



Research Article

The Effects of Selected Crash Parameters and Traffic Volume on Crash Frequency (the Case of Bahirdar City, Ethiopia)

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Abstract

The objectives of the study are to develop a mathematical model and understand the impact of selected crash parameters on crash frequency in high and low traffic volume in both straight sections and junctions. Comparing the effect of straight sections and junctions with selected crash parameters on crash frequency is also addressed. The method used in this research is loglinear analysis using SPSS software. Seven days' traffic data was collected from major junctions and straight sections in Bahirdar. The result depicted that in high traffic volume straight sections, Monday has the highest number of crash compared to the base case, Sunday. In low traffic volume junctions, Wednesday has the highest number of crash compared to Saturday. In high-traffic-volume straight sections, the 18-29-year-old age group has a 3.5 times higher number of crash compared to the base case (>45 years). 30-44-year-old drivers also have a 2.1 times higher number of crash compared to >45-year-old drivers. In low-traffic-volume straight sections, both 18-29- and 30-44-year-old drivers have increased the number of crash. In low traffic volume junctions, both 18-29- and 30-44-year-old drivers have increased highly, with 47.9 and 38.1 times the base case (>45 years). In low-traffic-volume straight sections, a high number of crash is observed in < 5 years of driving experience compared to the base case (>15 years). In low traffic volume junctions, <5 years of driving experience also has a high number of crash compared to the base case.

Keywords

Log-linear Modeling, Traffic Crash, Traffic Volume, Junction

1. Introduction

1.1. Background of the Study

Road transport has a great role for the movement of goods and services in developing countries and includes 95% of interurban transportation, including Ethiopia [1]. Nowadays there is a high traffic growth rate in Ethiopia; traffic crashes also increase and become one of the major causes of death in

the country. Approximately 1.2 million people die and 20 to 50 million people are injured each year across the world due to road traffic crashes; the majority of deaths (90%) are observed in developing countries, which have only 48% of the world's vehicles [15]. More than 54.8% of the accidents occurred on interstate highways. Passengers accounted for the largest share of road traffic deaths across the region, and pedestrians were the main victims in the urban areas [7]. pedestrian injuries are more

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severe when a car is driven by family, friends or relatives of the vehicles owner as compared to the vehicle's owner in Addis Ababa [10, 13]. One of the study in Amhara, Ethiopia was by [9]. This research was aimed at identifying the significant factors contributing to road traffic crash in Amhara regional state, Ethiopia. Fourteen year trends of road traffic crashes in Amhara Regional State, Ethiopia, reported from 2003 to 2015 by selecting a simple random sample of 286 accidents. A research which was conducted by [12] about investigating pedestrian injury crashes on modern roundabouts in Addis Ababa. In this study the data were taken from 22 modern roundabouts in Addis Ababa. Random effect Poisson and random effect binomial regression were estimated and compared. One study on traffic safety modeling compared motorcycle riders and non-riders in terms of risk factors for driver fatalities in single-vehicle crashes. using Taiwan's traffic data from 2000 [4]. In Amhara National Regional State, car owners accounted for 8.5% of the deaths; however, in the USA, car owners accounted for 60% of the deaths [5]. [8] conducted another study in Bahirdar, Ethiopia. The main goal of this study was to identify the key variables influencing the prevalence of traffic accidents in Bahir Dar, North Western Ethiopia.

1.2. Statement of the Problem

Three main junctions from Gonder, Debretabour, and Dangla roads meet at Bahirdar; because of this, the city is under a high traffic growth rate. A lot of tourist sites of monasteries within the Lake Tana islands, Tisissat Falls, and its location along the main roads can be considered as additional factors for the growth of traffic volume in the city. Along with the increase of traffic volume in the city, there is a high increase of the road traffic crash rate in Bahir Dar, which affects both the direct economic losses and the social lives. [3] show that 1241 crashes occurred (giving an average of 206.8 RTC/year) support this observation. But no significant study

is conducted for the cause of the crash and means of crash reduction in the city.

Junctions have a significant role in increasing crash frequency if they are not properly managed. With an increase in AADT, crashes are increased as well. In addition, while at junctions, more crashes than no-junctions occur at low and medium volumes [14]. But still there is no tangible study regarding the comparison of the effect of junctions and straight sections on crash frequency in the city. I hope this study will address the abovementioned problems.

1.3. Objectives

The general objective of the study is to determine the effect of crash parameters and traffic volume on crash frequency in both junction and straight sections and to recommend taking immediate countermeasures for crash reduction in Bahir Dar.

Specific objectives

To compare the effect of straight sections and junctions with selected crash parameters on crash frequency in Bahirdar, to analyze and compare the effect of traffic volume on the number of crashes in junctions and straight sections, and to develop a mathematical model so as to capture adequately the relationship between the total number of crashes and selected crash parameters.

1.4. Significance of the Study

This study mainly deals with crash frequency on junctions compared to straight sections in Bahir Dar city. More concern is given to the effect of the junction on a crash when there is high and low traffic volume. So the following are listed as significance of the study. The result of the study would be helpful to get information about the influence of junctions on crashes and help to decide on its countermeasures. It also helps to conduct further research regarding road traffic crashes.

