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SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

SCHOOL OF GRADUATE STUDIES

Analyzing Road Traffic Crash Injury Severity Causing Factors and Remedial actions on Modjo-Hawassa Road

A Thesis in Road and Transport Engineering stream

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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 **Civil and Environmental Engineering** in **Road and Transport Engineering Stream**.

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Addis Ababa, Ethiopia

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Approval Sheet

The undersigned have examined the thesis entitled '**Analyzing Road Traffic Crash Injury Severity Causing Factors and Remedial actions on Modjo-Hawassa Road**' presented by **Gobe Wakeyo Tume**, a candidate for the degree of **Master of Science** and hereby certify that it is worthy of acceptance.

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UNDERTAKING

I certify that research work titled **"Analyzing Road Traffic Crash Injury Severity Causing Factors and Remedial actions on Modjo-Hawassa Road"** is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged / referred.

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ABSTRACT

Worldwide, approximately 1.35 million people die each year from traffic crashes. Also Ethiopia share this traffic crash death. Modjo to Hawassa road is in Oromia Regional State one of Ethiopia's high fatal and other traffic crash injury severity roads. The road inter connects Addis Ababa city with some parts of south eastern Ethiopia. The main objective of this thesis is to analyze effects of drivers', vehicle and road characteristics on injury severity of crash victims and assessing the remedial actions. The five year traffic crash data was used. Multinomial logistic regression model is used to analyze the dependent and independent variables. Explanatory variables such as drivers not obey traffic rule and regulation, drivers their ages are between 18-30 years, drivers education levels are high school level, vehicle types are small truck such as Isuzu and FSR and medium trucks like Sino trucks, when roadway conditions are damaged, vehicle defects, light conditions are dark night are identified as factors increasing fatal, severe, and slight injury severity of pedestrians, passengers, drivers and cyclists. Explanatory variable factors such as higher drivers driving experience in years, newer vehicles, when drivers' age increases, when drivers' education level above high school, when vehicle types are trucks and trailers and light conditions are day light decreased fatal, severe and slight injury severity traffic crash. Drivers of small trucks such as fright Isuzu, FSR and medium trucks like Sino Truck, which do not obey the roadway rule and regulation most of the time engaged in pedestrians' fatal crashes and crashes with cars results in fatal and severe injury severity of traffic crashes. The unknown drivers and vehicle types (drivers hit and runs) are drivers which hit and run post crashes and they crashes with pedestrians, animal cart drivers and cyclists at the rural area, night, early morning and evening time. The remedial actions are giving the training on road rule, regulations and guidelines for the drivers, regularly doing road maintenance and rehabilitations for damaged roadway, traffic signs, signals, pedestrians crossing painting color. The findings of the study and evaluations of remedial actions significance are compared with the results of developed country scholar's researches. The details evaluations of the significance of remedial actions, comparing the results model with mixed logit model, ordered logistic models and factoring independent variable are the research gap of this study and it is recommended as future study.

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Acronyms

AADT…….Annual Average Daily Traffic
ADT……Average Daily Traffic
CRDP……..City Road Development Program
ECE…….Economic Commission for Europe
EBR…….Ethiopian Birr
EC……Ethiopian calendar
ERA…….Ethiopian Roads Authority
FHWA…….Federal Highway Administration
FI …….Fatality Injury
GC……Gregorian calendar
GRDP……Gross Regional Domestic Product
LOS……Level of Service
Mlogit…….....Multinomial logistic regression models
OECD ……Organization for Economic Cooperation and Development
PCU……Passenger Car Unit
PDO……property damage only
TRB……Transportation Research Board
RSDP……..Road Sector Development Program
RTA ……Road traffic accidents
STATA……**STA**tistics and Da**TA** science
WHO ……...World Health Organization

CHAPTER 1 INTRODUCTION

1.1 Background

Worldwide, approximately 1.35 million people die each year from traffic crash and up to 50 million sever injured as a global level every year, the mean of 3,700 fatalities per day in highway crashes. As reported in the (WHO, 2018) the global number of roadway traffic crash fatal continues to increase, reaching 1.35 million per year in 2016 G.C. However, the rates of death relative to the size of the world's population has stabilized in recent years. In addition, approximately 20 to 50 million people suffer non-fatal injuries as a result of road crash (WHO, 2018). It is the second leading cause of death among the most active population (15-44 years old). Low-income countries with a small number of vehicles experience a huge burden of fatalities (WHO, 2018). Ethiopia, according to WHO report is considered one of the worst countries of the world where road transport kills and injuries a large number of road users each year.

Recently, roadway traffic crashes have increased throughout the Ethiopia (Tulu, Washington and King, 2013). Modjo-to-Hawassa road is one of the high volume vehicle roads in East Shewa and West Arsi zones in Oromia Regional State of Ethiopia. The roadway interconnects Addis Ababa city and some parts of South Eastern Oromia Regional State, SNNP regional state, sidama regional state, Somalia regional state and Kenya. Addis Ababa city is the capital city of Africa Union, Ethiopia, and Oromia Regional State. Modjo is located in Ethiopia with (8°35'12.5"N 39°07'16.0"E) coordinates and Hawassa is located in Ethiopia with (7°03'43.6"N 38°28'35.0"E) coordinates respectively. The road length between Modjo and Hawassa is 201 km.

The road type is two way two lane which give service for all types of vehicles. Vehicles are an important mode of freight operations and a country's economic well-being. It also has the ability to boost carrier economic productivity by assuring the timely and efficient movement of commodities. In addition, most heavy vehicles are very old and have already finished their expected running life (Abegaz, et.al. 2014). Because of the injury severity and economic impact of heavy vehicle and passenger car involved incidents, there is growing concern about traffic safety as the number of vehicles increases on the roadway (Anarkooli, Hossein and Kardar, 2017; Chen

and Chen, 2011; Dong, et.al., 2014). This traffic crashes causes a lot of serious injuries on pedestrians, passengers and drivers.

The traffic crash injury severity study identified various factors that cause vehicle-related injury severity, such as driver age and gender, driver driving experience, traffic crash type, roadway conditions and weather conditions. Studies on drivers' factors, vehicle condition factors and environmental factors on traffic crashes, even the age of the driver is an important factor that has contributed to injuries from heavy vehicle crashes (Eluru et al., 2012; Haleem and Gan, 2013). Drivers' gender has also been reported as a leading cause of injury in crashes (Obeng, 2011). The report of (Obeng, 2011) study found significant differences in injury severity between women and men, as the groups had significant differences in injury severity. These differences can be significant; for example, crashes involving male drivers are more likely to be fatal than those involving female drivers. Drivers with older ages are clearly an important factor than the median age, that is older drivers are died or severely injured during road crashes (Haleem and Gan, 2013; Eluru et al., 2012).

