ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL & ENVIRONMENTAL ENGINEERING

Assessment of Reported Road Traffic Crash in Kolfe Keranyo Sub city, Addis Ababa

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in a Partial Fulfilment of the Requirements for the Degree of Master of Science in Road and Transport Engineering

By

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GSR/3409/06

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June, 2016

ACKNOWLEDGEMENTS

I praise the almighty God for all the work. My instructor Dr.Getu Segni is to be appreciated as his contributions towards this research is notable. I also want to thank kolfe keranyo sub city police statistics department. Especially, Sergeant Tegafaw and Sergeant Belachew have helped me by providing the data records relevant for this research. Also, I thank the staff of the statistics bureau of Addis Ababa Police Commission. Finally, my special gratitude goes to my beloved family.

ABSTRACT

Safety is the timely issue of the road transport sector due to high frequency and severity of Road traffic crashes. The world health organization report shows 1.2 million People are killed and 50 million injured annually in road crashes worldwide. In Ethiopia, the age standardized death rate is 20 per 100,000 population taking the 68th rank in the world as per the crash fatality. Road traffic crash accounts for 2.50% of the top fifty causes of deaths in the country. The road user, the vehicle and the environmental factors to varying degree affect the crash rate and severity. Integrated solutions need to be studied to bring about safe and efficient functioning of the road system. Based on this, different Injury analysis are studied by different researchers around the world. The police-reported crash data of Kolfe Keranyo for four years (July 2012 -June 2016), consisting of 173 fatal, 1060 serious injury, 1064 slight injury and 4723 property damage crashes was used as a basic input for this study. The injury severity is examined as a function of range of explanatory variables available in the daily record. The explanatory variables considered for the analysis include driver and victim demographic characteristics, roadway features, land use and vehicle characteristics. The assessment on severity of crashes is based on descriptive analysis and multinomial logistic regression model. The descriptive statistics is prepared using the distribution of crash severity level with each explanatory variables. The multinomial regression was done using SPSS software by taking property damage crashes as a reference category. The result of this study implies that severity of crashes increase with male young drivers (18-30) of primary education; non-owners; low driving experience; presence of intersections and raised median; downhill and level topography; dry asphalt paved road surface; during good weather condition and older commercial vehicles. Fatality also increases with darkness; over the weekend; involving heavy vehicles like trucks and buses; residential and institutional land use. Young and old, male pedestrians to be the most victimized groups. Black spot analysis was conducted on the road segments and intersections of the sub city using crash frequency, crash rate and severity index from the four years crash data. The result of the black spots analysis show Ayer Tena (China Camp), karakore, Alembank and Weira- Bethel road segments are identified to have the leading rank of crashes. The roundabouts at Zenebwork, Ayertena and 18 mazoria are the top ranked intersections with high fatality. These output illustrate crash severity and identify areas to consider when planning programs, policies, and countermeasures to make difference in reduction of crashes. This research also helps to identify important factors and support further studies on the issue of road traffic safety.

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LIST OF ABBREVIATIONS

AACRA- Addis Ababa city roads

AADT- Annual Average Daily Traffic

ADT- Average Daily Traffic

CSA -Central Statistics Agency

CRDP-City Road Development Plan

E.C.-Ethiopian Calendar

GDP- Gross Domestic Product

GPS - Global Positioning System

IRTAD- International Road Traffic and Accident Database

MUTCD – Manual on Uniform Traffic Control Devices

PDO -Property Damage Only

RTA- Road Transport Authority

SPSS- Statistical Package for Social Sciences

TRACECA- Transport Corridor Europe-Caucasus-Asia

WHO- World Health Organization

WSI- Weighted Severity Index

1. INTRODUCTION

1.1 General Background

Addis Ababa city, the capital city of Ethiopia, covers 527 sq.km divided into 10 sub-cities and 116 woredas. The overall population of the city is estimated to be 3.385 million with aggregate population density of 4,847.8 persons per square kilometre. This accounts for 3.4% of the country's population. Addis Ababa serves as the country's political and economic centre. Addis Ababa's sub cities are Akaki Kaliti, Nefas Silk- lafto, Kolfe Keraniyo, Kirkos, Gulele, Ledeta, Arada, Addis Ketema, Bole and Lideta. (Addis Ababa city Adminstration, 2014)

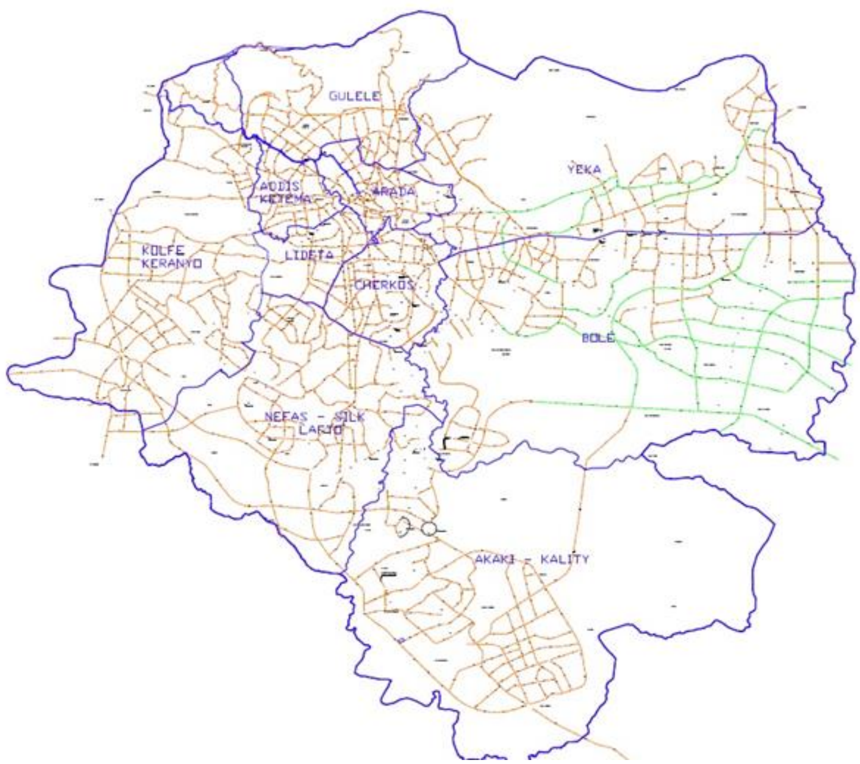

Figure 1: Road network of Addis Ababa

Addis Ababa with higher volume of traffic flow also has relatively high crash records than other cities of the country. Rapid urbanization, industrialization and migration along with other social changes have resulted in increasing necessity for travel in the city. The expansion of the road network and the large increase in number of vehicle in the city has exposed the prevalence of road traffic crashes. Even though, the road network density and vehicle ownership is low as an urban city, the crash rate is virtually high.

Road traffic crash are causes to loss of valued human life, physical disability, property damage and congestion of roads. Road crash records of the city are categorized into three severity classes: fatal, injury and property damage. Injured causalities are further classified to slight and serious injury. Slight injury is when victims face minor scratches not requiring hospitalization where as serious injury denotes persons with major but not life threatening injuries. All reported crashes not involving injuries or deaths are classified as property damages.

Traffic engineering is the planning, functional design, and operational management of facilities in order to provide safe, convenient, economical and environmentally compatible movement of people and goods. This discipline is, therefore, concerned with this current issue of road traffic crashes integrating the different components. The human factors of crash include the driver's perception, choice of speed, strain, orientation and anticipation. The other contributing factor is the condition of the vehicles under operation. The vehicles on the road vary in capabilities, characteristics and qualities. The environmental factors involve the road condition, design defects, road side facilities, and natural hazard risks such as rain (fog), sunshine reflection, storm, flood, land sliding, moisture, skidding pavement, lack of maintenance, poor street lighting etc. These factors with varying degree contribute to the rising crash severity and rate.

The frequent occurrence and the elevating rate of road traffic crashes is now a pressing issue of the road transport system which requires reversing integrated action. Road traffic injuries are currently ranked fifth globally among the leading causes of disease burden, in terms of Disability Adjusted Life Years lost. Road Traffic Injuries are one of the leading causes of death and disability with 90% of global mortality concentrated in the low and middle income countries. Pedestrian injury crashes represent nearly 85% of the total injury crashes in Addis Ababa. (WHO, 2016)

According to the World Health Organization's report, traffic crashes in Ethiopia accounts for the age adjusted Death rate of 20 per 100,000 of population. This is 2.50% of the total deaths in the country making the 68th rank in the world as per the crash fatality. The fatality of road traffic crashes takes 12th level of the top twenty causes of death in the country. The report also states the economic costs of road crashes and injuries to be 1% of Gross Domestic Product (GDP) in low-income countries such as Ethiopia. (WHO, 2016)

The increase use of motorized transport to maintain the socio economic and physical integration is a result of the lately seen modernization and the urbanization of the city. Many new roads have been constructed and the existing roads have been upgraded in order to gear up the economic growth and to cope with this motorization rate. According to Addis Ababa City Road Authority (AACRA) the road coverage in Addis Ababa City reached more than 20%. But, the rise in automobile ownership together with the poor condition of the roads and the poorly functioning traffic system have resulted in high level of congestion particularly at peak hours. (AACRA, 2016) The active population, commuters rush to and from work at similar time. The mixed usage of road by motorized traffic and pedestrians also impedes traffic flow.

There are different stake holders in relation to traffic crashes. Some of these are the public, the Police Commission, the Ministry of Health, the Road and Transport Authorities, the Ministry of Education and the policy makers. The Addis Ababa Transport Bureau in collaboration with the city administration started mobile traffic monitoring in 2015, to check problems of traffic crash and minimize fatalities. Traffic police commission plays an important role in crash prevention and safety improvement through enforcement of laws and regulations. The police is also responsible for documentation of crash data with the respective sub city police stations. The daily, monthly and annual crash data are accumulated and reported to the Addis Ababa police commission office to get the overall statistics.Despite this hierarchical organization of crash records, the under-reporting of road crashes in Addis Ababa is considerable.

In order to have a limited scope for detailed research, Kolfe kernayo subcity is selected among the ten sub cities. Kolfe keranyo sub city is the fourth largest district located in the western edge of Addis Ababa. It is considered as one of the semi-peripheral parts of the city recognized for its informal business activities. According to Central Statistics Agency (2011), the population of the sub city was estimated to be 546,219 in the year of 20011/12 accounting for 15.65% of the city‘s population. As stated by the subcity’s atlas (2014),   kolfe keranyo is the most populated sub city followed by Nifas silk and Bole sub cities.With a total area of around 6510.4 ha, it borders with Oromia in the north, south and west, Lideta sub city in the east, Addis ketma sub city and Gulele sub city in the north east, Nifas silk lafto sub city in the South east. The largest area (39%) is designated as residential area. There are 11 preparatory; 303 elementary and secondary schools. There are 8 hospitals and 136 religious institutions in the region.

Regarding the road coverage of the sub city, 40.4 k.m is asphalt paved and the remaining are gravel and earth roads. Among the asphalt roads the ring road covers the largest part of the sub city. The ring road that was constructed in 2004 dissects Kolfe on the west and the east side and covers about 12.5 k.m. (AACRA, 2016) Despite the reduction of traffic congestion in the area, the ring road is believed to have detached the neighbourhoods from their market places, schools, churches and clinics. The absence of close footbridges has also forced local people to cross the highway and jump over restricted areas presenting a high risk of traffic crashes.

1.2 Statement of the problem

The harm of road traffic crash have significantly increased globally posing a problem to the whole society. Addis Ababa is one of the top ranked cities for high road traffic fatality by the world health organization report taking 75th place in 2016. The issue of road traffic crashes has different aspects that are relevant for in depth study. Most of the local studies conducted on this subject are done at macro level using summarized data of crashes. To reduce the gap and uncover unknown details with more specific researches at lower levels is needed. This research works on the crash data of Kolfe keranyo as it is one of the areas in the city with high exposure to road traffic crashes. The number of road traffic crash of this sub city has increased by 1.4% within the past four years (2004 E.C. -2008 E.C.). Within the past ten years, kolfe keranyo police has recorded 10,095 crashes 462 of which are fatal. This shows more consideration regarding this ongoing problem of road safety is required

1.3Objective of the study

The general objectives of this research is identifying the contribution of primary factors to severity of crashes in the study area. This can be broken down to specific objectives to find explanation for The specific points considered are:

- the effect of the drivers and victim demographic characteristics
- the effect of the type and condition of vehicles involved in crashes
- the effect of the road / environment related conditions
- to identify roadways and intersection with higher risk of crashes (Black spots)

1.4 Scope and Limitations

The research will focus on road traffic crashes in kolfe karanyo sub city, Addis Ababa. The driver/ victim demography, location characteristics, road way characteristic and time of crash are to be considered from the daily police crash records. The research studies the correlation of these different explanatory variables stated and crashes injury severity. The extent of the study considers all reported fatal crashes, serious injuries, slight injuries and property damage. The explanatory variables used are not inclusive of all items of the crash reports but rather focuses on relevant parameters. All reported crashes within the past four years (July 2004 - June 2008 E.C) of the stated area are used for the descriptive analysis. To avoid any bias in the output, crash data with missing variables are neglected in the SPSS analysis. The black spot analysis is done to identify vulnerable locations with higher risk of crashes by using different parameters.

1.5 Significance of the research

The engineering aspect of roads has much to do with the road way design, traffic flow and infrastructural facilities. Therefore, studying the demographic, vehicular and infrastructural features associated with road traffic crashes can help to better understand the scale and related links of the situation. This in turn will facilitate to get solutions of safer road conditions. Preventive measures with a target to reduce the occurrence of road traffic crashes can be made based on these type of studies. The severity model will help to explain the different features of road crash fatality by considering the available data. By recognizing the key influences, this research also provides suggestions for concerned bodies to take effective measures to reduce road traffic crash impacts and improve traffic safety by focusing on primary factors. Stake holders can assess the potential impacts of the factors that contribute to increasing severity of traffic crashes; and implement efficient crash reduction procedures.This can serve as the stepping stone for further development towards an effective and scientific approach to road traffic crashes. This in turn can save lives of many and ease the psychological, economic and social impacts.

1.6 Organization of the research

The rest of this report is organized as follows. The second chapter provides a summary of the available literatures on facts of road traffic crash, associated causes of crash and previously conducted research works. The third chapter will explain the description and sampling of the data obtained from the daily records of the sub city's police. The different aspects of the methodology used by this research for the regression analysis is also explained. It will present the different options available to carry out the study and explains the selection of a particular method. The fourth chapter focuses on the analysis of the data using descriptive and regression analysis with interpretation of the results. The sixth chapter explains the study on identification of black spots in Kolfe keranyo sub city. Conclusions drawn from the results of this study and suggested recommendations are stated in final seventh chapter.

2. LITERATURE REVIEW

Despite the numerous worldwide researches conducted on traffic injury severity, relatively little is known about the factors influencing traffic injury severity in developing countries. On the other hand, developed countries have given great attention to this issue and organized detail studies on the subject matter. A number of studies are considered for the planning of transport and mobility as road traffic crashes causes significant cost to the society. Sustainable transport system cannot be achieved without non-motorized forms of transportation such as walking. Despite the necessity of movement across the country either with motorized means or walking, it can impose some road safety risks compromising human security.

The Addis Ababa City Roads Authority has stated that the road transport system takes 95% of the freight transport and 90% of the passenger travel. It is estimated that about 77% of the registered motor vehicles in Ethiopia are in Addis Ababa. [4] Road transportation is preferred among other modes of transport available due to its flexibility. Transport ownership in Addis Ababa is shared by public and private operators of motorized and non- motorized traffic. Modes of transport in the city include public bus; minibus; taxi, bajaj (motor), walking and animal carts dominate the periphery. According to WHO (2015), Ethiopia's four-wheel vehicles motorization increases by 6 percent annually.

According to the Federal Transport Authority (2016), there are 700,000 vehicles in Ethiopia with Per capita car possession of 3 cars per 1,000 people. Addis Ababa has total vehicle fleet estimated at about 300,000 (60 percent of the total fleet of the country) in 2015. Car ownership has grown rapidly at about 7.0% per annum on average but manifests low motorization rates by global standards. The construction of roads is one of the major focal areas of the government to fast-track economic growth. Although the vehicle population growth rate per annum is increasing, the number of total vehicles remains low compared to other developing countries. In the report of Road transport authority of 2008, the registered number of cargo vehicles consisting of 36,865 trucks, trailers and 2,648 tankers. The passenger vehicles involve 103,862 distributed among different vehicles types. The WHO report in 2012/2013 shows 478,244 registered safer vehicles in the country. (WHO, 2016)

Akloweg, Hayshi and Kato (2011) explained the dependency of Ethiopia as other developing countries on the importation of used cars from higher income countries. Used cars supplied to developing countries typically do not undergo safety inspections and do not meet national safety standards of the exporting country. The technical efficiency of old cars is undoubtedly at a very low standard.

The regulation Ethiopia shares with other 6 African countries include: the responsibility of driver to wear seat belts, which is implemented in recent years. Ethiopia is also one of the 34 countries that have accepted the issuance of ‘no driving after drinking’ and the avoidance of sitting children in the front seats. Despite the rules set on paper, not much has been done in practice. (UNECA,2009) According to the Federal Police Commission (2015), at least one person dies and on average eight persons are injured every day. In the past five years (2003- 2007 E.C.), 15,000 people have died and 4,687 records of serious and slight injuries took place in the country.

2.1 Definition of crash

Road traffic crash is defined by International Road Traffic and Accident Database, IRTAD (2007) as collision of a moving vehicle on a public road in which a road user is injured. The Economic Commission for Europe defines road traffic crash as crashes that resulting in one or more person’s death or injury on a way or open street at least involving at least one moving vehicle. The world health organization, WHO (2016) defines a road traffic injury as a fatal or non-fatal injury incurred as a result of a collision on a public road involving at least one moving vehicle. The law of Ethiopia designates road traffic crash to be any collision that occurs when a motor or a vehicle strikes another vehicle, a stationary object, a pedestrian, or an animal. Road crash records of the city are organized into: fatal, serious injury, Slight injury, and property damage. Injured causalities are further classified to slight and serious injury. Taking this facts into consideration, this thesis takes road traffic crash as an event occurring on a street, road or highway, in which at least one motor or vehicle in motion causes death, physical injury or damage to property due to collision or losing control. Those involved in collisions can be between vehicles; vehicles and pedestrians; vehicles and animals; or vehicles and fixed obstacles.

2.2 Risk factors of crash

The causes of crash vary in time and spatial characteristics. Every crash is not usually attributable to a single cause but to a chain of unique multiple factors or failures associated with the road design deficiencies, vehicle defects, and road user errors. In most cases the traffic police associate traffic crash with a single most important cause on the spot of crash and is unable to list the multiple factors.

Risk factors are used to explain crash involvement and crash severity. Nassar (1996) developed an integrated crash Risk Model using negative binomial regression. The model identified risk factors affecting both crash occurrence and injury severity of occupants. Nassar described risk factors in terms of course of the crash, traffic conditions, environmental conditions, Human factors, and Vehicle conditions. The crash severity model is developed and evaluated using a sequential binary logit formulation to provide occupant specific injury profiled by region, road type, crash type and vehicle type. Using as many risk factors in road crash models improves overall model fit and reduce the amount of unexplained variation given that the models do not include unnecessary variables.

Most safety studies have been based upon a person approach and stress the role of human error in the production of 75-90% of crashes. Van Elslande et al. (2008) argued that it would be wrong to regard ' human error' as the primary cause of crashes. But, safe system approach will rather consider it as a consequence of malfunctions further upstream. The study explained drivers are only a link in the chain of events leading up to crash. The ‘human error’ may be explored in many different approaches on the basis of how it is perceived. Atubi (2009)studied the crash rate of Lagos state, Nigeria and stated road crashes appear to occur regularly where there are sharp bends, potholes and at bad sections of the highways. The multi linear regression implied over speeding drivers usually find it difficult to control the vehicles, which then result to fatal traffic crashes, especially at night.

Elizabeth et al. (2003) described crash risk as a function of the underlying probability of a crash given a particular exposure, the probability of injury given a crash and the outcome of injury. The study points out that risk arises as a result of human error within the traffic system; the size and nature of the kinetic energy of the impact; the tolerance of the victim to this impact and the availability of qualified emergency services.

Abdel-Aty’s (2003) study predict driver injury severity in Central Florida, with crashes occurring in specific roadway sections, signalized intersections and toll plazas of expressway systems. The study illustrates the factors that affect injury severity between different locations. The models developed showed the role of driver's age; gender; seat belt use; point of impact, speed and vehicle type on the injury severity level. Alcohol, lighting conditions, and the existence of a horizontal curve affected the likelihood of injuries in the roadway sections' model. Other variables used in the models were weather condition, type of location, and some interaction factors. It was found that crashes happening in signalized intersections with bad weather and dark street lighting had a significantly higher probability of severe injury. The study also stated that an angle and turning collision in the adverse weather and dark street light conditions contribute higher probability of injuries.

Fantahun (2012) described the road network of Addis Ababa as suffering from many inadequacies including quality of roads, low accessibility level, narrowness, limited network extent and pedestrian walkway, shortage of road network with respect to the size of the city, lack of street parking facility and over utilization of off street parking facility, poorly designed road junctions, and inconvenient bus stations and taxi bays.

