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Modeling Pedestrian Level of Service for Crosswalks at Signalized Intersection in Kathmandu Valley

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Abstract

Modeling pedestrian level of service (PLOS) in developing countries, such as Nepal, is essential for effective planning, designing, and maintaining pedestrian facilities. PLOS provides valuable insights into the quality of the pedestrian environment and can serve as a basis for establishing standards for pedestrian facilities. This research attempted to create a system for predicting the PLOS model at signalized intersection crosswalks in Kathmandu Valley, Nepal. This was accomplished by considering pedestrians' perspectives on factors that may influence it. Initially, information was gathered from five crosswalks through a videographic survey. A questionnaire survey was carried out onsite to understand perceptions regarding PLOS. This survey captured details from 408 individuals and also recorded the traffic characteristics entering the signalized intersection via the crosswalk. The questionnaire, after an internal consistency evaluation using Cronbach's alpha, was condensed from 13 to 10 questions, maintaining a 5-point Likert scale with total scores ranging from 10 to 50. To identify the significant elements impacting the PLOS score, Pearson's correlation test was employed. Using the perceived PLOS score from the questionnaire as the dependent variable and the significant factors as independent variables, a stepwise regression analysis was conducted to establish the most suitable predictive model. The significant factors were: the volume of right-turning vehicles, the volume of through vehicles, the average number of pedestrians crossing the crosswalk, and the average pedestrian delay with each factor measured across 15-minute intervals. The threshold values of the PLOS ranges were established by k-means clustering for six categories ranging from A to F. The intervals were set as follows: Scale A spanned values from 10 to 16.76, Scale B from 16.76 to 23.69, Scale C from 23.69 to 29.65, Scale D from 29.65 to 36.59, Scale E from 36.59 to 44.06, and Scale F from 44.06 to 50.

Keywords

Pedestrian, Pedestrian Level of Service, Pedestrian Delay, Crosswalk, Signalized Intersection

1. Introduction

As a result of swift urban growth in Nepal, road traffic is experiencing a significant upsurge. For quite a while, the enhancement of vehicular transit systems has been the focal point for transportation planners and engineers. To this day, priority is predominantly given to motorized transport systems over those catering to non-motorized users like cyclists and pedestrians. Yet, recent years have seen a shift toward embracing multi-modal strategies to improve pedestrian facilities and operations. The diversity of traffic on Nepalese city streets is striking, with vehicles exhibiting a broad spectrum of static and dynamic characteristics. All types of vehicles, regardless of their category, share the same road space without segregation and can occupy any part of the road based on the availability of space at that moment, often disregarding lane discipline. Under such unregulated traffic conditions, pedestrian spaces are steadily shrinking, making them increasingly susceptible to accidents.

Intersections are among the most challenging spots on any road network due to their inherent nature of accommodating vehicles moving in different directions who desire to occupy the same area simultaneously. Not only vehicles, but pedestrians also seek to utilize these spaces for crossing, adding to the potential for conflict between different road users at the intersections. The call for enhancement in pedestrian facilities has been catalyzed by factors like the challenges of crossing densely trafficked intersections, vehicles interrupting pedestrians' paths during green signals, clashes between pedestrians and motorized vehicles, physical impediments, low visibility, and poor design of accessible ramps for the pedestrians with disability [1]. An effective solution would be to devise a method for gauging the level of difficulty users encounter while crossing these intersections. The development of a Pedestrian Level of Service (PLOS) model could serve as a viable technique to ascertain the complexity of intersection crossings, and thus assess the quality of pedestrian infrastructure.

A significant portion of existing research has focused on PLOS studies for four-legged intersections. However, the present study aims to assess PLOS specifically at three-legged intersections. Characterized by one road terminating at a junction with another, creating a 'T' shape, the traffic maneuvers at these intersections are typically composed of vehicles turning left or right from the main road, merging onto the main road from the terminating leg, or crossing the intersection altogether. Geometric parameters, such as the width and alignment of the intersecting roads, curb radii, and safe sight distance, are meticulously designed to facilitate these maneuvers.

