Journal of Transportation System and Engineering (JoTSE)
ISSN: 3059-9865(Print) 3059-9873(Online)
Vol. 1. Issue 1, 2025(May): 25-36
©Society of Transport Engineers Nepal (SOTEN)

Research Article
Received Date: November 12, 2024
Accepted Date: March 06, 2025
Published Date: May 25, 2025

Assessment of Pedestrian Safety at Crosswalks of Unsignalized Intersection: A Case Study of Machhapokhari Intersection, Kathmandu

Hari Krishna K.C.[a], Thusitha Chandani Shahi[a,*]

[a]Nepal Engineering College, Center for Postgraduate Studies (nec-CPS) Bhaktapur, Nepal

Abstract

The rapid urbanization of Kathmandu Valley, coupled with increasing vehicle and pedestrian traffic, has highlighted the critical need for pedestrian safety, particularly at intersections. Despite the growing number of vehicles and pedestrians, pedestrian safety remains a largely overlooked aspect of traffic management in Nepal. The Machhapokhari intersection, an unsignalized and uncontrolled junction, has been identified as dangerous for pedestrians, with high crash frequencies and pedestrian fatalities. This study focuses on assessing pedestrian safety using the Ordered Logit (OL) model at the Machhapokhari intersection. Pedestrian safety assessment was conducted using a structured questionnaire survey of 400 pedestrians crossing the crosswalks of the Machhapokhari intersection. The survey data were analyzed using an ordered logistic regression (OL) model to identify the qualitative factors influencing pedestrian safety perceptions. Key variables included pedestrian age, previous crash history, vehicle volume, road width, traffic control, and pedestrian behavior. Findings from the study indicate that younger pedestrians (age=15-24 years) and those controlled by traffic perceive higher safety levels. Factors such as traffic police control, pedestrian road markings, and less road width at crossings of pedestrians significantly improved the safety of pedestrians at the Machhapokhari intersection. Conversely, higher vehicle volume and speed were associated with lower safety perceptions. The research offers actionable insights for researchers and policymakers to study pedestrian safety at similar intersections across Kathmandu and other urban areas.

Keywords: Pedestrian Safety; Ordered Logistic Regression; Traffic Control

1. Introduction

A pedestrian is defined as any person who travels at least part of their journey on foot. This includes individuals who are sitting, lying down, jogging, trekking, or running on the road. Pedestrians also encompass those using walking aids such as wheelchairs, walkers, canes, and skateboards (WHO, 2013). Due to their increased exposure when interacting with large or fast-moving vehicles, pedestrians are the most vulnerable road users (Galanis et al., 2017). Walking is often the most practical and efficient method of traveling from one location to another, whether directly or indirectly (Litman, 2017).

Pedestrians, cyclists, and motorcyclists are among the most vulnerable road users, collectively accounting for more than half of all traffic fatalities. This issue is particularly prevalent in low and middle-income countries (WHO, 2023). Pedestrians are especially vulnerable due to two main factors their unique characteristics and behavior, which affect their interaction with motorized traffic, and their lack of mass, speed, and safety compared to other road users (OECD, 1998, 2012; ERSO, 2008; Yannis et al., 2007). Policymakers could benefit from a deeper understanding of pedestrian attitudes, perceptions, and behaviors when planning and implementing measures to enhance pedestrian safety. This understanding could also help address issues related to pedestrian behavior and safety needs more effectively (Papadimitriou et al., 2012). Official data on pedestrian crashes may be underreported, suggesting that the actual number of pedestrian injuries and fatalities could be higher than

* *E-mail address:* thusithacs@nec.edu.np

reported. Pedestrian crashes account for 23% of road deaths worldwide(Organization, 2023). One significant risk factor for pedestrian traffic injuries is the slow progress in updating regulations and safety standards (WHO, 2023).

At intersections as opposed to mid-blocks, pedestrians exhibit different behaviors (Sisiopiku & Akin 2003), which may result in varying risks of accidents. In dense urban areas, the intersection density (number of intersections in a specific area) is comparatively higher, potentially leading to a significant portion of pedestrian accidents occurring at intersections (Alavi et.al.,2013). Approximately 40% of all traffic crashes were attributed to intersections, according to the National Highway Traffic Safety Administration (NHTSA,2024) in the USA This statistic highlights the significant occurrence of crashes at intersections where roads meet. Several factors contribute to these crashes, including the pedestrian's age, the width of the crossing, intersection with wide turning radii that enable faster-moving vehicles, and misunderstandings of pedestrian signals (Hossain et. al,2023).

According to data from the Metro Traffic Police Division (MTPD, 2024), pedestrian negligence accounted for 0.05% of total traffic crashes over the last five years in Kathmandu Valley. While this percentage may seem low, the actual involvement of pedestrians in crashes and fatalities is significant. Pedestrians represent 18.40% of all road traffic crash victims and account for 32.41% of road traffic deaths in the past five years in Kathmandu Valley. This highlights the urgent need to address pedestrian safety issues. Consequently, transportation planners, traffic engineers, policymakers, and researchers in Nepal should prioritize pedestrian safety.

According to Bhattarai (2019), Crashes in unsignalized intersections are higher than signalized in Kathmandu Valley. According to data from MTPD (2024), the Machhapokhari intersection includes the highest number of crashes and pedestrian deaths among unsignalized intersections.

