Investigating Pedestrian Perceptions towards Road Infrastructure and Facilities in Denpasar, the Capital City in Bali, using Discrete Choice Analysis

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Abstract: Similar to neighbouring countries in Asia, Indonesia experiences high pedestrian fatality rate. This study aims to analyse pedestrians' perceptions towards road safety and to identify novel measures to improve safety of pedestrians in developing cities. Data collection involved self-reporting questionnaires from respondents based in Denpasar, Bali. Binary and multinomial logit models were estimated using pedestrian perception data to identify the factors that influence pedestrian accidents. This study found that reckless or careless driving/riding, both night and day times contributed significantly to pedestrian accidents. In addition, junctions and pedestrian crossings were perceived to be dangerous for pedestrians compared to other road infrastructures such as footpaths. The outcome of the study also reveals that motorcycles will be more influential for pedestrian accidents than cars. In order to reflect upon the findings, some countermeasures for enhancing pedestrian safety in Denpasar, Bali were discussed with attention to engineering, policy, enforcement and education perspectives.

Keywords: Pedestrians, Perceptions, Road Safety, Multinomial Logit, Binary Logit

1. INTRODUCTION

According to the recent statistics by the United Nations, 55% of the world's population lives in urban areas as of 2018; this share is expected to increase to 68% by 2050. Projections also show that nearly 90% of this increase will take place in global south in general, Asia and Africa in particular (United Nations, 2018). As cities and urban areas are subjected to rapid growth and urbanisation, policy makers as well as national, regional and local authorities will require to cater for growing demands for public services and facilities, including better and safer infrastructure. This should be done with a focus of the urban poor and other vulnerable groups for their basic needs for transportation, housing, education, health care, and more importantly, a safe and livable urban environment. This study particularly focusses road safety aspects with attention to pedestrians. Pedestrians are often the most vulnerable road user group in our society, so investigating the causes and consequences of pedestrian accidents is important (Cookson et.al, 2011).

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Previous research on pedestrian safety covered various aspects involving child pedestrians (Aryaija et al., 2007; Dissanayake et al., 2009), gender aspects (Wedagama et. al., 2008; Wedagama et al., 2011); and perceptions across many countries in Europe (Papadimitriou et al., 2013). The pedestrian safety research in developing countries has been receiving considerable attention in recent years, for instance in India (Marisamynathan and Vedagiri, 2018), in Philippines (Mateo-Babiano, 2016), and in China (Kim and Mateo-Babiano, 2018; Wang et.al. 2018).

Both actual and perceived risk are considered to be important when achieving road safety targets; Speck (2012) particularly stated that safety is not just about being safe but also feeling safe. Therefore, exploring pedestrian attitudes and perceptions will help to generate understanding amongst decision makers of safety requirements and allow development of strategies as well as implementation of appropriate measures to make sure that the safety targets will be achieved.

According to the most recent statistics from Indonesia, pedestrian fatalities contributed to 40% of the total road fatalities in Indonesia (Poerwo and Indris, 2000 in Koushki and Ali, 2003). When compared to neighbouring countries in Asia, similar figures were noted, for example, Bangladesh (41%), China (25%), Pakistan (41%), Sri Lanka (32%) and India (40%) (World Health Organization, 2015). The reasons for the high pedestrian fatality rate are due to the speed of passing vehicles on pedestrian areas, lack of footpaths, lack of crossing provision for pedestrians with associated speed control and warning signage for vehicles, and vehicles failing to give way to pedestrians (Mohan, 2011; Howard, 2015). Pedestrians, therefore, are considered as one of the most vulnerable road user groups in developing countries where their safety have been given inadequate attention from the policy makers (Marisamynathan and Vedagiri, 2018; Wang et.al, 2018). Previous research mainly focused on analysing pedestrian accidents based on the country based statistics and accident datasets collected by police authorities.