According to Addis Ababa City Roads Authority, the common implementation problems raised are very limited traffic management, lack of enforcement action of traffic regulations, inefficiency of drivers' training and licensing system, non-operation of traffic facilities such as traffic lights and signs, weak traffic management system and public consciousness on traffic safety. The common risky driving behaviours include running red lights, exceeding the posted speed limit, and aggressive driving. Aggressive driving comprises speeding, tailgating, offensive gestures, dangerous manoeuvres and, physical violence.

The fact that on-street parking is prevalent in Addis Ababa contributes to the reduction in the capacity of the road networks. Despite mixed population of the road users of which there is a large volume of pedestrians, the walk ways are inadequate and poorly utilized. There are no walkways over a large length (63%) of the roadway network. Ethiopia Transport Authority (2012) acknowledges this as a major concern because it contributes to the increased pedestrian involvement in traffic crashes. The government is working to tackle this problem through improvement of infrastructural facilities by involving the private sector. New policies on driving license and penalty system is on the process of implementation. Few constructions are seen on road sides which are to be more appropriate to pedestrians. Increasing the number of buses for mass transportation and reconstruction of critical junctions are expected to decrease congestion and in turn crash vulnerability.

2.3 Under reporting of crashes

All countries have mandatory requirements for the public to report road traffic crashes to the police, however, under-reporting is still a serious problem worldwide. Almost all crash databases used in the Ethiopia are taken from police-reported crash data records. Individuals involved in no injury or minor injury crashes are far less likely to have their crashes reported to police. Hauer and Hakkert (1989) conducted a meta-analysis of studies comparing police, hospital, and insurance-reported injury data. The results show approximately 20 percent of severe injuries, 50 percent of slight injuries, and up to 60 percent of property damage crashes pass unreported.

Ibrahim (1992) studied reporting in official crash statistics of 49 studies in 13 developed and developing countries is incomplete at all levels of injury severity. The mean reporting level in the countries was found to be 95% for fatal injuries, 70% for serious injuries, 25% for slight injuries, and 10% for property damage or very slight injuries. Reporting levels showed variation among countries, ranging from 21 to 88% for hospital-treated injuries. The study also shows the Reporting is highest for crash including car occupants and lowest for cyclists.

Elvik et al. (1999) studied the crash under reporting from statistics of 13 countries and determined the mean reporting level in the countries to be 95% for fatal injuries, 70% for serious injuries, 25% for slight injuries, and 10% for very slight injuries.This study illustrated the capture-recapture method can be useful to assess the completeness of official data sources. The analysis showed that the rate of ascertainment by police records and hospital surveillance were incomplete. Road traffic incident deaths and injuries were significantly under-reported by traffic police and hospitals.

James (1991) did a summary of different under-reporting studies to determine the factors affecting reporting of crash in official records. Estimates of the total number of crashes not included in official figures for Britain were calculated to adjust the national data for under-reporting. Lopez et al. (2006) also examined the consistency of hospital and police reporting of outcomes of road traffic crashes in Western Australia linking crash details based on, injury severity and the number of vehicles involved. Police classification of injury severity was correct in 78% of cases according to the linked records.

There are also problems with the quality of the data that is recorded. Data fields such as lighting condition, weather, pedestrian movement/action, and road surface condition, often appear not to be accurately or comprehensively recorded. Missing data are frequent, especially with such fields as vehicle service years, technical problems associated with the vehicle or the age of casualty as the police focus on driver information for prosecution purposes. The content of the road crash data record obtained from the Traffic Police misses some relevant details of the crash. The form available for daily crash report book at the local traffic police office is sometimes not completely filled due to various reasons. This missing values for some variables limits the precision of related studies due to increased uncertainty. The records are available in hard copy which limits the transport and health sectors to do in-depth analysis through crash registries.

It is believed that the police-reported road crash data is subjected to underreporting of less severe crashes. Kim et al. (2008) indicated reporting rate for crashes involving pedestrians (fatal, serious injury and slight injury) is thought to be fairly better than other types of crashes as victims may not have any protection material that can reduce the consequences of crashes, and are relatively motivated to report the incident to the police for being compensated.

2.4 Previous Studies Related to Injury Severity

Different studies have investigated the effects of geometric design attributes –including vehicle type, road width, number of lanes, presence of marked pedestrian crosswalks, presence of median, types of turn restrictions, and other related road way factors of crash. Harwood et al. (2008) have implied in his comprehensive study of pedestrian crash the effect of some geometric attributes that the number of lanes and the presence of raised medians had significant effects in reduction of collision frequency. The study also states that the safety of the road network is affected by safety-awareness in the planning, the incorporation of safety features in new road design, safety improvements to existing roads, and remedial actions taken on high-risk crash sites. Hanley et al. (2008) also studied some of infrastructural elements in relation to crashes and concluded that increasing the shoulder and lane widths decreases crash rate.

Moghaddam et al. (2009) studied crash severity on highways of Tehran, Iran. They determined crash severity varied with the influence of multiple factors interacting simultaneously rather than the effect of any single factor. Factors such as age and gender of the driver, light conditions, behaviour of the driver, defective vehicular components, manner of collisions, multivehicle crashes were found to increase crash severity.

Sweedler's (1995) study in Britain show that about 20-30 percent of personal injury crashes involve a vehicle having some deficiency. In most cases, defects associated with the break, tire, light and other mechanical defects are associated with crash. O'Neill et al. (2001) determined size difference between colliding vehicles also affects the severity of injury, particularly, in cases when heavy vehicles impact light vehicles. Older vehicles with mechanical defects and poor maintenance cause higher fatal injuries and property damage. Adequate maintenance of the vehicle during its working life is necessary. Even though there is no evidence that periodic motor vehicle inspections reduce crash rates, this can definitely avoid some risks. In contrast to this, the crash records of this study show very low rate of vehicular defect. This may be due to lack of onsite technical investigation of the vehicles involved at the time of crash.

Islam and Mannering (2007) studied crash injury severity relation with driver age and sex in Indiana State, using multinomial logit models. The results show young (16-24) and middle-aged (25-64) male drivers have high probabilities of fatality and severe injuries. Vichikairagavarapu (2015) analysed the injury severity in pedestrian crashes using classification regression trees and determined that older (60+) pedestrians are six times more likely to be killed when compared to younger pedestrians when struck in daylight.

Prichard (2015) used multinomial regression and frequency distributions to determine the statistical significance of different independent variables to crash severity in work zones of Alabama. Aggressive behavior was found to be the primary contributor to the fatality of crashes. The resulting severity of a crash is highly dependent on the manner of crash. Head-On Collision with Bike/Pedestrian on federal highways yields the highest percentage of fatalities. (Prichard B.,

Ali et al. (2014) conducted study on 11,771 traffic crashes in the Erzurum and Kars reported by the Turkey police. Multinomial logit analysis on crash records of five years from January 2008 to December 2013 was used to determine the risk factors affecting the severity of traffic injuries. The results reveal that drivers over the age of 65; primary-educated drivers; crashes occurring on state routes, highways or provincial roads; and the presence of pedestrian crosswalks increase the probability of fatal injuries.

Kim et al. (2008) used a heteroskedastic generalized extreme value model to explore the injury severity of pedestrians in crashes. The developed model highlighted the effect of several factors in increasing the probability of fatalities. Distinguished factors include intoxicated driving, which increases the probability of fatal pedestrian injury by 2.7 times, and darkness (with or without streetlights), which poses 2–4 times greater risk of fatalities to pedestrians. Lower risk of fatalities is associated with increasing driver age, driving during afternoon peak hours, and crosswalks.

Wedagama and Dissanayake (2010) studied the influence of crash related factors on road fatalities considering Bali province in Indonesia as a case study. Logistic regression models was developed for crashes considering data from Bali. The study found the probabilities of female motorcyclists and motorists were contributing more on motorcycle - vehicle fatal crashes than males. In addition, age was also significant to influence all vehicle fatalities. Age was accounted for about 50% to influence all vehicle fatalities.

Niveditha et al. (2015) studied the development of crash prediction models considering the major influencing factors for the cause of road crashes in Hyderabad city. Three regression models were used for development of crash prediction models as Multiple Linear regression, Poisson regression and Logit regression. Among the three models the logit regression was found to be more suitable for prediction of crashes in the city.

Persson (2008) studied road traffic crashes in Ethiopia to identifying the magnitude, main causes of the problem; and to give recommendations. The Haddon Matrix was used to classify the key determinants of road traffic crashes which explains injuries in terms of factors and time sequence. Poor road network; absence of knowledge on road traffic safety; mixed traffic flow system; poor legislation and failure of enforcement; poor conditions of vehicles; poor emergency medical services; and absence of traffic crashes compulsory insurance law have been identified as key determinants of the problem.

Obeng and Rokonuzzaman (2013) analyzed pedestrian injury severity from automobile crashes in North Carolina to identify its statistically significant correlates. The study considered driver characteristics and condition, land use, vehicle type, environmental conditions and road characteristics vehicle occupants, crash location, number of vehicles involved, alcohol / drug use and types of injuries. It estimates an ordered logit model of injury severity using crash data from February 1999 to October 2005 at signalized intersections. The findings show vehicle type, gender, land-use, speed limit, traffic volume, the presence of sidewalks and visual-obstruction significantly explain pedestrian injury severity. In particular, female drivers and pedestrians are found to be disproportionately involved in crashes.

Berhanu (2004) carried out a research to develop crash predictive models based on the data collected on arterial roads in Addis Ababa. In this study, Poisson and negative binomial regression methods were used to relate the discrete crash data with the road and traffic flow explanatory variables. The negative binomial is found to be preferable than the Poisson for their general handling of over dispersed data (the variance of the observed data was found to be higher than the mean). The results show that the existing inadequate road infrastructure and poor road traffic operations are the potential contributors of road traffic crashes in Addis Ababa. According to the study, the improvements in roadway width, pedestrian facilities, and access management are found to be effective in reducing road traffic crashes.

Abay (2013) investigated the injury severity of pedestrians considering detailed road user characteristics and alternative model specification using Denmark's road crash data. The empirical analysis considered road user characteristics, pedestrian characteristics, driver characteristics, vehicle attributes, environmental characteristics, roadway features, land use features and crash characteristics of the crashes. From the data, road user characteristics such as crime history of drivers and momentary activities of road users at the time of the crash provided an interesting insight in injury severity analysis. From comparison of alternative models, the standard ordered logit model has underestimated the marginal effects of some of the variables considered, and forced some important variable effects to be statistically insignificant, while they remain significant predictors in the other relatively flexible models.

Bhat and Frank (2006) have described the recent development for the analysis of discrete data using mixed logit models. The mixed logit regression addresses the limitations of the multinomial logit by allowing for the correlations in unobserved factors. A mixed logit model is derived with the addition of a second error term to the severity function. Unlike the multinomial probit, its error terms are not limited to normal distributions. Mixed logit probabilities are expressed as the integrals of the multinomial logit probabilities over a density of parameter. Mixed logit improves the limitations of a standard logit model by allowing random variations among the explanatory variables.

A mixed logit was implemented by Milton, Shankar and Mannering (2008) to capture injury severities of crashes. Their model results indicate the average daily traffic per lane result in a decrease in property damage only crashes, which implies an increase in more severe injury outcomes. They also found that increasing pavement friction decreases the likelihood of possible injury and increases the likelihood of property damage and injury; and the number of interchanges per mile in the roadway segment reduces the likelihood of injury crashes.

2.5 Studies Related to Black spot analysis

Black spot in road traffic generally represents the location in which above-average number of traffic crash occurs. These spots are also named as dangerous road location or "hot spots" of road traffic. As per the definition of Elvik (2008), black spot is considered as every section of road, length not greater than 100 m, with at least four traffic crash with injuries registered in the past five years. Elvik claims that the length of the period used to identify black spots varies from 3 year to 5 years, a period of 3 years is used frequently. Using longer periods will increase the probability of changes in the road layout or traffic pattern. TRACECA Countries propose a common definition for Regional usage. The Black Spot is defined as "Any location on a road with a maximum length of 300 meters, at which at least four fatal crashes have been recorded during the last three years". And, Black Road Section is defined as "any road section with a maximum length of 1000 meters, at which at least six fatal crashes have been recorded during the last three years".

The study of black spots has been done using simple models based on actual crash counts to advanced statistical models based on estimates. Initially, descriptive statistics were used to evaluate the data. Now days, crash frequency and crash rate are calculated. As Geurts and Wets (2003) pointed out, there is no universally accepted definition of what should be considered as 'Black spots'. Some researchers rank locations by crash rate (crash per vehicle-kilometers), some use crash frequency (crash per km-year or crash per year) and some use a combination of the two. European Union Road Federation (2002) suggested seven methods that can be used to identify dangerous sites on the road network, each with different order of importance and precision. These are Crash frequency, Hazard potential ratio, Joint method with crash frequency and crash risk ratio, Confidence interval method, Method of the crash severity ratio, Risk rate method and Inventory of the crash risk elements in the road.

Most of the information on road safety intervention are based on research conducted in high income countries. Aside from research on behavioural interventions, there are very few scientific studies on the road safety of infrastructures in low income countries. This issue is significant, as it cannot be expected that studies done in high income countries will have the same outcomes in low income countries. Different studies are conducted on this subject in developing countries exist even though they are few in number and need more detailed analysis. Some of the local studies on traffic crash include that of Getu et al. (2015): 'Injury Severity of Pedestrians Involved in Road Traffic Crashes in Addis Ababa, Misganaw and G/Yohannes (2011) 'Determinants of Traffic Fatalities and Injuries in Addis Ababa'; Berhanu G. (2004):'Models Relating Traffic Safety with Road Environment and Traffic Flows on Arterial Roads in Addis Ababa' and others. But, these studies are integrated in macro level and generalizes the city using aggregated data. To gain more depth, this study covers the data at the root level and focuses on specific area of the issue. This will enable to study not only the frequency of crashes but also the injury severity by considering individual cases.

Van den Bossche et al. (2003) investigated on the question whether a ranking alone can give enough evidence for the selection of dangerous sites. The authors concluded that ranking hazardous sites is an interesting means to get insight in dangerous locations, but there is no such thing as "the" correct ranking.

Tamburri and Smith (1970) introduced the notion of the safety index which is actually a combined criterion of crash number and crash severity. The establishment of this criterion led to the development of a method of black spot identification which initially incorporated the crash-severity based prioritization in identifying black spots. As a result, crash severity was employed as a new parameter in black spot identification.

In Geurts et al. (2003) an association algorithm is used to identify crash factors that frequently occur at high frequency crash locations. These patterns are analysed and compared with frequently occurring crash characteristics at low frequency crash locations. The strength of this approach lies within the identification of relevant variables that make a strong contribution towards crash circumstances and patterns to profile black spots and black zones.

Elvik (2008) evaluated criteria used to identify black spots and provided the list of the five most common ones : Upper tail crash count, Upper tail crash rate, Upper tail crash count and high crash rate, Upper tail expected number of crash (Empirical Bayes estimate), and Upper tail Empirical Bayes (EB) dispersion criterion. Comparing this he concluded that out of the five criteria, Empirical Bayes estimates of safety was found the most reliable.

The Empirical Bayes method is a statistical method that combines the observed crash frequency with the predicted crash frequency using the Safety performance functions to calculate the expected crash frequency for a particular site. This method pulls the crash count towards the mean. This requires the determination of crash frequency mean and variance to make the adjustment. It is applied to calculate an expected crash frequency, which lies somewhere between the observed value and the predicted value from the Safety performance functions.

Empirical Bayes approach compares the crash history of each site with similar reference sites. This is a key issue as any method must be capable of identifying the high crash locations that will continue to be so, not merely those that have random fluctuations. The Empirical Bayes method was also supported by Elvik (2008), although only for use in mid-blocks. Bayesian methods can be used not only to produce a ranked list of hot spots, but also for identifying sets of sites worthy of further engineering investigation.

Another method of black spot identification is called Rate – Quality – Control Method. In this method, Crash rate, crash frequency and severity index values are compared with the respective critical values. If a certain road section shows higher values than the critical ones for all these three parameters, the section is considered to be a black spot. The method treats junctions and road sections separately which are grouped based on similarity of geometry and other features. Average crash rate, average crash frequency, and average severity are then calculated within each group.

3. METHODOLOGY

This section discusses the methodology used for the regression analysis of crash injury severity. Different types of crash analysis are recognized base on the number of crashes considered. This analyses can be done at micro level, intermediate level, and macro level. At a macro level analysis a set of crashes on specific area or for specific road users involved. This can help identify problems that are likely to take place and for prioritizing safety actions. The intermediate level analysis focuses on crash records at the same locations with previous record in order to reduce additional crash on the site. On micro level crash analysis is a detailed study beginning from the scene of the crash. This will require the participation of police, witnesses, engineers and doctors that have observed victims of the specific crash. This research uses micro level analysis of road networks within kolfe keranyo sub city based on the data captured by the respective police department. Convenient sampling was used to select this sub city from the other sub cities. From the ten sub city's kolfe keranyo covers the largest land area of Addis Ababa. This sub city is also the third most vulnerable sub city based on the crash data of past four years (2011/12 – 2015/16).

3.1. Description of data

The research is set to collect and analyze the traffic road crash data of kolfe keranyo sub city as a sample area. The temporal limit of four years is used to study the injury severity and specific characteristics of the chosen area. Extraction of data was done manually from the police daily report documents of the period 2011/12 – 2015/16. The categories within each explanatory parameters were summarized. This is done in order to generate an accurate, unbiased model from the independent variables.

There are different Sample size calculation for logistic regression in different literatures. Some of these are considered to satisfy the minimum requirement of cases to include in the study. Peduzzi et al. (1996) suggested the minimum number of cases to include can be estimated using the following formula:

$$N = 10\, k / p$$

Where: N -the minimum number of cases

p - the smallest of the proportions of cases in the population k - the number of independent variables

For the 3 covariates in the model and the proportion of positive cases in the population is 0.33 (33%). The minimum number of cases required is

$$N = 10 \times 19 / 0.33 = 576$$

When using the rule of thumb, Hosmer, Lemeshow, and Sturdivant (2013) and Agresti (2007) suggest a minimum sample of 10 observations per independent variable in the mode. With 19 independent variables considered for the study the sample size requirement would be 190. The purpose of adjusting the sample size is to comprehend the effects on the data and to come up with a model that best represents the data and does not contradict things that are already known well from other studies.

The three response variables (fatal, serious injury, slight injury) with Property damage treated as the base condition. The sample used in this study satisfies the minimum requirement with a total of 7020 cases registered out of which are 173(2.46%) are fatal, 1100(15.67%) are Serious, 1064(15.16%) are Slight and 4683(66.7%) are Property Damage only. The latest four years (July 2004 E.C. - June 2008 E.C.) daily traffic police crash record from kolfe keranyo sub city police commission is considered to account for all crashes in the area within the given time. All reported crashes within the study time limit and sample area used are shown in the Table 1 below.

Table 1: Crash data taken from the kolfe keranyo sub city

YEAR(E.C)	**Fatal**	**Serious**	**Slight**	**Property Damage**	**Total**
2005	39	199	265	930	1433
2006	33	271	298	1103	1705
2007	52	309	287	1224	1872
2008	49	281	214	1466	2010
	173	1060	1064	4723	7020

Some variation exists among the sampled crash data due to variation in road user, vehicle type, road type etc. Fixed parameters are used to restrict the effects of explanatory variables to be the same across individual injury observations. The road traffic crash database describes several variables related to the crash, including roadway characteristics, environmental factors, vehicle attributes, and road user demographics. In this research, a total of twenty two variables were selected to study their association with injury severity of crashes, and included in the model as explanatory variables. The explanatory (independent) variables extracted from the records include:

- Crash time (seasonal variation, day of the week, time of the day)
- Drivers characteristics (Age, Gender, Level of education, Driving experience, Ownership)
- Vehicle characteristics (Type, Service years, Proprietorship)
- Land use
- Road topography
- Road surface type/ condition
- Presence of Raised Median
- Lighting condition
- Weather condition
- Victim characteristics (Age, Gender, Driver-Victim movement)

These selected items that are considered pertinent to satisfying the research objectives were summarized to a unique, codified spreadsheet. The form used to extract crash data is attached in the appendix section (Appendix a). After the completion of data entry, resulted in a spreadsheet with 7020 cases including those with some missing data for specific parameters. The detail descriptions of the independent variables are considered in this study are discussed.

The pattern of past experience can be indicative of possible causes and consequences of crashes. The individual cases of crash data within kolfe keranyo sub city within the past four years 2011/12 – 2015/16 are the major inputs for the research. This different qualitative and quantitative data is used as a key indicator. Multinomial regression requires a large sample size as it uses a maximum likelihood estimation method. It needs an even larger sample size than ordinal regression or binary logistic regression.

3.2. Analysis methods for crash severity

Regression analysis has been widely used in crash severity prediction and determination of contributing factors. Many statistical logit models have been applied to traffic crash injury severity modelling, including: ordered probit model, ordered logit, multinomial logit model, nested logit model and ordered mixed logit model. Injury severities in the same crash, occurring during the same time and same location are likely to share unobserved effects. The appropriate methodological approach can be selected based on the number of observations, available dataset of the explanatory variables, and other related characteristics.These Regression models have their own assumptions and predefined underlying relationships between dependent and independent variables.

Injury severity levels can be analysed using either ordered or unordered response models. The ordered response framework can be considered as relatively effective in representing the data generation process. Though, ordered response models impose some inconvenient restriction on the data, which guides the way independent variables of the model affect successive probability outcomes. Unordered response framework include multinomial, nested and mixed logit models. Though these do not capture the ordinal nature of the response outcomes, they allow for flexible variable effects across the successive injury severity levels. (Abay, 2013) This implies that the choice of injury severity modelling approaches involves potential trade-off.

