Investigating the Perception, Behaviour and Safety of Pedestrians Near Urban Bus Stops

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ABSTRACT

The transportation facilities are used for the efficient transfer of goods and services. Even though the safety is the major concern for a transportation engineer. Among the road users, the pedestrians are the ones more vulnerable to conflicts. When conflicts occur, pedestrians came to direct impact without any protection rather than other road users such as vehicle users and passengers having some means of protection. Many studies have been done related to safety of pedestrians near intersections where the violation behaviour is more. But there is lack of study in midblock locations which was identified as the gap for study. The study mainly aimed to analyse the perception of pedestrians towards bus stop, crosswalk and sidewalk and to find out the violation behaviours while using these facilities and model creation to find out the safety of pedestrians in Kollam district at 3 selected bus stops. The data collected through questionnaire and video were used for analysis of perception of pedestrians towards each facility, violation behaviour and model creation. The modelling was done with help of IBM SPSS Statistics. The results indicated that the charging facility is one of the requirements in all the selected bus stops and the violation behaviour due to various factors were also identified. A model was also developed to predict the post encroachment time based on walking speed and waiting time of pedestrians and vehicle speed. Based on the predicted value, if it is lower than critical PET value then the bus stop location can be considered as unsafe, which requires additional safety improvements. The model given 57% predictive accuracy based on the selected attribute walking speed, waiting time and vehicle speed depending on each pedestrian behaviour, which is indicated by the R^2 value from multilinear regression analysis. So, there are other factors in which the post encroachment time depends which indicates the safety level of pedestrians.

Keywords: PET (Post encroachment time), Safety, Behaviour, Perception, Pedestrian

1 Introduction

In a developing country like India the main challenge nowadays faced is in the transportation system and its efficient management. The main aim of the transportation system is to help in the movement of goods and passengers from one place to another in most economical manner. Even though proper transportation systems and modes are available the issues arise due to congestion and other complex interactions. Since all the modes are sharing the common space for movement such complex interactions are developed, also pedestrians are involved in it. All vehicles and pedestrians are vulnerable to conflicts, but the critical ones are the pedestrians due to their direct contact with the traffic without any resistance measures. The vehicle users have some measures of protection in the form of airbags, shield etc. So better safety should be guaranteed to the pedestrians with suitable facilities. The facilities can be in the form of suitable crosswalks, sidewalks, rest rooms, signals, enforcement etc. The study related to the safety of pedestrians near intersections were studied by many researchers but there is a lack of idea of safety, perception and behaviour of pedestrians near urban bus stops and a proper review is required to identify the scope in this area. The

study focusses on investigating the safety, perception and behaviour of pedestrians near the urban bus stops based on the usage of facilities such as crosswalks, sidewalks and bus stops by the pedestrians.

2   Materials and Methods

Survey related to pedestrian's safety, perception and behaviour near urban bus stops can be divided to 5 categories as Attributes selected for the study, Objective of the study, Data collection methods adopted, Data analysis methods used, and results obtained from studies.

2.1   Attributes selected for the study

Mukherjee and Mitra [1] studied relation to the influence of road geometrics, vehicle speed, age of pedestrian, post encroachment time, percentage violation, accident frequency etc was carried out in 24 intersections in Kolkata as 12 representing safe signalized intersections and 12 representing unsafe signalized intersections. As we all know the sidewalk is one of the main facilities that are provided for pedestrians to get safe and efficient movement while accessing towards the bus stops. The bus stop is one of the main points where the pedestrian presence is high, so the safety of pedestrians near the bus stops is very much important to study. Cheranchery *et al.* [2] conducted a study related to the safety of urban bus stops in Kharagpur using the unsafe acts that are shown by the pedestrians, such as the usage of carriageway for waiting, violated crossing behaviour and the casual factors which stimulates to do such unsafe acts such as the lack of facilities, more waiting time, inadequate sight distance The road geometric factors also have a critical role in influencing the behavioural changes in pedestrians. When the road width and surface condition change it also affects the behaviour of road users especially pedestrians. Mukherjee and Mitra [3] conducted a study related to the influence of road infrastructure and land use such as the width of road, type of median, speed of vehicle, type of land etc on the violation behaviour of pedestrians in Kolkata.