There was some attention originated from the developed world on the subject of pedestrian perception since the late 1990s (for example, Assum, 1997; Yagil, 2000; Lam, 2000; Yannis et al., 2004; Rosenbloom et al, 2004; Granie, 2007; and Bernhoft and Carstensen, 2008). In contrast, there are only a few studies that focus on pedestrian perception, particularly from developing countries in Asia and Africa including Guo et al. (2014); Mateo-Babiano (2016); and Kim and Mateo-Babiano (2018). Guo et al. (2014) stated that some pedestrians preferred not to use crossing facilities, insteadcrossing roads illegally from random locations, because they did not think the facilities can meet their demands (Guo et al., 2014).

Accident locations, main mode of transportation, time of accidents and major cause for accidents have been given attention in pedestrian safety research (Tulu et al., 2013; Anciaes and Jones, 2018; Marisamynathan and Vedagiri, 2018). Additionally, other demographic variables such as age and gender have also been considered in pedestrian accident studies (Kahlert and Schlicht, 2015; Hanan et al., 2015). Therefore, the factors that have been identified in the previous research will be given adequate attention in this study.

This study will lead to generate some fundamental understanding of the contributory factors that influence pedestrian safety considering Denpasar, the capital city in Bali, as the case study area. In addition, it provides insight into the influencing factors on pedestrians' characteristics and perceptions towards pedestrian accidents. Increased awareness of pedestrians' perceptions towards the measure of pedestrian accidents will allow promotion of educational and enforcement initiatives aiming to improve pedestrian safety. In addition, some useful information can be shared with pedestrians as an attempt to achieving safer walking. In other words, it is expected that pedestrians may use knowledge gained to make positive changes in their travel activities. This study provides some understanding of safety problems from pedestrians' standpoint and essential information on components affecting pedestrians traffic accidents.

This paper aims at analysing pedestrians' perceptions towards traffic safety by constructing binary and multinomial logit models. With the constructed model, pedestrians' perceptions towards traffic safety are examined in mixed traffic conditions. This paper begins with a research methodology in Section 2. In Section 3, data analysis using discrete choice methods is described. Finally, the paper draws conclusions and makes recommendations in Section 4.

2. RESEARCH METHODOLOGY

2.1 Discrete Choice Modelling Framework

A multinomial logit model (MNL) is used to predict the outcome probabilities of a function with a dependent variable with unordered categories (Williams, 2018). The reference category is normally chosen at either the first or last value, or the value with the lowest or the highest frequency. The probability of each category is subsequently compared to the probability of reference category.

For categories $i = 2....K$, the probability of category i can be written as follows:

$$Pr\ (Y = i) = \frac{\exp(Z_i)}{1+\sum_{h=2}^{K}\exp(Z_{hi})} \tag{1}$$

where,

$\alpha_i + \sum_{h=1}^{H} \beta_{ih} x_{ih} = Z_{i.}$ in which for the reference category,

$$Pr\ (Y= 1) = \frac{1}{1+\sum_{h=2}^{K}\exp(Z_{hi})} \tag{2}$$

Equations (1) and (2) are rearranged so the MNL model can be expressed as follows:

$$Ln\left(\frac{P(Y=i)}{P(Y=1)}\right) = \alpha_i + \sum_{h=1}^{H} \beta_{ih} X_{ih} = Z_i \tag{3}$$

where,

β_{ih}, X_{ih}	:	vectors of the estimated parameters and predictor variables respectively
$\frac{P(Y=i)}{P(Y=1)}$	:	the probability of pedestrian injuries either fatal, serious injury or slight injury with the first category as reference.
i	:	the number of injury categories

The equation above stated the logit (log odds) as a liner function of the predictors (Xs). When there are only two dependent outcomes, it is named as binary logit model. Logistic regression is employed to estimate a function with a binary dependent variable in this study. The dependent variable is the probability (P) of population in which the outcome is equal to one (1). Predictor variables produce parameters that can be employed to predict odds ratios for each of the predictors in the model (Washington et.al, 2003). The logistic regression model is expressed as follows:

$$\pi(x) = P = \frac{e^{\beta_o + \beta_1 x}}{1 + e^{\beta_o + \beta_1 x}} \tag{4}$$

