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STUDY ON THE VIOLATION BEHAVIOR OF PEDESTRIANS AT INTERSECTIONS

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ABSTRACT

Pedestrian violation behaviors at intersections have become significant concern in India. These behaviors include jaywalking, crossing against signal and crossing outside of the designated crosswalks. Such behaviors can result in serious accidents and fatalities for pedestrians and motorists alike. This study aims to investigate the factors that contribute to pedestrian violation behaviors at two intersections, a signalized and a non-signalized intersection at Thiruvananthapuram. The study uses the combination of observational data as well as videographic surveys to collect information about pedestrian behavior and the data collected is analyzed using SPSS software. The study also aims in finding location specific factors like inadequate pedestrian infrastructure, drivers riding through footpaths and vehicles stopping at crosswalks. By addressing these factors, it is possible to reduce pedestrian violations and promote safer pedestrian behavior at intersections. Thus, this study aims in contributing to the development of a safer and more sustainable urban environment in Thiruvananthapuram and other rapidly growing cities in India.

Keywords: Pedestrian behavior, Pedestrian safety, traffic violations

1.INTRODUCTION

Signalized pedestrian crossings are places set aside for pedestrians to cross the street while motorised traffic is stopped in their path. They are frequently found in the centre of roads (sometimes referred to as mid-block crossings) or at intersections where two or more roads meet. If there is a lot of competing motor traffic and time separation is required for a safe crossing, traffic lights are installed at pedestrian crossings. Road users can reduce disagreements (and therefore accidents) by rigorously observing the traffic signal rules and exercising caution. However, occasionally, if a person is impacted by personal demands (such as being late for a meeting) or by environmental factors (such as severe rain), he or she may take a risk.

2. LITERATURE REVIEW

In past studies, researchers have highlighted the effects of vehicle and pedestrian volume on violation behaviour (Chakraborty et al., 2019). Several studies findings indicate that pedestrian's demographic factors such as age and gender significantly affect signal violation behavior. Mukherjee and Mitra (2017) documented that in Kolkata city, India, the possibility of pedestrian signal violation is considerably higher for the age group 16 to 49. On the other hand, the chances of signal violation by the age group above 50 is significantly less. Van Houten et al. (2007) and Brosseau et al. (2013) also documented that long length of "red duration" is the key factor in pedestrians' signal violation behavior. The authors

recorded nearly 60% reduction in pedestrian violation after the redesign of the signal, which indicates strong influence of the junction improvement on safety. K. Aghabayk et. Al (2021) considered the influence of demographic variables and group crossing on crossing behavior. The study observed that considering traffic before and while crossing as a safe behavior indicator could result in misinterpretation because the jaywalkers also did the same check for their dangerous crossing.

3.OBJECTIVE OF THE STUDY

From most of the studies analyzed, most of them focuses on the change in the walking speed of

the waiting time of pedestrians. This study aims to investigate comprehensively on factors affecting the violation behavior of pedestrians at a signalized and unsignalized intersections at Thiruvananthapuram.

4. METHODOLOGY

The methodology includes Site Selection, Survey and Data collection, Identification of Pedestrian Behavioural Violations and Data Analysis and Modelling, Discussion and Conclusions.

4.1 Selection of Study of Intersections

After a field survey, one major signalized (Ambalamukku junction) and an unsignalized intersection (Thirumala junction) at Thiruvananthapuram shown in Fig 1 was selected for the study. The selected intersections have substantial pedestrian and vehicular traffic volume with a wide range of pedestrian vehicular intersection. Selected signalized intersection are provided with enforcement police and traffic cameras while the unsignalized doesn't have traffic enforcement cameras and refuge island.

4.2 Survey and Data collection

A preoperational survey was conducted to monitor the crossing behaviour of certain random pedestrians in order to analyse pedestrians before and while crossing and to understand the crossing behaviour indicators for the study. Videographic survey was then conducted at the signalized and unsignalized intersections during the peak hours to collect information regarding pedestrian volume as well as pedestrian crossing behaviour. The survey was carried out without disturbing the traffic. Pedestrian movements were recorded without their realization in order to get their naturalistic behavior. The video coverage included ends of the road, zebra crossing and traffic signal. Gender, age group, Group crossing, carrying object, technological distractions, crossing pace, spatial violation, temporal violations and situational violations were recorded. Age group was categorized into three groups, young (< 30), middle (between 30 and 65) and old (>65) [4]. Carried items such as backpacks, suitcases, handbags and plastic bags were specified as for carrying objects. In case of technological distractions hand held phone, calling and text messaging were considered in the survey. Running across the road were considered as a factor of violation and was also included in walking pace.