There are harmful roadway factors which a roadway defects directly causes traffic crash, where some section of the road environment misinform a roadway users and there by creates a mistake (Tulu and Mokonnen, 2018). The research conducted in the Northern Virginia on the influence of roadway condition, other factors, and driver characteristics on the driver behaviors by (Kidd et al., 2016) conclude that, the drivers characteristics may involve in traffic crash injury severity when driving claim is reduced due to roadway condition, passenger existence and other explanatory variables like time of day and their prevalence were varied significantly according to exposure to passenger existence, driver characteristics and time of day.

The Ethiopian Road Administration (ERA) has recently been working on developing on improvements of transportation system, which includes the construction of the upgrade of existing road networks and construction of new expressway at the corridor than road safety (Tulu, and Abegaz, 2021). Recently in Ethiopia, (Tulu, Washington and King, 2013) assured in their research that traffic crash injury severity has increased in Ethiopia. Harmful roadway factors include where a road defects directly help a traffic crash, where some section of the roadway environment misinform a roadway users and it creates a mistake (Tulu and Mokonnen, 2018).

Heavy vehicle-drivers collision is the most common collision type in the developing countries that has a higher probability of fatal and severe injuries (Chen and Chen, 2011). Vehicle type involves both governmental vehicles as well as private vehicles used for commercial purposes and other function. Also, it has significant potential to increase economic productivity for carriers by ensuring timely and efficient flow of commodities. The different types of vehicles play a vital role in the freight logistics and economic well-being of a one country. With the increase in vehicle volume, there is growing concerns related to traffic safety due to the magnitude of injury severity and economic impact of vehicle involved in the traffic crashes. In reality, there are studies that investigated the cause parameters related with traffic crashes.

1.2 Statement of the Problem

Roadway traffic crash occurs worldwide but the incidence rate is higher in developing countries including Ethiopia due roadway safety is difficult and poor. The roadway in developing countries is also known for having the maximum amount of roadway crashes that involves vehicle. More than half of all roadway fatal of traffic crash are among vulnerable roadway users: pedestrians, cyclists and bikers (WHO, 2018). Furthermore, roadway geometric characteristics which increase traffic crash injury severity are roadway cross-sectional component and alignments.

The research that conducted previously addressed factors such as alcohol use, a sleeping while driving, driving at evening time in the not street light, a minibus or vans vehicle type (Abegaz, et.al. 2014) were found to be increased traffic crash injury severity at the study area. These causes may include poor road geometry with reduced facilities, drivers' performance and careless driving, vehicles type, pedestrians' problem, over speeding, failure to give way to pedestrians and violating traffic regulations. But the traffic crash problems still not solved or the traffic crash injury severity is not decreased due to the increment of vehicle volume and no implementations of the previously addressed remedial actions. Tulu et al. (2013) indicated that in Ethiopia pedestrians' traffic crash fatal reach 55% per annum and policy makers in developing country like Ethiopia have failed to remediate the growing scale of pedestrian crash risk, which is accompanied by the rapid increasing of motorization.

Traffic Crash injury severity database of the study roadway details indicated fatal crashes, sever injury, slight injury and property damage only. Jilcha, (2009) the total cost of traffic crash property

damage only between 1999-2000 E.C years estimated by the statistical sector to be 259,255,452 EBR at the study road. This research is tried to fill the gap by analyzing effects of the drivers' characteristics behaviors, vehicle characteristics and roadway condition characteristics on injury severity of traffic crash on crash victims from Modjo to Hawassa roadway.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of the study is to analyze the effects of drivers', vehicle and roadway condition characteristics on injury severity of traffic crash victims and its remedial actions; the case of Modjo-Hawassa road**.**

1.3.2 Specific Objectives

- ✓ Investigation of drivers' characteristics which cause and increase traffic crashes injury severity between Modjo and Hawassa road.
- ✓ To assess the vehicle type and road condition factors that influences injury severity of traffic crashes victims on the Modjo-Hawassa road.
- ✓ Proposing remedial actions for driver's behavior, vehicle type and roadway condition characteristics factors which influence injury severity of traffic crash victims.

1.4 Research Questions

This study is attempted to answer the following research questions that promise to provide a better insight into the effects of driver's behaviors, vehicle type and road condition characteristics on roadway traffic crashes. The main research questions are:

- ✓ What are the drivers' characteristics factors that influences injury severity of traffic crashes victims on the Modjo-Hawassa road?
- ✓ What are the effects of the vehicles types and roadway condition characteristics on the injury severity of traffic crash victims in the study areas?
- ✓ What is the remedial actions for drivers' behavior, vehicles types and roadway condition characteristics factors which cause and increase injury severity, in traffic crash involved heavy vehicles?

1.5 Scope and Limitation of the Study

The study focuses on the effects of driver's behaviors, vehicle type and roadway condition characteristics on traffic crashes victims injury severity occurrences on roadway between Modjo and Hawassa. The traffic crash start at (Modjo) and ends at Hawassa cities which both cities are not included in the study. The study used traffic crash injury severity database of five years from July 2014 to June 2019. Motor cycle, passenger cars, taxies, small heavy vehicles, medium heavy vehicles and large heavy vehicles were included in the study. The environmental variables and land use are not included as exposure variables. Furthermore, the study used drivers' behavior characteristics, vehicle type characteristics, crash types, temporal conditions, as exposure variables. However, drivers driving license type and level are not compiled in the study due to lack of full information in many woredas. Mixed logit model, response parameter ordering models, model compering and independent variable factoring method not used due to time shortage. Furthermore, a one-hour counting method was used to calculate peak hour volume and to know heavy vehicles volume percentage.

1.6 Significance of the Study

The study focuses on the effects of driver's behaviors, vehicles types and roadway condition characteristics on Modjo-Hawassa roadway traffic crashes injury severity. The study used traffic crash injury severity of five years from July 2014 to June 2019 database in East Shewa and West Arsi zones in Oromia regional state. Thus, the significances of the research findings are detailed as below.

1.6.1 Theoretical significance of the research

This research can help as a reference for other researchers who wants to do their research on the effects of drivers' behaviors and vehicles characteristics on roadway traffic crashes injury severity. It used to identify effects of drivers' behaviors, road condition and vehicles characteristics in developing countries like Ethiopia and others with similar roadway condition and traffic characteristics.

1.6.2 Practical significance of the research

This research provides inputs for decision-making on Modjo-Hawassa roadway traffic crashes mitigation measures. This research expected to give inputs for Modjo-Hawassa roadway safety

authorities, road designers and planners on the effects of drivers' behaviors, roadway conditions and vehicles characteristics on roadway traffic crashes injury severity reduction and prevention designs and implementations.

