Proceedings of 14th IOE Graduate Conference
Peer Reviewed
Year: 2023 Month: December Volume: 14
ISSN: 2350-8914 (Online), 2350-8906 (Print)

Assessment of Pedestrian Waiting Time at Unsignalized Crosswalk of Kathmandu: A Case Study of Jamal Crosswalk

Sudeep Thapaliya [a], Rojee Pradhananga [b]

[a, b] *Department of Civil Engineering, Pulchowk Campus, IOE, Tribhuvan University, Nepal*
[a] sudeepthapaliya9@gmail.com, [b] rojee.pradhananga@pcampus.edu.np

Abstract
The choice of pedestrian waiting time significantly affects pedestrian signal design. This research focuses on the assessment of factors that influence pedestrian waiting time at an unsignalized crosswalk. An investigation into pedestrian behavior is carried out at the unsignalized crosswalk of Jamal, Kathmandu. The discrete choice model is applied due to its effectiveness in handling individual choice behavior. Based on the level of service, pedestrian waiting time is categorized into no waiting time, short waiting time, and long waiting time. Multinomial logistic regression is adopted to analyze different categories of pedestrian waiting time using SPSS. Gap at crossing in the nearer lane, gender, pedestrian size, crossing pattern, and carrying object are the significant factors that affect the pedestrian waiting time. The findings could be utilized by the planners to align the design of pedestrian crossing facilities with the pedestrian behavior patterns at unsignalized crosswalk.

Keywords
Multinomial logistic regression, Waiting time, Unsignalized crosswalk, Pedestrian

1. Introduction

1.1 Background

Walking encompasses two fundamental types of movements: walking along the road and crossing the road. While pedestrians engage in walking along the road to reach their desired destinations, road crossing becomes an integral and unavoidable aspect of walk trips. During road crossing, they rely solely on their senses and judgment to navigate the traffic and ensure their safety. Therefore, pedestrians are considered to be vulnerable road users in the realm of road safety literature due to their increased susceptibility to harm or injury in traffic crashes. Compared to other road users, pedestrians are approximately four times more prone to injury in traffic crashes [1]. Furthermore, due to their lack of protection and exposure during traffic crashes, pedestrians are 23 times more likely to suffer fatal injuries compared to occupants of vehicles. [2]. In Kathmandu Valley, approximately 35 percent of all journeys are undertaken on foot [3]. Pedestrians are often given low priority in metropolitan areas of developing country, particularly as the number of motorized vehicles on the road increases, leading to an increased risk of crashes involving pedestrians. As a result, they are considered vulnerable users of the traffic system. Numerous studies have been conducted on pedestrian behavior across a range of fields, such as urban planning, architecture, land use, and marketing, focusing on perceptual, attitudinal, psychological, and motivational factors.

According to the Metropolitan Traffic Police Division, Kathmandu, there are 107 zebra crossings in the capital. A Kathmandu Walkability Study, 2018, conducted in 35 different sections of the metropolis, shows that 60 % of the zebra crossings in the capital have already faded away, and 80 % of the roads do not even have zebra crossings. In the modern world, planners are giving greater importance to pedestrian facilities due to the deep-rooted advantages of walking trips.

The safety of pedestrians is a top priority in urban transportation planning. In developing countries like Nepal, pedestrians face a variety of challenges due to inadequate infrastructure and ineffective traffic management. One of the most prominent issues is how pedestrians behave when crossing roads, especially at unsignalized crosswalks. Assessing the pedestrian behavior can help lessen number of crashes that involve pedestrians in city areas [4]. A principal factor that affects pedestrians' decisions is how long they wait before crossing at the crosswalk.

1.2 Objectives of Study

The study's main objective is to analyze the waiting time of pedestrians before crossing at unsignalized crosswalk in Kathmandu. The specific objectives are enlisted below:

- To study the pedestrian waiting time (PWT) behavior and identify the factors that influence it at unsignalized crosswalks
- To model relationship between the PWT with different identified factors

2. Literature Review

Safety for pedestrians has been a major issue in Nepal, particularly in metropolitan places like Kathmandu. A principal factor influencing pedestrian behavior is the amount of time people wait before crossing at the crosswalk. The factors that affect how long people wait to cross at uncontrolled crosswalks in Kathmandu, Nepal, have not been well studied. As a result, research is required to pinpoint the variables that affect pedestrian waiting times and offer insights into pedestrian behavior.