(a)

(b)

(c)

Figure 1: (a) Broad view of Location 1, (b) Satellite view of location 1 (c) Broad view of location 2, (d) Satellite view of location 2

4.2 Descriptive Data

Table 1: Descriptive statistics of signal violation behaviour indicators at signalized intersections

Variables	Categories	Signalized crosswalks
Gender	Male Female	59.3% 40.8%
Age group	Young Middle Old	15.16% 73.4% 11.44%
Walking Pace	Walk Run	82.46% 17.54%
Spatial violation	through the crosswalk zone beyond the crosswalk zone	72.04% 27.96%
Carrying Object	Yes No	37.5% 62.5%
Group crossing	Alone In-group	59.7% 40.3%
Technological distractions	Yes No	5.7% 94.3%
Temporal violation	start of crossing on “don’t walk signal start of crossing on “walk signal”	69.2% 30.8%
Waiting time	Least WT of Signal violating pedestrian Maximum waiting time	1.96 seconds 48.91 seconds

Table 2: Descriptive statistics of violation behaviour indicators at unsignalized intersections

Spatial violations at both signalized and unsignalized intersections were considered as pedestrians walked beyond the crosswalk zone during crossing. Temporal violations at signalized intersections were classified into two categories in which start of crossing on “don’t walk signal” and start of crossing on “walk” signal was considered.

Crossing time of pedestrians at these intersections was measured using a stopwatch.

VARIABLES	CATEGORIES	UNSIGNALIZED INTERSECTIONS
Gender	Male female	69.33% 30.67%
Age group	Young Middle Old	30.67% 37.33% 32%
Walking Pace	Walk Run	85.33% 14.67%
Crossing Path	Straight Oblique	44% 56%
Carrying Object	Yes No	51% 49%
Conflicts	experienced by pedestrian avoided by pedestrian	25% 74.67%
Distraction	Technological distraction	13%
Group crossing	Alone In-group	72% 28%
Waiting time	Mean waiting time	1.52 seconds
Situational factor	Looking left and right for traffic before crossing Looking at the ground while crossing Looking left and right while crossing	82% 25% 64%
Spatial violation	through the crosswalk beyond the crosswalk	28%

Above TABLE 1 shows descriptive statistics for signal violation indicators from video data at signalized intersection and table 2 shows descriptive statistics of violation behaviour indicators at unsignalized intersections. According to descriptive statistics at signalized intersection, majority of the observations consisted of male middle-aged pedestrians most pedestrians in signalized and unsignalized crosswalks were alone. Group composition of pedestrians observed at signalized and unsignalized crosswalk consisted of five to six pedestrians. Group crossing was categorized as “alone” and “in group”. Similarly carrying items was considered binary as whether pedestrians carried any item or not.

Almost 69% of observed pedestrians started their crossing on “don’t walk” signal. Spatial violation rate was observed more at unsignalized rather than signalized intersection. Checking traffic while crossing was more prevalent in signalized crosswalk, while at unsignalized crosswalk most of the pedestrians looked left and right for traffic before crossing. Pedestrians crossed the signalized intersection faster as compared to unsignalized crosswalks.

4.3 Data analysis and modelling

Correlation matrix was performed during data analysis in order to identify dependent variables which are highly and significantly related with the independent variable which is the violation behaviour of pedestrians at the intersections using the IBM SPSS Statistics 22 software. By using statistically significant variables, a binary logistic regression model (BLR)was developed to identify comprehensively the factors affecting the violation behaviour of pedestrians at these intersections. BLR is used when the target variable is binary A pedestrian has only two choices while crossing the road – SVB YES or NO [1]. In BLR model, the probability of selecting an alternative is based on a linear combination function which is expressed as:

$$U_i = \beta_0 + \beta_1 x_{1,i} + \beta_2 x_{2,i} + \beta_3 x_{3,i} + \cdots \beta_N x_{N,i} \quad \text{.....} (1)$$

$$P(i) = \frac{e^{U_i}}{1+e^{U_i}} \quad \text{.....} (2)$$

Where U_i =the utility of choosing alternative i ; i= the alternative; N= number

of independent variables; β_0= model constant; β_N= coefficients of predictor variables; x= predictor variables that determine the probability of outcome of alternative; $P(i)$= probability of violation