2. Research Methodology

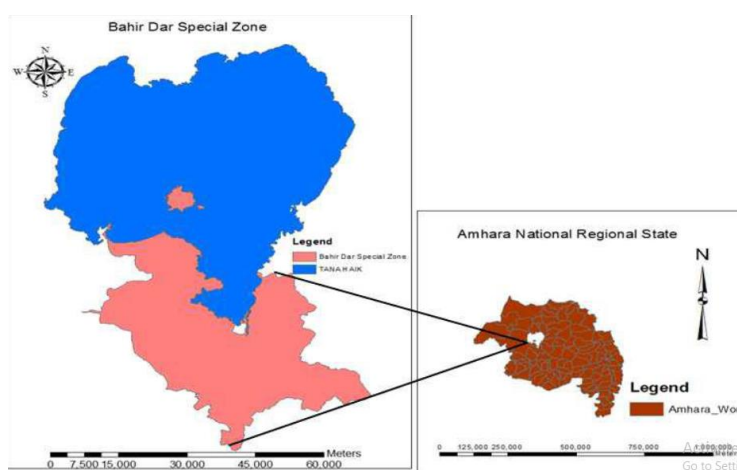


Figure 1. Map of study area.

2.1. Study Area and Structure

Bahirdar is the capital city of the Amhara national regional state, which is located approximately 570 km northwest of Addis Ababa with a latitude of 11°36' N and longitude of 37°23' E. The city has a total area of 16000 hectares [11]. From the total area of the city, 17.2 percent is covered with water. The area that is covered by river Chambel, lake tana, and Abay basin, is 1.2, 6.3, and 3.8 percent respectively. Ponds and swamps cover 17 and 498 hectares respectively in the city. The city lies on flat topography at the lake tana sub-basin. The topography of the city is predominantly flat area with an elevation ranging from 1786 - 1870 meters above sea level. The slope varies from near 0 to 20% in a few hillsides, but for most parts the city the slope is less than 2%.

2.2. Data Source

This study needs primary and secondary data for analysis and modeling. The primary data is traffic volume data, which is collected from main road sections and junctions of the city. Secondary data included in the study is traffic crash data, which is collected from the Bahirdar City Police Commission.

2.2.1. Traffic Data Collection

Primary data (traffic volume count) is collected from Bahir Dar city at selected main junctions and straight sections to obtain hourly variation of current traffic volume throughout the

day. It is used as a reference to develop a model with different traffic volumes in junctions and straight sections. Traffic data is collected at selected junctions and straight sections on all days of a week at different road sections in the selected city from 7.00 am to 8.00 pm to get maximum and minimum traffic volume by using video cameras and the manual counting method. That means when traffic volume is high and if it is difficult to count manually, a video camera recorder is used; otherwise, the manual traffic count method is applied. In primary data collection only 13 hours' worth of traffic data is collected because of difficulties in collecting at nighttime. The remaining 11 night hours are classified under low-volume traffic hours because traffic volume is in decreasing condition up to 8.00 p.m., and it would continue throughout the night with low movement of traffic.

2.2.2. Traffic Composition

It is not fair to give similar value to different vehicle types for transport planning, design, and implementation. So trucks, buses, and other types of vehicles have to be changed into passenger car units (PCU). There is a standard for passenger car units in Addis Ababa, which is developed by the Ethiopian Railway Corporation. So this standard is applicable for this research since most of passenger car unit factors (vehicle composition, traffic stream and roadway environment) are similar with Addis Ababa and no other better standard is found.

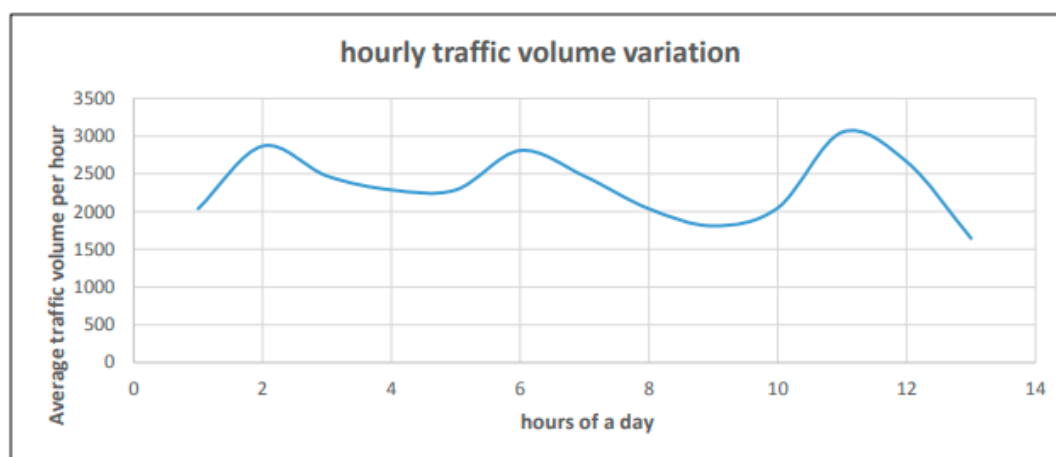


Figure 2. Hourly traffic variation in Bahirdar.

Table 1. Seven days Average traffic volume (pcu) in papyrus roundabouts.

Time	7.00am-8.00am	8.00am-9.00am	9.00am-10.00am	10.00am-11.00am	11.00am-12.00pm	12.00pm-1.00 pm
Average Traffic volume	2030	2875	2474	2285	2277	2814

Time	1.00pm-2.00pm	2.00pm-3.00pm	3.00pm-4.00pm	4.00pm-5.00pm	5.00pm-6.00pm	6.00pm-7.00pm	7.00pm-8.00pm
Average Traffic volume	2467	2033	1805	2047	3067	2654	1675

From the above result, 13 hours are classified into high traffic volume hours and low traffic volume hours depending on counted traffic volume. Traffic volume that is greater than the average traffic flow per hour (2346 PCU) is classified under high traffic volume hours, and traffic volume that is less than

the average traffic flow per hour (2346 PCU) is classified as low traffic volume hours. The rest of the 11 night hours are classified under low traffic volume hours. By this classification method the result is listed in the following table.

