



ADDIS ABABA UNIVERSITY

SCHOOL OF POST GRADUATE STUDIES

**The effects of selected crash parameters and traffic volume on crash
frequency (the case of Bahirdar city, Ethiopia)**

Submitted to school of civil and environmental engineering

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**A Thesis Submitted to The School of Graduate Studies of Addis Ababa
University in The Partial Fulfilment of the Degree of Master of Science in
Civil Engineering (Road and Transport Engineering)**

Advisor: Dr. Bikila Teklu

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ADDIS ABABA UNIVERSITY
SCHOOL OF POST GRADUATE STUDIES

M.S.C thesis on

The effects of selected crash parameters and traffic volume on crash frequency (in case of Bahirdar city, Ethiopia)

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Declaration

I, the undersigned, declare that this thesis is my original work performed under the supervision of my research advisor Dr. Bikila Teklu and has not been presented as a thesis for a degree in any other university. All sources of materials used for this thesis have been duly acknowledged.

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Date: November 2018

Dedication

This work is dedicated to MY parents Ato Gashaw Kebede and Wro Yenework Tesfaye for your love and support throughout my life next to almighty God.

Acknowledgment

First, and foremost, I thank God of my ancestor for giving me the opportunity to pursue my graduate study, patience and wisdom to complete this work. I owe the deepest gratitude to my advisors, Dr. Bikila Teklu, for his guidance, advice and support throughout the entire project, for all what he delivered to me in class sessions during my stay in the university; and also want to appreciate his valuable comment that makes me to think out of the box. I feel I have really been lucky to be working with someone like him. It has been amazing how somebody can have so much knowledge of, and interest in my project, while working on so many projects concurrently.

Next my appreciation goes to Bahir Dar special zone police commission Staffs especially traffic control and investigation staffs of record section that helped me during the research work, by giving any necessary documents and information for the study.

My gratitude also goes to my friends for their unforgettable encouragement to me during Academic class and research and I would like to thank persons who have great significance but not cited for giving me successive encouragement.

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Abstract

The aim of the study is to develop mathematical model to understand the impact of selected crash parameters on crash frequency in in high and low traffic volume in both straight section and junction. Comparing the effect of straight section and junction with selected crash parameters on crash frequency is also addressed. Four models are developed, these are crash condition at high traffic volume in straight section, low traffic volume in straight section, high traffic volume in junction and low traffic volume in junction.

The method used in this research is loglinear analysis using SPSS software. Seven days' traffic data was collected from major junction and straight section in Bahirdar. The purpose of traffic data collection was to categorize hours of the day into high traffic volume hours and low traffic volume hours. This classification helps to know the relationship between traffic crash and traffic volume at straight section and junction. Five-year traffic crash was also collected to conduct the analysis and modelling in **SPSS** software by loglinear modelling. Variable selection and coding were also addressed in methodology part.

The result depicted that in high traffic volume straight section Monday has the highest probability of crash occurrence compared to base case, Sunday. In low traffic volume junction Wednesday has the highest probability of crash occurrence compared to Saturday. in high traffic volume straight sections 18-29-year age group 3.5 times higher probability of crash occurrence compared to base case (>45 year). 30-44 year drivers have also 2.1 times probability of crash occurrence compared to >45 year drivers. In low traffic volume straight sections both 18-29 and 30-44-year-old drivers have increased the probability of crash occurrence. In low traffic volume junction both 18-29 and 30-44-year-old drivers have increased highly with 47.9 and 38.1 times the base case (>45 year). In low traffic volume straight section high probability of crash occurrence is observed in < 5 years driving experience compared to the base case (>15 years). In low traffic volume junction <5 years driving experience has also high probability of crash occurrence compared to the base case. In high traffic volume straight section and low traffic volume junction road with median has 90 % less probability of crash occurrence compared to road without median. In low traffic volume straight section road with median has 70 % less probability of crash occurrence compared to road without median. In high traffic volume priority junctions have 3.5 times higher

probability of crash occurrence compared to round about. And 60% less probability of crash occurrence in signalized junction compared to roundabout.

Key words: log linear modelling, traffic crash, traffic volume, junction.

Table of content

Contents	page
1.0 INTRODUCTION	1
1.2 Junction Safety.....	2
1.3 Causes of road crashes	3
1.4 Statement of The Problem	3
1.5 Objectives	4
1.51 Specific objectives	4
1.6 Significance of The Study.....	4
1.7 Scope and limitation of the study	4
1.71 Limitation.....	5
1.8 Research Questions.....	5
1.9 Organization of the thesis	5
2.0 LITERATURE REVIEWS	6
2.1 International Crash Trends.....	6
2.3 Road Traffic crash in Ethiopia.....	8
2.4 Causes of Road Traffic Crash.....	11
2.5 Crash's at Signalized Junction.....	13
2.6 Crashes at Unsignalized Junctions.....	14
2.7 Traffic Safety Modellings.....	14
2.8 Research On Log Linear Modeling	16
3.0 RESEARCH METHODOLOGY	18
3.1 Study Area and Structure	18
3.2 Data Source.....	19
3.21 Traffic Data Collection.....	19
3.22 Traffic composition.....	20
3.22 Secondary data collection.....	30
3.3 Selection of Variable and Coding.....	30
3.4 Data Analysis	32
3.5 Log Linear Analysis.....	32

3.6 Data Preparation	34
3.7 Analysis Procedure and Interpretation.....	35
4.0 ANALYSIS AND DISCUSSION	37
4.1 Variable Correlation	37
4.2 Development of The Model by Loglinear Modelling.....	39
4.3 Model 1 (High Traffic Volume at Straight Section).....	39
4.4 Model 2: (Low Traffic Volume at Straight Section)	42
4.5 Model 3: (High Traffic Volume at Junction).....	44
Model 4. (Low Traffic Volume at Junction).....	46
4.8 Discussion.....	48
5.1 Conclusions.....	57
5.2 Recommendations.....	58
5.3 Future Study Areas	58
Reference	59
Appendix A: data entered in SPSS	63
Appendix B: Correlation coefficients	65
Appendix C: final model (equations).....	70
Appendix D: Samples photos of crash data file.....	72

List of tables

Table	page
Table 2.1 Trends of road traffic Crash in Ethiopia, 2012/2013-2016/2017	8
Table2.2 Regional distribution of road traffic crash in Ethiopia 2012/13-2016/17	9
Table 2.3 7-year traffic crash trends in Amhara region	10
Table2.4 History of traffic crash in Bahirdar	11
Table 3.1 Traffic count dates	19
Table 3.2 Ethiopian railway corporation PCU standard	21
Table3.3 Sunday hourly traffic volume in papyrus roundabout	22
Table 3.4 Monday hourly traffic volume sec (yetebaberut – Azwa hotel)	23
Table 3.5 Tuesday hourly traffic volume (poly round about)	24
Table 3.6 Wednesday hourly traffic volume (Azwa hotel – lake tana)	25
Table 3.7 Thursday hourly traffic volume (Papyrus hotel – St George church)	26
Table 3.8 Friday hourly traffic volume (Geter menged – St George church)	27
Table 3.9 Saturday hourly traffic volume (NOC roundabout)	28
Table 3.10 Seven days Average traffic volume (pcu) in papyrus roundabouts	29
Table 3.11 Hourly traffic volume category	30
Table 3.8 Selected variables for further analysis	31
Table 4.1 Example of variable correlation HTVH section	38
Table 4.3 Goodness of fit test for nested model	40
Table 4.4 Goodness-of-Fit Tests	40
Table 4.5 Parameter estimate for high traffic volume on straight section	42
Table 4.6 Goodness of fit test for nested model (LTVJ)	42
Table4.7 Goodness of fit test for saturated model(LTVJ)	42
Table 4.8 Parameter estimate for low traffic volume at straight section	43
Table 4.9 Goodness-of-Fit Tests saturated model (HTVJ)	44
Table 4.10 Goodness-of-Fit Tests nested model (HTVJ)	44
Table 4.11 Parameter Estimates for high traffic volume at junction	45
Table 4.12 Goodness-of-Fit Tests saturated model (LTVJ)	46
Table 4.13 Goodness-of-Fit Tests nested model (LTVJ)	46
Table 4.14 Parameter Estimates for Low traffic volume at junction	47

List of figures

Figure	page
Fig1.1 Trends of road traffic crash in Amhara region in 2007-2011	2
Fig 2.1 global road traffic death	6
Fig 2.2 Road traffic fatality rate per 100000 populations by WHO region	7
Fig 4.1 Odds ratio of day of week	48
Fig 4.2 Odds ratio of age	49
Fig 4.3 Odds ratio of educational status	50
Fig 4.4 Odds ratio of driving experience	51
Fig 4.5 Odds ratio of Vehicle type	52
Fig 4.6 Odds ratio of road type	53
Fig 4.7 Odds ratio of Junction type	54
Fig 4.8 Odds ratio of lighting condition	55
Fig 4.9 Odds ratio of weather condition	56

Acronyms

BSZ	Bahirdar Special Zone
DF	Degree of Freedom
EMA	Ethiopian Mapping Agency
ERC	Ethiopian Railway Corporation
HTVJ	High Traffic Volume Junction
HTVS	High Traffic Volume Straight
LTVJ	Low Traffic Volume Junction
LTVS	Low Traffic Volume Straight
NUPI	National Urban Planning Institute
PCU	Passenger Car Unit
RTA	Road Traffic Accident
SPSS	Statistical Package for Social Science
TRL	Transport Research Laboratory
WHO	World health Organization

1.0 INTRODUCTION

1.1 Background of The Study

Road transport has great role for the movement of goods and services in developing countries and includes 95 % of inter urban transportation, including Ethiopia (UNTACDA,2010). Nowadays there is high traffic growth rate in Ethiopia, traffic crash also increases and becomes one of the major cause of death in the country.

Approximately around 1.2 million people died and 20 to 50 million people injured each year across the world due to road traffic crash; the majority of death (90%) observed in developing countries which have only 48% of worlds vehicle (World Health Organization, 2013).

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 (Fissiha H and Sileshi T,2014)

Traffic crash death distribution also differs based on the economic status of the country (low income, middle income, high income). The main crash death involvement in high income countries is car owners (Persson et al., 2008). 8.5% of the fatalities were car owners in Amhara national regional state, but 60% of the fatalities were accounted for car owners in USA (Chisholm Hn, Baker Td,2009) In low income countries pedestrian encounter 45% of the road crash fatalities, where as in middle income and high income countries pedestrian crash fatalities include 29% and around 21,985 traffic crash were recorded in which 2,761 of them were fatalities in five-year period (2007-2011) in Amhara region (Fisseha and Mekonnen,2014)

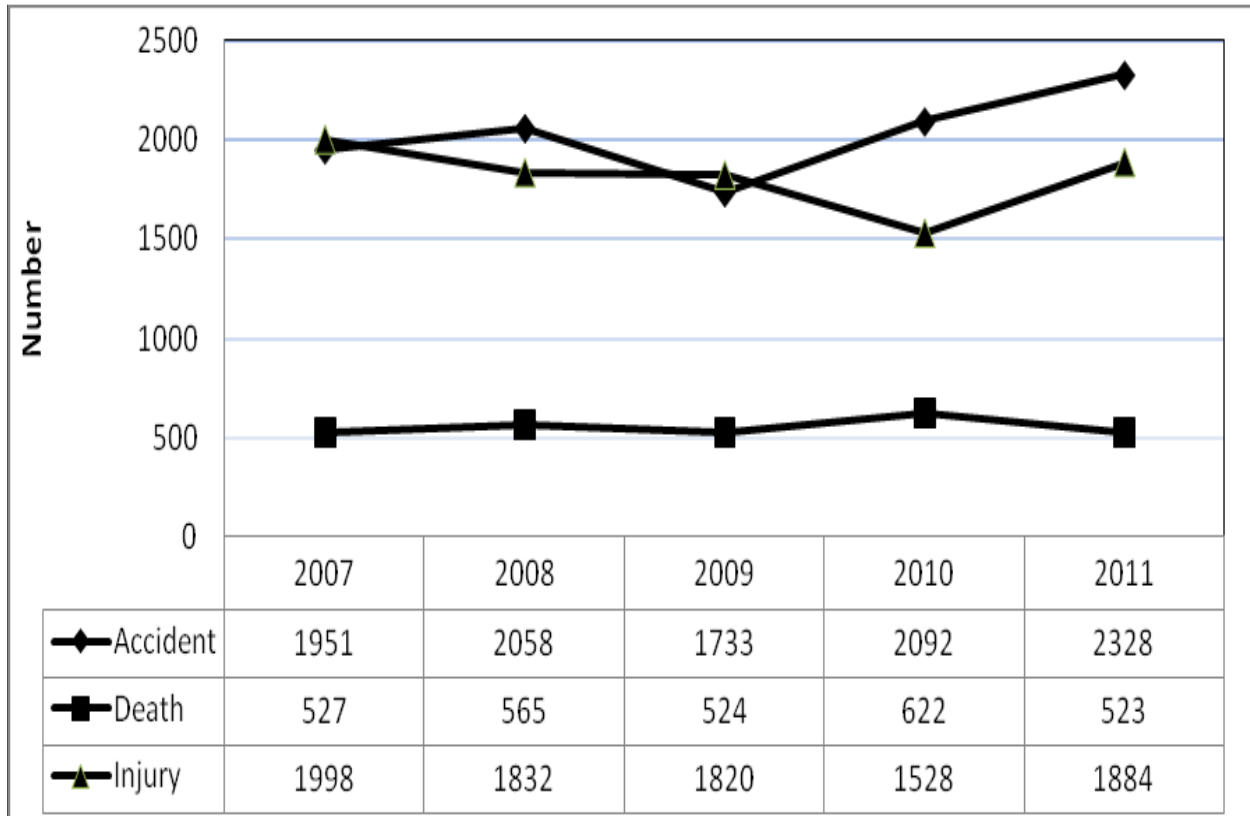


Fig1.1 Trends of road traffic crash in Amhara region in 2007-2011(Fisseha and Mekonnen, 2014)

1.2 Junction Safety

A study conducted by (Konstantinos K, 2014) investigating impact of junction on crash in Florida city. The analysis has led to several conclusions such as angle and left turn collisions have much higher probability of occurrence at junctions and that crashes which occur at junctions are much more probable for low and medium volumes compared to no-junctions. Junctions are crucial part of a given road network, where a lot of crashes are recorded. Because when two or more roads are intersecting each other, a lot of conflicting points are occurred. (NHTSA, 2010).

1.3 Causes of road crashes

There are three influencing factors for road safety. These are vehicle factor, road way factor and human factor (Highway Safety Manual, 2010). The below listed points are also detail crash factors in road and road environment (Kanellaidis., 2008):

- ✚ Inefficient geometric characteristics
- ✚ Improper design, construction and management of roadside signage
- ✚ Traffic management problem
- ✚ Insufficient road lighting
- ✚ Insufficient traffic control and signage during road construction
- ✚ Unfavorable weather condition

1.4 Statement of The Problem

Three main junctions from Gonder, Debretabour and Dangla, roads are meet at Bahirdar because of this the city is under high traffic growth rate. A lot of tourist sites of monasteries with in lake tana islands, tisissat fall of and Its location along the main roads, can be considered as additional factors for the growth of traffic volume in the city. Along with increasing of traffic volume in the city, there is high increase of road traffic crash rate in Bahir Dar and affects both the direct economic loses and the social lives. This observation is supported by Bahir dar city traffic police (2009/10-2014/15) crash statistics which shows that 1241 crashes occurred (gives an average of 206.8RTC/Year). But no significance study is conducted for cause of crash and means of crash reduction in the city.

Junctions have significance role in increasing crash frequency if it is 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 (Konstantinos K, 2014). But still there is no tangible study regarding the comparison of effect of junctions and straight sections on crash frequency in the city. I hope this study will address the above mentioned problems.

1.5 Objectives

The general objective of the study is determining the effect of crash parameters and traffic volume on Crash frequency in both junction and straight section and to recommend for taking immediate counter measure of crash reduction in Bahir Dar.

1.51 Specific objectives

- ✚ To compare the effect of straight section and junction with selected crash parameters on crash frequency in Bahirdar.
- ✚ To analyze and compare the effect of traffic volume on number crash in junction and straight section.
- ✚ To develop mathematical modelling so as to capture adequately the relationship between the total number of crashes and selected crash parameters.

1.6 Significance of The Study

This study is mainly deals about crash frequency on junction compared to straight section in Bahir Dar city. More concern is given to the effect of junction on 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 junction on crash and helps to decide its counter measures.
- ✚ It helps to conduct further research regarding to road traffic crash.
- ✚ Gives information for those institution which concerns about road traffic safety.
- ✚ For better prediction of number of people who are killed by traffic crash to plan for future occurrence.

1.7 Scope and limitation of the study

The research focuses only on Bahir Dar city. The analysis will have done by **SPSS** software with log linear modelling. This study has limited in scope, time and coverage area.

1.71 Limitation

- ✚ Only limited crash variables are included since there are variables which are not recorded properly in traffic police office and these variable makes the result unreliable. So some variables are removed from the analysis.
- ✚ Since 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 represent exactly crash recorded time traffic volume condition.
- ✚ The effects of geometric design parameters are not considered since the research area is the whole city, it is difficult to assess design of all junctions and straight sections.

1.8 Research Questions

1. What is the relationship between traffic volume and total number of crash in junction and straight section?
2. Is frequency of crash at junction is higher than straight section?
3. What are the impact of independent variables on crash?

