ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

Post Graduate Studies on Road and Transport Engineering

Determinants of Road Traffic Accident Occurrences in Amhara Region. (A Case Study from Debre Markos to Injibara Road Section).

BY
GEDEFAYE GEREMEW

ADVISOR
ALEMAYEHU AMBO, PhD

A thesis submitted to the school of civil and environmental engineering,Post Graduate Studies of Addis Ababa Institute of Technology in partial fulfillment of the requirements for the Degree of Masters of Science in Civil Engineering (Road and Transport Engineering Stream).

October, 2018
Addis Ababa

ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

Post Graduate Studies on Road and Transport Engineering Stream

Determinants Of Road Traffic Accident Occurrences In Amhara Region. (A Case Study From Debre Markos To Injibara Road Section).

By

Gedefaye Geremew

Approved by The Board of Examiners:

Dr. Alemayehu Ambo	________________	__________
Advisor	Signature	Date
Dr. Tofik Tesfaye	________________	__________
Internal Examiner	Signature	Date
Dr. Bikila Teklu	________________	__________
External Examiner	Signature	Date
Dr. Biruk A	________________	__________
Chair man	Signature	Date

Statement of Certification

This is to certify that Gedefaye Geremew has carried out his research work on the topic entitled **"Determinants of Road Traffic Accident Occurrences in Amhara Region. A Case Study From Debre Markos To Injibara Road Section".**

The Work Is Original in nature and is suitable for submission for the award of Master Degree in Civil Engineering (Road and Transport Engineering Stream).

____

Advisor: Alemayehu Ambo, PhD

____

Date:

Statement of declaration

I, the undersigned, declare that this study is my original work and has not been presented for a degree in any other university, and that all sources of materials used for the study have been duly acknowledged.

Declared by:

Name: Gedefaye Geremew Signature ______________________ Date ___________

Confirmed by advisor:

Name: Alemayehu Ambo (PhD) Signature __________________ Date ___________

Acknowledgments

I feel like I am just starting when I finish. I still feel the search for orientation in my life continues. However, I would like to express my deepest gratitude to those who made orientation in my life's journey much easier so far.

With a heart full of praises and adorations will I exalt you Lord for what you have done for me. Without your help I wouldn't have been here. I thank you **my Almighty God** in the name of your begotten son JESUS CHRIST for your continuous support, protection and blessing since the inception of my study up to this second.

Next, I would like to express my special and deepest gratitude and respect to my advisor, Dr. Alemayehu Ambo, for his unreserved help and intellectual guidance, invaluable comments and corrections from the beginning of my paper to the end.

I would also like to forward my profound thanks, deep love and respect to all my parents mainly to my mom Obse Borena and dad Tefera Ayana for their continuous support, heartfelt love and encouragement in all aspect of my life.

Thanks to all government officers who help me by giving different documents relevant for this research and any resources available in good will without reservation.

Last but the best, I would like to thank my wonderful brother Mengistu Tefera, my lovely fiancée Bilisumma Kinati . It is awesome to have you in my life. I am so grateful for all your Love, Care and Support.

Statement of Certification

This is to certify that Gedefaye Geremew has carried out his research work on the topic entitled **“Determinants of Road Traffic Accident Occurrences in Amhara Region. A Case Study From Debre Markos To Injibara Road Section”.**

The Work Is Original in nature and is suitable for submission for the award of Master Degree in Civil Engineering (Road and Transport Engineering Stream).

____

Advisor: Alemayehu Ambo, PhD

____

Date:

Statement of declaration

I, the undersigned, declare that this study is my original work and has not been presented for a degree in any other university, and that all sources of materials used for the study have been duly acknowledged.

Declared by:

Name: Gedefaye Geremew Signature ________________________ Date ______________

Confirmed by advisor:

Name: Alemayehu Ambo (PhD) Signature ____________________ Date ______________

Acknowledgments

First of all; with a heart full of praises and adorations, I would like thanks to god for everything, since I still feel the search for orientation in my life continues.

Next, I would like to express my special and deepest gratitude and respect to my advisor, Dr. Alemayehu Ambo, for his unreserved help and intellectual guidance, invaluable comments and corrections from the beginning of my paper to the end.

I would also like to forward my profound thanks, deep love and respect to all my parents mainly to my mother Yeweginesh Getahun and my Father Geremew Yayeh for their continuous support, heartfelt love and encouragement in all aspect of my life.

Thanks to all government officers who help me by giving different documents relevant for this research and any resources available in good will without reservation.

ABSTRACT

According to the European Union reports (2014) and WHO (2009), 1.3 million people lose their lives every year from road traffic accidents (RTAs).

Although road traffic accidents (RTAs) are a major global public health problem, most of it occurs in low- and middle-income countries including Ethiopia. Pedestrians, drivers and passengers of vehicles are the most vulnerable in Ethiopia; whereas, in high-income countries, crashes involve primarily privately owned vehicles with the driver being the main car occupant injured or killed.

Determinants of RTAs have become a major public health concern worldwide: However, unlike developed or high-income countries, many developing countries have made very little progress towards addressing this problem. Nonetheless, there are ways to strengthen the reduction of injured persons that will help to lower the toll from road RTAs. The purpose of this paper is to elucidate ways to accomplish these goals in the context of along the road section from considering the Debre Markos-Injibara (150km) road (locating in the Amhara region of Ethiopia) as a cause study. The determinants will established mainly through Descriptive and Inferential analysis. Inferential analysis was carried out using STATA software v14 program (odds ration model regression) and results were generated. This implies that the proportion of variation in the dependent variable (i.e. road traffic accidents) explained by the independent variables (i.e. length of roads, road geometry, road users, presence of road safety, environment and speeding).In this regard a total of 11 sections of the case study road were dealt with using secondary data from the Amhara Police Commission records.

Based on the results of priority value analysis, out of the 11 sections of the subject road; the Burie, near Finote Selam, Banja, and Finote Selam were highly prone to accidents and corresponding values as: 13, 10.79, 10 and 9.64respectively.

Based on the data analyses and prioritization values result the more vulnerable section was found and ranked to diagnose, prioritize, evaluate and give low cost and effective solution to reduce the RTAs on the study road. Possible solutions are using traffic signs, make enforcement for unlegal drivers, strengthen public awareness through campaigns, exercise pertinent policy revisions, permanent geometry and pavement modifications etc.

Table of Contents……………………………………………………………………………….. .ii

List of tables

List of figures

CHAPTER ONE

INTRODUCTION

1.1. General

The World Health Organization WHO (2009) estimated that 1.3million deaths occur each year worldwide due to road traffic accidents. A breakdown of the figure indicates however, that about 70 percent of the deaths occur in developing countries. WHO (2009) asserted that road traffic crashes are the leading cause of death and disablement second only to HIV/AIDS for people under the age of 44 years. The continuing advance of motorization in many developing countries is likely to further exacerbate the problem. The increased rate of fatal road traffic crash worldwide has been attributed to population explosion and increased motorization. Increased motorization may be characterized briefly as the “automotive revolution”, that is the motorizing of urban population especially in the developing countries (WHO 2009).

The social, economic, and political impacts of road traffic accidents are widespread all over the world. The loss of lives, damage to property, and the sorrow it leaves in human mind are profound though the degree varies (Peden et al, 2004). Geographically, 35% to 70% of all crashes occur in urban areas and urban road networks contribute to a significant proportion of countries’ national road traffic crash problem (Downing *et al,* 2000). These make traffic accident the third major killer next to HIV/AIDS and Tuberculosis (TB) as stated by Peden et al, 2009.

Road traffic accidents appear to occur regularly at some flash points such as where there are sharp bends, potholes and at bad sections of the highways. At such points over speeding drivers usually find it difficult to control their vehicles, which then result to fatal traffic accidents, especially at night (Atubi, 2009b).

In Ethiopia, the situation has been worsened as the number of vehicles has increased consequently due to increased traffic flow and conflicts between vehicles and pedestrians (Guyu, 2013). Despite government efforts in the road development, road crashes remain to be one of the critical problems of the road transport sector in Ethiopia (UNECA, 2009). Every year, many lives are lost and huge property is destroyed due to road traffic accidents in the Country. According to Ethiopian police commission report; The Country has experienced RTAs of over the 83,960 in the past 4 years (2005-2009 E.C.).

Table 1.1: Number of RTAs in Ethiopia over the year 2005-2009

no	Region	Year in E.C.					total	percent
		2005	2006	2007	2008	2009		
1	Tigray	1037	1124	1267	1447	1391	6266	7.46
2	Afar	252	338	257	309	374	1530	1.82
3	Amara	3521	3736	3449	3915	4215	18836	22.43
4	Oromia	4690	3272	7357	4949	4485	24753	29.48
5	Somali	366	356	236	352	961	2271	2.70
6	B/gumz	382	358	205	487	652	2084	2.48
7	South	756	1390	1808	2037	2561	8552	10.19
8	Gambella	90	95	148	172	155	660	0.79
9	Hareri	144	198	370	256	460	1428	1.70
10	AA	3155	4022	3438	4040	3794	18449	21.97
11	D/Dawa	327	369	325	345	352	1718	2.05
	Total	14720	15258	16273	18309	19400	83960	100.00

Source: Ethiopian federal traffic police commissions:

As shown the above Ethiopian Federal Police Commission (2005-2009 E.C.) report; Total summary of RTAs of the country increases year to year and In Amhara region has high RTAs (18,838) next to Oromia region (24,753) from other regions. Therefore, various categories of RTAs are also involved in these road traffic accidents in this region, specifically along the Debre Markos - Injibara (150 Km) road.

The aim of this paper is to describe, characterize, evaluate and determine the hazardous locations of road crashes based on Amhara road traffic record data and sit investigation along the road section from Debre Markos to Injibara (150 km).The characteristics considered included: where the crashes occurred, when the crashes occurred, who was involved in the accidents, what events or conditions were present, which area was more susceptible and the contributing circumstances.

1.2. Statement of the Problem

Road traffic accidents (RTAs) constitute major health, economic, and developmental challenges of developing countries, especially adversely affected sub Saharan African Countries (Chen, 2009). In 1999, for instance, 750,000-880,000 people died in RTAs of which, about 85% of these occurred in developing countries (Downing, Jacobs, Aeron-Thomas & Sharples,2000).The World Health Organization (WHO,2009) puts the number of fatalities and injuries due to RTAs was 1.25 million.

In Africa, 28.3 per 100,000 die in RTAs. And In Ethiopia, a country with a small vehicle population ratio, 95 deaths per 10, 000 vehicles were registered between 2007 and 2008(WHO, 2004). Despite government efforts in the road development, road crashes remain to be one of the critical problems of the road transport sector in Ethiopia (UNECA, 2009).

This research evaluates and analyzes RTAs and safety concerns in case of Debre Markos to Injibara(150 km) major road section, as this road section is one of the locations where severe high RTAs.

Local authorities and police officers of this road locations attest that the road section has recorded the worst traffic accident as compared to the vehicle density. The estimated main reason behind the concentration of major accidents is that this road section composed high movement of traffic since it hosts the main roads Addis-Abeba to Bahir-Dar to Gonder. Ethiopian traffic police commission (2007/08) reports show that this road sections has the largest number of RTAs, fatalities and injuries.

The RTAs number for both fatal and injured people is a major problem for this road section. Hence this research will find out the main causes and magnitude of RTAs in the Debre-Markos to Injibara major Road section and evaluate the safety condition.

1.3. Objectives of the Study

1.3.1. General Objective

The main objective of the study is to assess the determinants of RTAs occurrences in Amhara Region and necessary to identify hazardous locations on roads commonly termed as black spots**,** considering the Debre Markos - Injibara road as a case study.

1.3.2. Specific Objectives

The specific objectives of the study regarding the Debre Markos - Injibara road are:

- To examine the types and causes of road traffic accidents(RTAs) severity along the study road:
- To compare and contrast the extent of road users involvement in RTAs by sex and age along the study area:
- To determine locations of black spots along this road section:

- To identify the magnitude of major determinants of RTAs severity with special emphasis on fatal severity by binary logistic regression model on the study area. and
- To propose implementable engineering solutions for the study road.

1.4. Research Questions

- What are the types of road traffic accidents happening along the study road?
- What are the major causes of RTAs in this study area?
- Which factors are more susceptible to RTA along the study road?
- Which locations along the road are more vulnerable to traffic accidents?

1.5. Significance of the Study

Previously, no significant studies were undertaken to find out the determinants of RTAs and black spot areas along the Debre Markos -Injibara road (150km). Hence, the current study has the importance of:

- Determining the magnitude of determinants of RTAs severities with special emphasis on fatal severity by binary logistic regression model on the study area;
- Adding knowledge on the gap created around the issues;
- Contributing towards the reduction of the problems associated with road traffic accidents;
- Offering information regarding the basic causes of road traffic accidents and the sites of black spots;
- Findings of this study leading to new problems for further investigation;
- Signaling and motivating pertinent stakeholders to take appropriate actions by incorporating the issues in their policies and strategies; and
- Providing policy makers, researchers, institutions etc. with adequate and reliable data so as to implement feasible and appropriate engineering solutions to reduce road traffic accidents.

1.7. Limitation of the Study

During the study, many limitations and constraints were observed. In this regard, limited information were acquired, particularly lack of well-organized secondary data regarding on the RTAs data recording system. That means during accident season the accident variable recorded indifferent form. This leads to challenges to develop multiple regression models. Another limitation and similarly, limitations of published researches and articles on the research topic developed multiple regression models. In order to compromise some of the limitations related to lack of published documents that developed multiple regression model and lack of well-organized data recorded system, by making some organization, the researcher made binary regression model.

1.9. Organization of the Report

This thesis comprises six chapters. Chapter one deals with introduction / background of the study, statement of the problem with research questions, objectives of the study, significance of the study and limitation of the study. Chapter two deals with literature review. Chapter three of the thesis discusses the research design, sources, instruments, sampling techniques, and procedures of collecting data for the study. Chapter four focuses on the analysis and discussions of the data gathered in light of the aforementioned research questions. Chapter five presents summary of the main findings draws conclusions, foreword recommendations and chapter six presents proposed future research areas in the study road.

CHAPTER TWO

LITERATURE REVIEW

A Road traffic accident (RTAs) is one of the causes for the death of people and has been ranked as one of the top leading causes of death in the world. Over millions of people are killed each year.

Every day, thousands of people are killed and injured on road by traffic accident. It is the leading cause of death, disabilities and hospitalization, severe socioeconomic costs, across the world. According to the (WHO 2009), it has been estimated that RTA takes the lives of nearly 1.3 million each year, As a result; nearly 3,500 people die each day. In addition, the people who suffer serious injuries including disability are about 20 to 50 million worldwide.

RTAs injuries are becoming public health issues, disproportionately affecting vulnerable group of the road users, including the poor. More than half the people who die in traffic crashes are young adults with age's between15 to 44.

In the world, nearly half (46%) of all RTAs involve pedestrians, motorcyclists and cyclists (vulnerable) road users. The economic consequences due to RTAs have been estimated between 1% to 3% of GNP of the world countries. In 2004, (WHO) RTAs were the 9th leading cause of death and the study forecasts that at current rates by 2030, the RTAs will rise to 2.4 million deaths each year and will be the third leading cause of death overtaking diabetes and HIV. Table 2:1 below shows the top leading cause of death by presenting what happened in 2004 and what will happen in 2030.

According to the WHO study (2008) Global Burden of Disease, in 2004, RTAs injuries affect all age groups, but their impact is most striking among the young. RTAs have become the second leading cause of death worldwide among the people with age 5 to 14 the leads cause of death for the age's 15 to 29 years, and the third leading cause of death among the people with ages 30 to 44.

Table 2.1: Ten leading causes of burden of disease, world, 2004, and 2030

Figure 27: Ten leading causes of burden of disease, world, 2004 and 2030

2004 Disease or injury	As % of total DALYs	Rank	Rank	As % of total DALYs	2030 Disease or injury
Lower respiratory infections	6.2	1	1	6.2	Unipolar depressive disorders
Diarrhoeal diseases	4.8	2	2	5.5	Ischaemic heart disease
Unipolar depressive disorders	4.3	3	3	4.9	Road traffic accidents
Ischaemic heart disease	4.1	4	4	4.3	Cerebrovascular disease
HIV/AIDS	3.8	5	5	3.8	COPD
Cerebrovascular disease	3.1	6	6	3.2	Lower respiratory infections
Prematurity and low birth weight	2.9	7	7	2.9	Hearing loss, adult onset
Birth asphyxia and birth trauma	2.7	8	8	2.7	Refractive errors
Road traffic accidents	2.7	9	9	2.5	HIV/AIDS
Neonatal infections and other[a]	2.7	10	10	2.3	Diabetes mellitus
COPD	2.0	13	11	1.9	Neonatal infections and other[a]
Refractive errors	1.8	14	12	1.9	Prematurity and low birth weight
Hearing loss, adult onset	1.8	15	15	1.9	Birth asphyxia and birth trauma
Diabetes mellitus	1.3	19	18	1.6	Diarrhoeal diseases

Source*:* Study Global Burden of Disease undertaken by the (WHO, 2008)

Using a 30-day definition modeled data for the 178 countries including Ethiopia, almost all death sources show that about ¼ of RTAs death are among men and the highest impact is on the economically active age ranges. Men, women, or children walking, biking, or riding to work, school, playing in streets or setting out long trips are never having guarantee to reach their destinations or to return home safely (WHO). Each year, thousands of people have spent many weeks in hospital, often facing severe crashes with many of them unable to live, work or play as they used to do. For instance, according to 2013, it is estimated that 1.25 million people lost their live as a result of RTAs (WHO). Although; RTAs are the major global public health problem worldwide with 90% of deaths and morbidities occurring in low- and middle-income countries.

As a result of urbanization and increasing vehicle ownership in developing countries RTA Problem in low and middle income countries is the highest, and 90 percent of road traffic deaths occur in low and middle income countries which claim less than half (48%) of the worlds registered vehicle fleet. Fatality rate for low-income countries is 21.5 per 100,000 population, and it is 19.5 per 100,000 population in middle-income countries, but high-income countries register the least fatality rate which is 10.3 per 100, 000 population (see Table 2.2)

Table 2.2: Global fatality rates per100000 population WHO (2004)

WHO REGION	HIGH-INCOME	MIDDLE-INCOME	LOW-INCOME	TOTAL
AFRICAN REGION[b]	—	32.2	32.3	32.2
REGION OF THE AMERICAS[c]	13.4	17.3	—	15.8
SOUTH-EAST ASIA REGION[b]	—	16.7	16.5	16.6
EASTERN MEDITERRANEAN REGION	28.5	35.8	27.5	32.2
EUROPEAN REGION	7.9	19.3	12.2	13.4
WESTERN PACIFIC REGION	7.2	16.9	15.6	15.6
GLOBAL	10.3	19.5	21.5	18.8

[a] 30-day definition.
[b] No high-income countries.
[c] No low-income countries.

In 2005, WHO reported that traffic accidents had taken the second leading cause of death for the people whose age is 5 to 14 next to lower respiratory, the first cause for death of people whose age is 15 to 19, and the third leading cause of death for the people whose age is between 30 to 40 next to HIV/AIDS and Tuberculosis. The WHO reported that in 2000, l.26 million deaths occurred worldwide (20.8 per 100,000 people). Out of this, 90% of the deaths occurred in low and middle-income countries with South East Asia and Africa having the highest rates. In 2010, 1.25 million lives were lost as the result of RTAs, of which 80 % was in middle-income countries where 27 % of the world's population lives, but where only half of the world-registered vehicles are owned and driven. The African region has the highest road traffic fatality rate (32.2per 100,000) while the European region has the lowest fatality rate (13.4 per 100,000) (WHO, 2012).Table 2.3 below presents the estimated global road traffic injury related deaths.

Table 2.3: Estimated global road traffic injury related deaths

Estimated global road traffic injury-related deaths

	Number	Rate per 100 000 population	Proportion of total (%)
Low-income and middle-income countries	1 065 988	20.2	90
High-income countries	117 504	12.6	10
Total	1 183 492	19.0	100

Source: WHO Global Burden of Disease project, 2002, Version 1

According to the detailed analyses of global accident statistic by the united kingdom(UK) Transport Research Laboratory (TRL 2000), the change in road accident fatalities in the low and middle-income countries from 1965-85 was found increasing highly. Figure 2.1 below shows that African countries had the highest rate as compared to the others between 1968 and 1985. The number of deaths increased by over 300% in African countries and 170% in Asian. It is about 20 to 30 times as high when compared with the high-income countries. However, the accident fatalities in the developed countries have been decreasing yearly.

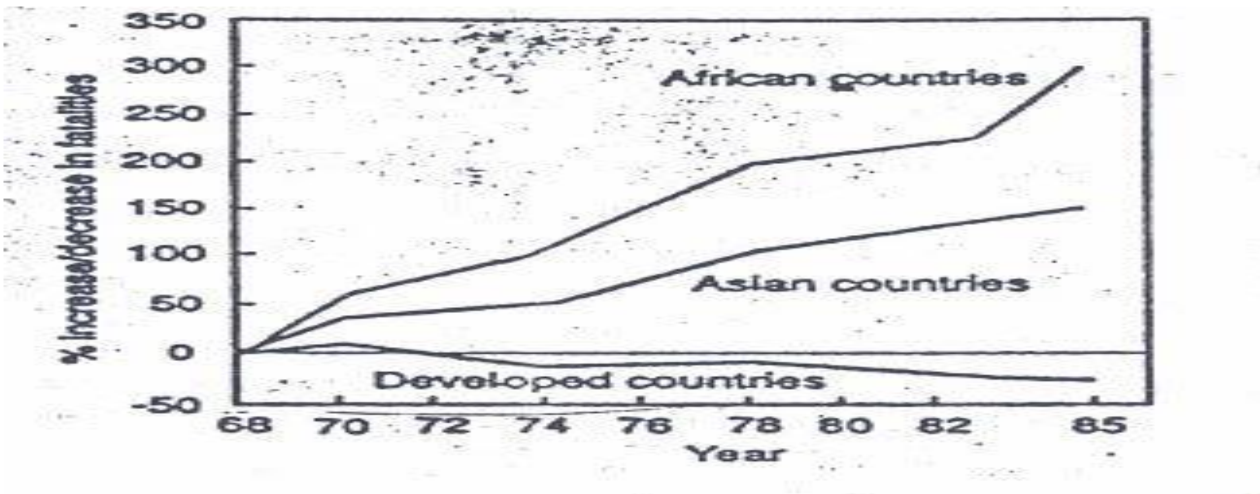


Figure 2.1: Percentage change in RTAs in Asia, Africa and developed Countries 1968-1985

Source: TRL, (2000)

From the low-income countries, Ethiopia has been found one of the countries with the highest rate of fatalities per year in the world .According to the Ethiopian Government reports (2007/8 Ethiopian calendar), at least 17% and 10% RTAs increases per year respectively. And also the Ethiopian police commissions (Jun 2016) reports 10 people die in every day from RTAs.

2.1 The Factor that Cause Traffic Accident

2.1.1 General

The causes of traffic accidents are: road, the driver, the road users, vehicle, and environmental factors. According to Ruman,(1985), studies from the American and British reports; accidents occurred 57% due to driver factor, 27% due to combined roadway and driver factor, 6% combined vehicles and deriver factor ,3%

a combination of the road, drivers, vehicles ,2% vehicle factor and,1% combined of vehicle and road user factor. The above percentages do not add up to 100. Road network in Africa is expanding fast, and similarly maintenance standards are improved resulting in safe standard of the road. However, in Ethiopia, due to lack of trainings on the subject area, contribution of roads and environment to traffic accidents are underestimated. In general, the various factors that cause accidents can be broadly categorized into road user related, road related, vehicle related and driver related.

2.1.2. Vehicles

The main cause for the traffic accident is due to vehicles' malfunction of the braking system, body, tyre, and vehicle service year, improper inspection and maintenance.

According to the TRL study; conducted from 1968 to 1969, on the spot investigation of 274 accidents, vehicle defects contributed to 18% of the accidents. University for the United States Department of Transportation in 1973, Vehicle defects were the contributor to 5% of defect related accidents and contributed to 13% of defect-related accidents when considered in correlation with either the human factor or the environment. Moreover, braking systems were identified as the major cause followed by tires and wheels.

2.1.3. Drivers

The driver's characteristics are important variables to be considered in the analysis of traffic accidents. Since drivers have a major role in many accidents, the driver is the key factor in most of the accidents and this is due to driver's judgment, skill and emotional makeup, age, sex, marital status, training, use of alcohol and drug, fatigue, use of crash helmets and safety belts, and speed. The Traffic Injury Research Foundation of Canada (1991; in NHTSA, 1995) reported findings of attempts to separate the effects of age and experience-related factors in traffic crashes. Crash rates were observed to decrease with increasing driving experience, among drivers of the same age. With respect to gender findings, it showed that younger male drivers, who commit more violations, are more likely to behave in a risk-taking manner, displayed through faster and more deviant driving styles and they have also been observed to be more likely to be involved in traffic accidents.

2.1.4. Road Users

Road user characteristics are important variables to be considered in the analysis of traffic accidents. Since road users have a major role in many accidents, the road user is the key factor in most of the accidents and this is due to road user's judgment, education, awareness and emotional makeup, age, sex, marital status, use of alcohol and drug and use safety belts.