Table 2. Hourly traffic volume category.

High traffic volume hours	Traffic volume	Low traffic volume hours	Traffic volume
8.00am-9.00am	2875	7.00am-8.00am	2030
9.00am-10.00am	2474	10.00am-11.00am	2285
12.00pm-1.00pm	2814	11.00am-12.00pm	2277
1.00pm-2.00pm	2467	2.00pm-3.00pm	2033
5.00pm-6.00pm	3067	3.00pm-4.00pm	1805
6.00pm-7.00pm	2654	4.00pm-5.00pm	2047
		7.00pm-8.00pm	1675

2.2.3. Secondary Data Collection

In order to conduct the study, traffic crash and traffic volume data are required. Traffic crash data is collected from the Bahirdar city traffic police office. 1507 Road crash data for about five years (2012/2013-2016/2017) is collected from the above-mentioned police station [2, 6]. The crash data consists of type of severity, type of crash, crash hour, day of the week, date, year, gender, educational status of driver, driver relation with vehicle, experience of the driver, vehicle type, vehicle age (service year), vehicle ownership, land use, road type, road geometry, intersection type, pavement type, road condition, lighting condition, weather condition, and defendant vehicle maneuvering condition. But all these variables are not included in the model.

2.3. Data Analysis

After collection of data from traffic police, it has to be analyzed for modeling and statistical analysis. SPSS is widely used for in-depth data access and preparation, decision management, analytical reporting, graphics, modeling, and forecasting.

2.4. Log-linear Analysis

Loglinear modeling is best as a procedure to identify factors that affect the relative frequency of occurrence of various crash characteristics such as crash type, location, severity, etc. [16]. This is the reason why the loglinear model is selected in this study. Many standard statistical software packages have the capabilities to analyze log-linear models. Most software has at least two ways of analyzing the data using log-linear analysis. The most general way is the generalized linear models commands; however, most statistical packages also have specific commands for log-linear models. In this research GELOG is applied.

$$\text{LnF}(ij) = \mu + \lambda_i A + \lambda_j B + \lambda_{ij} AB$$

Where $\text{lnf}(ij)$ is the log of the expected cell frequency of the case for cell ij

μ = the overall mean of the natural log of the expected frequencies

A, b = the variables; i, j = the categories within the variables

In the case of this study, the dependent variable is the number of crashes, and the ten independent variables can be related

as follows.

$$\ln(\text{NC}) = \mu + a_1 * \text{Age} + a_2 * \text{DW} + a_3 * \text{DE} + a_4 * \text{VT} + a_5 * \text{DES} + a_6 * \text{JT} + a_7 * \text{RD} + a_8 * \text{LC} + a_9 * \text{Sex} + a_{10} * \text{WC}$$

$$\text{NC} = (\mu + a_1 * \text{Age} + a_2 * \text{DW} + a_3 * \text{DE} + a_4 * \text{VT} + a_5 * \text{DES} + a_6 * \text{JT} + a_7 * \text{RD} + a_8 * \text{LC} + a_9 * \text{Sex} + a_{10} * \text{WC})$$

Where NC = Number of crashes

μ = constant term

$a_1, a_2, a_3, a_4, \dots, a_{10}$ = Coefficient of variables

DW = day of the week, DE = driver experience

VT = vehicle type, DES = driver educational status

JT = junction type, RD = road division

LC = lighting condition, WC = weather condition

2.5. Data Preparation

After the data collection process is completed, grouping of data into different categories follows. Depending on the traffic volume data, 24 hours of a day are divided into two groups: high traffic volume hours and low traffic volume hours. These classifications depend on those data, which are collected on-site by video camera recorder and by counting traffic volume at home. Those hours that have greater than 2346 pcu are grouped as high, and those hours that have less than 2346 pcu are classified as low-volume hours. After identifying high and low volume hours, filtering crash data into the selected hours means that those crashes that occurred in high volume hours should be classified into one group and crashes that occurred in low volume hours should be classified into another group. And these grouped crash data should be filtered into straight sections and junctions to analyze and compare the effect of traffic volume on crash frequency at junctions and straight sections.

Depending on the group classified above, four will develop at the junction and straight section with high traffic volume hours and low traffic volume hours. These are

Model 1: crash at junction (high traffic volume hours)

Model 2: crash at junction (low traffic volume hours)

Model 3: crash at straight section (high traffic volume hours)

Model 4: crash at straight section (low traffic volume hours)

The way of segregating crashes into junction and straight sections is based on crash location, which is recorded by traffic police during crash occurrence. So if the crash is recorded as “Adebabay Akababi” (around roundabout), “Traffic Mebrat Akababi” (around traffic signal light), “Bale Sost Megetatemia” (three-leg intersection), or “Bale Arat Megetatemia” (four-leg intersection), they are grouped under

junction crashes, and the rest are straight section crashes. Some crash variables have been removed from the crash parameters group due to the reporting of false crashes. In addition, the data recording has been inconsistent for these variables. Therefore, even though these variables may be significant in the study, they have been excluded, and their use is not advisable, as they may offer misleading result.

3. Analysis and Discussion

This chapter focuses on the preliminary analysis of data to develop a model for different traffic volumes in straight sections and junctions (high traffic volume hour crashes in junctions, low traffic volume hour crashes in junctions, high traffic volume hour crashes in straight sections, and low traffic volume hour crashes in straight sections). Before model development, highly correlated variables should have been filtered and removed from the list of independent variables. Then, using the final selected variable, a model is developed by the loglinear modeling technique.