The logit is transforming the conditional mean π(x) using the *LN* (to base *e*) of the odds, or the likelihood ratio that the dependent variable is one (1), such that,

$$Logit\ (P) = Ln\ \left(\frac{P_i}{1 - P_i}\right) = \beta_o + \beta_i.X_i \tag{5}$$

where,

X_i	:	set of independent variables ($i = 1,2,.........,n$)
P	:	probability ranges from 0 to 1
β_i	:	the parameter estimates for the independent variables
β_o	:	the model constant
$\left(\frac{P_i}{1 - P_i}\right)$	:	the natural logarithm ranges from negative infinity to positive infinity

On the assumption that the predictor X increases by one (1) unit and the other variables stay constant, the odds [$P_i/(1-P_i)$] rises by a factor 7 This is defined as the odds ratio (OR). It varies from 0 to positive infinity and specifies whether the odds are either increasing (OR>1) or decreasing (OR<1). In addition, there is no real regression coefficient (R^2) in a logistic regression model. Alternatively, Cox & Snell Pseudo-R^2 and Nagelkerke Pseudo-R^2 can be employed as a proxy of an R^2:

$$\text{Cox \& Snell Pseudo-}R^2 = R^2 = 1 - \left[\frac{-2LL_{null}}{-2LL_k}\right]^{2/n} \tag{6}$$

The Cox & Snell pseudo-R^2 would not achieve the value of one (1), therefore, Nagelkerke is employed to modify it as follows:

$$\text{Nagelkerke Pseudo-}R^2 = R^2 = \frac{1 - \left[\frac{-2LL_{null}}{-2LL_k}\right]^{2/n}}{1 - (-2LL_{null})^{2/n}} \tag{7}$$

The goodness of fit of the model is measured with a Hosmer-Lemeshow (H-L) Test. If the model fits or does not fit the data, this represents either null or alternative hypotheses respectively. The H-L test is as follows:

$$\hat{C} = \sum_{k=1}^{g} \frac{(O_k - E_k)^2}{v_k} \tag{8}$$

where,

O_k	:	Observed number of events	v_k	:	Variance correction factor
E_k	:	Expected number of events	$\hat{C}$	:	The H-L test

Evidence against the null hypothesis will be obtained from the large value of H-L test.

This occurs when the observed numbers of events diverge from the model expectation.

2.2. Data Collection

A cross sectional survey, using a self-reported questionnaire design, was deployed for pedestrians in Denpasar, capital city in Bali. This methodology was in line with a previous study by Ulleberg and Rundmo (2003) showing that it is appropriate to consider self-reported pedestrians' perception as it showed a stable perception pattern and also predicted a consistent indicator of future intentions of pedestrians' behaviour. The questionnaires were distributed to 400 randomly selected pedestrians living in Denpasar in June-July 2017. Due to missing data however, only 310 samples (77.5% of the total number of samples) were considered during the analysis

As shown in Table 1, the questionnaire consists of four sections and a total of 16 main questions. The data relating to pedestrians' perceptions towards traffic safety, together with respondents' socio-demographic factors, were collected. In addition, pedestrian perceptions on measures taken to improve traffic safety were identified. Pedestrian perceptions towards traffic safety were measured by their knowledge and awareness of transport safety and traffic accidents measures. The respondents were requested to choose the answers for the questions in the questionnaire; also they were allowed to choose more than one answer.