2.1.5. Roads

The characteristics of a road have a great influence on traffic accidents. Improper standards of road construction and maintenance have a relationship with RTAs. The road can bring immeasurable change in the accident (using properly designed standard construction of the road with the correct specification, vertical alignment, sight distance, supper elevation, carriageway width, width condition, shoulder, road signs, road markings, junctions' designs, pavement surfaces, narrow bridges and culverts, median, width, street lighting and length of road).

2.1.5.1. Horizontal Alignments

i. Curve Radius

Most of the past studies show that accidents often occur at curves. Jianmei and Yulong (2000) reviewed the study on Shenda Freeway in china; that accident rate and curve radius has a close relationship. This means, accident rate reduces as the radius of the road increases; and the curves with the same or similar radius are safer than with different radius. A small radius, which is inserted into long and straight line, is dangerous, and the study concluded that modification of horizontal alignment is one of the effective countermeasures for highway accidents.

All being equal, crashes are more likely to occur on highway curves than on tangents (straight sections of road). Glennon (1987) quotes results which suggest that the average crash rate for curved road segments is three times that of tangents, and the average single vehicle's, run off road crash rate is four times higher. Moreover, curved road segments have higher proportions of severe wet road and icy road crashes. Figure 2.2 below shows the relationship between accident rate (AR) and radius of the Shenda Freeway in China.

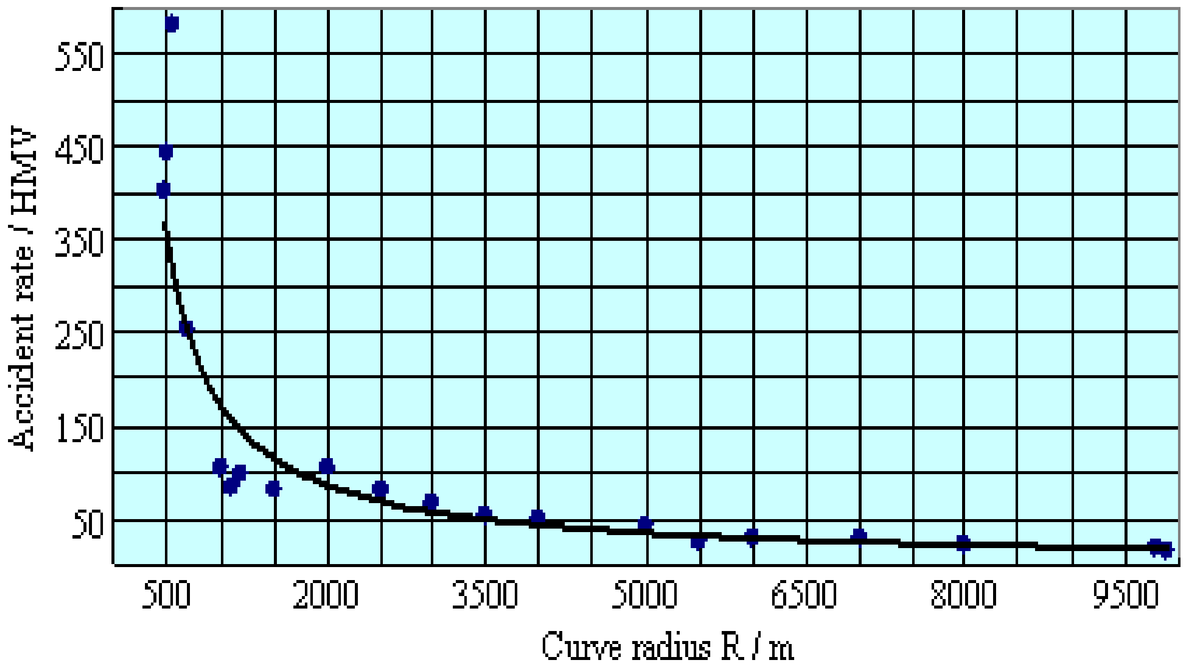


Figure 2.2: Relationship of Accident Rate (AR) and Radius on Shenda Freeway in China.

Dr. Getu (2009) reviewed that generally sharp curves result in high accident rate than more gentle curves; especially accident rate increases below 20 m radius. Almost, all previous studies' conclusions indicated that rate of accident is high on horizontal curves, at intersection and bridges. Brinkman (1984) claimed that the average rate of accidents on highway curve is three times that of average rate of accident at highway tangent and as the radius of horizontal curve decreases, the rate of the accidents increases.

Garben & Hoel (2009) showed that the accident rate for horizontal curves is 1.5 to 4 times greater than straight section. Sarbaz & Thomson (2009) studied the effect of the curvature on the accident rate and summarized that accident rate decreases with increasing radius of curves, for both right and left curves. Left turn curves have higher accident rate than right turn curves. Road sections with left curve and radius less than 100 meter have two times accident rate as compared to right curve radius less than 100 meter. In addition, road section with left curve radius of less than 100 m has accident rates four times as high as those on section with curve radius greater than 500 m. According to Iyinam & Ergun (2000), as the radius of horizontal curves decrease, the accident rates on the curves increase. Figure 2.3 below shows dependence of relative accident rate on curvature rate of change and radius of curves (Iyinam & Ergun; 2000).

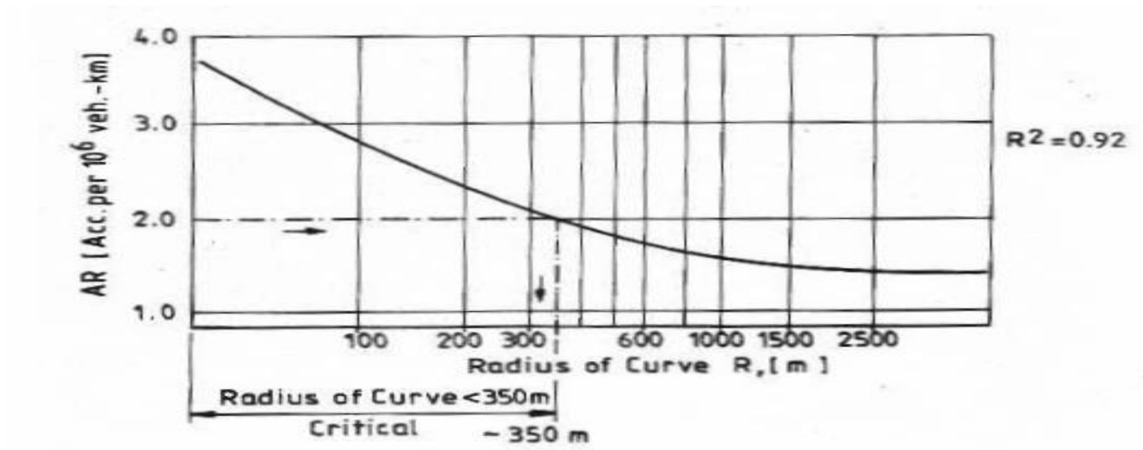


Figure 2.3: Dependence of relative Accident Rate on Curvature change Rate and Radius of Curve.

ii. Deflection Angle

According to the studies by Jianmei & Yulong(2000) on Shenda, Freeway in china ,small angle or deflection leads to steep curves to drive and unfavorable to traffic safety. Figure 2.4 below shows accident rate vs. deflection degree.

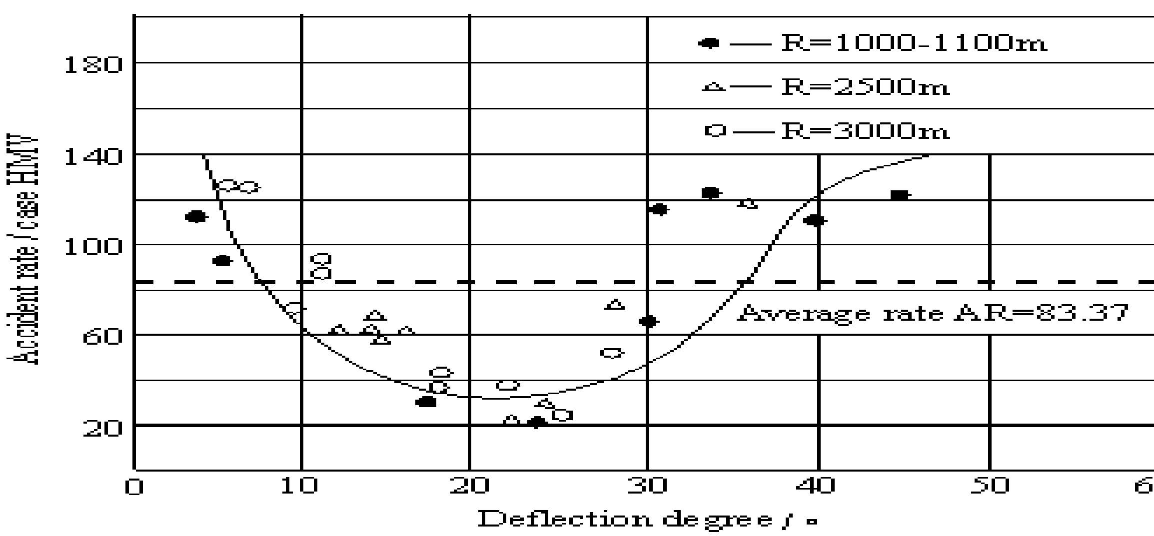


Figure 2.4: Accident Rate vs. Deflection Degree.

According to Figure 2. 4 above, when the angle of deflection varies from 0^o to 45^o, accident rate decreases with angle of deflection increasing to minimum level 7^o, and then less or equal to 7^o of deflection angle increases rate of accident with increasing of deflection angle. Getu (2009) reviews that section with curvature of 5 to 10 degrees is twice higher than a section with degree of deflection 1 to 5.

2.1.5.2. Vertical Alignments

I. Grade

Steeper grades are generally associated with higher crash rates. For example, Jorgensen (1978) suggested that both crash rate and severity increase with gradient, both upgrade and downgrade. Organization for Economic Cooperation and Development (1976), Hillier, and Wardrop (1966) reached a similar conclusion, but suggested that downgrades were the greater problem. Hoban (1988) concluded that steep grades above about 6 per cent are associated with a higher crash rate.

Bener & Joster (1999) stated that steeper grades increase accident rates; accident rate in mountainous terrain is higher than in flat terrain. They summarized that the effects of vertical road alignment on accident are: excessive speed, differential speed between vehicles and visibility difficulty for diver on crust curve.

Iyinam, & Ergun (2000) concluded that accident rate is highly increasing with increasing of road grades at the point of high slope section. At low radius of horizontal curves, the accident number is high. The effect of grade type on the accident rate was determined based on the Highway 72 km in the United States of America, Flzer Mountain from 1960 to 1996. The result of the study is clearly illustrated in Figure 2.5 below.

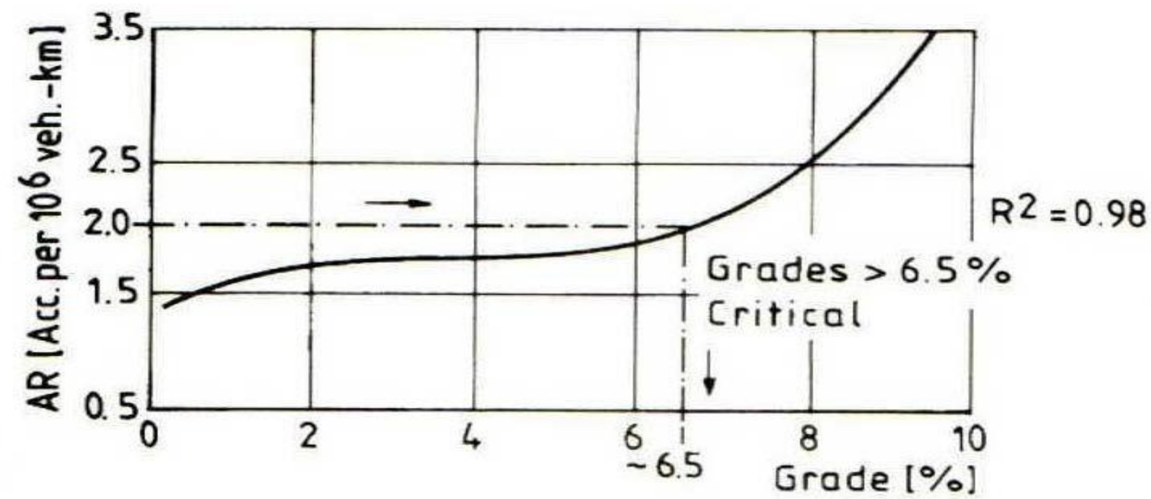


Figure 2.5: Relationships between Accident Rate and Grade

Emergency braking distance downgrade is longer than that of braking distance upgrade. Due to this, more accident occurs at downgrade than upgrade. Figure 2.6 below shows accidents at downgrade and upgrade.

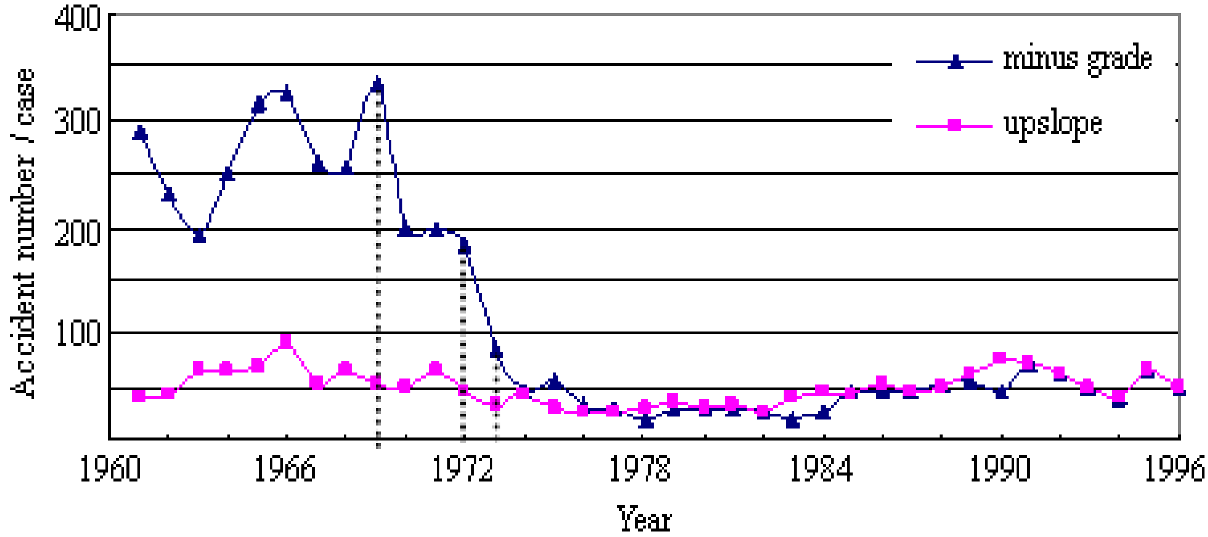


Figure 2.6: Accidents at minus Grade and Upslope.

Based on the above graph before safety measures was taken for the highway, accident rate was high on both upgrade and downgrades but significantly higher accident rate on downgrade than upgrade. After 1969, by increasing two directional lanes, remedial measures were taken to upgrade, and downgrade, and accidents are decreasing. Again, after installing a speed limit signs, the accidents get decreased and keep stable in absolve relatively. (Sarbaz Othman & Robert 2008).Thomson (2009) studied the effects of grades on accident rates and reported that accident rate on downgrade is slightly higher than on upgrades, and upgrades have less effect on accident rate while accidents' rate increases with increasing downgrade.

2.1.5.3. Cross Section Elements

I. General

Cross-section elements are one of the main important elements that will be considered in designing properly in order to decrease road accident. These include: lane width, shoulder width type, and cross section type.

Othman & Thomson (2009) studied the influence of carriageway width on the accident rate and suggested that accident rate decreases with increasing lane width greater than 5.8 m, and the carriageway width of 5.8 m has the lowest accident rate on one lane roads. According to Jianmei & Yalong studies (2009) ,from the acceptant data of 76 streets in Harbin, China, accident rates of a cross section element with different types were obtained as shown in Table **2.4** and Table **2.5**.

Table 2.4: Safety Influence Factor of Cross Section (TSIFCST) on urban streets (Yalong 2009)

Type of cross section	Accidents	AR (A/HMV)	Sample streets	Average AR (A/HMV)	SIFCST
Without any strip	1191	10011	61	164	1.26
With median strip	111	520	4	130	1.00
With separation strip	273	1341	10	134	1.03
With both median strip and separation strip	220	415	4	104	0.80

Table 2.5: Safety Influence Factor of Lanes Number (SIFLN) on urban streets (Othman & Thomson (2009)

Number of lanes	Type of lanes	No of Accidents	AR (A/HMV)	Sample streets	Average AR (A/HMV)	AR of different lanes number (A/HMV)	SIFLN
Double lanes	Double lanes	169	1584	18	88	88	
Four lanes	Four lanes	511	2075	25	83	86	1.00
	Four lanes with median strip	4	150	2	75		
	Four lanes with separation strip	59	404	4	101		
Six lanes	Six lanes	357	1078	11	98	83	0.97
	Six lanes with median strip	20	76	1	76		
	Six lanes with separation strip	214	450	6	75		
Eight lanes	Eight lanes	109	273	3	91	81	0.91
	Eight lanes with median strip	75	162	2	81		
	Eight lanes with separation strip	220	284	4	71		

II. Lane Widths

A study conducted by DeLuca (1985) in Miami-Dade,USA, showed a significant increase in sideswipe crashes with the decrease in lane width. Another study conducted by Zegeer et al. (1981) found that wide lanes had accident rates 10% to 39% lower than those on narrow lanes. The study showed that heavy vehicles overtaking other heavy vehicles remain centered in their lanes only when lanes were 12 feet (3.6 m) wide or wider. Studying the effects of lane width on trucks, Joshua and Garber (1990) found that lane width has the greatest effect on the probability of a truck accident, and that the probability for a truck accident increases as lane width decreases.

On the other hand, the study conducted by Hauer (2000) attempted to show the link between lane width and safety. Accordingly, the first link is that the wider the lane, the larger will be the average separation between vehicles moving in adjacent lanes. This may provide a wider buffer to absorb the small random deviations of vehicles from their intended path .The second link between safety and lane width is that a wider lane may provide more room for correction in near accident circumstances.

The National Association of Australian State Road Authorities (1988) quoted an Australian study where the sealed width on rural highways were widened from 4.9 to 5.5 m, and from 6.7 to 7.3 m, with a casualty crash reduction of 43 per cent. The Transportation Research Board (1987) quoted an American study where 2.7 m lanes on rural roads were widened to 3.3 m, and 3 m lanes were widened to 3.6 m , with a serious injury crash rate reduction of 22 %.

According to the Iyinam,& Ergun (2000) study as the pavement lane width increases, accident rates decrease and is illustrated in Figure 2.7 below.

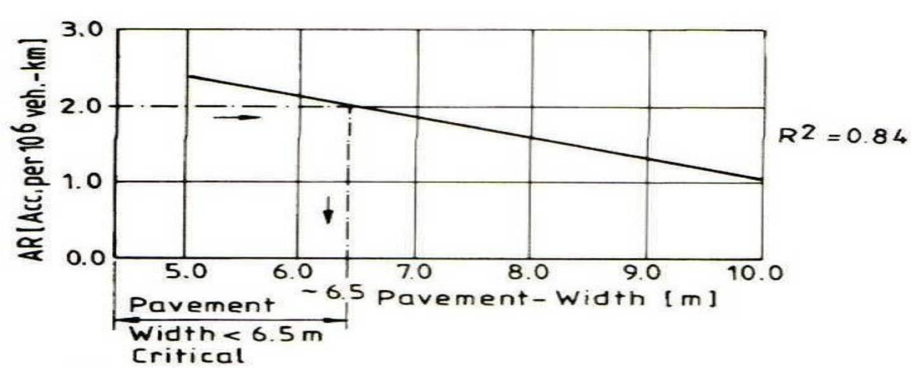


Figure2.7: Dependence of Relative Accident Rate on Carriageway Width

III. Shoulders

Shoulders are needed for parking, stopping vehicles, and overtaking crossing vehicles. The width of shoulder on crashes is less conclusive. However, there is some evidence that crash rates reduce as shoulder width increases up to 3m. For example, an American study (Zegeer, Deen and Mayes, 1981) produced results which showed a 21 % reduction in crashes when a road with no shoulders over the shoulders with 0.9-2.7 m in width.

The Chrisro J.Bener (1999) reviewed study showed that shoulders wider than 2.1m have significance lower accident rate than those narrower than 2.1m.The Iyinam, A.F.,Iyinam,S.& Ergun,M.(2000) studies tested the relationship between accident rate and shoulder width and showed that ,as the width of a shoulder is increased, the number of accident is decreased with respect to the type of shoulders Bener & Joster(1999) reviewed from various studies that accident rates become high on roads with a wider lane and paved shoulder than on wide lane with a gravel shoulder with 2 to 2.1m wide.

IV. Medians

The separation of opposing streams by a median leads to significant crash reductions. In urban areas, medians should ideally be wide enough to protect turning or crossing vehicles. The National Association of Australian State Road Authorities (1988) reports of Victorian study where 42 km of 2-lane highway was replaced with a 4-lane divided highway which resulted in, a 30 % crash reduction. It also reported an Adelaide study, which compared crash rates for 4-lane roads having wide medians, narrow medians, and painted narrow medians with 4-lane roads without medians. Compared with the undivided roads, the reduction crash rates were 30% in narrow painted median, 48% in narrow raised median, and 54% in wide median.

2.1.5.4. Sight Distance

Sight distance is a distance along the road surface at which a driver has visibility of objects stationary or moving at a specified height above the carriageway. Getu’s (2009) reviews from studies in Sweden concluded that increasing of sight distance results in decreasing of accident rate. Sight distance is particularly important for trucks since their poorer braking performance must be in part compensated by greater sight distance (Jarvis, 1994).

Neuman and Glennon (1983), in a study of stopping sight distance found that different geometric conditions were associated with hazards. These were divided into three groups as follows:

- Minor hazards: tangent horizontal alignment, mild horizontal curvature (>600m radius), mild downgrade (< 3 percent);
- Significant hazards: low-volume intersections, intermediate horizontal curvature (300-600m radius), moderate downgrade (3-5 per cent), structures; and
- Major hazards: high volume intersections, Y-intersections, sharp curvature (< 300 m radius), steep downgrade (> 5 percent), narrow bridge, narrowed pavement, freeway lane drop, exit or entrance downstream along freeway.(December 2014)

2.2. Identification Black Spot Locations

For the identification of black spots, there is a wide range of methodologies available ranging from simple models based on actual accident count to advanced statistical models based to estimates. The common methods used to identify the black spots were:

2.2.1 Accident Frequency Method

This Method (Layton, 1996; McMillen, 1999) uses the number of accidents at a location to identify its safety performance. Locations with more than a predetermined number of accidents are classified as high-accident locations. However, the shortcomings in this method are that, the difference of road and traffic conditions were not taken into account.

2.2.2 Accident Density Method

The Accident Density Method (Ogden, 1996) was used to calculate the number of accidents per unit length for a section of subject road sections with more than a predetermined number of accidents that are classified as high accident locations.

2.2.3 Accident Rate Method

The Accident Rate Method was developed by Layton (1996) and McMillen, (1999) which uses accident numbers divided by the number of vehicles to provide rates such as accidents per million entering vehicles per spot location and accidents per million vehicle-km for sections of highways. Locations with higher than a predetermined rate are classified as high accident locations. However, the shortcoming of this method is that the estimated accident rate value will be high in the sections where traffic number and accident number values are low. The other shortcoming is that, the estimated accident rate value will be low at the section where traffic number and accident number values are high.

2.2.4 Accident Severity Method

According to Layton (1996) and McMillan 1999), the concept of the Accident Severity Method is that the number of fatal and/or injury accidents at a location or section of highway are given greater weights than property damage- only accidents.

2.2.5 Quality Control Methods

Quality Control Methods (Homburger, 1996; Layton, 1996);The logic of this method is that a location is considered to be a black spot if its safety parameter shows higher values than the critical value. The control of the quality of the analysis is assured by applying a statistical test. This is based on the assumption that occurrences of traffic accident follow the Poisson Distribution. In this regard, several parameters can be used such as: accident rate, accident frequency and accident severity. For example, when using accident rate as a parameter, the locations with an accident rate that is greater or significantly greater than the average accident rate for the similar region are pointed out. In other words, the locations with accident rate greater than the critical rates are classified as black spot locations. All the above common methods for black spot identification are used by many transportation research centers. However, the availability of input data decides the method to be employed for identification of black spots. For instance, for the above listed methods of black spot identifications, the respective data requirements are depicted in Table 3.1 below.