3.1. Variable Correlation

These steps demonstrate that all independent variables that will be included in the final models are independent of each other. The goal is to separate the effect of each one of the independent variables in the model. There should be no correlation between the independent variables included in the model to know the impact of each independent variable on the dependent variable. When the correlation coefficient of variables is close to 1, there is high correlation, so they should be removed, and if the correlation coefficient is close to zero, there is no correlation between variables, and they are taken as independent variables.

3.2. Model 1 (High Traffic Volume at Straight Section)

In high traffic volume on straight sections, driver experience has a high correlation with day of week and gender. So driver experience should be removed from the variable list. The remaining variables were gender, age, driver educational status, driving experience, vehicle type, lighting condition, weather condition, and road type.

Table 3. Goodness-of-fit test for nested model.

	Chi-square	df	Sig.	Adjusted	
				df	Sig.
Likelihood ratio	1608.238	11319	.000	8079	.000

	Chi-square	df	Sig.	Adjusted df	Sig.
Pearson	1077529.493	11319	.000	8079	.000

Table 4. Goodness-of-Fit Tests.

	Chi-square	df	Sig.
Likelihood ratio	.000	6144	.000
Pearson	.000	6144	.000

Likelihood ratio for nested model L2 model1 = 1608.238

Likelihood ratio for saturated model L2 model2 = 0.000

Df nested model = 11319

Df for saturated model = 6144

$L2_{comparison} = L2_{model1} - L2_{model2} = 1608.238 - 0.000 = 1608.238$

$Df = df1 - df2 = 11319 - 6144 = 5175$

So from the above result, the likelihood ratio is not significant compared to df. Therefore, the nested (parsimonious) model is the best-fitted model.

$\ln(F(x)) = 17.633 + 1.48(\text{mon}) + 0.49(\text{tue}) + 0.89(\text{wed}) + 1.14(\text{thur}) + 0.59(\text{fri}) + 4.5(\text{male}) + 1.25(\text{young}) + 0.73(\text{adult}) - 1.44(\text{illiterate}) - 0.59(\text{prim}) - 0.56(\text{high school}) - 0.3(\text{prep}) + 1.56(\text{Bajaj}) + 3.32(\text{small vehicle}) + 0.827(\text{bus}) + 1.17(\text{small truck}) -$

$2.36(\text{with median}) + 4.86(\text{daylight})$

3.3. Model 2: (Low Traffic Volume at Straight Section)

In low traffic volume on straight sections, the day of the week has a high correlation with road type and lighting condition. Therefore, day of week should be removed from the variable list since it is highly correlated with two variables. The remaining variables were gender, age, driver educational status, driving experience, vehicle type, lighting condition, weather condition, and road type.

Table 5. Goodness-of-fit test for nested model (LTVJ).

	Chi-square	df	Sig.	Adjusted df	Sig.
Likelihood ratio	2382.123	5650	.020	2815	.000
Pearson	483906.253	5650	.000	2815	.000

Table 6. Goodness of fit test for saturated model (LTVJ).

	Chi-square	df	Sig.
Likelihood ratio	.000	1824	.000
Pearson	.000	1824	.000

Likelihood ratio for nested model L2 model1 = 2382.123

Likelihood ratio for saturated model L2 model2 = 0.000

Df nested model = 5650

Df for saturated model = 1824

$$L2_{\text{comparison}} = L2_{\text{model1}} - L2_{\text{model2}} = 2382.123 - 0.000 = 2382.123$$

$$Df = df1 - df2 = 5650 - 1824 = 3826$$

So from the above result, the likelihood ratio is not significant compared to df, so the nested (parsimonious) model is the best-fitted model.

3.4. Model 3: (High Traffic Volume at Junction)

In high traffic volume at junctions, age and lighting conditions, day of the week, and vehicle type have high correlation

coefficients. Age has a high correlation coefficient with other variables compared to lighting condition, and day of the week also has a high correlation coefficient with other variables compared to vehicle type, so age and day of the week should be removed from the variable list. The remaining variables were day of week, gender, lighting condition, driver educational status, driving experience, vehicle type, weather condition and road type. Condition.

Table 7. Goodness-of-Fit Tests saturated model (HTVJ).

	Chi-square	df	Sig.
Likelihood ratio	.000	12864	.000
Pearson	.000	12864	.000

Table 8. Goodness-of-Fit Tests nested model (HTVJ).

	Chi-square	df	Sig.	Adjusted df	Sig.
Likelihood ratio	1185.926	79353	.040	30213	.000
Pearson	129130.168	79353	.000	30213	.000

Likelihood ratio for nested model L2 model1 = 1185.926

Likelihood ratio for saturated model L2 model2 = 0.000

Df nested model = 79353

Df for saturated model = 12864

$$L2_{\text{comparison}} = L2_{\text{model1}} - L2_{\text{model2}} = 1185.926 - 0.000 = 1185.862$$

$$Df = df1 - df2 = 79353 - 12864 = 66489$$

So from the above result, the likelihood ratio is not significant compared to df, so the nested (parsimonious) model is the

best-fitted model.

MODEL 4. (LOW TRAFFIC VOLUME AT JUNCTION)

In low traffic volume at junctions, vehicle type and gender have a high correlation coefficient. But gender has a higher correlation with other variables compared to vehicle type. So gender should be removed from the variable list. The remaining variables were gender, age, driver educational status, driving experience, vehicle type, lighting condition, weather condition, and road type.

Table 9. Goodness-of-Fit Tests saturated model (LTVJ).

	Chi-square	df	Sig.
Likelihood ratio	.000	23424	.000
Pearson	.000	23424	.000

Table 10. Goodness-of-Fit Tests nested model (LTVJ).