1.9 Organization of the thesis

The study includes six parts and abstract which summarizes the whole study, acknowledgment, table of content, table of figure, and list of abbreviation. The appendix and the reference would also be found after the last chapter. The first chapter includes introduction, background information, scope of the research, organization of the research, the limitation and objective. Chapter two includes literature review, chapter three contains methodology of the research, chapter four deals about data analysis and modelling, chapter five includes results and discussion. The last one includes conclusion, recommendation and summarizing the findings.

2.0 LITERATURE REVIEW

Literature review part mainly includes causes of road traffic crash which is done in different countries with different road condition, crash occurrence in junction (signalized and signalized junction). It also includes reviewing of previous studies to choose appropriate analysis type on the given data (log linear modelling) previous crash occurrence trends around the study area also revised.

2.1 International Crash Trends

Over 1.2 million people die each year on the world's roads, with millions more sustaining serious injuries and living with long-term adverse health consequences. Globally, road traffic crashes are a leading cause of death among young people, and the main cause of death among those aged 15–29 years. Road traffic injuries are currently estimated to be the ninth leading cause of death across all age groups globally, and are predicted to become the seventh leading cause of death by 2030. This rise is driven by the escalating death toll on roads in low- and middle-income countries – particularly in emerging economies where urbanization and motorization accompany rapid economic growth. In addition to deaths on the roads, up to 50 million people incur nonfatal injuries each year as a result of road traffic crashes (WHO, 2015).

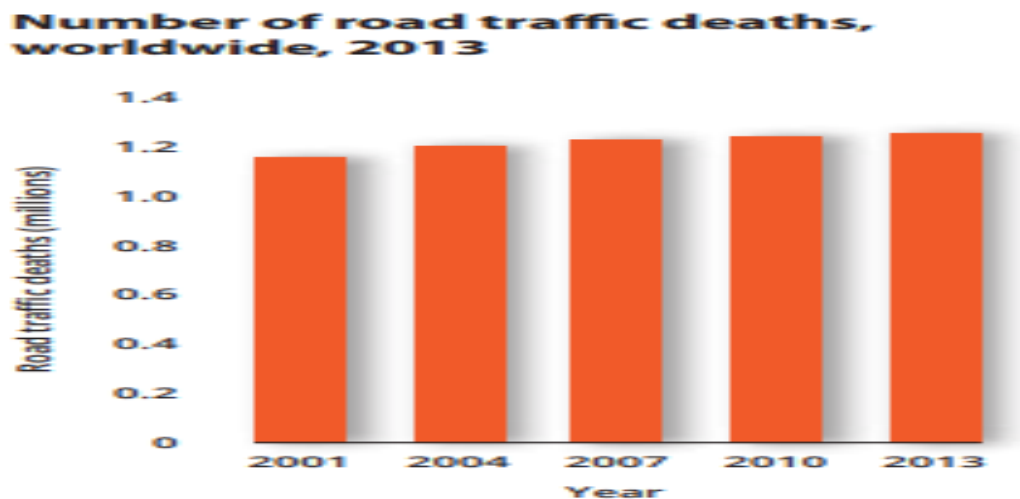


Fig 2.1 global road traffic death
Source WHO, 2015

The above figure shows change of global road traffic crash death from 2001 to 2013.

2.2 Road traffic crash in africa

Every year, road crashes are estimated to claim over 300,000 lives in Africa. The correct number is unknown due to the very poor accident data recording and management system in the region. It is estimated to be the fourth leading cause of death of persons aged 5 through 44 years. Several studies have shown that vulnerable road users in African countries constitute over 65% of the road crash victims. In urban areas, pedestrian fatalities range between 50% in South Africa and up to 90% in Ethiopia. Over 75% of the casualties are of productive age between 16-65 years. Of these, males account for about 73% of deaths and 70% of all the disability-adjusted life years (DALYs) lost because of road traffic injury most of whom are bread winners for their family. The World Report on Road Traffic Injury Prevention⁴ predicts more than 80% increase of road crash deaths in Sub-Saharan Africa in the period 2000-2020. The increase is not proportional to the level of motorization and road network density in Africa (Africa Development Bank, 2013).

Road traffic fatality rates per 100 000 population, by WHO region

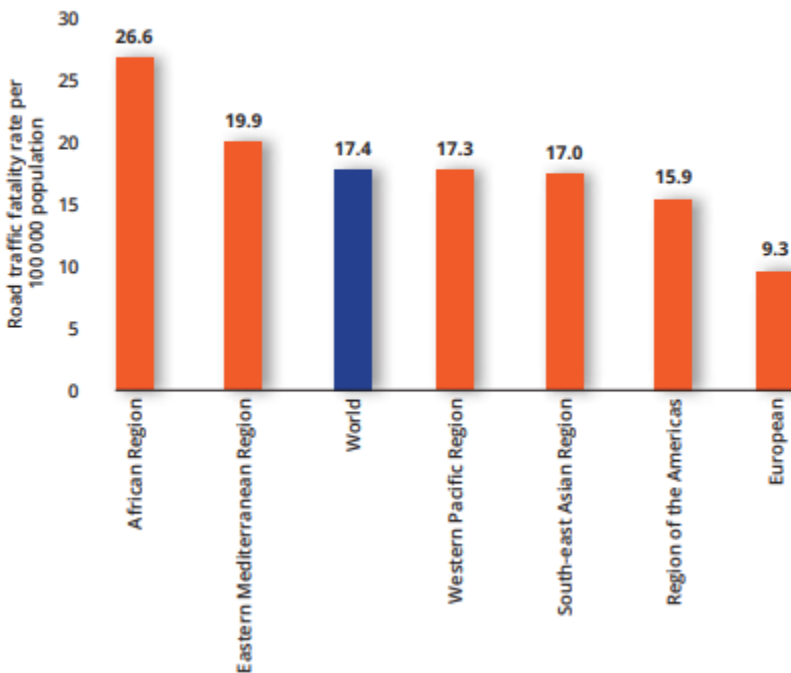


Fig 2.2 Road traffic fatality rate per 100000 populations by WHO region
Source: (World Health Organization, 2015)

2.3 Road Traffic crash in Ethiopia

Ethiopia is one of the highest in road traffic crash death rates recorded in the world. currently according to federal police traffic office over 3600 people being killed annually. Every day, some 10 people have been killed on Ethiopian roads.

Table 2.1 Trends of road traffic Crash in Ethiopia, 2012/2013-2016/2017

Year	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	% Increase 2013 to 2017
Severity						
Fatal	2575	2664	3172	3475	3606	20
Serious injury	3183	3558	4046	4095	4449	39
Slight injury	3423	3474	3561	2819	2803	-18
Property damage	16819	18743	221241	23158	27879	65
Total	26000	28439	32020	33547	38737	48

Source: Federal police traffic office

As stated in the above table all crash severity types increase in high percent from 2012/2013 to 2016/2017 except slight injury this indicates that there is no significance crash protection mechanism is taken.

Table2.2 Regional distribution of road traffic crash in Ethiopia 2012/13-2016/17

no	Region	Year					Total	Share In %
		12/13	13/14	14/15	15/16	16/17		
1	Tigray	1037	1124	1267	1447	1391	6266	7
2	Afar	252	338	257	309	374	1530	2
3	Amara	3521	3736	3449	3915	4215	18836	22
4	Oromia	4690	3272	7357	4949	4485	24753	28
5	Somali	366	356	236	352	961	2271	3
6	B/gumz	382	358	205	487	652	2084	2
7	South	756	1390	1808	2037	2561	8552	10
8	Gambella	90	95	148	172	155	660	1
9	Hareri	144	198	370	256	460	1428	2
10	A/Ababa	3155	4022	3438	4040	3794	18449	21
11	D/Dawa	327	369	325	345	352	1718	2
	Total	14720	15258	16273	18309	19400	83960	100

Source: Federal police traffic office

As shown from the above table more than 70% of crash is occurred in three regions (Oromia, Amhara and Addis Ababa). So special controlling mechanism should apply to overtake this significant digit. The lowest Crash is recorded in Gambella, Hareri and Afar.

Table 2.3 7-year traffic crash trends in Amhara region

No	Zone	2009	2010	2011	2012	2013	2014	2015	total	Crash in %
1	N/gonder	342	128	223	231	242	204	150	1520	8.6
2	S/gonder	140	213	244	207	179	187	190	1360	7.7
3	Gonder city	0	192	289	271	295	407	232	1686	9.5
4	Bahirdar city	159	230	288	319	281	360	315	1952	11.0
5	Awi	123	89	84	134	130	111	118	789	4.5
6	W/gojjam	248	215	276	230	269	258	247	1743	9.8
7	E/gojjam	145	169	211	180	204	193	268	1370	7.7
8	N/shewa	138	129	220	243	297	278	322	1627	9.2
9	S/wello	280	181	196	153	207	254	231	1502	8.5
10	Dessie city	70	165	188	156	156	189	235	1159	6.5
11	N/wello	213	194	175	189	218	277	346	1612	9.1
12	Oromia	116	127	149	213	179	210	199	1193	6.7
13	Waghmra	13	20	41	21	27	32	33	187	1.1
	Total	1987	2052	2584	2547	2684	2960	2886	17700	100

Source: ANRS police commission

As shown from the table Bahirdar city is the prior in traffic crash records from the region with 11% of crash occurred in the region. By following Bahirdar, Gonder city, N/wello and N/shewa are also recorded a significant crash.

Table2.4 History of traffic crash in Bahirdar

Crash severity	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	Total
Fatal	29	28	28	32	16	36	241
Serious injury	14	25	39	29	30	34	256
Slight injury	75	94	88	51	122	62	757
Property damage	112	142	164	169	192	183	1241

Source: Bahirdar special zone traffic police office

The above table stated that all crash severity type increases from year to year except slight injury. Specially property damage highly increases in five-year period.

2.4 Causes of Road Traffic Crash

A study done by (Yosef A ,2015) descriptive analysis of road traffic crash in Addis Ababa. Statistical analysis is used in this study the result of the study had shown that Drivers' Age, Educational background and Place of crash highly affect the number of death/ injuries per crash. Drivers who are in the age group of 18-30 exposed to most of the crashes. Drivers with secondary school level of education take the major responsibility for the increased number of injuries. places of crashes, particularly in central business districts, organizational and residential areas are where the highest crash occurrences places. The main causes of traffic crashes are failure to give -way for vehicle, failure to priority for pedestrians, and following too closely. On average, about 89 % of the road traffic crash fatalities are pedestrians. From the total traffic crashes occurring yearly. Many researchers have come out with the causes, effects and recommendations to vehicular Crash. Numerous Crash on our road networks have been linked to various causes which include, drink driving, over speeding, poor road network, wrong over taking and the rickety vehicles which ply on our roads (Afukaar, 2007).

One of the study in Amhara, Ethiopia was by (Haile M., Demeke L., and Essey K., 2017) 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. Logistic regression methods were used to analyze the data and a total of 1003 accidents were registered in the selected files. Of these, (35.5 %) were deaths and (64.5 %) were injuries. It was found that out of 356 deaths, the majority, 286 (80.33%) were caused by drivers who didn't use seat belt. Most of the accidents, 454 (45.4%) were caused by Cargo vehicles.

Poor vision of driver also be a major contributory factor to road traffic crash (Ocansey, 2011). The cause of road traffic crash has also been connected on or combination of the following four factors (road design, equipment failure, poor road maintenance and bad behavior of drivers. But most studies show that the main cause (95%) of road traffic crash is due to behavior of driver (Driving Guideline).

Some researchers have attributed the escalating number of carnage in sub Saharan Africa to bribery and corruption. The study which is conducted in Russia to find out the contribution of corruption to road toll, it was found out that people were paying \$800.00 to obtain driving license without going through driving school (“Russia” today, 2010).

Another study in Bahirdar, Ethiopia was by (Haile M., Demeke L., and Essey K., 2014) In this study the major objective was to determine the major factors that affect existence of traffic accidents at Bahir Dar city, North Western Ethiopia. The drivers were selected using simple random sampling methods and descriptive statistics, The Hosmer and Lemeshow test showed that the model fits the data in a good manner. The result showed that drivers giving priority stated by the law, pedestrian’s manner while crossing the road, driver’s usage of seat belt have statistically significant impact for the occurrence of traffic accidents in the city. But pedestrian manner while crossing the road is the major factor for the occurrence of traffic crashes.

Risk factors influencing road traffic fatalities and injuries (WHO, 2009) categorized risk factors into four groups, these are;

- ❖ Factors influencing exposure to risk (thus, social deprivation, age and sex)
- ❖ Risk factors influencing crash involvement (thus, young male, fatigue inadequate visibility).
- ❖ Factors influencing crash severity (thus, not wearing safety equipment, excessive speed alcohol)
- ❖ Severity of injuries after road traffic crash (thus, delay in detecting crash, and transportation).

- ❖ The report shows in developing countries there is high exposure of risk factors to road traffic crash due to unsafe transportation, high urbanization and unlimited speed of vehicles.

2.5 Crash's at Signalized Junction

A study which was executed by (Chin, 2003) The research mainly used negative binomial regression model to determine those factors that affect intersection safety. The model examined the relationship between accident frequencies and the geometric, traffic and regulatory control. Results showed that, the number of phases per cycle, the total approach volumes, the presence of a surveillance camera and uncontrolled left-turn lane are among the variables that significantly affected traffic crashes. Then, (Abdel-aty., 2005) determines those factors that affect crash severity level in Florida. Data were obtained from the Florida department of transportation (FDOT), the department of highway safety and counties' databases were combined for the analysis, from 832 signalized junctions during 2000-2001. Ordered probit modeling has been adopted in this study. Results depicted that a divided minor roadway or a higher speed limit On the minor roadway decreased injury levels but crashes involving a vulnerable road user (pedestrian/bicyclist) and left turn crashes had high probability of severe Crashes occurrence. Another research was done by (Obeng, 2007. The researcher identifies factors of possible injuries on crashes at 303 signalized junctions in the city of Greensboro, conditional probability model is used.

The result of this research include: presence of airbags in crashes, male driving (compared to female driving), crashes at junctions near residential areas and the existence of sidewalks reduce the conditional probability of sustaining possible injuries. In other hands, impairment from alcohol/drugs, when a driver falls ill or due to an existing medical condition, when the number of involved vehicles or vehicle occupants in a crash increases and when vehicle type is passenger car or van the conditional probability of sustaining possible injuries is higher. In addition, (Wong., 2007) found the contributory factors that affect traffic crashes at 262 signalized junctions in Hong Kong from 2002-2003. negative binomial regression and Poisson Regression were used to quantify the result of possible contributory factors in killed and severe injury crashes and slight injury crashes, respectively. The result for slight injury crashes outline that presence of tram stops, road environment (signalized intersections, numerous commercial locations, aggressive driving) and

increase of curvature degree and increase the crash risk, while the traffic volume have a decreasing effect on crash risk. In other hands, as for killed and severity injury crashes, road environment, the number of pedestrian streams, proportion of commercial vehicles, road environment, average lane width, curvature degree and presence of tram stops increase the risk of killed and severity injury crashes. Finally, the effect of traffic volume on killed and severity injury crashes was low.

2.6 Crashes at Unsignalized Junctions

A research which was conducted by (Tulu, G.S.,2015) 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. Pedestrian, traffic volume and the presence of public transport terminal around roundabout had positive association with pedestrian crash at roundabout. But maximum gradient of approach road and provision of raised median along the approach has negative association with pedestrian crash.

Moreover, (Alexander, 2010) explore the effect of selected parameters with the use of an interactive driving simulator. A probit model was built to predict the probability of an incident occurring as a result of a right-turn across left-hand traffic at an unsignalized intersection. The model was developed from the results of experimental trials. They included the vehicle characteristics (size, color, velocity), driver characteristics (age, sex), size of the gap between successive vehicles, daytime and night-time conditions. The results showed that driver and vehicle characteristics affect both the gap size and time of crossing.

There was a study to examine the effect of updating the parameters of the covariates in the fitted negative binomial and bayesian models in order to predict crash frequencies at 433 unsignalized intersections in Florida. Both models yielded good results. but, in terms of standard errors as a measure of uncertainty, bayesian models performed better. Finally, as for the model structure, the log-gamma likelihood function for updating parameter estimates. (Haleem, 2010)

2.7 Traffic Safety Modellings

A study done by (Tulu, G. S., Washington, S., King, M. J., & Haque, M. M, 2017) The police reported pedestrian crashes have been modelled by a random parameters logistic regression model, a cutting-edge statistical model that account for unobserved heterogeneities potentially resulting

from various sources like underreporting and unobserved human behavioral factors. Significant factors increasing the probability of fatal pedestrian injury included crashes along high speed roads, intersection crashes, crashes during night time, and heavy vehicle-pedestrian collisions. Less educated drivers—a common issue in developing countries—were found to be more involved in crashes with fatal pedestrian injuries. Interestingly, the severity of pedestrian injuries was lower when the crash-involved driver drove their own vehicle, but higher when they drove a vehicle owned by their family, friends or relatives.

Another study conducted by (Rakesh Kumar Singh & S.K.Suman, 2012) developed a model with eleven year data (2000-2010) from the police station. The data were analyzed to evaluate the effect of influencing variables on Crash rate. Heavy vehicles are involved in maximum number of crashes. It is predicted that a heavy vehicle is involved in almost 48% accidents followed by two-wheelers 16%, car 12% and bus 10%. monthly variation in accident in month of July and January are generally higher. Accident rate in terms of number of accidents per km-year increases when traffic volume increases. But the accidents rate in terms of number of accident per million-vehicle kilometer-year decreases with increase in traffic volume. Accident rate per million vehicle kilometer year increases during the study year, whereas both injury and fatality rate per million vehicle kilometer year show a declining trend over the study period. The developed model for crash prediction represents that the number of accidents per-km-year increases with AADT.