1.7 Thesis Organization

The thesis is organized in to five chapters and have been outlined as follows: (i) introduction: it provides overviews at the background of the study, elaborate the statement of the problem, research objectives and questions, the scope and limitation of the study, the significance of the study, and finally, it looks at the thesis organization. (ii) literature review: this section included a review of the relevant theoretical and empirical works that provide a theoretical ground to the study. Thus, a selected research works were compiled to support the research. (iii) materials and methodology; this chapter describes the materials gathered and the methodology applied through which the objectives of research was achieved. (iv). Results and discussions: in this chapter, the general analyses of the study is presented and discussed. In addition, results models were explained. (v) conclusions and recommendations: these are presented at the end chapter of the research that summarized the research outputs and forwarded recommendations based on the findings of the study. Finally, the reference used in the study and some other data formats including appendices are attached at the end of the report.

CHAPTER 2 LITERATURE REVIEW

2.1 Definition of Roadway Traffic Crashes

Worldwide, approximately the fatality of 1.35 million people each year recorded from traffic crash. This means more than 3,700 death claims per day following a traffic crash, the world health organization (WHO, 2018). In addition, approximately 20 to 50 million people suffer non-fatal injuries as a result of roadway traffic crashes (WHO, 2018). It is the second leading cause of death among the most active population (15-44 years old). Low-income countries with a small number of vehicles experience a huge burden of fatalities (WHO, 2018). In addition, there is slight execution of risk control mechanism like speed limit, seat belt, drunk driving, child restraints and helmet use is not in use until now in the many of the countries of the world. In most countries, there is rarely traffic law implementation, traffic law and post-crash cure in the region. In the world 45 countries have bring into line with best exercise on drink-driving law, 49 countries on motorbike helmet usage, 33 countries on the use of child restraint schemes and 105 countries on the practice of seat-belts and Less improvement has been made on accepting best practice on speed limits, even with the significance of speed as a key cause of fatal and severe injury (WHO, 2018). Ethiopia, according to (WHO, 2018) report, is considered one of the worst countries of the world where road transport kills and injuries a large number of road users each year. Ethiopian Road Sector development program (RSDP) detail the areas in development Plan report. There is a serious lack of hierarchical arrangement in the roadway network where there are un-equivalent narrow bridges that change road lane service in to bottlenecks at reduction of number of lane, poorly designed intersections, and alignments. With linear expansions nearby to the major roadway system, there is no technology supported methods of access control. On street parking and little traffic management are major factors which bound the capability of the current network. Usually the known definition of highway traffic crash is given by the Economic Commission for Europe (ECE) that is “Road Traffic Crashes (RTCs) are those crashes that occur on a way or street open to public traffic; resulted in one or more persons being killed or injured, and at least one moving vehicle was involved.” It implies that RTA is collisions between vehicles, vehicles and pedestrians, vehicles and animals and between vehicles and fixed obstacles (ECE, 2005). The World Health

Organization (WHO, 2018) defined road traffic crash as “any crashes involving a device designed primarily for, or being used at the time primarily for, conveying persons or goods from one place to another”. Alternatively, road crash classified on the basis of the following conditions; the death of a person within 30 days of the crash; or personal injury to the extent that the injured person was admitted to hospital; the crash occurred on any road, street, or any place open to public, the crash involved one or more road vehicles which were in motion at the time of the crashes (WHO, 2018). Generally, road crash is an event which is unexpected, undersigned with an element or chance or probability or unfortunate result" and sometimes it is defined as "the occurrence which usually produces injury, death (fatal) or property damage only (PDO)". Therefore, it is very essential studying on driver’s behavior characteristics to reduce traffic crashes injury severity that involved heavy vehicle by integrating safety awareness design and planning of drivers education licensing and campaigns.

2.2 Characteristics of Roadway Traffic Crashes as Global

As reported in the (WHO, 2018), an estimated 1.35 million people are died and up to 50 million sever injured as a global level every year, the mean of 3,700 fatalities per day in highway crashes. As reported in the WHO (2018), the global number of roadway traffic crash fatal continues to increase, reaching 1.35 million per year in 2016 G.C. In 104 low-income country between 2013 and 2016 no reductions in fatal of roadway traffic crash injury severity unless it shows increased but there are some reductions in 48 middle- and high-income countries. The World Health Organization (WHO) defined road traffic crash as “any crash involving a device designed primarily for, or being used at the time primarily for, conveying persons or goods from one place to another”. Alternatively, road crash classified on the basis of the following conditions; the death of a person within 30 days of the crash; or personal injury to the extent that the injured person was admitted to hospital; the crash occurred on any road, street, or any place open to public, the crash involved one or more road vehicles which were in motion at the time of the crashes (WHO, 2018). The available crash data provide comprehensive information on time, roadway and environmental conditions (such as light and road surface conditions), crash attributes (such as manner of crash, cause of crash, events contributing to crash), vehicle characteristics such as type of the vehicle, vehicle service year, vehicle defects and driver attributes such as age and gender (Anarkooli, Hosseinpour, and Kardar, 2017). Behnood and Mannering (2015) estimated the traffic crash injury

severity models using the traffic crashes that occurred during each individual year to examine the effects of drivers' characteristics of traffic injury severity models. The studies by (Kelley, 2010; Bham; Javvadi and Manepalli, 2012; Kim, et al., 2013) detailed the seat belt usage reduced the chance of injury severity in traffic crashes to been fatal injury, severe injury, slight injury, and property damage only. The effects of drinking could be overestimated and when drivers used cell phone the chance of fatality injury a little growths and it also been safely associated to injury severity in single-vehicle traffic crashes (Abdel-Aty, 2003; Kim, et al., 2013). Drinking alcohol, driving in excess of speed limit, cell phone usage are the drivers characteristics behaviors conditions factors that affect traffic crash injury severity of heavy vehicle involved traffic crashes which have related to endangering economic and social condition of one country level (Abdel-Aty, 2003).

Chen et al. (2015) done a study using a Multinomial logistic model to analyze the driver crash injury severity level in rear-end traffic crashes based on the national wide traffic crashes database in 2 years (2010-2011) in New Mexico. The outcomes of the study showed that factors such as heavy vehicle trucks association, the volume of heavy vehicles involved, inferior lighting conditions, weather conditions such as wind involvement traffic crashes, etc. could significantly increase driver injury severity in rear-end traffic crashes. Ye and Lord (2011) studied by what means the multinomial logit model, ordered probit model, and mixed logit model traffic crash injury severity models accomplished when different traffic crash injury severity databases are under reported. Two simulation situations were constructed, and a Monte Carlo method was used to estimate those three traffic crash regression models. The outcomes of the research showed that the investigation using simulated and collected traffic crash data accomplished consistent outcomes with the consideration of underreporting traffic crash injury severity for each traffic crash injury severity levels. Wu et al. (2016) obtained the statistically significant causal factors and analyzed their effects on driver crash injury severities in their research. Two multinomial logistic models for young and mature drivers were developed using traffic crash database from 2010 to 2011 in New Mexico. The outcomes of the study showed that it is important to differentiate certain traffic crash injury severity characteristics specifically to develop effective roadway safety mitigations for the two drivers' age groups. Tay et al. (2011) executed a study on pedestrian and vehicle crashes to identify factors that contribute to the crash injury severity of pedestrian crashes

in South Korea. A multinomial logistic regression model was developed in the traffic crash injury severity study to relate pedestrian crash injury severity to several exposures, such as roadway condition, driver behavior characteristics, using traffic control technology, weather conditions characteristics, pedestrian characteristics and vehicle type characteristics. The results of traffic crash analyzing showed that the main factors are (heavy vehicles, drivers drunk and drives, male drivers, drivers below the age of 65, pedestrians who are above the age of 65 or female, pedestrians who are crashed with vehicle in the central of the roadway lane, on high speed limit roadways, on bridges, in severe weather conditions, at night time of day, on roadway intersections, in tunnels, on wider roadway lane in size and numbers) significantly increase the likelihood of traffic crash injury severity level of pedestrians injury. The study identified recommendation such as campaigns should be given by aiming at male drivers, male drivers under the age of 65, female and older pedestrians.

