# Association Between Built Environment and Pedestrian Fatal Crash Risk in Delhi, India

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**An analysis of fatal crashes involving pedestrians in Delhi, India, from 2006 to 2009 that used a geographic information system showed clusters of crashes at certain locations. An evaluation of the characteristics of the built environment around the high crash location clusters was necessary. This paper presents an analysis of the built environment factors that influenced the safety of pedestrians. Locations surveyed included roads around the fatal crash clusters of pedestrians. Factors that influenced the number of fatal crashes of pedestrians were analyzed with negative binomial regression. Types of locations were categorized into locations with a flyover and without a flyover. Results showed that an increase in traffic volume by 1% would increase pedestrian fatal crashes by 1.6% at locations with a flyover and by 0.9% at locations without a flyover. Arterial roads with more traffic volume, more road lanes, and higher speed tended to have more fatal crashes. Locations where medians were fenced or raised in height to prevent pedestrians from crossing were also found to be associated with a greater number of crashes. These findings are useful for improving the safety of pedestrians around specific road infrastructure.**

Nonmotorized transport is an integral element of urban transport in Indian cities. Nearly 32% of all commuter trips in Delhi are walking trips (*1*).

Significant investments have been made in Delhi, the capital city of India, for the construction of flyovers to relieve the vehicular congestion over arterial roads. A flyover or an overpass is a grade separator to ease the movement of vehicular traffic. Subways or pedestrian underpass or foot-over bridges and pedestrian overpass are provided at these locations for pedestrians for crossing the road but their usage is very poor. Often, pedestrians are exposed to higher risks of being involved in a road traffic accident. Pedestrians are the most vulnerable and the ongoing infrastructure improvement projects in Delhi are making them even more vulnerable (*2*).

In Delhi, pedestrians constituted 51% of total fatalities in road traffic crashes in the period 2006 to 2009. It indicates that pedestrians have the largest share in total fatalities in Delhi. This stems from a diverse mix of transport modes sharing the limited roadway space. Fatal pedestrian accidents were found significantly clustered ($p < .05$) over the intersections of a arterial road (Ring Road) in Delhi (*3*). Khatoon et al. have shown that the construction of flyovers has led to increased variability in risk taking behavior of pedestrians for crossing the road, owing to signal-free movement of motorized vehicles (*4*). In Delhi, the government has made significant investments for the construction of grade separated intersections or flyovers to make signal-free junctions to reduce delays faced by motorized vehicles on arterial roads. With the construction of flyovers, pedestrian crossing problems arise.

Understanding the influence of the built environment for pedestrians is necessary for understanding pedestrian crashes and what accounts for the increased risk in urban environments.

Analysis of pedestrian fatal accidents in 2006 to 2009, in Delhi, has been done using a geographic information system (GIS) in an earlier study (*3*). Clusters of crashes were found using Kernel Density, a spatial analyst tool in GIS. Forty high-density locations of pedestrian fatalities were discovered where the inventory survey was done.

The intent of this paper is to analyze the impact of built environment features on the number of pedestrian fatal crashes in Delhi.

## LITERATURE REVIEW

Large numbers of researchers have identified specific built environment factors contributing to pedestrian crashes. Schuurman et al. found that street parking, which could be interpreted as a buffer between pedestrians and motorists, actually contributed to increased occurrence of pedestrian crashes (*5*). The absence of certain features of the built environment and road infrastructure that are viewed as protective factors can contribute to a higher rate of pedestrian crashes. Lee and Abdel-Aty found that an absence of traffic signals can increase pedestrian risk (*6*). Lighting is an important feature for pedestrian visibility, and Loukaitou-Sideris et al. found that the majority of the high-risk intersections were lacking sufficient lighting (*7*). The type of street, as well as the width, can have an influence on pedestrian safety as well. Some studies found a concentration of crashes on major arterial streets, which tend to be wider and have a higher level of traffic density than on small, narrower streets, thus exposing the pedestrian at greater risk for a longer period of time while crossing the road (*5, 8*). However, another study found that the majority of midblock crashes occurred on streets less than 35 ft in width, while the majority of intersection crashes occurred on streets greater than 70 ft in width (*9*). These conflicting results suggest that confounding factors exist that might affect crash patterns at certain sites, for instance, block length and the presence of crosswalks and traffic signals. Schuurman et al. found that for both midblock and intersection crash locations, long block length was a contributing factor (*5*). While the street and sidewalk infrastructure are important