Badveeti & Mir (2021) studied pedestrian safety at unsignalized intersections considering no effect of vehicle speed on pedestrian safety at intersections. This study considers the effect of vehicle speed on pedestrian safety. The study time was also taken at pedestrian peak hour as pedestrian risk increases at peak hour due to high vehicle-pedestrian interaction (Ampereza et. al., 2024). Papadimitriou et. al. (2012) studied pedestrian safety using pedestrian perception only by questionnaire survey.

This research aims to assess pedestrian safety at the Machhapokhari intersection, considering factors such as Pedestrian demographics, trip information, and behavior while traveling. The findings of this study will contribute to the existing body of knowledge by providing evidence-based recommendations for improving pedestrian safety at unsignalized intersections. The results will be valuable for urban planners, policymakers, and traffic management authorities in designing safer pedestrian environments in Kathmandu and other similar urban settings.

2. Research Objective

The general objective of this research is to assess pedestrian safety at crosswalks at the Unsignalized Intersection at Machhapokhari Intersection in Kathmandu. The specific objectives of the research are to find the pedestrian peak hour in the Study area and to assess the existing status of pedestrian safety and qualitative factors influencing it at the crosswalks of the Machhapokhari intersection.

.

3. Literature Review

According to a study by Hamed (2001) on pedestrian behavior at crossings on undivided and divided streets, revealing that older pedestrians and those living nearby tend to wait longer and make fewer crossing attempts, while younger and frequent crossers are more likely to attempt crossing multiple times, especially during peak traffic. Key factors influencing crossing behavior include waiting time, vehicle type, and traffic conditions. The study highlights that pedestrians are more cautious when encountering large buses and that prolonged waiting increases the number of crossing attempts. Policy recommendations include enhancing traffic control, enforcing driver penalties, and promoting pedestrian safety through education and public awareness campaigns i.e. engineering, enforcement and education.

Arhin and Noel (2007) conducted field surveys and video analyses to investigate the impact of countdown pedestrian signals (CPS) on pedestrian behavior and perceptions of intersection safety in the District of Columbia, USA. Their study found that CPS installations did not lead to statistically significant improvements in most factors at the examined junctions. However, pedestrians generally reported feeling a greater sense of security due to the presence of CPS. The CPS appeared to enhance pedestrians' awareness of crossing behavior, which is a notable safety benefit. The survey results suggest that pedestrians' confidence and sense of safety when crossing intersections improved immediately after CPS implementation. However, the impact on pedestrian behavior was less clear.

Pervaz et al. (2016) conducted a study on pedestrian safety at intersections in Dhaka Metropolitan City, Bangladesh, using both field observations and user perceptions from pedestrians and drivers. They found that intersections became more pedestrian-friendly when the area was cleared of trash, hawkers, and illegal parking, and when footbridges were accessible for pedestrian use. Additionally, the study emphasized that properly educating drivers, enforcing traffic laws, and fostering a positive attitude towards road safety could effectively help prevent accidents.

In an intercept survey carried out by Ni et al. (2017) at 32 crosswalks in Shanghai, China, 1286 pedestrians were asked to rank their sense of safety on a scale of 1 to 5. The three types of pedestrian behavior were identified as follows late walkers (LW), who enter in flashing green, red walkers (RW), who enter in red, and green walkers (GW), who enter in green. Using a random-effects ordered logit model, they discovered that the presence of a refuge island had the greatest impact on improving LW's perception of safety, followed by RW and GW. This suggests that, despite its effectiveness in raising pedestrians' perceptions of safety when they obey signals, the presence of a refuge island encouraged signal violation because it may make pedestrians feel less risky when crossing the street on red or flashing green.

In Kolkata City, India, Mukherjee and Mitra (2019) conducted a comparative analysis of safe and unsafe signalized junctions from the perspectives of pedestrian behavior and perception through surveys and videography. Their findings indicated that in areas with documented pedestrian fatalities, there was significantly greater pedestrian dissatisfaction and signal disobedience. The analysis revealed several planning and design flaws, including longer waiting times before crossing, higher levels of pedestrian-vehicle interaction, and factors related to the pedestrian's crossing state, such as their intended mode of transportation, journey status, home location, and sociodemographic characteristics. These elements were all significant predictors of pedestrian violation behavior. The insights gained from this study are valuable for proactive measures to improve pedestrian safety.

The study by Santhosh et. al. (2020) examined pedestrian-vehicle conflicts at T-intersection (Oravackal) and X-intersection (Ayarkunnam) using field observations and simulations.At both sites, two-wheelers and male adults dominate, while elderly pedestrians are less than 10% of the total due to the study's focus on peak hours when this age group is less active. Pedestrians at both intersections cross at speeds (15th percentile of 1.5 m/s) higher than the Indian Road Congress standard (1.2 m/s), indicating aggressive behavior linked to peak hour congestion. Ayarkunnam, with its higher traffic volume, has more overall conflicts but less severe ones, likely due to police control during peak hours. The study suggests that limiting pedestrian crossings effectively reduces conflicts, with a notable reduction of 24.11% at Oravackal and 31.46% at Ayarkunnam when converting from uncontrolled to controlled intersections.