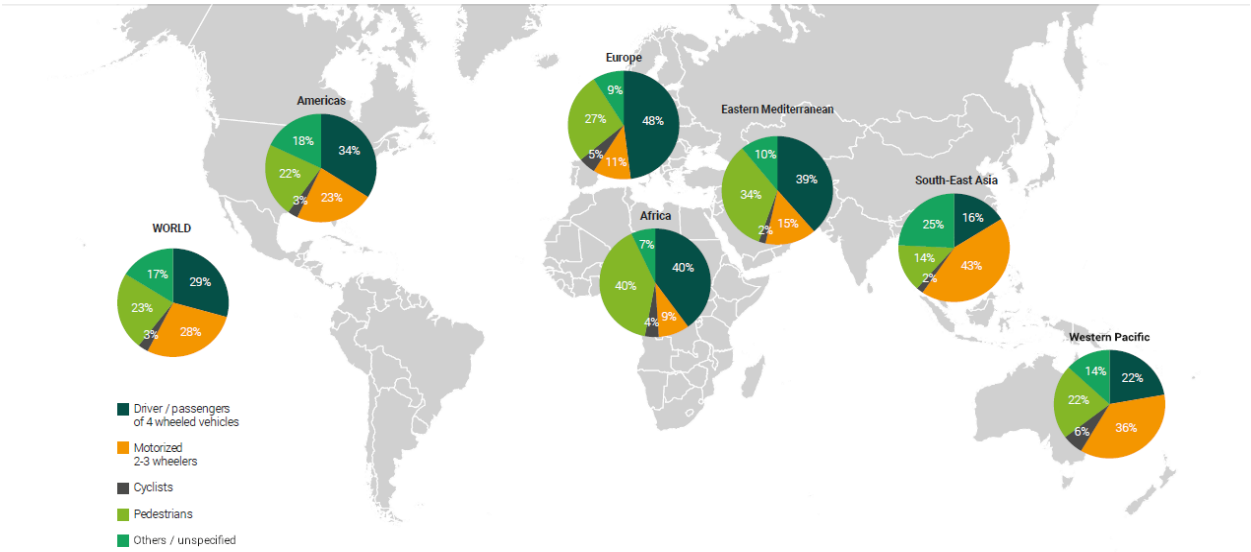


Figure 2-1: Rates of road traffic death by victims' categories per 100,000 population by WHO regions: 2013, 2016,

Source: World Health Organizations (WHO) global status report on road safety 2018.

2.3 Characteristics of Roadway Traffic Crashes as Africa

Recently, road crashes have increased throughout the Ethiopia (Tulu, Washington and King, 2013a). Heavy vehicles are an important part of freight operations and a country's economic well-

being. It also has the ability to boost carrier economic productivity by assuring the timely and efficient movement of commodities. Because of the injury severity and economic impact of heavy vehicle and passenger car involved incidents, there is growing concern about traffic safety as the number of vehicles increases on the roadway (Anarkooli, Hossein and Kardar, 2017; Chen and Chen, 2011; Dong, et.al., 2014). The underreporting of traffic crashes in Ethiopia due to personal settlement of claims are among the problem that shows to be solved by the roadway safety and management authority. Despite the frequency of drivers crashes and the importance of driving as a means of revenue, the road safety and management authority and Ethiopia road administration (ERA) often gives priority to the construction and maintenance of roadways but less facility attentions for drivers', pedestrians, vehicle and other road users (Tulu, et.al., 2015). Presence of motorized traffic in the area may have implications for roadway safety concern. High number of the total vehicle population of Ethiopia are operated on these roadway. In addition, most heavy vehicles are very old and have already finished their expected running life (Abegaz, et.al. 2014).

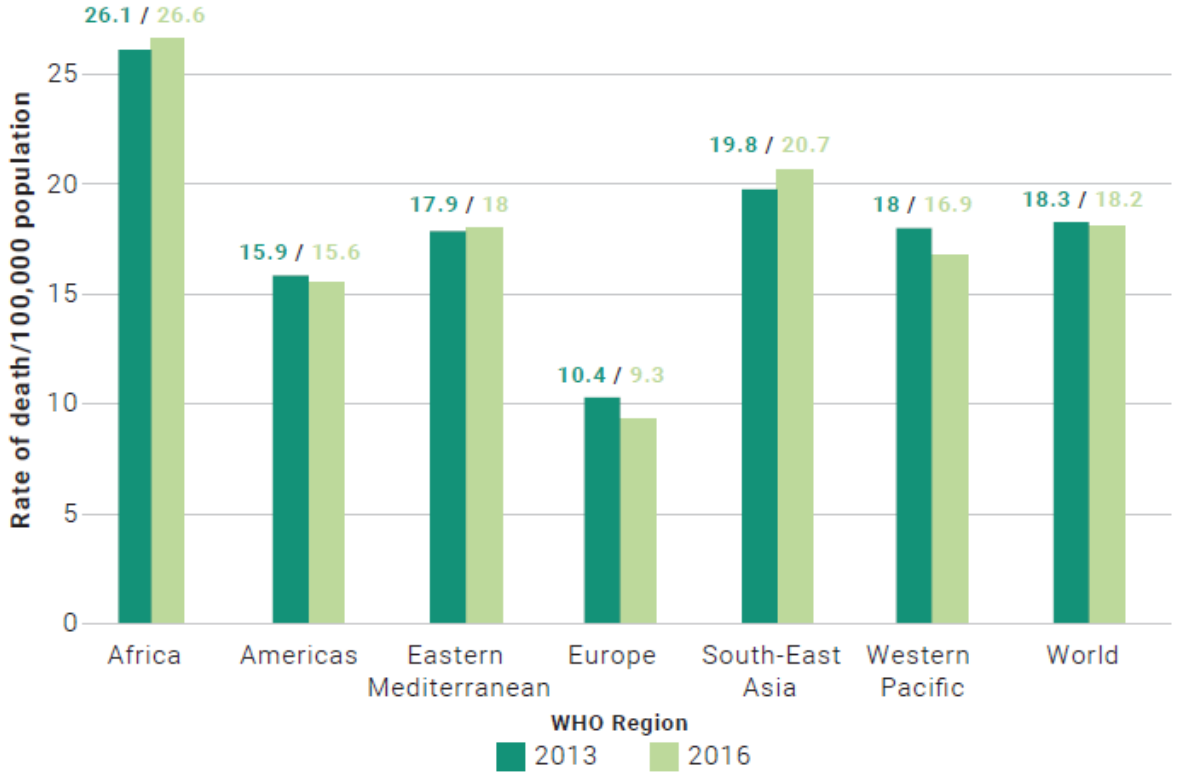


Figure 2-2: Rates of road traffic death per 100,000 population by WHO regions: 2013, 2016, Source: World Health Organizations (WHO) global status report on road safety 2018.