Table 3.1: Data Input Requirement for Different Black Spot Identification Methods

Data Input	Accident frequency method	Accident density method	Accident rate method	Accident severity method	Quality control methods
Accident summaries	X	X	X	X	X
Traffic volume data			X		X
Road data		X	X		X
Accident severity				X	
Average accident experience	X	X	X	X	X
Statistical constants					X

2.3. Black Spot Treatment

In most developed countries, by taking simple countermeasures, accidents were reduced from 40% to 50 % and in some areas 40% to 80 %. To treat black spot locations; engineering measures and planning improvement, such as, traffic signals, pedestrians' crossings, junction layouts, and speed control humps can affect road user behavior in such a way that errors are less likely to happen, or when they do happen, the environment can make them less serious (TRL 2000).Some of the common types of remedial measures are stated in Table 2.6 below.

Table 2.6: Accident Situation and Potential Remedial (TRL 2000)

General accident type	Potential Remedial
Skidding	Restoring surface texture
Collision with roadsides obstruction	-Better delineation - Guardrails - Safety fences - guide posts
Pedestrian /Vehicle conflicts	-Pedestrian /vehicle segregation - Facilities for pedestrians - Pedestrian protection
Loss of control	- Road marking - Delineation - Speed control - Guardrails
Darkness	- Reflection signs - Delineation - Road markings - Street light
Poor visibility	- Conspicuity - Realignment - Improved sightlines
Poor driving behavior	- Road markings - Enforcement - Media barriers
Intersection	
Turning Movement	- Channelization - Signals - Turn prohibitions - Round about
Overtaking	- Channelization

	- Markings
Pedestrian /vehicle conflict	- Refuges - Crossing facilities - Underpass/ over bridges - Guardrails /fences
Poor visibility due to parking	- Parking controls
Darkness	- Lighting - Reflecting signing /marking
Links	
Parked vehicles	- Parking controls - parking provision
Speeding	- Speed limits - Enforcement - Speed control devices
Pedestrians	- Access control / road closures - Crossing facilities - Guardrail / fences - Wider foot ways - Underpass / over bridge.

CHAPTER THREE

METHODOLOGY

3.1. The Study Area

The Debre Markos - Injibara road is 150 km long located along the major primary road between Addis Ababa, the capital city of Ethiopia and Bahar Dar town located in the northwestern part of the nation adjacent to Lake Tana, the largest lake in the country and the source of the Blue Nile.

Figure 3.1: Location of Study Road (Study Area)

The road accommodates significant traffic with average annual daily traffic (AADT) of well over 1,500. In addition; the road traverses the most significant agricultural area of the nation. However, the area has one of the highest numbers of accidents and casualty rates in the country (Traffic Accident Report of Ethiopia, 2007).

3.2 Study Design (Research Frame)

This study, in a broad sense, undertakes an analysis of road traffic accidents along the Debre Markos- Injibara, Amhara road (150km) located within the Amhara region of Ethiopia. This research is an attempt to conduct a detailed investigation of accident phenomenon on the study road. Secondary data were collected from various sources, which included the records of the Amhara region Police commission, the regional office of the Ministry of Transport; and the regional Office of Statistics.

The records contained information on crash severity (fatal, serious, slight and property damages), categories of road users affected, vehicles involved, and causes of crashes (defects-road geometry, human error, vehicle defect, or otherwise). The data collected were analyzed by using both descriptive and inferential statistics. The data included geometry of the road, accident time, weather condition, light condition, cause of accidents, types of accidents etc.

3.3. Sample Size and Sampling Procedures

Non -probability sampling techniques of purposive sampling were applied. All registered RTAs year of 2009 and the first 6 month of 2010 that were documented in police station registries between Debre Markos and Injibara towns were included in the sample. Besides, purposively selected traffic police commission officers who were used for key information for the RTAs data about the study area.

3.4. Study Variables

- **Independent Variables**: different factors that causes road traffic accidents such as road users related such as drivers, pedestrians and passengers, vehicle related such as vehicle type and vehicle service year, road related such as geometrical design elements, payment design element and road constructions materials, road user's sex and age etc.
- **Dependent Variables**: road traffic accidents (RTAs) and severity types such as:
  - **Fatal Crash or Killed**: A human casualty who dies within 30 days after the collision due to injuries received in the crash;
  - **Slight Injury:** a person hospitalized for less than 24 hours;
  - **Serious Injury**: a person seriously injured and hospitalized, other than for observation, for more than 24 hours; and
  - **Property Damage**: is a non-injury crash (property damage e.g. roadside objects, vehicles, etc.)

3.5. Data Collection Procedures

The research source considered both primary and secondary data. The research was conducted first by identification of the causes of traffic accidents through literature review and desk study on selected road project traffic accident data reports, documents, and manuals. Next, based on the above sampling areas and number of samples were identified.

This section of the study discusses how data were identified, extracted from the data source and collected (e.g traffic police) and systematically presented by organizing and summarizing data using standard formats. Other field measurements and technical observations were done to gather data on the geometrical features of different intersections for capacity analysis. These included; number of lanes, lane width, configurations of lanes, grade, width of median, movement policy road right of way (ROW).

3.6. Data Processing and Analysis

Both descriptive and inferential statistics were used in the data analysis that means, after collecting the necessary information, data processing and interpretations were done using the binary Regression Model and descriptive methods.

The analysis was done; in the form of tabulation, charts, and graphs. Furthermore, analysis was done to understand the significance of the results and apply prioritizing values to identify the hazardous locations on the road commonly termed as black spots. For the identification of black spots, there is a wide range of methodologies available ranging from simple models based on actual accident count to advanced statistical models based to estimates. The time interval used in processing of black spot identification is neither long nor short. If longtime data is used, traffic conditions can cause changes based on the pattern of accidents; and if it is short time data, it will enable early action to be taken at sites at which sudden increases in accident numbers or accident severity have occurred. Therefore, it is often considered that three years is a reasonable period for analysis. May (1964) use accident data which were collected over a 13-year period, but he concluded that the optimal time interval should be three years, and that there is no significant gain in reliability beyond a three-year period. Accordingly, the data that were used for identification of the black spot sections on the Debre Markos - Injibara roads were recent years of 2009 up to half of 2010. The common methods used to identify the black spots were: From the methods of identifications of black spot identifications; I apply the quality control method (Zegeer: 1982) of accident rate calculation, critical accident rates were calculated using the following analysis method. The result provides the data for ‘Accident Rate’, Equation (1) below which was used for determining ‘Average Accident Rate’ (Ra) and calculating critical accident rate (Rc), Equation (2) below. It was based on the assumptions that the crashes would be approximated by using the Poisson Distribution and injury accidents per million vehicles-km were calculated using Equation 3.

- **Accident Rate**

Uf = U x 106 / (AADT x 365 x n x L)...1

But**;**

- **For Junctions:**

Uf = U x 106 / (AADT x 365 x n)

- **For Road Sections**:

Uf = U x 106 / (AADT x 365 x n x L)

where

Uf = Injury accidents per million vehicles

U = Number of reported injury accidents during the period n

n = Period length (years)

L = Section length (km

The next step is

- **Critical Crash Rate:**

$$\mathbf{Rc} = \mathbf{Ra} + \mathbf{confidence\ level} * \sqrt{\left(\frac{\mathbf{Ra}}{\mathbf{MEV}} + \frac{\mathbf{1}}{\mathbf{2MVE}}\right)} \quad \text{..................................2}$$

where,

Rc = Critical Accident Rate (accidents per million vehicles or accidents per million vehicle-km)

MEV= Millions vehicle-km of vehicles traversing road segment during the analysis period

$$\mathbf{MEV} = \frac{\mathbf{ADT * 365 * n}}{\mathbf{1000000}}$$

where

ADT=Average daily traffic

n =Number of years

Rav =Average Accident Rate (accidents per million vehicles or million vehicle-km)

$$\mathbf{Rj} = \frac{\mathbf{fj*10^6}}{\mathbf{365.25*Y*Lj*AADT}}$$

$$\mathbf{Ra} = \frac{\mathbf{\sum fj*10^6}}{\mathbf{365.25*Y*\sum Lj*AADT}}$$

where

Rj **=**Accident rate of site j(acc/Mveh-km**)**

Ra =Average accident rate (acc/Mveh-km**)**

Fj **=**Accident frequency at site j

Y **=**Period of analysis (year)

L **=**Section length of site j(km)

❖ **For Road Sections**

$$\boldsymbol{Rc = Ra + [(K)\sqrt{\frac{Average\ crash\ rate}{365*Y*AADT*Lj}}/1000000][\frac{1}{2(365*Y*AADT*Lj}/1000000]}$$

❖ **For Junctions**

$$\boldsymbol{Rc = Ra + [(K)\sqrt{\frac{Average\ crash\ rate}{365*Y*AADT}}/1000000][\frac{1}{2(365*Y*AADT}/1000000]}$$

where,

AADT = Average Annual Daily Traffic for the spot (for an intersection, the sum of the volumes on all approaches).

Y = Number of years being analyzed

L = Length of the segment in kilometer (for intersection L is 1).

K = Confidence level

Base on the above; the location's crash rate to the critical crash rates was compared. If the location crash rate exceeds the critical crash rate, classify the location as an accident black Spot.

3.7 Ranking of Sites

For prioritizing those black spots, the ratios of accident costs by degree of severity were established by the TRL (2000). The weights provided were: 5 for fatal accident; 3 for serious jury; 2 for light injury and 1 for property damage. The following equation was used to estimate.

$$\mathbf{P} = \frac{\mathbf{1*W+2*X+3*Y+5*Z}}{\mathbf{D}}$$

Where**;**

P = Priority value;

W= Total number of property damages

X = Total number of light injuries;

Y = Total number of serious injury;

Z = Total number of fatalities; and

D = Total number of distance of the black spot section in kilometer

3.8. Determining the Magnitude of Determinants of Fatal RTAs.

The first task of a writer is determining the appropriate models that fit the nature of dependent variables with special emphasis fatal RTAs severity. Since this type of severity needs urgent solution from other types of RTAs severity. Thus, for this typical research work the dependent variable is probably of fatal accident which is suited for binary outcome models. Therefore, to examine the magnitude of major determinants of RTAs with special emphasis fatal RTAs severity; the writer used a binary logistics model given its mathematical simplicity. Accordingly the model is specified as:

$$\mathbf{y^* = X^I\beta + \varepsilon_i}$$

where;

Y^*- latent variable

X- a vector of explanatory variables

B- Parameters to be estimated

$$\mathbf{y = 1, if\ y^* > 0,}$$

$$\mathbf{y = 0, otherwise}$$

Then $$\mathbf{p = \frac{e^{X^I\beta}}{1+e^{X^I\beta}}}$$

But the researcher use a grouped data approach where:

$$\mathbf{p} = \frac{\textbf{Number of success(no.Fatal)}}{\textbf{Total RTAs severity}}$$

And hence the odds ratio is computed as

$$\textbf{odds ratio} = \frac{\mathbf{p}}{\mathbf{1-p}}$$

$$\textbf{logit index} = \textbf{ln(odds ratio)}$$

where

P=probability of occurrence

Based on the above; Data were entered and then analyzed in STATA Version 14.Binary logistic regression was used to assess associations between fatal RTAs severity and independent variables (driver-related characteristics, collision cause, land use, location, service year of vehicle, light condition, road user age, road geometry and types of collision). Odds ratios (OR) and 95%-90% confidence intervals (CI) with $P < 0.05-0.1$ were considered statistically significant. Chi-square tests were used to explore RTAs for linear trends.
The qualitative data were analyzed using a content analysis technique. The transcribed text was imported into Open Code to simplify the coding process. Units of relevant meaning were examined line-by-line and coded.

3.9. Expected Outcomes

At the end of this research, it was expected that all the research questions would be answered and possible solutions would be recommended. The outputs of the research will also serve as a reference material for those who need further investigation about road traffic accidents and pertinent government and public organizations may tend to reduce road traffic accidents.

Generally, the following findings are expected to generate at the completion of this research:

- Major road traffic accident factors that frequently occurred along the study road;
- Black spot locations will be identified on the subject road;
- Different causes, extent, and intensity of road traffic accidents would be identified on the study road.
- Models will be developed to determine the magnitude of determinants of fatal RTAs on the study road; and
- Best practices or measurements will be recommended to reduce road traffic accidents on the study road

CHAPTER FOUR

ANALYSIS, RESULTS, DISCUSSION AND INTERPRETATION

4.0. Chapter Overview

As was indicated in Chapter One, the specific objectives and subsequent research questions were indicated as follows:

(i) What are the types of RTAs occurring on Debre Markos -Injibara road?

(ii) What are the major causes of road traffic accidents on the study road?

(iii) Which factor is more significant to RTAs along the study road? And

(iv) Along the study road section, which locations are more vulnerable to RTAs?

In order to answer the above questions, the road traffic accident data were collected from traffic police commission then analyzed and interpreted. Observations were made in the process of gathering data and information needed during the study. The required methods were applied both descriptive and inferential analysis methods were applied. The rationale of combining the two methods was to ensure that the limitations of one type of data would be balanced by the strengths of the other. This ensured that understanding was improved by integrating different ways of thinking. In this regards, the research findings, interpretation and discussions are presented in the following sections.

4.1. Accident Severity Types and Major Contributing Factors on Debre Markos-Injibara Road

4.1.1. RTAs on the Study Road Sections

In this part, RTAs were discussed by: Severity types, Days of weeks, Times of accident occurrences, Land use, Collision type, Road features, Road junction type, Vehicle service year types, Road way surface condition, types of vehicle defects, and Road light condition.

4.1.2. RTAs Severity on the Study Road

As shown in Table 4.1 and Figure 4.1 below; 160, 75, 42 and 66 were fatal, serous, light and property damages data recorded in this study period respectively. From this recorded data, it was observed that fatality was the highest of the other types of RTAs.

Table 4.1: Types of RTAs Severity

Types of RTAs Severity	Fatal	Serous	Slight	Property
Amount of RTAs severity	160	75	42	66
%	46.65	21.86	12.24	19.24
Total RTAs Severity		**343**		

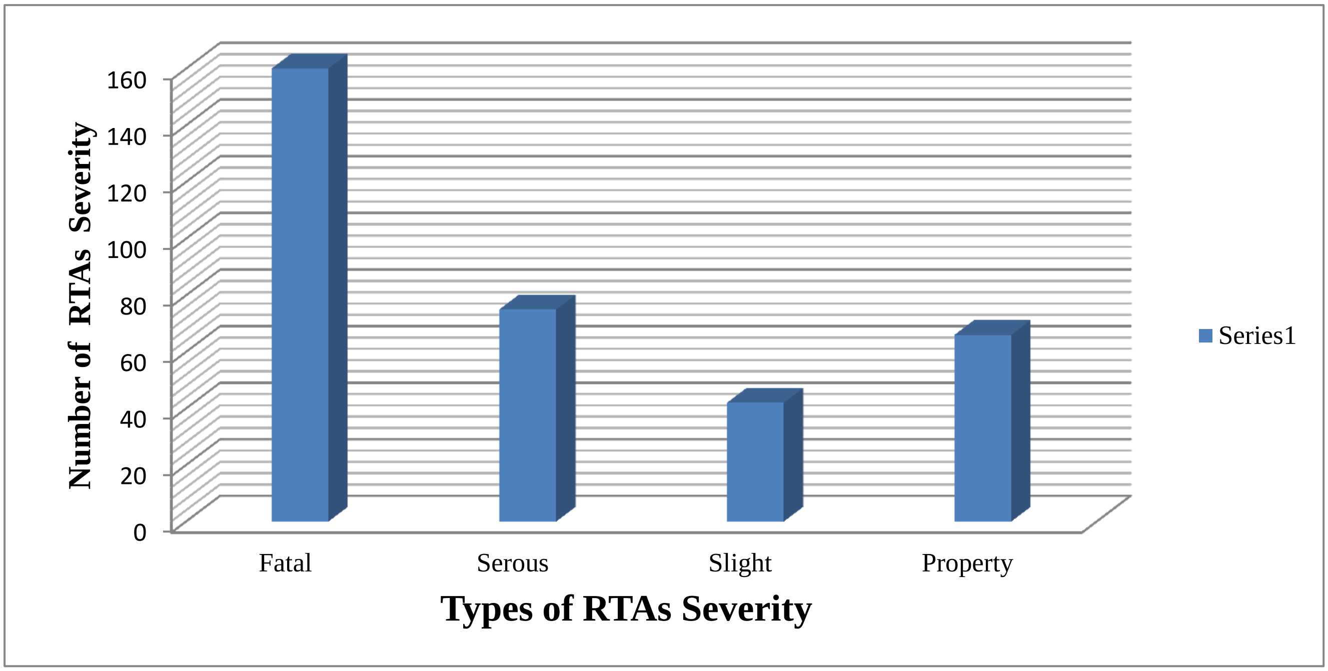


Figure 4.1: RTAs on the study road

4.2. Major Factors Contributing to Road Traffic Accidents on the Study Road

4.2.1 Introduction

This section focuses on the identification and analysis of the major factors contributing to the problem of road traffic accidents in respect of drivers, pedestrians, passengers' sex and age.

4.2.2 Drivers by Sex and Age

4.2.2.1 Drivers by Sex

Most of the times, the major contributing factor in the majority of traffic accidents is the behavior of the drivers; hence, worldwide studies such as those of the OECD show that about 80-90% of the RTAs are attributed to the fault of the drivers, and the majority of them are male drivers (Bitew, 2002). Similarly, the results of the analysis that are depicted in Table 4.2 below confirm this. Accordingly, 86.88% of the drivers' errors are caused by male drivers, only 1.75% by female drivers and 11.37% were caused by unknowns, in year 2009 and half year of 2010. Moreover out of the 86.88% of road accidents caused by male drivers, about 44.6% (133) were fatal accidents, 21.5% (64) were serious injuries; 13.1% (39) were slight injuries and 20.8% (62) were unknown accidents. Correspondingly, the female drivers' road traffic accident casualties were minimal, i.e., only 3 serious injuries and 3 property damages with no fatalities and slight injuries. Figure 4.2 below graphically illustrates RTAs by sex of drivers and accident severities.

Table 4.2: Sex of Drivers vs Types of RTAs Severity

Sex	Types of severity				Total	%
	Fatal	Serious	Slight	Property		
M	133	64	39	62	298	86.88
F	0	3	0	3	6	1.75
Unknown	27	8	3	1	39	11.37
Total	160	75	42	66	343	100.00

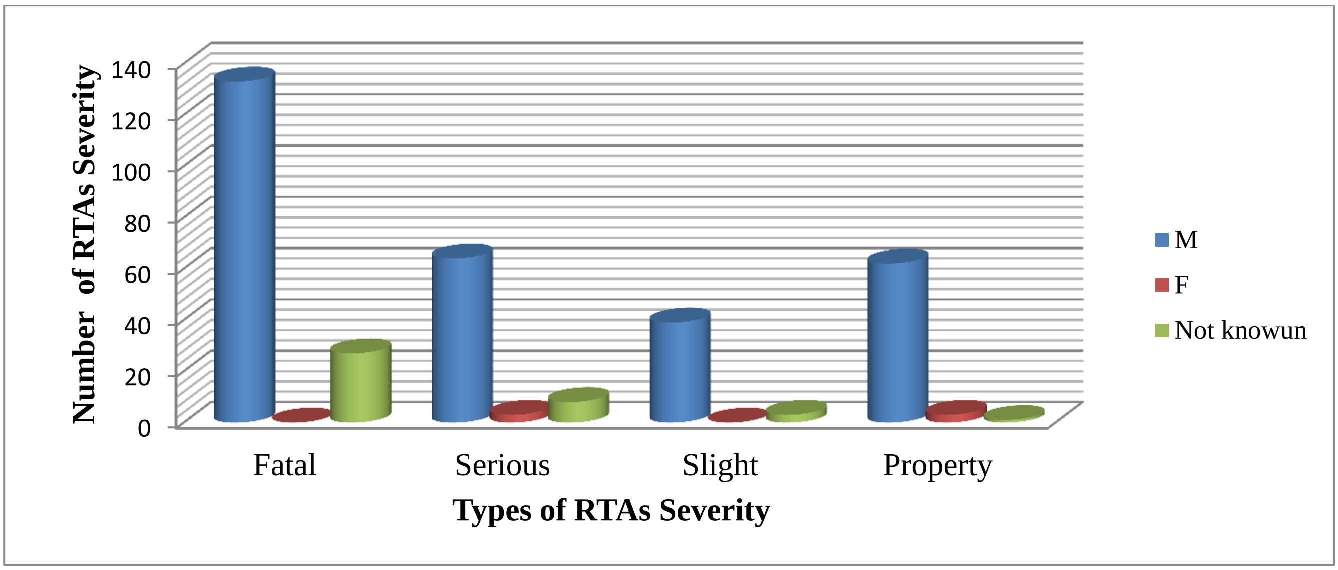


Figure 4.2: RTAs by Sex of Drivers and Accident Severities

Manually; Chi-square test was conducted to observe road accidents by sex of the drivers and frequency of accidents. It shows that the male participants were involved in accident more than the female participants with p value<0.05.

$$\boldsymbol{Chi-square\ (X^2)} = \frac{\sum(\boldsymbol{Observed\ Frequency - Expected\ Frequency})^2}{\textbf{Expected Value}}$$

$$\boldsymbol{Expected\ Frequency} = \frac{\sum \boldsymbol{Total\ accident\ for\ each\ row * Total\ accident\ for\ each\ collummn}}{\textbf{Total RTAs in this segment}}$$

For Example,

$$Expected\ Fatal\ Frequency\ for\ Male = \frac{298 * 160}{343} = 139.01$$

Similarly, expected frequencies were calculated and the results are shown in Table 4.8 below.

Table 4.3: Expected value calculation

Sex	Types of RTAs severity				Total
	Fatal	Serious	Slight	Property	
M	139.01	65.5	36.7	56.93	298
F	1.98	0.88	0.5	1.75	5
Unknown	18.8	8.6	4.8	7.32	40
Total	160	75	42	66	343

Based on the above observed frequency and expected frequency; Chi-Square test was calculated as follows:

$$Chi - square\ (X^2) = \frac{\sum(Observed\ Frequancy - Expected\ Frequancy)^2}{\text{Expected Frequancy}} = 19.098$$

Degree of freedom (Df) = n-1; Therefore, depending on the number of rows and colons, Df would be: (3-1)*(4-1) =2*3 = 6 and significant value p=0.05

Based on the above data, since p-value = 0.000 ≤ 0.05, the null hypothesis is rejected with Chi-square = *19.098* > 0.675727 = critical Chi-Square value. (p = 0.05 and df = 6) by using Chi-square table critical value of Chi-square is 0.675727.

Consequently, in agreement with the above analysis, the Chi-Square Test result confirms that the presence of statistically significant difference among male and female drivers in causing RTAs in this study road at probability level of p (0.000) and with Chi-Square value of 19.098. Meaning, the more the probability level approaching to 0.000 and the Chi square value greater than the critical value of 95% confidence interval i.e., 0.675727, show the presence of significant effects between the cross-tabulated variables; in this case, accident and sex of drivers.

Manually; Based on Odds Ratio/OR/ model, the probability of involvement of each sex in crashes is calculated as follows.

From the findings above, 86.88% of the males and 1.75% of the females were involved in crashes in a given year.

- Let P equal the probability a male is involved in crashes.
- Let Q equal the probability a female

- Odds males are involved in crashes: odds(M) = P/(1-P) = 0.87/0.13 = 6.69
- Odds females : odds(F) = Q/(1-Q) = 0.018/0.98 = 0.018
- The odds ratio for male vs. female involvement in crashes is then odds (M)/odds (F) = 6.69/0.018 = 371.67

Therefore based on the result, the odds of being involved in crashes are about 371.67 times greater for males than for females.

4.2.2.2 Drivers by Age

Table 4.4 and Figure 4.3 below elaborate the age distribution of the drivers and associated effects on the levels of RTAs. Accordingly, about 2.92%, 50.15%,19.83%, and 2.92% of the reported driver casualties have an age of <18, 18-30, 31-50, and >50 years respectively. When drivers' accident victims were compared by their age category, those drivers with an age less than 18 years old is the lesser affected age category since acquiring driving license considers at minimum of 18 years. In contrary, drivers with an age greater than 18 years, but less or equal to 50 years were the most affected drivers in RTAs in all categories of RTAs classifications. For instance, 50.15% and 19.83% of the drivers with ages of 18-30 and 31-50 years respectively were found in death report. Generally, the current study concluded that the number of drivers who suffered in deaths, serious injuries and light injuries have decreased as the age of drivers becomes above 50 years old as shown in Table 4.2.