Mukherjee &Kumar (2024) explored factors influencing pedestrian safety and satisfaction in Patiala, an Indian mid-sized city, using ordered logit models. Data from 2112 pedestrians across six intersections with different land-use types (religious, commercial, educational) was analyzed. Key factors affecting perceived safety include land use, pedestrian signals, road width, vehicular speed, and time-to-collision. Educational areas had the highest safety and satisfaction, while religious and commercial zones rated lower. Women, less-educated pedestrians, and those crossing for work or religious purposes felt less safe. The study provides policy recommendations to improve pedestrian safety in similar urban environments.

4. Methodology

4.1 Study Area

This study aimed to assess pedestrian safety conditions at unsignalized intersection. The research focused on three crosswalks of the Machhapokhari Intersection. This intersection is a 3-legged intersection The study examined three crosswalks at Machhapokhari during both morning and evening peak hours. The Ringroad side leg has 4 lanes while the Macchapokhari side leg has 2 lanes. The road width at the pedestrian crossing location is 33.50m, 28m, and 16.50 m respectively for Buspark, Balaju, and Machhapokhari side leg. This intersection experiences 5.79% of total crashes of intersection and 9.24% of pedestrian deaths (MTPD,2023), which is highest among unsignalized intersections in Kathmandu Valley. This intersection experiences many crashes and heavy pedestrian traffic due to its proximity to the bus park. Therefore, it was selected as the study area The data revealed that the Machhapokhari intersection is critical for pedestrians due to its lack of control, high crash frequency, heavy pedestrian traffic, and high vehicle volume.

4.2 Sample Population, Sample Size, and Sampling Method

The population was sampled by pedestrians who used the intersection. To guarantee a respectable degree of accuracy in the findings, a 5% margin of error (e = 0.05) was targeted for the sample size computation. Assuming maximal variability in the population, 0.5 was utilized as a cautious estimate of the proportion (p). Z = 1.96 at a 95% confidence level that was calculated. The complementary probability (q) was then computed as follows q = 1-p = 1-0.5 = 0.5. The formula is according to equation (1) (Cochran, 1963)

$$n = \frac{Z^2pq}{e^2} \quad \text{......(1)}$$

where, n=sample size,
Z= Standard error associated with the chosen level of confidence,
p=variability and
e= Acceptable sample error

By entering these values into the formula, the needed sample size (n), was found to be roughly 384 individuals. For the assessment of pedestrian safety, a questionnaire of 400 was asked to pedestrians who were using that crosswalk at the pedestrian peak hour of pedestrian flow on the second day of the study. Pedestrian safety assessment was done through wholly 400 data as a sum of all three legs. The proportioning of sample size for model calibration was based on the peak hour pedestrian flow. Accidental sampling method was used for this questionnaire survey.

4.3 Data Collection

4.3.1 Primary Data Collection

A pedestrian safety perception survey was conducted at crosswalks to assess pedestrian safety during the second-day study period. Respondents rated their perception of safety after crossing on a scale from 1 to 5, where 1 indicated the least safe perception and 5 indicated the safest according to the Likert Scale of increasing order. During the survey, pedestrian Demographic and Personal Information such as Gender, Age, Marital Status, highest completed education level, employment status of pedestrian, and Tentative monthly income were taken while crossing. Similarly, pedestrian trip information and perception related data such as previously crashed with vehicle at that intersection, how often crosswalk used by them, how often crosswalk blocked by vehicles, time of day using that crosswalk, public transport user or not, intended mode of transport after crossing and pedestrian perceived safety rating were also taken. Pedestrian group size, conflict with vehicle, distractor while crossing, waiting while crossing, crossing style and control of vehicle while crossing was collected from observation of pedestrian crossing in field.

4.3.2 Secondary Data Collection

For Pedestrian perception, pedestrian peak hour in the morning and evening time was found on the first day of the study. Video Record of the Machhapokhari intersection was obtained from the Metropolitan Police Office (MPO), Ranipokhari, Kathmandu for the whole day (i.e. from 6 AM to 8 PM) in the first day showing the pedestrian and vehicle movement at three crosswalks from two different cameras. The Pedestrian counting was done in every fifteen minutes on each leg in two directions (i.e. from left to right and right to left) (Shrestha,2023). The sum of all three legs was used for the analysis of peak hour findings. Four Combinations were made; they were 0:00- 0:00 (Example 6:00-7:00),0:15- 0:15 (Example 6:15-7:15), 0:30- 0:30 (Example 6:30-7:30), 0:45- 0:45 (Example 6:45-7:45) in Microsoft Excel. The highest value gave the pedestrian peak hour.

4.3.3 Data Analysis

The peak hour for pedestrian flow was determined by counting pedestrians at all three study site crosswalks from 6:00 AM to 8:00 PM on the first day. These peak hours were assumed to be the same on the second and third days (Li and Fernie, 2010). During these peak times on the subsequent days, data on pedestrian demographics, personal information, trip details, perceptions, and behaviors were collected through questionnaires and observational surveys.

Perception of pedestrians is in ordinal scale and effect of independent variables on dependent studies using Ordered Logit model. (Washington,2020; Mukherjee,2024). The Ordered Logit Model was used to analyze the data from these surveys. This model is appropriate for analyzing ordinal data, such as satisfaction levels related to pedestrian safety. It can handle both continuous and categorical data. The odds ratio, derived from the model, helps quantify the effect of each variable on pedestrian safety (Li et al., 2021). The results of the Ordered Logit Model reveal which factors significantly impact pedestrian safety.