2.4 Characteristics of Roadway Traffic Crashes as Ethiopia

The lack of enforcement of traffic laws might make an additional contribution to the poor safety record of drivers and the results raise the possibility that long-haul truck drivers are actually sleepier than they report, and thus are at an increased risk for not responding to sleepiness in a timely manner (Abegaz, et.al. 2014). A potential explanation for this behavior is lack of education and training on sleepiness among truck drivers. Using Trucks vehicles plays a vital role in economic development in our country, especially where there are no other choice for goods transportation and it serves as the backbone of the economy. The fast growth of economy in Ethiopia as a developing country has also been accompanied by traffic crash injury severity of fatalities, severe injury and property damage in truck involved crashes, among the drivers and passengers of the heavy vehicles as well as the other heavy vehicles involved crash. The Ethiopian road Administration (ERA) has recently been working on developing on improvements of transportation system, which includes the construction of the upgrade of existing road networks and construction of new expressway at the corridor (Tulu, and Abegaz, 2021). Recent urbanization in area has resulted in new urban difficulties such as roadway traffic collisions, primarily driver collisions as a result of traffic collisions involving heavy vehicles. Despite the sizable efforts to investigate the truck-involved crashes, very little is known about the safety of heavy vehicles movements in developing countries, and about the heavy vehicles crashes worldwide. The explanatory factors tested in the models include the drivers' characteristics, vehicles characteristics, and pedestrian movement characteristics. A random threshold random parameters hierarchical ordered probit model is utilized to consider heterogeneity across observations. It randomizes the parameters by introducing an error term that is correlated with observed and unobserved factors and converts individual heterogeneity to parameter heterogeneity (Christoforou et al., 2010). Several variables turned out to be significant in the model, including driver's education and high speed-limit. Marginal effects of each explanatory variable, which capture the effect that a one-unit change in any specific explanatory variable has on the probability an injury-severity outcome calculated to investigate the effect of individual parameter estimates on injury-severity probabilities (Anarkooli, Hosseinpour, and Kardar, 2017).

Table 2-1: Global status report on Ethiopian status of road traffic deaths

Ethiopia

Population: 102 403 200 | Income group: Low | Gross national income per capita: US$ 660

INSTITUTIONAL FRAMEWORK	
Lead agency	Ministry of Transport
Funded in national budget	Yes
National road safety strategy	Yes
Funding to implement strategy	Partially funded
Fatality reduction target	50% (2011-2020)
SAFER ROADS AND MOBILITY	
Audits or star rating required for new road infrastructure	No
Design standards for the safety of pedestrians / cyclists	Partial
Inspections / star rating of existing roads	No
Investments to upgrade high risk locations	No
Policies & investment in urban public transport	Yes
SAFER VEHICLES	
Total registered vehicles for 2015/2016	708 416
Cars and 4-wheeled light vehicles	–
Motorized 2- and 3-wheelers	–
Heavy trucks	–
Buses	–
Other	–
Vehicle standards applied (UNECE WP.29)	
Frontal impact standard	No
Electronic stability control	No
Pedestrian protection	No
Motorcycle anti-lock braking system	No
POST-CRASH CARE	
National emergency care access number	National, single number
Trauma registry	Some facilities
Formal certification for prehospital providers	Yes
National assessment of emergency care systems	No
DATA	
Reported road traffic fatalities (2015/2016)	4 352 [a] (78% M, 22% F)
WHO estimated road traffic fatalities (2016)	27 326 (95% CI 21 494 - 33 159)
WHO estimated rate per 100 000 population (2016)	26.7

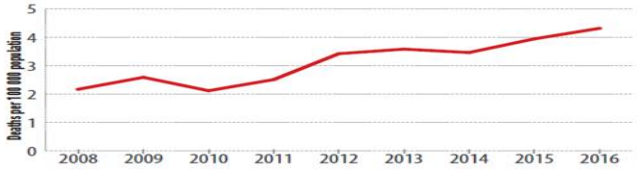
[a] Federal Police Commission. Died within 30 days of crash

SAFER ROAD USERS	
National speed limit law	Yes
Max urban speed limit	60 km/h
Max rural speed limit	70 km/h
Max motorway speed limit	100 km/h
Local authorities can modify limits	Yes
Enforcement	0 1 ② 3 4 5 6 7 8 9 10
Predominant type of enforcement	Manual
National drink-driving law	Yes
BAC limit – general population	≤ 0.08 g/dl
BAC limit – young or novice drivers	≤ 0.08 g/dl
Random breath testing carried out	Yes [b]
Testing carried out in case of fatal crash	All drivers tested
Enforcement	0 1 ② 3 4 5 6 7 8 9 10
% road traffic deaths involving alcohol	4% [c]
National motorcycle helmet law	Yes
Applies to drivers and passengers	Yes
Helmet fastening required	No
Helmet standard referred to and/or specified	No
Children passengers on motorcycles	Not restricted
Enforcement	0 1 ② 3 4 5 6 7 8 9 10
Helmet wearing rate	–
National seat-belt law	Yes
Applies to front and rear seat occupants	Yes
Enforcement	0 1 2 3 4 ⑤ 6 7 8 9 10
Seat-belt wearing rate	<1% All occupants [d]
National child restraint law	No [e]
Children seated in front seat	Prohibited under 13 yrs
Child restraint required	–
Child restraint standard referred to and/or specified	–
Enforcement	–
% children using child restraints	–
National law on mobile phone use while driving	Yes
Ban on hand-held mobile phone use	Yes
Ban on hands-free mobile phone use	Yes
National drug-driving law	Yes

[b] Legislation requires probable cause to test drivers
[c] 2012/2013, Ethiopian Federal Police Commission
[d] 2013/2014, Ethiopian Federal Police Commission
[e] Legislation requires that children under 7 years be either accompanied by an adult or "hugged by an instrument made for safety purpose"

Deaths by road user category

Trends in reported road traffic deaths



Source: World Health Organizations (WHO) global status report on road safety 2018.