Abdel-Aty (2003) modeled driver injury severity on roadway sections, signalized intersections and toll plazas of expressway systems. The crash model was developed using the multinomial logit, nested logit and ordered probit frameworks to identify factors affecting injury severity. The results concluded that the multinomial logit model produced poor results when compared to the ordered probit model. He designated the ordered probit model to be better than the nested logit model due to its simplicity.

The multinomial logistic regression model has been used to study the associations between pedestrian injury and explanatory variables such as vehicular characteristics, temporal trends, and road environment. Though this subject has gained sufficient recognition within the context of regression analysis, additional studies within this framework are still needed due to differences in crash data, in particular variation in risk factors. The key risk factors of traffic crashes and resulting adverse outcomes may be variable across different sections of roads even with similar factors. The formula for the choice probabilities takes a closed form and are readily interpretable.

Multinomial Logistic Regression is a form of linear regression analysis conducted when the dependent variable is has no intrinsic ordering with more than two levels. It is used to describe data and to explain the relationship between one dependent nominal variable and one or more continuous-level (interval or ratio scale) independent variables. This method helps to understand the effect of a series of variables on an unordered qualitative response variable as it can take more than two values. This is fitting to analyse the effect of the different explanatory variables on the different levels of injury severity. The sample used for this regression model is often report -based. When using nested logit model specification, estimation of model parameters can be biased if true shares of the outcomes in the population are not known. Savolainen et al. (2011) assessed different methodological alternatives used for crash injury severity analysis and explained this bias can be constrained by using multinomial logit model.

Washington et al. (2011) explained the multinomial logit model is particularly susceptible to correlation of unobserved effects from one injury severity level to the next. It also does not account for the ordering of injury-severity outcomes. Such correlation causes a violation of the model's independence of irrelevant alternatives property. But, multinomial model is advantageous as it does not impose the unrealistic parameter restrictions that traditional ordered probability models do. If the independence of irrelevant alternatives property holds, it can be shown that in the presences of underreporting of crashes all parameters will still be correctly estimated except for the constant term.

This research uses the multinomial logistic regression model for this report -based injury severity modeling to understand the effect of qualitative explanatory variables. The multinomial logistic regression is used to model nominal outcome of fatal, severe injuries, and slight injury due to crash, in which the log odds of the outcomes are modelled as a linear combination of the Explanatory variables. After cleaning and coding the data is analyzed using IBM SPSS statistics version 23 Software based on the available database of crash records to view different associations between the explanatory variables and injury severity of crashes. The severity model is to be developed using Property damage as the base outcome for fatality. The estimation is relative probability of outcomes to base outcome using logistic model is expressed by the formula:

$$\text{Logit(Y)} = \ln\left(\frac{p(x)}{1-p(x)}\right) = a + \beta_1 X_1 + \beta_2 X_2 + \ldots$$

Where: p(x) is the probability of injury severity (logit response)

Y is the intercept

β is the regression coefficients

X_i are explanatory variables

Assumptions considered in multinomial logistic regression include:

- There is no linearity since the injury severity at each level of the explanatory variable are not on straight line. (i.e.) the independent variables are not linear.

- Important variables are considered with the exclusion of unnecessary data
- The addition or elimination of an alternative does not affect the odds among the remaining outcomes. (i.e.) the irrelevant alternatives are independent
- Variance is not homogeneous as detecting outliers or influential data points is not easy
- The maximum likelihood estimation method uses large sample size

In the initial analysis, the p-values are generated for each independent variable. The p-value represents the probability of observing the sample, assuming that the null hypothesis is true. If the p-value is small, it indicates an extremely strong presumption against the null hypothesis, and the observed data is inconsistent with the assumption that the null hypothesis is true. This is an indication that the effect of the explanatory variable on the injury severity is significant.

Significance values are generated for each independent variable. This value represents the probability of observing the sample, assuming that the null hypothesis is true. If the value is small, it indicates an extremely strong presumption against the null hypothesis, and the alternative hypothesis accepted as true. An accepted alternative hypothesis indicates that the independent variable is statistically significant in determining the resulting severity of a crash. With logistic regression, instead of R^2 as the statistic for overall fit of the model, the deviance is used instead. When the chi-square analyses are used, chi-square is said to be a measure of "goodness of fit" of the observed and the expected values. The chi-square is used as a measure of model fit here in a similar way.

Additionally, the ratio of the probability of choosing one outcome category over the probability of choosing the baseline category is often referred to as relative risk (odds). Thus, determining the exponent of the linear equations above yields relative risks. Regression coefficients represent the change in log relative risk (log odds) per unit change in the predictor. Exponent of the regression coefficients will indicate relative risk ratios. The regression result with low significance value (close to 0) and high Chi-Square value shows better fit. Assessment of the model fit is done based on these outputs of the analysis.

The original model was constructed of 7020 cases but some of the crash records were ignored from the regression due to missing values of certain variables. From these 2015 cases with screened data are used as an input to the SPSS. This is done to avoid bias of the analysis to determine best fit that can correlate the dependent variable (injury severity) with the explanatory data. Since the missing-values are ignored, all the remaining cases are always included in the computation.

The SPSS software analyzes coded data and therefore characters were coded to values the can be understandable by the software and analyzed. Each major factors are analyzed independently excluding the missing values. Based on the output, the driver's characteristics, vehicle property, road environment and victim's characteristics outputs are explained. Trends are established among the independent variables and the dependent variables by using descriptive statistics and multinomial regressions.

3.3. Analysis methods for Black spot identification

Methodology of the identification the black spot ranges from simple marking of black spot to sophisticated techniques which implies evaluating the expected number of traffic crash and determination of potential for the safety improvement.

Crash frequency, the number of crashes on a location, can be used to identify safety performance. Locations with more than a predetermined number of crash are classified as high-crash locations. But, the difference regarding road and traffic conditions are not considered.

Crash rate is a measure of the number of crashes in a road way corridor per million vehicle miles travelled. This enables comparison of crash statistics for road ways with varying traffic volume. Crash rate method uses rates such as crash per million entering vehicles per spot location and crash per million vehicle-Km for sections of roads. The crash rate normalizes the crash frequency based on exposure. This method is preferred as it accounts for the random nature of crashes and the traffic exposure. It measures the level of risk road users' face. This is calculated using the following formula.

$$U_f = U \times 10^6 / (AADT \times 365 \times N \times L)$$

U_f =Crash Rate of road section

U = number of reported injury crash during the period n

N = period length (years)

L = Length of section (km)

The limitations of using crash rates are: it does not account for regression to mean bias; it does not identify a performance threshold; it does not account for crash severity; sites with low volumes may be overemphasize; and Comparisons among sites with significantly different volumes is limited. This errors may be due to the assumption of linear relationship between traffic volume and accident. When identifying potential safety issues, the statistical phenomenon of regression to the mean in which crash rates are artificially high during the before period and would have been reduced even without an improvement to the site.

Crash severity method compares the number of fatal and/or injury crash at a location with property damage- only crashes. The relative crash severity can be used as an indication of the crash severity of the location general severity of crash. The description of relative crash severity is the relative severity index (SI). The severity index is defined differently in various studies assigning weights to the severity levels. A study conducted by United States Department of Transportation in ohio (2011), defined the severity index as:

$$\mathrm{SI} = \frac{12(\mathrm{fatal}) + 3(\mathrm{injury}) + \mathrm{PDO}}{\text{Total number of crash}}$$

4. ANALYSIS AND DISCUSSION

The definition of the different levels of road traffic injuries is stated as per the definition of the Ethiopian law. Fatal crashes are those in which at least one individual involved in the crash died within thirty days of the crash date. Serious injury denotes the case where at least one person ends up with major but not life threatening injuries and he / she is hospitalized for a period of 24 hours or more. Slight injury is when victims face minor injuries requiring hospitalization or outpatient medical treatment for less than 24 hours. Crashes not involving injuries or deaths are reported as property damages.

The injury severity of road crashes is first studied using the descriptive distribution of crash among the different severity levels. Then, the multinomial regression analysis is conducted until finally the results are discussed in the following chapter integrating the outputs.

4.1 Analysis and Discussion Based on Descriptive statistics

All crashes (fatalities, injuries or property damages) within the stated study scope are represented in this study. The distribution of crash among the levels of injury severity is represented in the form of tables, graphs and percentage. The trend observed from these data can help in comparison and identifying patterns of crash, fatality, injury and property damage in a range of variables.

4.1.1 Demographic Characteristics of the Driver

The demographic variables related to driver involved in the crashes describe the human factor of the crash focusing on the driver on the role. The Human Factors considers the driver's operational error as the first step in a chain of events that may lead eventually to a crash. Many of the operational errors result from the direct interaction between the road and the driver's reaction characteristics.

Gender of drivers

This can help to identify the behavioural aspects related to the causes of crash. As it can be seen from the number of crash shown in Table 2, male drivers have the dominating share of drivers. The proportion of female drivers in the city as compared to the males needs to be known to make logical comparison. But, the involvement of female drivers in the crash is found to be much lower than male drivers as per the crash data studied. This can be explained by the higher population of male drivers (Table 3) and the aggressive risk taking driving of male drivers. The involvement of female drivers is only 1.7% of the fatal crashes and 5 % of serious injury crashes. In contrast to this, Abdel-Aty’s (2003) findings shows female drivers were more probable to be in a severe injury crash.

Table 2: Injury severity distribution based on gender of drivers

Crash severity	Gender of Driver's		
	Male	Female	unknown
PDO	4691	32	232
Slight	799	64	201
Serious	982	53	25
Fatal	158	3	12
Total	6630	152	470

Table 3 : Injury severity distribution based on gender of drivers

Year (E.C.)	Gender of Driver's	
	Male	Female
2008	31491	6858
2007	31491	6858
2006	9449	1960
2005	27887	5994
Total	100318 (82%)	21670(18%)

Drivers Age

The driver’s age is categorized so as to observe the most critical age group involved in crashes. The classification is done in a way that can indicate the wise judgment of the driver in contrast to eagerness and Irresponsibility observed in young drivers. As it can be seen in figure 2, the occurrence of crash is high among drivers aged in the range of 18-50. But, fatality is highest with drivers of 18-30 age range consisting of 68% of the fatal crashes. These severity of crashes gradually decreases as the age of the driver increases. Property damage, like other severity levels, is also prevalent among the age group of 18-30 (45 %) followed by 31 – 50 group (42 %). This shows aggressive driving and distraction among young drivers could be a risk factor. It is worth mentioning, twenty two of the crashes involved drivers with the age of under 18 (unlicensed). It should draw attention to the fact that they are illegal as per the law of the country. Moghaddam et al. (2009) reached the same conclusion that young drivers under 25 increase crash severity. The young group (18-30) should be given more focus when working on different measures of crash reduction. From the data obtained from Addis Ababa Transport Bureau (2017), 65% of the drivers are in the age range of 30-50.These figures show the higher share of young drivers in the city which can influence the high percentage of this group in severe crashes due to higher exposure to risk.

Table 4: Age of licensed drivers registered in Addis Ababa

Year (E.C.)	18-30	30-50	>50
2008	32680	33225	220
2007	10626	27503	270
2006	2437	8895	77
2005	5631	28004	246
Total	51374	97627	813

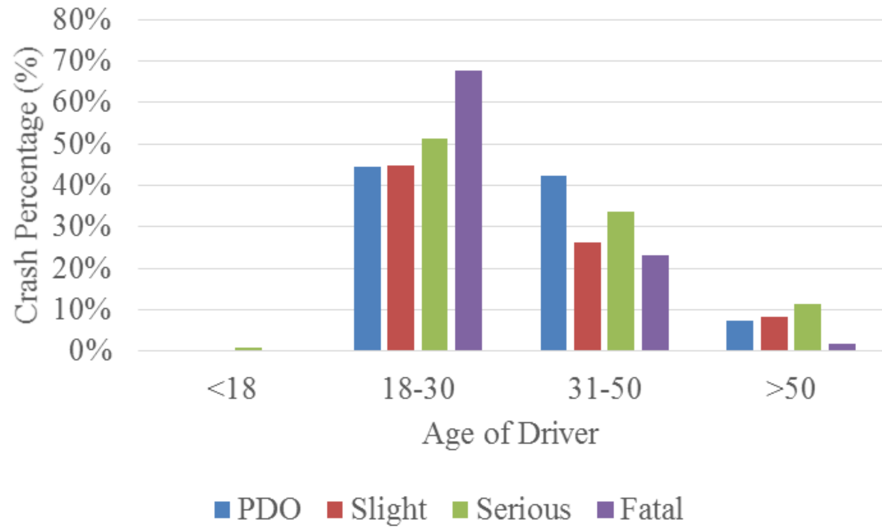

Figure 2: Injury severity distribution based on age of drivers

Educational Background

The highest education level achieved is considered in the report as it provides explanation for the contribution of educational background of the drivers and responsibility of safe driving ethics. As it is observed in the social status of the city, most drivers that take driving as a full time job are high school or college drop outs. This trend is similar to the crash risk associated with the age of the drivers. As figure 3 below implies, the highest fatal crash records are observed among the Primary schooled drivers followed by the secondary school education. The risk of crashes ranging from serious to property damage only is observed to be high among high school educated drivers. Generally, drivers with higher education than high school level have lower risk of severe crashes (fatality). Misganaw et al. (2011) study also implies that less educated drivers are associated with higher risk of traffic fatality and injury. It is difficult to get organized data on the education level of drivers in the city. It is likely that most drivers who didn't go further in the educational field of study people take on driving as profession. This can influence the elementary educated driver's implication as a risk factor for fatality.

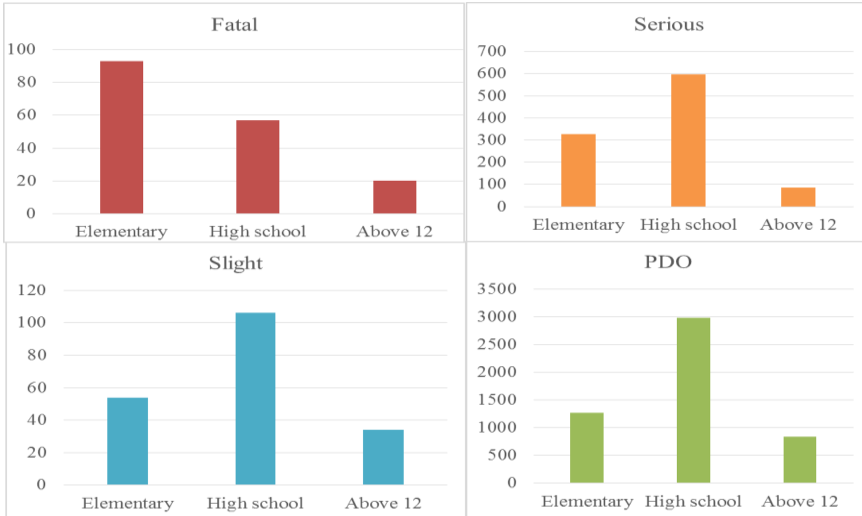

Figure 3: Injury severity distribution based on number of crash and education level of drivers

Driving Experience

The information obtained from the driver's licence is considered as another parameter. It can be seen from the graph that the rate of crash generally decreases as the driver's experience increases. And, novice drivers with driving experience of less than two years take up the higher proportion of the crash in all severity levels. Novice drivers with driving experience of less than two years are involved in 36 % of all fatal crashes which lowers down to 5 % for those with experience of above ten years. These drivers account for 34% of the serious injury crashes. This result is analogous to that of WHO Report (2016) that articulates young and novice drivers are subjected to an increased risk of road traffic crashes compared to older and more experienced drivers. Abay K. (2013) determined novice drivers increase the fatality of traffic crashes.

Figure 4: Injury severity distribution based on experience of drivers

Driver's relation with vehicle

This is to describe the relation of the vehicle with the driver at the time the crash took place. This can be predictive of familiarity of the driver with the vehicle and level of concern for the vehicle. The major part takers of crash in all severity levels are determined to be employees. The highest share of the fatal crashes is concentrated in this category. The group with indistinctive relation with the vehicle take more share in slight injury, severe injury and property damage crashes next to the 'employees'. This implies that owners of the vehicle are more cautious as compared to non -owners. From all the crashes caused by employees 59% are fatal whereas for owners only 10% are found fatal. The implication of this output is equivalent to Getu et al. (2015) results of his study on pedestrian's injury severity. He also concluded non owners have higher risk of fatality.

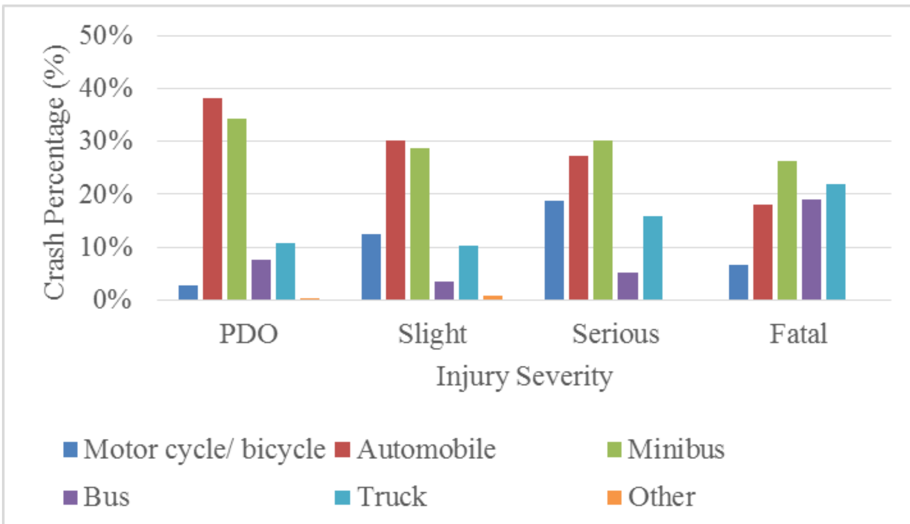

Figure 5: Injury severity distribution based on driver's relation with vehicle

4.1.2 Vehicle related parameters

The variables related to the vehicle responsible for the crash are described based on the type of vehicle, the ownership of the vehicle and the number of years the vehicle has served.

Type of vehicle

The vehicle type is studied based on the categorized group of the vehicle designated to be responsible for the crash. The vehicles classified under the group of 'Minibus' are inclusive of vehicles carrying from 12 to 15 people. The 'Truck' group is also inclusive of the truck and trailer as the proportion is insignificant to consider independently. The number of crashes including bicycle or motor cycle are merged as one group as these share common characteristics and have relatively less volume treated independently. Passenger cars are described as Automobiles for this case.

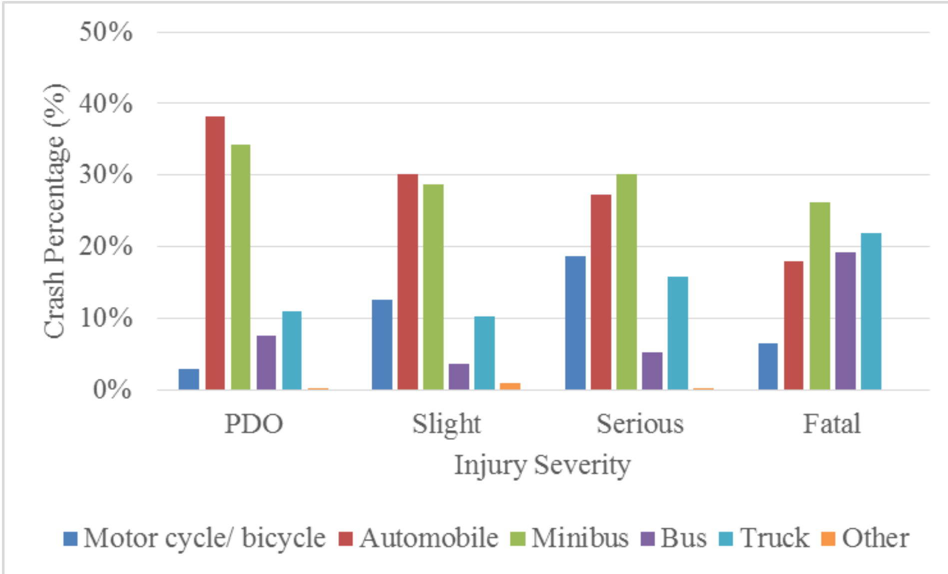

Figure 6: Injury severity distribution based on vehicle Type

The above figure 6 shows the distribution of crash among the different vehicle categories. It can be clearly seen that the involvement of Minibus in all crash severity levels is high. The crashes caused by minibus constitutes 26% of fatal crashes, 30% serious and 29% slight injury. This group has the dominating fatality followed by Trucks (22%) and Buses (19%). Automobiles account for 18% of fatal and 27% of serious crashes. The involvement of Trucks in crashes gradually increases as the severity increases from slight injury to fatal crashes. Whereas, Automobiles involvement decreases as severity of crash increases. 19% of serious injury crashes consist of the motor cycle group showing higher vulnerability. VichikaIragavarapu's (2015) analysis of injury severity in pedestrian crashes had analogous results. His finding also states commercial vehicles involvement in pedestrian crashes is associated with a greater probability of 41% pedestrian fatality. Damsere-Derry et al. (2010) also examined pedestrian injury in Ghana and concluded heavy vehicles are risk factors.