The percentage of people who chose each alternative as well as the sociodemographic characteristics of the relevant groups are used to create aggregate choice analysis (Chataut & Shrestha, 2020). In comparison to aggregate choice, discrete choice analysis are found to perform better in terms of their formulation and the parameters used. [5]

Chand & Marsani (2021) conducted a study on pedestrian gap acceptance such that it is concentrated on the size of the vehicular gaps accepted by the pedestrian for crossing at mid-block section of the ring road. They concluded that safety distance and vehicle speed were the most important independent variables that influence the gap acceptance behavior. [6]

Ferenchak (2016) conducted a study on the correlation between pedestrian behavior and motor vehicles. The findings indicated that waiting time increases with age, and older pedestrians experience fewer collisions with moving vehicles when crossing the street compared to younger pedestrians. Males were observed to be twice as likely as females to cause encounters with moving vehicles, but this difference was not statistically significant. Additionally, males had shorter waiting times and were less likely to use crossing infrastructure properly. The study also revealed that as age increases, the likelihood of causing a conflict decreases. [7]

Jamil et al. (2015) conducted a study on the pedestrian crossing choice models according to the traffic, road, and human factors. The findings indicated that the choice of pedestrian crossing is notably influenced by traffic flow and the type of road. Additionally, it was revealed that human-related factors exerted a greater influence compared to the factors mentioned. Three categories of pedestrians were identified, labeled as risk-takers, cautious pedestrians, and leisure-oriented pedestrians. [8]

Paudel (2014) explained that study of road crossing behavior is probably the most important element on establishing road crossing facilities. So, he conducted a study to develop a model to find out the critical gap on uncontrolled mid-block crossing under mixed traffic condition. The results showed that minimum gap size value was significantly explained by waiting time, pedestrian speed and gap type and gap acceptance of pedestrians. [9]

Li (2013) aimed to develop a model for pedestrians' intended waiting times at signalized intersections. The model considers factors such as the number of waiting pedestrians, pedestrian walking speed, pedestrian phase duration, and distance to the opposite sidewalk. The study also found that pedestrians' waiting time increases with the number of waiting pedestrians and decreases with the pedestrian's walking speed. Additionally, pedestrians' waiting time is found to be longer when the pedestrian phase is shorter. [10]

Oxley et al. (2005) investigated how various factors affect pedestrians' decisions about when to cross the road. The study examined age, distance from the oncoming vehicle, time gap, vehicle speed, and walking time as influencing factors. The findings revealed that the distance of the approaching vehicle was the most crucial factor in determining when pedestrians chose to cross. Older pedestrians had more difficulty choosing the right time gaps compared to younger pedestrians. [11]

3. Methodology

3.1 Variable Definition and Area of Study

During a half-hour observation period as part of field reconnaissance, the average waiting time for pedestrians was found to be approximately 5 seconds. Therefore, the dependent variable Pedestrian Waiting Time(PWT) is categorised into No Waiting Time(NWT) (0 s), Short Waiting Time(SWT) (0-5 s) and Long Waiting Time(LWT) (more than 5 s) with reference to Table 1 and independent variables are Gap at crossing in nearer lane (Gap 1), Gap at crossing in farther lane (Gap 2), Speed at crossing in nearer lane (Speed 1), Speed at crossing in farther lane (Speed 2), Average gap of rejected vehicles at nearer lane, Gender, Pedestrian Size, Crossing Pattern and Carrying any object based on review of relevant literatures and preliminary observations of intersections in Kathmandu.

Gap, speed and rejected gap are shown in Figure 1 and 2 respectively. As shown in Figure 3, the crossing pattern is divided into designated crossing (DC), designated start and peripheral exit (DS,PE), peripheral start and designated exit (PS,DE), peripheral start and peripheral exit (PS,PE). Due to the lower frequency of PS,PE, it is merged with DS,PE and named as Peripheral Start and Designated or Peripheral Exit (PS,D/PE). The average of all gaps that a pedestrian has rejected during his waiting is the average gap of rejected vehicles.