The Ordered Logit Model (OLM) was chosen because pedestrian-perceived safety is an ordinal variable with a natural order, making OLM the most suitable approach. Alternative models like Linear Regression and Multinomial Logit were considered but deemed inappropriate—Linear Regression assumes equal spacing between categories, which is unrealistic, while Multinomial Logit ignores the ordinal nature of the data. The Probit model, although similar, does not provide significant advantages over the Logit model. The test of parallel lines confirmed that the proportional odds assumption holds, justifying the use of OLM over more complex alternatives. The OLM ensures meaningful interpretation, efficient estimation, and statistically robust analysis of pedestrian safety perceptions.The ordered logit model is derived by defining an unobserved variable Z, which is used as a basis for modeling the ordinal data. In this study, pedestrian safety is an ordinal variable comprising five levels 1, highly unsafe to 5, highly safe. The general specification of the ordinal variable for each observation as shown in equation 2 is

$$Z = \beta X + \varepsilon i \qquad \text{(2)}$$

Where X is a vector of explanatory variables determining the discrete ordering i for each observation,

β is a vector of coefficients associated with the explanatory variables, and

εi is the random error term. Using the above equation, observed pedestrian safety at intersection Y can be defined in equation 3 as,

$$Y = \begin{cases} 1 \text{ if } Z \le \mu 1 \text{ (Highly unsafe/highly unsatisfied])} \\ 2 \text{ if } \mu 1 < Z < \mu 2 \\ 3 \text{ if } \mu 2 \le Z < \mu 3 \\ 4 \text{ if } \mu 3 \le Z < \mu 4 \\ 5 \text{ if } \mu 4 \le Z < \mu 5 \text{ (Highly safe/highly satisfied)} \end{cases} \qquad \text{(3)}$$

Here, μ is a threshold parameter.

Using the log-likelihood ratio test, the proposed OL model's goodness of fit will be estimated (Washington et al., 2020) The log-likelihood ratio index is calculated to measure the overall goodness-of-fit of the models (Washington et al.,2020).

5. Result and Discussion

5.1 Determination of Pedestrian Peak Hour

The study was carried out during pedestrian peak hour by manually counting the pedestrian crossing at each leg in every 15 minutes on both sides (from left to right and from right to left). The pedestrian peak hour was taken for the morning one hour and evening one hour, which was found 10 AM to 11 AM and 4.45 PM to 5.45 PM. The result of pedestrian counting of the sum of all three legs is shown in Figure 1.

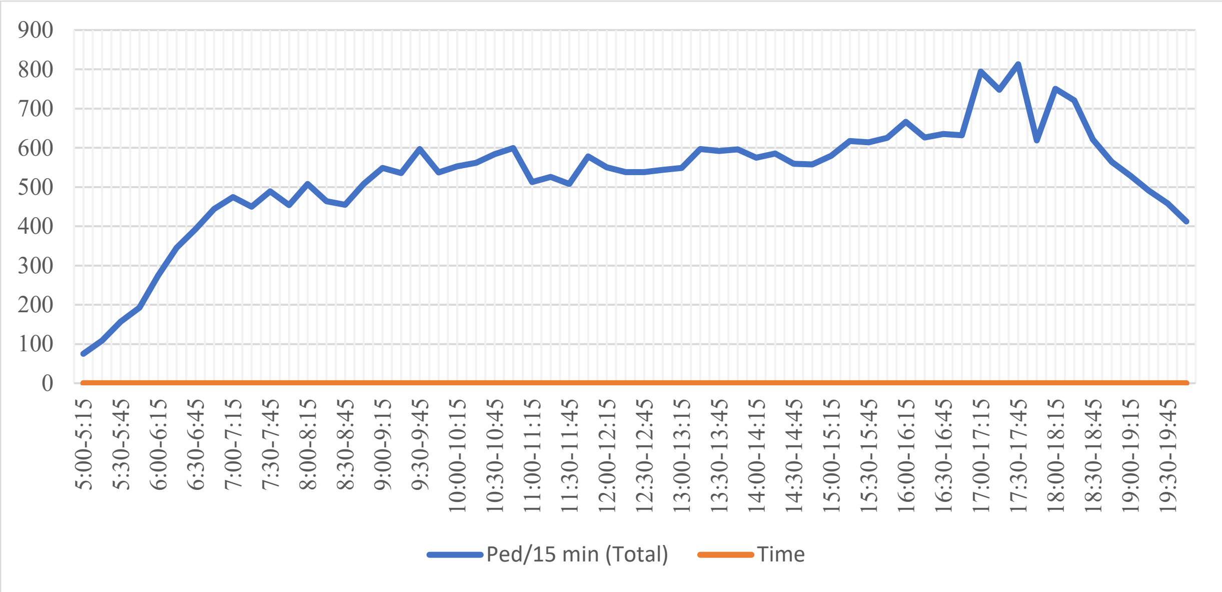

Figure 1 Pedestrian counting result on the first day

5.2 Assessment of Pedestrian Safety and Qualitative Factors Influencing it

The pedestrian safety assessment from pedestrian perception was conducted on three crosswalks at the Machhapokhari intersection. A structured questionnaire was asked of pedestrians while crossing the crosswalk. The behavioral study of pedestrians was observed during the crossing. The collected 400 data were used in the ordered logistic regression model. The study was carried out on the 2nd day of Pedestrian peak hour.