The construction of a PLOS model for crosswalks at signalized intersections could offer valuable insights into optimal pedestrian travel accommodations. PLOS reflects the quality of the pedestrian environment and could help shape standards for pedestrian facilities. The formulation of PLOS at intersections could lead to a better understanding of how to design intersections that safely and effectively accommodate pedestrian movement. Such an evaluative tool would facilitate the integration of pedestrian facility planning into the broader framework of transportation planning, design, and implementation. The PLOS at crosswalks could be used to establish a minimum PLOS standard, which would define the least acceptable LOS required to adequately facilitate pedestrian movement.

1.1 Objectives

The major objectives of the study are:

- Identifying the factors affecting pedestrian LOS at signalized intersection crosswalks,
- Proposing a suitable method for estimating a PLOS model at crosswalks of signalized intersection.

2. Literature Review

The Level of Service (LOS) concept was first introduced in the Highway Capacity Manual in 1965. It was utilized to qualitatively describe the performance, operation, and facilities provided for traffic movement. LOS offers a qualitative analysis of the operational conditions for vehicle and pedestrian traffic, informed by service indicators such as speed, travel time, maneuverability, traffic interruptions, comfort, and convenience.

Pedestrian Level of Service (PLOS) provides a measure of the quality of service extended to pedestrians as they traverse different environments, such as footpaths, crosswalks, stairs, etc. The assessment is based on various factors including the quality of crosswalks, pedestrian signals, street lighting, and other amenities that affect pedestrian comfort and safety. PLOS serves as a critical tool for gauging the walkability and pedestrian-friendliness of an area. It considers the pedestrian experience and delivers a quantitative evaluation of the comfort and convenience of walking in a specific area. Enhancing PLOS can incentivize walking as a transport option, improve access to services, reduce traffic congestion, and foster healthier, more sustainable communities.

Lautso and Murole pioneered research on Level of Service (LOS) to assess how environmental factors affect pedestrian facilities. Their work laid the foundation for future studies, which have further enriched the understanding and calculation of pedestrian LOS by adding various important elements [2].

Sarkar put forth a technique to evaluate the pedestrian level of service (LOS) by taking into account six factors: safety, security, convenience and comfort, continuity, system coherence, and attractiveness. However, the method is qualitative, which means that the attributes of pedestrian environments are described without being quantified. In practice, measuring each factor is challenging, and several of the factors are interdependent since it is a qualitative approach [3].

Khisty developed a methodology for quantifying the Level of Service (LOS) for pedestrian environments, drawing upon criteria analogous to those suggested by Sarkar. This approach yields a numerical assessment of LOS. Concerns arise regarding the extent to which such quantitative measures authentically capture pedestrian experiences and the degree to which pedestrians concur with these evaluative scales [4]. Dixon's method for evaluating pedestrian LOS incorporates various factors and uses a point scale from 1 to 21. The scores are then categorized into six levels, ranging from A to F, providing a quantifiable approach to the assessment [5].

Virkler's study investigated the impact of pedestrians ignoring signals on reducing delays. The research found that such behavior led to delays being 22 percent lower than if pedestrians had fully obeyed the signals [6].

Muraleetharan introduced the concept of "overall LOS" to provide a comprehensive assessment of pedestrian Level of Service. The study employed a conjoint technique to combine various factors, resulting in a single, integrated value for pedestrian LOS. He explored a variety of factors that influence PLOS at crosswalks. These factors include turning vehicles, signal delay, crossing infrastructure, corner space, and pedestrian-bicycle interaction. The study was pivotal in evaluating pedestrian LOS, especially at intersections with signal controls and mixed traffic. It not only looked at operational issues like signal timing but also considered pedestrian comfort and safety aspects such as perceived risks and potential conflicts. [7].

Chilukuri and Virkler aimed to improve the Highway Capacity Manual (2000) equation for calculating pedestrian delay at signal-controlled intersections. The original equation operates under the assumption that pedestrian arrivals at intersections are random [8].

The Highway Capacity Manual (2010) provides guidelines for assessing the LOS for pedestrians at intersections with traffic signals. This assessment is based on factors such as the amount of time pedestrians have to wait, the space available for pedestrian movement, and the general characteristics of the traffic at the intersection [9].