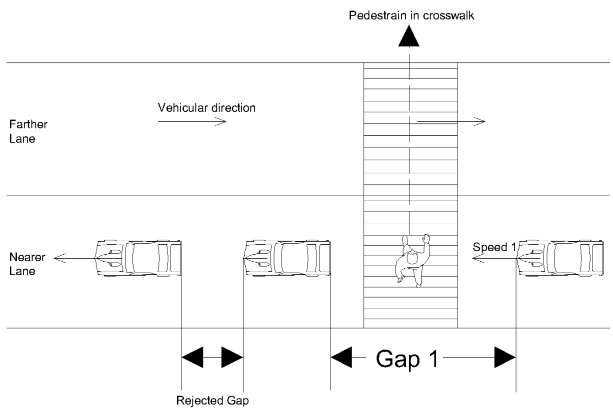

Figure 1: Rejected gap, Speed and Gap at the nearer lane

In order to analyze the waiting time of pedestrian, pilot survey at various crosswalk in the Kathmandu valley was done beforehand and crosswalk of Jamal was selected for the study. The site was selected ensuring high pedestrian flow, uninterrupted vehicular flow and availability of suitable place to position the camera.

Data were collected from 9 A.M. to 11 A.M. (for two hours) for two days on typical working days. So, total of 240 minutes of video recording was conducted. A total of 491 data was extracted for developing and ensuring the validity of the model. The Jamal crosswalk is on a two-way four lane road as shown

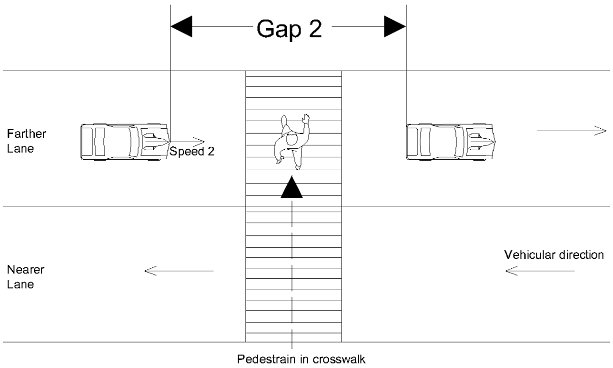

Figure 2: Speed and Gap at the farther lane

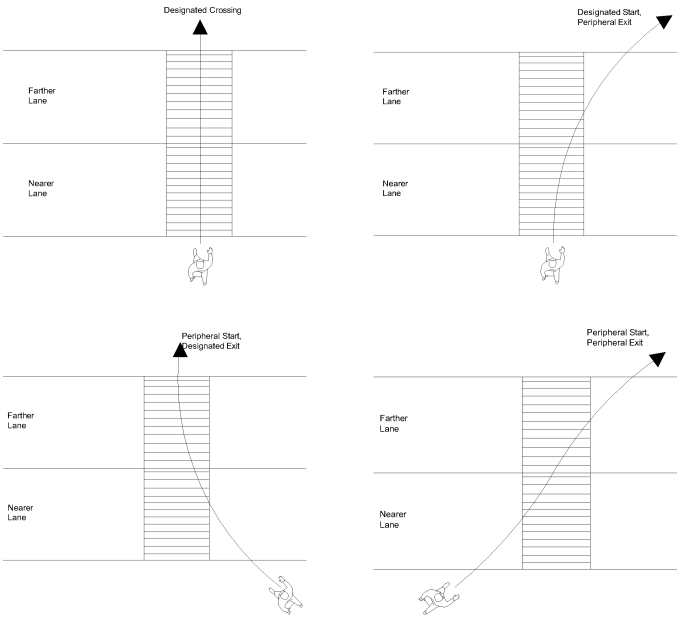

Figure 3: Crossing Pattern

Table 1: Waiting time ranges based on the LOS of pedestrian waiting time (Source: Nemeth, 2014) [12]

LOS	Descriptions	Waiting time ranges (s)
A	Usually, no conflicting traffic	0-5
B	Occasionally some delay due to conflicting traffic	5-10
C	Delay noticeable to pedestrians, but not inconveniencing	10-20
D	Delay noticeable and irritating	20-30
E	Delay approaches tolerance level, risk-taking behavior likely	30-45
F	Delay exceeds tolerance level, high likelihood of pedestrian risk-taking	≥45

in Figure 4. The length and width of Jamal crosswalk is 18.06 meters and 4 meters respectively.