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factors in pedestrian injury risk, equally important are the types of land use that are present in these urban environments. Retail density can often play an influential role in pedestrian density, as well as pedestrian injury risk (*5, 7, 10, 11*). Low neighborhood and retail density have been linked to reduced risk for both pedestrian and bicyclist injuries as a result of behavioral changes owing to high perceived risk in these areas (*11*). Built environment features linked with commercial and retail districts, such as surface parking lots (*7*) and the presence of driveways (*7, 10*) have also been shown to increase the risk of pedestrian crashes.

Hadi et al. used a negative binomial regression analysis to estimate the effects of cross-sectional design elements and found that increasing the lane width, shoulder width, center shoulder width, and median width were significant in reducing accidents (*12*).

Only a few studies have dealt with pedestrian safety at the area-wide level or site-specific level (*13*) and some at vehicle–pedestrian frequency at intersections (*6, 14, 15*).

However, these studies have not analyzed the built environment features distinctly for the locations with a flyover and without a flyover for the risk of crashes. In this paper, built environment features at these two types of locations having clusters of pedestrian fatal accidents are analyzed to quantify their effects distinctly. Although the study focused on the locations with pedestrian fatal accidents in Delhi, it can be applied to other metropolitan cities as well.

## METHODOLOGY

In regard to methodological perspectives, many applications of accident frequency statistical modeling have been undertaken. Miaou (*16*), Joshua and Garber (*17*), and Jovanis and Chang (*18*) demonstrated that conventional linear regression models are not appropriate for modeling vehicle accident events on roadways, and test statistics are often erroneous from these models. They concluded that Poisson and negative binomial regression models are more appropriate tools in accident modeling.

Accident counts at a given intersection are inherently discrete, positive numbers, and often small, as in the case of fatal and injury accidents. Furthermore, the distribution of accidents is often skewed in that most sites experience few accidents, while a small number of sites experience relatively many more accidents. Crash data are best characterized by Bernoulli trials with independence among crashes and unequal crash probabilities across pedestrians, vehicles and roadway factors. The Poisson distribution is generally thought of when dealing with rare, discrete events such as accidents. The Poisson distribution has only one parameter, namely, its mean. The variance of a Poisson distribution is, by definition, equal to its mean. This relationship between the mean and the variance (dispersion) is often violated for accident counts owing to inherent overdispersion in the data (i.e., variance of accident counts typically exceeds the mean). A flexible distribution that can be used to effectively model overdispersed count data is the negative binomial distribution. This distribution has two parameters: the mean and a dispersion parameter. When the dispersion parameter nears zero, the negative binomial distribution approaches the Poisson distribution (*19*).

Similar to the Poisson model, the negative binomial regression model relates the expected number of pedestrians' fatal accidents occurring at the $i$th element with probability density as

$$P[Y_i = y_i] = \frac{e^{\lambda_i}\lambda_i^{y_i}}{y_i!} \tag{1}$$

where

$Y_i$ = number of crashes at road section $i$ for a chosen period of time,
$\lambda_i$ = segment or intersection $i$'s expected frequency,
$y_i$ = realized value of crash frequency at $i$th element, and
$i = 1, 2, \ldots, N$.

To incorporate the explanatory variables $X_i$, the parameter $\lambda_i$ is specified to be

$$\lambda_i = e^{(\beta X_i + \varepsilon_i)} \tag{2}$$

where

$\beta$ = vector of estimated parameters,
$X_i$ = roadway element $i$'s explanatory variables, and
$\varepsilon_i$ = error term, which can reflect a specification error such as omitted explanatory variables or intrinsic randomness.

The negative binomial model assumes that $\exp(\varepsilon_i)$ has a gamma distribution with mean 1 and variance $\alpha^2$ ($\alpha$ = dispersion parameter). The addition of this term allows the variance to differ from the mean as follows:

$$\text{var}[y_i] = E[y_i][1 + \alpha E[y_i]] = E[y_i] + \alpha E[y_i]^2 \tag{3}$$

where $E$ is the expected value.

The model can be estimated by the standard maximum likelihood method. If $\alpha$ is not statistically different from zero, then the simple Poisson model is more appropriate.