Nagraj and Vedagiri created a pedestrian level of service framework specifically tailored for crosswalks at signalized intersections in Mumbai, India. Their approach involved incorporating pedestrians' perceptions of different factors that impact their movement. The crucial elements taken into account while formulating the model were the presence of turning and through traffic, the volume of pedestrians, and the amount of delay experienced by pedestrians [1].

Lee Cronbach introduced Cronbach's alpha (α) [10] to gauge the reliability of multi-item surveys, such as the Likert scale. This test assesses the consistency of scales measuring latent variables, which are challenging to measure directly. The alpha value classifies consistency into six categories: excellent (>0.9), good (0.8-0.9), acceptable (0.7-0.8), questionable (0.6-0.7), poor (0.5-0.6), and unacceptable (<0.5). A satisfactory α indicates reliable data for further analysis.

3. Methodology

3.1 Data Collection

Site Selection: Data was collected from five designated locations:

- Balkhu-Sanepa Crosswalk (Site ID: S-1, Co-ordinate: 27°41'3.46"N, 85°18'6.34"E),
- Sallahghari Crosswalk (Site ID: S-2, Co-ordinate: 27°40'17.82"N,85°24'31.01"E),
- Balkhu-Vayodhya Hospital Crosswalk (Site ID: S-3, Co-ordinate:27°41'4.80"N,85°17'54.23"E),
- Balkhu-Kalanki Crosswalk (Site ID: S-4, Co-ordinate: 27°41'5.85"N, 85°17'49.74"E), and
- Balkhu-Dakshinkali Crosswalk (Site ID: S-5, Co-ordinate: 27°41'4.85"N, 85°17'50.12"E).

The site location of sites S-1, S-2, S-3, S-4 and S-5 are shown in Figure 1, Figure 2, Figure 3, Figure 4 and Figure 5 respectively. All of these intersections feature a three-legged configuration, with the exception of the Balkhu-Sanepa Crosswalk where the volume of left-turning traffic is notably minimal. Furthermore, each crosswalk is typically comprised of eight lanes, although the Sallahghari and Balkhu-Sanepa crosswalks deviate from this standard, featuring only four lanes each. The characteristics of the sites are shown in Table 1.

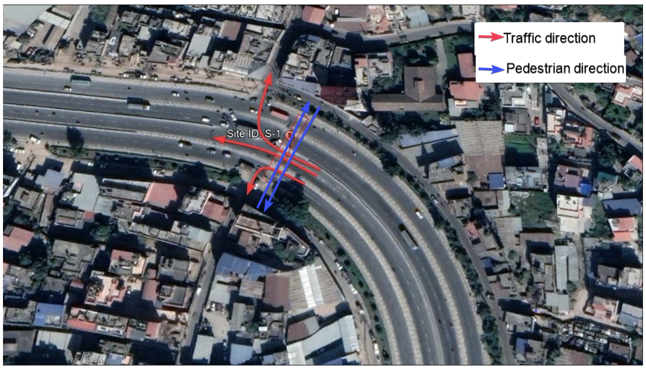

Figure 1: S-1 site location

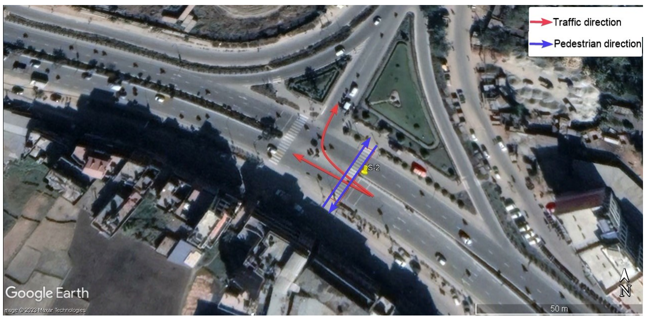

Figure 2: S-2 site location

The red arrows in the figures of site locations signify the direction of incoming traffic volume at each specified crosswalk under study, leading towards the intersection. The blue arrows in the figure of site locations signify the direction of the pedestrian crossing at each specified crosswalk under study.

