRF 2018).
- Truong, L.T., Nguyen, H.T.T., De Gruyter, C., 2016b. Mobile phone use among motorcyclists and electric bike riders: A case study of Hanoi, Vietnam. *Accid. Anal. Prev.* 91, 208–215.
- WHO, 2018. *Global Status Report on Road Safety 2018*. World Health Organization, Geneva.
- Wu, Y., Lu, J., Chen, H., Wu, L., 2014. Identification of contributing factors to pedestrian overpass selection. *J. Traffic Transp. Eng.* 1 (6), 415–423.