## DATA DESCRIPTION

Fatal crash data of pedestrians, which is 8,503 for Delhi from 2006 to 2009, were used as dependent variable (*20*). Data was collected from Delhi police. The built environment data set used in the modeling process was obtained from an inventory-based survey designed for the case study. Built environment variables at each location were collected based on buffer size of 300 m in and around the crash clusters that were identified using GIS in an earlier study by Rankavat and Tiwari (*3*). In the present study, exposure factors, roadway factors, land use factors, and transit characteristics were collected within the buffer area and analyzed. For the inventory survey, the buffers surrounding crash clusters were overlaid onto Google Maps, and printouts of individual locations were handed over to surveyors.

Buffers covered a total of 86 km of roads out of which arterial roads covered ~30 km length, subarterial roads ~17 km, collector roads ~7 km, and minor roads ~33 km. Thirty percent of total pedestrian fatal crashes were found in these locations, out of which 44% fatal crashes were found at midblocks and 56% at intersections. The number of fatal crashes in the cluster near the Inter State Bus Terminus in 4 years, 2006 to 2009, was 147. Further analysis of the buffer area with GIS showed the following:

- The total number of roads included in the buffer area was 354.
- Categorization of locations into with and without a flyover showed that more than 50% of roads were in locations with a flyover.
- Surveyed roads inside the buffer area had 42 four-way intersections and 51 three-way intersections.
- There were 24 intersections with marked crosswalks on all sides and 13 intersections with no marked crosswalks.

- Sixteen four-way intersections were found near schools.
- Six intersections in commercial areas were found to have 62 crashes.
- Residential areas had 43 crashes over midblocks and 7 crashes at intersections.
- Arterial roads had ~57% fatal crashes.
- Fifty percent of roads were with medians in which ~15% were raised or fenced and had ~36% fatal crashes.

Exposure factors include average daily traffic volume, pedestrian volume, and vehicle speed. For all the locations, pedestrian and traffic volumes were collected for the year 2012. Pedestrian and traffic volumes were obtained by a video recording of the locations at three peak periods: (*a*) morning (9 to 10 a.m.); (*b*) noon period (12:30 to 1:30 p.m.); and (*c*) evening (5 to 6 p.m.). The data at each location were collected on a weekday with normal weather condition. Because the clustering of crashes was denser at the Inter State Bus Terminus, video recording was done from 9 a.m. to 5 p.m., to avoid estimation error in daily traffic at such high risk areas. As had been done in previous studies, the natural logarithm transformation was applied to traffic and pedestrian volume variables in this analysis (*21*). Comparison of linear form and natural logarithmic form of these exposure variables showed that natural logarithmic form was a better fit to the data, owing to the nonlinear association between pedestrian and traffic volumes and pedestrian crashes (*14*).

Speed of motorized vehicles was measured with a LIDAR (light detection and ranging) speed gun, which uses the reflection time of light and takes several hundred samples over 1 s to calculate the speed. On all roads, a minimum of five samples of a type of vehicle was taken in peak hours to determine the average speed.

An inventory survey covered the rest of the variables. Table 1 shows the list of variables used in the models.

## DISCUSSION OF RESULTS

Since the data were collected for only clustered density crash locations for analysis, it was not desirable to create a model with all possible variables. To avoid problems of autocorrelation, some variables were not used in the final models. To select the best set of explanatory variables to include in the negative binomial model, an intercorrelation matrix was generated to identify the highly correlated variables. A basic negative binomial model with all the variables was then built. From the correlation matrix and the elements correlated with each other, the ones that were more significant in the basic model mentioned previously were chosen in the final models. For example, number of lanes was highly correlated [$\rho = .6$, where $\rho$ is the correlation coefficient] with crosswalks marked and lane width. Number of lanes was more significant in the model; therefore, it was kept in the final models, and the crosswalks marked and lane width variables were removed. The same principle was applied to the rest of the variables.