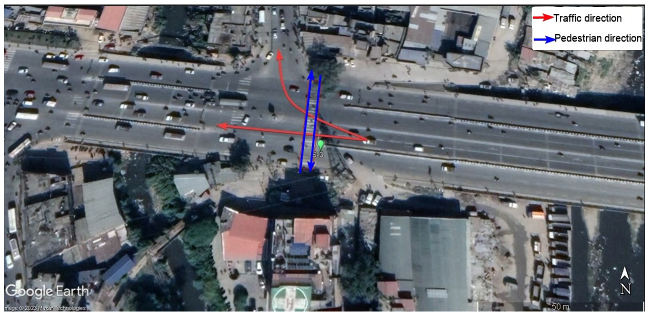

Figure 3: S-3 site location

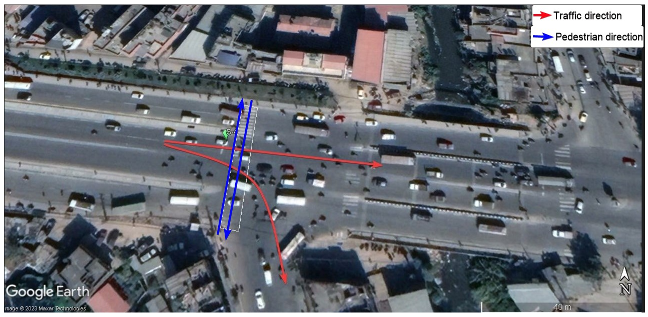

Figure 4: S-4 site location

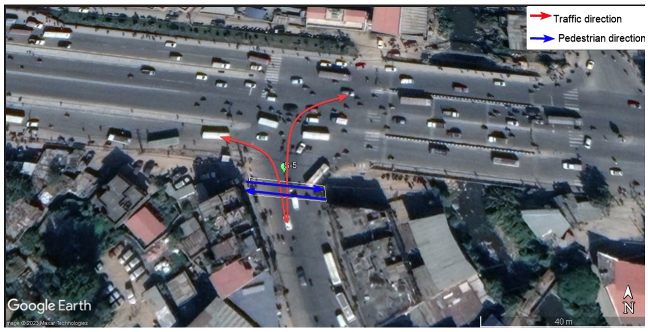

Figure 5: S-5 site location

3.2 Questionnaire and Field Survey

A structured questionnaire survey was administered at the aforementioned crosswalks to assess pedestrian perceptions of the Pedestrian Level of Service for each location. Prior to conducting the interviews, investigators defined the concept of PLOS to the participating pedestrians. Each query on the questionnaire, as well as the corresponding five-point Likert scale ranges, was explained in detail to respondents. The questionnaire consisted of a total of 13 questions, organized under the themes of efficiency, safety, and convenience. Initial PLOS scores ranged from 13 to 65.

Additionally, an on-site field survey was conducted at the specified crosswalks. This survey gathered comprehensive data pertaining to traffic conditions, specific crosswalk attributes, and the general state of the crosswalks. A videographic analysis was also undertaken at each location to capture various traffic characteristics, including the movements of turning and through vehicles, as well as factors affecting pedestrians such as delays and volume. Data was extracted in 15-minute intervals to facilitate subsequent model development. Table 2 shows the variables used in the questionnaire.

Table 1: Characteristics of data collected

Parameter	Site				
	S-1	S-2	S-3	S-4	S-5
Cycle time (s)	162	140	145	145	112
Green time (s)	25	20	45	45	25
Average no. of pedestrians arriving during green phase (ped/15min)	9	3	35	33	11
Average no. of pedestrian arriving during non-green phase (ped/15min)	45	11	58	51	43
Average pedestrian delay (s)	27.61	25.01	35.36	36.15	40.67
Signal non-compliance rate of pedestrians (%)	98%	73%	10%	77%	94%
Total average crossing time in green phase (s)	27	17	27	29	17
Length of crosswalk(m)	35.8	22.5	35.4	35.8	21
Average Speed of pedestrians (m/s)	1.33	1.32	1.31	1.23	1.24
Average Speed of males (m/s)	1.35	1.29	1.33	1.25	1.19
Average speed of females m/s)	1.21	1.32	1.25	1.21	1.09
Male compliance rate (%)	1	20	90	21	4
Female compliance rate (%)	4	32	59	18	7