2.2   Objectives of the study

Mukherjee and Mitra [1] conducted a study related to pedestrians near intersections was carried out in order to identify perception and behaviour of pedestrians that influence the violation behaviour and to relate the percentage violation behaviour with accident frequency of the area under study and to compare the crash recorded signalized intersections with no-crash recorded signalized intersections. Mukherjee and Mitra [4] done a study to find out the main factors that influence the violation behaviour of carriageway using pedestrians at signalized intersection and to relate it with crash frequency of the area so there by giving more weightage to such factors and to recommend proper remedial measures. Banerjee and Maurya [5] conducted a study related to different sidewalks conducted in Sikkim was aimed to understand the behaviour of pedestrians using these 3 sidewalks and to obtain the speed, flow, and density relationships. Cheranchery *et al.* [2] conducted a study at urban bus stops to identify the main unsafe acts and the casual factors responsible for it. And then based on the attributes obtained it should be listed in such a manner to identify which of them are the due to deficiencies due to non-proper design and which of them are reasons of management deficiencies. Barin *et.al.* [6] done a study based on use of markings in crosswalk is to identify the extent to which the pedestrians are obeying the rules based on the words included in the marking.

Gore *et al.* [7] done a study that relates to the use of sidewalk and carriageway by the pedestrians was analysed to get data related to the walking speed of users in both and to identify the distraction factors that triggers the users to use carriageway for walking instead of sidewalk.

2.3   Data collection methods adopted

Mukherjee and Mitra [1] collected data related to behaviour of pedestrians was done with help of video graphic surveys, the data related to perception was done with help of questionnaire survey, Speed radar gun

was used to find out the vehicle speed and geometric measurements of road components were also done. Mukherjee and Mitra [4] used data collection also including the census data to identify the socio demographic characteristics of pedestrians along with video data and questionnaire data. Banerjee and Maurya [5] identified the basic factors such as flow and speed of pedestrians using the sidewalk facility was obtained using video recording and marking a particular length for speed determination. Barin *et.al.* [6] conducted a study on identification on marking efficiency in reducing distraction of pedestrians at crosswalks was basically done with help of enumerators placed at different points and to get count related to the distraction behaviour manually, which is considered as one of the simplest way of data collection and also likely to be affected by human errors also.

2.4   Data analysis methods

Mukherjee and Mitra [1] used the data collected through study at 24 signalized intersections to make correlations with crash frequency and selected attributes, binary logit model was created with attributes and safe or unsafe criteria, regression models were also created using percentage violation and violating factors, t test was also performed to compare the safe and unsafe intersections. Mukherjee and Mitra [4] used statistical tests along with the correlation of different variables, identified as the violation factors with crash frequency. Regression model indicating the crash frequency in the dependant variable and violation percentage, traffic factors in independent variables is used for the predictions. Banerjee and Maurya [5] identified the flow of pedestrians through a selected section in such a manner that, counting the number of pedestrians passing a line per unit time and followed by dividing the obtained flow with width of the section to get the flow rate. The speed data collection was done with the help of fixed distance and time required for the pedestrians to pass this distance, simply by dividing the distance with the time. Then followed by the analysis part involves the plotting of green shield's model including the speed flow curves, speed density curves and flow density curves.

2.5   Results obtained

Mukherjee and Mitra [1] done a recent study in Kolkata indicates that 40% pedestrians violate traffic rules due to increased waiting time, 30% of the pedestrians violate traffic rules due to non-availability of required facilities and 22% violation is due to lack of awareness. Mukherjee and Mitra [4] done further studies in Kolkata city identified the lack of proper pavement markings, increased duration of length of signal, insufficient sight distance, non-proper parking influenced the pedestrians in violating the traffic rules for convenience and also positive relation was observed between the crash frequency obtained from past data and the violation behaviour. Mukherjee and Mitra [3] concluded that the results obtained from the study of relating the land use type and road geometric factors indicates that road width, land use type, absence of facilities greatly affect the violation behaviour of pedestrians at intersections and midblock. Barin *et.al.* [6] concluded that the results obtained from the study relating to the efficiency of markings in crosswalk for preventing distraction indicated that the use of marking reduced the distraction of pedestrians in using mobile phones up to a stage at which the markings started to vanish there by requiring maintenance for more durable working efficiency.

3   Theory and Calculation

The main objectives of the study deals with identification of facility's improvements and requirements based on the perception data, to find out the behaviour of pedestrians using sidewalk, crosswalk, and bus stop, to develop a model to predict the post encroachment time based on the walking speed, waiting time, and vehicle speed. Since research work was not yet done considering the pedestrian's perception, behaviour,

and safety near midblock locations especially near urban midblock bus stops, there safety level has to be identified at these locations also.

The methodology includes the study area identification, site selection, data collection, data extraction, data analysis and modelling. The study mainly aims to understand the perception of pedestrians towards the crosswalk, sidewalk and bus stop facilities and they behave while accessing these facilities and in the safety point of view to find out the chance of accidents with help of post encroachment time which is the best fit parameter that is having direct relation to the accident rate.