Table 4.4: Age Distribution of Drivers for RTAs Severity in this Road Section

Age of Drivers	Types of severity				Total	%
	Fatal	Serious	Slight	Property		
Below 18	4	2	2	2	10	2.92
18-30	67	36	26	43	172	50.15
31-50	31	17	5	15	68	19.83
Above 51	0	4	3	3	10	2.92
un known	58	16	6	3	83	24.20
Total	160	75	42	66	343	100.00

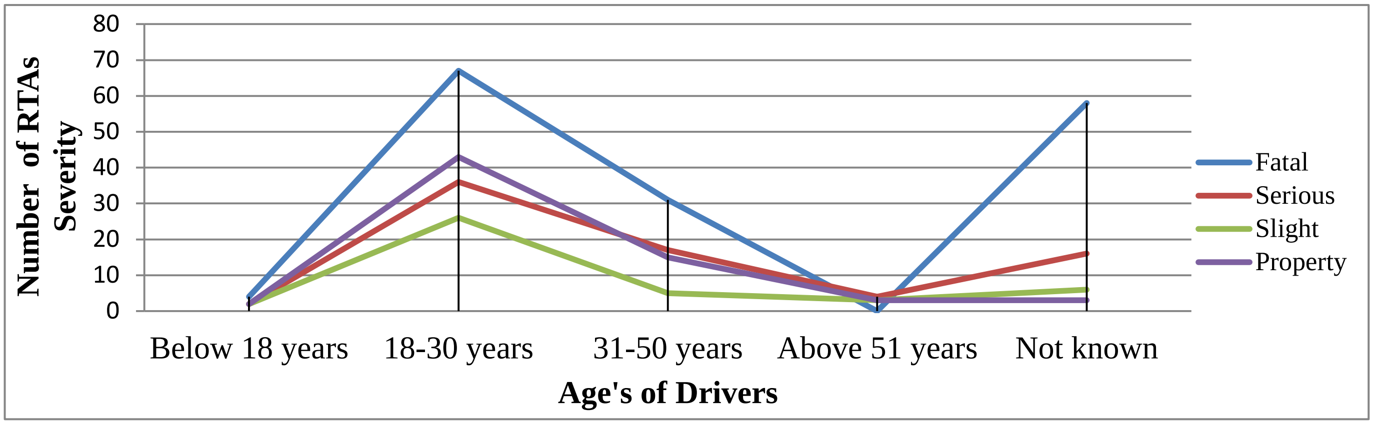


Figure 4.3: Age Distribution of Drivers by Accident Severity

Figure 4.3 above illustrates that the highest percentages of drivers who were involved in accidents were between the ages of 18 and 50. This trend shows that aged drivers are more careful on traffic safety than adults below 50 years old. It is possible that aged drivers have more experience and probably much more responsibility than the younger ones. In addition, it is also rational to say that the behaviors of young drivers towards traffic safety is poor sometimes due to peer group pressure by influencing on driving style leading to traffic accidents. However, young drivers have more endurance in driving longer distances than elder drivers.

4.2.2 Drivers, Pedestrians, and Passengers Casualties by Age and Sex on the Study Road

Road users (drivers, pedestrians and passenger) causalities by age and sex on the study road are discussed below based on Table 4.5 and Figure 4.4.

Table 4.5: Drivers, Pedestrians, and Passengers Casualties by Age and Sex

Road Users Injury severity	Age	RTAs by severity type, number of accidents by sex and age					
		Fatal		Serious		Slight	
		Male	Female	Male	Female	Male	Female
Drivers	below 18 years	0	0	1	0	0	0
	18-30 years	10	0	1	0	1	0
	31-50 years	3	0	1	0	1	0
	above 51 years	0	0	0	0	1	2
Pedestrians	below 7 years	3	4	3	0	2	2
	7-13 years	8	7	1	0	3	4
	14-17 years	0	3	0	0	1	1
	18-30years	26	14	18	9	13	3
	31-50 years	26	12	16	6	6	1

	above 51 years	4	2	1	2	0	1
Passengers	below 7 years	0	0	0	0	1	0
	7-13 years	0	1	2	0	0	0
	14-17 years	2	0	1	0	0	0
	18-30years	24	11	15	5	22	21
	31-50 years	18	9	17	7	20	4
	above 51 years	0	1	6	0	10	0

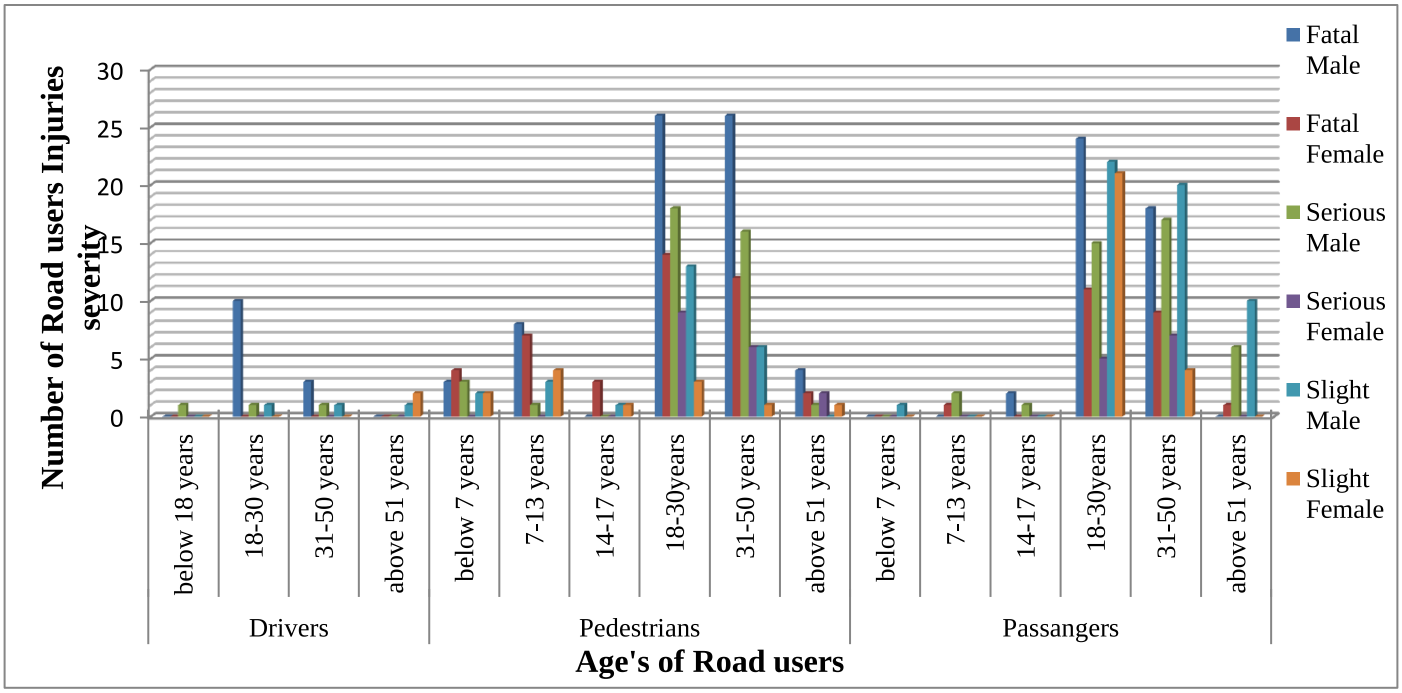


Figure 4.4: Drivers, Pedestrians and Passengers Casualties in this Road section by Age and Sex

Figure 4.4 above shows the distribution of RTAs victims by age group and sex. The findings show that pedestrians are more vulnerable to traffic accidents than passengers. Pedestrians aged 18-30 and 31-50 accounted for the highest percentages of accident victims than those groups who are aged below 7, 7-13, 14-17 and above 51. Generally, the magnitude of the road accident victims (drivers, pedestrians, and passengers) within the age group of 18-30 were the most affected during this period, followed by age group of 31-50 in the same period. In contrary, road users whose age is less than 7 were the least victims of RTAs along this road section. Moreover, in Figure 4.4 above, the road users RTAs severity analysis of the study confirms that there are more number of male passengers' victims than the female counterparts at all accident levels. For example, large number of road users' (passengers', drivers' and pedestrians') deaths, serious injuries, and light injuries have involved more males compared as female passengers. Shockingly, the most affected road users were younger productive groups under this period, i.e., those between the ages of 18 and 30, followed by 31-50 years of age categories shown in Figure 4.4. The trends of RTAs in all the three categories which included deaths, serious injuries, and slight injuries for both sexes in 18-30 and 31-50 age categories had disclosed increment as shown in Table 4.5, and Figure 4.4.

4.2.3. RTAs by Day of the Week on the Study Road

Analyses of RTAs severity on the study Road by day of the week were recorded in all days of the week. Since, there were significant number-accidents of 74 and 51 on Saturday and Thursday respectively; though, Sunday relatively has small RTAs. This may be because of low movements of vehicles, passengers, and pedestrians on weekends (see Figure 4.5). Generally, the analysis confirmed that higher accidents occurred from Wednesday to Saturday, especially on Thursday, and Saturday. Since along the study road these days are the market days.so; the movements of vehicles, passengers, and pedestrians on these days were high in the selected segment (see Figure 4.5)

Table 4.6: RTAs by Day of a Week on the Study Road

Day of the Week	Number of Severity	%
Monday	42	12.24
Tuesday	43	12.54
Wednesday	47	13.70
Thursday	51	14.87
Friday	46	13.41
Saturday	74	21.57
Sunday	40	11.66
Total	343	100.00

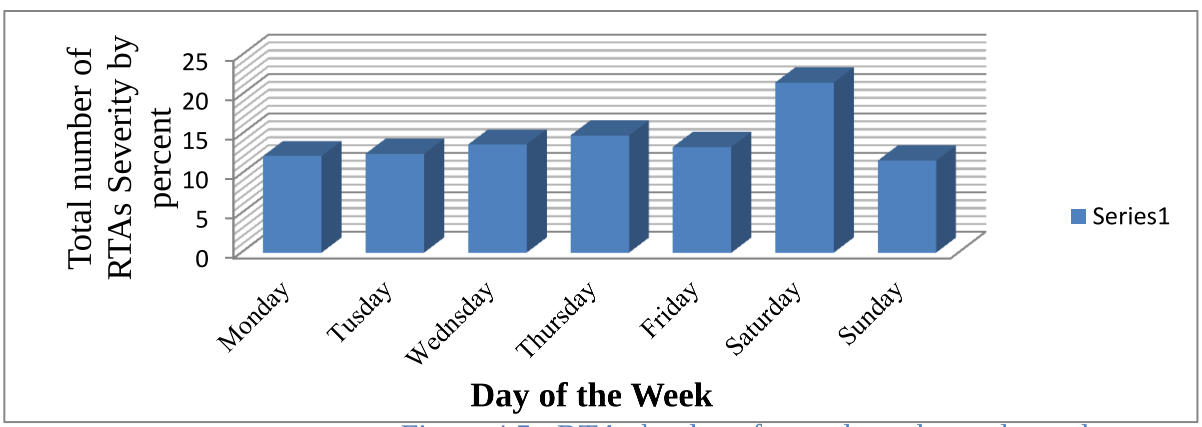


Figure 4.5: RTAs by day of a week on the study road

To reduce RTAs severity on the Study Road, the Government has exerted effort to undertake remedial measures like awareness creation activities through mass media for the community, students, drivers, and trying to upgrade the quality of drivers by adopting new licensing systems for different types of vehicles. Besides, much effort should be done to enforce the drivers and punish them when they pass the rule and when they drive with high speed.

4.2.4. RTAs on the Study Roads by Hour of the Day

Road traffic accidents vary by hours of a day; with maximum crashes when mobility of pedestrians, passengers, and drivers frequency increases. Accordingly, accident reports in this study have three basic stages as minimum stages, medium stages and maximum stages. Table 4.7: depicts this

Table 4.7: Time Period Corresponding to Accident Stage

Time period (local time)	Accident stages
6:00am-8:00am & 11:00pm-14:00pm	Maximum
2:00am-4:00 am morning & 15pm-17:00am	Medium
20:00am-24:00am	Minimum

In the first stage, 6:00 am-8:00 Pm and 11:00 Pm-14 am local time RTAs severity rates had maximum RTAs severity features for this period and it have peak values from 7:00pm – 8:00pm and from 12:00pm-13:00pm local time, But 20:00am to 24:00am have minimum RTAs severity. And on the other hand from 2:00-5:00, 8:00-11:00 and 14:00-17:00 have medium RTAs severity records for this period. (See Figure 4.6)

Generally Figure 4.6 below illustrates RTAs severity distributed over the hours of the Day. from 1:00-3:00,RTAs tremendously increased and reached maximum at 3:00,from 3:00 -6:00 RTAs tremendously decreases, from 6:00-8:00 RTAs tremendously increases,8:00-10:00 RTAs tremendously decreases,10:00-13:00 RTAs tremendously increases and from 13:00-24:00 RTAs tremendously decreases, and reaches minimum levels at 24:00 (12 pm) (see Figure 4.6). Hence, the accidents were highly associated with the number and time of movements of pedestrians, passengers, drivers, and vehicles. Decreasing trends of crashes per hour began with, slight decrease from 12:00 to 17:00(12 am-5 pm), and decreases after 18:00 (6:00 pm).

Time of the Day	Number of Severity	%
1:00-2:00	5	1.46
2:00-3:00	19	5.54
3:00-4:00	16	4.66
4:00-5:00	14	4.08
5:00-6:00	9	2.62
6:00-7:00	11	3.21
7:00-8:00	30	8.75
8:00-9:00	18	5.25
9:00-10:00	13	3.79
10:00-11:00	20	5.83
11:00-12:00	20	5.83
12:00-13:00	29	8.45
13:00-14:00	25	7.29
14:00-15:00	21	6.12
15:00-16:00	18	5.25
16:00-17:00	23	6.71
17:00-18:00	11	3.21
18:00-19:00	11	3.21
19:00-20:00	10	2.92
20:00-21:00	5	1.46
21:00-22:00	5	1.46
22:00-23:00	6	1.75
23:00-24:00	4	1.17

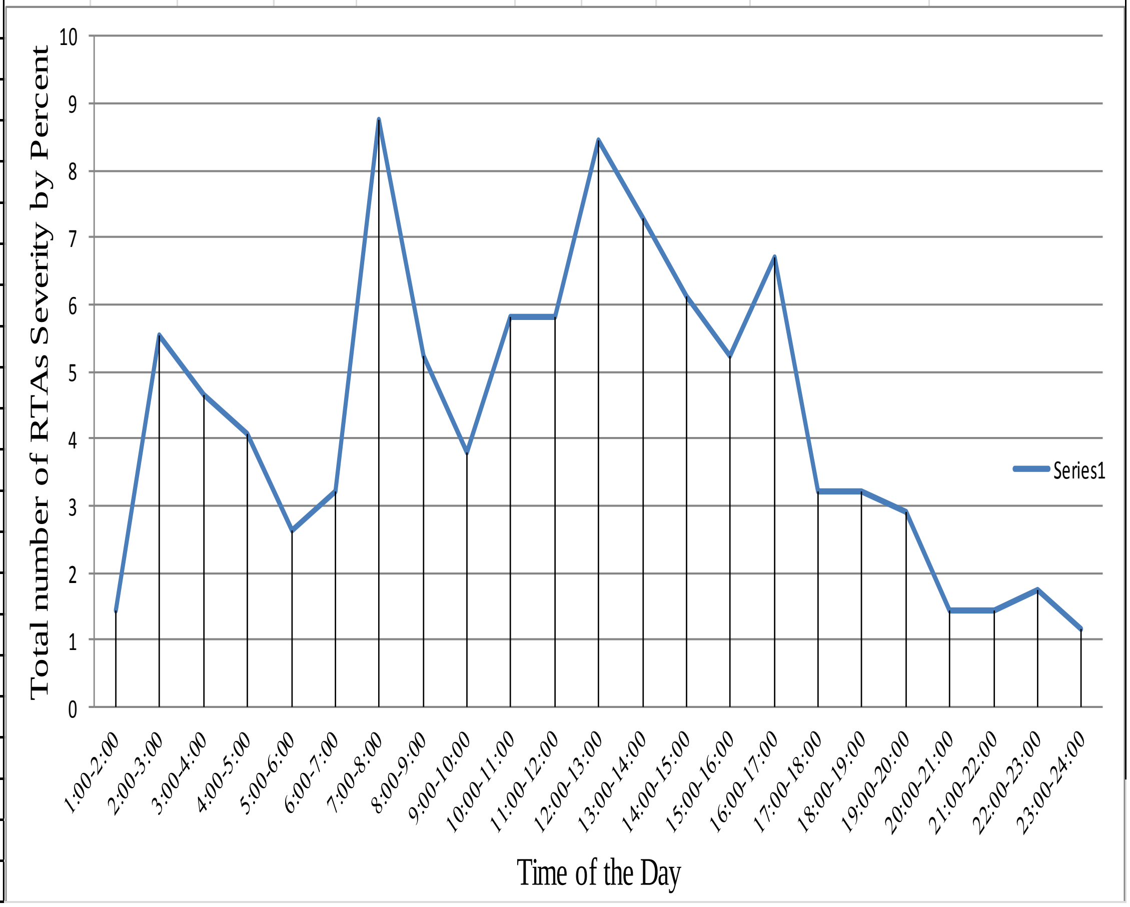


Figure 4.6: RTAs Severity Distributed over the Hours of the Day on the Study Road

4.2.5. RTAs by Land Use along the Study Road

Land uses of this road are divided into: Rural Village area, Agricultural area, School area, Industrial area, Church area, Market area, Recreational area, Hospital area, Urban Residential area and other types of land uses in order to examine the extents of the accidents in each area. In this regard, the research confirmed that land uses like Rural Village Areas and Residential Areas have very frequent RTAs with rural village areas having 136 accidents. Similarly, RTAs in Residential Areas were reported as 68. However, around hospitals, religious and industrial areas the number of crash was relatively low with the remaining selected land uses have medium level of accidents, and hence the study confirmed that the presence of significant difference in exhibiting road RTAs on the Study Road as depicted in Table 4.7 and illustrated in Figure 4.7 below.

Table 4.7: RTAs Severity by Land Use

Land Use	Types of severity				Total	%
	Fatal	Serious	Slight	Property		
Rural Village Area	67	19	18	32	136	39.65
Agricultural Area	12	11	8	11	42	12.24
Around School	8	2	3	0	13	3.79
Around Industrial Area	4	0	0	2	6	1.75
Around Religious Area	5	1	0	0	6	1.75
Around Market Area	7	4	3	0	14	4.08
Around Recreational Area	4	7	1	1	13	3.79
Around hospital Area	2	1	0	0	3	0.87
Around government office	13	5	1	4	23	6.71
Around Residential Area	31	19	7	11	68	19.83
Other	7	6	1	5	19	5.54
Total	160	75	42	66	343	100.00

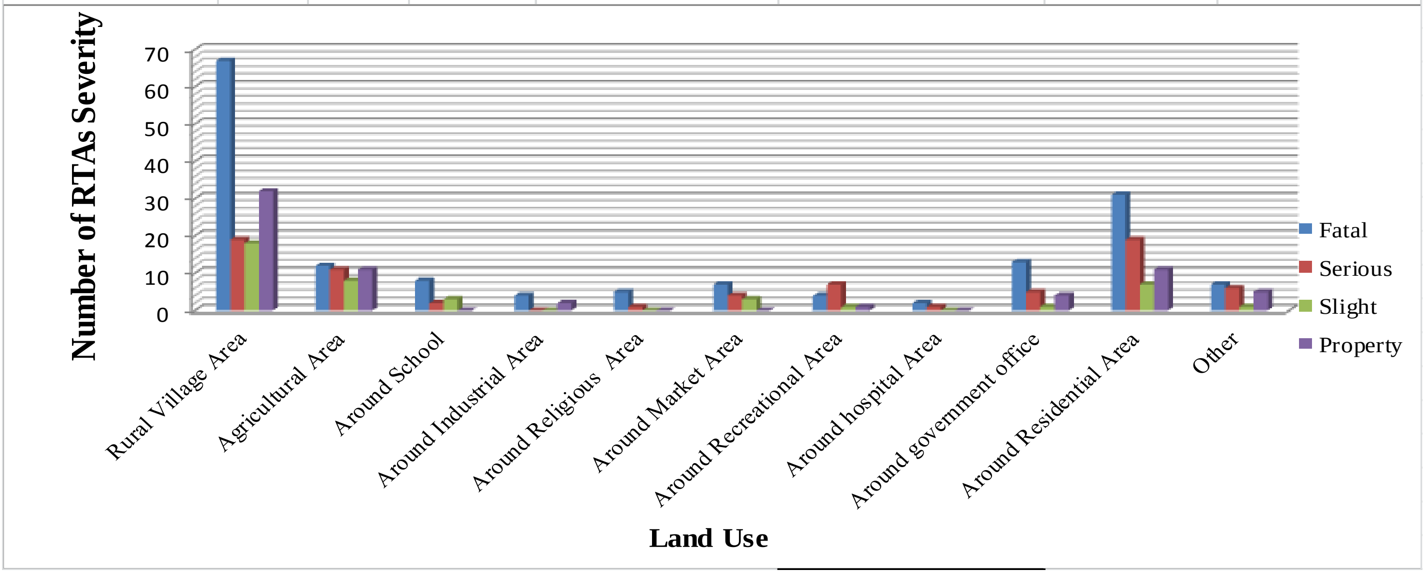


Figure 4.7: RTAs Severity by Land Use

4.2.6. RTAs by Collision Type along the Study Road

The collision type is often a good indicator of crash contributing factors. Collisions like: head on collisions, front and rear end collisions, rollover accidents, collision with animals and collision with pedestrians were the most dominant type of accidents which frequently occurred on the Study Road with values of: 49, 17, 64, 17 and 170 respectively. Whereas, collision types like collision with parked vehicles fall from vehicles, broad side, and others were very low in the number of accident reported. The remaining, front and side collisions also have relatively medium accident rates (see Table 4.8 and Figure 4.8).

Table 4.8: RTAs by Collision Type

Types of Accident	Types of Severity				Total	%
	Fatal	Serious	Slight	Property		
Head on collisions	22	9	1	17	49	14.29
Front and Rear End collisions	1	5	3	8	17	4.96
Front and Side	6	2	1	5	14	4.08
Broad Side	0	0	0	2	2	0.58
Rollover	35	15	7	7	64	18.66
Collisons with Pedestrian	93	42	27	8	170	49.56
Collisions with Animal	0	0	3	14	17	4.96
Fallen from Vehicles	2	0	0	2	4	1.17
Colisions with parked Vehicles	0	0	0	1	1	0.29
Other	0	2	0	2	4	1.17
Not known	1	0	0	0	1	0.29
Total	160	75	42	66	343	100.00

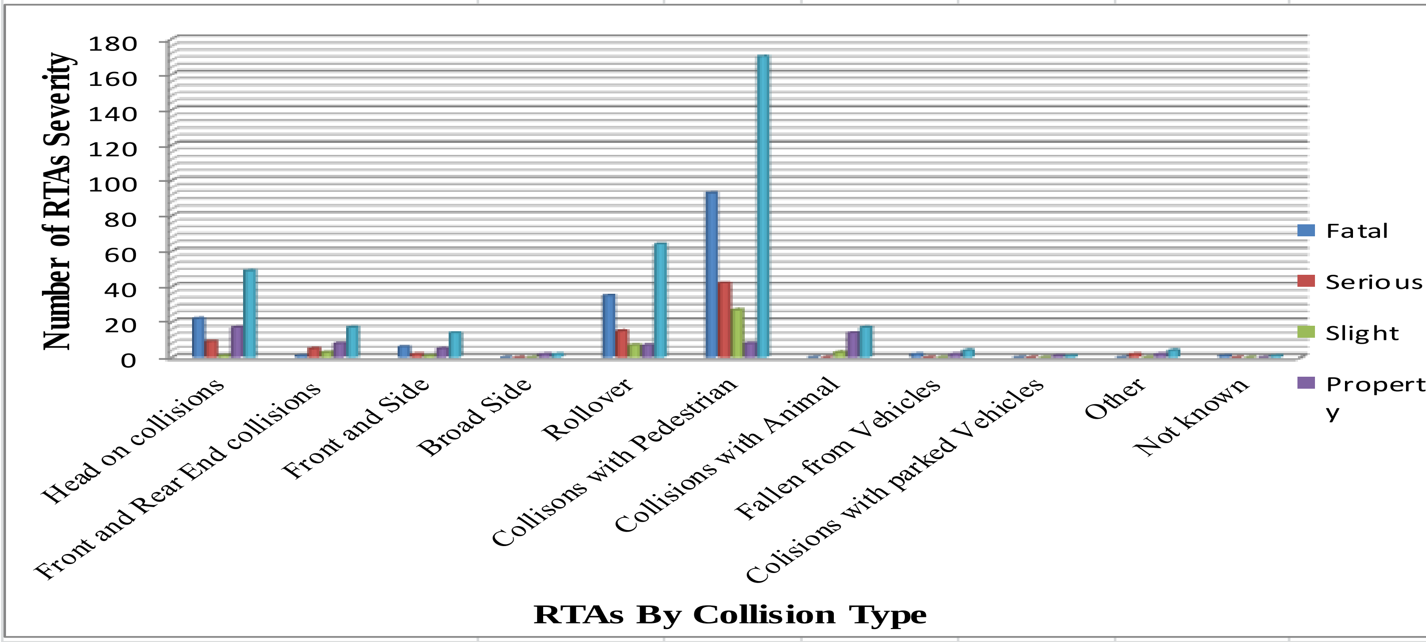


Figure 4.8: RTAs by Collision Type

4.2.7 RTAs by Intersections of the Study Road

Road intersections are generally categorized into different types including: Y-Intersection, T-Intersection, roundabout, four-leg Intersection, five-leg Intersection and Rail crossing. In this regard, no Intersections has the highest and most frequent RTAs rates as compared to the other Intersections; since at this location, drivers drive with high speed. Regarding the Study Road, the Y–and T-junctions have adequate/significant RTAs. The frequency of RTAs in the case of Y– junction was 24; and in the case of T – junctions the corresponding number of RTAs was 8. The remaining junction types like roundabout, four-leg junctions also have optimum level of RTAs numbers; while the five-leg junction has low RTAs. As we all know, rail-crossing RTAs is zero since train service has not yet been built in the study area. (SeeTable 4.9 &Figure 4.9).