	Chi-square	df	Sig.	Adjusted df	Sig.
Likelihood ratio	1219.341	119042	.030	58292	.000
Pearson	60793.640	119042	.000	58292	.000

Likelihood ratio for nested model L2 model1 = 1219.341

Likelihood ratio for saturated model L2 model2 = 0.000

Df nested model = 119042

DF for saturated model = 23424

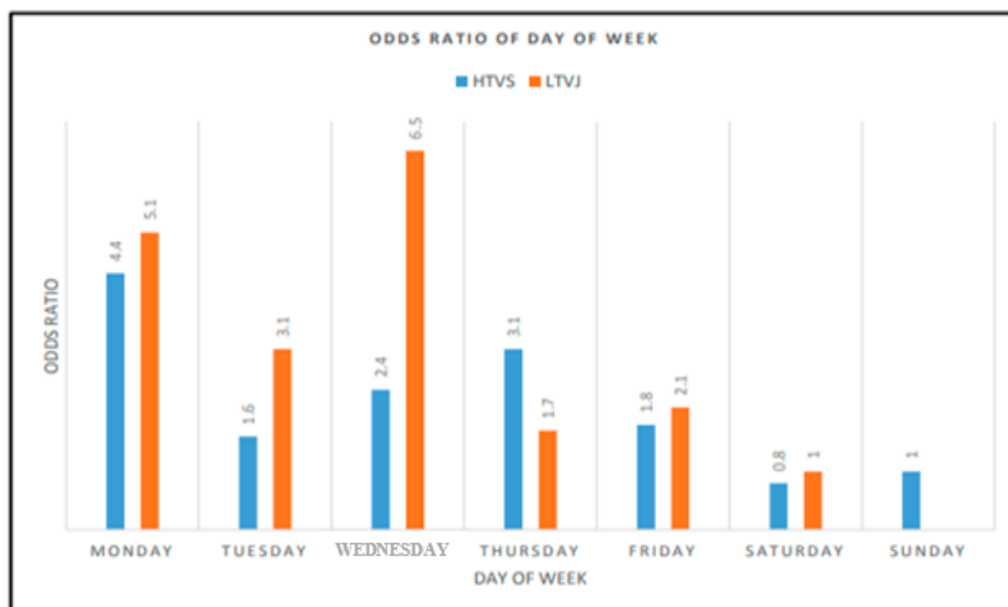
L2comparison = L2 model1 – L2 model2 = 1219.341 –

0.000 = 1219.341

Df = df1 – df2 = 119042 – 23424 = 95618

So from the above result, the likelihood ratio is not significant compared to df, so the nested (parsimonious) model is the best-fitted model.

3.5. Discussion

**Figure 3.** Odds ratio of day of week.

The analysis of variables in each model obtained in the previous section will be discussed and interpreted in this section. Mainly the effect of each parameter included in the model on the total number of crashes in straight sections and junctions with different traffic volumes was discussed.

In the high traffic volume straight section, Monday has the

highest number of crash compared to the base case, Sunday. This number may be due to Monday being a working day and a lot of pedestrians moving along the city and being exposed to crashes compared to Sunday, which is not a working day. Thursday also has a high number of crash frequency by the following Monday compared to the base case (Monday).

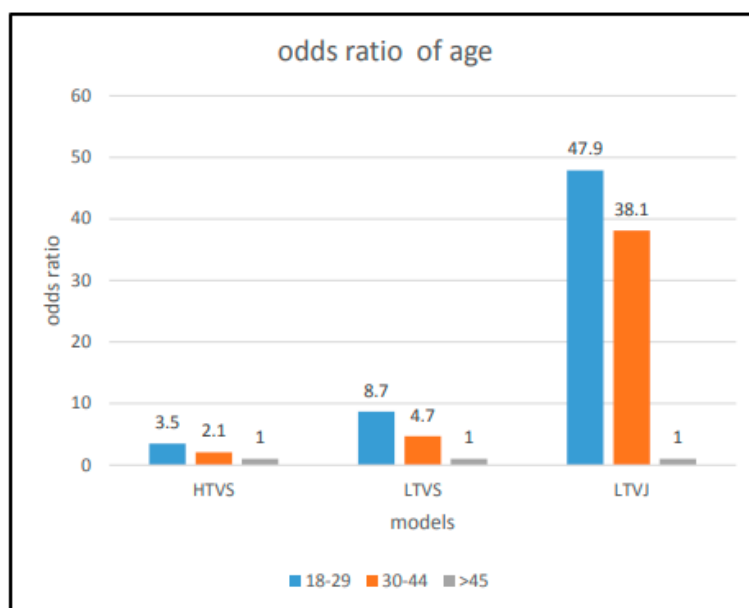


Figure 4. Odds ratio of age.

From the above figure, in high traffic volume straight sections, the 18-29-year-old age group has a 3.5 times higher number of crash compared to the base case (>45 years). This increasing of crash probability may be due to young drivers driving at high speeds and having no patience to give priority

to pedestrians. 30-44-year-old drivers also have a 2.1 times higher number of crash compared to >45-year-old drivers. The probability decreases compared to 18-29-year-olds because they are mature and have better patience to give priority to pedestrians.