3.1 Study area identification

Based on the literature survey conducted it is clearly identified that the behaviour and safety analysis of pedestrians were mainly done related to the intersections were most of the violation behaviours are observed and also the accidents are observed nearer to the intersections. But there are lack of studies focusing on the pedestrian's behaviour and safety at midblock and locations other than intersections where many violations are also observed. There identified the gap of study near to an urban bus stop which are away from the intersection having crosswalk, sidewalk, and bus stop facilities.

3.2 Site selection

Three bus stop locations were selected for the study in Karicode, Moonamkutty and Keralapuram in Kollam district.

3.3 Data collection

The data collection process uses the perception data collection in which the data were collected using questionnaire about the facilities and satisfaction level of users towards each of them giving 5 choices as

Questionnaire for perception data collection

1. Socio-Economic characteristics
   a) Age
   b) Gender
   c) Trip purpose
2. Traffic rules
   a) Prefer to use mobile phones while crossing?
   b) Prefer to use carriageway while waiting for bus?
   c) Prefer to cross the road during red signal?
3. Related to Bus stop facility
   a) Lighting facility
   b) Seating facility
   c) Safety
   d) Capacity
   e) Sight distance available
   f) Drainage facility
   g) Charging facility
   h) Accessibility
   i) Cleanliness

4. Related to crosswalk
   a) Width
   b) Length
   c) Accessibility
   d) Marking
   e) Safety
5. Related to sidewalk
   a) Width
   b) Continuity
   c) Lighting facility
   d) Cleanliness
   e) Surface condition

Figure 1: *Questionnaire sample*

highly satisfied to highly dissatisfied. The data collected were used to identify the improvements and requirements of each of these facilities. Figure 1 shows the sample questionnaire used for the data collection.

The video data collection was also done to identify the behaviour of pedestrians using the facilities. The data collection was done for 3 hours at each location at peak hour. The video data collected were used for identifying the violation behaviour, reasons behind the violations and to identify the values of attributes selected for the modelling. Also, the road geometric data were collected including width of road, length of section to make use in the modelling part.

3.4   Data extraction

The data extraction includes the collection of maximum information from the data available. The data collected includes the perception data, video data and road data. The road data and perception data are already in extracted form, but the video data has to be extracted. The video includes 9 hours video from 3 bus stop locations and 1 hour data collected from another bus stop for validation of the model. The data extracted from the video includes the post encroachment time, waiting time, walking speed and vehicle speed of pedestrians crossing the road.

3.5   Data analysis

The data analysis part included the use of obtained data set from the perception data and video data to find out the performance of each facility and model creation attributes selection. The data obtained from perception of pedestrians were stored in excel file are further analysed to find out the gender proportion, Age proportion and satisfaction level towards each facility. The analysis for each of these components are done with the help of pie chart in excel to find out the proportion of each of its distribution and to identify the facilities that require improvements or replacement. The data collected from video data extraction are further analysed for finding out the attributes that can be used for model creation. The independent variables used are waiting time, walking speed and vehicle speed and their correlation with the dependant variable was found out using excel, so that to confirm these attributes can be used for model creation. Also, the dependant variable post encroachment time values were used to create a frequency distribution curve to find out the critical post encroachment time value. Based on the critical value the bus stop location can be categorized into safe or unsafe section, if the model predicted value of post encroachment time is below the critical value the change of accident is more so that the section will be unsafe and if it is more than the critical value the section is safe. The figure 2 shows the critical PET value obtained as 2.1s, the value above the critical indicated severe condition.
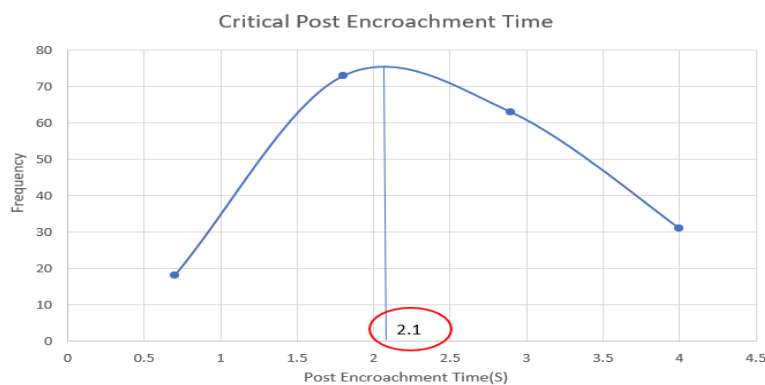
Figure 2*: Critical post encroachment time*

3.6   Modelling

The modelling starts with certain assumptions.