Category of vehicle

This describes the registration class of the vehicle as per the vehicles plate number that imply the intended functions of the vehicle. There are different types of licence plates for motorized vehicles indicating proprietorship. Addis Ababa Transport Bureau reported 498,070 vehicles to be registered in the city until 2008 E.C. The distribution of these vehicles is shown in the Table 5 below. Taxi are coded '1' written in red colour, private vehicles are '2' with blue, commercial of businesses vehicles are '3'written in green, government vehicles are '4' written in black, and red cross is codded '5'.

Unique plate numbers are used for United Nations, African union and temporary plates (UN, AU, red cross….). Commercial vehicles have dominating number followed by Private vehicles.

Table 5: Vehicles registered in Addis Ababa distributed by code and sub city (AATB)

Major Code	ServiceType	Addis ketema	Gulele	Nifasilk & Akaki	Kirkos & Arada	Kolfe	Lideta	Bole & Yeka	Total
1	Taxi	4,463	1,862	3,681	5,107	2,241	3,119	9,319	29,792
2	Private	17,351	6,759	44,803	33,299	13,973	10,537	43,542	170,264
3	Commecial	16,301	6,531	87,229	40,036	16,747	11,492	50,940	229,276
4	Government	1,191	1,234	3,156	10,350	1,899	1,325	4,975	24,130
5	Public	491	120	888	1,602	249	194	631	4,175
Other	AU,UN,CD,Police Null…	2,437	294	13,496	14,250	3,506	310	6,140	40,433
								Total	498,070

The results of the descriptive statistics as shown in Table 4 below indicate commercial vehicles are responsible for the majority of crashes. This result may be associated with the higher exposure and dominance of the vehicles on the road. 57% of fatal crashes happen with commercial/ business vehicles followed by Taxis (21 %) and Private vehicles (17%). Taxis are most frequent in serious injury. Crashes involving trucks or buses are more likely to be fatal as these vehicles have relatively larger mass and damaging angles. The study of Abay, Paleti and Bhat (2012) likewise empirically argued that larger mass vehicles reduce occupants' risk while it increases the risk of endanger other road users outside the vehicle.

Table 6: Injury severity distribution based on with Category of vehicle

Injury severity	Taxi	Commercial	Private	Government	Other
PDO	694	2676	1052	291	10
Slight	207	508	307	39	3
Serious	307	444	260	47	2
Fatal	36	98	30	8	1
Total	1244	3726	1649	385	16

The vehicle's Years of Service

The estimated time for which the vehicle was giving service is considered to comprehend if the deterioration of vehicles with time has an influence on the severity of crashes. Vehicles, commonly commercial Vehicles, need service as per the requirement. Negligence of this responsibility by drivers results in the deterioration over time. The defect associated with the vehicles is mostly neglected in the police records which makes it hard to estimate the correlation accurately. The occurrence of property damage crashes is related more with vehicles that served less than five years followed by those between five to ten years. Older vehicles that have served above ten years account for 34 % of fatal crashes and 31% of the serious injuries. The older vehicles also dominate the slight injury crashes with 59 % share of all slight injury records. The risk of severity of crashes for older vehicles (above ten years) is higher than new vehicles at all severity levels. Generally the vehicles with more service years are seen to be dominating among sever injury levels. This result is consistent with that of Akloweg, Hayshi and Kato (2011) that stated the increasing risk with older vehicles.

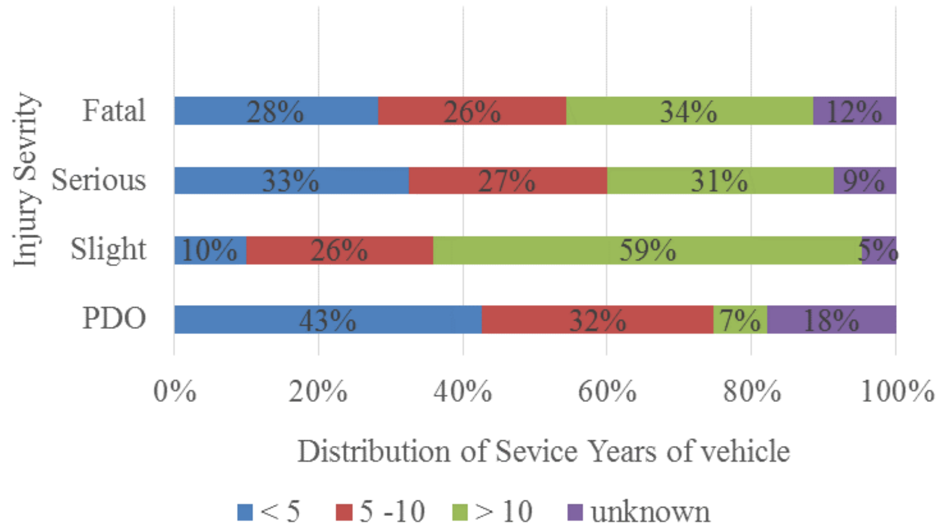

Figure 7: Injury severity distribution based on service years of vehicle

4.1.3 Road environment Parameters of Crash

Road features regulate driver’s behaviour. The road characteristics are planned and constructed to satisfy the user’s needs. This makes it possible and obligatory to take into consideration the human limitations of drivers' perception, information processing and action. The aim is to observe the operational errors due to environmental or road conditions and ultimately the probability of crashes leading to fatality.

Land use

The dominating function of the environment can be influential to the occurrence of crash. The correlation of this variable with injury severity is studied based on the classification of the area. Though this study is based on the land use of crash sites assigned in the police crash report, the function of some locations is not clearly defined as is serves mixed purposes. Classifying roads based on land use rather than functional level has its limitations.The land use of different locations are intertwined with many functional categories. As shown by the descriptive statistics, the Residential areas followed by commercial areas are much more prone to crashes than other categories. Institutional land use designate school, hospitals and religious areas. Industrial sector based and related areas are included in the 'other' group with relatively lower crash frequency.

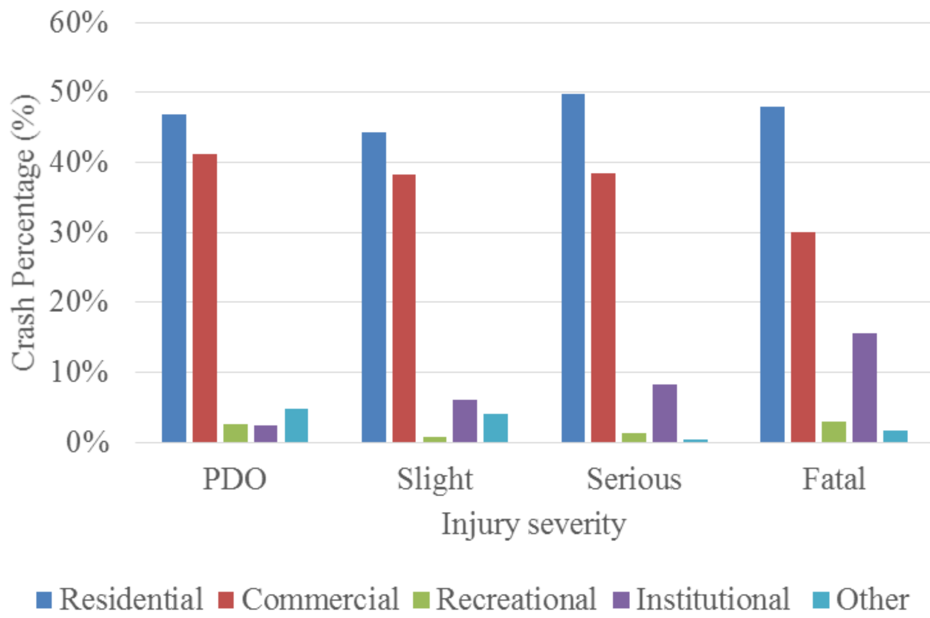

Figure 8: Injury severity distribution based on Land use

Residential areas have the leading role in increasing crash severity by 48 % of the fatal crashes and 50% of serious crashes. Commercial areas follow by 30% fatal and 38% of serious injury crashes. This result is parallel to Misganaw and Gebre-Yohannes (2011) findings that commercial and residential areas are associated with higher number of crashes. Institutional areas show mounting severity accounting for 16% all fatal and 8% of serious injury crashes. This study shows residential areas have the upper hand with increasing severity. A residential street can sometimes serve larger area with high traffic volume functioning as a collector or arterial road. Urban streets on residential areas are provided with frequent access to adjacent properties. These roads are designed as to encourage low speeds. Non-motorized road users are generally present in high proportion and also parking on streets is common adding difficulty for mobility.

Kolfe keranyo sub city is sub urban area where residential areas are common. This is suspected to raise the higher crash registered under residential area with respect to the other groups. This result is evident as numerous human activities and intricate land use are observed. The reason is that these areas always have higher human density and larger population flow.

Road Topography

The topography of the road affects the ease of driving and extent of vehicle control by the driver. This is also associated with the action taken in case of sudden happenings. Self-explaining roads through skilful combination of design elements lead road users to behave in a way that road planners and designers expect, thereby resulting in low crash rates and severity. From the records, the level topography is more vulnerable to crashes followed by downhill road ways. This can be explained with the higher speed associated with these areas leading to lack of caution and loss of control. In level road topography, drivers are likely to do overtaking manoeuvres and also may not be attentive to sudden crossing pedestrians which increases the risk of crash. Straight or flat terrain and downhill slopes are associated with high risk of fatality accounting for 61% and 21% of all fatal crashes. 73% of serious and 62% of slight injuries took place on level roads. This is linked to the speed of driving at this state of road topography. Most drivers are distracted under such conditions, resulting in a greater of risk of crash occurrence.

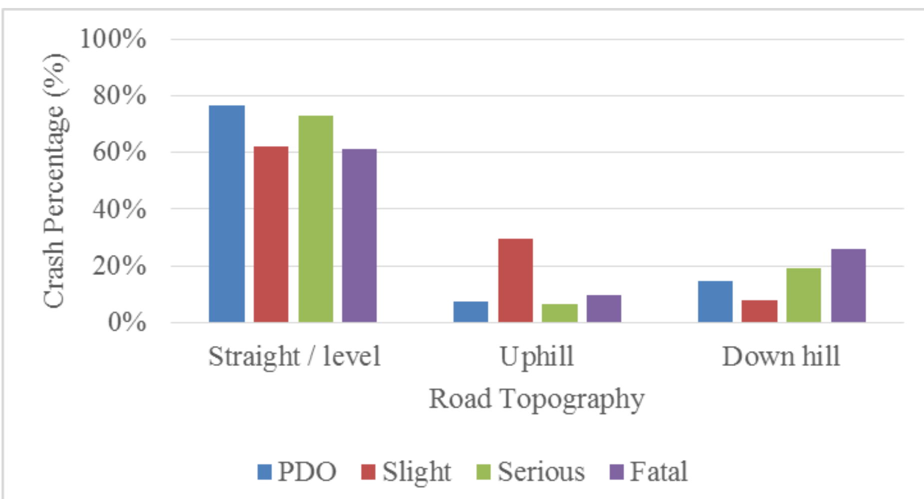

Figure 9: Injury severity distribution based on road topography.

Road Pavement Type

The pavement type represents the road surface condition to estimate the comfort level of the driver at the time of crash. As a limitation, the details of the surface condition with respect to the presence of potholes and the like is not considered in this case. The asphalt pavement is the dominant pavement type with most frequent crashes. Similar to the flat topography of roads asphalt paved road ways allows driving at higher speed and therefore severe crashes and higher probability of fatality. The contribution of earth roads is very low as compared to the other groups of pavement. This could be explained by the fact that most reported crashes take place at main roads with paved road surface. This is validated by the heavy volume of traffic on asphalted roads and the tendency to drive faster. On the other hand, driving on the cobble stone or muddy earth roads forces drivers to take care of their vehicles and drive slowly, which contributes to lower crash severity.

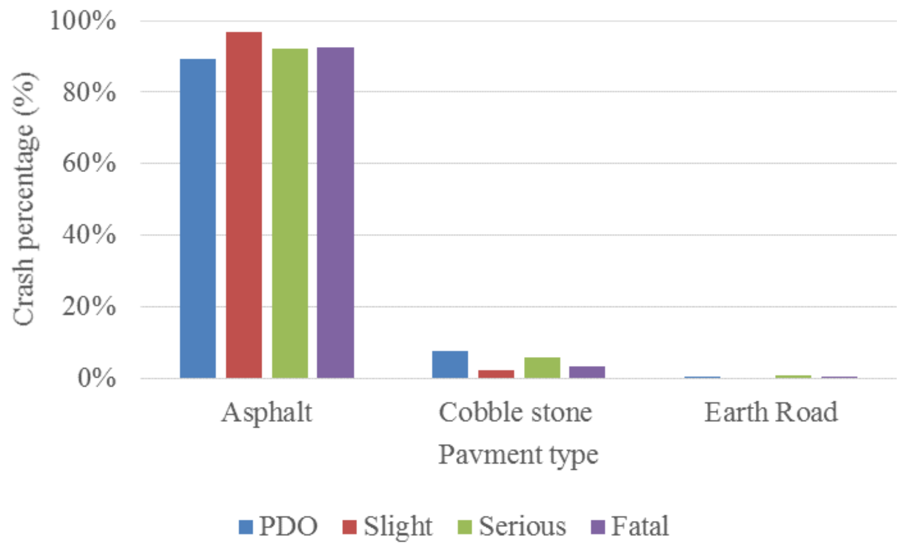

Figure 10: Injury severity distribution based on the road pavement type

Presence of road junction

Presence of road junction describes the availability of nearby intersection on to which two or more roads interconnect. Any signalized roundabout, T- junction, or Y-junctions within proximity of the crash site are considered as 'presence of junction'. The presence of intersection on these road ways implies increase in the conflict points and the number of vehicles involved in the crash. As seen from Figure 11, 58% of fatal crashes are observed near junctions where as 38% are known to have taken place on midblock road segments. The congestion generated at junctions is extended up stream posing risk for crashes. Drivers tend to hurry on approaching junctions to get the right of way or pass signals quickly. It is seen from the general crash records of this study that the number of crashes is higher with the presence of nearby junction which accounts for 62% of all sampled crashes. Abay's (2013) findings also showed crashes that occurred at intersections are more likely to induce fatal injuries to pedestrians. This is plausibly anticipated, as intersections are more complex road segments that can worsen victim's injury severity.

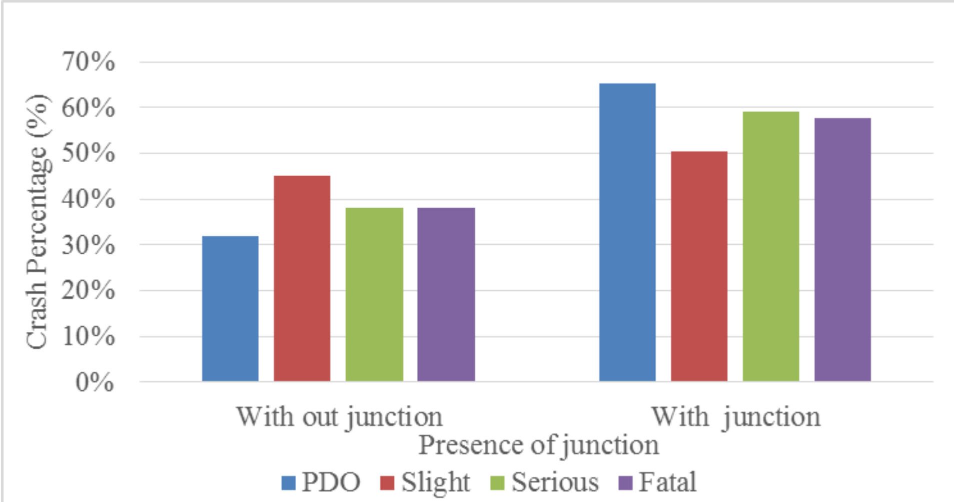

Figure 11: Injury severity distribution based on the presence of nearby junction

Presence of raised median

This is the description of the delineation of road way division using raised median. From the given categories, roads without raised median are found vulnerable to crash. 98 % of the fatal crashes took place at road ways without raised medians. Also, 92% of the serious injury crashes are associated with road ways without raised medians. This pattern is observed among all severity levels of crash more specifically on two way roads. The increased risk factor can be explained by the mixed population of road users with randomized movement patterns. The relatively lower percentage of crashes associated with raised median is indicative of reduction of crash risk by the presence of raised median through division of opposite traffic and protection of pedestrians. The study of Mahdi et al. (2016) explain multilane roadways without medians have higher probability of severe injuries. Designing roadways with higher vehicular demands and corresponding speed need to account for pedestrian crossing. Pedestrians, especially older ones, need extra time to cross roadways, which makes these vulnerable road users more exposed to crash risk.

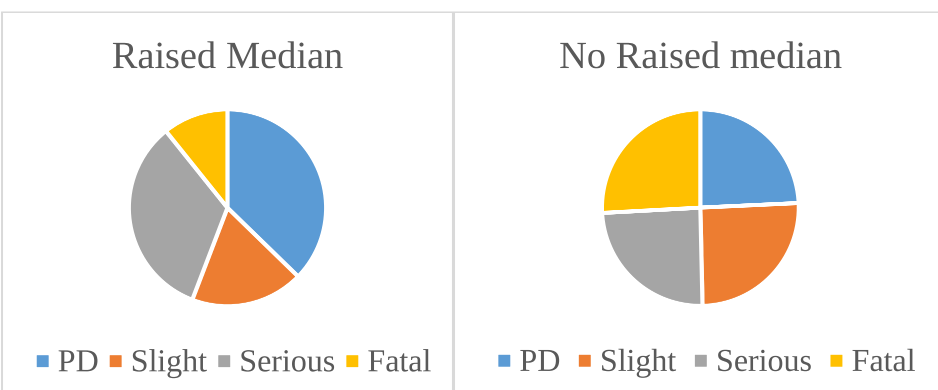

Figure 12: Injury severity distribution based on the presence of raised median

Lighting condition

The visibility condition at the time of the crash can be influenced by the lighting of the roads. This classification is generalized to maintain uniformity of record data by taking night time (with or without the presence of street lights) to be dark. As it is shown in Table 7 below, most of the crashes occur in the day time when darkness is not an issue. The number of crash is higher in the day time than for the night time for all severity levels. This can be related to the high volume of the vehicular flow during the day time. But, 2.97% (57 out of 1919) of crashes that occurred in the dark are fatal which is higher than the 2.2% (111 of 5053) fatal crashes in daylight. Harold, Weissa and Carlo (2013) also described various degrees of darkness with and without streetlights to be associated with crash injury severity. In the driver injury severity levels study of Abdel-Aty (2003) also dark roads were identified as significant contributors to increasing severity.

Table 7: Injury severity distribution based on lighting condition

Injury Severity	Day light	Night / Dark
PDO	3456 (74%)	1238 (26%)
Slight	738 (70%)	315(30%)
Serious	748 (71%)	309(29%)
Fatal	111 (66%)	57(34%)
Total	5053 (72%)	1919 (27%)

Weather condition

Adverse weather condition can be influential on driving manners. The weather condition in the records is summarized as good and adverse conditions. The Good weather condition dominates than adverse conditions in most cases. The weather condition is not directly related to the severity of crashes, but 93% of the fatal crashes happened in good weather. Since the weather of the city is good in most months of the year, there is lower exposure to severe condition which mostly takes place in the summer. Assuming ten months of the year have good weather condition, the crash per day for the good weather is higher than at adverse weather for all severity levels. This is also explained by the increased driver's caution under adverse conditions as compared to any good weather. This is due to the fact that drivers are driving more carefully and at slower speeds under these conditions. As such, the severity of crashes that occur under these conditions is reduced, even if the potential for crash occurrence is greater.

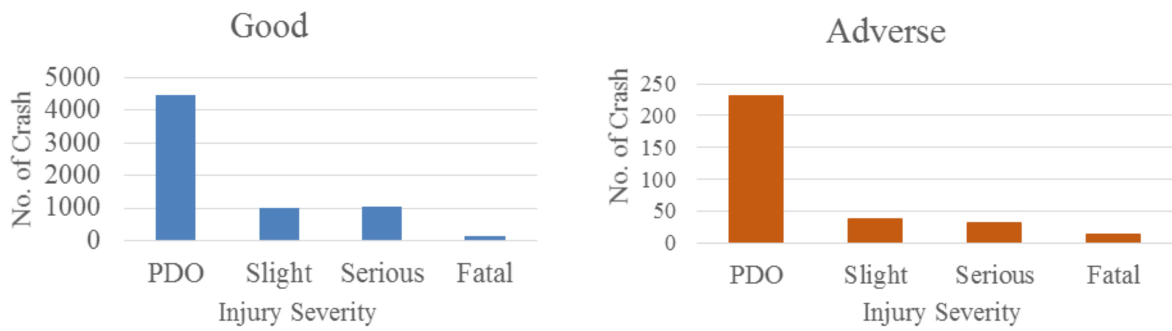

Figure 13: Injury severity distribution based on weather condition

Road surface condition

The surface condition is associated with the weather condition. The condition of the road surface is studied to investigate any influence the road surface has on crash severity. This comparison is done between dry and wet condition. Wet road surface is assumed to be slippery to the tyres of vehicles common in summer season. The findings of the descriptive analysis show the number of slight injury crashes and property damage is higher with wet road surface than the dry condition. But, fatal and serious injuries are more common in dry conditions. This can be explained by the extra caution that drivers take under wet road surface condition.