One of the studies on traffic safety modelling (Chang and Yeh, 2006) studied risk factors to driver fatalities in single vehicle Crashes and compared between motorcycle riders and non-motorcycle drivers Using 2000 traffic data in Taiwan. The objective was to investigate risk factors for the occurrence of driver fatality. The authors also compared the risk factors Contributing to non-motorcycle drivers and motorcycle rider fatalities. Four risk factor categories roadway environment, driver's Characteristics, single-vehicle crash type and vehicle type were Selected as the dependent variable categories in that study. The authors employed a Logistic regression model to estimate the relative probability of fatalities for drivers and Motorcyclists. The researchers compared using the logistic regression method and the least-square regression Method.

The logistic regression model can be used to predict a binary outcome from a Set of dependent variables that may be categorical, continuous, or a mixture of the two Unlike the least-squares

regression where the explanatory variable in the logistic Regression analysis can violate the assumptions of Conditional constant variances and continuous or normal distribution.

another study conducted by (Al-ghamdi, 20010) used logistic regression to investigate The influence of accident factors on fatal and non-fatal Crash in Saudi Arabia. The study found that causes of accident and accident location significantly Associated with fatal Crash. Accident factors used in the study including accident type, accident Location, accident time, collision type, accident cause, Vehicle type, driver age at fault, nationality and license status.

2.8 Research On Log Linear Modeling

The research done by (Oppong, Richard Asumadu, 2012) used log linear modelling to perform statistical analysis of road accident fatality. In this study The data was collected using accident report form with ten years (2001-2010) from the Motor Traffic and Transport Unit of the Ghana Police Service. The number of people killed by road accident was used as the dependent variable in all models and the other variables such as age of casualty, the day the accident occurred which resulted in the death of the people, the time people were killed, vehicle type and road user class as the independent variables. The results showed that the most affected people by road Crash in Ghana are the youth. Out of 1909 people who are killed by road Crash on the average, 447 are in the age group of 26-35, 298 are in 16-25 and 295 are from 36-45.

The study conducted by (Golob et al., 2006) used log linear modeling to analyze truck-involved in freeway Crash. In this study over 9,000 truck-involved Crash that occurred over a 2-year period in southern California. The log-linear method is illustrated by analyzing Accident characteristics by freeway rout segment and type. The method was used to associate accident characteristics with type of collision and to identify freeway Segments on which various accident categories were more prevalent than expected. The results showed significant differences between the types of collisions that occur at ramp locations and those that occur at the freeway.

In addition, conducted a research (Lee and Abdel-aty, 2005), analyzed vehicle-pedestrian crashes at intersections in Florida for 4 years, 1999–2002. The reseach used log-linear models to identify the group of pedestrians and drivers, and traffic and environmental characteristics that are correlated with pedestrian crashes. The research also estimates the likelihood of crash injury severity when pedestrians are involved in crashes. The result showed that road geometric,

pedestrian and driver demographic factors, traffic and environment conditions are closely related to the Frequency and injury severity of crashes.

Furthermore, (Haque., 2012) determined the effects of various roadway characteristics, environmental factors on motorcycle crashes and traffic control measures at different location including expressways and intersections. The research has developed a set of log-linear models to investigate road traffic crashes in Singapore. 2004 to 2008 crash data were used in the analysis. Results showed that night time influence increases crash risks of motorcycles, particularly during turning maneuvers at junctions.

3.0 RESEARCH METHODOLOGY

3.1 Study Area and Structure

Bahirdar is the capital city of Amhara national regional state which is located approximately 570 km North west of the Addis Ababa with a latitude of $11^{\circ}36'$ N and longitude of $37^{\circ}23'$ E. The city has a total area of 16000 hectares (BSZ, 2002/03). From the total area of 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 – 20% in few hillsides, but for the most parts of the city the slope is less than 2% (Devecon, 1999).

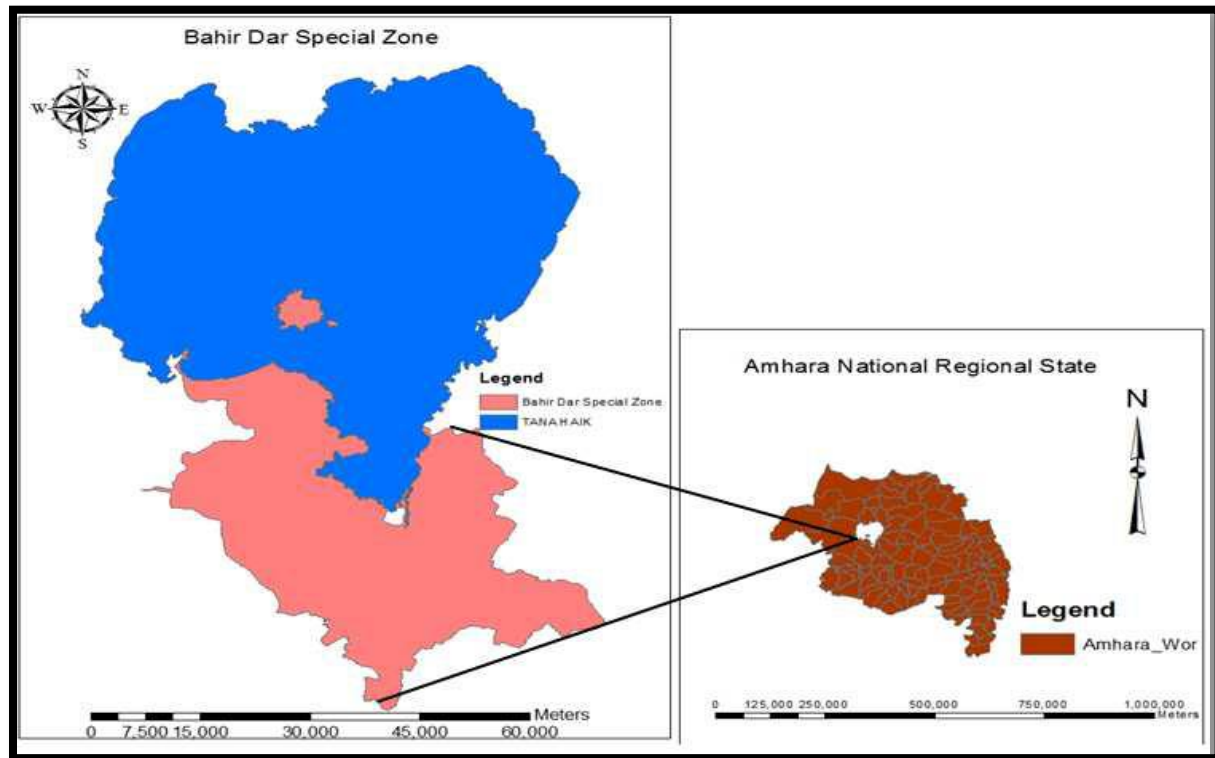


Fig 3.1 maps of Bahirdar city administration and Amhara national regional state.

3.2 Data Source

This study needs primary and secondary data for analysis and modelling. 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 Bahidar city police commission.

3.21 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 model with different traffic volume in junctions and straight sections. Traffic data is collected in selected junction and straight section in all days of a week at different road section in the selected city from 7.00 am - 8.00 pm to get maximum and minimum traffic volume by using video camera and manual counting method. that means when traffic volume is high and if it is difficult to count manually, video camera recorder is used other ways manual traffic count method is applied. In primary data collection only 13 hours' traffic data is collected because of difficulties to collect at the night time. The remaining 11 night hours are classified under low volume traffic hours because traffic volume is in decreasing condition up to 8.00pm and it would continue throughout the night in low movement of traffic.

Table 3.1 traffic count dates

Traffic Count Date	Location
4/22/2018 (Sunday)	Papyrus Rounabout
7/16/2018 (Monday)	Yetebaberut – Azwa Road Section
7/17/2018 (Tuesday)	poly Roundabout
7/18/2018 (Wednesday)	Azwa – Lake Tana Road Section
7/19/2018 (Thursday)	Papyrus – St Georg Road Section
7/20/2018 (Friday)	Geter Menged – St George Road Section
7/21/2018 (Saturday)	NOC Roundabout



Fig 3.2 Selected junction and straight sections for traffic volume counts

Source: Google map (2017)

3.22 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 has to be changed into passenger car unit (pcu). There is a standard for passenger car unit in Addis Ababa which is developed by 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. The following table shows PCU for different vehicle classes in Addis Ababa city. Thus

Table 3.2 Ethiopian railway corporation PCU standard

Vehicle type	Minimum	passenger car equivalent factors	
		Maximum	Suggested value
Bicycle	0.2	0.4	0.3
Moto cycles	0.2	0.64	0.4
Cars and vans	1.0	1.0	1.0
Minibus (4 tyres)	1	1.26	1.1
Bus(>4tyers)	1.5	3.6	2.25
Goods(>4tyers)	1.6	2.8	2.1

In this standard Bajaj is not included but maximum PCU values of motor cycles is used as Bajaj. The rest are used the recommended value of PCU.

The following tables are the collected traffic data at papyrus round about in Sunday to identify hourly traffic volume distribution.

Table3.3 Sunday hourly traffic volume in papyrus roundabout

Time	Motor	Bajaj	Car/taxi	Bus and truck	Total traffic volume in pcu
7.00am-8.00am	133	2816	893	89	2942
8.00am-9.00am	156	3816	1217	279	4327
9.00am-10.00am	142	3300	1013	193	3601
10.00am-11.00am	138	3200	996	194	3520
11.00am-12.00am	145	3325	890	110	3315
12.00pm-1.00pm	155	3706	1200	247	4170
1.00pm-2.00pm	134	3250	1098	189	3642
2.00pm-3.00pm	146	2950	1045	106	3221
3.00pm-4.00pm	127	2721	950	110	2981
4.00pm-5.00pm	131	2950	1001	131	3226
5.00pm-6.00pm	160	3952	1216	288	4434
6.00pm-7.00pm	146	3660	1197	199	4030
7.00pm-8.00pm	76	1650	667	81	1929

Table 3.4 Monday hourly traffic volume sec (yetebaberut – Azwa hotel)

Time	Motor	Bajaj	Car/taxi	Bus and truck	Total traffic volume in pcu
7.00am-8.00am	96	1206	822	58	1758
8.00am-9.00am	110	1451	1252	110	2463
9.00am-10.00am	101	1322	900	89	1980
10.00am-11.00am	76	1020	760	71	1597
11.00am-12.00am	80	1100	850	90	1781
12.00pm-1.00pm	108	1445	1200	106	2398
1.00pm-2.00pm	104	1200	900	89	1903
2.00pm-3.00pm	78	990	700	73	1523
3.00pm-4.00pm	74	983	692	69	1500
4.00pm-5.00pm	80	1063	720	85	1617
5.00pm-6.00pm	113	1485	1200	120	2456
6.00pm-7.00pm	106	1390	1550	103	2706
7.00pm-8.00pm	63	928	401	45	1118

Table 3.5 Tuesday hourly traffic volume (poly round about)

Time	Motor	Bajaj	Car/taxi	Bus and truck	Total traffic volume in pcu
7.00am-8.00am	93	1675	967	82	2254
8.00am-9.00am	111	2015	1320	152	2984
9.00am-10.00am	104	1985	1113	145	2740
10.00am-11.00am	84	1820	1060	91	2456
11.00am-12.00am	87	1896	1105	87	2542
12.00pm-1.00pm	108	1998	1317	148	2960
1.00pm-2.00pm	103	1990	1216	81	2707
2.00pm-3.00pm	83	1820	1067	72	2421
3.00pm-4.00pm	74	1809	97	52	1397
4.00pm-5.00pm	77	1873	982	68	2359
5.00pm-6.00pm	113	2100	1450	166	3199
6.00pm-7.00pm	78	1881	987	31	2289
7.00pm-8.00pm	29	1500	422	627	2754

Table 3.6 Wednesday hourly traffic volume (Azwa hotel – lake tana)

Time	Motor	Bajaj	Car/taxi	Bus and truck	Total traffic volume in pcu
7.00am-8.00am	29	562	290	5	672
8.00am-9.00am	48	704	360	0	830
9.00am-10.00am	34	600	305	3	709
10.00am-11.00am	39	650	312	2	748
11.00am-12.00am	42	680	341	3	800
12.00pm-1.00pm	43	691	340	3	806
1.00pm-2.00pm	39	590	320	4	722
2.00pm-3.00pm	29	550	291	1	657
3.00pm-4.00pm	25	529	250	2	603
4.00pm-5.00pm	21	531	219	3	574
5.00pm-6.00pm	49	722	355	7	852
6.00pm-7.00pm	39	640	310	4	744
7.00pm-8.00pm	16	520	250	1	591

Table 3.7 Thursday hourly traffic volume (Papyrus hotel – St George church)

Time	Motor	Bajaj	Car/taxi	Bus and truck	Total traffic volume in pcu
7.00am-8.00am	91	1200	1190	91	2192
8.00am-9.00am	110	1450	1600	94	2776
9.00am-10.00am	105	1400	1520	88	2649
10.00am-11.00am	90	1340	1352	85	2430
11.00am-12.00am	97	1450	1400	81	2543
12.00pm-1.00pm	112	1500	1580	100	2802
1.00pm-2.00pm	100	1423	1502	102	2674
2.00pm-3.00pm	85	1119	1070	89	2013
3.00pm-4.00pm	82	1085	1090	82	1995
4.00pm-5.00pm	89	1201	1300	96	2313
5.00pm-6.00pm	128	1600	1808	128	3161
6.00pm-7.00pm	122	1502	1611	109	2858
7.00pm-8.00pm	90	1200	1112	71	2070

Table 3.8 Friday hourly traffic volume (Geter manged – St George church)

Time	Motor	Bajaj	Car/taxi	Bus and truck	Total traffic volume in pcu
7.00am-8.00am	79	1022	1001	68	1834
8.00am-9.00am	89	1390	1520	98	2658
9.00am-10.00am	80	1120	1600	72	2505
10.00am-11.00am	70	1123	1200	59	2075
11.00am-12.00am	79	1230	1360	70	2331
12.00pm-1.00pm	86	1325	1450	99	2547
1.00pm-2.00pm	80	1261	1372	83	2391
2.00pm-3.00pm	68	989	1110	70	1922
3.00pm-4.00pm	58	981	1001	65	1793
4.00pm-5.00pm	63	1115	998	59	1865
5.00pm-6.00pm	110	1350	1620	115	2778
6.00pm-7.00pm	81	1290	1362	86	2407
7.00pm-8.00pm	25	827	890	12	1455

Table 3.9 Saturday hourly traffic volume (NOC roundabout)

Time	Motor	Bajaj	Car/taxi	Bus and truck	Total traffic volume in pcu
7.00am-8.00am	125	2009	986	109	2558
8.00am-9.00am	149	3201	1567	189	4085
9.00am-10.00am	130	2600	1068	160	3131
10.00am-11.00am	127	2620	1100	158	3170
11.00am-12.00am	132	2100	990	112	2630
12.00pm-1.00pm	146	3211	1502	185	4017
1.00pm-2.00pm	132	2650	1120	168	3233
2.00pm-3.00pm	90	1871	920	147	2472
3.00pm-4.00pm	87	1796	898	132	2369
4.00pm-5.00pm	89	1802	895	134	2375
5.00pm-6.00pm	150	3560	1720	243	4586
6.00pm-7.00pm	130	2900	1300	155	3544
7.00pm-8.00pm	86	1500	680	62	1809

After traffic volume is changed to passenger car unit using ERC standard, average hourly traffic volume of seven days would be calculated and the following result is obtained.

Table 3.10 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-12.00am	12.00pm-1.00pm	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	2030	2875	2474	2285	2277	2814	2467	2033	1805	2047	3067	2654	1675

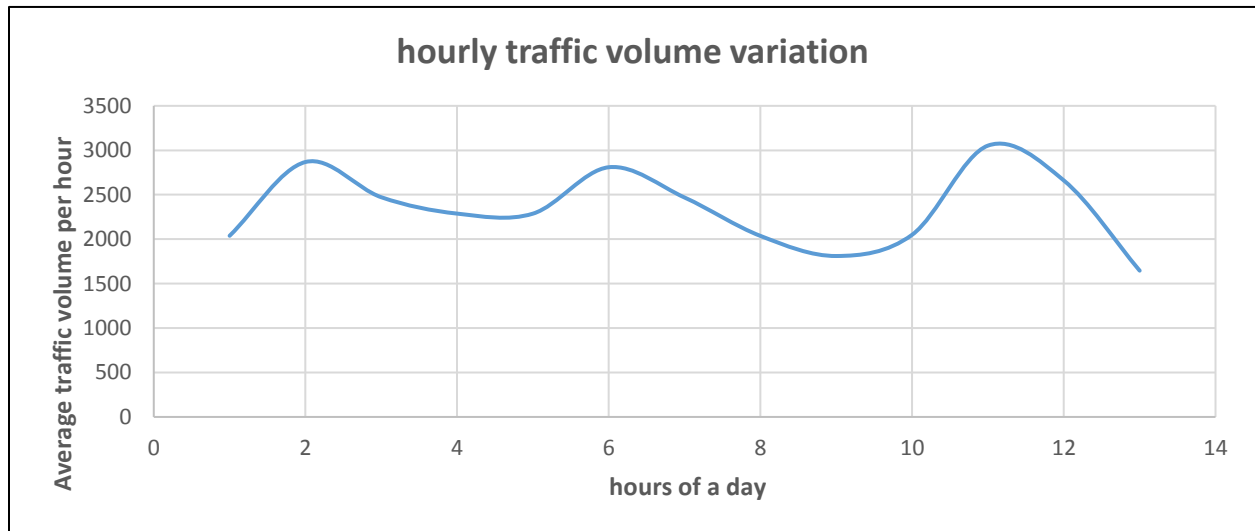


Fig 3.3 hourly traffic variation in Bahirdar

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 which is greater than the average traffic flow /hr(2346 PCU) is classified under high traffic volume hour and those traffic volume which is less than average traffic flow/hr (2346 PCU) is classified as low traffic volume hour. The rest of 11 night hours are classified under low traffic volume hours. By this classification method the result listed in the following table.