Table 1. Details of the questionnaire

I. Socio-demographic factors	
P11	Gender (Male = 1; Female = 2)
P12	Age (<20 years old = 1; 20-29=2; 30-39=3; 40-49=4; >50=5)
P13	Household income (< 3 million = 1; ≥ 3 million = 2; no answer = 3)
P14	Driving license ownership (Yes = 1; No =2)
P15	Primary mode of travel (Car driver = 1; Car passenger =2; Bus & taxi = 3; Motorcycle = 4; Non motorised transport=5)
P16	Purpose of main trip (working/studying = 1; social activity & shopping = 2; exercise/religious/others = 3)
P17	Frequency of main trip (everyday = 1; 2 or 3 times in a week = 2; once a week = 3; 2 or 3 times in a month & hardly ever = 4; once a month = 5)
P18	Experiences on traffic safety education at school (Yes=1; No =2)
II. Traffic safety tips	
P21	Understanding traffic rules (pedestrian crossing/bridge = 1; pedestrian signal/reflective items/cyclists on left side=2)
P22	Practices usually observed for traffic safety (following the pedestrian traffic signals (not walking through a red-light=1; not crossing a road and intersection without pedestrian crossing or bridge=2; making proper use of the footpaths=3; taking extra caution before road crossing/wear reflective items = 4)
III. Pedestrian accidents measures	
P31	Location of pedestrians' accident (junctions = 1; pedestrian crossing = 2; footpath = 3)
P32	Mode types as the main cause of traffic accident (car = 1; motorcycle = 2)
P33	Major cause of traffic accidents (careless or inattentive driving/riding=1; traffic violation=2; lack/shortage of pedestrian facilities=3)
P34	Time of traffic accidents most likely to happen (nighttime =1; daytime = 2; others = 3)
IV. Measures taken to improve traffic safety	
P41	Measures taken to improve traffic safety
P42	Groups in need of traffic education

3. MODEL DEVELOPMENT

3.1 Research Hypotheses

As mentioned earlier, this study explores the pedestrians' perceptions and their awareness of road safety. Hypotheses were drawn to investigate the multiple relationships amongst the measures shown in Table 1 as follows:

H_1: Socio-demographic factors influence pedestrians' perceptions towards road safety.

H_2: Travel exposure and traffic safety measures affect pedestrians' perceptions towards road safety.

3.2 Data Analysis using Discrete Choice Modelling Methods

The model is based on the hypotheses that the pedestrians are the decision makers regarding their choice of satisfactory facilities to cross the street. Table 2 shows a matrix of pedestrians' perception towards measures of pedestrian accidents. Each column indicates dependent variables consisting of P31 (location of pedestrians' accidents involving junctions, pedestrian crossings and footpaths), P33 (major cause of traffic accidents considering careless/inattentive driving/riding, traffic violation and lack/shortage of pedestrian facilities) and P34 (time of traffic accidents most likely to happen including nighttime, daytime and others). P31, P33 and P34 were modelled with Multinomial Logit (MNL) methods. In contrast, P32, relating to pedestrian views of the type of mode more likely to be involved in a traffic accident. Since the modes are car and motorcycle, Binary Logit (BL) methods were applied when analysis P32.

The higher goodness of fit (expressed with pseudo-R^2 value), the better the fitting of the MNL models (Washington et al, 2003). In contrast, O'Donnel and Connor (2002) argued that such measures are frequently disregarded, as there has been no conventional goodness of fit for these types of models. Alternatively, the classification accuracy is employed to examine the model accuracy.

The model classification accuracy rate usually should be 25% or more, higher than the proportional by chance of the data accuracy rate. The proportional by chance of the data accuracy rate was determined with the proportion of each category within a dependent variable. The overall classification accuracy rate, for example a variable of P31 (pedestrian perception of accident-prone location: junctions, pedestrian crossing and footpath) is 46.1% which is higher than the proportional by chance accuracy criteria of 41.67% (=1.25 x 33.73%) (Refer Tables 2 and 3). As the result, the criteria of model classification accuracy is satisfied (refers Table 4).