3.2 Sample Size

According to Peduzzi et al. (1996), in order to use the logistic regression, the minimum number of samples can be

Figure 4: Jamal Crosswalk

determined using Equation

$$\text{Sample Size (N)} = \frac{10k}{p} \tag{1}$$

Where,
k= Total number of predictor variables considered
p= Lowest proportion of positive or negative cases in the population

43.17% of the total population accounts for "No waiting time", whereas, 23.21% of total population accounts for "Short waiting Time". That means, 33.62% of total pedestrians fall under the "Long waiting time" category. Therefore, the lowest proportion is 0.23 is used for sample size estimation.

Since 9 independent variables were used in this study, the required number of samples can be calculated from Equation 1 as,

$\therefore$ N = $\frac{10\times9}{0.23}$ = 387.76 ≈ 388

The minimum of 388 samples are required to perform logistic regression. A total of 491 data have been used for developing and ensuring the validity of the model.

3.3 Multinomial Logit Model

As an extension of binary logistic regression, multinomial logistic regression can forecast a nominal dependent variable when one or more independent variables are present. The Multinomial Logit Model (MNL) is a statistical model used to analyze discrete choice data. In this model, individuals make a single choice from a set of mutually exclusive and exhaustive alternatives. The MNL model assumes that the choice probabilities are related to the utility (or preference) that individuals associate with each alternative.

Let the choice made by individual i as y_i, where y_i is an integer from 1 to j representing the chosen alternative out of the available j alternatives. The utility of j alternatives for individual i is given in Equation 2.

$$U_{ij} = \beta_j\, x_{ij} + \varepsilon_{ij} \tag{2}$$

Where,
U_{ij}= Utility of alternative j for individual i.
β_j= Vector of unknown parameters to be estimated.
x_{ij}= Vector of explanatory variables associated with

Table 2: Correlation Matrix

	Gap 1 (m)	Gap 2 (m)	Speed 1 (m/s)	Speed 2 (m/s)	Avg rejected gap (s)
Gap 1 (m)	–				
Gap 2 (m)	-0.133	–			
Speed 1 (m/s)	0.12	-0.054	–		
Speed 2 (m/s)	-0.005	0.102	0.036	–	
Avg rejected gap (s)	-0.767	0.146	-0.112	-0.027	–

alternative j for individual i.
ε_{ij}= Independently and identically distributed error term following the Type I extreme value (Gumbel) distribution.

The probability P_{ij} of individual i choosing alternative j is given by,

$$P_{ij} = \frac{e^{U_{ij}}}{\sum_{k=1}^{n} e^{U_{ij}}} \tag{3}$$

In the context of pedestrian waiting time, we can use a multinomial logit model to predict the probability of a pedestrian choosing one of several options whether they would choose to cross immediately or wait for some time or wait for longer time before start crossing.

4. Results and Discussions

4.1 Preliminary Analysis

A total of 398 data were used as a training data for modelling relationship between the PWT and the identified factors. The frequencies of pedestrian's crossing pattern were merged from four categories to three due to the very low frequency in the peripheral start and peripheral exit pattern. The variable "Gap 1" and "Average gap of rejected vehicles" have correlation value of -0.767, which is above the threshold value of 0.5 for behavioral analysis as shown in Table 2. Therefore, the variable "Average gap of rejected vehicles" was removed from further analysis.

Table 3 and 4 provides an overview of the statistical summaries of continuous and categorical variables for three categories of waiting time of pedestrian in the study location.

Table 3: Description of average of continuous independent variables with respect to PWT

Waiting Time Category	Gap 1 (m)	Gap 2 (m)	Speed 1 (m/s)	Speed 2 (m/s)
No Waiting	7.345	4.485	6.673	6.728
Shorter Waiting	5.609	4.717	6.572	6.862
Longer Waiting	4.050	5.318	6.472	6.332

Table 4: Description of average of categorical independent variables with respect to PWT

PWT Category	Gender		Pedestrian Size		Crossing Pattern			Carrying Object	
	Male	Female	Single	Two or more	DC	DS,PE	PS, D/PE	Yes	No
No Waiting	126	44	89	81	72	58	40	46	124
Shorter Waiting	16	76	33	59	41	49	2	25	67
Longer Waiting	37	99	48	88	63	72	1	98	38

4.2 Model Development

Likelihood Ratio Test of all variables: The Likelihood Ratio Test (LRT) is used as shown in Table 5 to test the significance of variable in the model. For categorical variables, the LRT is like an overall test of significance of an independent variable. Variables gap 1, gender, pedestrian size, crossing pattern and carrying object have p-value less than 0.05, so they are highly significant. Whereas, gap 2, speed 1 and speed 2 have higher p value (greater than 0.05) and considered non-significant predictor variables of pedestrian waiting time.