Table 3.11 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-12.00am	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

3.22 Secondary data collection

In order to conduct the study, traffic crash and traffic volume data are required. Traffic crash data is collected from 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. 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.

3.3 Selection of Variable and Coding

Only limited variables are incorporated for model development. The reason is that those variables which is not properly recorded in the dataset and highly correlated variables would be out of the model. Identifying mostly used variables and those variables that have significant effect on crash according to the literature. In junction 10 variables are selected from crash data file based on the following criteria.

- ✓ Variables which is available in traffic police office.
- ✓ Removing variables which has low effect on crash according to previous literature.

- ✓ Identifying and remove unreliable variable and frequently missed variable. For example, vehicle service year is not recorded or missed frequently, so this variable is not selected for further analysis. (Konstantinos kapetanakis, 2014)

But in case of straight section junction type is not included in the variable list. So 9 variables are selected in straight section data file. The age variable is categorized into young (18-29), adult (30-44) and old (45-64). Young drivers have common similar behavior, adult drivers also have common behavior and old drivers too. This is how age variable range is determined. In a similar way driver experience is categorized depends on low experience (1-5) years medium experience (5-15) years high experience (above 15 years). The following table shows 10 selected variables with their coding to use in **SPSS** software

Table 3.8 selected variables for further analysis

variables	Variable values	Variable coding
Age (driver)	18-29	1
	30-44	2
	45-64	3
Day of the week	Monday	1
	Tuesday	2
	Wednesday	3
	Thursday	4
	Friday	5
	Saturday	6
	Sunday	7
Driver experience	<5 years	1
	5-15 years	2
	>15years	3
Vehicle type	Motor and bajaj	1
	Small car	2
	Bus	3
	Small truck	4
	Medium truck	5
	Heavy truck	6
	Articulated	7

Lighting condition	Day	1
	Dark	2
	Street light	3
Weather condition	sunny	1
	Rainy	2
	Cloudy	3
Drivers educational status	Illiterate	1
	Primary school (grade 1-8)	2
	High school (grade 9&10)	3
	Preparatory (grade 11 &12)	4
	Higher education (above diploma level)	5
Junction type	Priority junction	1
	Signalized junction	2
	Round about	3
Gender	Male	1
	Female	2
Road type	Road with median	1
	Road without median	2

3.4 Data Analysis

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

3.5 Log Linear Analysis

loglinear modelling is best as a procedure to identify factors that affect the relative frequency of occurrence of varies crash characteristics such as crash type, location, severity etc. (Thomas f. Golob and Wilfred W. Reeker, 1987). This is the reason why 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; how-ever most statistical packages also have specific commands for log-linear models. In this research GELOG is applied. Log linear

analysis is a specialized case of generalized linear models (GLM) for multinomial and poisons distributed data and is used in a wide range of applications. Log linear analysis is an extension of an x-way contingency table (or cross tab), where the conditional relationship between x or more discrete, categorical variables is analyzed by taking the natural logarithm of the cell frequencies within a contingency table. Describe the association and interaction patterns among a set of categorical variables log linear models (Abdel-aty, 2005; Agresti, 2004). Log linear models are statistical models that can be used on contingency tables to determine relationships between categorical variables. Most often log linear models are used with higher order contingency tables because they use terminology and concepts that are similar to regression and Anova models. These models test relationships between variables in a similarly conceptual manner as do correlational measures of association.

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

Where $\text{Ln}F(ij)$ = 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 with in the variables

In case of this study dependent variable is number of crash and ten independent variables can be relating as follows.

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

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

(Oppong R., 2012)

Where NC = Number of crash

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

3.6 Data Preparation

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

Depending on the group classified above four will develop at junction and straight section with high traffic volume hour and low traffic volume hour. This 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 section 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) and “Bale Arat Megetatemia”(four leg intersection) are grouped under junction crashes and the rests are straight section crashes.

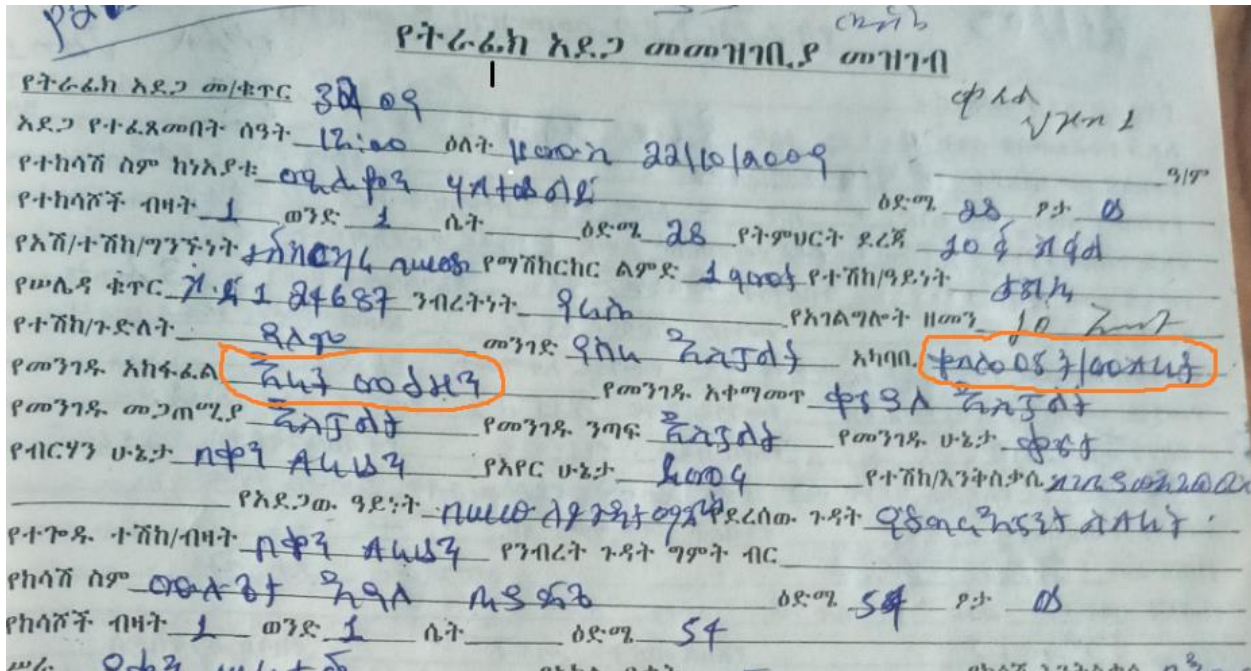


Fig 3.4 example of junction crashes

3.7 Analysis Procedure and Interpretation

After collection of traffic crash data and traffic volume data, the next step would be analyzing the collected data. By using traffic volume data high traffic volume hours and low traffic volume hours of a day are classified. Depending on this classification, traffic crash data are filtered and grouped as the above category. After these classifications is done, selecting variables and coding are followed as discussed in the previous section. These selected variables would be inserted to IBM SPSS Statistics 20 software for statistical analysis. The first task after inserting the data in to the software would be variable correlation process. Highly correlated variables would be removed from variable list. Checking fitting process for loglinear models ($\text{sig} \leq 0.05$) and finding the best models with least residuals. The parameter estimates would be followed. Those parameters which

have > 0.05 significance would be eliminated. Finally based on parameter estimate for logical interpretation odds ratio (probability of occurrence) calculation is followed.

$$\ln \frac{F_{ij}}{F_{1j}} = \ln(F_{ij}) - \ln(F_{1j}) = (u + \lambda_i^A + \lambda_j^B + \lambda_i^{AB}) - (u + \lambda_1^A + \lambda_j^B + \lambda_1^{AB})$$

Since the parameter estimates of the base case is always zero, the odds ratio for main effects would be $e^{\lambda_i^A}$. Parameters which have high odds ratio means there is high probability of crash occurrence due to this parameter. Parameters which have low odds ratio means there is low probability of crash occurrence compared to base case.

4.0 ANALYSIS AND DISCUSSION

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

4.1 Variable Correlation

This step will show that all independent variables that will be included in the final models, are independent between each other. The goal is to separate the effect of each one of the independent variables in the model. There should have no correlation between the independent variables included in the model to know the impact of each independent variable on dependent variable. When the correlation coefficient of variables is close to 1, there is high correlation so should remove and if the correlation coefficient is close to zero, there is no correlation between variables and taken as independent variables. there is no fixed limit to say highly correlated and to remove variables from the model but highly correlated variables are selected by comparing with other adjacent correlation values from the variable list.

Table 4.1 example of variable correlation high traffic volume hour crash at straight section

		Correlations									
		day of the weak	Gender	age	Driver education	Driver experience	Vehicle type	Road type	Intersection type	Lighting Condition	Weather Condition
day of the weak	Pearson Correlation	1	.065	-.086	.221	.014	-.155	.047	.103	.094	.080
	Sig. (2-tailed)		.116	.038	.000	.742	.000	.252	.013	.023	.054
	N	586	586	580	586	570	570	586	586	586	583
Gender	Pearson Correlation	.065	1	-.083	-.036	-.017	-.018	-.027	.016	-.022	-.014
	Sig. (2-tailed)	.116		.047	.387	.678	.673	.514	.690	.599	.732
	N	586	586	580	586	570	570	586	586	586	583
age	Pearson Correlation	-.086	-.083	1	-.029	.584	.173	.100	.132	.251	-.037
	Sig. (2-tailed)	.038	.047		.487	.000	.000	.016	.001	.000	.378
	N	580	580	580	580	564	564	580	580	580	577
Driver education	Pearson Correlation	.221	-.036	-.029	1	-.031	-.335	-.259	.057	.168	.039
	Sig. (2-tailed)	.000	.387	.487		.466	.000	.000	.167	.000	.349
	N	586	586	580	586	570	570	586	586	586	583
Driver experience	Pearson Correlation	.014	-.017	.584	-.031	1	.314	.185	.120	-.017	.028
	Sig. (2-tailed)	.742	.678	.000	.466		.000	.000	.004	.693	.508
	N	570	570	564	570	570	554	570	570	570	570
Vehicle type	Pearson Correlation	-.155	-.018	.173	-.335	.314	1	.125	.066	.018	-.010
	Sig. (2-tailed)	.000	.673	.000	.000	.000		.003	.118	.675	.806
	N	570	570	564	570	554	570	570	570	570	567
Road type	Pearson Correlation	.047	-.027	.100	-.259	.185	.125	1	-.051	-.026	.043
	Sig. (2-tailed)	.252	.514	.016	.000	.000	.003		.217	.534	.303
	N	586	586	580	586	570	570	586	586	586	583
Intersection type	Pearson Correlation	.103	.016	.132	.057	.120	.066	-.051	1	.035	.023
	Sig. (2-tailed)	.013	.690	.001	.167	.004	.118	.217		.403	.585
	N	586	586	580	586	570	570	586	586	586	583
Lighting Condition	Pearson Correlation	.094	-.022	.251	.168	-.017	.018	-.026	.035	1	.460
	Sig. (2-tailed)	.023	.599	.000	.000	.693	.675	.534	.403		.000
	N	586	586	580	586	570	570	586	586	586	583
Weather Condition	Pearson Correlation	.080	-.014	-.037	.039	.028	-.010	.043	.023	.460	1
	Sig. (2-tailed)	.054	.732	.378	.349	.508	.806	.303	.585	.000	
	N	583	583	577	583	570	567	583	583	583	583

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

From the above correlation coefficient table driver experience and age has high correlation coefficient with a value of 0.584. so since it is above the limited correlation coefficient value one of the two variable is taken and the other one is removed. Only 9 variables are remained to develop a model on straight section in high traffic volume hours.

4.2 Development of The Model by Loglinear Modelling

In the methodology part four different crash file were created and inserted into spss for variable correlation process. After variable correlation is done for each crash file separately, then removing highly correlated variables from the correlation coefficient table. The four prepared crash files were inserted to spss to get goodness of fit test and parameter estimate. both saturated model and nested or parsimonious model were calculated to check either the nested model is fitted or not. The likelihood ratio and degree of freedom for both saturated and nested model were calculated to compare the models by the following formulas.

$$L^2\text{comparison} = L^2\text{ model1} - L^2\text{ model2}$$

Where $L^2\text{ model 1}$ and $L^2\text{ model 2}$ are likelihood ratio for nested and saturated model respectively.

$$Df = df1 - df2$$

Where $df1$ and $df2$ are degree of freedom of nested model and saturated model respectively.

By comparing $L^2\text{comparison}$ and Df nested model could be chosen or rejected. If $L^2\text{comparison}$ statistics is not significant nested model could be chosen. after deciding goodness of fit test, parameter estimate would be followed. From parameter estimate significance of each parameter would be examined and if significance value of values of parameters are > 0.05 they should be out of the model. Odds ratio calculation also included in this step to interpret the final result easily.

4.3 Model 1 (High Traffic Volume at Straight Section)

In high traffic volume on straight section driver experience have 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 4.3 goodness of fit test for nested model

	Chi-Square	df	Sig.	Adjusted	
				df ^a	Sig.
Likelihood Ratio	1608.238	11319	.000	8079	.000
Pearson	1077529.493	11319	.000	8079	.000

Table 4.4 Goodness-of-Fit Tests

	Chi-Square	df	Sig.
Likelihood Ratio	.000	6144	.000
Pearson	.000	6144	.000

Likelihood ratio for nested model L^2 model1 = 1608.238

Likelihood ratio for saturated model L^2 model2 = 0.000

Df nested model = 11319

Df for saturated model = 6144

L^2 comparison = L^2 model1 – L^2 model2 = 1608.238-0.000 = **1608.238**

Df = df1 – df2 = 11319 – 6144 = **5175**

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

$\ln(F(x))=17.633+1.48(\text{mon})+0.49(\text{tue})+0.89(\text{wens})+1.14(\text{thur})+0.59(\text{fri})+4.5(\text{male})+1.25(\text{young})$
 $+0.73(\text{adult})-1.44(\text{illiterate})-0.59(\text{prim})-0.56(\text{high school})-0.3(\text{prep})+1.56(\text{Bajaj})+ 3.32(\text{small vehicle})$
 $+0.827(\text{bus})+1.17(\text{small truck})-2.36(\text{with median}) +4.86(\text{daylight})$

Table 4.5 parameter estimate for high traffic volume on straight section

Parameter	Estimate	Std. Error	Z	Sig.	Odds Ratio	95% Confidence Interval	
						Lower Bound	Upper Bound
Constant	-17.633	0.851	-20.709	0		-19.301	-15.964
[dayOfWeek = 1]	1.485	0.185	8.048	0	4.5	1.124	1.847
[dayOfWeek = 2]	0.494	0.211	2.336	0.019	1.6	0.08	0.909
[dayOfWeek = 3]	0.894	0.198	4.518	0	2.5	0.506	1.282
[dayOfWeek = 4]	1.144	0.191	5.977	0	3.2	0.769	1.519
[dayOfWeek = 5]	0.591	0.208	2.844	0.004	1.8	0.184	0.998
[dayOfWeek = 6]	-0.325	0.257	-1.264	0.206	0.7	-0.83	0.179
[dayOfWeek = 7]	0 ^a	.	.	.		.	.
[Gender = 1]	4.5	0.411	10.962	0	94.8	3.695	5.304
[Gender = 2]	0 ^a	.	.	.		.	.
[Age = 1]	1.254	0.124	10.081	0	3.6	1.011	1.498
[Age = 2]	0.729	0.134	5.452	0	2.1	0.467	0.991
[Age = 3]	0 ^a	.	.	.		.	.
[EducaST = 1]	-1.443	0.203	-7.108	0	0.2	-1.841	-1.045
[EducaST = 2]	-0.582	0.148	-3.924	0	0.6	-0.872	-0.291
[EducaST = 3]	0.567	0.111	5.109	0	1.8	0.35	0.785
[EducaST = 4]	-0.301	0.136	-2.211	0.027	0.7	-0.568	-0.034
[EducaST = 5]	0 ^a	.	.	.		.	.
[VehicleTyp = 1]	1.566	0.294	5.328	0	4.9	0.99	2.142
[VehicleTyp = 2]	3.322	0.272	12.211	0	28.8	2.789	3.855
[VehicleTyp = 3]	0.827	0.32	2.58	0.01	2.3	0.199	1.455
[VehicleTyp = 4]	1.168	0.306	3.815	0	3.3	0.568	1.767
[VehicleTyp = 6]	0 ^a	.	.	.		.	.
[RoadTyp = 1]	-2.362	0.153	-15.483	0	0.1	-2.662	-2.063
[RoadTyp = 2]	0 ^a	.	.	.		.	.
[LightinCon = 1]	4.864	0.502	9.69	0	137.1	3.88	5.847
[LightinCon = 2]	1.792	0.54	3.318	0.001	6.1	0.733	2.85
[LightinCon = 3]	0 ^a	.	.	.		.	.
[WeatherCon = 1]	4.677	0.449	10.409	0	113.4	3.796	5.557
[WeatherCon = 2]	-0.223	0.671	-0.333	0.739	0.8	-1.538	1.092
[WeatherCon = 3]	0 ^a	.	.	.		.	.