To study the actual risk for pedestrians, the models for fatal crashes as dependent variable were analyzed in two stages. First, the models were fitted with exposure variables only as predictors; second, built

**TABLE 1 List of Survey Variables**

| Factor or Characteristic | Variables | Description |
|---|---|---|
| Exposure factor | Pedestrian crashes | Number of police reported crashes at the selected road inside the buffer from 2006–2009 |
| | Traffic volume | Estimated traffic volume passing through the road |
| | Pedestrian volume | Estimated pedestrian volume passing through the road |
| | Speed | Average speed of traffic passing through the road |
| Roadway factor | Traffic signal | 0 = no; 1 = yes |
| | Footpath | 0 = no; 1 = yes |
| | Number of lanes | Number of lanes in one direction |
| | Median type | Navigable median; raised or fenced median[a] (0 = no; 1 = yes) |
| | Lane width | Average lane width in one direction |
| | Road type | Arterial road; subarterial road; collector road; local or minor road (0 = no; 1 = yes) |
| | Number of intersections | Number of intersections in selected road |
| | Number of T intersections | Number of T-intersections in selected road |
| | Number of segments | Number of segments in selected road |
| | Crosswalks marked | 0 = no; 1 = yes |
| | Total crosswalks | Count |
| | Lighting along the road | 0 = poor; 1 = good |
| | Sidewalk width | 0 = poor; 1 = good |
| | Sidewalk maintenance | 0 = poor; 1 = good |
| | Sidewalk continuity | 0 = poor; 1 = good |
| | Separation from traffic | 0 = poor; 1 = good |
| Land use factor | Foot-over bridge[b] | (0 = no foot-over bridge; 1 = foot-over bridge present) |
| | Subway[c] | (0 = no subway; 1 = subway present) |
| | Shops | Count |
| | Schools | Count |
| | Offices | Count |
| | Hospital | (0 = no hospital; 1 = hospital present) |
| | Land use characters | Industrial; commercial; mixed land use; residential; parks and recreational (0 = no; 1 = yes) |
| | On-street parking | (0 = no; 1 = yes) |
| Transit characteristic | Bus stops | Counts |
| | Metro station | (0 = no metro station; 1 = metro station present) |

[a]Raised or fenced medians to prevent pedestrians from crossing.
[b]A foot-over bridge is a bridge provided for pedestrians for crossing the road (i.e., overpass).
[c]A subway is a pedestrian underpass.

environment variables, which include roadway factors, land use factors, and transit characteristics, were also included in the model. As shown in Table 2, α, the negative binomial dispersion parameter, is significantly different from zero; this difference implies that the Poisson model would not have been appropriate for this data set. The addition of built environment variables increased the explanatory power of the model. Goodness of fit of models can be compared by using the Akaike information criterion (AIC) (*22*). This criterion is computed as AIC = −2 log likelihood + 2*k*, where *k* is the number of estimated parameters included in the model. The model with the lowest AIC is preferred. AIC values of the models shown in summary statistics indicate that after adding built environment variables, AIC values decreased. The lower AIC value indicates a better model (*12*). The examination of pseudo-$R^2$ statistics shows that the goodness of fit of the model for the locations without a flyover ($\rho^2 = .29$) is better than at locations with a flyover ($\rho^2 = .15$).

Results in Table 2 show that exposure factors traffic volume and speed are positively and statistically significant, while pedestrian volume is negatively related in all the models. Thus, one can say that locations with more traffic volumes are likely to have more crashes. However, studies by Wong et al. (*23*) and Abdel-Aty and Keller (*24*) have shown that a greater traffic volume is associated with decreased speed, in which the severity of crashes is reduced. But with the mixed traffic pattern of Delhi, one can say that increased traffic volume raises the exposure of pedestrians to crash involvement. In regard to elasticity, one can say that a 1% increase in traffic volume at locations with flyover increases the number of pedestrian fatal crashes by 1.6%, while at locations without a flyover fatal crashes increase by 0.9%. This shows that traffic volume is the major determinant for pedestrians' actual crash risk at locations with a flyover.

With the increase in pedestrian volume the risk is decreasing. This confirms the finding of safety in number concept (*25*). A driver is less likely to collide with a pedestrian if the number of walking people is found more or in a group (*25*). Studies by Zegeer and colleagues have shown that pedestrian crashes increased with pedestrian volume at signalized intersections and both marked and unmarked crosswalks (*26, 27*). The speed increase is significantly associated with increased crash risk. In other words, the very likelihood that a pedestrian-related crash will occur grows with an increase in the vehicle operating speeds. This is similar to the results found by Anderson et al. (*28*) and Eluru et al. (*29*) that a higher speed limit corresponded to an increase in the number of fatal pedestrian crashes. Garder also concluded that low speed streets experience lower rates of vehicle–pedestrian crashes, while wide travel lanes with higher speeds experience the highest rates (*30*).