3.3 Methodology for finding out average pedestrian delay

Data were gathered on pedestrian movement in two directional flows: from downstream to upstream, who first encountered vehicles approaching from downstream, and from upstream to downstream, who first encountered vehicles coming from upstream. Videographic data were captured using smartphones for each crosswalk, spanning a one-hour time frame from 9:15 AM to 10:15 AM. At each green and non-green phase, the arrival time of the pedestrians, the time at which the pedestrians depart from the starting end of the crosswalk and the time at which the pedestrians reach the other end of the crosswalk was noted. The average crossing time of the pedestrians was calculated as the time difference between the completion time and the arrival time of crossing. Along with it, the number of pedestrians complying/ non-complying with the signals was also noted.

To find the ideal time for each crosswalk, the average time taken by the pedestrians to cross the particular crosswalk during the green phase was taken with the assumption that there were no conflicts during the green time of pedestrians. Thus, the delay was calculated as the time difference between the actual crossing time and the ideal time of crossing. Total average delay was the sum of delay during the green phase and non-green phase.

The parameters that were directly found from the field survey were: Cycle time (sec), green time (sec), length of the crosswalk (m), Number of lanes, and width of the crosswalk (m). The parameters that were extracted from the videographic survey were: Pedestrian arriving during green and non-green phases, the average delay of pedestrians(sec), signal non-compliance rate of pedestrians (%), average crossing time (sec), through and turning traffic volumes (PCU/15min). The average speed of pedestrians (m/s) was calculated from the existing data.

Table 2: Questionnaire description

Grouping	Variable	Description
Efficiency	E-1	Flow of pedestrians
	E-2	Adequacy of signal timing
	E-3	Average waiting time
	E-4	Crosswalk length
Safety	S_a-1	Overall safety
	S_a-2	Frequency of vehicles blocking crosswalk
	S_a-3	Crosswalk marking/visibility
	S_a-4	Vehicle yield
	S_a-5	Effective traffic control
	S_a-6	Presence/size of refuge island
Convenience	C-1	Accessibility for disabled
	C-2	Sidewalk continuity
	C-3	Footpath condition

3.4 Methodology for developing PLOS model for signalized intersection crosswalks

Upon identification of the key variables impacting the Pedestrian Level of Service (PLOS), a series of statistical tests were executed for the purposes of both filtering and model development. The PLOS score derived from the questionnaire served as the dependent variable in these analyses. Pearson's correlation test was employed to ascertain the relationships between the dependent and independent variables. Stepwise regression was subsequently utilized to construct the most suitable predictive model. The main objective after modeling was to find out the ranges of the LOS in appropriate scale: LOS A, excellent; LOS B, good; LOS C, average; LOS D, inferior; LOS E, poor; LOS F, terrible.

4. Results

4.1 Data Analysis

A total of 408 pedestrians participated in the questionnaire survey (217 males, 191 females) in five different crosswalk locations. Gender and age distribution are shown in Table 3.

Table 3: Gender and age distribution of participating pedestrians

Site	Gender		Age (%)		
	Male	Female	< 25	25-59	> 60
S-1	49	37	37%	43%	20%
S-2	29	35	41%	31%	28%
S-3	49	44	44%	30%	26%
S-4	51	38	31%	38%	30%
S-5	39	37	37%	34%	29%

Site ID: S-1, S-2, S-4, S-5 were taken for model development, and Site ID: S-3 was taken for model validation.

The variables that were taken for the study were: Left-turning vehicles(LT), Through vehicles (T), Right-turning vehicles(RT), Average pedestrian volume (both directions) (P), Average delay (D), Crosswalk length(L), crosswalk width (W), number of lanes(N), pedestrian crossing time (CT) and pedestrian walking speed (S). Pearson's correlation test was conducted to find out the variables for model development. The correlation matrix is shown in Table 4. The correlation matrix shows that no. of lanes (N) and length of Crosswalk (L), no. of lanes (N) and crossing time (CT) are highly correlated with correlation values as 0.997 and 0.979 respectively.