2.5 Roadway Traffic Crashes Characteristics at study Area

Drivers' behaviors effects on traffic crashes injury severity accounts for high number of injury severity of Modjo-Hawassa roadway in West Arsi Zone and East Showa police office traffic crash database. These figures might be lower than the real figures, particularly for injury, due to possible crash underreporting (Tulu, et al., 2015). The speed at crash is a main to be studded variable when considering traffic crash injury severity. Tay, (2015) unluckily, an exact assessment of the speed of the traffic crash is rarely registered in traffic crash databases. However, other variables work to capture this effect, namely road classifications and the variable unsafe speed, which remains statistically significant in the model (Abdel-Aty, 2003; Tay, 2015). Pedestrian behaviour is influenced by a diversity of less well understood causal factors, leading to trouble in modelling and forecasting pedestrian crash injury severity in developing country when it is compared with developed one and isolating effective pedestrian roadway safety as remedial actions (Tulu et al.; 2013). Ethiopia's population number is 102.4 million in 2016 G.C and the income level is low. The differences between Ethiopian Police-reported traffic crash data fatalities and the World Health

Table 2-2: Global Status Report of road traffic deaths by country

Country / Area	General information			Road traffic deaths		
	Population numbers for 2016[a]	GNI per capita for 2016 in US dollars[b]	Income level[c]	Reported number of road traffic deaths	Modelled number of road traffic deaths[d]	
					Point estimate	95% Confidence Interval
Comoros	795 601	760	Low	23	211	177 - 245
Congo	5 125 821	1 710	Middle	308	1 405	1 124 - 1 687
Cook Islands	17 379	–	High	5[e]	3	–
Costa Rica	4 857 274	10 840	Middle	795[e]	812	–
Côte d'Ivoire	23 695 920	1 520	Middle	991	5 582	4 635 - 6 529
Croatia	4 213 265	12 110	Middle	307	340	–
Equatorial Guinea	1 221 490	6 550	Middle	41[e]	300	221 - 379
Eritrea	4 954 645	520[g]	Low	130	1 255	1 025 - 1 485
Estonia	1 312 442	17 750	High	71	80	–
Eswatini	1 343 098	2 830	Middle	203	361	296 - 427
Ethiopia	102 403 200	660	Low	4 352[e]	27 326	21 494 - 33 159

Source: World Health Organizations (WHO) global status report on road safety 2018.

Organization estimation for Ethiopia are reported the number of roadway traffic crash injury severity level of fatality is 4352 persons per year. But the WHO estimated by modelled number of roadway traffic crash fatality as 27326 persons per year at point estimate using 95% confidence interval.

2.6 Statistical logistic Regression Models

Two common approaches in modeling traffic crash injury severity are ordered discrete outcome models and unordered discrete outcome models. The important dissimilarity among these models are that the ordered discrete outcome/result models considers the ordinal nature of traffic crash injury severity whereas the unordered discrete outcome models does not consider the ordinal nature (Savolainen et al., 2011). To better understand the effect of each independent variable on the dependent variable, an elasticity analysis has been applied by (Shaheed, Gkritz, 2014; Wu et al., 2014). To compute the associations between exposure variables and several injury severity levels, a logistic function has been extensively used in earlier researches (Cerwick, et al., 2014; Shaheed, Gkritza, 2014; Wu et al., 2014; Behnood, and Mannering, 2015). The advance of statistical models and computational abilities led to various significant research that show urban roadway safety matters by examining the factors associated to roadway infrastructure, vehicles characteristics, human behavior, and traffic environments as well as their effects on traffic crash occurrence and injury severity (Kim et al., 2013;Wu et al., 2014).

Lee, and Fazio, (2005) studied the differences among urban and rural drivers injuries in traffic crashes involving heavy vehicle trucks, and they found that the key factors causing severe injury or fatal injury among drivers are train influence, drunk driving, drugged driving, and lighting condition. While both schemes have been accepted in former research on traffic crash injury severity. The unordered discrete result models also have the capacity of controlling under-reporting difficulties in exploring traffic crash injury severity, which is a characteristic existence with police traffic reported traffic crash databases (Washington et al., 2020). The ordered logit or probit models have been used in the past for injury severity analysis (Abdel-Aty, 2003; Ye and Lord, 2011).

Multinomial logistic model used to analyze traffic crash injuries severity (Tay, et al., 2011; Bham, Javvadi, and Manepalli, 2012; Wu et al., 2014; Behnood, and Mannering, 2015; Chen, et al., 2015;

Wu et al., 2016; Chen, and Fan, 2019; Wahab, and Jiang, 2019; Zhang, et al., 2021). Some of the studies that applied the multinomial logit model for single vehicle and multiple vehicle traffic crash analysis is by (Tay, et al., 2011; Bham, Javvadi, and Manepalli, 2012; Chen, C., Zhang, et al., 2015; Wu, et al., 2016). They hypothesized that the multinomial logit method is accessible more flexibility while taking discrete specific heterogeneity from driver behavior, roadway characteristics, and vehicle types. Multinomial logit models have been effectively used to study traffic crash injury severities in single-vehicle crashes (Bham, Javvadi, and Manepalli, 2012; Wu, et al., 2016). Cerwick, et al., (2014) related the three preeminent frequently-used traffic crash injury severity models; the multinomial logit model, the latent class model and the mixed logit model depending on the essential sample sizes for an effective estimation of the parameters. They used a Monte-Carlo method by means of simulated and detected traffic crash data.

The mixed logit model need the large sample size 5000 and the suggested sample sizes for the multinomial logit model is 1,000 (Kim et al. 2013). Bham, Javvadi, and Manepalli,(2012) evaluated the safety belt usage in single and multi-occupant vehicles using database collected from an observational roadway side assessment of safety belt usage in Indiana. The authors found that for single-occupant vehicles, male drivers, truck and van drivers, and those driving in the morning were less likely to use safety belts. However, the standard ordered models restrict the effects of explanatory variables on traffic crash injury severity level. That is, either they decrease the highest traffic crash injury severity level and increase the lowest traffic crash injury severity level, or decrease the lowest injury severity level and increase the highest injury severity level (Kim et al., 2013). Regarding severity studies on roadways (Tay, et al., 2011; Bham, Javvadi, and Manepalli, 2012; Wu, et al., 2016) studied the injury severity of traffic crashes on countryside roadways, and the significant variables were environmental conditions, roadway condition, vehicle, and driver behavior characteristics.