- a. This parameter is set to zero because it is redundant.
- b. Model: Poisson
- c. Design: Constant + dayOfWeek + Gender + Age + EducaST + VehicleTyp + RoadTyp + LightinCon + WeatherCon

4.4 Model 2: (Low Traffic Volume at Straight Section)

In low traffic volume on straight section day of week have high correlation with road type and lighting condition. So 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 4.6 goodness of fit test for nested model (LTVJ)

	Chi-Square	df	Sig.	Adjusted	
				df ^a	Sig.
Likelihood Ratio	2382.123	5650	.020	2815	.000
Pearson	483906.253	5650	.000	2815	.000

a. One degree of freedom is subtracted for each cell with an expected value of zero. The unadjusted df is an upper bound on the true df, while the adjusted df may be an underestimate.

Table4.7 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 L^2 model1 = 2382.123

Likelihood ratio for saturated model L^2 model2 = 0.000

Df nested model = 5650

Df for saturated model = 1824

L^2 comparison = L^2 model1 – L^2 model2 = 2382.123-0.000 = **2382.123**

Df = df1 – df2 = 5650 – 1824 = **3826**

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

Table 4.8 parameter estimate for low traffic volume at straight section

Parameter	Estimate	Std. Error	Z	Odds Ratio	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Constant	-17.71	0.893	-19.826		0	-19.46	-15.959
[Gender = 1]	5.638	0.708	7.961	276.1	0	4.25	7.026
[Gender = 2]	0	.	.	1.0	.	.	.
[Age = 1]	2.165	0.169	12.808	8.7	0	1.834	2.497
[Age = 2]	1.557	0.176	8.835	4.7	0	1.211	1.902
[Age = 3]	0	.	.	1.0	.	.	.
[EducaST = 1]	-1.492	0.184	-8.086	0.2	0	-1.853	-1.13
[EducaST = 2]	-1.743	0.205	-8.508	0.2	0	-2.144	-1.341
[EducaST = 3]	0.323	0.104	3.112	1.4	0.002	0.12	0.526
[EducaST = 4]	-0.296	0.121	-2.446	0.7	0.014	-0.533	-0.059
[EducaST = 5]	0	.	.	1.0	.	.	.
[DrivinExp = 1]	3.384	0.294	11.53	29.2	0	2.809	3.96
[DrivinExp = 2]	2.803	0.297	9.43	16.4	0	2.221	3.386
[DrivinExp = 3]	0	.	.	1.0	.	.	.
[VehicleTyp = 1]	1.792	0.279	6.425	6.0	0	1.245	2.338
[VehicleTyp = 2]	3.051	0.264	11.546	20.9	0	2.533	3.569
[VehicleTyp = 3]	0.818	0.31	2.64	2.3	0.008	0.211	1.426
[VehicleTyp = 4]	1.369	0.289	4.736	3.9	0	0.803	1.936
[VehicleTyp = 5]	0.182	0.35	0.522	1.2	0.602	-0.503	0.868
[VehicleTyp = 6]	0.726	0.315	2.308	2.1	0.021	0.109	1.342
[VehicleTyp = 7]	0	.	.	1.0	.	.	.
[RoadTyp = 1]	-1.196	0.1	-11.99	0.3	0	-1.391	-1
[RoadTyp = 2]	0	.	.	1.0	.	.	.
[LightinCon = 1]	3.764	0.32	11.766	42.6	0	3.137	4.39
[LightinCon = 2]	2.51	0.329	7.632	12.2	0	1.865	3.154
[LightinCon = 3]	0	.	.	1.0	.	.	.
[WeatherCon = 1]	2.549	0.168	15.13	12.7	0	2.218	2.879
[WeatherCon = 2]	0.051	0.227	0.226	1.1	0.821	-0.393	0.495
[WeatherCon = 3]	0	.	.	1.0	.	.	.

a. This parameter is set to zero because it is redundant.

b. Model: Poisson

c. Design: Constant + Gender + Age + EducaST + DrivinExp + VehicleTyp + RoadTyp + LightinCon + WeatherCon

4.5 MODEL 3: (HIGH TRAFFIC VOLUME AT JUNCTION)

In high traffic volume at junction Age and lighting condition, day of week and vehicle type have high correlation coefficient. Age have high correlation coefficient with other variables compared to lighting condition, and day of week have also high correlation coefficient with other variables compared to vehicle type So age and day of 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.

Table 4.9 Goodness-of-Fit Tests saturated model (HTVJ)

	Chi-Square	df	Sig.
Likelihood Ratio	.000	12864	.000
Pearson	.000	12864	.000

Table 4.10 Goodness-of-Fit Tests nested model (HTVJ)

	Chi-Square	df	Sig.	Adjusted	
				df ^a	Sig.
Likelihood Ratio	1185.926	79353	.040	30213	.000
Pearson	129130.168	79353	.000	30213	.000

a. One degree of freedom is subtracted for each cell with an expected value of zero. The unadjusted df is an upper bound on the true df, while the adjusted df may be an underestimate.

Likelihood ratio for nested model L^2 model1 = 1185.926

Likelihood ratio for saturated model L^2 model2 = 0.000

Df nested model = 79353

Df for saturated model = 12864

L^2 comparison = L^2 model1 – L^2 model2 = 1185.926-0.000 = **1185.862**

Df = df1 – df2 = 79353 – 12864 = **66489**

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

Table 4.11 Parameter Estimates for high traffic volume at junction

Parameter	Estimate	Std. Error	Z	Odds Ratio	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Constant	-11.116	0.9	-12.345		0	-12.88	-9.351
[Gender = 1]	2.723	0.344	7.913	15.1	0	2.048	3.397
[Gender = 2]	0	.	.	1.0	.	.	.
[EducaST = 2]	0.251	0.356	0.705	1.3	0.481	-0.447	0.95
[EducaST = 3]	1.792	0.289	6.207	6.0	0	1.226	2.358
[EducaST = 4]	0.762	0.324	2.355	2.1	0.019	0.128	1.397
[EducaST = 5]	0	.	.	1.0	.	.	.
[DrivinExp = 1]	0.082	0.166	0.496	1.1	0.62	-0.242	0.407
[DrivinExp = 2]	0	.	.	1.0	.	.	.
[VehicleTyp = 1]	0.305	0.352	0.867	1.4	0.386	-0.385	0.996
[VehicleTyp = 2]	2.07	0.284	7.3	7.9	0	1.515	2.626
[VehicleTyp = 3]	-2.639	1.035	-2.55	0.1	0.011	-4.668	-0.61
[VehicleTyp = 6]	-2.639	1.035	-2.55	0.1	0.011	-4.668	-0.61
[VehicleTyp = 7]	0	.	.	1.0	.	.	.
[RoadTyp = 1]	-3.57	0.507	-7.041	0.0	0	-4.563	-2.576
[RoadTyp = 2]	0	.	.	1.0	.	.	.
[JunctinType = 1]	1.243	0.207	5.999	3.5	0	0.837	1.649
[JunctinType = 2]	-0.916	0.342	-2.683	0.4	0.007	-1.586	-0.247
[JunctinType = 3]	0	.	.	1.0	.	.	.
[WeatherCon = 1]	1.825	0.241	7.572	6.2	0	1.352	2.297
[WeatherCon = 2]	-2.303	0.742	-3.105	0.1	0.002	-3.756	-0.849
[WeatherCon = 3]	0	.	.	1.0	.	.	.
[LightinCon = 1]	4.234	0.712	5.945	68.1	0	2.838	5.63
[LightinCon = 2]	1.099	0.816	1.346	3.0	0.178	-0.502	2.699
[LightinCon = 3]	0	.	.	1.0	.	.	.

a. This parameter is set to zero because it is redundant.

b. Model: Poisson

c. Design: Constant + Gender + EducaST + DrivinExp + VehicleTyp + RoadTyp + JunctinType + WeatherCon + LightinCon

MODEL 4. (LOW TRAFFIC VOLUME AT JUNCTION)

In low traffic volume at junction vehicle type and gender have high correlation coefficient. But gender have high 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 4.12 Goodness-of-Fit Tests saturated model (LTVJ)

	Chi-Square	df	Sig.
Likelihood Ratio	.000	23424	.000
Pearson	.000	23424	.000

Table 4.13 Goodness-of-Fit Tests nested model (LTVJ)

	Chi-Square	df	Sig.	Adjusted	
				df ^a	Sig.
Likelihood Ratio	1219.341	119042	.030	58292	.000
Pearson	60793.640	119042	.000	58292	.000

a. One degree of freedom is subtracted for each cell with an expected value of zero. The unadjusted df is an upper bound on the true df, while the adjusted df may be an underestimate.

Likelihood ratio for nested model L^2 model1 = 1219.341

Likelihood ratio for saturated model L^2 model2 = 0.000

Df nested model = 119042

Df for saturated model = 23424

L^2 comparison = L^2 model1 – L^2 model2 = 1219.341-0.000 = **1219.341**

Df = df1 – df2 = 119042 – 23424 = **95618**

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

Table 4.14 Parameter Estimates for Low traffic volume at junction

Parameter	Estimate	Std. Error	Z	Odds Ratio	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Constant	-19.286	1.433	-13.457		0	-22.095	-16.477
[EducaST = 1]	-1.705	0.314	-5.432	0.2	0	-2.32	-1.09
[EducaST = 2]	-4.19	1.007	-4.159	0.0	0	-6.164	-2.215
[EducaST = 3]	0.375	0.16	2.343	1.5	0.019	0.061	0.688
[EducaST = 4]	-4.19	1.007	-4.159	0.0	0	-6.164	-2.215
[EducaST = 5]	0	.	.	1.0	.	.	.
[DrivinExp = 1]	3.178	0.417	7.627	23.8	0	2.361	3.995
[DrivinExp = 2]	1.466	0.453	3.238	4.3	0.001	0.579	2.354
[DrivinExp = 3]	0	.	.	1.0	.	.	.
[VehicleTyp = 1]	3.258	1.019	3.198	25.7	0.001	1.261	5.255
[VehicleTyp = 2]	4.898	1.003	4.881	132.0	0	2.931	6.864
[VehicleTyp = 4]	2.708	1.032	2.623	14.9	0.009	0.685	4.732
[VehicleTyp = 7]	0	.	.	1.0	.	.	.
[RoadTyp = 1]	-2.236	0.255	-8.762	0.1	0	-2.736	-1.736
[RoadTyp = 2]	0	.	.	1.0	.	.	.
[JunctinType = 1]	0.592	0.165	3.584	1.8	0	0.268	0.915
[JunctinType = 2]	-1.27	0.283	-4.491	0.3	0	-1.825	-0.716
[JunctinType = 3]	0	.	.	1.0	.	.	.
[WeatherCon = 1]	3.497	0.454	7.703	32.7	0	2.607	4.386
[WeatherCon = 2]	0.182	0.606	0.301	1.2	0.763	-1.004	1.369
[WeatherCon = 3]	0	.	.	1.0	.	.	.
[LightinCon = 1]	2.457	0.301	8.168	11.6	0	1.867	3.046
[LightinCon = 2]	0.693	0.354	1.961	2.0	0.05	0	1.386
[LightinCon = 3]	0	.	.	1.0	.	.	.
[Age = 1]	3.882	0.714	5.434	47.9	0	2.482	5.282
[Age = 2]	3.651	0.716	5.097	38.1	0	2.247	5.054
[Age = 3]	0	.	.	1.0	.	.	.
[dayOfWeek = 1]	1.631	0.364	4.476	5.1	0	0.917	2.346
[dayOfWeek = 2]	1.135	0.383	2.962	3.1	0.003	0.384	1.886
[dayOfWeek = 3]	1.88	0.358	5.254	6.5	0	1.179	2.582
[dayOfWeek = 4]	0.511	0.422	1.212	1.7	0.226	-0.316	1.337
[dayOfWeek = 5]	0.747	0.405	1.847	2.1	0.065	-0.046	1.54
[dayOfWeek = 6]	0	.	.	1.0	.	.	.

a. This parameter is set to zero because it is redundant.

b. Model: Poisson

4.8 Discussion

The analysis of variables in each model obtained in the previous section would be discussed and interpreted in this section. Mainly the effect of each parameter included in the model on total number of crash in straight section and junction with different traffic volume was discussed.

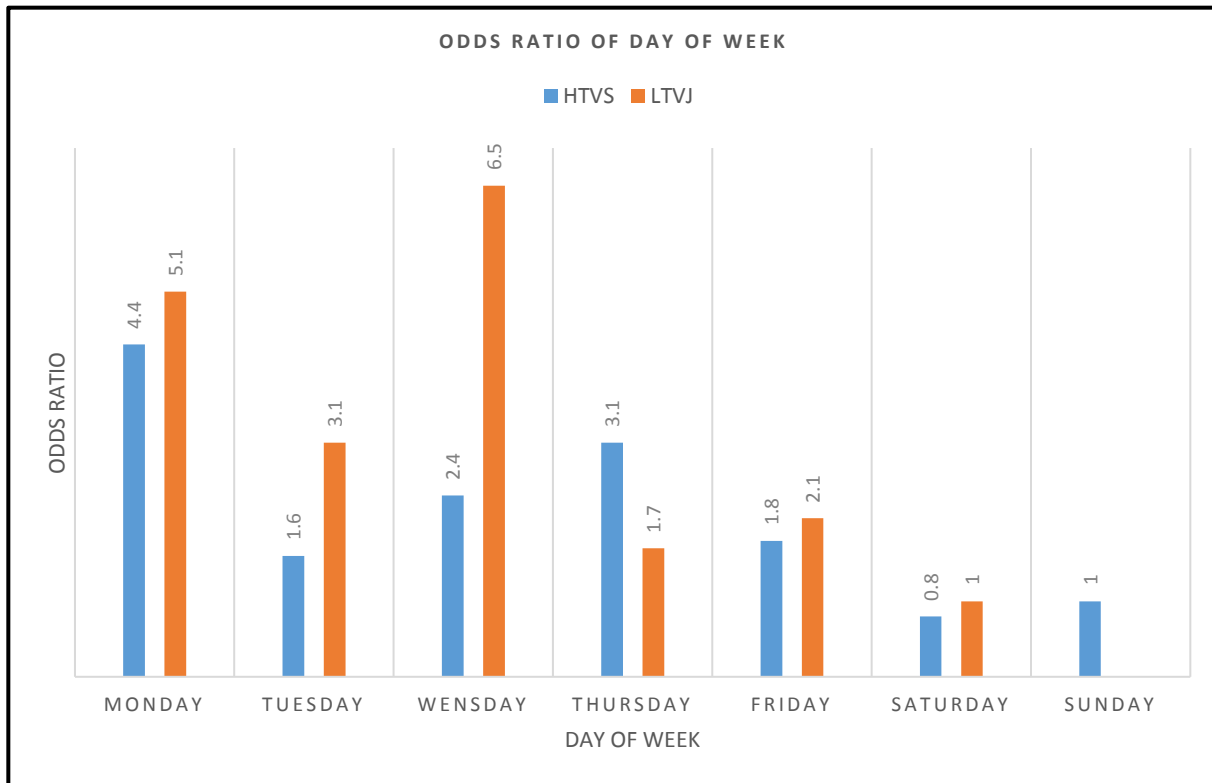


Fig 4.1 Odds ratio of day of week

In high traffic volume straight section Monday has the highest probability of crash occurrence compared to base case, Sunday. This probability may be due to Monday is a working day and a lot of pedestrians are moving along the city and exposed to crash compared to Sunday which is not a working day. Thursday has also high probability of crash frequency by following Monday compared to the base case (Monday).

In low traffic volume junction Wednesday has the highest probability of crash occurrence compared to Saturday which is the base case. This probability is due to Wednesday is a market day in the city and government working day, a lot of peasants and country side people are coming in to the city and they have no enough awareness to cross the road around junction and they are exposed to crash.

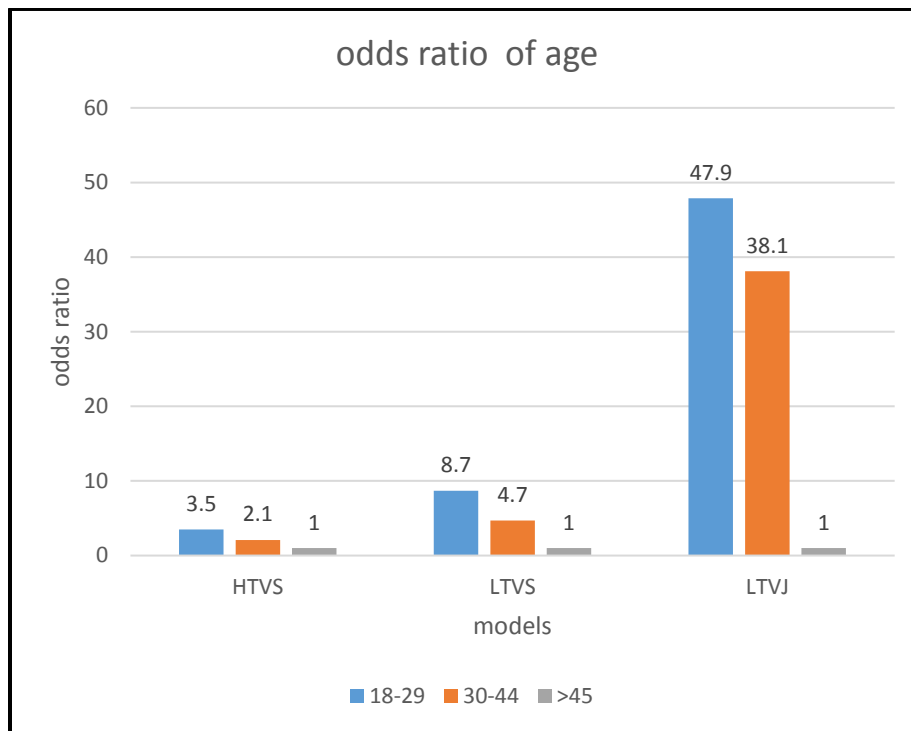


Fig 4.2 Odds ratio of age

From the above figure in high traffic volume straight sections 18-29-year age group 3.5 times higher probability of crash occurrence compared to base case (>45 year). This increasing of crash probability may be due to young drivers are driving in a high speed and they have no patience to give priority to pedestrians. 30-44 year drivers have also 2.1 times probability of crash occurrence compared to >45 year drivers. The probability decreases compared to 18-29 year because they are matured and have better patience to give priority to pedestrian.