Table 2. Proportion data of pedestrian perceptions of accident-prone locations

Accident prone locations	Number of Samples	Percentage	Percentage squared
Junctions (code = 1)	81	29.9%	8.94%
Pedestrian crossing (code = 3)	104	38.4%	14.75%
Footpath (code = 5)	86	31.7%	10.05%
	Total = 271		Total = 33.73%

Table 3. Overall classification rate

Observed	Predicted: Junctions (1)	Pedestrian crossing (3)	Footpath (5)	Percent Correct
Junctions (1)	13	49	19	16.0%
Pedestrian crossing (3)	9	70	25	67.3%
Footpath (5)	5	39	42	48.8%
Overall Percentage	10.0%	58.3%	31.7%	46.1%

Table 4. Model validity

Model	Data Observed	1.25*Data Observed	Model Results	Model Accuracy
MNL P31	33.73%	42.17%	46.1%	Satisfied
MNL P33	44.92%	56.16%	62.3%	Satisfied
MNL P34	36.82%	46.03%	52.3%	Satisfied

	H-L Test	Cox & Snell R^2	Nagelkerke R^2
BL P32	0.51	0.12	0.17

Notes:

P31 Location of pedestrians' accident involving junctions, pedestrian crossing and footpath)

P32 Mode types consisting of car and motorcycle as the main cause of traffic accident)

P33 Major causes of traffic accidents considering careless/inattentive driving/riding, traffic violation and lack/shortage of pedestrian facilities)

P34 Time of traffic accidents most likely to happen containing nighttime, daytime and others)

Table 3 shows R^2 measures of Cox & Snell, and Nagelkerke. Cox & Snell R^2 normally has the highest value less than one so that is commonly using Nagelkerke R^2. The reason is because Nagelkerke R^2 divides Cox & Snell R^2 with the maximum value to give a measure range between zero (0) and one (1). As an example, the P32 (mode types as the main cause of traffic accidents) model explains 17% of the variation in the outcome. In addition, Hosmer-Lemeshow (H-L) test demonstrates that the logistic regression models are statistically significant (p-value > 0.05).

3.3 Results and Discussion

The estimated results of the MNL models (P31, P33, and P34) and BL model (P32) are presented in Table 5. More specifically, all models explain that socio-demographic factors (attached to H_1) as well as travel exposures and traffic safety measures (attached to H_2) are highly instrumental for pedestrians' perceptions towards road safety. This has led to the acceptance of the two research hypotheses, H_1 and H_2, which were set in the initial stage of the study.

In addition, the alternative specific constants in all four models tend to be relatively small in value compared to the other coefficients in many occasions, indicating that the predictors used in the models are appropriate as they account for a larger proportion when accumulating pedestrians' perception towards road safety. The subsections below explain the results for each model.

<u>MNL model – P31:</u>

Location of pedestrians' accident (junctions = 1; pedestrian crossing = 2; footpath = 3)

- The reference category was considered as "footpath" for this MNL model.
- The significant and positive coefficient (β =1.07) for the driving license category indicates

that pedestrians with driving licenses perceive that junctions are not as safe as footpaths, in terms of the location of road traffic accidents. This means that the odds for pedestrians with a driving license over the odds for pedestrians without a driving license is 2.92 (OR = $\exp^{1.07}$). In terms of percent change, the odds for driving license holders are 192% higher than the odds for those who do not own driving licenses. This is consistent with recent studies from Kuwait (Koushki and Ali, 2003) and India (Marisamynathan and Vedagiri, 2018) which clearly states that the majority of pedestrian accidents take place at junctions.

- In addition, even though pedestrians take extra care by complying with traffic signals at pedestrian crossings, they still do not feel safe at pedestrian crossings compared to the reference category of "footpaths". The relevant coefficient was statistically significant at the 95% confidence level with a value of 0.95. Pedestrian crossings are shared among all road users and therefore are locations where the safety of pedestrians is compromised (Kim and Mateo-Babiano, 2018).