5.2.1 Model Variables and their Descriptions

The pedestrian safety, which is comprised of five categorical outcomes—"Highly Safe," "Safe," "Moderate," "Unsafe," and "Highly Unsafe" was used as the dependent variable in the ordered logit model. According to Figure 2, of the 400 replies, 1% thought pedestrian safety was "Highly Safe," and 7.5% thought it was "Safe." In the same way, 25.8% thought it was "Moderate," while 30.30% said it was "Unsafe." and 35.5% said that it was "Highly Unsafe."

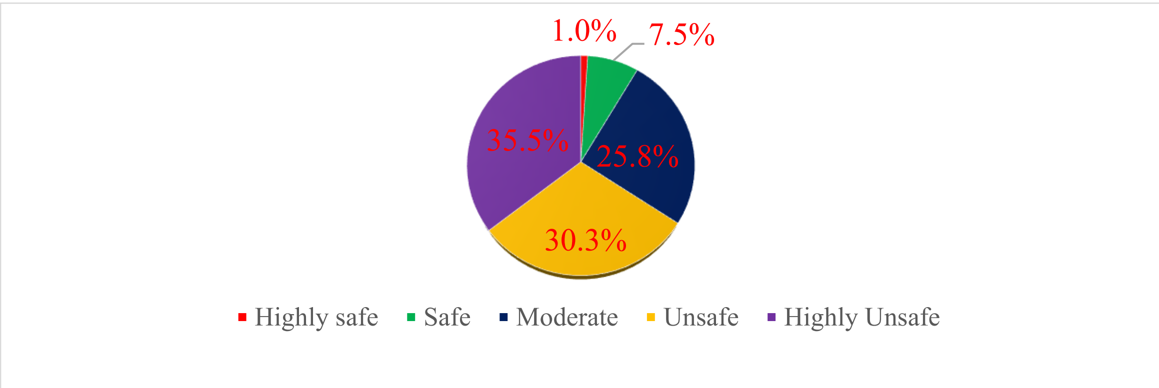

Figure 2: Result of Pedestrian Perceived Safety Based on Questionnaire Survey

Independent factors included the respondent's socioeconomic situation, demographic information, characteristics related to their travels, and their behavioral information while crossing. Pedestrian Demographic and Personal information included factors such as age, gender, marital status, educational level, employment status, and monthly income. Pedestrian trip information included previous crashes in that crosswalk, blockage of the crosswalk, repetition of the use of the crosswalk, time of crossing, trip purpose, public transport user, and intended mode of transport. Pedestrian behavioral information included group size, involvement of blockage with a motorized vehicle, distractor while crossing, waiting while crossing, crossing style, and control by traffic police.

5.2.2 Ordered Logit Model Result

SPSS (Statistical Package for Social Science) software was used to analyze the datasets for this study. To analyze the effects of several demographic, socioeconomic, travel activity, and behavioral variables on the overall perceived pedestrian safety, an Ordered Logit Model (OLM) was utilized in the research. Using the SPSS software version 27, the multivariable OLM was carried out via the Polytomous Logit Universal Model (PLUM) technique.

Before modeling, a multicollinearity test was performed, and as Table 1 illustrates, each independent variable's variance inflation factor (VIF) was less than 5, suggesting that there is no significant multicollinearity between the independent variables (Li et al., 2020). Next, to investigate the important factors connected to pedestrian safety, the OLM was created.

Table 1: Collinearity Results of Independent Variables.

Variables	Variance Inflation Factor (VIF)
Gender	1.057
Age	1.976
Marital status	1.705
Highest Completed Education	1.808
Employment Status	1.897
Tentative Monthly Income	2.692
Crash With Vehicle Previously	1.041
How often are crosswalks blocked by vehicles	1.423
How Often Do you use this crosswalk	1.954
At what time of day do you typically use this crosswalk	1.100
Trip Purpose	1.480
Public Transport User	1.919
Intended Mode of Transport after Crossing	1.836
Pedestrian Perceived Satisfaction Level	1.288
Pedestrian Group Size	1.194
Conflict With Vehicle	1.062
Distractor While crossing	1.120
Waiting While crossing	1.232
Crossing Style	1.143
Control of Vehicle by traffic while crossing	1.379

Tables 2, 3, and 4 provide an overview of the Ordered Logit Model's (OLM) estimation and prediction results regarding the qualitative factors influencing pedestrian safety at crosswalks.

The Test of Parallel lines results, which is displayed in Table 4 and Table 3, verified that the proportionate odds assumption was met. The test of parallel lines in SPSS assesses the proportional odds assumption. This assessment determines if the slope coefficients are consistent across all response categories in an ordered logit model. According to the null hypothesis, these coefficients are equal, indicating the model's validity. If the null hypothesis is rejected, it suggests that the coefficients differ across levels, requiring a more complex model such as the multinomial logit model. However, if the null hypothesis is not rejected, the ordered logit model remains suitable. In this instance, the significance of the Chi-Square statistic (.174) is greater than .05, indicating that the proportional odds assumption is upheld. The OLM is proportionate in terms of both the odds ratio and the log odds, according to the Likelihood Ratio Test (LRT) results (Adeleke and Adepoju, 2010).