Table 4.9: RTAs by Intersection Type on the Study Road.

Road Intersection Type	Types of severity				Total	%
	Fatal	Serious	Slight	Property		
Midblock	124	60	36	61	281	81.92
Y-Intersection	17	5	1	1	24	7.00
T-Intersection	6	0	1	1	8	2.33
Roundabout	3	1	2	1	7	2.04
Four leg Intersection	2	4	0	1	7	2.04
Five leg Intersection	0	0	0	0	0	0
Rail crossing	0	0	0	0	0	0
Other	8	5	2	1	16	4.66
Total	160	75	42	66	343	100.00

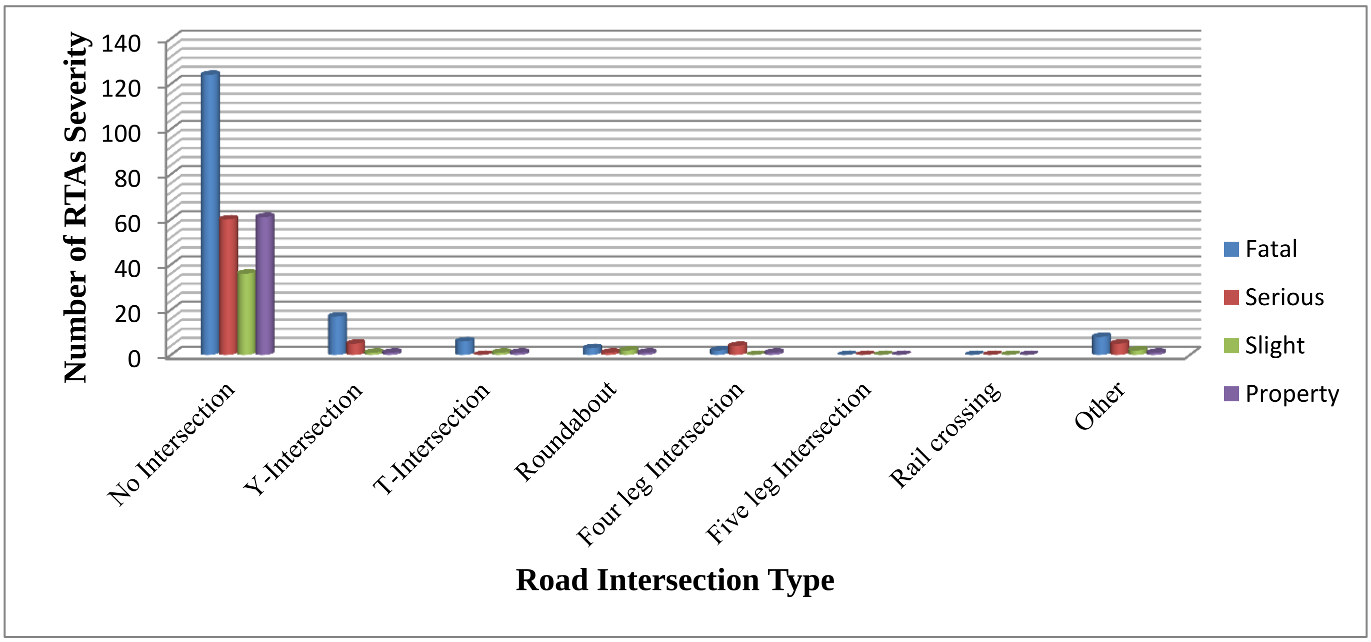


Figure 4.9: RTAs by Intersection Type on the Study Road

4.2.8. RTAs by Geometric Characteristics of the Study Road

Road characteristics have significant impact in determining the level and number of accidents in a given area. In this regard, Table 4.10 below presents the number of accidents by severity and Figure 4.10 below illustrates the same.

Table 4.10: RTAs by Road Geometric Character

Character of road Gometry	Types of severity				Total	%
	Fatal	Serious	Slight	Property		
Straight	101	58	36	43	238	69.39
Slight Upgrade	20	11	0	5	36	10.50
Highly Upgrade	2	3	1	3	9	2.62
Straight Up and Down	2	0	0	0	2	0.58
Slight Reverse Curve	14	1	1	8	24	7.00
Exactly Reverse Curve	2	0	0	1	3	0.87
Juntel Up Hill	3	0	0	1	4	1.17
Juntel Dowun Hill	15	1	4	3	23	6.71
Undifind	1	1	0	2	4	1.17
Total	160	75	42	66	343	100.00

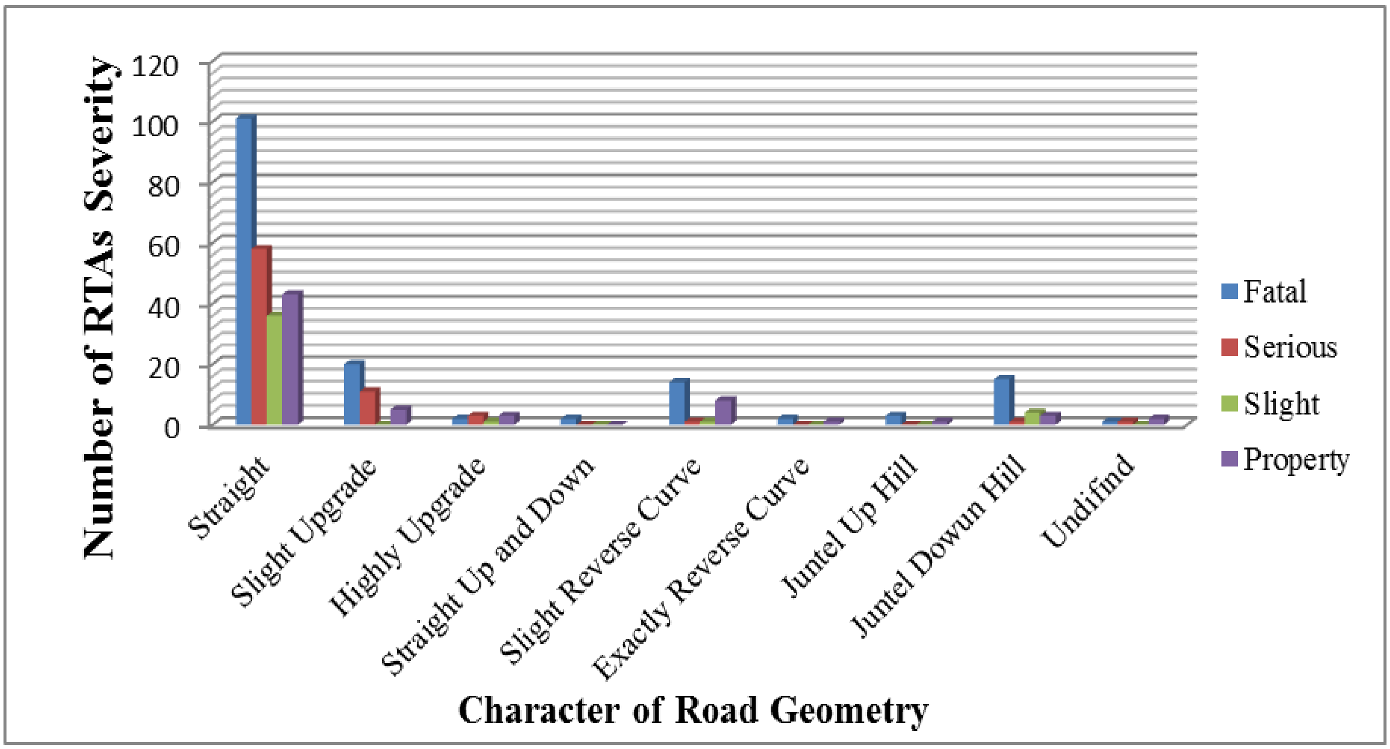


Figure 4.10: RTAs Severity by Road Geometry

Accordingly, Table 4.10 and Figure 4.10 above show the presence of adequate difference in various road characteristics of the study Road, i.e., highest accidents were recorded on straight and level road alignments with numbers of 101, 58, 36, and 43 as fatal, serious injury, slight injury and property damages respectively.

Besides, except slight upgrade, slight reverse curve and Juntl downhill, all the other subject road characteristics did not practice significant accidents.

4.2.9. Causes of Road Traffic Accidents (RTAs) and Severity on the Study Road.

Causes of RTAs severities leads to maximize RTAs severity for one Road segment. Table 4.11 below presents causes of RTAs and severities and subsequently Figure 4.11 illustrates the same.

Table 4.11: Causes of RTAs Severity

Causes of RTAs Severity	Types of Severity				Total	%
	Fatal	Serious	Slight	Property		
Alcohol	0	1	0	1	2	0.58
Addiction	0	0	0	0	0	-
By driving left side	3	3	1	3	10	2.92
Failure to give priority to driver	5	2	0	9	16	4.66
Overtaking problems	3	1	4	8	16	4.66
Failure to give priority to pedestrians	41	19	8	1	69	20.12
Passing in up and down grade	0	0	0	0	0	-
Passing in curves	0	0	0	0	0	-
over speeding	83	31	25	39	178	51.90
Turing without rule	1	2	0	1	4	1.17
Ignoring traffic light	0	0	0	0	0	-
Ignoring stop sign	0	0	0	0	0	-
Stopping without rule	0	0	0	0	0	-
Sleeping/Fatigue	1	0	0	0	1	0.29
Thinking	0	0	0	0	0	-
More lighting	0	0	0	0	0	-
Excess loading	7	1	1	1	10	2.92
Road failer	0	0	2	1	3	0.87
Pedestrian failer	5	5	0	0	10	2.92
Other	5	5	1	0	11	3.21
Not known	6	5	0	3	14	4.08
Total	160	75	42	67	343	100.00

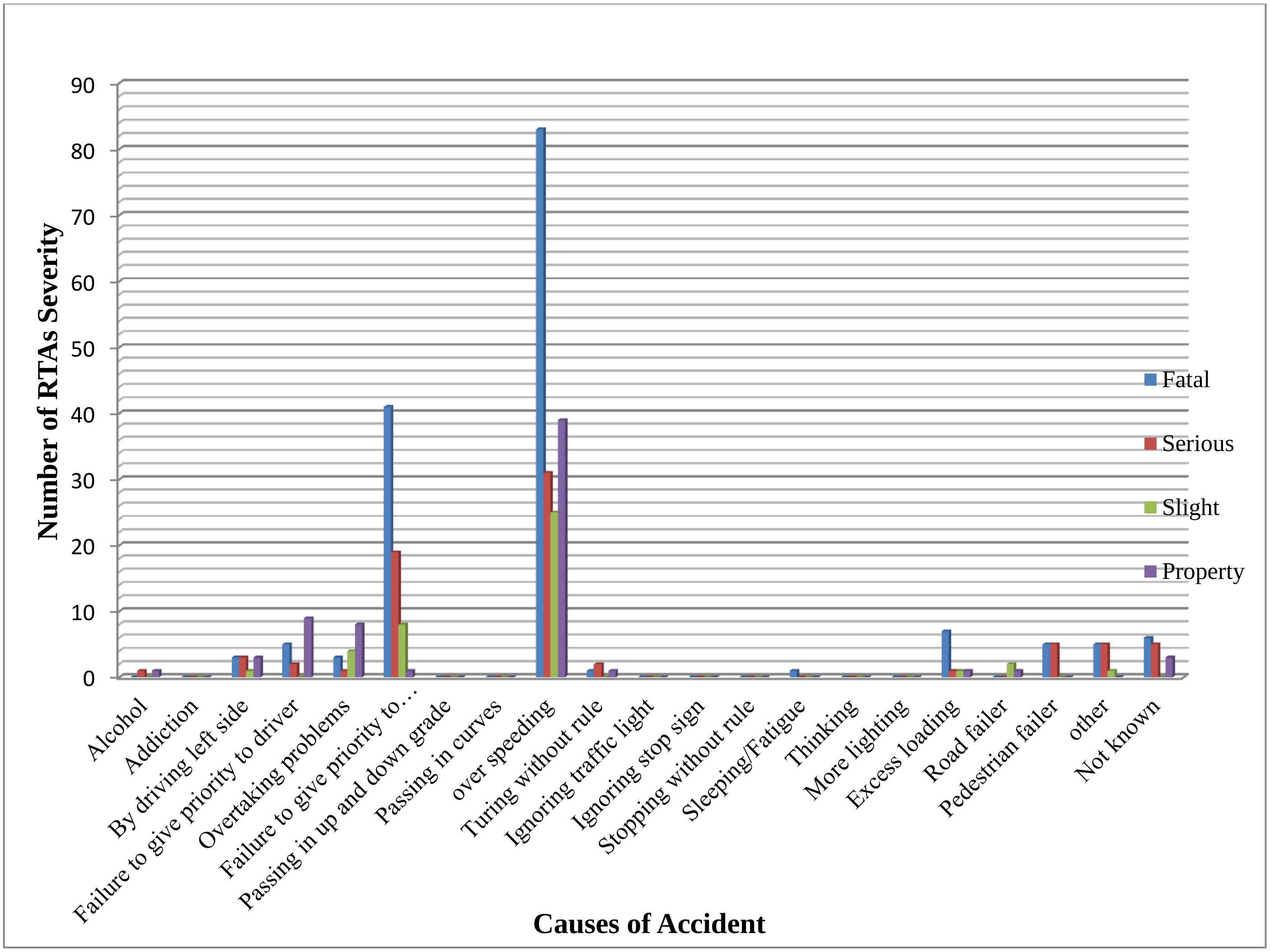


Figure 4.11: Causes of RTAs Severity

Based on the above results of the analysis, the major causes of RTA severities are: over speeding, failure to give priority to pedestrians, failure to give priority to drivers, overtaking; excess loading; pedestrian failures to be alert of vehicle movements; vehicles driving on the left side of road lanes. In this regard, the respective accidents were recorded as: 178, 69, 16, 16, 10, 10 and 10 aggregated to 343 crashes. As identified by many researchers; alcohol addiction, sleeping or fatigue were the major causes of RTAs severity; but, in this study, they were not found as the major causes RTAs.

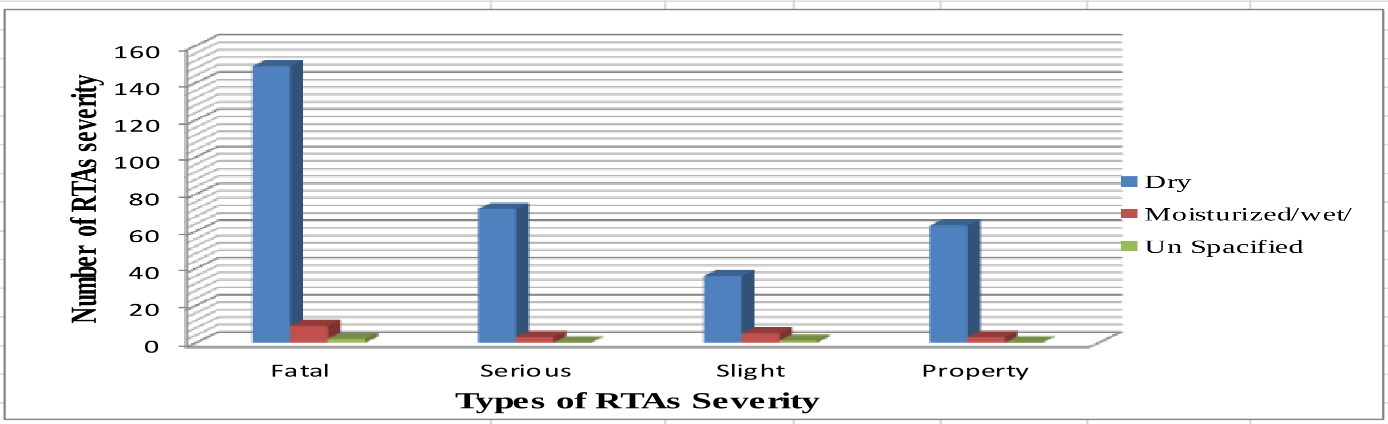
Generally, it was observed in the results that, drivers drive with high speed, violating traffic rules and so cause serious accidents along the Study Road. Therefore, traffic police should enforce drivers to drive with safe speed and to respect the driver rule otherwise punish them to minimize RTAs severity to this Road.

4.2.10. RTAs by the Carriageway Surface Condition of the Study Road

Regarding the road surface condition; dry, wet, and un-specified conditions were used to investigate the severity of RTAs by road conditions on the Study Road. Accordingly, Figure 4.12 below revealed that about 320, 19, and 3 of the RTAs occurred on dry, moisturized/wet and on unspecified road surface conditions respectively. Consequently, on dry road surface conditions, about 320 (93.29%) of the total RTAs occurred, since during this condition there is high volume of traffic movements. Hence, the analysis confirmed that most of the RTAs occur on dry road surface conditions. Table 4.12 below shows RTAs by surface conditions and Figure 4.12 illustrates the same.

Table 4.12: RTAs by Road way Surface Condition on the Study Road

Road surface condetion	Types of RTAs severity				Total	%
	Fatal	Serious	Slight	Property		
Dry	149	72	36	63	320	93.29
Moisturized/wet/	9	3	5	3	19	5.54
Un Spacified	2	0	1	0	3	0.87
Total	160	75	42	66	343	100



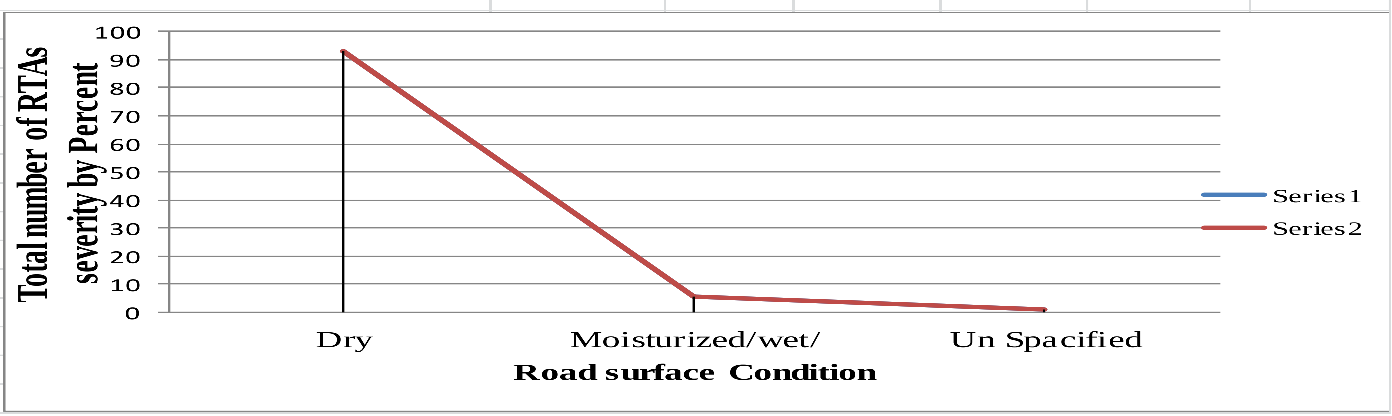


Figure 4.12: RTAS by Roadway Surface Condition on the Study Road

4.2.11. RTAs by Light Condition on the Study Road

Even though the existence of light is very important for the reduction of RTAs significantly, the analysis shows that almost all the RTAs occurred during day light. In this regard, 269, 22, 16, 15 and 10 accidents occurred during the day light, dark night, dawn, and night with poor light respectively. Unfortunately, poor light conditions leads for more RTAs severity; but this research revealed that day light condition led to more RTAs severity as compared to others (78.43%).This is because, more traffic flows occurred during the day light on the road. In addition, medium accidents occurred during dark night, with no lighted road; at dawn and during good light conditions.

Table 4.13 below presents RTAs under different light and no light conditions and subsequently, Figure 4.13 graphically illustrates the same.

Table 4.13: RTAs by Light Condition the Study Road

Lighting conditions	Types of RTAs severity				Total	%
	Fatal	Serious	Slight	Property		
Day light	116	67	39	47	269	78.43
Dawn	11	2	3	0	16	4.66
Dusk	1	1	0	3	5	1.46
Night with good light	7	4		4	15	4.37
Night with poor light	4	0	0	6	10	2.92
Night with no light	15	1	0	6	22	6.41
Un specified	6	0	0	0	6	1.75
Total	160	75	42	66	343	100

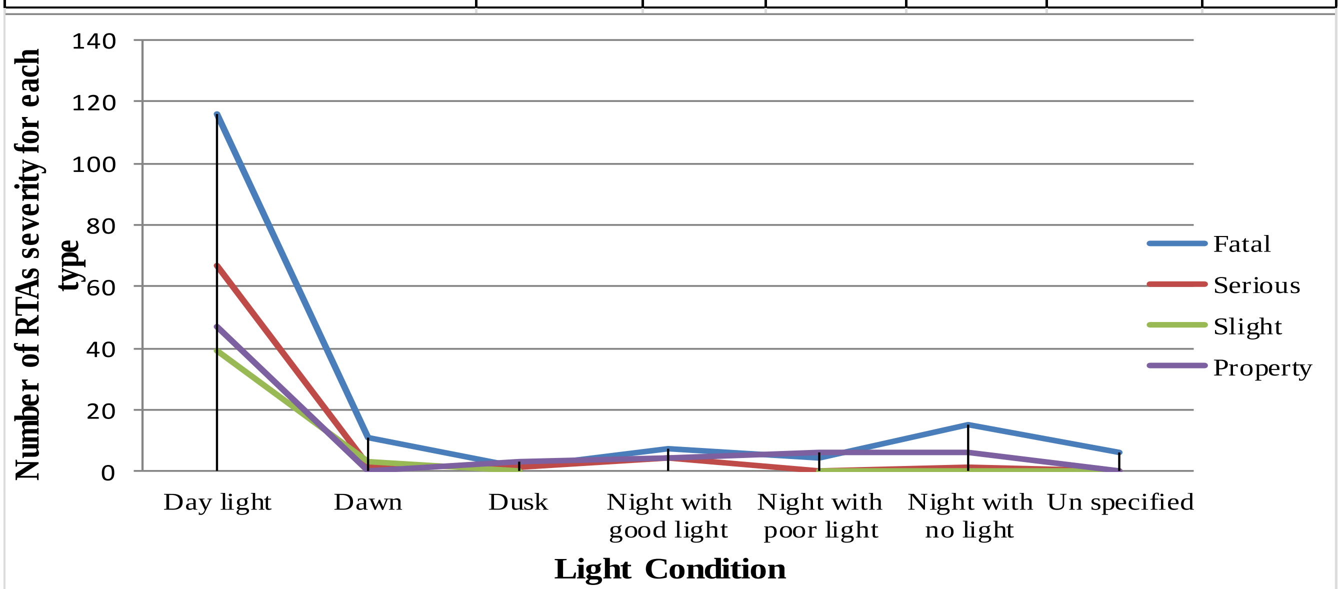


Figure 4.13: RTAs by Light Condition on the Study

4.2.12. RTAs by Weather Conditions on the Study Road

RTAs occurred under good, cloudy and light rainy conditions with values of 300 (87.46%), 12 (3.5%) and 12 (3.5%) respectively. But RTAs were low under other conditions as depicted in Table 4.14 below**.** Moreover, dramatically bad weather conditions led to high RTAs severity. However in this research, good weather condition resulted in high RTAs severity. Accordingly, the findings of this research indicated that high road accident severity might occur during good weather condition due to may be of high volume of traffic operating during this weather condition. Table 4.14 below presents RTAs by weather conditions and subsequently Figure 4.14 graphically illustrates the same.