To evaluate the internal consistency of the survey metrics, we utilized Cronbach's alpha value. Initially, the resultant value of Cronbach's alpha taking 13 parameters in the questionnaire, stood at 0.650. However, after discarding inconsistent queries, the alpha metric rose to 0.736 —a figure surpassing the threshold of 0.7, thus rendering it acceptable. Consequently, the survey was refined to a total of 10 questions, narrowing the spectrum for PLOS scores to span from 10 to 50. Following the reliability assessment, variables E-2, E-4, and S_a-6 were excluded from the PLOS score calculations.

The PLOS model was then developed with the PLOS score from the questionnaire as the dependent variable and significant independent variables using stepwise regression method. The training data is given in Table 7. The best-fit model is given in Equation 1.

$$\text{PLOS score} = \alpha_1 * \frac{RT}{10} + \alpha_2 * \frac{P}{10} + \alpha_3 * \frac{T}{10} + \alpha_4 * D + \text{constant} \quad (1)$$

Where,
RT = Right turning vehicles [Passenger Car Unit (PCU) / 15 min]
P = Average number of pedestrians crossing per 15 min
T = Through vehicles (PCU/15 min)
D = Average pedestrian delay (sec) per 15 min interval
Constant = regression model constant

The coefficients were found to be significant at 95% confidence interval. The coefficients from stepwise regression analysis are shown in Table 5.

The R-value of the best-fit model is 0.995 and the R-square value is 0.991. R-value of 0.995 suggests a very strong positive linear relationship between the predictor variables and the response variable (PLOS Score) in the stepwise regression model. R square value of 0.991 means 99.1 % of the variability in the PLOS Score is explained by the predictors included in the model.

After determining the PLOS score from the developed model, the PLOS scale was defined. The PLOS score ranged from 10-50. To define the threshold values of the PLOS scale with a minimum value of 10 and a maximum value of 50, k-means clustering was used. PLOS scale is shown in Table 6.

4.2 Validation

The developed model was validated for Site ID: S-3. The validation data for each 15-minute interval of the Site ID: S-3 is shown in Table 8. The field-observed PLOS score and predicted PLOS score are within the same PLOS scale. The mean absolute percentage error (MAPE) value of the validation model was found to be 3.09 %. Thus, the model can be concluded as a fairly accurate predictor of the PLOS of signalized intersection crosswalks of Kathmandu Valley.

4.3 PLOS comparison with Indo-HCM

According to Indo-HCM [11], PLOS for crosswalks have been categorized according to pedestrian delay values as shown in Table 9. Comparison of the values of the PLOS scale of Indo-HCM 2017 and the scale defined from our analysis is shown in Table 10. When comparing the values, we observed that most of the PLOS scores ranged in the same scale as that mentioned in Indo-HCM . But, some values didn't range in the same scale. This is due to the fact that Indo-HCM used only the pedestrian delay (in seconds) as the sole criteria for ranging the PLOS score range. But, in this analysis, pedestrian delay is not the sole criteria for ranging the PLOS score range but other variables like right turning traffic volume, through traffic volume, and pedestrian volume along with the pedestrian delay are considered during the model development.

Table 4: Pearson's correlation matrix

	PLOS	LT	T	RT	P	D	L	N	CT	S
PLOS	1	-0.316	-.685	.928	0.497	0.879	-0.342	-0.268	-0.231	-0.569
LT	-0.316	1	0.039	-0.292	-0.053	-0.387	0.496	0.498	0.445	0.202
T	-0.685	0.039	1	-0.886	0.152	-0.535	0.706	0.656	0.642	0.384
RT	0.928	-0.292	-0.886	1	0.174	0.760	-0.604	-0.539	-0.514	-0.498
P	0.497	-0.053	0.152	0.174	1	0.527	0.574	0.625	0.660	-0.370
D	0.879	-0.387	-0.535	0.760	0.527	1	-0.272	-0.209	-0.147	-0.626
L	-0.342	0.496	0.706	-0.604	0.574	-0.272	1	0.997	0.974	0.165
N	-0.268	0.498	0.656	-0.539	0.625	-0.209	0.997	1	0.979	0.123
CT	-0.231	0.445	0.642	-0.514	0.660	-0.147	0.974	0.979	1	-0.056
S	-0.569	0.202	0.384	-0.498	-0.370	-0.626	0.165	0.123	-0.056	1