Roadway factors that are significant in locations with a flyover are median type and road category. This can be interpreted as the locations with fenced medians are riskier than without fenced median. As is known, medians are either fenced or raised in height at locations where either a pedestrian overpass or pedestrian underpass is pres-

**TABLE 2 Negative Binomial Models for Fatal Crash Risk**

| | With Flyover | | | | Without Flyover | | | |
|---|---|---|---|---|---|---|---|---|
| | Model 1[a] | | Model 2[b] | | Model 3[c] | | Model 4[d] | |
| Independent Variable | Coefficient | *p*-Value | Coefficient | *p*-Value | Coefficient | *p*-Value | Coefficient | *p*-Value |
| Constant | — | — | −5.27 | 0 | −6.282 | 0 | 0.996 | .05 |
| Exposure factor | | | | | | | | |
| ln(traffic volume) | 1.87** | 0 | 1.623** | 0 | 1.944** | 0 | 0.933** | .002 |
| ln(pedestrian volume) | −0.001* | .09 | −0.65** | .022 | −0.457** | .05 | −0.45** | .016 |
| Speed | 0.005* | .1 | 0.191** | .045 | 0.003* | .082 | 0.164* | .087 |
| Roadway factor | | | | | | | | |
| Number of lanes | — | — | −0.56 | −3.36 | — | — | 0.643** | 0 |
| Median type | — | — | | | — | — | | |
| Raised or fenced | — | — | 0.913** | .001 | — | — | −0.34 | −1.51 |
| Road type | — | — | | | — | — | | |
| Arterial road | — | — | 1.070** | .025 | — | — | 1.65** | .00 |
| Collector road | — | — | 0.938** | .028 | — | — | 0.99** | .005 |
| Local or minor road | — | — | 0.33** | .025 | — | — | 0.83** | .00 |
| Number of T intersections | — | — | 0.099 | .171 | — | — | −0.29** | .001 |
| Number of intersections | — | — | 0.066 | .803 | — | — | −0.78* | .084 |
| Land use factor | | | | | | | | |
| Office | — | — | 0.44** | .046 | — | — | 0.2 | .8 |
| Land use character | — | — | | | — | — | | |
| Commercial | — | — | −1.38** | .003 | — | — | 0.85** | .046 |
| Mixed land use | — | — | −0.28 | .34 | — | — | 1.50** | .00 |
| Parks and recreational | — | — | 0.759* | .086 | — | — | 1.06** | .014 |
| On-street parking | — | — | 1.048** | .001 | — | — | 0.27** | .31 |
| Transit characteristics: bus stop | — | — | 0.065 | .698 | — | — | 0.39** | .014 |

NOTE: Actual risk, by grade design and model; — = not included in this model.
[a]$\alpha = 1.34$; log likelihood (LL) (null) = −502.378; LL(model) = −463.084; AIC = 936.168; pseudo-$R^2$ = .078.
[b]$\alpha = 0.766$; LL(null) = −499; LL(model) = −423; AIC = 895; pseudo-$R^2$ = .154.
[c]$\alpha = 1.53$; LL(null) = −280.1; LL(model) = −260.7; AIC = 531.33; pseudo-$R^2$ = .069.
[d]$\alpha = 0.237$; LL(null) = −280; LL(model) = −214; AIC = 469.5; pseudo-$R^2$ = .286.
*$p < .10$; **$p < .05$.

ent for crossing the road. This contradicts the fact that a foot-over bridge or subway are provided for better protection of pedestrians. It is similar to the study done by Gupta et al. at the All India Institute of Medical Sciences in Delhi, where, despite a median railing barrier and a nearby pedestrian underpass for avoiding pedestrians to cross at the site with traffic, 22% of 3,233 pedestrians were found crossing at the site or at-grade (*31*). Pedestrians may be taking higher risk of crossing the road at-grade and thus are more likely to be hit by traffic. This shows pedestrians' unwillingness to exert extra effort in walking up and down, at the pedestrian overpass and underpass, for crossing the road. Pedestrian overpasses and underpasses provide grade separation, but they may not be used by pedestrians if they are not perceived to be safer and more convenient than at-grade crossings (*32*). A study by Campbell et al. also shows that if the ratio of the time to cross the road on an overpass divided by the time to cross at grade level is 1, then 95% of pedestrians will use the overpass, whereas if the overpass route takes 50% longer, then few pedestrians will use it (*33*). Similar time ratios suggest that the use of underpasses by pedestrians is less than the use of overpasses (*33*).