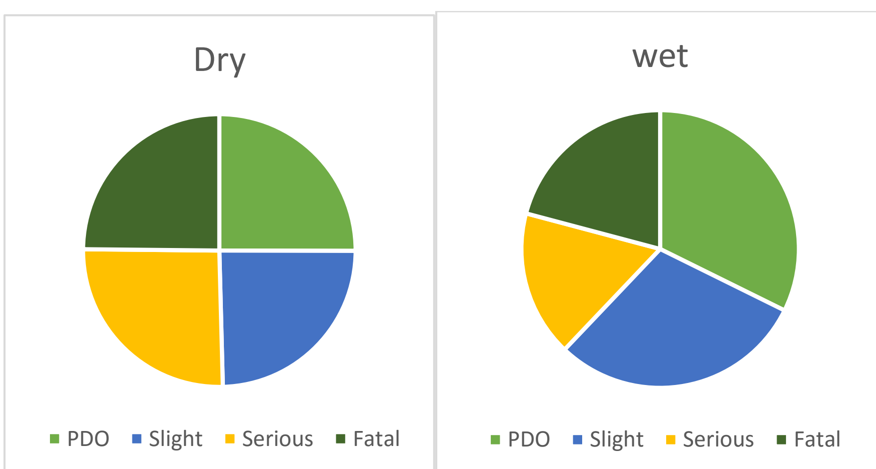

Figure 14: Injury severity distribution based on Road surface condition

Time of crash occurrence

This is studied to determine the range of time with high occurrence of crash for a more detailed information. Figure 15 below expresses the crash occurrence time in three hour intervals local time within 24 hours starting from mid night. It is observed that the highest overall crash number and the fatality of crash is found to be high in the morning peak hour interval of 06:00 a.m. – 09:00 a.m. and the night peak hour 06:00 p.m. – 09:00 p.m. The Serious injury crash rate is the highest in the night peak hour (06:00 p.m. – 09:00 p.m.) The slight injury shows only slight variation during the day but are seen most frequent in the afternoon peak of 03:00 p.m. – 06:00 p.m. The property damage also take the highest rate in morning rush hour. This is consistent with the variation of traffic flow pattern and the congestion of the city. The increment of injury severity towards the morning time can be associated with driver's rush and traffic congestion. Distracted driving and fatigue are also common which can associated to the high crash rate observed during the peak periods.

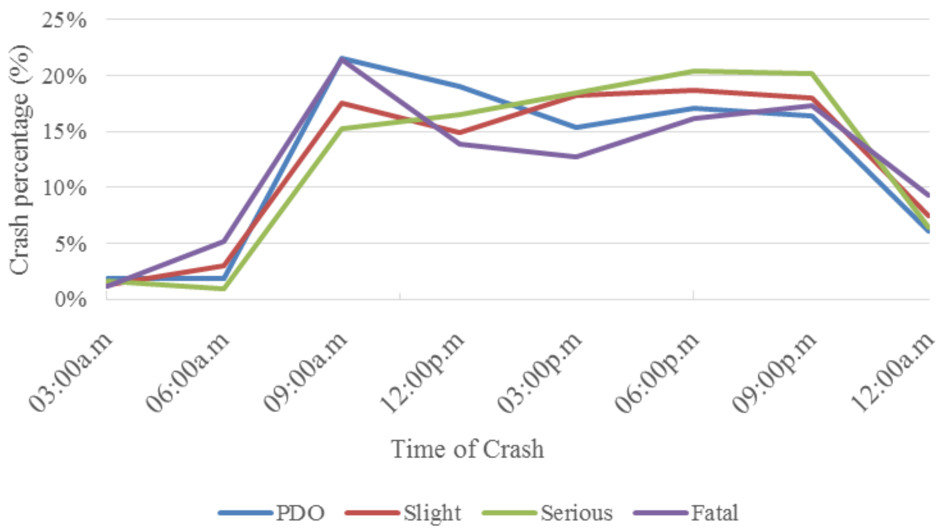

Figure 15: Injury severity distribution based on time of crash

Also, the day of the week was considered as one factor to injury severity of crashes. The number of crash that happened over the week days take 67% of the sampled crashes. As the study area is sub urban most trips are made within the week days increasing the risk of crash rather than weekends when there are fewer vehicles on the road. But, the ratio of the fatal crashes to the total number of crashes can be explanatory to the increasing fatality over the weekend. 2.25% of the crashes on weekdays are fatal whereas over the weekend the fatal crashes account for 3.04%.This pattern is represented by the crash records. Moreover, there are five weekdays and two days designated as weekend so it is better to study the ratio of crashes per day. The fatality is around 23 crashes per day for weekday and around 29 fatal crashes per day. The difference among the crash per day values of weekdays and weekends is around 71 and it decreases as the severity of crashes increases. These implications show severity of crashes increases on weekends.

Table 8: Injury severity distribution over the days of the week

Injury Severity	Weekdays		Weekends	
	Number	**Crash/ day**	**Number**	**Crash/ day**
PDO	3475	695	1248	624
Slight	790	158	274	137
Serious	765	153	295	148
Fatal	116	23	57	29
Total	5146	1029	1874	375

4.1.4 Demographic characteristics of Victim's

The victim may be pedestrian, passenger, driver of the other vehicle in the case of property damage. Studying the characteristics of the victims can be helpful to make effective counter measures.

Gender of the victim

This is considered to identify the more victimized population related to the crash. The male population is the major victim group at all severity levels. From the data obtained, 60% of the victims involved in crashes are males whereas 24% are known to be females. But, the relative frequency of female victims increases as the severity of the injury increases. Taking both perspective into consideration, it can be confirmed that the proportion of females is lower but increasing vulnerability with increasing severity of crashes. Men are mostly involved in more traffic crashes than women as they have higher exposure to road traffic crashes. The female road users are also seen to be cautious and obedient to traffic laws as compared to male. In contrast to this, the severity of female victim's has higher probability of fatality, severe and slight injury. Kim et al. (2010) found female to be vulnerable to increasing severity. They related the implication of female's vulnerability to bodily injury and death when involved in a crash can be due to their weaker physical constitution and potentially different reaction to a crash.

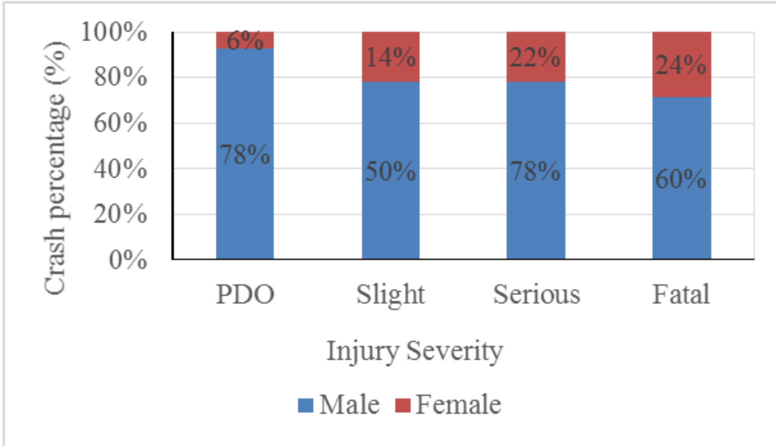

Figure 16: Injury severity distribution based on Victim's sex

Age of victim

Overall the crash is peaked at the age range of 18 to 30 years that accounts for 39% of the identified victim's. This shows the most vulnerable age group of road traffic crashes. The productive young and middle aged groups (18-50) account for 2702 of the sampled crashes. This group have higher risk to crashes at all levels of severity as they often travel to and from work / school. This entails the impact road traffic crashes have on the economy of the country as it spasms the productive group of the population. Most studies like that of Abay K. (2013) revealed that old-aged pedestrians (above 60 years old) are more likely to sustain fatal injuries. The vulnerability to severe injuries of the younger and old populations relates to the fact that they are more fragile. But, this study finds other implication, the fatality of the adolescent group (18-30) can be attributed to the negligence and mind distraction observed among this age group.

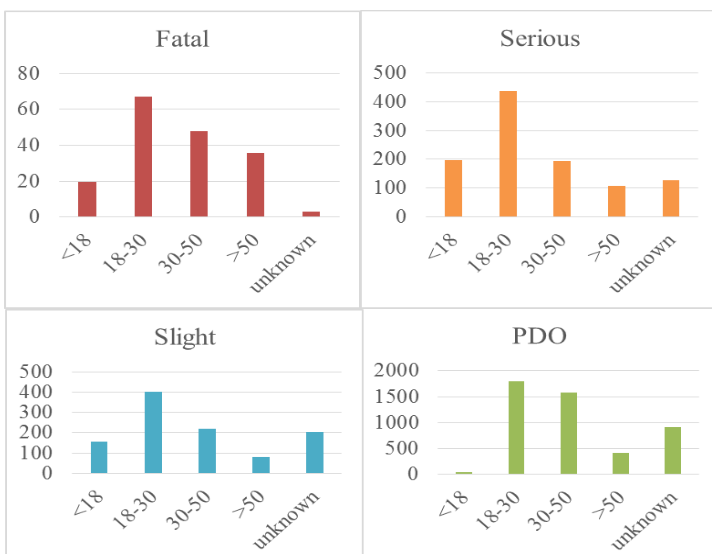

Figure 17: Injury severity distribution based on Victim's age

Movement of the victim during crash

The victim might be a vehicle or a person. The pattern of travel helps in identifying the most exposed segment of the roads and group of road users. Crossing pedestrians have the highest crash records with increasing severity. The straight travel path also has high risk of crash for casualties. The most common vehicle manoeuvre involved in property damage crashes happens to be travelling straight ahead with implication of the conflict among motorists along the same flow direction. 36% of the fatal crash victims are crossing pedestrians followed by 29% straight moving victims' (pedestrians or vehicles) along the same path. Turning vehicles also account for 23% of fatal crashes. Crossing pedestrians are the dominant victims of all severity levels that implies the common conflict between vehicular flow and pedestrian flow. This result comprehends with the fact that pedestrians are the most victimized by road traffic crashes and straight and turning travel path are the most common conflicting manoeuvres.

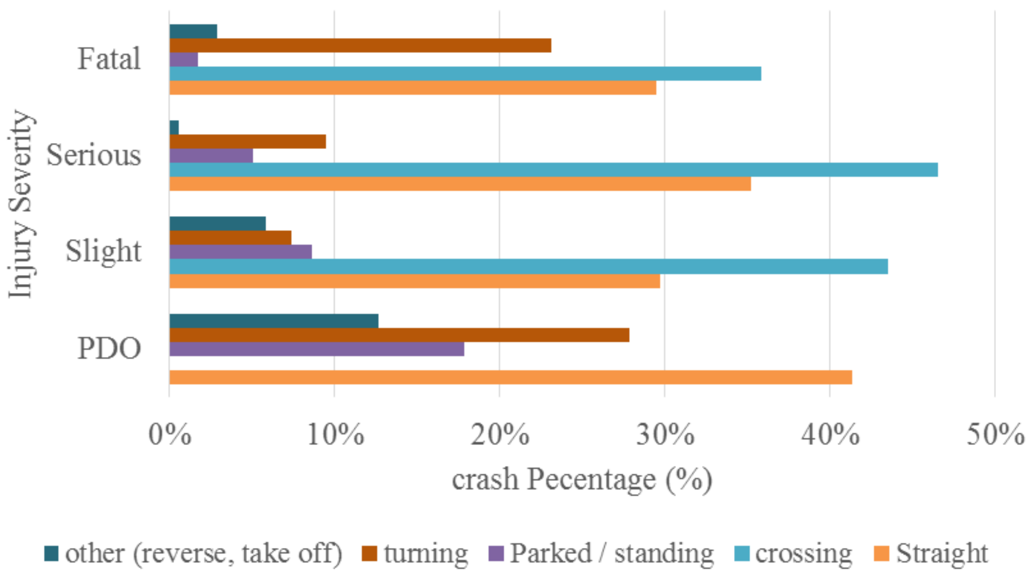

Figure 18: Injury severity distribution based on movement of victim

Category of the victim

Concerning the casualty type, Pedestrian and Passengers have the higher share as victims of road traffic crashes. Pedestrians have higher risk in all severity level accounting for 58% of fatal crashes 60% of serious injuries and 52% of slight injuries. Passengers are also vulnerable to severe crashes with a share of 35%, 36% and 44% of fatal, serious and slight injury crashes respectively. This finding is consistent with the WHO report (2015) literatures stating pedestrians are the most victimized by road traffic crashes. This draws attention to the attitudes of pedestrians, design of roads in addressing pedestrian facilities, and the transportation systems.

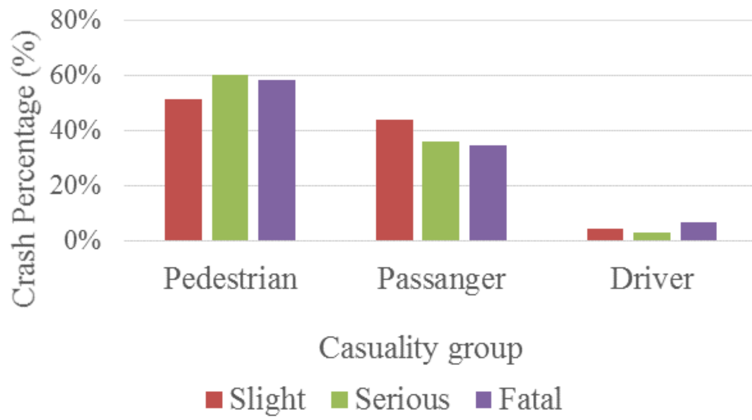

Figure 19: Injury severity distribution based on Victim's type

These data of the descriptive statistics is summarized as follows in Table 9a. These is used as a basis for the multinomial regression and the reference categories are implied.

Table 9: Summary of the Initial Data with Injury Severity

		Injury Severity			
Explanatory Variable		**PDO**	**Slight**	**Serious**	**Fatal**
Driver characteristics					
Gender					
	Male	4691(99%)	799(93%)	982(95%)	158(98%)
	Female (Ref)	32(1%)	64(7%)	53(5%)	3(2%)
Age					
	Less than 18	10(0.2%)	3(0.4%)	9(0.9%)	0(0%)
	Between 18 and 30	2066(46%)	483(57%)	584(57%)	117(73%)
	Between 30 and 50 (Ref)	1965(44%)	300(35%)	357(35%)	40(25%)
	Greater than 50	417(9%)	62(7%)	81(8%)	3(2%)
Education level					
	Elementary	1264(25%)	54(28%)	328(33%)	93(55%)
	High school (Ref)	2981(59%)	106(55%)	596(59%)	57(34%)
	Above 12	842(17%)	34(18%)	85(8%)	20(12%)
Experience					
	More than 10 years	1322(28%)	361(34%)	349(33%)	62(36%)
	2 to 5 years	1086(23%)	319(30%)	265(25%)	62(36%)
	6 to 10 years	1180(25%)	212(20%)	212(20%)	39(23%)
	Novice (Ref)	1133(24%)	180(17%)	222(21%)	8(5%)
Relation with the vehicle					
	Employee	2491(56%)	422(49%)	497(50%)	102(81%)
	Owner (Ref)	893(20%)	179(21%)	245(24%)	17(13%)
	Other	1073(24%)	263(30%)	260(26%)	7(6%)

Vehicle characteristics					
Vehicle type					
	Motor cycle group	136(3%)	134(15%)	198(19%)	12(9%)
	Automobile (Ref)	1803(41%)	321(35%)	289(28%)	33(24%)
	Mini bus	1620(36%)	306(33%)	320(31%)	48(35%)
	Bus	356(8%)	38(4%)	56(5%)	35(25%)
	Truck	514(12%)	109(12%)	167(16%)	10(7%)
	Other (cart,..)	13(0.3%)	9(1%)	2(0.2%)	0
Code					
	[code=a.1]	694(15%)	207(10%)	307(15%)	36(12%)
	[code=b.2]	1052(22%)	307(15%)	260(12%)	30(10%)
	[code=c.3]	2676(57%)	508(26%)	444(21%)	98(32%)
	[code=f.4] (Ref)	291(6%)	39(2%)	47(2%)	8(3%)
	[code=e.5]	10(0.2%)	3(0.2%)	2(0.1%)	1(0.3%)
Years of service					
	Less than 5	2016(52%)	106(10%)	345(36%)	49(32%)
	Between 5 and 10 (Ref)	1514(39%)	277(27%)	291(30%)	45(29%)
	Greater than 10	351(9%)	631(62%)	332(34%)	59(39%)
Environment characteristics					
Land use					
	Residential	2211(48%)	471(93%)	510(93%)	83(93%)
	Commercial	1946(42%)	407(93%)	393(93%)	52(93%)
	Institutional	114(2%)	65(93%)	85(93%)	27(93%)
	Recreational	123(3%)	8(93%)	13(93%)	5(93%)
	Other (Ref)	228(5%)	44(93%)	4(93%)	3(93%)
Lane median					
	Raised median	455(8%)	9(4%)	79(8%)	4(2%)
	No Median (Ref)	4921(92%)	205(96%)	962(92%)	160(98%)
Topography					
	Level	3610(78%)	659(63%)	775(74%)	106(63%)
	Uphill (Ref)	356(8%)	313(30%)	68(7%)	17(10%)
	Down hill	691(15%)	82(8%)	202(19%)	45(27%)
Weather condition					
	Good	4446(95%)	989(96%)	1022(97%)	157(92%)
	Rainy/cold (Ref)	231(5%)	37(4%)	32(3%)	13(8%)
Surface condition					
	Dry	4512(96%)	993(97%)	1034(98%)	164(98%)
	Wet (Ref)	169(4%)	35(3%)	20(2%)	4(2%)
Lighting condition					
	Night time	1238(26%)	315(30%)	309(29%)	57(34%)
	Day light (Ref)	3456(74%)	738(70%)	748(71%)	111(66%)
Pavement condition					
	Asphalt	4217(93%)	1031(93%)	976(93%)	160(93%)
	Gravel roads (Ref)	367(93%)	24(93%)	63(93%)	6(93%)
	Earth roads	24(93%)	0(93%)	9(93%)	1(93%)
Presence of Intersection					
	With nearby intersection	3085(67%)	538(53%)	627(61%)	100(61%)
	mid block road (Ref)	1503(33%)	481(47%)	405(39%)	65(39%)

Duration characteristics					
Day					
	Week-end	1248(26%)	274(26%)	295(28%)	57(33%)
	Week days (Ref)	3475(74%)	790(74%)	765(72%)	116(67%)
Time interval					
	12:00a.m. - 03:00a.m	882(2%)	13(1%)	17(2%)	2(1%)
	03:00a.m. -06:00a.m.	88(2%)	32(3%)	10(1%)	9(5%)
	06:00a.m. -09:00a.m.	1020(22%)	187(18%)	161(15%)	37(22%)
	09:00a.m. -12:00p.m. (Ref)	901(19%)	158(15%)	175(17%)	24(14%)
	12:00p.m. -03:00p.m.	727(15%)	194(18%)	196(19%)	22(13%)
	03:00 p.m.-06:00p.m.	808(17%)	199(19%)	216(20%)	28(17%)
	06:00p.m. -09:00p.m.	774(16%)	191(18%)	214(20%)	30(18%)
	09:00p.m. -12:00a.m.	288(6%)	79(8%)	68(6%)	16(10%)
Victim characteristics					
Gender					
	Female	278(7%)	148(22%)	228(22%)	41(28%)
	Male (Ref)	3702(93%)	532(78%)	827(78%)	103(72%)
Age					
	Less than 18	33(1%)	157(18%)	196(21%)	19(11%)
	Between 18 and 30	1796(47%)	401(47%)	438(47%)	67(40%)
	Between 30 and 50 (Ref)	1573(41%)	221(26%)	193(21%)	48(28%)
	Greater than 50	409(11%)	81(9%)	107(11%)	35(21%)
Type of victim					
	Pedestrian	-	548(52%)	639(60%)	101(58%)
	Passanger	-	468(44%)	386(36%)	60(35%)
	Driver (Ref)	4723(100%)	48(5%)	35(3%)	12(7%)
Movement of victim					
	Straight	1953(41%)	316(32%)	373(36%)	51(32%)
	Crossing	0(0%)	463(47%)	493(48%)	62(39%)
	Parked/ Standing	843(18%)	92(9%)	54(5%)	3(2%)
	Turning	1315(28%)	62(6%)	101(10%)	40(25%)
	Other(Reverse,Takeoff)	598(13%)	52(5%)	6(1%)	5(3%)

4.2 Analysis and Discussion Based on Multinomial Logistic Regression

For injury severity as the dependent variable, twenty two candidate independent variables were selected from the data set. The severity indicators, that is, number of fatalities, number of injuries and property damage, are studied with Multinomial logistic regressions. The multinomial logistic regression is used to get the interrelation of the explanatory variables have on the severity of crashes.

All hypothesized factors that are assumed to affect the severity of crashes were included in the regression model but finally the significant variables only are considered here. The major contributing factors and their effects are identified based on the significance of the outputs. The results of the analysis is summarized in Table 10 below and integrated for interpretation.