<u>BL model – P32:</u>

Mode types as the main cause of traffic accident (car = 1; motorcycle = 2)

- The reference category was considered as "motorcycle" for this BL model.
- Pedestrians aged between 30 and 39 years do not perceive that cars are the main cause for accidents when compared to motorcycles, as the relevant coefficient is negative and significant at 95% confidence level (β = -2.46). Furthermore, in terms of the OR, being a pedestrian belong to the age group 40-49 (a unit increase) indicates that the odds of perceiving cars as an unsafe mode over motorcycles is 0.085. In other words, increasing age group by one unit would decrease the odds by 91.5%.
- The negative and significant coefficient (β = -1.43), for taking extra care by complying with traffic signals at pedestrian crossings, indicates that the pedestrians perceive that it is less likely that cars are a main cause for accidents when compared to motorcycles.

<u>MNL model – P33:</u>

Major cause of traffic accidents (careless or inattentive driving/riding=1; traffic violation=2; lack/shortage of pedestrian facilities=3)

- The reference category was considered as "lack/shortage of pedestrian facilities" for this MNL model.
- The results indicate that pedestrians using motorcycles as the primary mode of travel perceived that careless or inattentive driving/riding is a major cause of pedestrian accidents compared to lack/shortage of pedestrian facilities (β = 1.34; OR=3.82). This can be interpreted as the odds for motorcycle users are 282% higher than the odds for car drivers.
- The pedestrians capitalising on "pedestrian traffic signals" and "take extra caution when crossing a road and intersection without pedestrian crossing/bridge" and/or "make proper use of footpath", perceive that human errors (e.g. careless driving or riding or traffic violation) would be a major cause of accident compared to non-existence of adequate infrastructure (e.g. lack of pedestrian facilities). This is in line with a past study which outlined that reckless and careless driving was responsible for nearly one half of all pedestrian accidents (Boni et.al., 2018).

Table 5. Influencing factors on pedestrian perception towards road safety

Variables	MNL model - P31 *Pedestrian accident locations*		BL model - P32 *Main mode of transport*	MNL model - P33 *Major cause of pedestrian accidents*		MNL model - P34 *Time of pedestrian accidents*	
	Junction	Pedestrian crossing	Car	Careless	Traffic violation	Night time	Day time
Constant	(**-1.37***)	(-0.71)	(0.17)	(-0.19)	(**-0.99***)	(**-1.83***)	(-0.97)
Age	--	--	30-39 years (**-2.46***)	--	--	30-39 years (0.54)	30-39 years (-0.81)
Household income	--	--	< 3m rupiahs (0.79)	--	--	< 3m rupiahs (**2.06****)	< 3m rupiahs (**1.46***)
	--	--	≥ 3m rupiahs (0.61)	--	--	≥ 3m rupiahs (**0.93***)	≥ 3m rupiahs (**0.84***)
Driving license ownership	yes (**1.07***)	yes (0.46)	yes (-0.93)	--	--	--	--
Primary mode of travel	--	--	motorcycle (0.84)	motorcycle (**1.34***)	motorcycle (1.03)	motorcycle (-0.75)	motorcycle (-0.17)
Experiences on traffic safety education at school	--	--	yes (0.19)	--	--	yes (**1.23***)	yes (**1.97****)
Understanding traffic rules	--	--	pedestrian crossing/bridge (1.01)	--	--	pedestrian crossing/bridge (**0.98***)	pedestrian crossing/bridge (0.49)
Practices usually observed for traffic safety	following pedestrian traffic signal (0.75)	following pedestrian traffic signal (**0.95***)	following pedestrian traffic signal (**-1.43***)	following pedestrian traffic signal (**2.36****)	following pedestrian traffic signal (**2.10****)	--	--
	not crossing a road and intersection without pedestrian crossing/bridge (0.77)	not crossing a road and intersection without pedestrian crossing/bridge (0.65)	not crossing a road and intersection without pedestrian crossing/bridge (0.51)	not crossing a road and intersection without pedestrian crossing/bridge (0.57)	not crossing a road and intersection without pedestrian crossing/bridge (**1.42***)	--	--
	making proper use of footpath (-0.24)	making proper use of footpath (-0.43)	making proper use of footpath (0.90)	making proper use of footpath (**1.65***)	making proper use of footpath (**1.49***)	--	--