Table 5: Likelihood Ratio Test including all variables

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	451.955	0.000	0	
Gap 1	626.908	174.953	2	0.000
Gap 2	452.804	0.849	2	0.654
Speed 1	452.243	0.288	2	0.866
Speed 2	456.007	4.052	2	0.132
Gender	500.876	48.921	2	0.000
Pedestrian Size	465.887	13.932	2	0.001
Crossing pattern	468.106	16.151	4	0.003
Carrying Object	469.814	17.860	2	0.000

Pseudo R-Square: From Table 6, the Nagelkerke pseudo-R square is 0.712 which indicates that the model explains approximately 71.8% of the variance in the pedestrian waiting time (dependent variable). Hence, it's essential to consider Mutinomial Logistic regression appears to be a reasonably good fit for the data.

Table 6: Pseudo R-Square (Significant Variables)

Cox and Snell	0.628
Nagelkerke	0.712
McFadden	0.463

Likelihood Ratio Test of Significant Variables: Table 7 presents the LRT of the significant variables only. Since, all of the p-value of variables presented are less than 0.05, Gap1, Gender, Pedestrian Size, Crossing Pattern and Carrying Object are the significant variables of PWT.

Table 7: Likelihood Ratio Test (Significant Variables)

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	450.538	0.000	0	
Gap 1	628.139	177.556	2	0.000
Gender	500.398	49.815	2	0.000
Pedestrian Size	463.747	13.164	2	0.001
Crossing pattern	466.018	15.435	4	0.004
Carrying Object	468.700	18.117	2	0.000

Parameter Estimates: From Table 8, parameter estimates provide a summary of the impact of each predictor. The B value represents the estimated coefficients from the multinomial logistic regression model. Additionally, Exp (B) values serve as odds ratios, comparing various predictor categories to the reference category. The p-value is a crucial metric for hypothesis testing. When the p-value is less than the significance level (in this case, 0.05), we reject the null hypothesis; otherwise, we fail to reject it. Null hypothesis defines there is no significant relation between variables (dependent and predictors). With three categories of pedestrian waiting time, two sets of logistic regression coefficients, often referred to as "2 logits," are formed as shown in Table 7. The first set of coefficients is associated with the short waiting time row, representing the comparison between short waiting time (SWT) and the reference category, no waiting time (NWT). The second set of coefficients corresponds to the long waiting time row, representing the comparison between long waiting time (LWT) and the reference category, no waiting time. These coefficients allow for the assessment of the impact and significance of predictors on both short and long waiting times relative to no waiting time.

Table 8: Parameter Estimates (Significant Variables)

PWTa		B	Std. E	Wald	df	Sig.	Exp(B)
SWT	Intercept	-0.135	1.241	0.012	1	0.914	
	Gap 1	-0.601	0.150	16.006	1	0.000	0.548
	Gender=0 (Female)	2.348	0.361	42.268	1	0.000	10.460
	Gender=1 (Male)	0b			0		
	Pedestrian Size=0 (Single)	-0.756	0.342	4.901	1	0.027	0.469
	Pedestrian Size=1 (Group)	0b			0		
	Crossing pattern=1 (DC)	2.128	0.818	6.766	1	0.009	8.397
	Crossing pattern=2 (DS,PE)	2.039	0.812	6.299	1	0.012	7.682
	Crossing pattern=3 (PS,D/PE)	0b			0		
	Carrying Object=0 (No)	0.558	0.369	2.294	1	0.130	1.748
	Carrying Object=1 (Yes)	0b			0		
LWT	Intercept	7.681	1.837	17.490	1	0.000	
	Gap 1	-1.917	0.212	81.671	1	0.000	0.147
	Gender=0 (Female)	1.248	0.411	9.230	1	0.002	3.484
	Gender=1 (Male)	0b			0		
	Pedestrian Size=0 (Single)	-1.503	0.432	12.109	1	0.001	0.223
	Pedestrian Size=1 (Group)	0b			0		
	Crossing pattern=1 (DC)	3.115	1.469	4.500	1	0.034	22.540
	Crossing pattern=2 (DS,PE)	2.633	1.462	3.244	1	0.072	13.911
	Crossing pattern=3 (PS,D/PE)	0b			0		
	Carrying Object=0 (No)	-0.930	0.397	5.484	1	0.019	0.395
	Carrying Object=1 (Yes)	0b			0		