In low traffic volume straight sections both 18-29 year-old drivers have increased the probability of crash occurrence. This is due young drivers have no enough experience, aggressiveness and lack of patience to give priority to pedestrians. All these driver's problem would be significant at

junction than straight section since vehicles and pedestrians are crossing and moving from unexpected direction. In low traffic volume junction both 18-29 and 30-44-year-old drivers have increased highly with 47.9 and 38.1 times the base case (>45 year). This dramatic increase of crash probability may due to in low traffic volume drivers have a high speed, most pedestrian crossing lines are around junction and mostly no enough sight distance around junction.

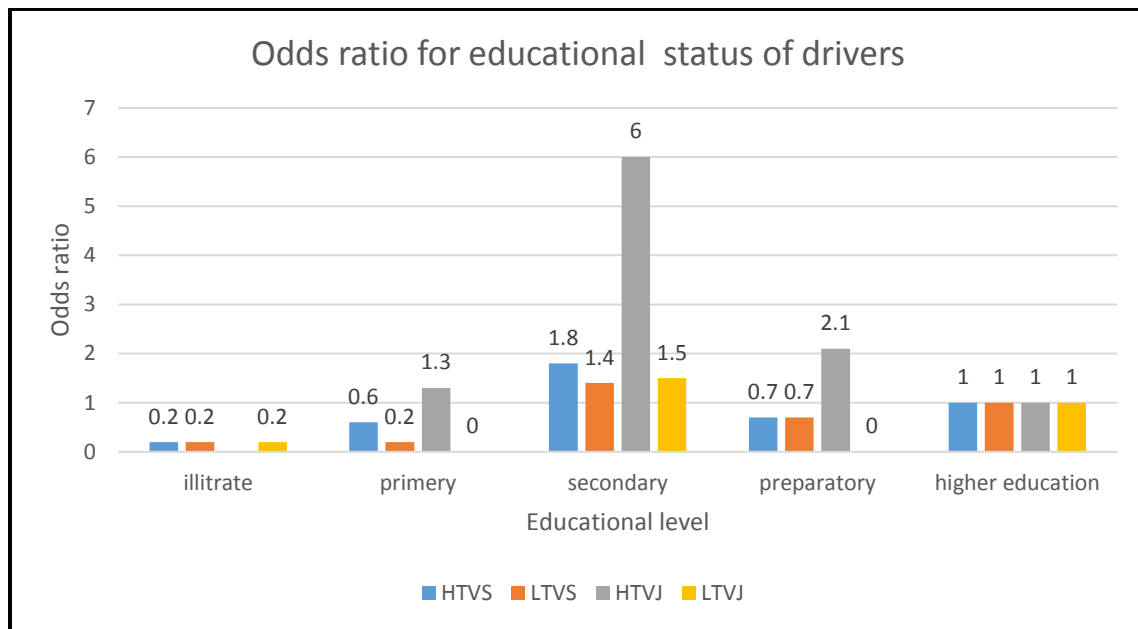


Fig 4.3 Odds ratio of educational status

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

In secondary school level drivers high traffic volume junction has 6 times higher probability of crash occurrence compared to base case (higher education drivers). When traffic volume is high at straight section there is 80% higher probability of crash occurrence compared to higher education. In low traffic volume at straight section there is 40% higher probability of crash occurrence. If traffic volume is low at junction, there is 50% higher probability of crash occurrence. This crash probability increasing may due to a lot of conflicting points are occurred in junction and high traffic volume than straight section and low traffic volume. Because of this there is a high

probability of crash frequency in high traffic volume than low traffic volume at junction in all educational level except illiterates. But in case of crash severity from the file 5.6% of crash is fatal in from total HVS crashes, 5.1% is fatal in LVS, 1% is fatal in LVJ and 2% is fatal in HVJ.

Generally, all educational level drivers have high probability of crash occurrence in junction with high traffic volume hours. This may be due to as traffic volume increases the number of conflict point also increases in junction.

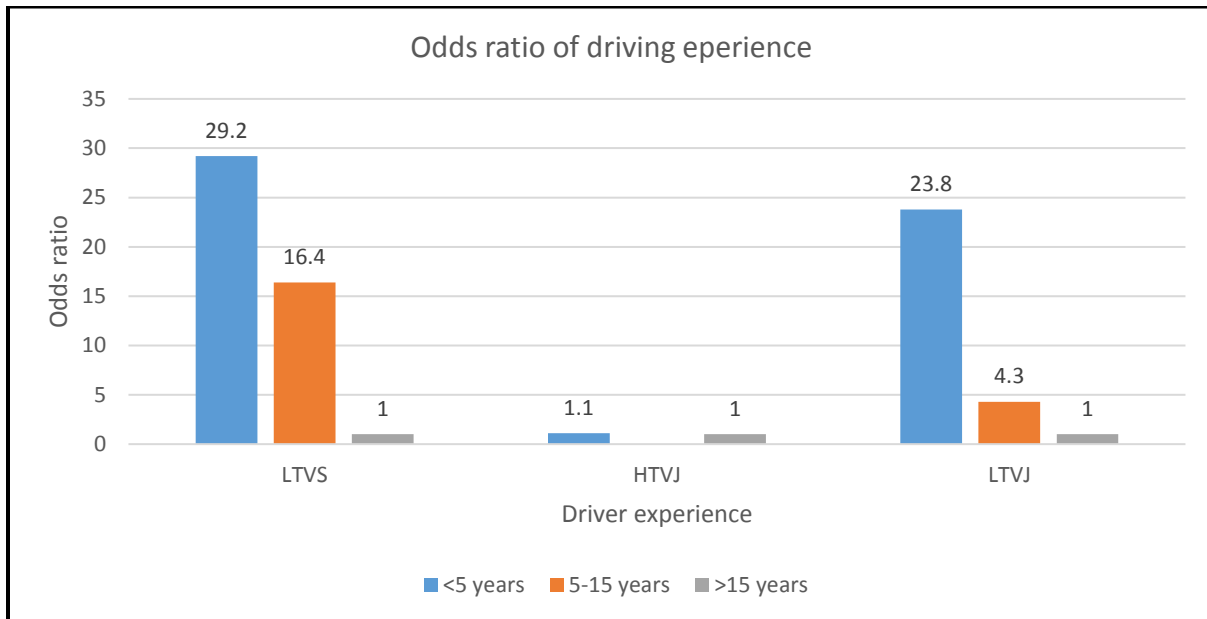


Fig 4.4 Odds ratio of driving experience

In low traffic volume straight section high probability of crash occurrence is observed in < 5 years and (5-15 years) driving experience compared to the base case (>15 years). This may be due to high experienced drivers have a good skill to drive safely than low experienced drivers. In low traffic volume junction <5 years driving experience has also high probability of crash occurrence compared to the base case.

But in high traffic volume junction there is less probability of crash occurrence of 5 years driving experience compared to low traffic volume straight section and low traffic volume junction. This may be due to when traffic volume is high less experienced drivers drives carefully with low speed but when traffic volume is low they drive at high speed and exposed to unexpected crash.

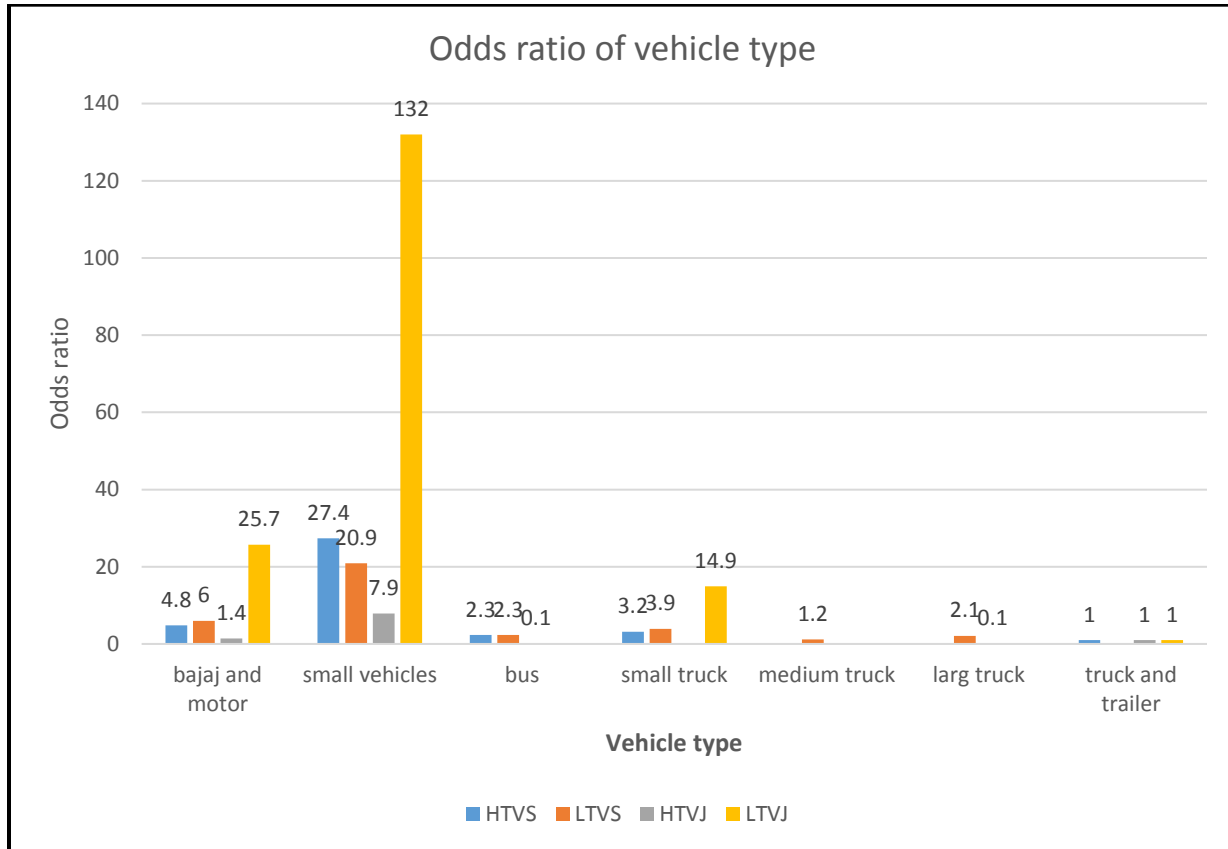


Fig 4.5 Odds ratio of Vehicle type

In high traffic volume straight section small vehicles have high probability of crash occurrence compared to the base case (truck and trailer), Bajaj and motor have 4.8 times higher probability of crash occurrence compared to truck and trailer. In all road sections and traffic volumes small vehicles have high probability of crash occurrence compared to all other vehicle groups.

In low traffic volume straight section small vehicles have 21 times higher probability of crash frequency compared to truck and trailer. Bajaj and bus have 6 and 4 times higher crash frequency respectively compared to base case. This increasing of crash probability of small vehicles may be due to small vehicle drivers are usually driving at a high speed compared to truck and trailer drivers.

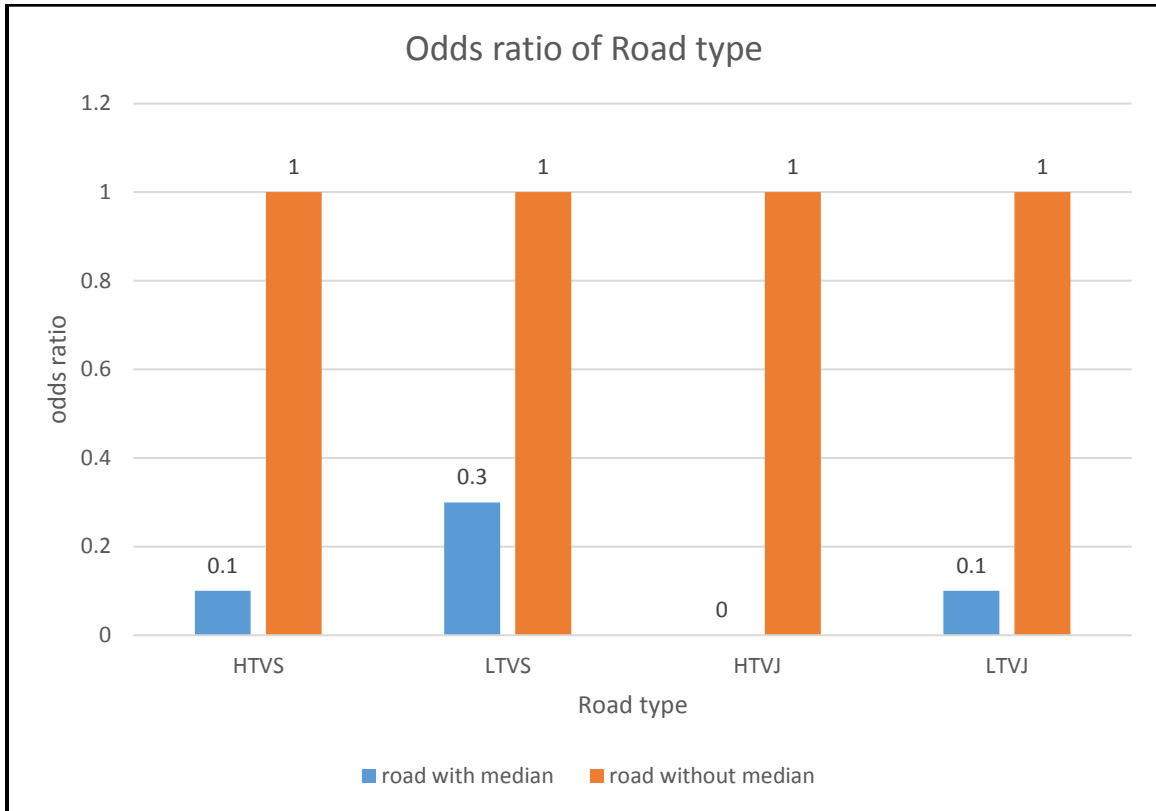


Fig 4.6 Odds ratio of road type

In high traffic volume straight section and low traffic volume junction road with median has 90 % less probability of crash occurrence compared to road without median. In low traffic volume straight section road with median has 70 % less probability of crash occurrence compared to road without median.

This decreasing of crash occurrence probability is due to moving of vehicles in one direction and pedestrian can easily observe and expect the direction of coming vehicles and stopping at the median and observe the other direction to cross the road without any ambiguity.

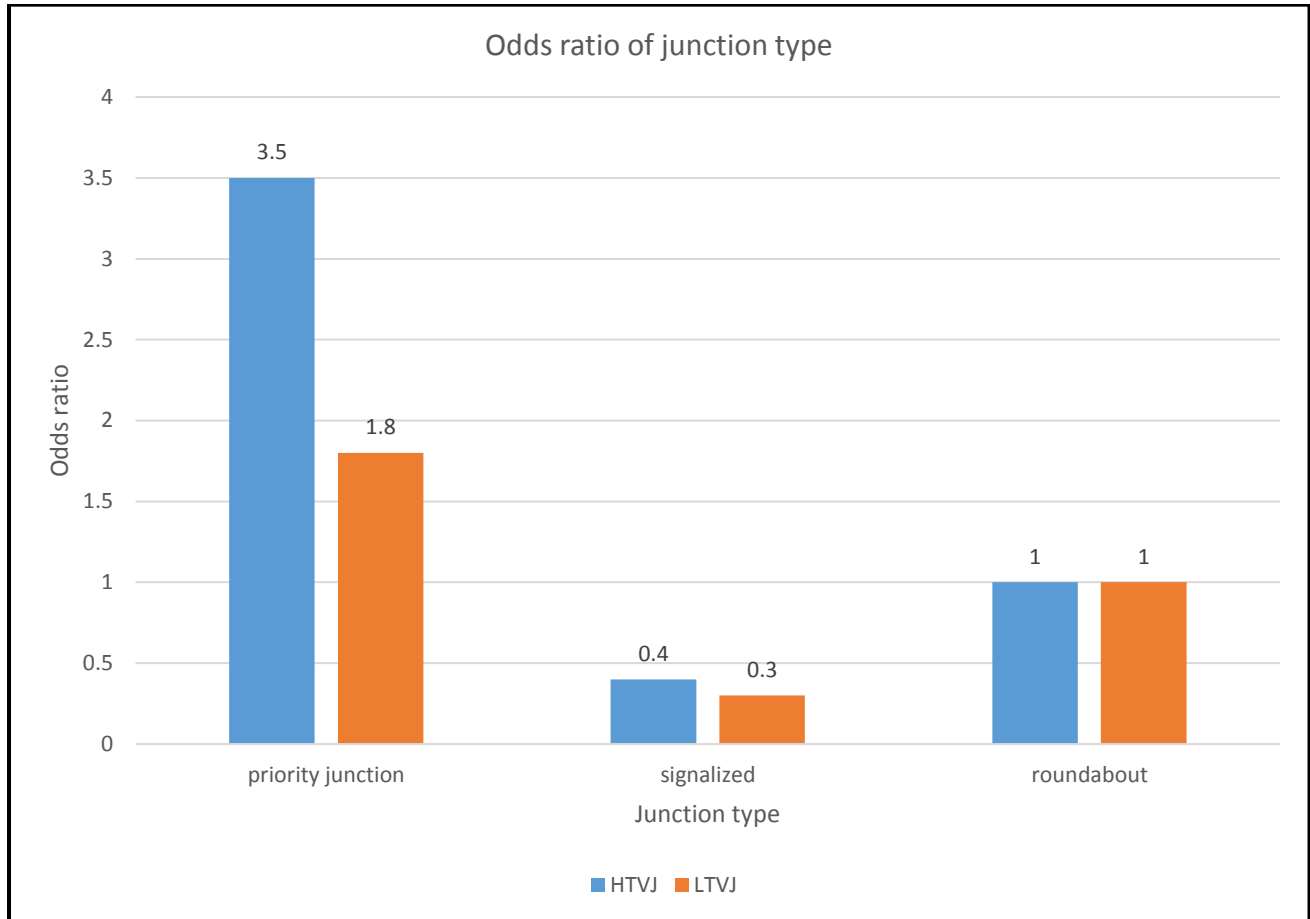


Fig 4.7 Odds ratio of Junction type

In high traffic volume priority junctions have 3.5 times higher probability of crash occurrence compared to round about. And 60% less probability of crash occurrence in signalized junction compared to roundabout.