Table 10: Results of Multinomial Logistic Regression on Injury Severity

Parameter	Fatal				Serious				Slight			
	β	**Std. Error**	**Sig.**	**Exp(β)**	**β**	**Std. Error**	**Sig.**	**Exp(β)**	**β**	**Std. Error**	**Sig.**	**Exp(β)**
Driver characteristics												
Gender												
Male	2.795**	1.216	0.021	16.367	1.539***	0.340	0.000	4.662	1.73***	0.335	0.000	5.642
Female												
Age												
Less than 18												
Greater than 50					1.143***	0.353	0.001	3.135	0.688	0.181	0.000	1.989
Between 18 and 30	1.864***	0.370	0.000	6.451	0.542**	0.184	0.003	1.720				
Between 30 and 50												
Education level												
Above 12												
Elementary	1.482***	0.276	0.000	4.402								
High school												
Experience												
More than 10 years	-1.657**	0.566	0.003	0.191	-1.216***	0.285	0.000	0.297	-1.149***	0.274	0.000	0.317
2 to 5 years												
5 to 10 years	-1.717***	0.466	0.000	0.180	-0.524**	0.229	0.022	0.592	-0.609**	0.225	0.007	0.544
Novice												
Relation with the vehicle												
Employee	1.576***	0.432	0.000	4.836	0.881***	0.216	0.000	2.414	0.846***	0.209	0.000	2.330
Other												
Owner												
Vehicle characteristics												
Parameter	**Fatal**				**Serious**				**Slight**			
	β	**Std. Error**	**Sig.**	**Exp(β)**	**β**	**Std. Error**	**Sig.**	**Exp(β)**	**β**	**Std. Error**	**Sig.**	**Exp(β)**
Vehicle type												
Truck	2.78***	0.512	0.000	16.124	0.78**	0.292	0.008	2.180				
Bus	1.714**	0.594	0.004	5.550	1.075***	0.335	0.001	2.929				
Mini bus	1.378**	0.460	0.003	3.966	0.44*	0.240	0.067	1.553	0.701**	0.225	0.002	2.015
Motor cycle group					1.191**	0.402	0.003	3.291	1.203**	0.394	0.002	3.328
Other (cart,..)												
Automobile												
Years of service												
Less than 5					0.816**	0.353	0.021	2.262				
Greater than 10	1.595***	0.450	0.000	4.932	0.358**	0.171	0.036	1.431	0.333**	0.167	0.045	1.396
Between 5 and 10												
Code												
[code=a.1]	1.299*	0.686	0.058	3.665	1.568	0.392	0.000	4.797	0.678*	0.376	0.071	1.970
[code=b.2]	1.092**	0.607	0.042	2.981	1.244	0.332	0.000	3.470	0.899**	0.314	0.004	2.457
[code=c.3]	2.642***	0.690	0.000	4.044	2.14	0.368	0.000	8.501	2.023***	0.345	0.000	7.562
[code=e.5]												
[code=f.4]												

Environment characteristics													
		Fatal				Serious				Slight			
Parameter		β	Std. Error	Sig.	Exp(β)	β	Std. Error	Sig.	Exp(β)	β	Std. Error	Sig.	Exp(β)
Land use													
	Commercial												
	Residential	1.791**	0.898	0.046	5.997	0.713*	0.375	0.057	2.040				
	Institutional	2.153**	1.097	0.050	8.608	1.296**	0.559	0.021	3.654				
	Recreational												
	Other												
Lane median													
	Raised median	-1.481***	0.335	0.000	0.228	-0.479**	0.177	0.007	0.619				
	No Median												
Topography													
	Straight	1.162**	0.543	0.032	3.198	1.854***	0.308	0.000	6.386	1.899***	0.280	0.000	6.677
	Down hill	2.117***	0.586	0.000	8.305	1.818***	0.353	0.000	6.157	1.5***	0.336	0.000	4.483
	Uphill												
Weather condition													
	Good	-0.779**	0.374	0.038	0.459					0.49**	0.241	0.042	1.632
	Rainy/cold												
Surface condition													
	Dry	1.322**	0.655	0.043	3.751	0.73**	0.302	0.015	2.076				
	Wet												
Lighting condition													
	Night time	1.4***	0.531	0.008	4.055	1.773***	0.333	0.000	5.887	2.106***	0.338	0.000	8.219
	Day light												
Pavement condition													
	Asphalt	2.054***	0.981	0.036	7.796	2.204***	0.457	0.000	9.063	1.107**	0.375	0.003	3.026
	Earth roads												
	Gravel roads												
Presence of Intersection													
	With nearby intersection	1.143***	0.262	0.000	3.135	0.963***	0.167	0.000	2.620	0.5**	0.166	0.003	1.648
	mid block road												
Duration characteristics													
Day													
	Week-end	0.748**	0.303	0.013	2.113	0.541**	0.179	0.003	1.717	0.5**	0.178	0.005	1.648
	Week days												
Time interval													
	12:00a.m. - 03:00a.m	2.798**	1.208	0.021	16.415								
	12:00p.m. -03:00p.m.	1.323**	0.513	0.010	3.753	0.926***	0.274	0.001	2.524	1.013***	0.281	0.000	2.754
	03:00 p.m.-06:00p.m.	1.527**	0.508	0.003	4.606	0.923***	0.279	0.001	2.516	1.002***	0.286	0.000	2.724
	06:00p.m. -09:00p.m.	1.381**	0.660	0.037	3.978								
	09:00p.m. -12:00a.m.	2.662**	0.768	0.001	14.322								
	03:00a.m. -06:00a.m.									-1.624*	0.958	0.090	0.197
	06:00a.m. -09:00a.m.	1.631***	0.465	0.000	5.108	0.525**	0.267	0.050	1.690	1.221***	0.265	0.000	3.392
	09:00a.m. -12:00p.m.												
Victim characteristics													
		Fatal				Serious				Slight			
Parameter		β	Std. Error	Sig.	Exp(β)	β	Std. Error	Sig.	Exp(β)	Estimate	Std. Error	Sig.	Exp(β)
Gender													
	Female	2.293***	0.413	0.000	0.101	2.318	0.342	0.000	0.098	1.975***	0.342	0.000	0.139
	Male												
Age													
	Less than 18	5.261***	1.275	0.000	192.694	3.765***	1.143	0.001	43.185	3.411**	1.147	0.003	30.283
	Greater than 50	0.807***	0.667	0.227	2.240	1.914***	0.333	0.000	6.777	1.459***	0.337	0.000	4.303
	Between 18 and 30	0.879***	0.298	0.003	2.409					0.899***	0.172	0.000	2.457
	Between 30 and 50												
Type of victim													
	Pedestrian	3.898***	0.421	0.000	49.286	2.239***	0.215	0.000	9.382	2.075***	0.213	0.000	7.967
	Passanger	3.058***	0.441	0.000	21.289	0.787***	0.215	0.000	2.198	0.743***	0.212	0.000	2.103
	Driver												

4.2.1 Demographic Characteristics of Drivers

From the descriptive variables of the driver in the daily crash records, the characteristics are: Driver's sex, age, education level, driving experience and the relation with the vehicle. These parameters considered to explain the characteristics of the drivers in this study. As in developed countries, driver impairment is an important component of road traffic crashes in developing countries. Driving at excess speeding, while under the influence of alcohol or drugs, while sleepy or tired, when visibility is compromised, or driving without protection for vehicle occupants are factors recognized by WHO (2016) world report on road traffic injury prevention in increasing crashes severity.

Male drivers are found to involve in most crashes but are significant risk factors in fatal, serious and slight injury crashes with reference of property damage. The risk ratio of fatal crashes increases by 16.37 for male drivers. This exponential value for male drivers with reference to females of serious and slight injuries is 4.66 and 5.64 respectively. This implies that the injury severity increases for male drivers. The result is concurrent with that obtained from the descriptive analysis. This is also consistent with the results of Ali and Ötüken (2014) study in turkey that showed male drivers are more associated with increased severity of crashes. Kim et al. (2010) also argued male drivers are probably more aggressive and risk taking drivers that induce pedestrians to be fatally injured.

The driver's age is analyzed using 30-50 age group as reference variable. The output shows the group of drivers' aged between eighteen to thirty years have significant role in fatal and serious injury crashes with risk ratio of 6.45 and 1.72. Even though this adolescents group (18-30) are significant, the older drivers (>50) are found to have higher correlation to serious injury crashes with relative risk ratio of 3.14. Slight injuries are also associated with these 'old' drivers aged above fifty. The results observed for the driver's age are analogous to the results of the descriptive crash distribution that imply the adolescent group to increase the severity of crashes. This outcome conforms to the study of Islam and Mannering (2007) that show young (16-24) and middle-aged (25-64) drivers have high probabilities of fatality and severe injuries. In contrast to this, Abdel- Aty (2003) found older drivers were more likely to be involved in a severe injury crash than younger drivers.

Driver's education level is significant for fatal and serious injury crashes is positively associated with Primary educated drivers using high school educated drivers as reference. The relative log odds of being in fatal crashes than property damage will increase by 1.48 with education level of elementary school. These drivers increase the relative risk ratio of fatal crashes by 4.4 than high school educated drivers. This predicts having higher educational background promotes better judgment of drivers and responsible behaviors. Drivers educated above high school level are insignificant with reference of high school educated drivers. This leads to the deduction that drivers with lower level of education than secondary school have increased probability of fatality. Misganaw and Gebre-Yohannes (2011) came up with similar conclusion regarding driver's education. Ali and Ötüken (2014) result also conforms to this output.

The driving experience of drivers is an inversely related parameter with the severity of crashes. A driver with driving experience above ten years decreases the relative log odds of fatal crashes by 1.66 and serious injuries by 1.22. An increase in the experience of drivers above five years is expected to reduce the relative log odds of fatal crashes by 1.72, serious injuries by 0.52 and for slight injury by 0.61. This result indirectly implies the role of novice drivers in crash at all severity levels. The outputs are still supported by the results of the descriptive analysis. This is parallel with the results of Simons- Morton and Hartos (2013) that states crash risk associated with young drivers and found that motor vehicle crashes are extremely high among young drivers during at least the first year of licensure. Newly licensed drivers have greater risk exposure and Injury severity decline with increased experience.

The relation of the driver with the vehicle is another significant factor with the 'owner' set as reference. This parameter shows the relative log odds increases by 1.58 for fatal crashes, 0.88 for serious injury and 0.49 when non owners are driving the vehicle instead of the owner. This implies the severity of crashes increases when the vehicle was driven by an employee, other relative or friend rather than the owner. Generally, this labels unfamiliarity or the lack of responsibility when the vehicle is not in the hand of the owner as a risk factor. As most commercial vehicles are driven by employed drivers it can influence the higher number of employees (non-owners) involved in crashes. This outcome is concurrent with that of Getu et al. (2015) on his study of injury severity of pedestrians involved in traffic crashes. He stated this is a critical factor since vehicles can be shared among different people in developing country like Ethiopia.

4.2.2 Vehicle related parameters

The vehicle type, ownership of the vehicle, defect of vehicle and the vehicle's years of service were the parameters considered to explain the influence of the vehicle. The police records show this parameters as description of the vehicle responsible for the crash. The study of

Mohan (2002) showed that in developing countries, buses and trucks are involved in a much greater proportion of crashes, as they lack relevant safety standards.

Trucks, Bus and Minibus have the leading role in the fatal crashes respectively with reference of Automobiles. The relative risk ratio of trucks is 16.12 for being in fatal crash versus property damage. Buses (5.55) and Minibuses (3.97) followed with significant risks. The 'Motor cycle' group, Minibuses, Buses and Trucks have significant role in serious injury crashes. The 'Motor cycle' group increase the relative risk of serious injury by 3.29 followed by Buses with relative risk of 2.93. The serious injury crashes are found to increase with the involvement of 'Motor cycle' group and Minibuses. Despite the individual perspective of these vehicle types, the results shown here give the comparative risk of severe injuries than property damage using automobile as the reference vehicle. As compared to the descriptive analysis output, heavy vehicles are seen to be more influential than minibuses. Generally, these result put emphasis on the effect of the commercial vehicles on increasing severity with reference to private vehicles (automobiles). The fatality of crashes is seen to increase with the involvement of heavy vehicles. The research of Kim et al. (2010) also confirms the finding that trucks, vans and buses cause more severe crashes than other vehicles. The increase in severity can be associated with their larger masses, longer stopping distances and greater momentum.

The output for number of years the vehicle served indicates the effect on crash severity with reference of new vehicles that served less than five years. The relative log odds of fatal crashes with vehicles of less than ten years increases by 1.595 with risk ratio of 4.93. For the serious injury crashes, the relative log odds of vehicles above ten years of service is 0.36 and 0.816 for less than five years. The performance years of the vehicle above ten years increase the relative log odds of slight injuries by 0.33 but this increment is not significant for those exceeding ten years. This is because new vehicles are commonly involved in slight injury crashes as compared to the older vehicles. Generally, the pattern of crashes show the significant increase in fatality of crashes with older vehicles. The distribution diagram of the performance years of vehicles also arrives at the same deduction.

The risk of road traffic crashes is favorable for older vehicles. As the number of years the vehicle serves increases, the condition of the vehicle degrades. This is partly due to the deterioration that comes with lack of 'on-time' service. It is known the annual vehicular inspection, 'Bolo' system, is established in Ethiopia to detect the qualification of vehicles on the roads. Further study should be done on this parameter, as the records of defective vehicles is given low attention.

The functional categories of the vehicles involved in crash are analyzed using the plate number code with reference to government vehicles coded 4. Commercial vehicles (code 3) are found to have the most prevailing involvement in severe crashes than property damage. The fatality relative risk ratio of Commercial vehicles is 4.04 followed by marginal significant risk ratio of 3.67 for Taxis' (code 1). Private vehicles (code 2) also have significant association with fatal crashes with risk ratio of 2.98. This pattern is analogous to serious injury crashes too. But, in the case of slight injuries commercial vehicles (Code 3) have higher risk followed by private vehicles (Code 2). The rises in the severity of crashes can be associated with the increase in flow of commercial vehicles and Taxi's throughout the day and night. This goes the same for Private vehicles whereas the governmental vehicles mostly operate mostly during the day and have relatively fewer number.

4.2.3 Road environment Parameters of crash

The temporal and seasonal variation land use, the presence of raised median, the topography, weather condition, pavement condition, lighting and the presence of nearby junction are the parameters used to estimate the influence the road environment has on the severity of crashes. The roadway of crash location was considered in order to understand the influence of condition and character of the road on the severity of crash.

The designation of the crash records may have some limitations as to be precise about the land use but this report is organized in as per the recorded crash data. The institutional and residential land use of environment are found significant for fatal crashes versus property damage. Institutional areas are most affected mainly that of school areas with relative risk ratio of 8.61. This could be due to the location of schools near main roads with high traffic flow. The relative risk ratio of fatal crashes in residential areas increases by 6.00 and by 5.77 for commercial areas. Serious injury is most probable in institutional areas with relative risk of 3.65 and in the Residential areas with relative risk of 2.04.The higher risk observed among institutional areas in the multinomial regression model is different from the implication of the descriptive statistics showing residential and commercial areas as risky. Though the extent of crash involvement of these categories is observed in both methods, the regression has shown the amplified rise of severity in the institutional group as compared to the others.

A road segments or approaches of intersections with 'Raised median' are associated with a 1.48 decrease in the relative log odds of being in fatal crash than property damage. Similarly, the relative log odds serious injury decreases by 0.48. The presence of Raised median has significant effect in reducing the severity of crashes. Two way roads without raised medians are seen to be the most prone to crashes of higher severity. Raised medians plays a great role in reduction of injury severity by serving as a refugee for pedestrians crossing and also hamper jay walking at mid blocks. Bowman, Vecellio and Miao (1994) studied the effect of different types of medians on pedestrian crashes. They considered crossings on the near side of the intersection creating a potential collision situation thus as a conflict situation. The vehicle brakes or swerves when a pedestrian crosses in front of a vehicle, then continues through the intersection. Their findings suggested that medians play role in reducing crashes by blocking vehicle interactions in different directions and providing a safe refuge area for pedestrians.

The topography of the environment is analyzed with reference taken as 'Uphill'. The relative log odds of being in fatal injury increases by 2.12 for 'Downhill' topography and by 1.16 for straight topography. Straight (level) and downhill topography are found to increase the risk of serious injury by 1.85 and 1.82 respectively. Similarly, the relative log odds of slight injury increases by 1.9 on level road surface and by 1.5 for downhill road way. Level topography and downhill slopes are associated with higher risk of injury severity with reference to uphill crashes. This is linked to the tendency to drive on high speed and loss of control at this state. Most vehicles travel under such conditions, resulting in a greater probability of severe crashes.

Pavement condition is another parameter under the road environment factors. This is analyzed with reference of gravel roads. The result shows that asphalt pavement is a significant risk factor for all crash severity levels. The relative risk ratio of fatality on asphalt paved roads than gravel roads is 7.8. This correlation is also significant for serious and slight injuries with risk ratio of 9.06 and 3.03 respectively. The higher role of asphalt roads is consistent in the frequency distribution and regression outputs. This shows that the severity of crashes increases with increasing comfort and speeding associated with asphalt paved roadways. This is validated by the heavy volume of traffic on asphalted roads and the tendency to drive too fast on asphalt roads. On the other hand, driving on the gravel roads or muddy earth roads forces drivers to take care of their vehicles and drive slowly, which contributes to lower crash severity. In general, dry surface conditions, straight/level surface and asphalt paved characteristics are observed to increase the severity of crashes. These findings are in line with that of Misganaw and Gebre-Yohannes (2011) study of traffic crashes in Addis Ababa which also predicted that asphalt paved, flat terrain with wet surface contributes to higher number of fatality and severity of crashes. But, the out puts of this research show dry road surface is positively associated with increasing severity.

The lighting condition of the roads is compared between day and night taking day light as the reference category. The dark condition (with or without street lights) is determined to be significant in serious injury crashes. The relative risk ratio of fatal crashes in the dark is 4.06 than property damage. The relative risk ratio of serious injury versus property damage increases in the night time by 5.89 and by 8.22 for slight injury. The dark condition is significant factor of crash than day light with reference of property damage. The result comprehends with other studies that state the susceptibility to higher severity crashes due to limited visibility by the lack of appropriate lighting on roads. Dissanayake's (2012) results stated percentages of crashes under other lighting conditions (dim, dark…) were considerably low when compared to the daylight condition. But, it is different from the injury severity which has inverse relation with lighting.

The presence of nearby intersection at the location of crash is the parameter analyzed by setting the 'absence of a junction' as a reference. The presence of intersection is found to significantly increase the relative risk ratio of fatal crashes by 3.14 and serious injury crashes by 2.62. Also, the relative risk ratio and slight injury increases by 1.65. This can be associated with the manner of travel by vehicles and pedestrians directed in different directions by the rule of the intersection. The congestion generated on intersection can have propagating effect upstream and downstream of the location. In contrast to this, the finding of Lee and Abdel –Aty (2005) states the chance of a vehicle-pedestrian crash increases at intersections with higher traffic volumes.

The day of the week is analyzed to determine variation of crash occurrence in weekdays and weekends. The odds of fatal crashes increase by 0.748 on week end. The relative risk ratio of a crash being fatal over the week end is 2.113. Similarly, the odds of serious crash increases by 0.54 and slight injury by 1.65 over the weekend. This can be explained by the higher volume of traffic on weekdays than weekends which creates congestion whereas the freedom on roads during the weekends encourages increasing speed. The number of crash occurrence is seen to be high on weekdays mostly on morning and evening peak hours. Despite the high number of crash on weekdays, the probability of severe and fatal injury increases on weekend.

The time of crash occurrence is analyzed with three hour intervals. The late morning (09:00 a.m. - 12:00 p.m.) is used as reference category. Fatal injury is positively related to all time intervals except the time before morning. The highest risk of fatal crashes is observed around midnight (12:00 a.m.- 03:00 a.m.) with relative log odds of 2.80. Drinking of either drivers or pedestrians is expected to be associated with higher fatality during this period. This is also associated with exceeding speed and visibility issues. The previous distribution of crash severity with time also implies fatality governs during this interval.

The significant interval for serious and slight injury crashes are the afternoon intervals (12:00 p.m. - 06:00 p.m.) and the morning peak hour (06:00 a.m. -09:00 a.m.). The afternoon time (12:00 p.m. - 06:00 p.m.) has relative risk ratio 2.52 for serious injuries than property damage. The morning time interval (06:00 a.m. - 09:00 a.m.) has the higher relative risk for slight injuries with ratio of 3.39 than property damage. Getu et al. (2015) study of road crash injury severity arrived at similar results regarding the higher fatality in the night. He explained the increase in higher operating and impact speed, increased perception and reaction times during night time have contributed to the increasing injury severity. The prevalence of fatal and serious injury crashes in the night time can also be associated with drink and drive. To encounter this situation, the government is now implementing the drinking restriction based on random drinking level detection on the roads.

4.2.4 Demographic characteristics of Victim's

The influence the victim has in the occurrence of crash is studied using the recorded parameters such as: the victim's gender, age, the working position, the category of the victim and movement during crash**.**

The female victims are significant risk factors with reference to males. Female victims are associated with a 2.29 increase in the relative log odds of fatality and 2.32 increase in the relative log odds of being in serious injury. This is also true for slight injury with relative log odds of 1.98. In general, the implications of this outcome is females take up the higher portion among the different severity levels. This is compiles to Obeng and Rokonuzzaman's (2013) findings that states females are associated with higher injury severity. In contrast to this, Abay (2013) determined men pedestrians are 16% more likely to sustain fatal injury compared to women pedestrians. This suggest that the condition of work and mobility patterns will lead to increment of male casualties but the injury severity of traffic crashes increases among females. These inconsistencies show that these effects are contextual and that likely differences in results can be obtained based on sample variation.