a. The reference category is: No Waiting Time.
b. This parameter is set to zero because it is redundant.

4.2.1 Analysis of Short Waiting Time In Reference To No Waiting Time

Gap 1: The odds of choosing the short waiting time in reference to no waiting time decreases by 45.2% if gap 1 increases by 1 second, assuming all other predictor variables remain constant. As gap 1 increases in short waiting time pedestrian chooses no waiting time.

Gender: The odds of choosing short waiting time, in reference to no waiting time, increase by 10.460 times when pedestrians are female rather than male, assuming all other predictor variables remain constant. The study reveals that females prefer short waiting time, while males choose no waiting time.

Pedestrian Size: The odds of choosing the short waiting time in reference to no waiting time decreases by 53.1% if the pedestrians are alone rather than in group, keeping all other predators variable constant. From this study, pedestrian in group choose short waiting time whereas single pedestrian chooses no waiting time.

Crossing Pattern: The odds of choosing the short waiting time in reference to no waiting time increases by 8.397 times if pedestrians aim to cross the road within the marked designated crosswalk rather than peripheral start for crossing. Similarly, odds of choosing the short waiting time in reference to no waiting time increases by 7.682 times if the pedestrians aim to cross the road with designated start but peripheral exit pattern rather than peripheral start pattern for crossing, assuming all other predictor variables remain constant. Thus, short waiting time is more preferred by the pedestrian who crosses the road in designated path or at least start to cross from designated point rather than pedestrians who start crossing from periphery of cross walk.

Carrying any Object: The p value of carrying object is 0.130 which is greater than 0.05 as presented in Table 8. So, the estimated coefficient for carrying object is statistically insignificant, indicating that carrying object have no significant impact on choice between short waiting time and no waiting time.

4.2.2 Analysis of Long Waiting Time In Reference To No Waiting Time

Gap 1: The odds of choosing the long waiting time in reference to no waiting time decreases by 85.3% if gap 1 increases by 1 second, assuming all other predictor variables remain constant. Pedestrian chooses no waiting time when gap 1 increases in longer waiting time category.

Gender: The odds of choosing long waiting time, in reference to no waiting time, increase by 3.484 times when pedestrians are female rather than male, assuming all other predictor variables remain constant. The study reveals that females choose longer waiting time while males prefer not to wait before crossing.

Pedestrian Size: The odds of choosing the long waiting time in reference to no waiting time decreases by 77.7% if the pedestrian is alone rather than in group, keeping all other predators variable constant. From this study, pedestrian in group is more inclined to wait longer whereas single pedestrian chooses immediate crossing without any wait.

Crossing Pattern: The odds of choosing the longer waiting time in reference to no waiting time increases by 22.540 times if pedestrians aim to cross the road within the marked designated crosswalk rather than peripheral start for crossing. Thus, longer waiting time is more chosen by the pedestrians who cross the road in designated path rather than any other pedestrians.

Carrying any Object: The odds of choosing long waiting time, in reference to no waiting time, decreases by 60.5% when pedestrians are empty handed rather than carrying any object, assuming all other predictor variables remain constant. The pedestrian carrying object in hand chooses to wait for longer time.

5. Model Validation

This validation process helped to verify that the model's predictions can be trusted and applied to new datasets, enhancing its practical utility and applicability. Out of 491 samples, 93 samples were used for the model validation with respect to the model specifications. The prediction ability of the developed multinomial logit model is found to be 82.8% as shown in Table 9. It is found that, the pedestrian's no waiting time, short waiting time and longer waiting time have 85.7%, 72.7% and 86.2% of prediction accuracy. The overall accuracy 82.8% of model represented that the actual choices and the predicted choices of waiting time of pedestrian matches.