In low traffic volume junction there is 1.8 times higher probability of crash occurrence in priority junction compared to round about. There is 70% less probability of crash occurrence in signalized junction compared to roundabout. This high probability of crash frequency in priority junction may be due to not giving priority to corresponding vehicles and also have a lot of conflicting points compared to roundabout.

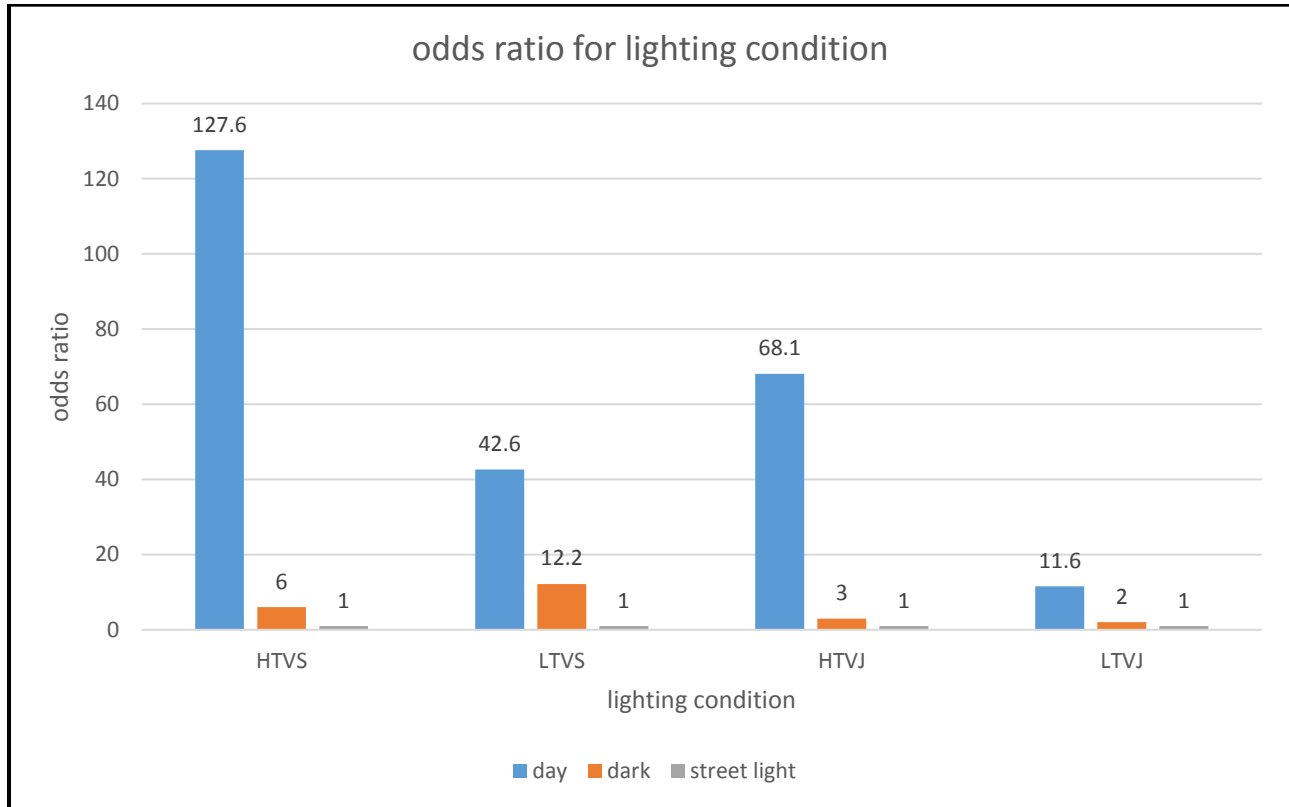


Fig 4.8 Odds ratio of lighting condition

In high traffic volume straight section day light has high probability of crash occurrence compared to street light crash occurrence. And in dark time 6 times probability of crash occurrence compared with street light. In low traffic volume street section day time has 42.6 times higher probability of crash occurrence compared to street light. And dark time has 3 times higher probability of crash occurrence compared to street section.

In general, for all traffic volume and road sections there is high probability of crash occurrence in day compared to dark and street light. But from crash data file 3.7% of crash occurred in day time are fatal and 7.7% of crash occurred in night time are fatal. This may due to high traffic movement (vehicles and pedestrian) in day time driving with low speed compared to night time. In night time drivers are not willing to obey traffic rules and crashes are exposed to fatal injury compared to day time crashes.

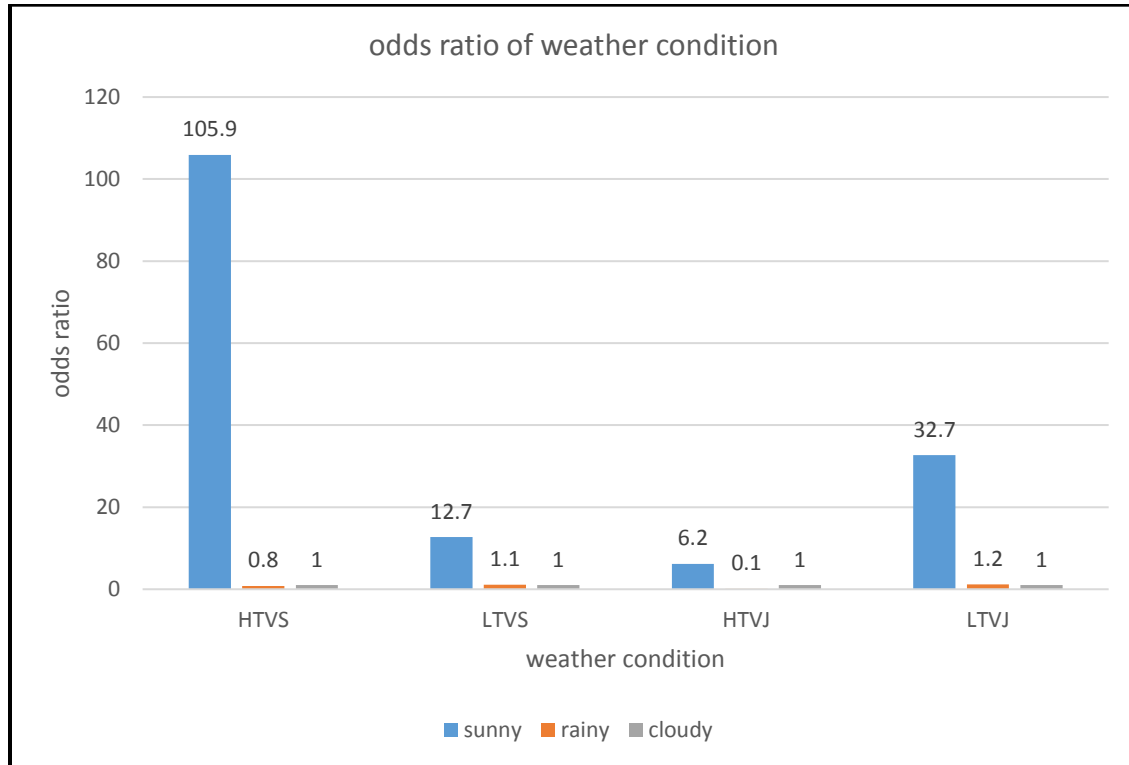


Fig 4.9 Odds ratio of weather condition

In high traffic volume straight section there is very high probability of crash occurrence in sunny weather condition compared to cloudy. But there is 20% less probability of crash occurrence in rainy condition compared to cloudy. In low traffic volume straight section sunny weather condition has 12.7 times higher probability of crash occurrence compared to cloudy. In rainy time 10% higher probability of crash is observed compared to cloudy condition.

In high traffic volume junction sunny condition has 6.2 times higher probability of crash occurrence and 90% less probability in rainy condition compared to cloudy. In low traffic volume junction there is 32.7 times higher crash occurrence probability in sunny condition and 20% higher probability of crash occurrence in rainy condition compared to cloudy. This high probability of crash frequency in sunny condition compared to cloudy and rainy may be due to high movement of traffic (vehicles and pedestrians) in sunny condition than rainy condition.

5.0 Conclusions and Recommendations

5.1 Conclusions

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

- ✚ When traffic volume is low frequency of crash occurrence in Wednesday at junction is high and in high traffic volume there is high frequency of crash in Monday at straight section.
- ✚ In low traffic volume high frequency of crash occurrence is observed in 18-29 years old drivers at junction. In High traffic volume low crash probability and in low traffic volume high probability of crash is observed. 30-44 year drivers have also 2.1 times probability of crash occurrence compared to >45 year drivers in high traffic volume at straight section.
- ✚ High school level drivers have high frequency of crash at junction in high traffic volume and less frequency of crash in low traffic volume at straight section.
- ✚ In low traffic volume straight section high probability of crash occurrence is observed in < 5 years and (5-15 years) driving experience compared to the base case (>15 years). In low traffic volume junction <5 years driving experience has also high probability of crash occurrence compared to the base case.
- ✚ In high traffic volume straight section small vehicles have high probability of crash occurrence compared to the base case (truck and trailer), bajaj and motor have 4.8 times higher probability of crash occurrence compared to truck and trailer. In all road sections and traffic volumes small vehicles have high probability of crash occurrence compared to all other vehicle groups
- ✚ In all traffic volume junction and straight section road with median has less probability of crash frequency than road without median.
- ✚ In priority junction there is high crash frequency in high traffic volume but less crash frequency in high traffic volume at signalized junction.
- ✚ There is high frequency of crash in day time condition at junction and straight section in different traffic volume but less crash frequency in street light condition.

- ✚ In sunny weather condition high crash frequency is observed in high traffic volume at straight section and low at junction. But less crash frequency is observed in rainy condition with low traffic volume at junction.

5.2 Recommendations

- ✚ Awareness creation how and when does cross the road should be intensified specially for peasants and countryside peoples.
- ✚ Special traffic operation should be given in market days.
- ✚ Small vehicle drivers should be given special training to avoid repetitive crash occurrence.
- ✚ The concerned body should enforce to apply traffic rules and regulation specially in Monday and Wednesday.
- ✚ Traffic police should enforce drivers to minimize their speed around junction specially when there is low traffic volume.
- ✚ Special attention should be given to priority junction when there is high traffic volume.
- ✚ Finally, under reporting of crash is visible in Bahirdar, thus develop crash database is better to do reliable study and to overcome crash related problems.

5.3 Future Study Areas

Future research recommendation are arising from this research which is not addressed due to time and money constraint. Analyzing and examining the impact of speed, geometric design parameters and traffic volume on crash frequency around junction and straight section by installing fixed camera for recording of traffic volume (which represent exact traffic volume while crash is occurred) and vehicle speed.

During model development only main effects of variables were analyzed in this research but the interaction effect between variables has great effect on model quality so interaction effect of variables should have examined to know effect of variables interaction on crash frequency.

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Appendix A: data entered in SPSS

Effects of Selected Crash Parameters and Traffic Volume on Crash Frequency in Bahirdar City

	crashseverity	dayOfWeek	GENder	Age	EducaST	DrivinE	VehicleT	RoadTyp	JunctionType	LightinCon	WeatherCon	var
1	4	3	1	1	3	1	2	2	1	1	1	
2	4	3	1	2	5	1	2	2	2	1	1	
3	3	2	1	1	1	1	1	2	3	2	1	
4	4	5	1	2	5	1	2	2	1	1	1	
5	4	3	1	2	5	2	2	2	1	1	1	
6	4	2	1	2	5	3	2	2	3	3	2	
7	3	1	1	1	3	1	2	1	1	1	1	
8	4	4	1	1	3	1	4	2	3	1	1	
9	2	1	1	1	3	1	2	2	3	1	1	
10	4	1	1	1	3	1	2	2	1	2	3	
11	4	3	1		3	2	2	2	1	2	1	
12	2	6	1	1	3	1	2	2	1	1	1	
13	4	3	1	1	3	1	2	2	1	1	1	
14	4	3	1	2	5	1	2	2	2	1	1	
15	3	2	1	1	1	1	1	2	3	2	1	
16	4	5	1	2	5	1	2	2	1	1	1	
17	4	3	1	2	5	3	2	2	1	3	3	
18	4	2	2	1	3	1	2	1	1	1	1	
19	4	2	1	2	5	1	2	2	3	1	1	
20	3	1	1	1	3	1	2	1	1	1	1	
21	4	4	1	1	3	1	4	2	3	1	1	
22	2	1	1	1	3	1	2	2	3	1	1	
23	4	1	1	1	3	1	1	2	1	1	1	

Appendix B: Correlation coefficients

Correlation coefficient of high traffic volume straight section

Correlations										
		DayOW	GENder	Age	EducaST	DrivinE	VehicleT	ROAdT	LightinCon	WeatherCon
DayOW	Pearson Correlation	1	.064	-.101*	.216**	.002	.007	.053	.091*	.078
	Sig. (2-tailed)		.128	.016	.000	.971	.877	.206	.029	.064
	N	571	571	565	571	555	555	571	571	568
GENder	Pearson Correlation	.064	1	-.086*	-.037	-.020	-.006	-.026	-.022	-.015
	Sig. (2-tailed)	.128		.042	.380	.645	.897	.532	.594	.729
	N	571	571	565	571	555	555	571	571	568
Age	Pearson Correlation	-.101*	-.086*	1	-.037	.578**	.127**	.108*	.249**	-.040
	Sig. (2-tailed)	.016	.042		.382	.000	.003	.010	.000	.342
	N	565	565	565	565	549	549	565	565	562
EducaST	Pearson Correlation	.216**	-.037	-.037	1	-.038	-.057	-.257**	.167**	.038
	Sig. (2-tailed)	.000	.380	.382		.372	.180	.000	.000	.371
	N	571	571	565	571	555	555	571	571	568
DrivinE	Pearson Correlation	.002	-.020	.578**	-.038	1	.259**	.193**	-.021	.025
	Sig. (2-tailed)	.971	.645	.000	.372		.000	.000	.622	.552
	N	555	555	549	555	555	539	555	555	555
VehicleT	Pearson Correlation	.007	-.006	.127**	-.057	.259**	1	.116**	.064	.008
	Sig. (2-tailed)	.877	.897	.003	.180	.000		.006	.134	.853
	N	555	555	549	555	539	555	555	555	552
ROAdT	Pearson Correlation	.053	-.026	.108*	-.257**	.193**	.116**	1	-.024	.044
	Sig. (2-tailed)	.206	.532	.010	.000	.000	.006		.567	.296
	N	571	571	565	571	555	555	571	571	568
LightinCon	Pearson Correlation	.091*	-.022	.249**	.167**	-.021	.064	-.024	1	.460**
	Sig. (2-tailed)	.029	.594	.000	.000	.622	.134	.567		.000
	N	571	571	565	571	555	555	571	571	568
WeatherCon	Pearson Correlation	.078	-.015	-.040	.038	.025	.008	.044	.460**	1
	Sig. (2-tailed)	.064	.729	.342	.371	.552	.853	.296	.000	
	N	568	568	562	568	555	552	568	568	568

*. Correlation is significant at the 0.05 level (2-tailed).