Table 4.14: RTAs by Road way Weather Conditions on the Study Road

Weather Condition	Types of RTAs severity				Total	%
	Fatal	Serious	Slight	Property		
Good	139	69	36	55	299	86.67
Gum	1	0	0	0	1	0.29
Cloud	5	3	0	4	12	3.48
Light rainy	3	2	5	3	13	3.77
Heavy rainy	4	0	0	1	5	1.45
Heavy wind	0	0	0	0	0	-
Hot	2	1	0	2	5	1.45
Cold	3	0	0	2	5	1.45
Un specified	4	0	1	0	5	1.45
Total	161	75	42	67	345	100

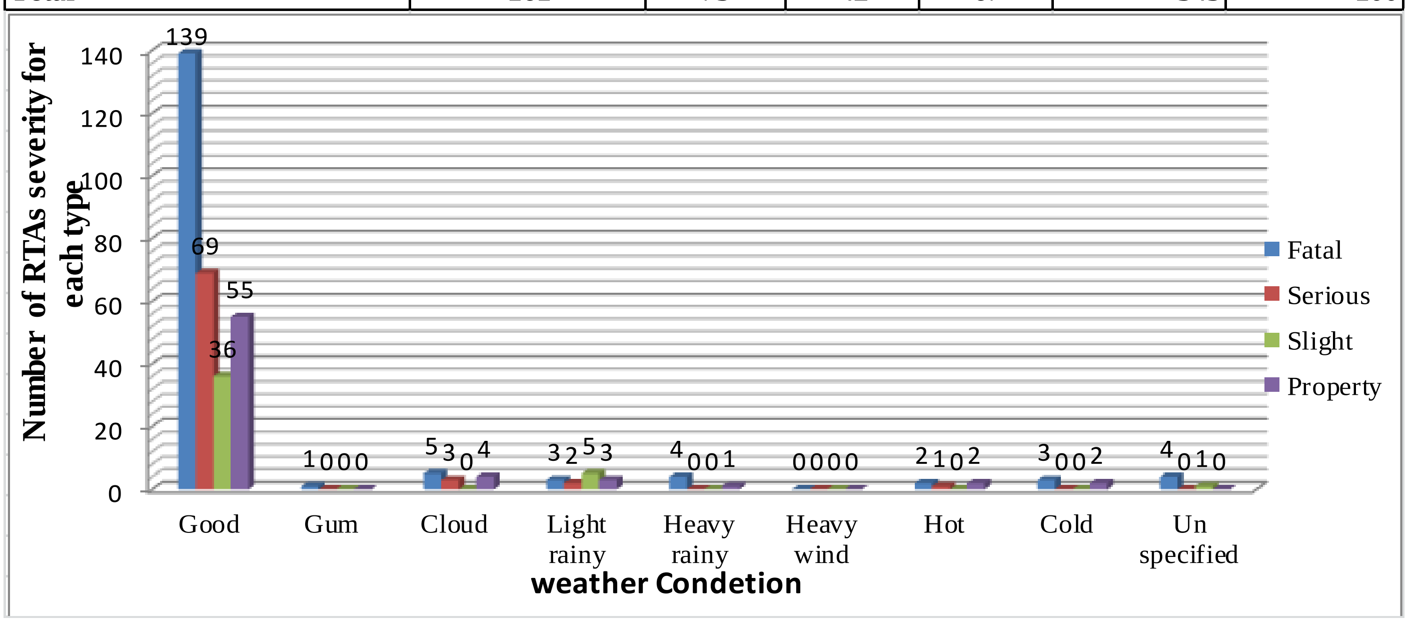


Figure 4.14: RTAs by Road way weather Conditions on the Study Road

4.2.13. RTAs by Vehicle Service Year on the Study Road

As the methodology part of chapter three described; Vehicle related factor is one of the factors of the RTAs independent variable. So, based on vehicle service year data, vehicle factors on RTAs are discussed as follows. Table 4.15 below shows RTAs severities by vehicle service years and Figure 4.15 illustrates the same.

Table 4.15: RTAs by Vehicle Service Year on the Study Road

Vehicle Service Year	Types of RTAs severity				Total	%
	Fatal	Serious	Slight	Property		
Up to 1 year	13	3	1	3	20	5.8309
1 -2 year	19	8	1	7	35	10.2041
2 -5 year	54	28	21	35	138	40.2332
5 -10 year	16	15	12	18	61	17.7843
> 10 year	10	6	2	0	18	5.24781
Not known	48	15	5	3	71	20.6997
Total	160	75	42	66	343	100

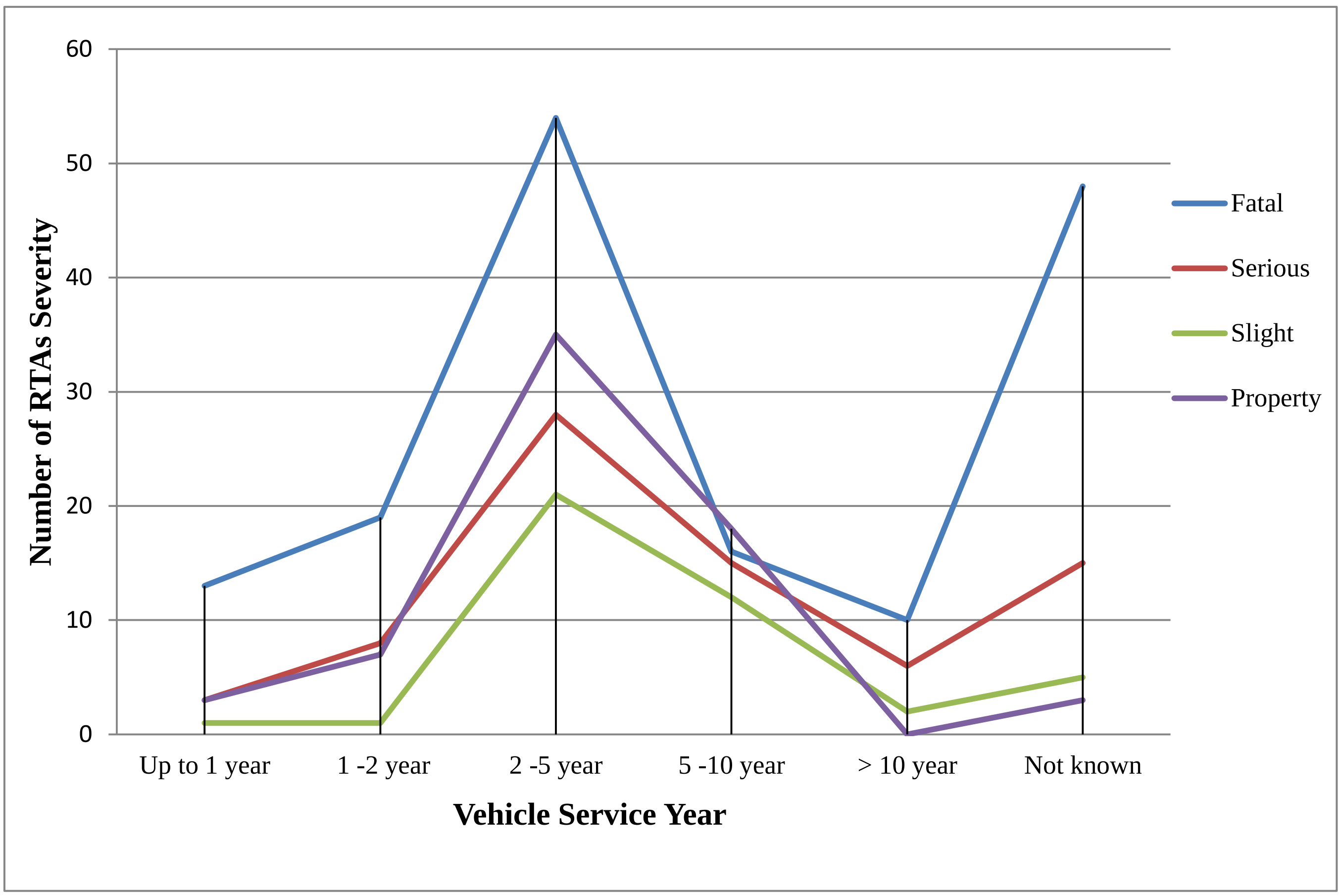


Figure 4.15: RTAs by Vehicle Service Year on the Study Road

According to Table 4.15 and Figure 4.15 above, the highest number of RTAs severity occurred under vehicle service year of 2 - 5. In this regard, it should be noted that there are high number of vehicles under this service year category in the Country in general in the study road in particular.

4.2.14. RTAs by the Experiences of Drivers on the Study Road

As stated above under the methodology part, drivers are one of the independent variables of the RTAs factors. So based on acquired experiences of drivers, the factors and effect on RTAs are discussed as follows. Table 4.16 and Figure 4.16 below present RTAs severity by driver experience.

Table 4.16: RTAs by Experience of Drivers on the Study Road

Experience of Drivers	Types of RTAs severity				Total	%
	Fatal	Serious	Slight	Property		
Have not license	4	3	1	1	9	2.62
≤ 1 year	14	9	3	5	31	9.04
1 -2 year	17	8	9	12	47	13.70
2 -5 year	35	22	13	31	101	29.45
5- 10 year	22	11	8	13	54	15.74
> 10 year	5	4	4	1	14	4.08
Not known	63	18	4	3	88	25.66
Total	160	75	42	66	343	100.00

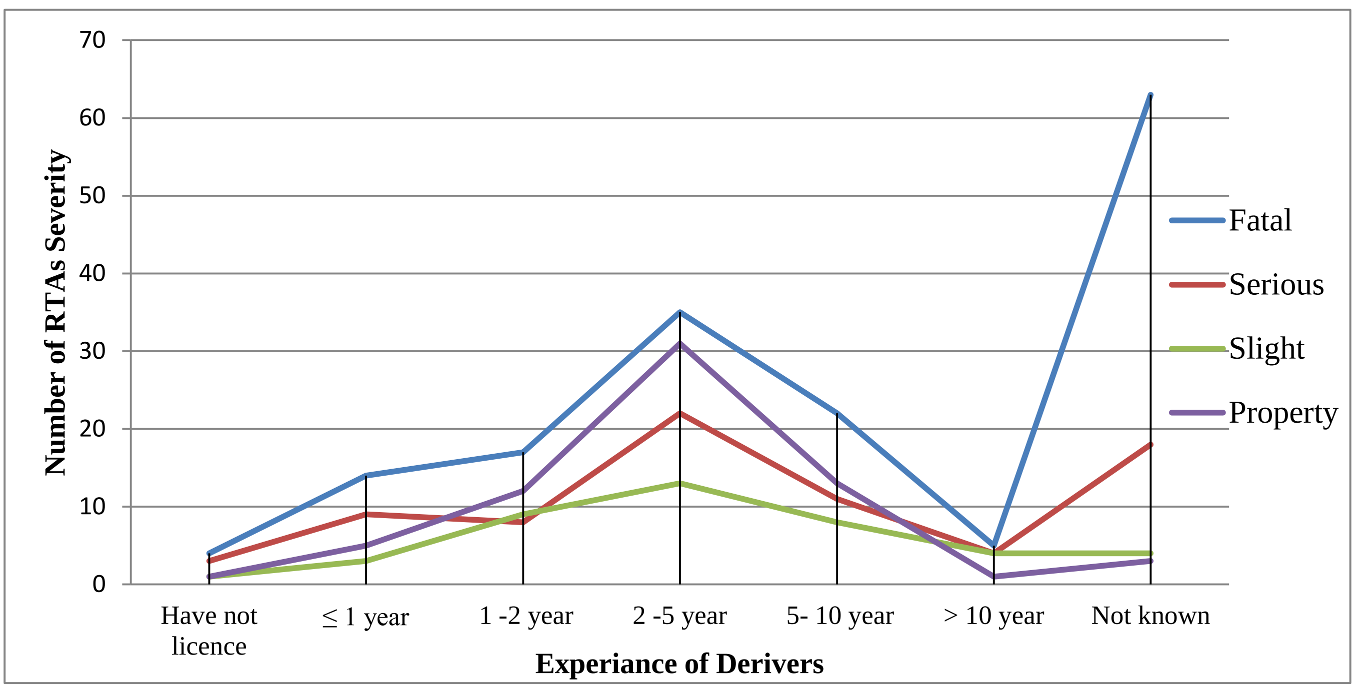


Figure 4.16: RTAs by Experience of Drivers on the Study Road

According to the above Table 4.16 as well as Figure 4.16 in all types of RTAs severity high RTAs occurred under experience of driver of 2-5. This indicates that; young drivers are driving irresponsibly and carelessly because they have nothing to worry about and are less experienced and most young drivers are frequently involved in the collision. Older drivers have family responsibilities and most of them drive their own vehicles. Therefore, older drivers drive more carefully which decreases their risk of collision.

4.2.15. Spatial Distribution of Accidents in Spot Areas on the Study Road

The aim of this study was to clearly identify the location of major road traffic accidents, black spot areas, and then to rank the sites and suggest engineering solutions (black spot treatments). Initially, locations and segments of road traffic accident data were identified to ease the computation of black spot areas and to minimize potential crashes, Table 4.17 below shows that in 2009 and half of 2010, the total number of fatalities was between 6 and 22. The highest number of accidents with value of 22 was recorded at Banja/Tilili/ location; 19 each accident were recorded at Burie and Debre-Markos locations and 17 RTAs were recorded near Finote Selam; but low fatalities were recorded within Dembecha town and near Dembecha village with 6 and 10 respectively. Serious injuries vary between 2 to 15 and the highest recorded was 15 at Debre Markos; 13 were record near Finote Selam. Medium number of accidents, that is between 5 and 11 occurred at Banja, Guagusa Shikudad, Gozamin, Machakel and Finote Selam town with values of 5, 5, 7, 8 and 11 respectively. Spatial areas that have less serious injuries between 2 and 4 were at Burie and near Dembecha with 2 each, Injibara town with 3 and Dembecha with 4 accidents. Slight injuries vary between 0 and 11 accidents. Accordingly, areas like: Gozamin, near Finote Selam and Debre Markos have recorded light injuries of 11, 10 and 9 respectively. In contrary; near Dembecha, Dembecha town, Finote Selam, Guagusa Shikudad and Injibara RTAs were recorded as slight injuries with 0, 0, 0, and 1 and respectively. The remaining locations have medium slight injuries. Furthermore, the property damages in this period were recorded with minimum and maximum values of 0, 0 and 20 at Dembecha, near Dembecha and Gozamin respectively (see Table 4.17 and Figure 4.17).

Table 4.17: Spatial Distribution of RTAs in Areas along the Study Road

Location of RTAs severity	Types of Severity					%
	Fatal	Serious	Slight	Property	Total	
Banja/Tilili/	22	5	4	7	38	11.08
Burie	19	2	3	10	34	9.91
Debre Markos	19	15	9	8	51	14.87
Dembecha	6	4	0	0	10	2.92

F/selam	14	11	0	3	28	8.16
Gozamen	13	7	11	20	51	14.87
Guagusa Shikudad	13	5	1	8	27	7.87
Injibara Towun	11	3	1	3	18	5.25
Machakel	16	8	3	0	27	7.87
Near Dembecha	10	2	0	0	12	3.50
Near F/selam	17	13	10	7	47	13.70
Total	143	62	32	59	343	100.00

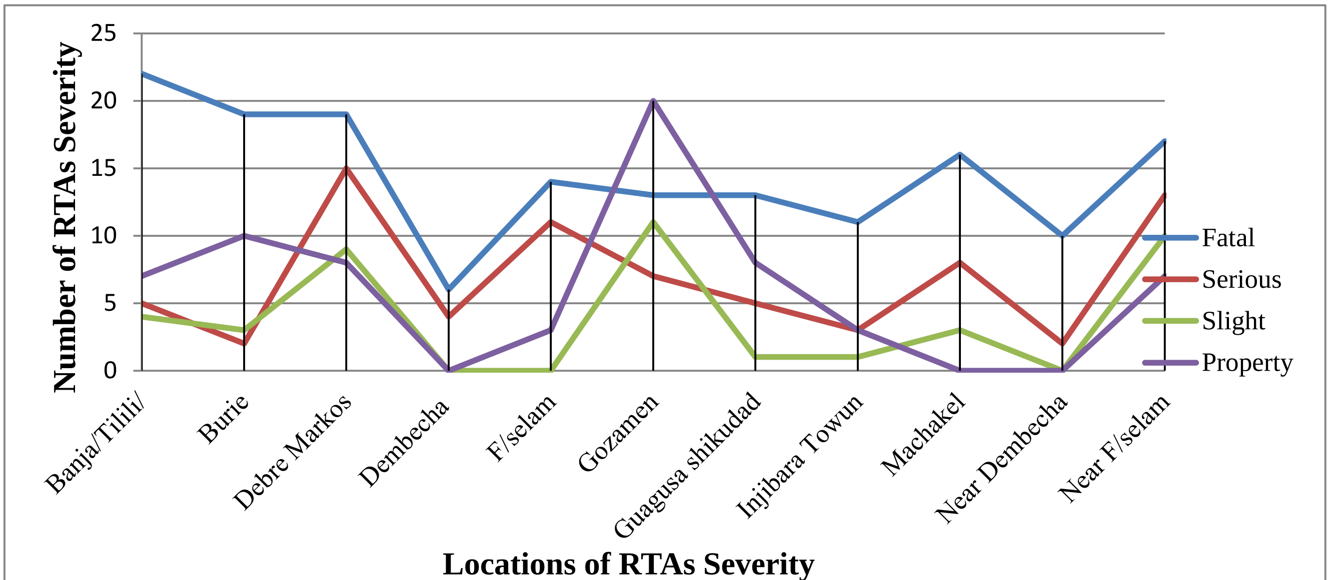


Figure 4.17: Spatial Distribution of RTAs in Spot Segment Areas

Generally, Figure 4.17 illustrates that, at the identified spot areas during the accidents recorded period, the highest RTAs severity were exhibited at Debre-Markos, Gozamen, Burie, Banja and near Finote-Selam areas with values of: 51, 51, 34, 38, and 47 respectively. Whereas during this period, comparably low aggregated RTAs were reported within Dembecha town and near Dembecha areas with values of 10 and 12 respectively. All the remaining locations have medium RTAs severities presented and illustrated above in Table 4.17 and Figure 4.17 respectively.

4.3. Identification of Black Spot Areas on the Study Road

A location whether link or node that experiences abnormal crash frequency rate is considered as an accident black spot. The method also incorporates exposure data such as traffic volume and length of the road section to determine if the critical accident rate at particular location is significantly higher than the average for each factor. Accordingly, accident rate calculation and black spot identification were undertaken by using the Quality Control /Critical Crash Rate Factor /Method (TRL 2000). The following two steps should be accomplished.

(i) Determination of Locations During Accident Rate

Accident location is determined on the basis of exposure data such as traffic volume; and length of the road section is being considered at rate per million vehicle kilometers (**U_f**) and it is calculated as follows;

- **For Junctions:**

Uf = U x 106 / (AADT x 365 x n) ……………………………………………………1

- **For Road Sections:**

Uf = U x 106 / (AADT x 365 x n x L)

where

Uf = Injury accidents per million vehicle.-km

U = Number of reported injury accidents during the period n

n = Number of years

L = Section length (km

(ii) Determining the Critical Crash Rate

Critical crash rate factor method involves the following expression. The result provides the data for calculating critical accident rate (**Rc**). It is based on the assumptions that the crashes are approximated by Poisson Distribution.

$$\mathbf{Rc = RA + Confidence\ level * \sqrt{\frac{Ra}{MEV}} + \frac{1}{2*MEV}} \quad \text{...2}$$

where

Rc = Critical Accident Rate (accidents per million vehicles or accidents per million vehicle-km)

Ra = Average crash rate

MEV= Millions vehicle (km) during the analysis period

$$\mathbf{MEV = \frac{AADT*365*Y}{1000000}}$$

$$\mathbf{Rj = \frac{fj*10^6}{365.25*Y*Lj*AADT}}$$

$$\mathbf{Ra = \frac{\sum fj*10^6}{365.25*Y*\sum Lj*AADT}}$$

where

Rj = Accident rate of site j(acc/Mveh-km)

Ra = Average accident rate (acc/Mveh-km)

Fj = Accident frequency at site j

Y = Period of analysis (year)

L = Section length of site j(km)

<u>For Road Sections</u>

$$\mathbf{Rc} = \mathbf{Average\ Crash\ Rate} + \left[(\mathbf{k})\sqrt{\frac{\mathbf{Average\ Crash\ Rate}}{\mathbf{365*Y*(AADT)*\frac{Lj}{100000}}}}\right]\left[\frac{\mathbf{1}}{\mathbf{2(365*Y*(AADT)*Lj/1000000}}\right]$$

<u>For Junctions</u>

$$\mathbf{Rc} = \mathbf{Average\ Crash\ Rate} + \left[(\mathbf{k})\sqrt{\frac{\mathbf{Average\ Crash\ Rate}}{\mathbf{365*Y*(AADT)/1000000}}}\right]\left[\frac{\mathbf{1}}{\mathbf{2(365*Y*(AADT)/1000000}}\right]$$

where,

AADT =Average annual daily traffic for the spot (for an intersection, the sum of the volumes on all approaches.

Y =Number of years being analyzed

L =Length of the segment in kilometer (for intersection L is 1).

K =Confidence level (95% confidence, k=1.645)

(iii) Compare the Location's Crash Rate with the Critical Crash Rate.

If the crash rate exceeds from the critical crash rate, classify the location as an accident Black Spot.

4.4 Ranking of Sites

For prioritizing the black spots, the ratios of accident costs by degree of severity were established by TRL. The weight given for fatal accident is 5, for serious injury is 3, for light injury and property damage are 2 and 1 respectively. The formula for estimating ranking of sites is stipulated as follows:

$$\mathbf{P} = \left[\frac{\mathbf{1*W+2*X+3*Y+5*Z}}{\mathbf{D}}\right]$$

Where:

P = Priority value;

W=Total number of property damages;

X =Total number of light injuries;

Y =Total number of serious injury;

Z =Total number of deadly injuries;

D = Total number of distance of the black spot section in kilometer.

The following accident segments were considered on the Study Road (see Table 4.18)

Table 4.18: RTAs Severity Spot Segment Areas on the Study Road

Location of RTAs severity	**Types of Severity**					**%**
	Fatal	Serious	Slight	Property	Total	
Banja/Tilili/	22	5	4	7	38	11.08
Burie	19	2	3	10	34	9.91
Debre Markos	19	15	9	8	51	14.87
Dembecha	6	4	0	0	10	2.92
F/selam	14	11	0	3	28	8.16
Gozamen	13	7	11	20	51	14.87
Guagusa Shikudad	13	5	1	8	27	7.87
Injibara Towun	11	3	1	3	18	5.25
Machakel	16	8	3	0	27	7.87
Near Dembecha	10	2	0	0	12	3.50
Near F/selam	17	13	10	7	47	13.70
Total	143	62	32	59	343	100.00

Thus, the above formulas were used for the identification of black spot segment and by using the data in Table 4.18 above and Table 4.19 below

Table 4.19: Acquired Data and Calculated Values Regarding Black Spot Segments on the Study Road

Accident Segment Areas	Length Km	AADT	Accident Frequency	Individual Accident Rate(Acci/MVeh-Km	Average Accident Rate(Acci/MVeh-Km	Critical Crash Rate(Rc)	Conditions
Banja/Tilili/	14	2,114	38	2.34	1.97	2.23	Black spot
Burie	9	2,114	34	3.26	1.97	2.23	Black spot
Debre Markos	18	1,736	51	2.98	2.40	3.76	Under
Dembecha	7	2,037	10	1.28	2.05	3.04	Under
F/selam	11	2,037	28	2.28	2.05	3.04	Under
Gozamen	16	1,736	51	3.35	2.40	3.76	Under
Guagusa shikudad	15	2,114	27	1.55	1.97	2.90	Under
Injibara Towun	9	2,114	18	1.73	1.97	2.90	Under
Machakel	17	1,736	27	1.67	2.40	3.76	Under
Near Dembecha	20	2,037	12	0.54	2.05	3.04	Under
Near F/selam	14	1,705	47	3.59	2.45	3.52	Black spot
Total	150	21,480	343				

Based on the values in Table 4.19 above, location/individual/crash rate is more than critical crash rate at the locations of Burie, Banja and near Finote-Selam. Therefore, it indicates that these locations were considered as black spots. and with their rank orders ranging for the segment section between1-10.They are Burie, near Finote Selam, Banja (aroundTilili), Finote Selam, Debre-Markos, Gozamin, Injibara, Machakel, Guagusa Shikudad, near Dembecha, Dembecha town that ranked from 1-10 respectively(see Table 4.20).

Generally, ranking of accident spots helps to assess which place is to be given immediate attention. Quality control is the method used for identification of black spot segments in this road so that the accident frequencies of all the spot segments over this period are calculated. The logic of this method is that a location is considered to be a black spot if its safety parameter shows higher values (location's crash rate) than the critical value, and then ranking of accident spots based on calculated severity established by the TRL values.