- Only far side bus stops are considered.
- Individual crossing behaviour is only considered.

The safety related modelling for the proposed study was done with the help of Multi Linear Regression (MLR) in SPSS software. So main aim was to find the relation of selected independent variables with the dependent variable.

The data collected and stored in the excel sheet was used to enter in the SPSS software to do the regression analysis. The hypothesis testing has to be conducted to identify whether the variables are normally distributed. The hypothesis testing is as follows:

- Null hypothesis: The variables are normally distributed.
- Alternate hypothesis: The variables are not normally distributed.

The testing was done with SPSS to find the skewness and kurtosis values.

The model equation obtained from the regression result is used to predict the 50 data collected for the validation and the difference in observed and predicted data were identified and also a paired t test was done to validate the results.

4   Results and Discussion

The perception results include the age proportion, gender proportion, traffic rules knowledge and satisfaction level with different facility characteristics. The pie chart representations indicate the facility characteristics that needs improvements or replacement. The respondents include 56% females and 44% males. 94% of respondents are aware of the traffic rules whereas 6% of respondents are not aware of the traffic rules. Also, the improvements required in each facility were identified from the respondent's choice selection and the main improvements required are safety, accessibility, charging facility, capacity and lighting facility for bus stops and accessibility, safety and marking for crosswalk and surface condition and cleanliness for sidewalk. The violation behaviour of pedestrians while using the bus stop, crosswalk and sidewalk were identified. The results obtained from the video shown that the violation in not using the bus stop facility is identified as 36%, 62% and 37%. The violation identified in not using the crosswalk are 67%, 74% and 98%. The violation identified in not using the sidewalk are 25%, 52% and 50%. The reasons behind the violation behaviour observed at bus stop locations were due to lack of capacity and difficulty to get access, whereas the violation reasons at crosswalk locations were identified as obstruction due to vehicles, lack of proper marking and misleading due to wrong markings. The violation at sidewalk facility were identified due to parked vehicles and mobile phone usage. The correlation curves obtained indicated that the selected variables are correlated with the dependant variable and can be used for modelling. The skewness and kurtosis values obtained from the SPSS model testing indicated that the variables are normally distributed. The results shown the correlation of PET and Walking speed as 0.714, PET and Waiting time as 0.459, PET and Vehicle speed as 0.627 and all are negatively correlated, So as the PET value increases the independent varibales value get decreases. And the independent variables are found to be weakly correlated to each other. Figure 3 shows the model result of SPSS analysis, with R^2 value of 0.57. The model result indicated that the selected variables are capable of explaining 57% of variability of the post encroachment time.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.761[a]	.579	.572	.75739	.579	89.671	3	196	<.001

a. Predictors: (Constant), VS, WT, WS

Figure 3: *Model result of SPSS analysis*

Model Equation PET=5.238-0.995WS-0.111WT-0.137VS   (1)

5   Conclusions

The conclusion can be summarized as

- Improvements required in selected bus stops includes charging facility, capacity,safety, lighting facility and accessibility.
- The violation behaviour identified at bus stop, crosswalk and sidewalk was due to lack of capacity, for getting easy access to bus, blockage due to vehicle, group crossing behaviour, difficulty to access, parking of vehicles and mobile phone usage. These are to be avoided.
- The model output indicates R^2 value of 0.572 and the correlation values are obatined as 0.714, 0.459, 0.627 which indicates the variables are correlated to the dependent variable and model as significant.
- Paired t test results indicated a correlation of 0.9 and the standard error value obtained in validation was below 0.7 which is obtained from regression result, so the model is significant.

These models can be used to create simulation models which can be incorporated in traffic signal systems to change the time interval between the signal phases based on the observed PET value at the location or can be used to give warning signals if the PET value is below the critical value to give a warning to the pedestrians about a chance of conflict.

6   Limitations and Future scope

The main limitations of the work inlcudes the following

- Very much difficult to get perception data from pedestrians, as they are in a hurry to get access to the bus service.
- So the perception data will be less compared to behavoural data collected.
- The study focussed on midblock bus stops, So the model can only be used for such bus stops.

Future scope in this study can be done by incorporating the perception and behavioural data together to identify their influence on safety of pedestrians based on models similar to this work, inaddition to this more attributes from perception and behaviour of pedestrians can be considered for model creation with advanced analysis methods.

7   Publisher's Note

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How to Cite

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