Victims below eighteen have the highest vulnerability for all levels of injury severity. The relative log odds of being in fatal crash versus property damage will increase by 5.26 for victims of age is below eighteen and by 0.88 for those between eighteen and thirty with reference to the 'matured group' (31-50). Older people are also significant victims of fatal crashes with relative log odds of 0.81 and 1.91 for serious injury. These age groups have similar vulnerability of slight injuries. But, the older group has the upper hand than those aged in range of eighteen to thirty. Whereas, the relative log odds of being in serious injury increased by 3.77 for under eighteen victims. The relative log odds of serious injury increase significantly by 1.19 for victims of above fifty. These finding is reasonable as it shows the weak (young and elderly) are the most at risk. It is also true that this group are common pedestrian casualties. As seen in the study of Downing (2000), the risk of death is greater for a pedestrian than a vehicle occupant. Thus, it is anticipated that fatality of children road crash victims is also high. This outcome also conforms to the study of Islam and Mannering (2007) that show young (16-24) and middle-aged (25-64) male drivers have high probabilities of fatality and severe injuries.

Pedestrians and Passengers much more victimized than drivers at all severity levels. The relative log odds of fatal crashes increase by 3.9 for pedestrians and by 3.06 for passengers. The odds of serious injuries increases by 2.24 for pedestrians and by 0.79 for passengers. This shows pedestrians and passengers have higher vulnerability with reference of drivers. And, for the case of slight injury the relative log odds is 2.08 for pedestrian and 0.74 for passenger. The results imply the fact that pedestrian –vehicle interaction needs more attention to improve the situation. Persson (2008) also illustrated pedestrians and passengers to be the most vulnerable in Ethiopia, whereas in high-income countries crashes involve primarily the driver.

As an empirical assessment, the estimations given for these explanatory variables is based on this particular case. The coefficients and the constant term vary with variation of reference category as well as the significant explanatory variables selected for the regression. The trends for each severity level can be studied independently with reference to property damage. The constant term and coefficients for each severity level with reference to the property damage can be represented by the multinomial regression model developed. The probability for injury severity is difficult to summarize in one equation but any data can be inserted as an input to get the probability.

Since the interactions of vehicle, roadway, and human factors have on resulting crash-injury severities is multifaceted, this empirical assessment can be an input for injury-reduction countermeasures, policies, and regulations as required. Reduction over time, not only in the number of crashes but also in the injury severity levels, should be used to measure the progress achieved by different measures to be taken. The conclusion drawn from these significant parameters and the result of the descriptive analysis in this paper are aggregated together and summarized in the next chapter.

5. BLACK SPOT IDENTIFICATION

The prime goal of road safety engineering is to limit the number and severity of traffic crash by identifying, implementing and evaluating measures to improve safety. As the roadway improvements are to be applied to hazardous locations where they have the most momentous impact, identification of hot spots is a vital step in road safety. In this section, the common hot spots in Kolfe keranyo sub city are identified based on four year crash records. The GIS location of crash sites are not yet incorporated in the crash records, which makes it difficult to identify the black spots precisely. Because of the nature of the crash records, the designation of crash location have some weaknesses and adaptations were necessary to serve the purpose.

There are two approaches of safety, nominal and substantive safety. Nominal safety refers to whether or not the road design meets minimum design criteria based on standards such as the Ethiopian Road Authority manual and the Manual on Uniform Traffic Control Devices (MUTCD). Whereas, Substantive safety refers to the actual or expected safety on a roadway. If a roadway meets minimum design criteria, it can be characterized as nominally safe, not necessarily substantial safety. Substantive safety may be quantified in terms of crash frequency, crash rate, crash type and/or severity. This research looks through the substantial safety of the selected sites through reactive approach.

Developed countries do not usually use fully similar principles of identification of black spots as developing countries. The cause for this variation is different traffic and technology factors of the countries and general level of their traffic safety. Mungnimit et al., (2009) explained the most common assumption for a black spot determination to be the repetition of crashes. The threshold used to identify black spots among different countries based on crash is provided in Table 10.

Table 11: Black spot identification standards of different countries

Country	**Section length**	**Frequency**
Australia	Fairly Short	At least 3 casualty crashes in 5 years
England	300 meters	12 crashes in 3 years
Germany	300 meters	8 crashes in 3 years
Norway	100 meters	4 crashes in 3 years
Portugal	200 meters	5 crashes in 3 years
Thailand	Vary	At least 3 crashes

It is necessary to adopt methods used internationally, since there is no recognizable coefficient formulated for Ethiopia or other developing countries. Despite the variation in coefficient factors, this analysis is sufficient by maintaining uniformity throughout. Severity rate is a measure of the severity of crashes per million vehicle kilometres (MVkm)

$$\text{Severity rate} = \text{crash rate} * \text{severity index}$$

In India, Rakesh (2015) studied crash data collected from Police stations of India and analysed the secondary data using the Weighted Severity Index **(**WSI) method. The value of WSI was used to identify black spot. The higher Severity value indicates the higher dangers of the road section/site.

$$\text{WSI} = (5 \text{ x fatal}) + (3 \text{ x Serious Injury}) + (1 \text{ x Slight Injury})$$

Liyamol Isen, et al. (2013) used different set of coefficients for assigning scores based on the severity of crashes in particular locations for 3 years.

$$\text{WSI} = (41 \text{ x fatal}) + (4 \text{ x Serious Injury}) + (1 \text{ x Slight Injury})$$

The distribution of traffic crashes in the road space can be decentralized or intensive. Decentralized distribution of crashes mostly implies the unsafe behavior of the drivers and other road users. But intensive distribution of crashes can be related to the road level, conditions of traffic facilities and the traffic environment. The pattern of traffic crashes distribution in the roads of the study area are seen to be decentralized. The final Black Spot list of this study consists of newly identified Spots and those which have already been analysed, but not yet treated in the past. The Addis Ababa Transport Authority has conducted studies on black spot areas based on annual fatality using three years data. From those places identified by the Authority crash locations in kolfe keranyo sub city are indicated on the figure 20 below.

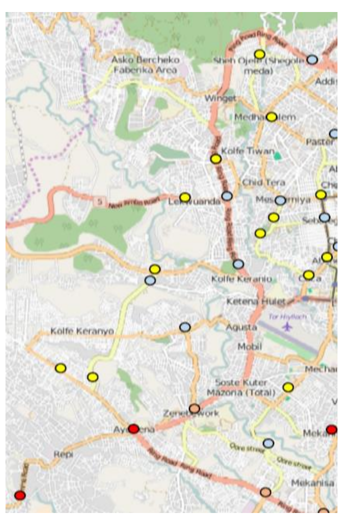

Figure 20: Locations identified in Kolfe keranyo with high number of crash

(Addis Ababa Transport Bureau)

Understanding the most typical situation, which produces the Black Spots is important. These causes could be corrected in the design phase, construction works and road maintenance. In most locations, there is a lack of appropriate pedestrian walk ways, signings and markings, to provide adequate guidance and information to road users, as well as missing guardrails to protect road users.

Procedures used for the Black Spot Analysis

- **Data collection**

Basic data on the crash scene is recorded by the traffic police. Therefore, the important Crash data by severity and location for crash analysis retrieved from the daily crash report of police. The Traffic data (ADT or AADT) and Geographic setting of the road network are also considered for the black spot analysis.

- **Traffic volume**

Annual average daily traffic (AADT) counts represent the average 24-hour traffic volume at a given Location averaged over a full 365-day year. Average daily traffic (ADT) counts represent a 24-hour count at the specified location. The traffic data is the basis of all analysis in a traffic impact study considering the location and duration of counts. The two basic methods of collecting traffic data are manual observation and automatic recording used depending on the type of information needed for analysis. The number of vehicles passing a point or entering an intersection is often used in the analysis of roadway operations. Automatic recording are obtained by placing an automatic counter at the analysis location for a 24-hour period. Accuracy of the ADT data depends on the count being performed during typical roadway, weather, and traffic demand conditions. Recording data onto tally sheets is the simplest means of conducting manual counts. The data is recorded with a tick mark on a pre-prepared form using stopwatch with the desired count interval.

The traffic data compatible with the crash data are collected for the evaluation of crash locations. The AADT values on these road sections are calculated from the peak hour traffic flow volume on the selected road sections. This is calibrated with the appropriate coefficients to account for the variation among peak hour and the average daily traffic flow. This coefficient rates the ratio between peak hour flow and average annual daily traffic. For urban area roads the value ranges from 9 to 14. For this study the average value of 12 is used to compute the ADT as it is calibrated for Addis Ababa (Berhanu, 2004).

$$ADT = q_i * k_d$$

$$ADT = V_0 * g_{i*} \; k_d$$

$$ADT = \frac{3600 * L_0}{t_0} * \frac{N}{L_i} * k_d$$

Where: ADT- Average daily traffic (veh /day)

q_i - peak hour traffic flow on the selected road section

k_d – calibration coefficient

V_o- mean speed of traffic flow

g_i- estimate of flow density

t_0- traffic count time (sec)

N_i- number of vehicle counted

L_o – length of the observed road section

L_i – length of road section under study

With the assumption of calibration coefficient (k_d) of 12, and the length of road section observed (L_o) is equal to the length of the road section under study (L_i) the formula for AADT can simplified to:

$$AADT = \frac{3600 * L_0 * N * 12}{t_0 * L_I} = 43200 * \frac{N}{t_0}$$

- **Identification of spots in the road network**

The list of high crash frequency locations within the sample area are identified. Separating the crash location to spots (intersections) and mid-block road sections. As traffic flow on intersection areas and mid-block of roads have differing characteristics, these locations are analysed independently.Several year data are required, from which a mean, annual road crash rate can be calculated. Three years is generally regarded as a practical minimum period for which a reasonably reliable annual average rate can be calculated. Most researches prefer three-to-five-year period as it provides a sufficient number of crashes for meaningful results and limit traffic variation that may bias results. This gives a consistent base for before and after comparisons.

- **Calculation of comparison parameters and ranking**

The calculation of parameters like severity index and crash rate from crash frequency. Then, the spots of the road network are ranked on the basis of the magnitude of the outputs. Such ranking is useful to have further detailed studies. More attempt is needed find out which factors explain the occurrence of crashes on the specific sites, or which countermeasures should be taken to reduce their number.

The crash rate is calculated using the formula:

$$U_f = U \times 10^6 / (AADT \times 365 \times N \times L)$$

The severity index is calculated using the formula:

$$SI = \frac{12(\text{fatal}) + 3(\text{injury}) + \text{PDO}}{\text{Total number of crash}}$$

Table 12: Location of crash on road segments based on injury severity

Location	Injury Severity				Crash frequency	AADT	Crash Rate	Severity Index
	FATAL	SERIOUS	SLIGHT	PDO				
Winget-Kaojj	4	43	56	92	195	965	5052	1.67
Ayer tena - China Camp	13	66	178	413	670	859	19499	1.41
Kara kore Girar-Repi	21	36	90	632	779	1056	18442	1.39
keranyo- mendida	15	40	52	141	248	3055	2029	1.99
Yeshi debele- mendida	4	56	86	78	224	5299	1057	1.70
Torhailoch - holland embassy	2	19	74	219	314	4975	1578	1.19
Asko- Tikur Abay	8	15	59	156	238	5123	1161	1.50
Atena tera- Lomi meda	9	51	47	249	356	6985	1274	1.56
Bethel - Weira	12	44	23	62	141	3568	988	2.56
Alembank- Anfo	12	92	76	56	236	4583	1287	2.34
Kidanemihret- Bethel	3	69	42	96	210	7890	665	1.81
Abune aregawi - zenebework	3	38	71	128	240	5840	1027	1.45

Table 13: Location of crash on intersections based on injury severity

Location	Injury Severity				Crash frequency	AADT	Rate (veh-km)	Severity Index
	FATAL	SERIOUS	SLIGHT	PDO				
18 mazoria Roundabout	5	44	48	248	345	246204	0.96	1.41
Torhailoch Roundabout	7	42	91	405	545	283550	1.32	1.30
Ayer tena Roundabout	22	50	107	312	491	257494	1.31	1.70
zenebework Roundabout	8	73	58	426	565	216199	1.79	1.41

Sites with higher vulnerability for fatal crashes were selected. Then, these sites are compared based on the parameters of Crash frequency, Crash rate and Severity index. The site observed to have high crash frequency is the road segment of karakore with total of 779. Followed by that of china camp road with 670 crashes. But, Ayer Tena (China Camp) and Karakore (Girar) have the highest crash rate with values of 19,499 veh- km and 18442 veh-km respectively. Similarly, severity index implies Alembank and Weira- Bethel routes to be the most affected by severe injuries. This varying results show the advantages of looking at different perspectives of crash location in order to determine the highly prone areas.

With regard to the intersections analysed using this parameters, the Zenebwork and Ayertena roundabouts are recognized to be black spots of the area based on crash frequency of 565 and 545 respectively. These results are consistent with that of crash rate ranking. Ayertena is the black spot identified based on severity index of 1.70. The zenebwork and 18 mazoria roundabouts have equal severity index of 1.41 ranked as the second black spots. This results have different implication from that of fatality considered independently. The result obtained by categorizing the major locations with fatal crashes are Ayertena, Karakore and Keranyo.

Table 14: Fatality of identified black spots

Location	Fatality		
	Number of Fatal crashes	**Average annual death**	**Ranking**
Kara kore	21	5.3	2
Ayertena	22	5.5	1
Kolfe	14	3.5	6
Alembank	15	3.8	5
Keranyo	19	4.8	3
China Camp	13	3.3	7
zenebework	11	2.8	9
Asko	16	4.0	4
Torhailoch	9	2.3	10
Bethel	12	3.0	8

A visual interpretation of the Black Spot pin map provides a better presentation of potential Black Spot locations. A more sophisticated and detailed analysis could be provided using GIS. Based on the pin map and adopted definition, a preliminary Black Spot list is drafted based on different criteria. The list includes intersections and road sections and serve as a basis for further Black Spot investigation. The details of the locations identified by this research can be seen in the Appendix c attached.

Roads with higher traffic volume have higher exposure to crashes. Since they are exposed to potential hazards. When deciding on safety improvement roads with higher traffic volumes should recive the priority for cost effective measeures. Also, it is worthy to evaluate the existing situation from the view of each traffic active group including those that do not drive. Establishment of the safety objectives for the future project based on the needs of pedestrians, childern and seniour citizens.

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

These results are summarized based on the output of frequency distribution and the multinomial regression analysis outputs. The highly significant factors determined to increase severity of crashes are determined to be male drivers of eighteen to thirty years; elementary and secondary level educated; driving experience of less than two years and non-owners of the vehicle. Commercial vehicles (specifically, minibuses and trucks) that served above ten years, absence of raised median, dry, asphalt paved and downhill topography road surface are also factors identified to be boosting severity of crashes. Severity is observed to increase in the morning peak hour (06:00 a.m. - 09:00 a.m.) and in the afternoon peak hour (06:00 p.m. - 09:00 p.m.) on weekdays and under good weather condition. The midblock roads show higher rate of crashes rather than junction. Similarly, the number of crash during daylight is high in day light but the severity/ fatality increases under dark lighting condition. Residential and commercial areas have positive association with increasing severity for institutional areas. Adolescent (18-50 years) male, crossing pedestrians are the common victims of severity crashes. But, Young (<30 years) female, turning movement have higher risk for injury severity.

The findings of the analysis reported here have mostly confirmed previous understandings rather than any major surprises. Although most urban casualties are male and of prime working age, the vehicle types involved vary. Never the less, there are some inestimable causes of crash including poor visual guidance or signs, narrow road, poor road surface and lack of adequate pedestrian facilities. Unobserved variation is likely to exist among the population of crash-involved road users due to differences in risk-taking behavior, physiological factors, and other varying characteristics.

With regard to the black spots identified based on this research, the locations observed to have high crash frequency are the road segment of karakore and Ayer Tena (China Camp). But, by ranking based on severity index Alembank and Weira- Bethel routes have the top spots. Also, using annual fatality of the selected location implied the higher risk of road traffic fatality on Ayer Tena and karakore roads. Despite these variation, karakore and Ayer Tena (China Camp) are determined to be highly prone areas. Roundabouts are the common intersections observed to have high crash occurrence. From the analysis, the roundabouts at Zenebwork and Ayertena are recognized to be black spots of the study based on crash frequency, crash rate and severity index. The roundabout at ‘18 mazoria’ have equal severity index as the zenebwork roundabout.

6.2 Recommendation

If this much is known about the elements of injury severity of road traffic crashes, appropriate measures need to be taken to deal with this problem. Government's plan is to increases the road network as part of increasing the nation's infrastructural base. The benefits of such developments will have to be balanced with the expected increase in road traffic crash. Improvements on road safety are multifaceted since the behavior of drivers, vehicle types and environmental conditions vary in time and space. Some of the measures that are expected to help in coping with this issue are suggested here below.

- **Improving documentation**

The necessary details associated with road design such as traffic count need to be properly documented. The availability of full data on road project is important for detail study of roads from the design perspective and also aids in making logical decisions on any related modification (improvement). The crash reporting system also needs to develop in order to understand the concealed problems associated with road traffic crashes. This will provide quality input for different organizational approaches. It also allows a broad understanding of the impact of certain factors on occurrence of traffic crashes, as well as the severity of their consequences.

- **Improving road designs considering the needs of pedestrians**

Pedestrian protection measures are necessary as these group constitute up to 85% of the causality. Appropriately designed crossings coordinated with the vehicular traffic flow, with clear markings and fencing to direct pedestrian's movements. Providing proper sidewalks alongside the road that can prevent the pedestrian forced onto the road. Commuter passengers of buses, trucks and minibuses need consideration when designing crossings, bus stations, taxi bays and the like by coupling with zebra crossings; making walkways and pedestrian facilities more accessible. Working on 'self-explanatory road design' to increase the unmistakable interpretation of road features for the road user not to be confused or encouraged to take risks.

- **Local traffic safety policies**

Traffic safety policies Traffic safety policies must be based on local evidence and research than just adopting measures taken in developed countries for effective results to take specific measures as per the determinant problems. The government should set targets for first stabilising and then reducing road traffic crashes. National strategies should set out the road safety approaches and investments rather than increasing the kilometre counts.

- **Strict control on the safety of vehicles on roads**

As the results of this research show old vehicles have higher risk of increasing crash injury severity. The dominance of old vehicles on the roads have many disadvantages to the society. Improving the current taxation system to that discourages the import of new vehicles can reduce the over use of old vehicles.

- **Implementation on road safety laws and regulations**

Implementation of some of the laws on road safety management and on major risk factors is seen to be nominal. Not giving the right of way; exceeding speed limit and control of blood alcohol levels in drunk-driving are yet to be properly enforced. Improvements on seat belt use, cell phone conversations has been observed only with the fear of penalty by traffic police. This shows the perception of penalty likelihood or apprehension of traffic police officers is much stronger restraining than the severity or the swiftness of the penalty.

- **Educational programs**

Advanced driving education is crucial, as most young and inexperienced drivers are seen to take part in crashes. Also, educational programs at regular intervals targeting behavioral change to address the major proportion of the victims is also important. The pedestrian safety education for children can develop road safety knowledge and their road crossing behavior.

Further study can be done on similar analysis inclusive of speed limit of roads, collision pattern and specific causes of crash. In depth study is required on black spot analysis with specific characteristics of the stated areas to suggest rigorous counter measures.