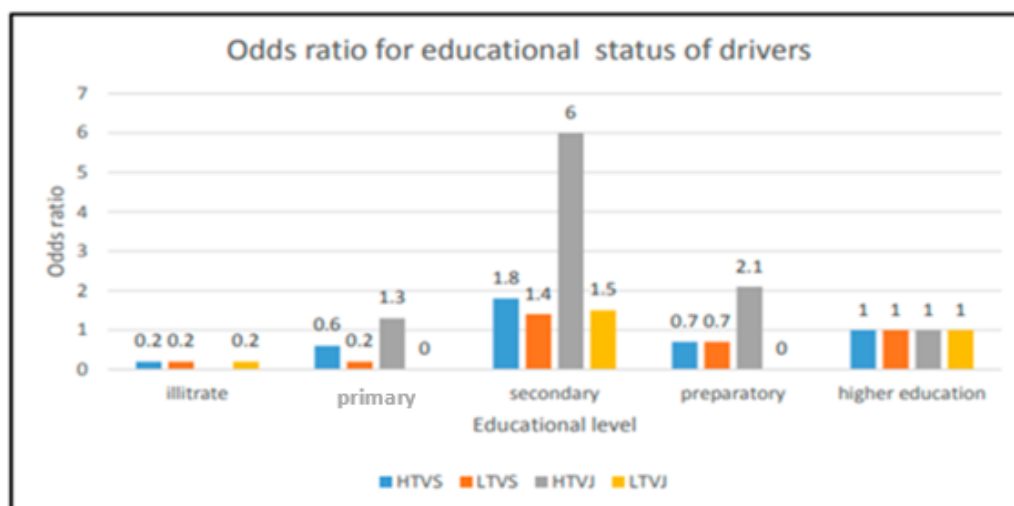


Figure 5. Odds ratio of educational status.

In the preparatory level there is a 2.1 times higher number of crash compared to the base case (higher education) in high traffic volume junctions. This increase of crash probability may be due to higher education level drivers having a better understanding of traffic rules compared to preparatory level

drivers. At the secondary school level, a driver's high traffic volume junction has a 6 times higher number of crash compared to the base case (higher education drivers). When traffic volume is high at a straight section, there is an 80% higher number of crash compared to higher education.

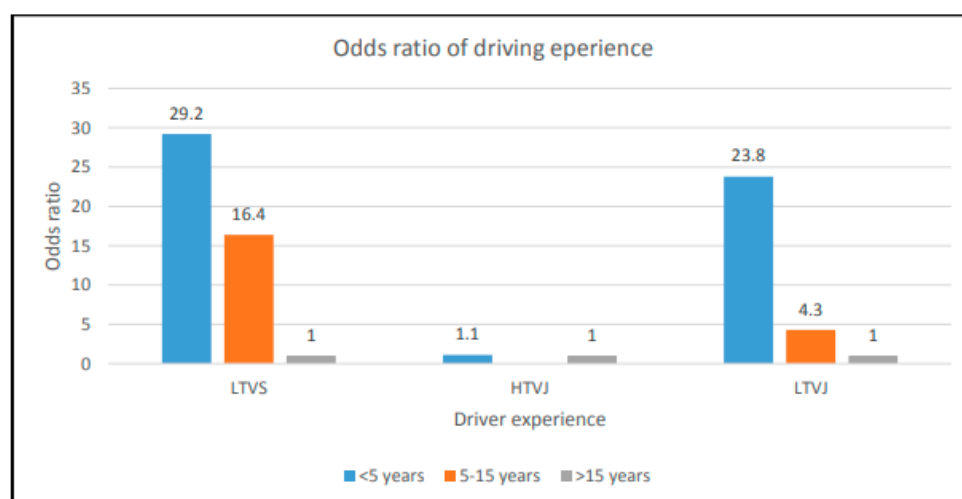


Figure 6. Odds ratio of driving experience.

In low-traffic-volume straight sections, a high number of crash is observed in < 5 years and 5-15 years of driving experience compared to the base case (>15 years). This may be due to highly experienced drivers having better skills to drive safely than

less experienced drivers. In low traffic volume junctions, <5 years of driving experience also has a high number of crash compared to the base case.

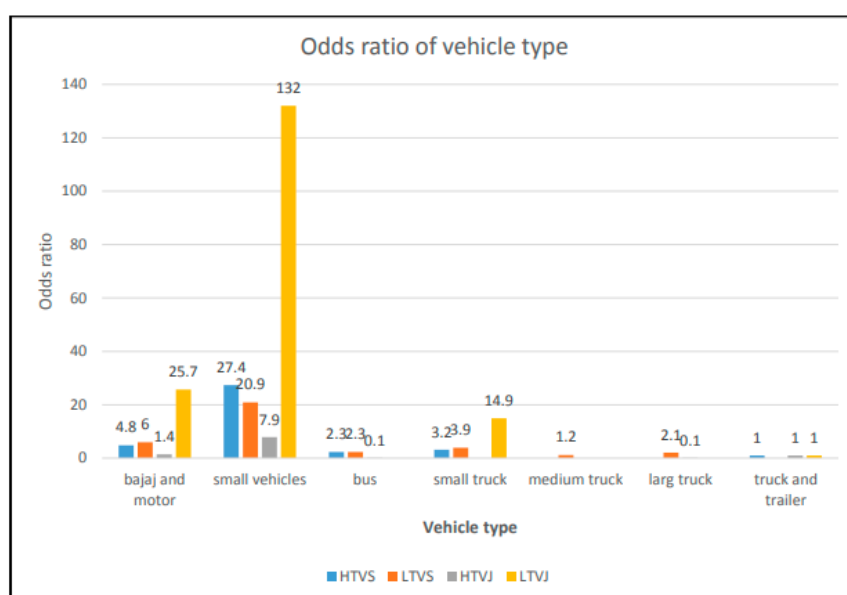


Figure 7. Odds ratio of vehicle type.

In high-traffic-volume straight sections, small vehicles have a high number of crash compared to the base case (truck and trailer); Bajaj and motor have a 4.8 times higher number of crash compared to truck and trailer. In all road sections and traffic volumes, small vehicles have a high number of crash

compared to all other vehicle groups. In low-traffic-volume straight sections, small vehicles have a 21 times higher probability of crash frequency compared to trucks and trailers. Bajaj and bus have 6 and 4 times higher crash frequency, respectively, compared to the base case.