Notes: ** significantly different from zero at the 0.01 level; * significantly different from zero at the 0.05 level

MNL model – P34:
Time of traffic accidents most likely to happen (nighttime =1; daytime = 2; others = 3)

- The reference category was considered as "others" for this MNL model.
- The findings of this model indicate that pedestrians with an income of less than 3 million rupiahs, as well as more than or equal to 3 million rupiahs, perceived that night time are 7.84 and 2.53 times respectively more significant than other times of day, for pedestrian accidents. In addition, pedestrians with an income of less than 3 million rupiahs and more and equal to 3 million rupiahs considered that day time are 4.30 and 2.32 times respectively more significant than other times of day, for pedestrian accidents. It is noted that 3 million rupiahs is approximately the regional minimum wage of Denpasar city (1 US$ = 14,000 rupiahs).
- Pedestrians exposed to traffic safety education at school perceived that pedestrian accidents may happen both at night time and at day time, as the model generated positive and significant coefficients, 1.23 (at 95% significant level) and 1.97 (at 99% significant level) respectively. The slightly larger coefficient for day time than night time may be due to the consideration of the higher pedestrian flow in the day time, by the respondents.
- Pedestrians who follow the traffic rules on pedestrian crossing/bridge perceived that pedestrian accidents are more likely to happen at night time as the relevant coefficient is positive and significant (β = 0.98) than others as time of pedestrian accidents. A previous study also showed the association of darkness, and its contribution to pedestrian accidents (Yao et.al., 2018).

Based on Figure 1, the results indicated that the probability of junctions, pedestrian crossings and footpaths considered as the location of pedestrians' accidents (P31) are 43%, 41% and 16% respectively. A previous study conducted in Malaysia also confirms our findings that junctions and pedestrian crossings are significantly considered as the prone location of high pedestrian injuries (Ariffin, et.al., 2010).

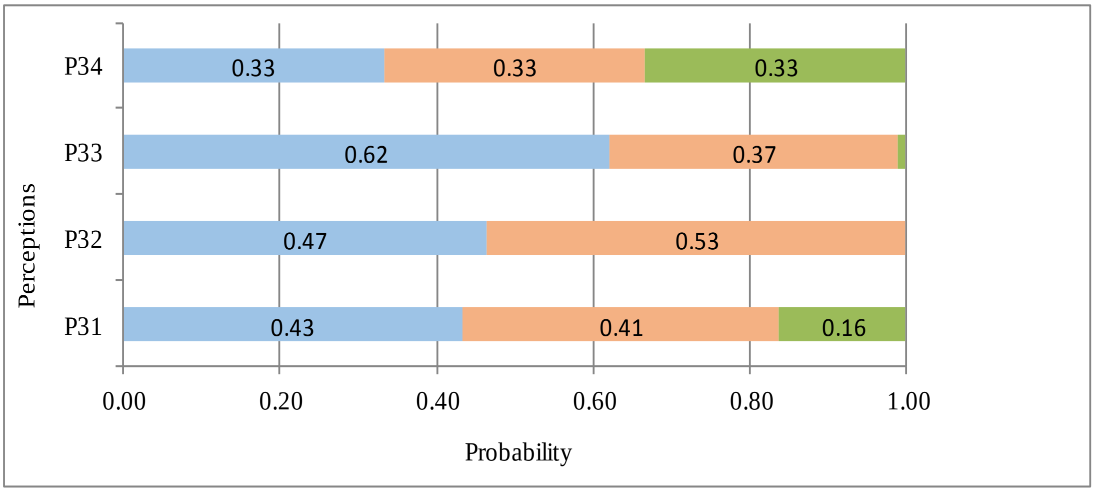

Figure 1. Shares for each category included in the statements P31, 32, 33 and 34

Notes:

P31 Location of pedestrians' accident (junctions = 1 (43%); pedestrian crossing = 2 (41%); footpath = 3 (16%))

P32 Mode types as the main cause of traffic accident (car = 1 (47%); motorcycle = 2 (53%))

P33 Major cause of traffic accidents (careless or inattentive driving/riding=1 (62%); traffic violation=2 (37%); lack/shortage of pedestrian facilities=3 (1%))

P34 Time of traffic accidents most likely to happen (nighttime =1 (33%); daytime = 2 (33%); others =3 (33%))

The probability of cars and motorcycles perceived as the main mode of transport causing pedestrian traffic accidents (P32) is 47% and 53% respectively. A study in Malaysia also shows that cars and motorcycles significantly contributed to pedestrian traffic accidents, involving single-vehicle accidents wit single pedestrian casualties (Ariffin, et.al., 2010).

The probability of careless or inattentive driving perceived as a major cause of traffic accidents (P33) is 62%, followed by traffic violation (37%) and lack/shortage of pedestrian facilities (1%). A prior study in Indonesia, also found that disobedient behaviour and careless driving were one of the main reasons causing traffic accidents (Santosa et.al., 2017). In addition, all categories (night time, day time and others) considered as time of pedestrian traffic accidents most likely to happen (P34) shares an equal probability around 33%.

Meanwhile, the pedestrians are also allowed to choose more than one measure for each statement in the questionnaire (P41-measures taken to improve traffic safety). As the result, pedestrians perceived that “improving traffic signals, pedestrian crossings, and street lights”, “banning on-street parking”, “speed limit enforcement for drivers and riders”, “traffic education to drivers” and “traffic education to pedestrians” at 58.39%, 47.74%, 35.16%, 21.29% and 15.16% respectively, would be important activities to be able to improve road safety in Denpasar, Bali. This is in line with past studies (Anciaes and Jones., 2018; Yao et.al., 2018); providing good pedestrian facilities and road infrastructure including footways, pedestrian crossings, and street lighting can accommodate pedestrian safety. Meanwhile, a past study by Fransman, (2018) indicated that lack of traffic rules and regulation enforcement, and limited road user education program, may result in a disproportionately high number of pedestrian injuries and fatalities. This indicates that enhancing pedestrian safety should be looked at an integrated manner with attention to all aspects of engineering, policy, enforcement, as well as safety education programmes.

In addition, pedestrians are interviewed using the questionnaire and expected to identify group of road users that need to have traffic education (P42). Based on the information from the questionnaire, pedestrians identified groups of road users need to have traffic education including all motorists (67.10%), pedestrians of school students (17.10%), motorcyclists (13.87%), car drivers (10.97%), pedestrians (adult) (10.32%), bus drivers (5.16%), truck drivers (2.58%) and bicyclists (1.61%).

4. CONCLUSIONS

The perceptions of pedestrians toward pedestrian accidents and safety were analysed, and possible measures to improve pedestrian traffic safety in Denpasar, Bali were identified. This study found that junctions and motorcycles were considered more responsible than roadways and cars respectively, to influence pedestrian accidents.

This study outlined that reckless and careless behaviour during driving and riding was responsible for pedestrian accidents. Pedestrians with both high and low incomes perceived that both night and day times are significant times where pedestrians accidents occur. Pedestrians who had previous experiences on traffic safety education at school also perceived that night and day times are significant times of day for pedestrian accidents. Meanwhile, the pedestrians that adhere to traffic protocols at pedestrian crossings and bridges considered that night time is more significant than other times of day, for pedestrian accidents.

In order to respond to the study findings, the measures considered are relevant to enhance pedestrian safety in Denpasar, Bali. These measures have covered the aspects of engineering, policy, enforcement and education. This includes improving road infrastructure (traffic signalling, pedestrian crossings, street lights, etc), banning on-street parking, speed limit enforcement for drivers and riders, traffic education to drivers and pedestrians. Moreover, this study highlights that all motorists are recommended to be exposed to traffic education.

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