Table 2 Test of Proportional Odds Assumption

Test of Parallel Lines				
Model	-2 Log Likelihood	Chi-Square	Df	Sig.
Null Hypothesis	831.682			
General	637.137	194.545	177	0.174

Table 3 displays the model fitting data for the predicted OL model. The null hypothesis is that all of the regression coefficients in the model are equal to zero. The LRT result was utilized to evaluate the variations between the intercept-only model's -2 log-likelihood and the full model. The chi-square value (204.129), with df = 59, indicated that this difference was highly significant (P< 0.05), which would lead to the conclusion that at least one of the regression coefficients in the model is not equal to zero. This figure demonstrated the general fit of the OL model.

Table 3 Model Fitting Information

Model Fitting Information				
Model	-2 Log Likelihood	Chi-Square	Df	Sig.
Intercept Only	1035.811			
Final	831.682	204.129	59	0.000

The overall goodness-of-fit of the OLM to the service quality dataset is further confirmed by the Pearson chi-square value (1420.736, P>0.05) and deviance chi-square value (812.274, P>0.05) (Moawed and El-Aziz, 2022). Figure 4.4 displays the OL model's model fitting data along with the corresponding values for Deviance and Pearson chi-square value.

Table 4 Goodness of Fit

Goodness-of-Fit			
	Chi-Square	Df	Sig.
Pearson	1420.736	1401	0.351
Deviance	812.274	1401	1.000

The pseudo-R-square estimates (Cox and Snell=0.4, Nagelkerke=0.43) show that at least 40% of the variation in the likelihood of denoting a highly safe pedestrian safety was explained by the selected independent variables, indicating that OLM was able to explain the variability among pedestrian safety categories. Nagelkerke R-Square is typically used to confirm the goodness-of-fit of the OL model (Eboli and Mazzulla, 2009).

The relatively low pseudo-R-square values may be attributed to multiple factors. First, pedestrian safety perception is inherently complex and influenced by various unmeasured behavioral, environmental, and situational factors that were not included in the model. For instance, psychological aspects such as risk perception, prior experiences, and cultural attitudes toward pedestrian safety may contribute significantly but were not directly captured in the model.

Second, some independent variables may have weak predictive power, meaning they contribute minimally to explaining pedestrian safety variation. It would be beneficial to examine which variables have the least significant coefficients or high standard errors, as these could indicate weak predictors. For example, variables such as pedestrian group size or trip purpose may not have a strong association with perceived safety compared to variables like prior crash experience or conflicts with vehicles.

To improve the model's predictive accuracy, future research could explore additional variables such as traffic volume, road design, pedestrian infrastructure quality, and driver behavior. Furthermore, alternative modeling approaches, such as mixed-effects models or machine learning techniques, could be considered to capture non-linear relationships and interaction effects that may not be fully accounted for in the current OLM framework.

Table 5 Pseudo R Square Value

Pseudo R-Square	
Cox and Snell	0.400
Nagelkerke	0.430

Nineteen variables in the OL model are gender, age, marital status, educational level, employment status, monthly income, crash with vehicle previously, blocking of crosswalk by vehicle, usage of that crosswalk, time of use of that crosswalk, trip purpose, intended mode of transport after crossing, public transport user, pedestrian group size, conflict with vehicle, distractor while crossing, waiting while crossing, crossing style and control by traffic police while crossing as indicated in Table 6 provides summary of only significant variables. The Maximum Likelihood approach is used to estimate the vector of β parameters, and the Wald tests' p-values are used to determine the statistical significance of each variable (Eboli et al., 2009).

Table 6 Odd Ratios of Significant Variables

Variable	Estimate	Interval	Odd ratio
Age	Positive	15-24 Year	4.933
		>=65 Year	Reference Category
Crash With Vehicle Previously	Negative	Yes	0.075
		No	Reference Category
How Often Crosswalk Blocked by Vehicle	Negative	Never	0.007
	Negative	Rarely	0.102
	Negative	Sometimes	0.249
		Always	Reference Category
Time of day Using that crosswalk	Negative	6 AM -10 AM	0
	Negative	10 AM 2 PM	0
	Negative	2 PM-6 PM	0
		6 PM-10 PM	Reference Category
Trip Purpose	Positive	Job	2.626
	Positive	Religious	5.554
		Others	Reference Category
Intended Mode of Transport After Crossing	Positive	Bike/Scooter	4.54
		Car	Reference Category
Pedestrian Group Size	Positive	One	15.227
	Positive	Two	9.989
	Positive	Three	6.756
		>=6	
Control by Traffic	Negative	No	0.156
		Yes	

5.2.3 Interpretation of Ordered Logit Model Result

To objectively evaluate the influence of qualitative important factors on the perceived level of safety at the crosswalk of the MachhaPokhari intersection, the study employed odds ratios (OR). The ORs obtained from the results of the OL model are shown in Table 6.

The study utilized odds ratios (OR) to quantitatively assess the impact of key factors on the perceived pedestrian safety at crosswalks of the Machhapokhari intersection. Table 6 presents the ORs derived from the OL model outcomes. It was observed that as compared to older pedestrians (the age group of pedestrians >=65 years), younger pedestrians (age group =15-24 years) perceived better safety by 4.9 times. This result is consistent with the study carried out by Georgious (2021) in Greece entitled “Perceived Pedestrian Level of Service in an Urban Central Network The Case of a Medium size Greek City”. According to their research, young pedestrians (18–24) are more likely to perceive higher LOS than people aged 55–64 and ≥ 65 as well by approximately 5 times and 4.6 times respectively. Similar research showed that anxiety levels and mobility can be negatively impacted by older pedestrians' elevated perception of risk, especially at intersections (Baskind, 2023; Rod et al., 2023).