Table 4.20: Prioritized and Ranked RTAs Segments on the Study Road

Location of RTAs Severity	Types of Severity				PRIORITIZATION						Rank
	Fatal	Serious	Slight	Property	Z	Y	X	W	D	P	
Burie	19	2	3	10	95	6	6	10	9	13.00	1
near F/Selam	17	13	10	7	85	39	20	7	14	10.79	2
Banja/Tilili/	22	5	4	7	110	15	8	7	14	10.00	3
F/Selam	14	11	0	3	70	33	0	3	11	9.64	4
Debre Markos	19	15	9	8	95	45	18	8	18	9.22	5
Gozamen	13	7	11	20	65	21	22	20	16	8.00	6
Injibara	11	3	1	3	55	9	2	3	9	7.67	7
Machakel	16	8	3	0	80	24	6	0	17	6.47	8
Dembecha	6	4	0	0	30	12	0	0	7	6.00	9
Guagusa Shikudad	13	5	1	8	65	15	2	8	15	6.00	9
near Dembecha	10	2	0	0	50	6	0	0	20	2.80	10
Total	143	62	32	59	343				150		

4.5 Determining the Magnitude of Determinates of Fatal RTAs on the Study Road.

This section was done to examine the magnitude of major determinants of RTAs with special emphasis fatal RTAs severity; and analyzed by STATA Version 14. Binary logistic regression was used to assess associations between fata RTAs severity and independent variables. (See Table 4.21)

Table 4.21: STATA software result of Binary/Odds Ratio) Regression Model

Explanatory Variables	Fatal FQ	Total FQ	Coefficient	Standard Error	t value (coefi/stdr)	p-value	Odds Ratio
Location of RTAs Severity vs Fatal							
Burie	19	34	-0.531	1.458	-0.360	0.778	0.588
Near Finote Selam	17	47	-0.668	0.729	-0.920	0.528	0.513
Banja/Tilili/	22	38	-0.449	1.458	-0.310	0.810	0.638
Finote Selam	14	28	-0.768	1.458	-0.530	0.691	0.464
Debre Markos	19	51	-1.289	1.458	-0.880	0.539	0.276
Gozamen	13	51	-1.840	1.458	-1.260	0.427	0.159
Injibara	11	18	-0.316	1.458	-0.220	0.864	0.729
Machakel	16	27	-0.393	1.458	-0.270	0.832	0.675
Dembecha	6	10	-0.362	1.458	-0.250	0.845	0.696
Near Dembecha	10	12	-0.262	1.458	-0.180	0.556	0.769
Guagusa Shikudad	13	27	Benchmark				
Light condition of RTAs vs Fatal							
Day light	116	269	-0.455	1.011	-0.45	0.731	0.634
Dawn	11	16	0.610	1.011	0.6	0.654	1.840
Dusk	1	5	-1.565	1.011	-1.55	0.365	0.209
Night with good light	7	15	-0.312	1.011	-0.31	0.81	0.732
Un specified	6	6	-0.178	1.011	-0.18	0.88	0.837
Night with no light	15	22	0.341	1.011	0.54	0.201	1.407
Night with poor light	4	10	Benchmark				
Causes of RTAs Severity vs Fatal							
By driving left side	3	10	-0.612	0.091	-6.710	0.094	0.542
Failure to give for priority to driver	5	16	-0.553	0.091	-6.070	0.104	0.575
Overtaking problems	3	16	-1.231	0.091	-13.490	0.047	0.292
Failure to give priority to pedestrians	41	69	0.616	0.091	6.760	0.094	1.852
over speeding	83	179	0.100	0.091	1.100	0.057	1.105
Turing without rule	1	4	-0.864	0.091	-9.460	0.067	0.422
Excess loading	7	10	1.082	0.091	11.860	0.054	2.951
Pedestrian failer	5	10	0.235	0.091	2.580	0.236	1.265
Other	5	11	0.135	0.091	1.480	0.236	1.145
Not known	6	14	Benchmark				
Vehicle service year of RTAs severity vs Fatal							
Up to 1 year	13	20	0.140	0.444	0.310	0.806	1.150
1 -2 year	19	35	-0.308	0.444	-0.690	0.614	0.735
2 -5 year	54	138	-0.921	0.444	-2.080	0.286	0.398
5 -10 year	16	61	-1.513	0.444	-3.410	0.182	0.220
> 10 year	10	18	0.479	0.256	1.870	0.313	1.615

Unknown	48	71	Benchmark			
Experience of derivers of RTAs vs Fatal						
Have not license	4	9	-0.368	1.350	-0.270	0.830	0.692
≤ 1 year	14	31	-0.339	1.350	-0.250	0.843	0.712
1 -2 year	17	47	-0.713	1.350	-0.530	0.691	0.490
2 -5 year	35	101	-0.520	1.350	-0.390	0.766	0.595
5- 10 year	22	54	-0.733	1.350	-0.540	0.683	0.481
> 10 year	5	14	-0.845	1.35	0.626	0.575	0.429
Unknown	63	88	Benchmark				
Land us of RTAs vs Fatal							
Rural Village Area	67	136	0.329	0.314	1.050	0.485	1.389
Agricultural Area	12	42	-0.558	0.314	-1.780	0.326	0.572
Around School	8	13	0.828	0.314	2.640	0.230	2.289
Around Industrial Area	4	6	2.857	0.314	9.112	0.047	2.861
Around Religious Area	5	6	3.987	0.314	12.715	0.035	7.152
Around Market Area	7	14	0.358	0.314	1.140	0.458	1.430
Around Recreational Area	4	13	-0.453	0.314	-1.440	0.385	0.636
Around hospital Area	2	3	1.051	0.314	3.350	0.185	2.861
Around government office	13	23	0.620	0.314	1.980	0.298	1.860
Around Residential Area	31	68	-0.463	0.314	-1.476	0.395	0.646
Other	7	19	Benchmark				
Road users age vs Fatal							
below 7 years	5	13	-0.105	1.050	-0.100	0.937	0.901
7- 13 years	6	10	0.706	1.050	0.670	0.623	2.026
14-17 years	4	8	0.706	1.050	0.670	0.623	2.026
18-30 years	83	155	0.794	1.050	0.760	0.588	2.213
31-50 years	55	120	0.206	1.050	0.196	0.952	1.229
above 51 years	7	32	Benchmark				
Road Geometry of RTAs Vs Fatal							
Straight	101	238	-0.070	1.496	-0.050	0.970	0.933
Slight Upgrade	20	36	0.458	1.496	0.310	0.811	1.581
Highly Upgrade	2	9	-1.018	1.496	-0.680	0.620	0.361
Straight Up and Down	2	2	0.235	1.496	0.160	0.901	1.265
Slight Reverse Curve	14	24	0.571	1.496	0.380	0.768	1.771
Exactly Reverse Curve	2	3	0.928	1.496	0.620	0.037	2.530
Juntel Up Hill	3	4	1.334	1.496	0.890	0.054	3.795
Juntel Down Hill	15	23	0.427	1.496	0.286	0.811	1.581
Undefined	1	4	Benchmark				
Types of collision vs Fatal of RTAs							
Head on collisions	22	49	-0.299	0.164	-1.830	0.318	0.741

Front and Rear End collisions	1	17	-2.867	0.164	-17.540	0.036	0.057
Front and Side	6	14	-0.382	0.164	-2.340	0.257	0.682
Rollover	35	64	0.094	0.164	0.570	0.669	1.098
Collisions with Pedestrian	93	170	0.094	0.094	1.000	0.500	1.099
Fallen from Vehicles	2	4	Benchmark				

Based on the above regression result (p-values>0.05-0.1); the road user's age, driving experience, service year of vehicle and location of RTAs were not statistically significantly associated with the fatality of RTAs in a bivariate analysis. However, In a logistic regression model results, magnitude of determinants on fatalities of RTAs it was found that; by causes of collision (over speeding: OR =1.105, failing to give priority for pedestrians: OR=1.852, excess loading: OR=2.951 and pedestrian errors :OR=1.265), by land use (around industrial area :OR=2.861 and religious area :OR=7.152, and, due to road geometry (straight up and down :OR =3.874,exactly reverse curve :OR = 2.530 and Juntel uphill :OR = 3.795) were statistically significantly associated with fatality of RTAs.

Although not statistically significant, experience of drivers such as have not license (OR=0.692) and less than one year(OR=0.712),Vehicle service year such as up to one year (OR=1.15) and greater than10 year(OR=1.615),road users age such as from 18-30 years(OR=2.213) and 7-14 years (OR=2.026),Collision type such as collision with pedestrian(OR=1.099) and rollover (OR=1.098),and location of RTAs such as near Dembecha(OR=0.769) and Dembecha(OR=0.696) significantly associated with fatality of RTAs and also increased fatality of RTAs with relative to their categories.

4.6. Engineering Solution Measures for Black Spot Segments

4.6.1. Burie

Site description which is also known as "**Burie**" by the local people, is located on the dense traffic areas with majority of heavy to medium tracks, local shops, tsebel areas and many schools. Moreover, due to the presence of "**Burie** "in the area, many Ethiopian Orthodox Tewahdo Church followers from different parts visit the area frequently on foot, by taxis, and by their own vehicles, besides the local communities' massive movement on the road to get Tsebel (holy water). Thus, the area practiced the highest RTAs compared to other Black spots identified on the Study Road. Consequently, the data indicated that 85% of the RTAs occurred between 7:00 a.m. in the morning and 7:00 p.m. in the evening on Sunday and Monday comprising 10%-17% of the total accidents. According to the collision type of the accidents, rear-end collisions, sideswipe collision and collisions with pedestrians comprised about 92% of the whole collision categories.

Field investigations: Burie town is surrounded by many residential, commercial, administrative settlements; and also churches, schools. There are market areas for agricultural product distribution since there is one distribution center at this location with a significant number of heavy vehicles using the road, especially during early in the morning and late in the afternoon/early evening. Photographs taken during field observation of the area are presented below showing deficiencies of local and surrounding roads that contribute to collisions, especially with pedestrians and also vehicle with vehicle conflicts.

Geometrical and Topographical problem:

In the middle of Burie town at an intersection, there is steep slope followed by horizontal curve with no super elevation; due to this geometrical problem, it leads to many RTAs severity of vehicle overturn, vehicle with vehicle and pedestrian with vehicle collisions (see Figure 4.18 below)

In view of the Figure below, the following have observed at the Burie Town surroundings:

- ❖ Pedestrian crossing lines had faded out almost completely at all approaches; in the median also, absence of proper routine maintenance had been observed.
- ❖ There is high volume of on-street parking and those parked vehicles had not been safely, rather parked inside the travelled lane and these conditions continue disturbing smooth traffic movements and they create serious problems for drivers and vulnerable road users.

Figure 4.18: Photo of Black Spot Location by Geometric Design Problem at Burie Town.

From the center of Burie town, with 1.5 kilometers apart in the direction of Injibara, there is a steep slope followed by horizontal curve with no super elevation. In addition to this, the area is surrounded by many trees and an excavated topography. Due to this geometrical and topographical problems, many RTAs severity occur in respect of vehicle with vehicle collision and vehicle overturns (see Figure 4.19 below)

Figure 4.19: Photo of Black Spot Location Conditions with Deficient Geometric Design.

- ❖ Along this segment in front of the Burie University Collage, at the agricultural product distribution center, the road width is very small. Due to this reason, RTAs severity was very high at this location since there is more vehicle flow and high pedestrian movements at this location.
- ❖ There are no roadside barriers used to separate roadways from pedestrian in order to direct the pedestrian to the correct way rather than to unsafe crossing.(see figure 4.20 below)

Figure 4.20: Deficient Road Width, Lack of Traffic Sign and Pedestrian Walkway at Burie Town

Improvement needs: Engineering solution must design to reduce the number and severity of crashes. Based on the identified type of crashes that were observed during the analysis of the data base and site inspection; the related countermeasures which have been successful in similar circumstances, related to the types of crashes were found. Thus, easily implementable improvements are suggested for these black spots as follows:

- ❖ Zebra crossings should be provided and warning sign of pedestrian crossing should be placed at zebra crossing on both sides and provide shoulder for pedestrian in front of the Burie University College in order to minimize accident collisions with pedestrians.
- ❖ Provide fence to direct the pedestrians to safe crossings and avoid trading on the walkways so that it will be likely to minimize vehicle collisions with pedestrians.

- At the center of Burie Town, redesign the geometric alignment and provide super elevation or make it to intersection by providing roundabout by the island to minimize RTAs severity of vehicle overturning and also vehicle with vehicle and vehicle with pedestrian collisions.
- Improve visibility by providing street lightings, pedestrian crossing lightings, and accessibilities to all road users. Lighting is important to include at all pedestrian crossing locations for the comfort and safety of the road users. Lighting should be present at all marked crossing locations. Lighting provides cues to drivers to expect pedestrians earlier and this will reduce the accident occurring at nighttime.

At the location of 1.5 km from Burie town towards Injibara, re designing of geometrical alignment is required and super elevation be provided to reduce centrifugal force. In addition, trees should be removed and the topography should be excavated to make a safe sight distance for drivers. Furthermore, the following are suggested:

- Traffic regulations should be strictly enforced on the drivers to reduce their vehicle speeds and to respect the required rules.
- The traffic police and pertinent government officials should be aware of road users to reduce RTAs severity and be supplied with modern equipment and facilities to carry their tasks to reduce RTAs severity.

4.6.2. Near Finote Selam

Site Description and Traffic Data Analysis: The place Near Finote-Selam is located from Finote-Selam town towards Mankusa village. On this Road segment, many large, small and medium trucks and large buses travel along entire area. The frequency of community mobility to the markets and to health centers is very high and hence, the area practices high road accidents with fatalities, serious and slight injuries and also property damages exacerbating the rate of causalities. The accident types are: rear-end collisions, head on collisions, broadside collision, rollover, sideswipe collision, and collisions with pedestrians. As observed, collisions with pedestrians accounted for about 44.6 % during the analysis period, which is the highest collision type occurred on the road segment. With regard to time, the highest accident crash occurred between 8:00 a.m. and 10:00 a.m. accounted for 15 (about 32%) of the total 47 accidents. Furthermore, road users are not well aware of traffic rules and regulations in this area.

In this regard, road sections, carriageways/edge of carriageways are used by pedestrians. It was common to observe pedestrian-vehicle conflicts. Photographs during field observations of the area showed deficiencies of the road segment contributing to collisions, especially the pedestrian and vehicle conflicts. In this regard, pertinent issues observed during the files visit are presented below.

Site Inspection

- ❖ The road terrain is almost leveled and so vehicles are driven at high speeds and cause accidents and also drivers may be under fatigue or sleeping conditions and so cause accidents; and at some locations, there are trees that obstruct from avoiding obstacles. Due to this, many crashes did occur.
- ❖ There was a complete absence of lane marking. The absence of lane marking caused vehicle drivers to miss a particular travelled lane that creates confusion among motorists causing serious accidents of head on collisions.
- ❖ There is no route edge line marking throughout the observed route section; drivers using inner lane mistakenly hit the median edge due to the edge line missing and create accidents.
- ❖ There was complete absence of transverse markings of the route, and this condition led to serious intersection accidents during pedestrian and vehicle conflicts.
- ❖ Absence of proper routine maintenance of the road caused vehicles to have sudden break or parked on the outer travelled lane leading to serious accidents. There is no pedestrian walkway provided. Carriageways and the edges of carriageways are used as footways. It is common to observe pedestrian and vehicle conflicts. (There is no approach safety barrier (lack of guard fencing) and road markings at the curves and approaching bridges.
- ❖ No pedestrian crossing is provided although pedestrians are susceptible for accidents.

See Figure 4.21 regarding the above statements.

Figure4.21: Photos Showing Lack of Routine Maintenance, Travers and Lane Markings of the Route

Improvement needs: The treatment was designed to reduce the number and severity of crashes. Based on the identified types of crashes found from analysis of the database and site inspection, improvement needs were required that are related to countermeasures that have been successful in similar circumstances and to the type of crashes observed. So easily implementable improvements are suggested for these black spots as follows:

- ❖ The traffic police enforce the driver with safe speed other with punish them and also the traffic police and government official should be ordered the concerned body to remove trees from this area to minimize RTAs severity from this area.
- ❖ Walkway facilities should be provided on the overall route section in order to protect and separate pedestrian from moving vehicles. This will avoid or minimize the accident collision which is the highest collision type facing the area, especially with pedestrians.
- ❖ Warning sign of pedestrian crossing should be placed at zebra crossings on both sides in order to minimize accident collision with pedestrians.
- ❖ Prohibit vehicle overtaking at the curves to minimize the rear-end and sideswipe collisions that are common in the area. Installation of traffic controls like **DO NOT OVERTAKE (at Mankusa).**

- Zebra crossings should be marked with vertical signs and horizontal markings.
- To separates the opposing streams of vehicles, the median should be identified by road marking so as to minimize head on and sideswipe collisions.
- Markings should be durable and visible during the day and at night; skid resistant, and unambiguous. They must give clear information to drivers in order to guide them safely along the road and through any potential conflict points.
- Absence of proper routine maintenance, which caused vehicles to have sudden break or parked on the outer travelled lane that could lead to serious accidents was observed.
- At the time of high crash hours (8 a.m.-10 a.m.), traffic police should be available in the area.
- A pool of water on the road and hanging branches of trees on roadsides can cause accident; as such, obstructions will make the pedestrians /drivers to take sudden lateral (cross) movement and result in accidents. Hence, the obstruction on roadsides which cause a cross movement should be completely rectified timely.

4.6.3. Banja (Around Tilili))

Site Description: Banja is located in Awi Zone of the Amhara Region. It is surrounded by many residential, commercial, administrative settlements, shops, schools and market centers. There are a significant number of heavy, small and medium trucks and similarly large vehicles using this road. Hence, the area practiced high accident fatalities, serious and slight injuries as well as property damages; which exacerbate the frequency of causalities and RTAs in the area. As far as the time is concerned, the highest number of accident crashes occurred between 6 :00 am and 8:00 pm which was 10 (26.3%) accidents out of the total 38. The accident types facing the area were: collisions with pedestrians, rollovers and head on collision with values of 19, 9 and 4 respectively. Photographs of some field observations of the area showing the deficiencies of the road that contribute to those types RTAs severity. (see Figure 4.22 below)

Figure 4.22: Photo of Invisible Pedestrian Crossing, Lane Markings and Lack of Routine Maintenance

Site Inspection:

- ❖ The road is almost straight and at some curves there were trees that obstruct drivers from avoiding obstacles.
- ❖ The condition of the road markings was very poor on almost all sections of the road; particularly, on carriageways road markings were completely absent.
- ❖ The road has faded markings, especially at the pedestrian crossings with overall condition of road marking along the route being terrible.
- ❖ There was a complete absence of lane markings. The absence of lane markings caused vehicle drivers to leave a particular travelled lane that creates confusion among drivers, and causing serious accidents.
- ❖ There were complete absences of road edges and line markings throughout the observed sections; so, drivers who use the inner lane might mistakenly hit the median edge due to the edge line missing and create accidents.
- ❖ There was complete absence of transverse markings of the route, and this could lead to serious intersection accidents of vehicles with pedestrians.

- Absence of proper routine maintenance, which caused vehicles to have sudden break or parked on the outer travelled lane that could lead to serious accidents was observed.
- Poor drainage systems and open channels were observed and these conditions create high potential safety problems to vehicle drivers and vulnerable road users.

Improvement needs: Countermeasures are designed to minimize the number and severity of RTAs. Based on identified problems from analysis of the data and site inspection, related countermeasures that have been successful in similar circumstances have found. So, easily implementable improvements are suggested for the black spots as follows.

- The traffic police should enforce the drivers to drives with safe speed and be aware of the surroundings and the impacts of RTAs severity to the road users.
- The road should be maintained periodically and obstructive trees should be removed from this road to make safe sight distance to drivers.
- Zebra crossing should be marked with vertical signs and horizontal marking
- Warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimize accident collisions with pedestrians.
- Traffic police should be available at the time of high potential crash hours (6AM-8PM),
- The median should be identified by road markings

4.6.3. Finote Selam

Site Description: Finote Selam town is located along the trunk road between Addis Abeba and Bahir Dar with a diameter of 11 km. This segment is located along dense traffic road vehicle comprising of: big trucks, buses medium vehicles as well as small vehicles and also commuting pedestrians. Hence, the movements of the pedestrians are more frequent. Besides, it is observed that there are massive movements of local communities on the road. As a result, the area has practiced the highest number of RTAs with sever causalities .The highest crush hours period was observed during 12:00 pm-2:00 pm. In this study, it was found that 8 (28.6%) accidents occurred during this time out of total 28 RTAs during the day. Regarding types of accidents, 10, 6 and 5 were vehicle collision with pedestrians, overhead collisions and rollover respectively.

Site Inspection:-

Along this road segment, the terrain is almost level and so vehicle speeds are very high. In addition, the following are observed:

- ❖ There was no properly constructed side walkway;
- ❖ Parking's of freight vehicles on roadside shoulders were common;
- ❖ The road median markings and pedestrian crossing were faded with no sign to road users;
- ❖ Since Damot Preparatory school was in the side of on the study road; hence there is no traffic sign for drivers.
- ❖ High movements of intercity freight vehicles, passenger vehicular traffic, pedestrians and many animals crossing the road segment. Specially, much animals pass along the road in front of the town hospital area.

Figure 4.23 below shows improper drainages, lack of pedestrian and animal walkways, lack of road median marking and pedestrian crossing marking and lack of traffic sign.

Figure 4.23: Improper Drainages, Lack of Traffic Sign, Pedestrian and Animal Walkways.

Improvement needs: The countermeasure is designed to minimize the number and severity of RTAs. Based on the identified problems found from analysis of the database and site inspection, together with related countermeasures that have been found successful in similar circumstances, the following implementable improvements are suggested regarding the black spots:

- The traffic police and government officials should enforce drivers to abide by the traffic rules and regulations regarding vehicles speeds;
- Make pertinent communities aware of the RTAs severity;
- Zebra crossings should be marked with vertical signs and horizontal marking;
- Warning signs of pedestrian crossing should be placed at zebra crossings on both sides the road in order to minimize vehicle collusions with pedestrians; and
- Provide pedestrian and animals walkways to reasonably accommodate the subjects.

4.6.4. Debre Markos

Site Description: Debre Markos town is located 300 km northwest of Addis Ababa, the capital city of Ethiopia. The diameter of the town is 18 km long connecting Addis Ababa with Bahr Dar town which is located at about 265 km north of Debre Markos. The Addis Ababa- Bahir Dar trunk Road via Debre Markos is the major national trunk road that accommodates a significant number of traffic comprising of all types of vehicles. The road mainly accommodates large truck movements which transport export and import commodities, goods, machineries and other services within the county as whole at significant rate. Thus, the area is practicing high rate of RTAs. The types of RTAs are: rear-end collisions, sideswipe collisions and vehicle-pedestrian collisions.

Site Inspection

During this study, the following have observed:

- Absence of proper routine maintenance of the road which caused vehicles to have sudden breaks and also parking on the outer travelled lane leading to serious accident.
- Poor drainage systems and open channels have been observed and these conditions create high potential safety problems to vehicle drivers and vulnerable road users.
- The road was cracked and destroyed.
- There were no properly constructed side walkways.
- Road markings were faded with no signs to road users.
- Pedestrian crossing markings were faded.
- Parking of freight vehicles on road side shoulders.
- High intensity of intercity freight and passenger vehicular traffic passes through the entire road segment.

Figure 4.24 below shows improper drainages, lack of pedestrian walkways, lack of road median marking and pedestrian crossing marking, lack of routine maintenance and lack of traffic sign.

Figure 4.24: Improper Drainages, Lack of pedestrian walkways, routine Maintenance and Traffic Sign

Improvement needs: Based on the above findings, countermeasures are designed to minimize the number and severity of RTAs. So, implementable improvements regarding the black spots are suggested as follows.

- The traffic police should enforce the drivers to drives with safe speed and make road users in general aware of RTAs severity;
- The road should be maintained periodically to reduce sudden breakdowns of vehicles;
- Poor drainage systems and open channels have been observed and these conditions have created high potential safety problems to vehicle drivers and vulnerability to road users so provision of good drainage system and maintenance of channels should be carried out to avoid this problem;
- widening of the pavement, bus bay, passenger shed, installation of markings, signs, and improvement should be done;
- Zebra crossings should be marked with vertical signs and horizontal marking;
- Warning signs of pedestrian crossings should be placed at Zebra crossings on both sides in order to minimize accident collisions with pedestrians;
- Traffic police should be available at the required places along the road at the time of potential high crash hours (12 a.m. - 2 p.m.); and.
- The median should be identified by road markings.

4.6.5. Gozamin

Site Description: Gozamin is located close to Debre Markos town which practiced similar crowded traffic movements dominated by big trucks; commuting workers; small, medium and large passengers' buses. Besides, there are also high and frequent pedestrians, taxis and buses movements. Hence, the area practiced RTAs of high fatalities, serious and slight injuries and property damages. As a result, frequency of causalities and RTAs in the area were magnified. The highest crush hours occurred during 2:00 a.m.-4:00 a.m. (local time) time of the day. Accordingly, 14 (27.5%) of the total 51accidents occurred during this time. Regarding the types of RTAs severity; 23, 13 and 11 happened due to: collusion with pedestrians, collision with animals and vehicle rollovers respectively.

Figure 4.25. Absence of Rehabilitation, Traffic Sign, Pedestrian Crossing and Lane Marking

Site Inspection:

The following were observed regarding site inspection:

- ❖ The road was almost straight and so drivers were driving at high speed.
- ❖ Movements of farmers and animals were frequent on the road section. There was no properly constructed traffic sign.
- ❖ There were no pedestrian crossings and lane markings. Hence high intensity of intercity freight and passenger vehicular traffic passes through the entire road segment.
- ❖ Absence of proper rehabilitation of the road segment forces vehicles for sudden break.

Improvement needs:

Countermeasures have designed to minimize the number and severity of RTAs on the road segment. These were based on identified problems observed during the analysis of the database and site inspection and considering the success of countermeasures in similar circumstances. So, easily implementable improvements have been suggested for the black spots on the road segment as follows:

- ❖ Traffic police should be available at accident area, especially from 2 a.m. to 4 a.m. and enforce the traffic rules and regulations;
- ❖ Enhance community awareness to reduce vehicle collision with animals;
- ❖ Zebra crossings should be marked with vertical signs and horizontal marking;
- ❖ Warning signs of pedestrian crossings should be placed at Zebra crossings on both sides of the road in order to minimize the accident collision with pedestrians.; and
- ❖ The median should be identified by road markings.
- ❖ Improve routine maintenance or rehabilitation the affected pavement.