Wu, et al., (2016) analyzed the consequence of speed limit increases on the injury severity of most severe occupant injury in single-vehicle crashes of federal roadways. When the speed limits are increased from 104.6 to 112.7 km/h did not show a significant injury severity effect on injury severity of traffic crash and it is their one result from the study. Haleem and Gan, (2013) compared the traffic crash injury severity along expressways and arterials of the two critical facilities

roadways. Van vehicle showed an injury severity increase on freeways and pick-up vehicle injury severity decrease on arterials roadways (Cerwick, et al., 2014; Kaplan and Prato, 2012). Applications of using the mixed logit framework to analyze crash injury severity on urban freeways have been relatively limited and the use of the mixed logit model in the study will provide the ability to identify the non-uniform effects of the crash injury severity predictors on the observations. Kim et al. (2013) developed a mixed logit model of drivers' injury severity in single-vehicle crashes to evaluate the consequences of driver age on the particular traffic crash injury severity. The known factors which increased fatal injury severity likelihood comprised older drivers (65 years and above), male drivers, drunk driving, matured drivers driving aged heavy vehicles, and darkness with no streetlights. The marginal effects are the partial derivatives of the probability of crash injury severity with respect to the vector of independent variables (Milton et al., 2008). The heavy vehicle percentage and weather condition such as snowfall, roadway variables, such as the number of horizontal curves, number of speed breaker per km, average daily traffic, average daily heavy vehicle traffic, and pavement condition, were well modeled as stationary. From the studies that examined the multinomial logit model (Wahab, and Jiang, 2019) modeled the traffic crash injury severity resulting from motorcycle crashes using crash database from 2011 to 2015 from road research institute in Ghana. The authors separated the factors that positively affected the motorcycle crashes injury severity as; crash at intersection, weekend motorcycle crash, poor roadway shoulder, good roadway surface and traffic crash between motorcycle and heavy goods vehicles. Multinomial logit model performed significantly elastic well. Chen and Fan (2019) estimated multinomial logistic regression models to detect the causal factors of the injury severity of traffic crashes which involved heavy vehicles. Chen and Fan (2019) analyzed police-reported database traffic crashes from 2005 to 2012 from North Carolina to investigate pedestrian injury severity and vehicle type explanatory variable using the multinomial logit model method. He identified independent variable factors that significantly increased the likelihood of fatal traffic crash injury severity and severe injuries such as drivers behaviors, motorcycle and heavy vehicle type, pedestrian with age of the (26–65 and over 65), weekend days, when light condition is dawn, and dark light condition, roadway characteristics (horizontal and vertical curve), roadway surface condition (wet), and driving in excess of maximum speed limit. Naik, et al., (2016) investigated traffic crash injury severity under diverse weather conditions,

roadway and climate-related variables in single heavy vehicle crash injury severity by using random parameters ordinal and multinomial logistic regression models. Tay, et al., (2011) empirically explored the effects of drivers who were used alcohol, male under the age of 65; female pedestrians with age above 65, involving heavy vehicles, roadway and light condition effects on the driver injury severities of traffic crashes. In another study, Kim et al. (2013) analyzed the difference in male and female drivers' injury severity and with males associated with fatal when vehicles are old on average, a higher likelihood of fatal injury severity in a firsthand vehicle related with females. (Sullivan and Flannagan, 2012) requiring conspicuity treatments on heavy vehicle tracks and trailers, was determined in studies of the probabilities of fatal crashes in night dark. The effects of lighting condition on traffic crash injury severity on rural and urban roadways is also studied by (Uddin, and Huynh, 2017). The multinomial logit regression model often used to check the appropriateness of distinct models over one collective model is to use likelihood ratio tests (Pahukula et al., 2015). In this study, once the three models were developed, a series of likelihood ratio tests were performed following the procedures articulated Washington et al. (2003).

Separate outcome traffic crash severity approaches employed in recent heavy vehicle track safety studies consist of mixed logit models (Horswill and Coster, 2002; Chen and Chen, 2011; Hasan Kabir and Jalayer, 2021). Abdel-Aty, (2003) used ordered probit models, (Abegaz et al.; 2014) applied generalized ordered logit model and (Tulu and Mokonnen, 2018) Poisson and Negative Binomial regression traffic crash models to analyse the effects of roadway cross-sectional features on the traffic crash injury severity in Addis Ababa. Researchers like (Haleem and Gan, 2013; Kim et al. 2013; Wu et al., 2014; Wu et al., 2016) additionally used the mixed logistic regression model and pointed that roadway traffic crashes in urban areas had a lower chance of severe injury crashes, whereas excess use of speed limits were linked with higher severe injury of traffic crashes probability. Also, they found that the current method for allowing design exceptions did not have a significant effect on roadway traffic crash injury severity. The identification of significant predictors of the injury severity of traffic crash injuries in these facilities can help select more effective remedies to address underlying safety deficiencies. (Cerwick et al., 2014) employed a mixed logit model based scheme to evaluate the injury severity of all roadway users of the different heavy vehicles and a mixed logit model together survey the injury severity of the drivers in heavy vehicle involved crashes and used this statistical models for heavy vehicles involved crash to

investigate factors that facilitate injury severity of city road users and this models used to differentiate injury severity of risk holders in different heavy vehicles involved crashes. The advantage and disadvantage of Random parameter models are more elastic than the old-style permanent parameter models in accounting for unobserved heterogeneity and difficult estimation process; may not be simply transferable to further datasets respectively (Lord, D. and Mannering, F., 2010). The normal and uniform distributions of the random parameters were examined, and the normal distribution was shown to yield more plausible estimates. The parameters found random were those that yielded statistically significant standard deviations for the normal distribution (as in Milton et al., 2008; Train, 2009). Mixed (random parameters) logit model is a logit model which use varying independent variable parameters from one observation to another observations. It is therefore a model that takes the heterogeneity of the population into account. The mixed logit model requires numerical integration of the logit formula over the distribution of potentially observation specific parameters and its estimation is undertaken using maximum likelihood estimation method (Train, 2009). In fact, the process of determining the random parameters needs many trials have to be performed up to a significant set of parameters is estimated. Alternatively, random parameters ordered logit model and random parameters ordered probit model were applied to switch the intuitive ordering of traffic crash injury severity. Random parameters logit model is used to analyze the risk factors of traffic crash injury severity on rural and urban roadways (Xiong, and Mannering, 2013; Cerwick, et al., 2014; Russo, et al., 2014; Tay, 2015). The results shows that; the random parameters logit model can accommodate the unobserved heterogeneity satisfactorily, and some important differences in the risk factors between urban and rural were clarified. Traffic Crash injury severity is often modelled using ordinal or nominal model as a traffic crash can have multiple injury severity results, whereas the effects size of possible inducing causes are not definitely monotonic. To escape biased estimations cause by within roadway correlation, the spatial heterogeneity varying across roadway segments is address by a two-level modeling scheme (Xu, Huang, and Guo, 2020). It should be noted that advanced versions of the ordered models such as the generalized ordered logit model and the partial proportional odds model can reduce the independence of irrelevant alternatives (IIA) assumption (Savolainen et al., 2011). The proportional odds assumption in the ordered probability models allows for a positive coefficient to unambiguously indicate that the variable associated with the positive coefficient increases the