** . Correlation is significant at the 0.01 level (2-tailed).

Correlation coefficient of Low traffic volume straight section

Correlations										
		DayOW	GENder	Age	EducaST	DrivinE	VehicleT	ROAdT	LightinCon	WeatherCon
DayOW	Pearson Correlation	1	-.044	-.005	-.115**	.203**	.280**	-.002	.010	-.111**
	Sig. (2-tailed)		.292	.902	.006	.000	.000	.964	.816	.008
	N	576	576	576	576	568	572	576	576	576
GENder	Pearson Correlation	-.044	1	.034	-.056	-.011	-.039	-.067	-.055	-.040
	Sig. (2-tailed)	.292		.416	.178	.790	.347	.110	.190	.342
	N	576	576	576	576	568	572	576	576	576
Age	Pearson Correlation	-.005	.034	1	.058	.451**	.209**	-.070	.018	-.041
	Sig. (2-tailed)	.902	.416		.161	.000	.000	.092	.666	.331
	N	576	576	576	576	568	572	576	576	576
EducaST	Pearson Correlation	-.115**	-.056	.058	1	-.116**	-.108**	-.115**	.094*	.275**
	Sig. (2-tailed)	.006	.178	.161		.006	.010	.006	.025	.000
	N	576	576	576	576	568	572	576	576	576
DrivinE	Pearson Correlation	.203**	-.011	.451**	-.116**	1	.057	-.156**	.036	-.124**
	Sig. (2-tailed)	.000	.790	.000	.006		.177	.000	.393	.003
	N	568	568	568	568	568	564	568	568	568
VehicleT	Pearson Correlation	.280**	-.039	.209**	-.108**	.057	1	.061	.119**	-.056
	Sig. (2-tailed)	.000	.347	.000	.010	.177		.142	.004	.179
	N	572	572	572	572	564	572	572	572	572
ROAdT	Pearson Correlation	-.002	-.067	-.070	-.115**	-.156**	.061	1	-.123**	-.098*
	Sig. (2-tailed)	.964	.110	.092	.006	.000	.142		.003	.019
	N	576	576	576	576	568	572	576	576	576
LightinCon	Pearson Correlation	.010	-.055	.018	.094*	.036	.119**	-.123**	1	.541**
	Sig. (2-tailed)	.816	.190	.666	.025	.393	.004	.003		.000
	N	576	576	576	576	568	572	576	576	576
WeatherCon	Pearson Correlation	-.111**	-.040	-.041	.275**	-.124**	-.056	-.098*	.541**	1
	Sig. (2-tailed)	.008	.342	.331	.000	.003	.179	.019	.000	
	N	576	576	576	576	568	572	576	576	576

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Correlation coefficient of high traffic volume junction

Correlations											
		DayOW	GENder	Age	EducaST	DrivinE	VehicleT	ROAdT	JunctionT	LightinCon	WeatherCon
DayOW	Pearson Correlation	1	-.040	.093	-.165*	-.027	.180	.029	-.210*	.026	.303**
	Sig. (2-tailed)		.631	.264	.046	.750	.030	.727	.011	.756	.000
	N	147	147	147	147	147	146	147	147	147	147
GENder	Pearson Correlation	-.040	1	-.220**	.139	-.149	.028	-.619**	-.163*	-.061	-.112
	Sig. (2-tailed)	.631		.007	.094	.071	.738	.000	.048	.463	.177
	N	147	147	147	147	147	146	147	147	147	147
Age	Pearson Correlation	.093	-.220**	1	.485**	.346**	.226**	.136	.213**	-.008	.215**
	Sig. (2-tailed)	.264	.007		.000	.000	.006	.100	.010	.920	.009
	N	147	147	147	147	147	146	147	147	147	147
EducaST	Pearson Correlation	-.165*	.139	.485**	1	-.084	.281**	-.096	.347**	-.220**	-.586**
	Sig. (2-tailed)	.046	.094	.000		.310	.001	.247	.000	.007	.000
	N	147	147	147	147	147	146	147	147	147	147
DrivinE	Pearson Correlation	-.027	-.149	.346**	-.084	1	.322**	.076	-.072	.056	.355**
	Sig. (2-tailed)	.750	.071	.000	.310		.000	.362	.386	.500	.000
	N	147	147	147	147	147	146	147	147	147	147
VehicleT	Pearson Correlation	.180	.028	.226**	.281**	.322**	1	-.065	-.201*	-.069	-.113
	Sig. (2-tailed)	.030	.738	.006	.001	.000		.432	.015	.405	.173
	N	146	146	146	146	146	146	146	146	146	146
ROAdT	Pearson Correlation	.029	-.619**	.136	-.096	.076	-.065	1	.101	.038	.069
	Sig. (2-tailed)	.727	.000	.100	.247	.362	.432		.224	.649	.405
	N	147	147	147	147	147	146	147	147	147	147
JunctionT	Pearson Correlation	-.210*	-.163*	.213**	.347**	-.072	-.201*	.101	1	-.025	-.201*
	Sig. (2-tailed)	.011	.048	.010	.000	.386	.015	.224		.764	.014
	N	147	147	147	147	147	146	147	147	147	147
LightinCon	Pearson Correlation	.026	-.061	-.008	-.220**	.056	-.069	.038	-.025	1	.496**
	Sig. (2-tailed)	.756	.463	.920	.007	.500	.405	.649	.764		.000
	N	147	147	147	147	147	146	147	147	147	147
WeatherCon	Pearson Correlation	.303**	-.112	.215**	-.586**	.355**	-.113	.069	-.201*	.496**	1
	Sig. (2-tailed)	.000	.177	.009	.000	.000	.173	.405	.014	.000	
	N	147	147	147	147	147	146	147	147	147	147

*. Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Correlation coefficient of low traffic volume at junction

Correlations											
		DayOW	GENder	Age	EducaST	DrivinE	VehicleT	ROAdT	JunctionT	LightinCon	WeatherCon
DayOW	Pearson Correlation	1	-.041	.325**	.301**	.132	.293**	.375**	-.240**	-.046	-.030
	Sig. (2-tailed)		.586	.000	.000	.078	.000	.000	.001	.539	.691
	N	179	179	176	179	179	179	179	179	179	179
GENder	Pearson Correlation	-.041	1	-.067	-.039	-.035	-.004	-.239**	-.059	-.037	-.017
	Sig. (2-tailed)	.586		.374	.605	.638	.955	.001	.433	.620	.819
	N	179	179	176	179	179	179	179	179	179	179
Age	Pearson Correlation	.325**	-.067	1	.807**	.438**	-.107	.282**	-.166*	.187*	.127
	Sig. (2-tailed)	.000	.374		.000	.000	.158	.000	.028	.013	.093
	N	176	176	176	176	176	176	176	176	176	176
EducaST	Pearson Correlation	.301**	-.039	.807**	1	.196**	.061	.163*	-.190*	-.128	.168*
	Sig. (2-tailed)	.000	.605	.000		.009	.417	.030	.011	.088	.024
	N	179	179	176	179	179	179	179	179	179	179
DrivinE	Pearson Correlation	.132	-.035	.438**	.196**	1	.044	.148	-.323**	.266**	.138
	Sig. (2-tailed)	.078	.638	.000	.009		.554	.048	.000	.000	.065
	N	179	179	176	179	179	179	179	179	179	179
VehicleT	Pearson Correlation	.293**	-.004	-.107	.061	.044	1	.067	.180	-.222**	-.032
	Sig. (2-tailed)	.000	.955	.158	.417	.554		.371	.016	.003	.666
	N	179	179	176	179	179	179	179	179	179	179
ROAdT	Pearson Correlation	.375**	-.239**	.282**	.163*	.148*	.067	1	.247**	.089	.018
	Sig. (2-tailed)	.000	.001	.000	.030	.048	.371		.001	.237	.808
	N	179	179	176	179	179	179	179	179	179	179
JunctionT	Pearson Correlation	-.240**	-.059	-.166*	-.190*	-.323**	.180	.247**	1	.068	-.030
	Sig. (2-tailed)	.001	.433	.028	.011	.000	.016	.001		.364	.687
	N	179	179	176	179	179	179	179	179	179	179
LightinCon	Pearson Correlation	-.046	-.037	.187*	-.128	.266**	-.222**	.089	.068	1	.622**
	Sig. (2-tailed)	.539	.620	.013	.088	.000	.003	.237	.364		.000
	N	179	179	176	179	179	179	179	179	179	179
WeatherCon	Pearson Correlation	-.030	-.017	.127	.168*	.138	-.032	.018	-.030	.622**	1
	Sig. (2-tailed)	.691	.819	.093	.024	.065	.666	.808	.687	.000	
	N	179	179	176	179	179	179	179	179	179	179

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Appendix C: final model (equations)

1. High traffic volume at straight section

$$\begin{aligned} \text{Ln}(f(x)) = & -17.633+1.485(\text{mon}) +0.494(\text{tues})+0.894(\text{wends})+1.144(\text{thurs})+0.591(\text{frid}) \\ & +4.5(\text{male})+1.254(\text{age1})+0.729(\text{age2})-1.443(\text{illiterate})-0.582(\text{primary})+0.567(\text{highschool})- \\ & 0.301(\text{prep})+1.566(\text{vehicle1})+3.322(\text{vehicl2})+0.827(\text{vehicle3})+1.168(\text{vehicle4})- \\ & 2.362(\text{road1})+4.864(\text{light1})+1.792(\text{light2})+4.677(\text{weather1}) \end{aligned}$$

2. Low traffic volume at straight section

$$\begin{aligned} \text{Ln}(f(x))= & -17.71+5.638(\text{male})+2.165(\text{age1})+1.557(\text{age2})-1.492(\text{illiterate})-1.743(\text{primary})+0.323 \\ & (\text{highschool})-0.296(\text{prep})+3.384(\text{experience1})+2.803(\text{experience2})+1.792(\text{vehicle1})+3.051 \\ & (\text{vehicl2})+0.818(\text{vehicle3})+1.369(\text{vehicle4})+0.726(\text{vehicle6})-1.196(\text{road1})+ \\ & 3.164(\text{lightcon1})+2.51(\text{lightcon2})+2.549(\text{weathercon1}) \end{aligned}$$

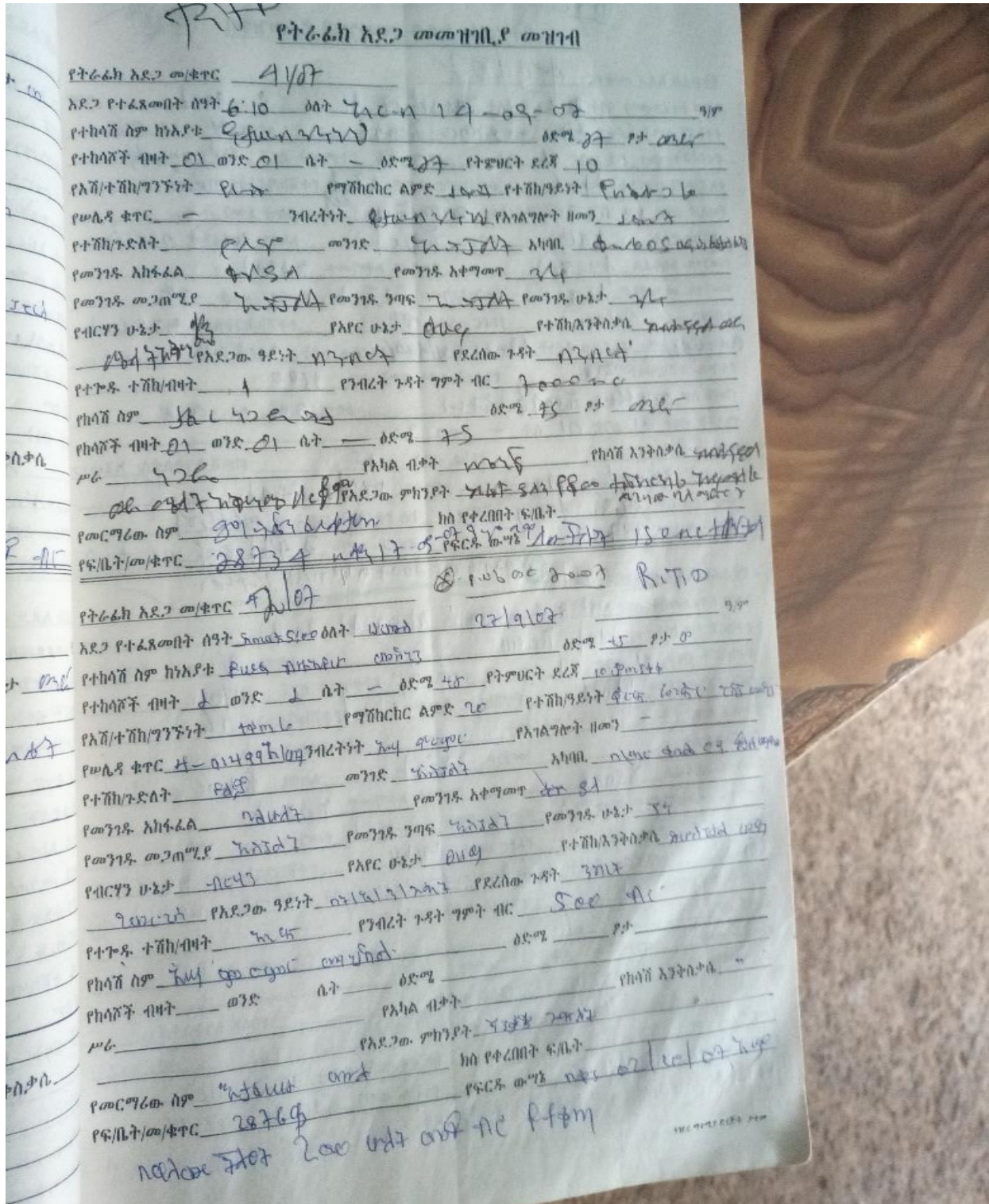
3. HIGH TRAFFIC VOLUME AT JUNCTION

$$\begin{aligned} \text{Ln}(f(x))= & -11.116+2.723(\text{male})+0.251(\text{primary})+1.792(\text{highschool})+0.762(\text{preparatory}) \\ & +2.07(\text{vehicle2})-2.69(\text{vehicle3})-2.639(\text{vehicle6})-3.57(\text{road1})+ 1.243(\text{junction1})- \\ & 0.916(\text{junction2})+1.625(\text{weathercon1})-2.030(\text{weather2})+4.234(\text{lightcon1}) \end{aligned}$$

4. Low traffic volume at junction

$$\begin{aligned} \text{Ln}(f(x))= & -19.286-1.631(\text{Monday})+1.135(\text{Tuesday})+1.88(\text{wednesday})+ 3.882(\text{age1})+3.651(\text{age2})- \\ & 1.705(\text{illiterate})-4.19(\text{primary})+0.375(\text{highschool})-0.419(\text{preparatory})+3.178 \\ & (\text{experience1})+1.466(\text{experience2})+3.258(\text{vehicle1})+4.849(\text{vehicle2})+2.708+(\text{vehicle4})- \\ & 2.236(\text{road1})+0.592(\text{junction1})-1.27(\text{junction2})+3.497(\text{weathercon1})+ 2.457(\text{lightcon1}) \\ & +0.693(\text{lightcon2}) \end{aligned}$$

Appendix D: Samples photos of crash data file



የትራፊክ አደጋ መመዝገቢያ መዝገብ

25/07

አደጋ የተፈጸመበት ሰዓት 2:30 ሰዓት 25/7/07 9/9

የተከሰባበት ክፍለ-ክፍለ-ክፍል አደጋው ስም 27 የትምህርት ደረጃ 9016

የተከሰባበት ብዛት 1 ወንድ 1 ሴት 1 ወንድ 27 የትምህርት ደረጃ 9016

የአሽ/ተሽከርካሪው ስም የማሽከርካሪው ስም የተሽከርካሪው ስም

የሠላጽ ቁጥር A37070 አሽ/ተሽከርካሪው የሥራ ቤቱ የአሽ/ተሽከርካሪው ስም

የተሽከርካሪው ስም የተሽከርካሪው ስም የተሽከርካሪው ስም

የመንገዱ አካላዊ ስም የመንገዱ አካላዊ ስም የመንገዱ አካላዊ ስም

የመንገዱ መጋጠሚያ ተጠቃ የመንገዱ ንጣፍ ተጠቃ የመንገዱ ሁኔታ ከፍተኛ

የብርሃን ሁኔታ ብርሃን የአየር ሁኔታ ብርሃን የተሽከርካሪው ስም

የአደጋው ዓይነት የአደጋው ዓይነት የአደጋው ዓይነት

የተገጥሞ ተሽከርካሪው ስም የተሽከርካሪው ስም የተሽከርካሪው ስም

የከሰባበት ስም የከሰባበት ስም የከሰባበት ስም ወንድ 24 የትምህርት ደረጃ

የከሰባበት ብዛት 1 ወንድ 1 ሴት 1 ወንድ 24

ሥራ ስም የአካል ብቃት ተጠቃ የከሰባበት ስም

የመርጫው ስም የአደጋው ምክንያት የአደጋው ምክንያት

የፍ/ቤት/መ/ቁጥር 28129 በታ 26/3/07 የፍርድ ውሳኔ 2 ክፍል የአደጋው ስም

20/07

አደጋ የተፈጸመበት ሰዓት 4:00 ሰዓት 20/7/07 9/9

የተከሰባበት ክፍለ-ክፍለ-ክፍል አደጋው ስም 31 የትምህርት ደረጃ 1013

የተከሰባበት ብዛት 1 ወንድ 1 ሴት 1 ወንድ 31 የትምህርት ደረጃ 1013

የአሽ/ተሽከርካሪው ስም የማሽከርካሪው ስም የተሽከርካሪው ስም

የሠላጽ ቁጥር የአደጋው ዓይነት የአደጋው ዓይነት የአደጋው ዓይነት

የተሽከርካሪው ስም የተሽከርካሪው ስም የተሽከርካሪው ስም

የመንገዱ አካላዊ ስም የመንገዱ አካላዊ ስም የመንገዱ አካላዊ ስም

የመንገዱ መጋጠሚያ የመንገዱ ንጣፍ የመንገዱ ሁኔታ

የብርሃን ሁኔታ የአየር ሁኔታ የተሽከርካሪው ስም

የአደጋው ዓይነት የአደጋው ዓይነት የአደጋው ዓይነት

የተገጥሞ ተሽከርካሪው ስም የተሽከርካሪው ስም የተሽከርካሪው ስም

የከሰባበት ስም የከሰባበት ስም የከሰባበት ስም ወንድ 31

የከሰባበት ብዛት 1 ወንድ 1 ሴት 1 ወንድ 31

ሥራ ስም የአካል ብቃት ስም የከሰባበት ስም

የመርጫው ስም የአደጋው ምክንያት የአደጋው ምክንያት

የፍ/ቤት/መ/ቁጥር 29127 የአደጋው ስም የአደጋው ስም