4.6.6. Injibara

Site Description: Injibara town is located in Awi Zone of the Amhara Region and is subject to residential areas, commercial centers, administrative offices, shops, schools and market areas. There is a high number of heavy vehicles using the road. Hence, the area has practiced different types of accidents: fatalities, serious and slight injuries and also property damages that all exacerbate the frequency of causalities and accidents of RTAs in the area. As far as the time of accidents is concerned, the highest accident crash occurred between 11:00pm-1:00 p.m. (local time). According to the observed data,6 (33.33%) of the total 18 accidents occurred during this time. The collision types were: vehicle collision with pedestrians, and vehicle rollovers with values of 13 and 2 respectively.

Site Inspection

The following were observed during site inspection:

- ❖ The roundabout of the Injibara Town has very small radius and so drivers cannot drive safely.
- ❖ Parking’s of freight vehicles on roadside shoulders were common.
- ❖ There were faded road markings especially at the pedestrian crossings; and the overall conditions of road markings along the road were terrible.

- ❖ There was complete absence of lane marking and this caused vehicle drivers to leave a particular travelled lane creating confusions among drivers and serious accidents.
- ❖ There were complete absences of route edge line markings throughout the observed route section; so, drivers who use inner lanes mistakenly hit the median edge due to the edge line missing and create accidents.
- ❖ There was complete absence of transverse markings of the route and this could lead to serious intersection accidents especially vehicle-pedestrian collisions.
- ❖ Poor drainage systems have been observed and these conditions create high potential safety problems to vehicle drivers and vulnerable road users. (see Figure 4.26 for all above inspections)

Figure 4.26: Deficient Geometric Design, Lack of Pedestrian Walkway, Lane and Crossing Marking

Improvement needs

Counter measures have been designed to minimize the RTAs severities. Based on identified solutions observed from the results of the analysis of the database and site inspection and also based on related countermeasures that have been successful in similar circumstances rational implementable improvements have been suggested in this case regarding the black spots on the subject road segment and they are stated as follows.

- Traffic police should enforce the drivers to drives with safe speed and make awareness about RTAs severity to the road users.
- Geometric design of roundabouts should be redesigned with safe radius to reduce crashes.
- Provide good drainage systems to reduce the observed high safety problems to vehicle drivers and vulnerable road users.
- Zebra crossings should be marked with vertical signs and horizontal marking.
- Warning sign of pedestrian crossings should be placed and also at zebra crossing on both sides of the road in order to minimize accident collisions with pedestrians.
- Traffic police should be available at the road segment during peak hours that is 12 a.m. to 2 p.m. local time to avoid RTAs.
- The median should be identified by road marking.

4.6.7. Machakel

Site Description: Machakel is located close to Gozamen which practiced similar crowded traffic movements dominated by big trucks; commuting workers; small, medium and large passengers' buses. Besides, there are also high and frequent pedestrians, taxis and buses movements. Hence, the area practiced RTAs of fatalities, serious and slight injuries and property damages.

Site Inspection

The following have observed during site inspection:

- Absence of controlled pedestrian crossing facilities;
- There was no properly constructed side walkway;
- The road markings were faded with no sign to road users;
- There was complete absence of transverse markings of the route, which could lead to serious intersection accidents with pedestrians;
- There was complete absence of pedestrian crossing warning and no head sign on the overall route section.(see Figure 4.27 for the above inspection)

Figure 4.27: Lack of Pedestrian Walkways, Lane and Pedestrian Crossing Marking

Improvement needs:

- ❖ Traffic police should enforce traffic rules and regulations and accordingly drivers should respect them especially regarding vehicle speeds to avoid RTAs severities to the road users.
- ❖ The road should be maintained mainly in respect of the following:
  - ➢ Widening of the pavement, bus bay, passenger shed, installation of marking, signs, and improvement should be done.
  - ➢ Zebra crossings should be marked with vertical signs and horizontal marking;
  - ➢ Warning sign of pedestrian crossing should be placed at Zebra crossings on both sides of the road in order to minimizing accident collision with pedestrians; and
  - ➢ The median should be identified by road markings.

4.6.8. Guagusa Shikudad

Site Description: Guagusa Shikudad is found Awi zone and located near Injibara. This Road was Trunk road and large trucks, small, medium and large buses pass through the entire. Hence, the area practiced the high fatal, serious, slight and property damage accidents next to the above, which exacerbate the frequency of causalities and accidents of RTAs in the area. As far as the time is concerned, the highest accident crash occurs at 7 pm-9 pm (local time),that is 8 accidents from the total 27 crash numbers. The collision types facing on the area are Head on collisions, collisions with pedestrians and rollover with values of 9, 7 and 6 respectively. Photographs of some field observations on the area, which shows deficiencies of the rout contribution exposures for those types of collisions (see Figure 4.28. below).

Figure 4.28: Lack of Pedestrian Walkway, Routine Maintenance and Traffic Sign at Intersection

Site Inspection

- ❖ The road marking condition was very poor at almost all sections route, particularly at the travelled way where there was no road marking completely.
- ❖ The route has faded markings, especially at the pedestrian crossing location, but the overall condition of road marking along the route was terrible.
- ❖ There was a complete absence of lane marking. The absence of lane marking caused vehicle drivers to leave a particular travelled lane that creates confusion among Drivers, and causes a serious accident. There were complete absences of route edge line markings throughout the observed route section, so drivers who use inner lane might mistakenly hit the median edge due to the edge line missing and create accidents.
- ❖ There was complete absence of transverse markings of the route, and this could lead to serious intersection accidents Vehicles with pedestrians.
- ❖ Absence of proper routine maintenance, which caused vehicles to have sudden break or parked on the outer travelled lane that could lead to serious accidents has been observed.

Improvement needs:

- ❖ The traffic police should enforce the drivers to drives with safe speed and make awareness about
- ❖ RTAs severity to the road users.
- ❖ The road should be maintained periodically.

- Widening of the pavement, bus bay, passenger shed, installation of marking, signs, and improvement should be done.
- Zebra crossing should be marked with vertical signs and horizontal marking
- Warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimizing the accident collision with pedestrians.
- On the time of high crash hour (12AM-2PM), traffic police should be available.
- Prohibit overtaking to minimize the rear end collisions and sideswipe collisions.
- The median should be identified by road marking.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The following findings were revealed regarding Road Traffic Accidents (RTAs) severities on the road from Debre Markos to Injibara (150 km). The accident types incorporated: fatalities, serious, light injuries, and property damages. Based on the findings of the research, the following conclusions are drawn:.

- Regarding the RTAs severity types, high fatality rates were observed at 46.65% of the total. Corresponding values in respect of: serious injuries, slight injuries and property damages were calculated at 21.86%, 12.24%and 19.25% respectively.
- The study implied the existence of large differences in road traffic victims among drivers, passengers, and pedestrians. In this regard, the results of the research showed that pedestrians are more vulnerable to RTAs and further showed that male drivers, male passengers, and male pedestrians were the most affected compared to their female counterparts.
- The results of the research confirmed that RTAs with regard to fatalities, serious injuries and light injuries on the Study Road mostly affected age categories between 18 and 50, regardless of sex, and started declining after age 50. Generally, most of the road traffic accidents highly affected the economically active citizens that is youths and young adult groups, which, in turn, negatively affects the economy of the country and the social structure of the population.
- The results of the study revealed high RTAs occurred on Saturday and Thursday for this period.
- RTAs varied by hours of the days considered, therefore, the findings of research revealed that crashes reached maximum when pedestrians, passengers, and drivers frequency of movement increased. Accordingly, most of the highest RTAs in this road segment and at selected Black spot areas during 6:00-9:00 in day light time; 11:00-3:00 evening time and 2:00-4:00 morning time (local time).
- According to the findings of research, the most dangerous location or black spot segments were: Burie, Near Finoteselam and Banja (around Tilili). Overall, rankings of 1-11 were established for: Burie, Near Finoteselam, Banja (around Tilili), Finoteselam, Debremarkos, Gozamin, Injibara, Machakel, Guagusa Shikudade, Near Dembecha Town and Dembecha Town respectively.

- The results of the research confirmed that land uses like Rural Villages and Residential Areas have very frequent accidents. Accordingly, Rural Village had accidents of 136 and 68 in the case of Residential Areas. However, RTAs severities were small around hospitals, religious and industrial areas. The remaining considered land uses had medium level of accidents.
- The study has identified collision types that occurred on the Study Road; Accordingly, collision with pedestrians, rollover, head on collision, front and rear end collision and collision with animals; The results of the research also revealed that Y junction and T junction had the highest and most frequent accident rates as compared to the other junctions in this road section.
- It was observed during the study that high accidents occurred on straight and level road terrain; but, road terrains like: straight with grade, straight with ups and downs, curve and level, curve and grade, uphill, and downhill did not reveal significant accident frequency.
- Most of the RTAs occurred under dry road surface conditions rather than under wet road surface conditions.
- Based on inferential analysis result; the road user's age, driving experience, service year of vehicle and location of RTAs were not statistically significantly associated with the fatality of RTAs in a bivariate analysis. However, magnitude of determinants on fatalities of RTAs it was found that caused by over speeding (OR =1.105), failing to give priority for pedestrians (OR=1.852), excess loading (OR=2.951) and pedestrian errors (OR=1.265) and land use such as around industrial area (OR=2.861) and religious area (OR=7.152) and due to road geometry such as fatalities straight up and down (OR =3.874), exactly reverse curve (OR = 2.530) and Juntel uphill (OR = 3.795) were statistically significantly associated with fatality of RTAs.
- Finally, the study revealed that the major causes of RTAS severities were: over speeding, not giving priority to pedestrians, not giving priority to primary drivers, unlawful overtaking, excess loading, pedestrian failure to respect traffic rules, and driving on the left side. The respective number of RTAs were: 178, 69, 16, 16, 10, 10 and 10 which was aggregated to 343 crashes.

5.2. Recommendations

On the basis of the findings of the study and the conclusions, the following recommendations have been forwarded:

i. In the middle of Burie town, re-design of the geometric alignment and provide super elevation or make it to intersection by providing a roundabout by the island. In addition, at the location of 2 km apart from Burie town towards Injibara, re-design the geometric alignment and provide super elevation to reduce centrifugal force; also, remove trees and excavate the topography.

ii. Traffic police should enforce drivers to drive with safe speed and to respect the driver rule otherwise punish them to minimize RTAs severity to this Road.

iii. At the previous identified black spot locations, put black spot signs at all black spot location, and give awareness to road users and vehicle operators about black spot locations and put an appropriate traffic sign at all road sections.

iv. As the study findings confirmed, the majority of the RTAs on Debre-Markos - Injibara road have been adversely affecting the surrounding communities; the extent to which they affect youths and young adults is overwhelming. Thus, safety education regarding RTAs should be given to societies, including pedestrians, drivers and traffic police by using schools, work areas, and even using mass medias within the required areas as a short-term solution. But, in the long-term, this should be included in the school curricula, and widely addressed at national level through mass Medias, including the private Medias.

v. The analysis of the study verifies that driver deficiencies are among the dominant causes of RTAs. The young, and less experienced drivers are responsible for most of the accidents. Therefore, drivers' trainings and testing should be revised; a minimum time of driving experience should be imposed before a license is issued to a driver. In addition, there should be additional prerequisite for drivers with regard to their educational background and good behavior, maturity of their ages, ample driving experience, free from any addiction like chewing chat, alcoholic drinks, free from criminal acts as well as offending and frequent violation of traffic regulations.

vi. Most of high RTAs on the Study Road and at selected Black spot areas happened during day light that is during 6:00 - 9:00, 11:00 - 3:00 evening and 2:00 - 4:00 morning time. Therefore, Traffic police should be available at this time at the black spot locations to reduce RTAs.

vii. The job done on pedestrians in some parts of our country shows significant awareness improvements regarding RTAs and so pedestrians have started using their right or left side properly when vehicles come. The same education and awareness raising should be given with the necessary attention. Pedestrian traffic education should be offered and encouraged through radios, television, newspapers, magazines, books, films, leaflets and posters as well as by giving traffic related education at schools, religious places, work areas, worship places and public gatherings, and the like.

viii. The scarcity of traffic signals such as traffic lights and their frequent technical failure creates chaos at squares and junctions leading to the incidence of traffic accidents. Therefore, in addition to the maintenance of the existing ones, the expansion of traffic lights to other accident-prone squares and junctions should receive immediate response.

ix. Generally To summarize RTAs, the following recommendations should be implemented:

- .Make geometrical re design for the concerned above black spot areas.
- Raised Zebra crossing should be implemented, especially in front of schools.
- Zebra crossing should be marked with vertical signs and horizontal marking.
- Warning signs of pedestrian crossings and other difficult areas should be placed on both sides of the subject road.
- Provide properly constructed side walkways.
- Provide fences to keep away pedestrians from the main road.
- Widening of the pavement, bus bay, passenger shed, installation of marking, and traffic signs should be done
- Prohibition of on road side parking
- Traffic channelization should be implemented.
- At the time of high crash hours as described above, strict traffic police enforcement should be applied.
- Median should be identified by road markings.

- Trimming of trees from inner side of road should be made.
- Provide new guard fencing at the approach of the bridge.
- If possible, Provide Street lighting, and pedestrian crossing lighting.

5.3. Proposed Future Research Areas in the Study Road

The following future research areas are proposed to strengthen this study:

- Road traffic accidents cost the country a lot of resources in terms of deaths, injuries and destruction of properties. In this regard, further research on the detailed information about total costs of accidents is commendable.
- This research was conducted on the whole segment of the Debre Markos - Injibara Road. In this regard, conducting detail research by section or by segment will significantly enhance this study.
- .Make individual research on RTAs: RTAs severity Vs road geometry, RTAs severity Vs Drivers, RTAs severity Vs Vehicle, RTAs Vs road users and RTAs severity Vs speed; etc.
- This analysis was conducted using one approach from the two key approaches that is traffic engineering road safety that is namely the hazardous road location approach achieve crash reduction through the development of remedial measures. In this regard, further research using a second approach based on the concept of road safety audit aimed at crash prevention in order to evaluate the overall safety condition of the road network from Debre Markos to Injibara.

References

- *Alan & others (1994), towards safer roads in developing countries, guide for planners and engineers, transport research laboratory, England.*
- *Ali Aram & others (2010), effective safety factors on horizontal curves of two lane highways, journal of applied sciences, v 10, 2814-2822.*
- *Berhanu, G. (2000). Effects of Road Safety and Traffic Factors in Ethiopia; Dr. Ing thesis; Norwegian University of Science and Technology, Trondheim*
- Anderson, T, *Review of Current Practice in Recording Road Traffic Incident Data with Specific Reference to Spatial Analysis and Road Policing Policy, Centre for Advanced Spatial Analysis, University College London, 1-19 Torrington Place Gower Street, London, WC1E 6BT, 2003.*
- Almquist .S and Ekman .L *(1999), The Swedish traffic conflict technique –observers manual loud university, department of technology and society, traffic engineering*.
- Dr. Bikila Teklu, *Lecture Note in Traffic Safety and Environmental Engineering, Addis Ababa University, Addis Ababa, (2014).*
- Dr .Getu Segeni, *Msc thesis on cause of road traffic accident and possible counter measure on Addis Ababa to shashemene road .(2007)*
- Ethiopian Roads Authority. (2011). *Road Sector Development Program (RSDP): 13 Years Performance and Phase IV*.
- Griswold, J., Fishbain, B., Washington, S., & Ragland, D. R. (2011). Visual assessment of pedestrian crashes. *Accident Analysis and Prevention,*
- Haddon Jr W. *The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based. American Journal of Public Health, 1968,*
- *Hauer, E., Council, F. M., & Mohammedshah, Y. (2004). Safety Models for Urban Four-Lane Undivided Road Segments*. *Journal of the Transportation Research Board, 1897*.
- Mekonnen, H. (2007). *Design Consistency of Horizontal Alignments on Two - Lane Trunk.*. Msc Degree Thesis, Addis Ababa, Ethiopia.
- Misganaw, B., & Gebre-Yohannes, E. (2011). Determinants of Traffic Fatalities and Injuries in Addis Ababa. *Journal of the Ethiopian Statistical Association,*

- Murray, C. J. L., Lozano, T. V. R., Naghavi, M., & et al. (2012). Disability-adjusted Life Years (DALYs) for 291 Diseases and Injuries in 21 Regions, 1990–2010: A Systematic Analysis for the Global Burden of Disease Study 2010. *The Lancet,* (December,2012),
- Nantulya, V. M., & Reich, M. R. (2002). The neglected epidemic: road traffic injuries in developing countries. *Education and debate,*
- National Road Safety Coordination Office. (2006). *Overview of the Road Safety Activities in Ethiopia*.
- Oliver Michaud and Jean Francois Corte, *Road Safety Manual: by the member of road safety committee of the world road association (PIARC), 2004*.
- Professor yulong pei, *the analysis of causes and study of countermeasure of road traffic accidents, harbin institute of technology (2002)*
- Road traffics accidents: *epidemiology, control and prevention. Geneva,World Health Organization, 1962.*
- TRL, Ross Silcock Partnership, *Study for Sect oral Road Safety Program in Ethiopia, Volume II, Transport Research Laboratory, Addis Ababa 2001.*
- United Nations Economic Commission for Africa. (2009). *Case Study: Road Safety in Ethiopia.*
- WHO. (2009). *A Leading Cause of the Global Burden of Disease*
- Ethiopian police commission report of RTAs(2005-2008 E.C).
- WHO. (2009). *Global status report on road safety: Time for action. Geneva: World Health Organization*. Retrieved Feb 24, 2011

Appendix: Actual and compiled RTAs data of from Debre Markos to Injibala Major Road. (Source- Amhara Police Commission)

Table A-1: RTAs severity Data by Location.

Accident Segment Areas	Types of Severity				
	Fatal	Serious	Slight	Property	Total
Banja/Tilili/	22	5	4	7	38
Burie	19	2	3	10	34
Debre Markos	19	15	9	8	51
Dembecha	6	4	0	0	10
F/selam	14	11	0	3	28
Gozamen	13	7	11	20	51
Guagusa Shikudad	13	5	1	8	27
Injibara Towun	11	3	1	3	18
Machakel	16	8	3	0	27
Near Dembecha	10	2	0	0	12
Near F/selam	17	13	10	7	47
Total	143	62	32	59	343

Table A-2: RTAs severity Data by causes of RTAs

Causes of RTAs Severity	Types of Severity				Total
	Fatal	Serious	Slight	Property	
Alcohol	0	1	0	1	2
Addiction	0	0	0	0	0
By driving left side	3	3	1	3	10
By no giving primary driver	5	2	0	9	16
Overtaking problems	3	1	4	8	16
By no give 1st for pedestrians	41	19	8	1	69
Passing in up and down grade	0	0	0	0	0
Passing in curves	0	0	0	0	0
over speeding	83	31	25	39	178
Turing without rule	1	2	0	1	4
Ignoring traffic light	0	0	0	0	0
Ignoring stop sign	0	0	0	0	0
Stopping without rule	0	0	0	0	0
Sleeping/Fatigue	1	0	0	0	1
Thinking	0	0	0	0	0
More lighting	0	0	0	0	0

Excess loading	7	1	1	1	10
Road failer	0	0	2	1	3
Pedestrian failer	5	5	0	0	10
Other	5	5	1	0	11
Not known	6	5	0	3	14
Total	160	75	42	67	343

Table A-3: RTAs severity data by sex

Sex	Types of severity				Total
	Fatal	Serious	Slight	Property	
M	133	64	39	62	298
F	0	3	0	3	6
Not known	27	8	3	1	39
Total	160	75	42	66	343

Table A-4: RTAs severity data by age of drivers.

Age of Drivers	Types of severity				Total
	Fatal	Serious	Slight	Property	
Below 18 years	4	2	2	2	10
18-30 years	67	36	26	43	172
31-50 years	31	17	5	15	68
Above 51 years	0	4	3	3	10
Not known	58	16	6	3	83
Total	160	75	42	66	343

Table A-5 RTAs severity data by Time of the Day

Time of the Day	Amount of Severity
1:00-2:00	5
2:00-3:00	19
3:00-4:00	16
4:00-5:00	14
5:00-6:00	9
6:00-7:00	11
7:00-8:00	30
8:00-9:00	18
9:00-10:00	13

10:00-11:00	20
11:00-12:00	20
12:00-13:00	29
13:00-14:00	25
14:00-15:00	21
15:00-16:00	18
16:00-17:00	23
17:00-18:00	11
18:00-19:00	11
19:00-20:00	10
20:00-21:00	5
21:00-22:00	5
22:00-23:00	6
23:00-24:00	4
Total	343

Table A-6: RTAs severity data by Day of the week

Day of the Week	Amount of Severity
Monday	42
Tuesday	43
Wednesday	47
Thursday	51
Friday	46
Saturday	74
Sunday	40
Total	343

Table A-7: RTAs severity data by Land use

Land Use	Types of severity				Total
	Fatal	Serious	Slight	Property	
Rural Village Area	67	19	18	32	136
Agricultural Area	12	11	8	11	42
Around School	8	2	3	0	13
Around Industrial Area	4	0	0	2	6
Around Religious Area	5	1	0	0	6
Around Market Area	7	4	3	0	14

Around Recreational Area	4	7	1	1	13
Around hospital Area	2	1	0	0	3
Around government office	13	5	1	4	23
Around Residential Area	31	19	7	11	68
Other	7	6	1	5	19
Total	160	75	42	66	343

Table A-8: RTAs severity data by road intersection type

Road Intersection Type	Types of severity				Total
	Fatal	Serious	Slight	Property	
No Intersection	124	60	36	61	281
Y-Intersection	17	5	1	1	24
T-Intersection	6	0	1	1	8
Roundabout	3	1	2	1	7
Four leg Intersection	2	4	0	1	7
Five leg Intersection	0	0	0	0	0
Rail crossing	0	0	0	0	0
Other	8	5	2	1	16
Total	160	75	42	66	343

Table A-9: RTAs severity data by Road Geometry

Road Geometry	Types of severity				Total
	Fatal	Serious	Slight	Property	
Straight	101	58	36	43	238
Slight Upgrade	20	11	0	5	36
Highly Upgrade	2	3	1	3	9
Straight Up and Down	2	0	0	0	2
Slight Reverse Curve	14	1	1	8	24
Exactly Reverse Curve	2	0	0	1	3
Juntel Up Hill	3	0	0	1	4
Juntel Down Hill	15	1	4	3	23
Undefined	1	1	0	2	4
Total	160	75	42	66	343

Table A-10: RTAs severity data by lighting conditions

Lighting conditions	Types of RTAs severity				Total
	Fatal	Serious	Slight	Property	
Day light	116	67	39	47	269
Dawn	11	2	3	0	16
Dusk	1	1	0	3	5
Night with good light	7	4		4	15
Night with poor light	4	0	0	6	10
Night with no light	15	1	0	6	22
Un specified	6	0	0	0	6
Total	160	75	42	66	343

Table A-11: RTAs severity data by vehicle service year

Vehicle Service Year	Types of RTAs severity				Total
	Fatal	Serious	Slight	Property	
Up to 1 year	13	3	1	3	20
1 -2 year	19	8	1	7	35
2 -5 year	54	28	21	35	138
5 -10 year	16	15	12	18	61
> 10 year	10	6	2	0	18
Not known	48	15	5	3	71
Total	160	75	42	66	343

Table A-12: RTAs severity data by experience of drivers

Experience of Drivers	Types of RTAs severity				Total
	Fatal	Serious	Slight	Property	
Have not license	4	3	1	1	9
≤ 1 year	14	9	3	5	31
1 -2 year	17	8	9	12	47
2 -5 year	35	22	13	31	101
5- 10 year	22	11	8	13	54
> 10 year	5	4	4	1	14
Not known	63	18	4	3	88
TOTAL	160	75	42	66	343

Table A-13: RTAs severity data by road users' injury

Road Users Injury Severity	Age	Types of Severity					
		Fatal		Serious		Slight	
		Male	Female	Male	Female	Male	Female
Drivers	below 18 years	0	0	1	0	0	0
	18-30 years	10	0	1	0	1	0
	31-50 years	3	0	1	0	1	0
	above 51 years	0	0	0	0	1	2
Pedestrians	below 7 years	3	4	3	0	2	2
	7-13 years	8	7	1	0	3	4
	14-17 years	0	3	0	0	1	1
	18-30years	26	14	18	9	13	3
	31-50 years	26	12	16	6	6	1
	above 51 years	4	2	1	2	0	1
Passengers	below 7 years	0	0	0	0	1	0
	7-13 years	0	1	2	0	0	0
	14-17 years	2	0	1	0	0	0
	18-30years	24	11	15	5	22	21
	31-50 years	18	9	17	7	20	4
	above 51 years	0	1	6	0	10	0

Abbreviations and Acronyms

WHO=World Health Organization

RTAs=Road Traffic Accidents

ERA = Ethiopian Roads Authority

ERTA = Ethiopian Road Transport Authority

GDP = Gross National Product

NGO's = Non-Government Organizations.

NUPI = National Urban Planning Institute.

OAU = Organization of African Unity.

OECD = Organization of Economic Co-operation and Development

TRL = Transport Research Laboratory

UN = United Nations