Table 5: Hosmer lemeshow Table

		B	S.E	Wald	df	Sig.	Exp(B)
Step 1[a]	GENDER	-1.002	1.369	.535	1	.464	.367
	AGE_GROUP	2.034	1.384	2.161	1	.142	7.647
	WALKING_PACE	5.567	1,984	7.873	1	.005	261.777
	SPATIAL_VIOLATION	13.443	6.458	4.333	1	.037	689188.774
	CARRYING_OBJECT	1.946	3.833	.258	1	.612	7.000
DISTRACTIONS		-1.579	14.457	.012	1	.913	.206
	TEMPORAL_VIOLATION	13.715	5.726	5.737	1	.017	904673.457
	Constant	-6.617	14.897	.197	1	.657	.001

5. RESULTS AND DISCUSSIONS

5.1 Signalized intersection

A BLR model is developed in IBM SPSS Statistics using statistically significant variables pertaining to signal violation behaviour (SVB). The model outcomes for SVB are shown in TABLE 3.

Pedestrians run across the crosswalk during the red signal showing dangerous temporal violation attributes to more violation behaviour. Pedestrian crossing in oblique way has more chances of signal violation. Oblique crossing pedestrians enter the intersection from random directions without noticing the signal and thus exhibiting SVB. This result is consistent to the previous findings [1,2]. Group crossing is negatively related with SVB, thus suggesting that pedestrians crossing alone violate signal often than in group. After preliminary analysis it was noted that technological distraction doesn't affect the walking speed of the pedestrians. Pedestrians who reach their threshold value of waiting time, become impatient and shows dangerous temporal violation.

The model has an accuracy 98.6% which indicates how well the model is able to predict the correct category. Hosmer and lemeshow test were performed to test the model fit. The Hosmer and lemeshow statistic indicate a poor fit if the significance level is less than 0.05. Here, the model adequately fits the data. TABLE 4 and 5 shows the corresponding values of Hosmer and lemeshow test.

Table 4: Model summary

Step	Chi-square	Df	Sig.
1	7.649	8	.468

Significant at: [a] 95% CL

5.2 Unsignalized intersection

Model outcomes for BLR at unsignalized intersection is shown in TABLE 6. Pedestrians committing spatial violation cross the zebra crossing too fast showing violation behaviour pedestrians experiencing conflict finished the crossing slower than others. Technological distraction is positively related to violation behaviour of pedestrians. After performing correlation matrix, the least correlated independent variable object carrying is neglected. The mean waiting time is less than 1.6 seconds. The model has a predictive accuracy of 97% indicates how well the model is able to predict the correct category.

Hosmer and lemeshow test were performed to test the model fit. Here, the performed to test the model fit [5]. Here, the model adequately fits the data. TABLE 7 and 8 shows the model accuracy and corresponding values of Hosmer and lemeshow test.

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	20.554[a]	.679	.958

Table 3: BLR model outcome for SVB

Table 6: BLR model outcome for VB

Step 1[a]	GENDER	1.843	1.303	2.001	1	.157	6.315
	AGE_GROUP	1.094	.814	1.801	1	.180	2.981
	WALKING_PACE	-4.851	3.462	1.963	1	.161	.008
	CROSSING_PATH	-5.999	3.484	2.966	1	.085	.002
	CONFLITS	7.817	3.507	4.968	1	.026	2483.267
	GROUP_CROSSING	.006	1.523	.000	1	.997	1.006
	SPATIAL_VIOLATION	-13.501	5.196	6.751	1	.009	.000
	DISTRACTION	10.526	16.795	.393	1	.531	37277.257
	Constant	-13.415	16.854	.633	1	.426	.000

CONCLUSION

The present study analysed violation behaviour of pedestrians at a major signalized and unsignalized intersection at Thiruvananthapuram. The following conclusions are made from the study. Binary Logistic Regression (BLR) were applied to model pedestrian violation behaviour at these intersections and have excellent predictive accuracy. Pedestrians shows more spatial violation and accident tendency in unsignalized intersection than signalized intersection mainly due presence of traffic enforcements. There is always a need to educate the pedestrians the risk of illegal crossing. Rectangular rapid flashing beacons (RRFB) can be used at unsignalized intersection to enhance pedestrian safety. It is a flash pattern to catch the attention of motorist to alert the pedestrians presence in the crossway. Illuminated in ground light emitting diodes as well as pedestrian countdown signal (PCS) are recently shown as an emerging solution to facilitate the pedestrians in safe road crossing. Medians or refuge islands implementation can help the pedestrian to wait more safely for safe crossing opportunity. Thus, proper awareness and safety implementations helps to reduce risk and promote a more sustainable urban environment.

Step	Chi-square	Df	Sig.
1	1.578	8	.991

Table 7: Hosmer and lemeshow test

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	21.552[a]	.513	.912

Table 8: Modal summary

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