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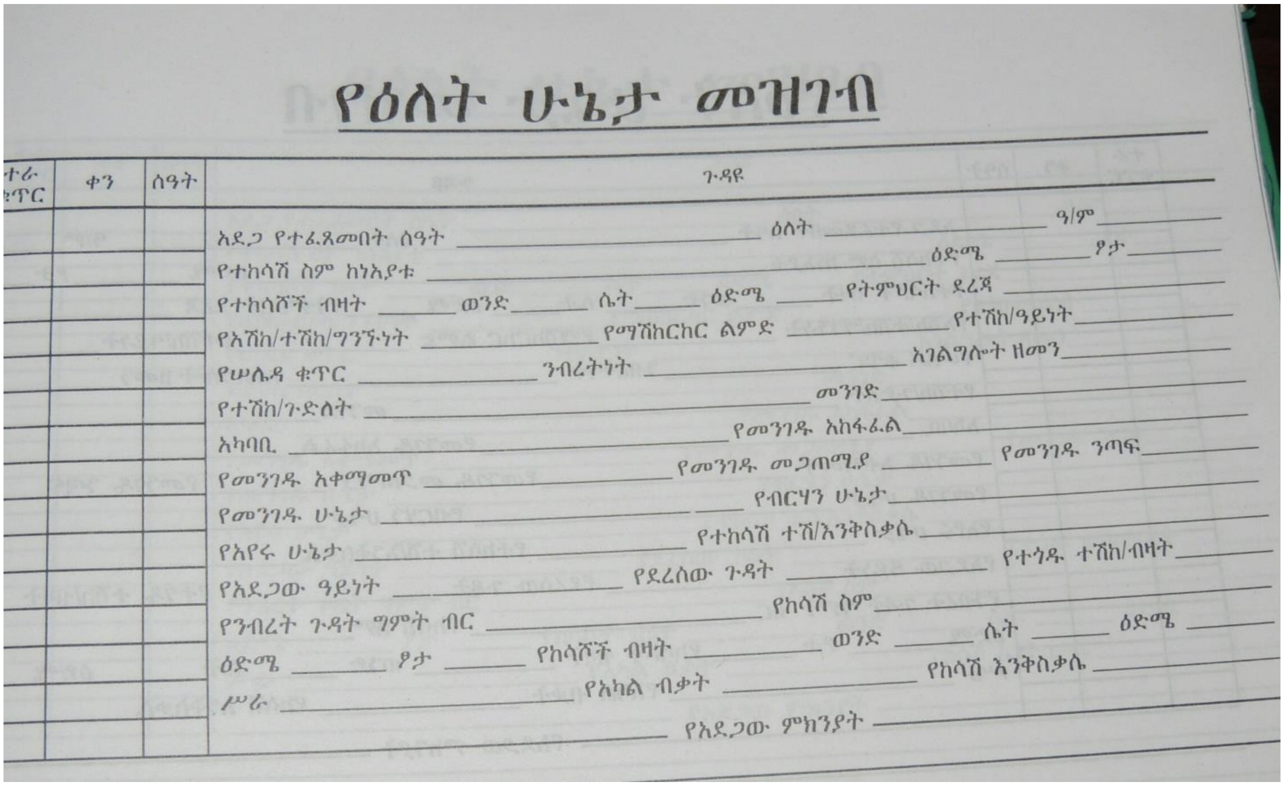
APPENDIX

Appendix a: format of daily crash report data record sheet



የዕለት ሁኔታ መዝገብ

ተራ ቁጥር	ቀን	ሰዓት	ጉዳዩ
			አደጋ የተፈጸመበት ሰዓት ____ ዕለት ____ ዓ/ም ____
			የተከሳሽ ስም ከነአያቱ ____ ዕድሜ ____ ፆታ ____
			የተከሳሾች ብዛት ____ ወንድ ____ ሴት ____ ዕድሜ ____ የትምህርት ደረጃ ____
			የአሽከ/ተሽከ/ግንኙነት ____ የማሽከርከር ልምድ ____ የተሽከ/ዓይነት ____
			የሠሌዳ ቁጥር ____ ንብረትነት ____ አገልግሎት ዘመን ____
			የተሽከ/ጉድለት ____ መንገድ ____
			አካባቢ ____ የመንገዱ አከፋፈል ____
			የመንገዱ አቀማመጥ ____ የመንገዱ መጋጠሚያ ____ የመንገዱ ንጣፍ ____
			የመንገዱ ሁኔታ ____ የብርሃን ሁኔታ ____
			የአየሩ ሁኔታ ____ የተከሳሽ ተሽ/እንቅስቃሴ ____
			የአደጋው ዓይነት ____ የደረሰው ጉዳት ____ የተጎዱ ተሽከ/ብዛት ____
			የንብረት ጉዳት ግምት ብር ____ የከሳሽ ስም ____
			ዕድሜ ____ ፆታ ____ የከሳሾች ብዛት ____ ወንድ ____ ሴት ____ ዕድሜ ____
			ሥራ ____ የአካል ብቃት ____ የከሳሽ እንቅስቃሴ ____
			____ የአደጋው ምክንያት ____

Appendix b: Outputs of SPSS

Likelihood Ratio Tests				
	Model Fitting Criteria	Likelihood Ratio Tests		
Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	3172.211[a]	0.000	0	
day	3184.217	12.006	3	.007
time_A	3255.756	83.545	21	.000
sex	3214.480	42.269	3	.000
Age_D	3217.543	45.332	9	.000
educationlevel	3213.497	41.286	6	.000
experience_A	3209.252	37.041	9	.000
relationwiththevehicle	3201.925	29.715	6	.000
VehicleType	3262.873	90.662	15	.000
Performancetime_A	3210.294	38.083	6	.000
code	3241.895	69.684	12	.000
sex_V	3233.510	61.300	3	.000
Age_V	3257.893	85.683	9	.000
position	3249.704	77.493	6	.000
Typeofvictim	3366.563	194.352	6	.000
Landuse	3193.090	20.879	12	.052
lanemedian	3214.098	41.888	3	.000
Topography	3256.261	84.050	6	.000
lightingcondition	3220.784	48.573	3	.000
pavementcondition	3223.908	51.697	6	.000
intersection	3211.012	38.802	3	.000

Severity[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	Upper Bound
1	Intercept	-19.578	2.329	70.643	1	.000			
	[day=a.Weekday]	.748	.303	6.105	1	.013	2.113	1.167	3.825
	[day=b.Weekend]	0[b]			0				
	[time_A=00:00-3:00]	2.798	1.208	5.367	1	.021	16.415	1.538	175.137
	[time_A=12:00-15:00]	1.323	.513	6.648	1	.010	3.753	1.373	10.256
	[time_A=15:00-18:00]	1.527	.508	9.029	1	.003	4.606	1.701	12.472
	[time_A=18:00-21:00]	1.381	.660	4.371	1	.037	3.978	1.090	14.515
	[time_A=21:00-24:00]	2.662	.768	12.006	1	.001	14.322	3.178	64.547
	[time_A=3:00-6:00]	.454	1.431	.101	1	.751	1.575	.095	26.031
	[time_A=6:00-9:00]	1.631	.465	12.277	1	.000	5.108	2.051	12.717
	[time_A=9:00-12:00]	0[b]			0				
	[sex=a. male]	2.795	1.216	5.287	1	.021	16.367	1.511	177.345
	[sex=b. female]	0[b]			0				
	[Age_D=]	-9.813	9783.209	.000	1	.999	5.473E-05	0.000	.[c]
	[Age_D=>50]	.961	.899	1.144	1	.285	2.616	.449	15.235
	[Age_D=18-30]	1.864	.370	25.333	1	.000	6.451	3.122	13.333
	[Age_D=31-50]	0[b]			0				
	[educationlevel=a.Above 12]	.080	.549	.021	1	.884	1.083	.370	3.175
	[educationlevel=b.Elementary]	1.482	.276	28.788	1	.000	4.402	2.562	7.564
	[educationlevel=c.Secondary]	0[b]			0				
	[experience_A=>10]	-1.657	.566	8.580	1	.003	.191	.063	.578
	[experience_A=2-5]	-.301	.302	.993	1	.319	.740	.410	1.338
	[experience_A=5-10]	-1.717	.466	13.573	1	.000	.180	.072	.448
	[experience_A=Novice]	0[b]			0				
	[relationwiththevehicle=a. Employee]	1.576	.432	13.337	1	.000	4.836	2.076	11.268
	[relationwiththevehicle=b. Other]	.693	.468	2.193	1	.139	2.000	.799	5.006

c

[relationwiththevehicle=c. Owner]	0[b]			0				
[VehicleType=a.Truck]	2.780	.512	29.517	1	.000	16.124	5.914	43.962
[VehicleType=b.Bus]	1.714	.594	8.327	1	.004	5.550	1.733	17.778
[VehicleType=c.Mini bus]	1.378	.460	8.980	1	.003	3.966	1.611	9.764
[VehicleType=d.TWD]	.005	.725	.000	1	.995	1.005	.243	4.161
[VehicleType=e.Other]	-2.634	0.000		1		.072	.072	.072
[VehicleType=f.Automobile]	0[b]			0				
[Performancetime_A=>10]	1.596	.450	12.550	1	.000	4.932	2.040	11.926
[Performancetime_A=5-10]	.095	.277	.118	1	.731	1.100	.639	1.894
[Performancetime_A=below 5]	0[b]			0				
[code=a.1]	1.299	.686	3.588	1	.058	3.665	.956	14.050
[code=b.2]	1.092	.607	2.981	1	.072	2.981	0.907	9.796
[code=c.3]	2.642	.690	4.044	1	.000	14.044	3.633	54.291
[code=e.5]	-17.183	5080.332	.000	1	.997	3.449E-08	0.000	.[c]
[code=f.4]	0[b]			0				
[sex_V=Female]	-2.293	.413	30.865	1	.000	.101	.045	.227
[sex_V=male]	0[b]			0				
[Age_V=<18]	5.261	1.275	17.015	1	.000	192.694	15.820	2347.037
[Age_V=>50]	.807	.667	1.461	1	.227	2.240	.606	8.288
[Age_V=18-30]	.879	.298	8.698	1	.003	2.409	1.343	4.321
[Age_V=30-50]	0[b]			0				
[position=a. Private]	2.038	.867	5.519	1	.019	7.672	1.402	41.990
[position=b. Other]	2.633	1.144	5.301	1	.021	13.917	1.479	130.913
[position=c. Government]	0[b]			0				
[Typeofvictim=a. Pedestrian]	3.898	.421	85.792	1	.000	49.286	21.604	112.439
[Typeofvictim=b. Passanger]	3.058	.441	48.189	1	.000	21.289	8.978	50.484
[Typeofvictim=c. Driver]	0[b]			0				
[Landuse=a.Commercial]	1.752	.909	3.718	1	.054	5.766	.972	34.220
[Landuse=b.Residential]	1.791	.898	3.979	1	.046	5.997	1.032	34.863
[Landuse=c.Institutional]	2.153	1.097	3.851	1	.050	8.608	1.003	73.900

d

	[Landuse=d.Recreational]	-10.438	1437.279	.000	1	.994	2.931E-05	0.000	.[c]
	[Landuse=e.Other]	0[b]			0				
	[lanemedian=a.Raised median]	-1.481	.335	19.526	1	.000	.228	.118	.439
	[lanemedian=b.No median]	0[b]			0				
	[Topography=a.Straight]	1.162	.543	4.576	1	.032	3.198	1.102	9.276
	[Topography=b.Downhill]	2.117	.586	13.047	1	.000	8.305	2.633	26.195
	[Topography=c.Uphill]	0[b]			0				
	[lightingcondition=a.night time]	1.400	.531	6.960	1	.008	4.055	1.433	11.475
	[lightingcondition=b.day light]	0[b]			0				
	[pavementcondition=a.asphalt]	2.054	.981	4.381	1	.036	7.796	1.140	53.342
	[pavementcondition=b.earth road]	-1.614	4.380	.136	1	.713	.199	3.718E-05	1065.692
	[pavementcondition=c.gravel road]	0[b]			0				
	[intersection=a.yes]	1.143	.262	18.949	1	.000	3.135	1.874	5.244
	[intersection=b.no]	0[b]			0				
2	Intercept	-10.626	.963	121.675	1	.000			
	[day=a.Weekday]	.541	.179	9.083	1	.003	1.717	1.208	2.441
	[day=b.Weekend]	0[b]			0				
	[time_A=00:00-3:00]	.005	.844	.000	1	.995	1.005	.192	5.262
	[time_A=12:00-15:00]	.926	.274	11.403	1	.001	2.524	1.475	4.320
	[time_A=15:00-18:00]	.923	.279	10.926	1	.001	2.516	1.456	4.348
	[time_A=18:00-21:00]	-.220	.371	.351	1	.553	.803	.388	1.660
	[time_A=21:00-24:00]	.406	.494	.675	1	.411	1.501	.570	3.953
	[time_A=3:00-6:00]	-1.222	.845	2.093	1	.148	.295	.056	1.543
	[time_A=6:00-9:00]	.525	.267	3.858	1	.050	1.690	1.001	2.854
	[time_A=9:00-12:00]	0[b]			0				
	[sex=a. male]	1.539	.340	20.484	1	.000	4.662	2.394	9.080
	[sex=b. female]	0[b]			0				
	[Age_D=]	-16.055	5079.273	.000	1	.997	1.065E-07	0.000	.[c]
	[Age_D=>50]	1.143	.353	10.457	1	.001	3.135	1.568	6.267

e

[Age_D=18-30]	.542	.184	8.711	1	.003	1.720	1.200	2.466
[Age_D=31-50]	0[b]			0				
[educationlevel=a.Above 12]	-.008	.263	.001	1	.976	.992	.593	1.660
[educationlevel=b.Elementary]	.250	.181	1.911	1	.167	1.284	.901	1.830
[educationlevel=c.Secondary]	0[b]			0				
[experience_A=>10]	-1.216	.285	18.193	1	.000	.297	.170	.518
[experience_A=2-5]	-.336	.212	2.514	1	.113	.715	.472	1.082
[experience_A=5-10]	-.524	.229	5.226	1	.022	.592	.378	.928
[experience_A=Novice]	0[b]			0				
[relationwiththevehicle=a. Employee]	.881	.216	16.719	1	.000	2.414	1.582	3.683
[relationwiththevehicle=b. Other]	.214	.235	.827	1	.363	1.238	.781	1.963
[relationwiththevehicle=c. Owner]	0[b]			0				
[VehicleType=a.Truck]	.780	.292	7.123	1	.008	2.180	1.230	3.865
[VehicleType=b.Bus]	1.075	.335	10.273	1	.001	2.929	1.518	5.650
[VehicleType=c.Mini bus]	.440	.240	3.350	1	.067	1.553	.969	2.487
[VehicleType=d.TWD]	1.191	.402	8.799	1	.003	3.291	1.498	7.229
[VehicleType=e.Other]	-2.828	10230.808	.000	1	1.000	.059	0.000	.[c]
[VehicleType=f.Automobile]	0[b]			0				
[Performancetime_A=>10]	.816	.353	5.354	1	.021	2.262	1.133	4.515
[Performancetime_A=5-10]	.359	.171	4.416	1	.036	1.431	1.024	2.000
[Performancetime_A=below 5]	0[b]			0				
[code=a.1]	1.568	.392	15.967	1	.000	4.797	2.223	10.351
[code=b.2]	1.244	.332	14.064	1	.000	3.470	1.811	6.648
[code=c.3]	2.140	.368	33.780	1	.000	8.501	4.131	17.494
[code=e.5]	-2.006	6.087	.109	1	.742	.135	8.864E-07	20419.728
[code=f.4]	0[b]			0				
[sex_V=Female]	-2.318	.342	45.852	1	.000	.098	.050	.193
[sex_V=male]	0[b]			0				
[Age_V=<18]	3.765	1.143	10.848	1	.001	43.185	4.594	405.932

f

	[Age_V=>50]	1.914	.333	32.956	1	.000	6.777	3.526	13.025
	[Age_V=18-30]	1.035	.177	34.078	1	.000	2.815	1.989	3.985
	[Age_V=30-50]	0[b]			0				
	[position=a. Private]	1.275	.341	13.983	1	.000	3.579	1.834	6.983
	[position=b. Other]	3.463	.659	27.591	1	.000	31.911	8.765	116.177
	[position=c. Government]	0[b]			0				
	[Typeofvictim=a. Pedestrian]	2.239	.215	108.394	1	.000	9.382	6.155	14.300
	[Typeofvictim=b. Passanger]	.787	.215	13.400	1	.000	2.198	1.442	3.350
	[Typeofvictim=c. Driver]	0[b]			0				
	[Landuse=a.Commercial]	.523	.387	1.827	1	.176	1.686	.790	3.598
	[Landuse=b.Residential]	.713	.375	3.609	1	.057	2.040	.978	4.257
	[Landuse=c.Institutional]	1.296	.559	5.367	1	.021	3.654	1.221	10.938
	[Landuse=d.Recreational]	.933	.991	.887	1	.346	2.542	.365	17.722
	[Landuse=e.Other]	0[b]			0				
	[lanemedian=a.Raised median]	-.479	.177	7.311	1	.007	.619	.438	.877
	[lanemedian=b.No median]	0[b]			0				
	[Topography=a.Straight]	1.854	.308	36.281	1	.000	6.386	3.493	11.674
	[Topography=b.Downhill]	1.818	.353	26.453	1	.000	6.157	3.080	12.307
	[Topography=c.Uphill]	0[b]			0				
	[lightingcondition=a.night time]	1.773	.333	28.424	1	.000	5.887	3.068	11.295
	[lightingcondition=b.day light]	0[b]			0				
	[pavementcondition=a.asphalt]	2.204	.457	23.224	1	.000	9.063	3.698	22.212
	[pavementcondition=b.earth road]	-13.979	792.139	.000	1	.986	8.492E-07	0.000	.[c]
	[pavementcondition=c.gravel road]	0[b]			0				
	[intersection=a.yes]	.963	.167	33.337	1	.000	2.620	1.889	3.634
	[intersection=b.no]	0[b]			0				
3	Intercept	-7.867	.854	84.773	1	.000			
	[day=a.Weekday]	.500	.178	7.908	1	.005	1.648	1.163	2.335
	[day=b.Weekend]	0[b]			0				
	[time_A=00:00-3:00]	-1.651	1.216	1.843	1	.175	.192	.018	2.079

g

[time_A=12:00-15:00]	1.013	.281	13.032	1	.000	2.754	1.589	4.775
[time_A=15:00-18:00]	1.002	.286	12.272	1	.000	2.724	1.555	4.771
[time_A=18:00-21:00]	-.329	.380	.753	1	.386	.719	.342	1.514
[time_A=21:00-24:00]	-.325	.527	.380	1	.538	.723	.257	2.030
[time_A=3:00-6:00]	-1.624	.958	2.872	1	.090	.197	.030	1.290
[time_A=6:00-9:00]	1.221	.265	21.176	1	.000	3.392	2.016	5.706
[time_A=9:00-12:00]	0[b]			0				
[sex=a. male]	1.730	.335	26.735	1	.000	5.642	2.928	10.870
[sex=b. female]	0[b]			0				
[Age_D=>50]	1.075	.346	9.685	1	.002	2.931	1.489	5.769
[Age_D=18-30]	.688	.181	14.491	1	.000	1.989	1.396	2.834
[Age_D=31-50]	0[b]			0				
[educationlevel=a.Above 12]	.179	.249	.520	1	.471	1.196	.735	1.947
[educationlevel=b.Elementary]	.033	.181	.032	1	.857	1.033	.725	1.472
[educationlevel=c.Secondary]	0[b]			0				
[experience_A=>10]	-1.149	.274	17.564	1	.000	.317	.185	.543
[experience_A=2-5]	-.283	.208	1.852	1	.174	.754	.501	1.133
[experience_A=5-10]	-.609	.225	7.301	1	.007	.544	.350	.846
[experience_A=Novice]	0[b]			0				
[relationwiththevehicle=a. Employee]	.846	.209	16.339	1	.000	2.330	1.546	3.512
[relationwiththevehicle=b. Other]	.276	.230	1.448	1	.229	1.318	.841	2.067
[relationwiththevehicle=c. Owner]	0[b]			0				
[VehicleType=a.Truck]	.142	.304	.219	1	.640	1.153	.635	2.094
[VehicleType=b.Bus]	.312	.351	.792	1	.373	1.366	.687	2.717
[VehicleType=c.Mini bus]	.701	.225	9.671	1	.002	2.015	1.296	3.135
[VehicleType=d.TWD]	1.203	.394	9.323	1	.002	3.328	1.538	7.202
[VehicleType=e.Other]	16.014	6431.060	.000	1	.998	90153.222	0.000	.[c]

h

[VehicleType=f.Automobile]	0[b]			0				
[Performancetime_A=>10]	-.379	.406	.872	1	.350	.685	.309	1.517
[Performancetime_A=5-10]	.334	.167	4.002	1	.045	1.396	1.007	1.936
[Performancetime_A=below 5]	0[b]			0				
[code=a.1]	.678	.376	3.254	1	.071	1.970	.943	4.116
[code=b.2]	0.899	.314	8.174	1	.004	2.457	1.327	4.551
[code=c.3]	2.023	.345	34.361	1	.000	7.562	3.845	14.873
[code=e.5]	-18.044	3157.738	.000	1	.995	1.457E-08	0.000	.[c]
[code=f.4]	0[b]			0				
[sex_V=Female]	-1.975	.342	33.410	1	.000	.139	.071	.271
[sex_V=male]	0[b]			0				
[Age_V=<18]	3.411	1.147	8.844	1	.003	30.283	3.199	286.698
[Age_V=>50]	1.459	.337	18.794	1	.000	4.303	2.224	8.323
[Age_V=18-30]	.899	.172	27.291	1	.000	2.457	1.754	3.443
[Age_V=30-50]	0[b]			0				
[position=a. Private]	-.469	.248	3.568	1	.059	.626	.385	1.018
[position=b. Other]	1.856	.620	8.978	1	.003	6.401	1.901	21.559
[position=c. Government]	0[b]			0				
[Typeofvictim=a. Pedestrian]	2.075	.213	95.076	1	.000	7.967	5.250	12.092
[Typeofvictim=b. Passanger]	.743	.212	12.336	1	.000	2.103	1.389	3.183
[Typeofvictim=c. Driver]	0[b]			0				
[Landuse=a.Commercial]	.452	.371	1.480	1	.224	1.571	.759	3.254
[Landuse=b.Residential]	.409	.363	1.269	1	.260	1.505	.739	3.063
[Landuse=c.Institutional]	-.155	.613	.063	1	.801	.857	.257	2.851
[Landuse=d.Recreational]	1.090	.875	1.554	1	.213	2.975	.536	16.521
[Landuse=e.Other]	0[b]			0				
[lanemedian=a.Raised median]	.198	.172	1.314	1	.252	1.219	.869	1.709
[lanemedian=b.No median]	0[b]			0				

[Topography=a.Straight]	1.899	.280	45.890	1	.000	6.677	3.855	11.565
[Topography=b.Downhill]	1.500	.336	19.884	1	.000	4.483	2.318	8.667
[Topography=c.Uphill]	0[b]			0				
[lightingcondition=a.night time]	2.106	.338	38.864	1	.000	8.219	4.238	15.937
[lightingcondition=b.day light]	0[b]			0				
[pavementcondition=a.asphalt]	1.107	.375	8.734	1	.003	3.026	1.452	6.307
[pavementcondition=b.earth road]	-15.173	906.962	.000	1	.987	2.572E-07	0.000	.[c]
[pavementcondition=c.gravel road]	0[b]			0				
[intersection=a.yes]	.500	.166	9.077	1	.003	1.648	1.191	2.281
[intersection=b.no]	0[b]			0				

a. The reference category is: 4.

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

c. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.