Table 5: LOS model parameters

Coefficient	Value	Std Error	t-statistics	p-value
constant	19.6			
α_1	0.3	1.019	10.56	0
α_2	0.46	0.214	4.736	0
α_3	0.08	0.253	2.98	0.01
α_4	0.07	0.127	2.213	0.05

Table 6: PLOS range

PLOS Category	PLOS Score Range
A	10-16.76
B	16.76-23.69
C	23.69-29.65
D	29.65-36.59
E	36.59-44.06
F	44.06-50

Table 7: Training data

ID	Time	LT	T	RT	P	D	L	N	CT	S	LOS
S-1	0-15min	1	402.5	41	61	33.8	35.8	8	28.21	1.27	28.29
S-1	15-30min	4	307	48.5	42	25.5	35.8	8	29.50	1.21	28.24
S-1	30-45min	1.5	362.5	38	68	26.5	35.8	8	29.27	1.22	27.93
S-1	45-60min	2.5	397.5	51	46	24.65	35.8	8	25.34	1.41	28.75
S-2	0-15min	0	398.5	45	10	33.6	22.5	4	18.00	1.25	26.27
S-2	15-30min	0	388	25.5	16	22	22.5	4	16.00	1.41	25.92
S-2	30-45min	0	398	35	13	21.15	22.5	4	18.00	1.25	26.28
S-2	45-60min	0	354.5	40.5	15	23.3	22.5	4	18.00	1.25	25.84
S-4	0-15min	0	524.5	78.5	90	36.3	35.8	8	28.27	1.27	32.53
S-4	15-30min	0	577.5	59.5	79	31.25	35.8	8	29.53	1.21	32.05
S-4	30-45min	0	575	62.5	76	37.95	35.8	8	28.83	1.24	32.68
S-4	45-60min	0	487.5	65.5	87	39.1	35.8	8	30.19	1.19	32.57
S-5	0-15min	0	46.5	522	54	40.1	20.9	4	18.36	1.14	40.71
S-5	15-30min	0	50.5	487.5	46	45.5	20.9	4	17.29	1.21	40.50
S-5	30-45min	0	67	490.5	64	45	20.9	4	16.71	1.25	40.76
S-5	45-60min	0	74	417.5	70	57	20.9	4	18.75	1.11	40.71

Table 8: Validation Data

ID	Time	RT	P	T	D	Field PLOS	Field PLOS Scale	Predicted PLOS	Predicted PLOS Scale	% error	MAPE
S-3	0-15min	141	70	434.5	41.9	32.44	D	33.58	D	3.52%	3.09 %
S-3	15-30min	132.5	81	413.5	32.4	32.12	D	32.97	D	2.65%	
S-3	30-45min	150.5	91	361	37.2	33.15	D	33.90	D	2.26%	
S-3	45-60min	111	102	485.5	44.95	33.45	D	34.77	D	3.94%	