Table 9: Validation Table

		Predicted			
		PWT			
Observed		No Waiting Time	Shorter Waiting Time	Longer Waiting Time	Percent Correct
PWT	No Waiting Time	36	3	3	85.7%
	Shorter Waiting Time	3	16	3	72.7%
	Longer Waiting Time	2	2	25	86.2%
	Overall Percentage	44.1%	22.6%	33.3%	82.8%

6. Conclusion and Recommendation

A discrete choice model was developed with the help of five significant independent variables for three different hierarchy of waiting time and offered an alternative approach to other existing different models of pedestrian behavior.

The probability of waiting at both the short and long level increases than the probability of being not waiting if the gap between the vehicles at crossing reduces in the nearer lane. The probability of waiting of females are found to be more than males in both the short and long levels indicating that females are more careful, low risk taking and show alert nature before crossing the road. Similarly, the probability of pedestrian to wait increases for both short and long level of waiting time if the pedestrian starts the crossing road from the designated starting point of the crosswalk. However, the probability of a pedestrians not to wait any seconds drastically increases if they intent to start the crossing other than the designated starting point of crosswalk. Also, the probability of waiting greatly decreases when pedestrians are single rather than two or more in number. The likelihood of waiting time is more for longer waiting time when the pedestrian is not empty handed and are carrying an object in their hand in comparison to no waiting time.

In further studies ordered logit model, nested logit model, probit model, generalized extreme models, etc. can also be used for thorough understanding of the waiting time behavior. Additionally, more locations with different traffic nature, geometry, etc. can be included as well. Since the type of vehicles were not included as variable in this study it can be used in further studies as well.

References

[1] Rune Elvik. The non-linearity of risk and the promotion of environmentally sustainable transport. *Accident Analysis & Prevention*, 41(4):849–855, July 2009.

[2] Luis F. Miranda-Moreno, Patrick Morency, and Ahmed M. El-Geneidy. The link between built environment, pedestrian activity and pedestrian–vehicle collision occurrence at signalized intersections. *Accident Analysis & Prevention*, 43(5):1624–1634, September 2011.

[3] ESCAP. Piloting Sustainable Urban Transport Index (SUTI) in Kathmandu Valley, Nepal, 2019.

[4] Sylvain Lassarre, Eleonora Papadimitriou, George Yannis, and John Golias. Measuring accident risk exposure for pedestrians in different micro-environments. *Accident Analysis & Prevention*, 39(6):1226–1238, November 2007.

[5] Piyush Chataut and Pradeep Kumar Shrestha. Mode choice modeling of graduate level engineering students of kathmandu valley. Master's thesis, Tribhuvan University, Pulchowk Campus, August 2020.

[6] Krishna Chand and Anil Marsani. Prediction of Pedestrian Gap Acceptance Behavior in Urban Mid-Block Illegal Crossing under Mixed Traffic Condition.

[7] Nicholas N. Ferenchak. Pedestrian age and gender in relation to crossing behavior at midblock crossings in

India. *Journal of Traffic and Transportation Engineering (English Edition)*, 3(4):345–351, August 2016.

[8] Rolla Jamil, Shengwu Xiong, Xiangzhen Kong, Senwen Zheng, and Zhixiang Fang. Pedestrian Crossing Patterns Preference at a Non-signalized Crosswalk. *Procedia Manufacturing*, 3:3353–3359, 2015.

[9] Bishnu P. Paudel. *Modelling Pedestrian Road Crossing Behavior under Mixed Traffic Condition in Kathmandu*. PhD thesis, Tribhuvan University, Pulchowk Campus, Pulchowk Campus, November 2014.

[10] Baibing Li. A model of pedestrians' intended waiting times for street crossings at signalized intersections. *Transportation Research Part B: Methodological*, 51:17–28, May 2013.

[11] Jennifer A. Oxley, Elfriede Ihsen, Brian N. Fildes, Judith L. Charlton, and Ross H. Day. Crossing roads safely: An experimental study of age differences in gap selection by pedestrians. *Accident Analysis & Prevention*, 37(5):962–971, September 2005.

[12] Bryan Nemeth. Uncontrolled Pedestrian Crossing Evaluation Incorporating Highway Capacity Manual Unsignalized Pedestrian Crossing Analysis Methodology. 2014.