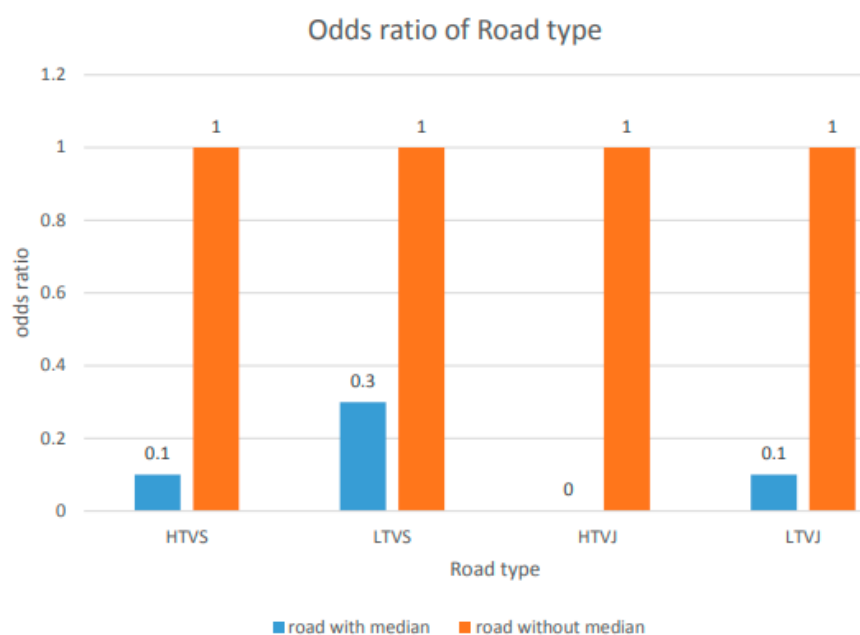


Figure 8. Odds ratio of road type.

A high-traffic-volume straight section and a low-traffic-volume junction road with a median have a 90% lower number of crash compared to a road without a median. In a low-traffic-volume straight section of road, a median has a 70% lower number of crash compared to a road without a median.

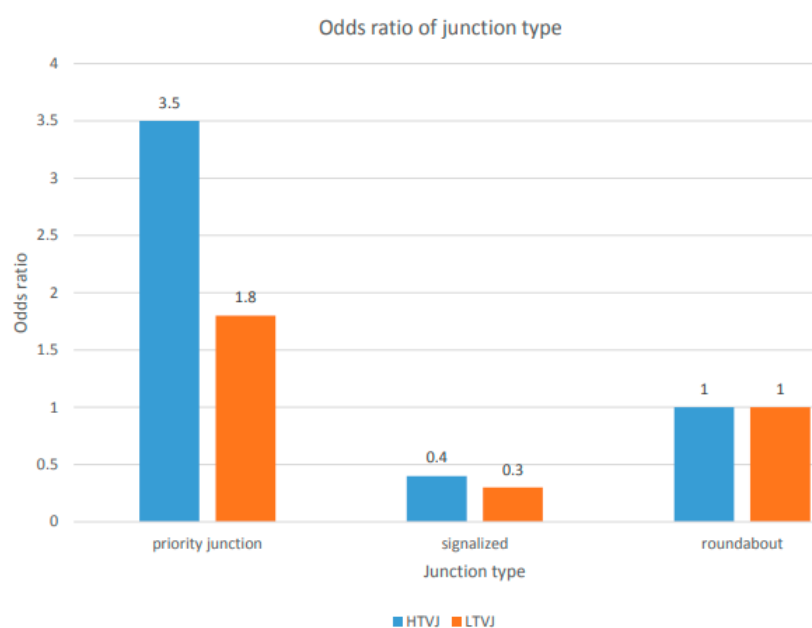


Figure 9. Odds ratio of junction type.

In high traffic volume priority junctions have a 3.5 times higher number of crash compared to roundabouts. and 60% less number of crash in signalized junctions compared to roundabouts. In low-traffic-volume junctions, there is a 1.8

times higher number of crash in priority junctions compared to roundabouts. There is 70% less number of crash in signalized junctions compared to roundabouts.

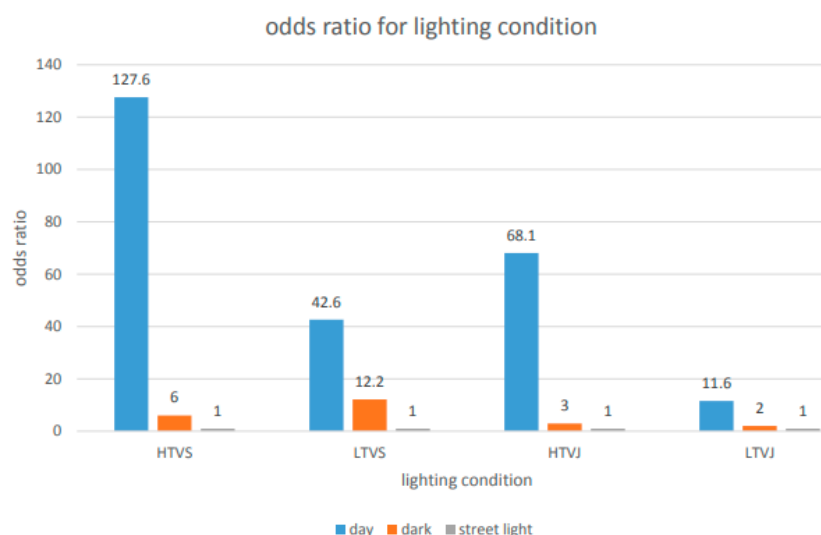


Figure 10. Odds ratio of lighting condition.