Table 9: PLOS classification according to Indo-HCM

LOS	Pedestrian delay (in seconds)
A	<= 5
B	5-10
C	11-25
D	26-45
E	46-80
F	>80

Table 10: Comparison of Indo-HCM scale and proposed PLOS scale

ID	Time	Delay (sec)	PLOS score	Indo-HCM PLOS scale	Proposed PLOS scale
S-1	0-15min	33.8	29.29	D	C
S-1	15-30min	25.5	27.28	C	C
S-1	30-45min	26.5	28.67	D	C
S-1	45-60min	24.65	28.20	C	C
S-2	0-15min	33.6	27.04	D	C
S-2	15-30min	22	25.79	C	C
S-2	30-45min	21.15	25.96	C	C
S-2	45-60min	23.3	26.03	C	C
S-4	0-15min	36.3	32.91	D	D
S-4	15-30min	31.25	31.89	D	D
S-4	30-45min	37.95	32.31	D	D
S-4	45-60min	39.1	33.30	D	D
S-5	0-15min	40.1	41.16	D	E
S-5	15-30min	45.5	40.18	D	E
S-5	30-45min	45	41.18	D	E
S-5	45-60min	57	40.18	E	E
S-3	0-15min	41.9	33.58	D	D
S-3	15-30min	32.4	32.97	D	D
S-3	30-45min	37.2	33.90	D	D
S-3	45-60min	44.95	34.77	D	D

5. Conclusion

The development of a Pedestrian Level of Service model for signalized intersection crosswalks is not just a theoretical advancement, but a practical necessity, especially in areas like Kathmandu Valley that face complex traffic conditions and growing pedestrian demands. This model serves as a cornerstone for transportation authorities to quantitatively evaluate and qualitatively enhance the pedestrian environment, thereby ensuring a more balanced and inclusive urban mobility landscape.

In Nepal, the infrastructure at many signalized intersections lacks dedicated pedestrian crossings and signals, and where such facilities do exist, they are often found to be non-operational. For the purpose of this study, five sites were chosen that had functional pedestrian signals and availability of crosswalks. Despite this, there is a high incidence of pedestrians disregarding the signals, leading to frequent conflicts with vehicular traffic. The quality of the pedestrian environment can be measured through PLOS model.

The formulated Level of Service (LOS) model precisely reflects the perception of pedestrians at signalized crosswalks. It includes factors of perceived safety and convenience along with functional aspects (such as delay and signalization). The information used to construct the model was gathered through field observations. The data comprises pedestrians' perception of their sense of safety, ease, and functionality as they navigate specific signalized intersections, in addition to the design and operational characteristics of these crosswalks. The derived model offers an assessment from the pedestrian viewpoint regarding the adequacy of an intersection's design and functionality in fulfilling their requirements.

The real promise of the PLOS model lies in its potential to become an integral part of the transportation planning and design process. With the significant variables identified (right turning traffic, through traffic, average pedestrian delay, and average number of pedestrians), city planners and traffic management authorities can prioritize intersections that are most at risk. The model provides insights into the specific factors that most affect the pedestrian experience. As a result, when designing new intersections or updating existing ones, these factors can be prioritized. Establishing a minimum LOS standard, forces consideration of pedestrian requirements and ensures that they are not secondary to vehicular needs.

As Kathmandu Valley develops and urbanizes, this model can guide the positioning and design of future developments, ensuring pedestrian-friendly environments. Beyond standardization, the PLOS metrics could be used to prioritize funding for infrastructure improvements, as well as offer data-backed guidance for revisions to traffic signal timings, crosswalk designs, and pedestrian amenities. The developed PLOS model could serve as an invaluable tool for intersection designers, enabling them to optimize the traffic flow by efficiently separating conflicting vehicles, all while enhancing both the comfort and safety of pedestrians. This PLOS model provides a quantitative metric that assesses the performance of a crosswalk in terms of pedestrian safety and comfort through real-time perception of the pedestrians crossing the intersection. By applying this model, roadway designers are better equipped to evaluate how effectively a specific intersection accommodates pedestrian movement.

6. Recommendation

It is imperative to recognize the constraints and potential areas of enhancement within our study. This research specifically targeted certain signalized intersections within the Kathmandu Valley. The precision and relevance of the model are dependent on the data at hand. By integrating a more comprehensive set of questionnaire survey data and metrics related to both pedestrians and traffic from a broader range of sites, the model's robustness could be markedly elevated. A potential research trajectory might involve broadening the model's parameters to account for diverse intersection types across pedestrian environmental contexts. The model could benefit from an expansion of both questionnaire and on-field parameters to encompass more scenarios. Furthermore, the typical delay experienced by pedestrians at the chosen intersections presents another potential dimension for subsequent investigation.

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