Similarly, through OR analysis, it was determined that pedestrians who crashed previously in that crosswalk perceived lesser safety than pedestrians who did not crash previously. The perceived safety decreased by 92.5% (i.e. for a crash with a vehicle previously, OR = 0.075, change in odds = (1- OR)*100% = (1-0.075)*100% =92.5%). This is in line with a study that found relatives of those who had lost property in an earthquake or been involved in vehicle crashes were more dedicated to taking precautions (Turkum, 2006). Lesser perceived safety might be due to the reason that they expect more safety facilities for pedestrian crossing. Similar research Studies revealed that pedestrians' views of safety are considerably influenced by their prior experiences in crashes. When crossing similar places, those who have been in accidents frequently report feeling less secure and more anxious (Kwon et al., 2022).

Additionally, pedestrians who answered that the crosswalk was never blocked by a vehicle perceived lesser safety than those who thought that blocked always. Also who thought that crosswalk was blocked rarely and sometimes perceived 89.8% and 74.1% less safe than those who thought that crosswalk was blocked always. This might be according to a study, pedestrians frequently judge their level of safety by how predictable it is that cars will behave, which can be impacted by whether or not they believe crosswalks to be constantly blocked or clear (Taima & Daimon, 2023).

As compared to trip purpose others, the job is religious trip makers feel safer by 2.6 and 5.6 times respectively. Regarding the intended mode of transport as a car, the bike as an intended mode of transport feels safer by 4.5 times. As the pedestrian group size increased, the safety status of pedestrians decreased. As, compared to pedestrian group sizes equal to or more than 6, pedestrian group sizes three, two, and one felt safer by 6.8, 10, and 15.2 times respectively. This result is consistent with, a study by Thompson et al. (2013) found that social distraction among group members causes pedestrians to behave less cautiously. In contrast, other studies found that group crossings were slower (Hussein et al., 2015) and safer (Brosseau et al., 2013). The results of this investigation demonstrated that individual crossing is safer than group crossing.

Last but not least, Pedestrians who were controlled by traffic felt safer than those not controlled by traffic. OR analysis suggested that pedestrians (OR=0.156) who were not controlled by traffic felt 84.4% lesser safer than pedestrian who were controlled by traffic. This is consistent to Kim et al. (2024), where pedestrians who walk in controlled traffic situations perceive safety as higher than those who walk in uncontrolled settings.

Overall, age, previous crash pedestrian, blocking of vehicle, time of crossing, trip purpose, intended mode after crossing, pedestrian group size, and control by traffic significantly affected pedestrian safety at the crosswalk of the intersection.

6. Conclusion and Recommendation

The status of pedestrian safety is unsafe in the Machhapokhari Intersection. 35.5% of pedestrians perceived the crosswalk as highly unsafe. Similarly, 30.30% perceived unsafe, 25.8% moderate. Only 7.5% perceived safety and 1% highly safe. This result showed that the pedestrian safety status of the Machhapokhari intersection at the crosswalk is highly unsafe. As compared to older pedestrians, younger pedestrians perceived better safety while crossing. Pedestrians whose intended mode was bike perceived better safety than pedestrians whose intended mode was the car. The presence of traffic increased the safety of pedestrians.

The study results indicated that Machhapokhari Intersection's present pedestrian safety index value is between 2 and 3 indicating that safety condition is unsafe/moderate. It is therefore suggested that the government and pertinent parties for the possible resolution and strategic planning. This study shows that control of vehicles by traffic police enhances pedestrian safety highly, thus it is advised to control vehicles by traffic during pedestrian peak time

7. References

Adepoju, A., & Adeleke, K. (2010). Ordinal logistic regression model: An application to pregnancy outcomes. Journal of Mathematics and Statistics, 6, 279–285. https://doi.org/10.3844/jmssp.2010.279.285

Alavi, H., Charlton, J., & Newstead, S. (2013). Factors driving intersection pedestrian crash risk in concentrated urban environments. In Proceedings of the 2013 Australasian Road Safety Research, Policing & Education Conference, 28th–30th August, Brisbane, Queensland. Monash University Accident Research Centre (MUARC).(Alavi et al., 2013)

Ankunda, A., Ali, Y., & Mohanty, M. (2024). Pedestrian crash risk analysis using extreme value models: New insights and evidence. Accident Analysis & Prevention, 203, 107633. https://doi.org/10.1016/j.aap.2024.107633

Arhin, S. A., & Noel, E. C. (2007). Impact of countdown pedestrian signals on pedestrian behavior and perception of intersection safety in the District of Columbia. In 2007 IEEE Intelligent Transportation Systems Conference, Bellevue, WA, USA, 2007 (pp. 337-342). https://doi.org/10.1109/ITSC.2007.4357761

Badveeti, A., & Mir, M. S. (2019). Using video-graphic technique for the pedestrian safety analysis (PSA) at mid-block crossings in urban areas of developing countries under mixed traffic conditions. International Journal of Research in Advanced Engineering and Technology, 5(2), 19-23. ISSN: 2455-0876. Available at: www.newengineeringjournal.in

Bhattarai, S. (2019). Crash prediction for prioritization of intersections for safety improvement: Case study of Kathmandu Valley. Journal of Advanced College of Engineering and Management, 5, 165-179. https://doi.org/10.3126/jacem.v5i0.26765

Cochran, W. G. (1963). Sampling Techniques (2nd ed.). New York: John Wiley & Sons, Inc.