In high-traffic-volume straight sections, daylight has a higher number of crash compared to street light crash occurrence. And in dark time, the number of crash is 6 times higher compared with street lights. In low traffic volume street sections, daytime has a

42.6 times higher number of crash compared to street lighting. And dark time has 3 times higher number of crash compared to the street section.

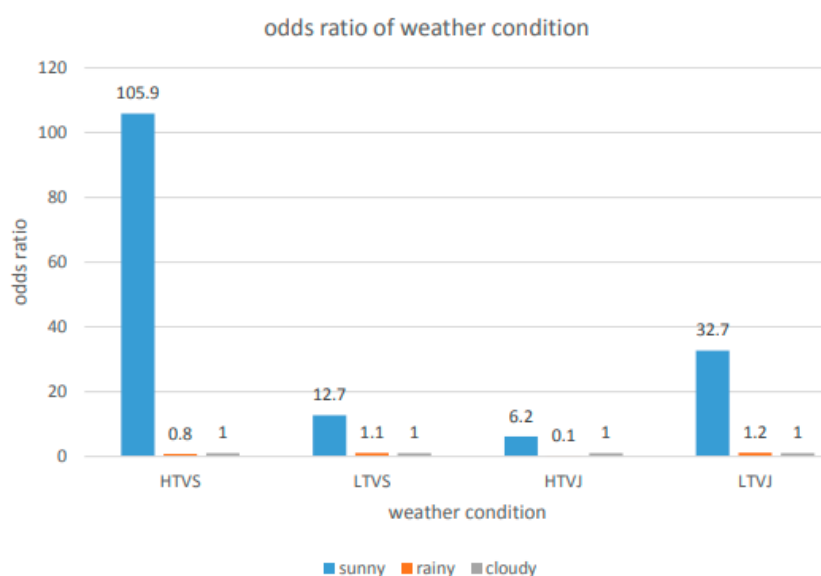


Figure 11. Odds ratio of weather condition.

In high-traffic-volume straight sections, there is a very high number of crash in sunny weather conditions compared to cloudy. But there is a 20% less number of crash in rainy conditions compared to cloudy. In low-traffic-volume straight sections, sunny weather conditions have a 12.7 times higher number of crash compared to cloudy. In rainy times, a 10% higher probability of a crash is observed compared to cloudy conditions.

4. Conclusions and Recommendations

4.1. Conclusions

Based on the discussion and the result of this research, the following ideas can be generalized.

When traffic volume is low, the frequency of crash occurrence on Wednesday at the junction is high, and in high traffic

volume, there is a high frequency of crashes on Monday at the straight section. In low traffic volume, high frequency of crash occurrence is observed in 18-29-year-old drivers at junctions. In high traffic volume, low crash probability, and in low traffic volume, high probability of a crash is observed. 30-44-year-old drivers also have a 2.1 times higher number of crash compared to >45-year-old drivers in high traffic volume at straight sections.

High school-level drivers have a high frequency of crashes at junctions in high traffic volume and a lower frequency of crashes in low traffic volume at straight sections. In low-traffic-volume straight sections, a high number of crash is observed in < 5 years and 5-15 years of driving experience compared to the base case (>15 years). In low traffic volume junctions, <5 years of driving experience also has a high number of crash compared to the base case.

In high-traffic-volume straight sections, small vehicles have a high number of crash compared to the base case (truck and trailer); Bajaj and motor have a 4.8 times higher number of crash compared to truck and trailer. In all road sections and traffic volumes, small vehicles have a high number of crash compared to all other vehicle groups. In all traffic volume junctions and straight sections of road, roads with medians have a lower probability of crash frequency than roads without medians.

4.2. Limitation of the Study

Only limited crash variables are included since there are variables that are not recorded properly in the traffic police office, and these variables make the result unreliable. So some variables are removed from the analysis. Since there is no recorded hourly traffic volume variation data during crash occurrence in the city, the primary data used in the study is current traffic volume data, and the crash data is for the last five years, so current traffic volume data may not exactly represent the traffic volume condition at the recorded time of the crash.

It should be noted, however, that although the study in this paper is based on observational data and makes use of statistical association between various road and traffic conditions/concerns and environmental aspects and accident outcomes, it should be recognized that the findings are correlative in nature and should not be considered as causal in any way.

4.3. Recommendations

Awareness creation of how and when to cross the road should be intensified, especially for peasants and countryside peoples.

Special traffic operation should be given on market days.

Small vehicle drivers should be given special training to avoid repetitive crash occurrence.

The concerned body should enforce the application of traffic rules and regulations, especially on Monday and Wednesday.

Traffic police should force drivers to minimize their speed around junctions, especially when there is low traffic volume.

Special attention should be given to priority junctions when there is high traffic volume.

Finally, underreporting of crashes is visible in Bahirdar; thus, developing a crash database is better for doing a reliable study and for overcoming crash-related problems.

The outcomes of this research should therefore be interpreted carefully. The established relationship is meant to facilitate an understanding of factors that are related to crash likelihood but it should not be assumed that making a variation on one element will lead to decrease in crash occurrence. The outcomes should be assessed within the context prior to making any safety intervention based on this research, where possible.

Abbreviations

AADT	Annual Average Daily Traffic
HTVJ	High Traffic Volume Junction
HTVS	High Traffic Volume Straight Section
LTVJ	Low Traffic Volume Junction
LTVS	Low Traffic Volume Straight Section
PCU	Passenger Car Unit
RTC	Road Traffic Crash
SPSS	Statistical Package for Social Science
WHO	World Health Organization

Author Contributions

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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