The coefficient for road category shows that as one moves from arterial road to minor road category, the risk is decreasing. This result is significant for both types of locations. Thus, arterial roads are found to have greater crash risk, confirming the buffer analysis using GIS that ~57% fatal crashes were on arterial roads.

Land use factors such as number of offices and on-street parking were significantly related to crashes in the locations with flyovers. An increase in on-street parking is associated with an increase in pedestrian crashes at locations with a flyover. Numbers of offices are also positively associated with pedestrian crashes at these locations. The commercial land use coefficient is negative for the locations with a flyover, while it is positive for the locations without a flyover. This shows that pedestrian safety should be increased in commercial areas without a flyover. Mixed land use and parks or recreational land use were also found with a positive coefficient for areas without the flyover, indicating high risk for the pedestrians.

In locations without flyover, the number of four-way intersections and three-way intersections was significant, but negative, showing that with the increase in number of intersections, crash risk decreases. That is, the buffers surrounding the locations without the flyover, having a greater number of intersections, have fewer crashes. This is contradictory to the results by La Scala et al. that numbers of cross streets per kilometer roadway have a greater number of pedestrian crashes (*34*). With fewer intersections, segments are longer. This result indicates that the number of crashes increases as the length of road segment increases. It confirms the finding by Caliendo et al. (*35*). Thus, one can infer that segments in locations without a flyover are more risky.

Numbers of lanes are statistically significant and positively associated with the number of crashes at locations without a flyover. This shows that crashes are more likely to occur on roads with more lanes. Wider lanes encourage faster travel speeds, as shown by the relationship between lane width and free flow speed in the *Highway Capacity Manual* (*36*). The crossing distance for pedestrians also grows with the increase in the number of lanes on a roadway segment, and that raises the exposure of pedestrians to vehicles (*32*). This result is contradictory to the findings of Greibe, that an increase in road width relatively reduces the associated crash risk (*37*).

The number of bus stops was statistically significant in crash Model 4 (95% level), indicating that more bus stops create greater pedestrian crash risk at the locations without a flyover. Merging of buses into the roadway from bus stops is associated with a higher risk of colliding with other vehicles. So, to avoid this risk, buses used to stop a distance away from bus stops at some places in Delhi, posing a greater risk for pedestrians. Also, a study by Tiwari about midblock conflicts shows that maximum mixing of pedestrians with motor vehicles occurs at bus stops (*38*).

## CONCLUSIONS

In this study, fatal traffic crash data for 2006 to 2009 in Delhi were used to identify the factors contributing to pedestrian fatal crashes. Fatal crash clusters, which were found using GIS, were surveyed for collecting built environment factors. At these locations, more than 50% of roads were found to be in locations having a flyover. Thus, the impact of built environment factors with fatal crashes was analyzed distinctly for locations with a flyover and locations without a flyover. Built environment factors consisted of exposure factors, roadway factors, land use factors, and transit characteristics.

Negative binomial modeling was used for analysis of built environment factors in pedestrian fatal crashes. Addition of built environment variables improved the goodness of fit of the models, which shows their significance or contribution to greater numbers of pedestrian fatal crashes.

Exposure factors included traffic volume; pedestrian volume and speed were found to be significantly associated at locations with a flyover and without a flyover. Traffic volume is found as a major determinant of pedestrian crash risk at locations with a flyover.

Other built environment features significantly associated with pedestrian fatal crashes at locations with a flyover are median type, road type, number of offices, and on-street parking. Results for median type showed more risky behavior of pedestrians at raised and fenced medians. This has an important implication for road designers to provide facilities for road crossings, from the pedestrian's perspective of convenience, to avoid crashes. The major significant factors to be given prominence for pedestrian safety at locations without a flyover are number of lanes and bus stops.

With the results, it is confirmed that arterial roads with more traffic volume and more road lanes tended to have more crashes. Also, in designing the traffic facilities to ease the movement of motorized traffic, pedestrian safety should be given equal importance. Although additional research is needed, these findings can help design practices and provide a safer environment for pedestrians.

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