Eboli, L., & Mazzulla, G. (2009). An ordinal logistic regression model for analysing airport passenger satisfaction. EuroMed Journal of Business, 4(1), 40-57. https://doi.org/10.1108/14502190910956684

ERSO – The European Road Safety Observatory. (2008). Traffic safety basic facts – Pedestrians. http://erso.swov.nl/safetynet/fixed/WP1/2008/BFS2008_SN-KfV1-3-Pedestrians.pdf

Galanis, A., Botzoris, G., & Eliou, N. (2017). Pedestrian road safety in relation to urban road type and traffic flow. Transportation Research Procedia, 24, 220-227. https://doi.org/10.1016/j.trpro.2017.05.111

Georgiou, A., Skoufas, A., & Basbas, S. (2021). Perceived pedestrian level of service in an urban central network: The case of a medium-sized Greek city. Case Studies on Transport Policy, 9(2), 889–905. https://doi.org/10.1016/j.cstp.2021.04.009

Hamed, M. M. (2001). Analysis of pedestrians' behavior at pedestrian crossings. Safety Science, 38(1), 63-82. https://doi.org/10.1016/S0925-7535(00)00058-8

Hossain, A., Sun, X., Zafri, N., & Codjoe, J. (2023). Investigating pedestrian crash patterns at high-speed intersection and road segments: Findings from the unsupervised learning algorithm. International Journal of Transportation Science and Technology, 14. https://doi.org/10.1016/j.ijtst.2023.04.007

Li, F., Li, Y.-Y., Liu, M.-J., Fang, L.-Q., Dean, N. E., & Wong, G. W. K. et al. (2021). Household transmission of SARS-CoV-2 and risk factors for susceptibility and infectivity in Wuhan: A retrospective observational study. The Lancet Infectious Diseases, 21(5), 617-628. https://doi.org/10.1016/S1473-3099(20)30981-6

Litman, T. (2017). Economic value of walking: Connecting sustainable transport with health. Sustainable Transport, 9(5). https://doi.org/10.1108/S2044-994120170000009005

Metro Traffic Police Division (MTPD). (2023). Data on road crashes in Kathmandu Valley. Kathmandu: MTPD.

Mukherjee, D., & Kumar, A. (2024). Identification of factors influencing pedestrian perceived safety and satisfaction level using ordered logit models in an Indian midsized city. International Journal of Transport Development and Integration, 8(2), 283-299. https://doi.org/10.18280/ijtdi.080207

National Highway Traffic Safety Administration (NHTSA). (2024). What is the leading cause of intersection accidents? Phillips Law Offices. https://phillipslawoffices.com/leading-cause-of-intersection-accidents

Ni, Y., Cao, Y., & Li, K. (2017). Pedestrians' safety perception at signalized intersections in Shanghai. Transportation Research Procedia, 25, 4727-4734. https://doi.org/10.1016/j.trpro.2017.05.222

OECD. (1998). Safety of vulnerable road users. OECD Publishing.

OECD – International Transport Forum. (2012). Pedestrian safety, urban space and health. OECD Publishing.

Papadimitriou, E., Yannis, G., & Golias, J. (2012). Analysis of pedestrian exposure to risk in relation to crossing behavior. Transportation Research Record, 2299(1), 79–90. https://doi.org/10.3141/2299-09

Pervaz, S., Hasanat-E-Rabbi, S., & Newaz, K. (2016). Pedestrian safety at intersections in Dhaka Metropolitan City.

Santhosh, D., Bindhu, B. K., & Koshy, B. (2020). Evaluation of pedestrian safety in unsignalized T and X intersections through comparison of the frequency and severity of pedestrian conflicts. Case Studies on Transport Policy, 8, 1352-1359. https://doi.org/10.1016/j.cstp.2020.09.006

Shrestha, A. R. (2023). Modeling Pedestrian Level of Service for Crosswalks at Signalized Intersections in Kathmandu Valley. MSc thesis, Tribhuvan University, Institute of Engineering, Pulchowk Campus, Department of Civil Engineering, Lalitpur, Nepal.

Sisiopiku, V. P., & Akin, D. (2003). Pedestrian behaviors at and perceptions towards various pedestrian facilities: An examination based on observation and survey data. Transportation Research Part F: Traffic Psychology and Behaviour, 6(4), 249-274.

Washington, S. P., Karlaftis, M. G., Mannering, F., & Anastasopoulos, P. (2020). Statistical and Econometric Methods for Transportation Data Analysis. New York: Chapman and Hall, CRC Press.

World Health Organization. (2013). Global and regional estimates of violence against women: Prevalence and health effects of intimate partner violence and non-partner sexual violence. World Health Organization. https://iris.who.int/bitstream/handle/10665/79753/9789241505352_eng.pdf

World Health Organization (WHO) African Region. (2024). Status report on road safety in the WHO African Region, 2023. WHO African Region. https://apps.who.int/iris

Yannis, G., Kanellaidis, G., Dimitropoulos, J., & Muhlrad, N. (2007). Assessment of pedestrian safety measures in Europe. ITE Journal, 77(12), 40–48.