Table 2-3: Important research Literature Review on traffic crash injury severity

Authors	Research highlights	Model type	independent	Dependend
Richard Tay, (2015):	Found that; the urban intersection crashes are more likely to be associated with hit and run behaviors, roads with higher traffic volume, wet surfaces, four lanes and skewed intersections, and crashes on weekdays and off-peak hours, roads with higher speed limits, exit and entrance terminals, gravel, curvature and two lanes, peak hours and night-time, run-off-road crashes	Random parameters probit model	Traffic characteristics, Roadway geometric characteristics	Crash rate
Chunjiao Dong, David B. Clarke, Stephen H. Richards, Baoshan Huang,(2014) :	The findings suggest that traffic volume, truck percentage, lighting condition, and intersection angle significantly affect intersection safety. Important differences in car, car–truck, and truck crash frequencies with respect to various risk factors were found to exist between models.	univariate Poisson-lognormal , multivariate Poisson, and multivariate Poisson-lognormal regression models	Traffic factors, and geometric design of roadway intersections.	Crash rate

Zoi Christoforou, Simon Cohen, Matthew G. Karlaftis, (2010):	explore the influence of speed and traffic volume on the injury level sustained by vehicle occupants involved in accidents	random parameters ordered probit model	Speed of vehicle and traffic volume	injury severity
Cong Chen, Guohui Zhang, Zhen Qian, Rafiqul A. Tarefder, Zong Tian, (2016):	investigated driver injury severity patterns in rollover crashes based on two-year crash data gathered in New Mexico	Support vector machine (SVM) models, regression tree (CART) model	crash characteristics, environmental characteristics, vehicle characteristics, and driver characteristics	injury severity
Ali Behnood, Fred L. Mannering, (2015).	explores the temporal stability of factors affecting driver-injury severities in single-vehicle crashes possible presence of temporal instability in injury-severity models can have significant consequences in highway-safety practice where accurate forecasting of the impacts of alternative safety countermeasures is sought	mixed logit model, Likelihood ratio tests	Driver characteristics, location and time of day, roadway characteristics, environmental conditions, and vehicle characteristics	injury severity
Tulu, Getu & Mokonnen, Alemu. (2018).	Examined the influence of roadway cross sectional elements on road	Poisson regression models, Negative	Road cross-sectional characteristics, Traffic	Crash frequency

	traffic crashes occurrence in Addis Ababa Investigated the relationship between road traffic crashes and road's contextual factors	Binomial regression models	characteristics, Land use,	
Song, Xiuguang & Pi, Rendong & Zhang, Yu & Wu, Jianqing & Dong, Yuhuan & Zhang, Han & Zhu, Xinyuan. (2021).	Identified the critical contributing factors and to predict the possibility of Multi-vehicle crash injury-severity. Machine learning-based models performed better than the statistical models did when taking the overall accuracy as an evaluation indicator The statistical models had a better prediction performance than the machine learning models had considering crash costs	Random parameters logit model (RPL), Random Forest (RF), Machine learning model likelihood ratio tests	Traffic crash characteristics, Traffic crash cost	Injury severity
Haleem, Kirolos & Abdel-Aty, Mohamed. (2010).	presents multiple approaches to the analysis of crash injury severity at three- and four-legged un-signalized intersections in the state of Florida from 2003 until 2006 Several important factors affecting crash severity at un-signalized intersections were identified	ordered probit model binary probit model	traffic volume characteristics, Roadway geometric factors characteristics, Driver characteristics,	Injury severity

	The analysis identified some counter measures to reduce injury severity at un-signalized intersections.	nested logit model		
Wu, Qiong & Chen, Feng & Zhang, Guohui & Liu, Xiaoyue Cathy & Wang, Hua & Bogus, Susan. (2014).	Clarified the relationship between crash severity and various risk factors, The study generally recognized that weather has a significant influence on crash severity. They conducted research clarified the various risk factors will affect the severity of rural single and multi-vehicle crashes, and the relationship between risk factors and crash severity	Mixed logit model Random parameters ordered logit model	Driver characteristics, Crash characteristics, and Environmental characteristics	Injury severity

Source: Developed by thesis author.

likelihood of the highest ordered outcome occurring (such as fatality) and decreases the likelihood of the lowest ordered outcome (such as no injury or property damage only). Such correlation causes a violation of the model's independence of irrelevant alternatives (IIA) property. This requirement is relaxed in a latent class model, where a discrete distribution, represented by a finite and specified number of mass points, is used to identify homogeneous subgroups of data (Cerwick, et al., 2014). A disadvantage of the latent class method is that it does not account for the possibility of variation within a class as it assumes homogeneous characteristics of the observations within-class (Eluru, et al., 2012). Random parameters logit, which assumes that the distribution of the parameters in the population is described by a multivariate normal distribution. Mixed logit (random parameters logit) models are used to provide a better understanding of the interaction between traffic crash factors found in the dataset and unobserved factors (unobserved heterogeneity). The authors used the multinomial logit model to analyze and identify drivers behaviors, vehicle and roadway condition characteristics affecting injury severity of victims at study area locations.

CHAPTER 3 MATERIALS AND METHODOLOGY

3.1 Introduction

To perform this investigation, traffic crash database on vehicle involved crashes of passengers cars, light vehicles, heavy vehicle and large heavy vehicle involved crashes, and pedestrian crashes is drawn from all reported crashes in East Shewa and West Arsi zones in Oromia regional state of Ethiopia during five years of July 2014 to June 2019. The databases are recorded by Shashemene City and Woreda, Arsi Nagele city and Woreda, Adami Tulu Jiddo Kombolcha Woreda and Batu City, Dugda Woreda, Bora Woreda and Lume Woreda Police office of the East Shewa and West Arsi zones. This yields traffic crash database in number of fatal crash 741, severe injury 456, slight injury 287 and property damage only 1405 and the total traffic crashes are 2889 observations. Eluru, et al., (2012), established a roadside environmental safety valuation model considering the two characteristics of the chance that a vehicle will move off roadway lane and the physical appearance of roadway side safety condition.

Savolainen et al., (2011) has attempted to analyse traffic crash injury severity by binomial model, supposing that a traffic crash can have dichotomous results, i.e., severe injury versus no injury. In spite of that the level of traffic crash injury severity of slight injuries, severe injuries and fatalities can be greatly different, it is common that the multiple traffic crashes outcomes are combined into two, such as injury versus non-injury or severe injury versus non-severe injury.

3.2 Description of the Study Area

This study explores the effects of drivers' behaviors, vehicle types and roadway condition characteristics factors affecting traffic crash injury severities. Using database from East shewa zone and west Arsi zone Police offices woredas which Modjo-Hawassa roadway cross through traffic crash database for a five-year period from July 2014 to June 2019 G.C are used. The road type is two way two lane which give service for different vehicles. Modjo is located in Ethiopia with (8°35'12.5"N 39°07'16.0"E) coordinates and Hawassa is located in Ethiopia with (7°03'43.6"N 38°28'35.0"E) coordinates. The road length between Modjo and Hawassa is 201 km.

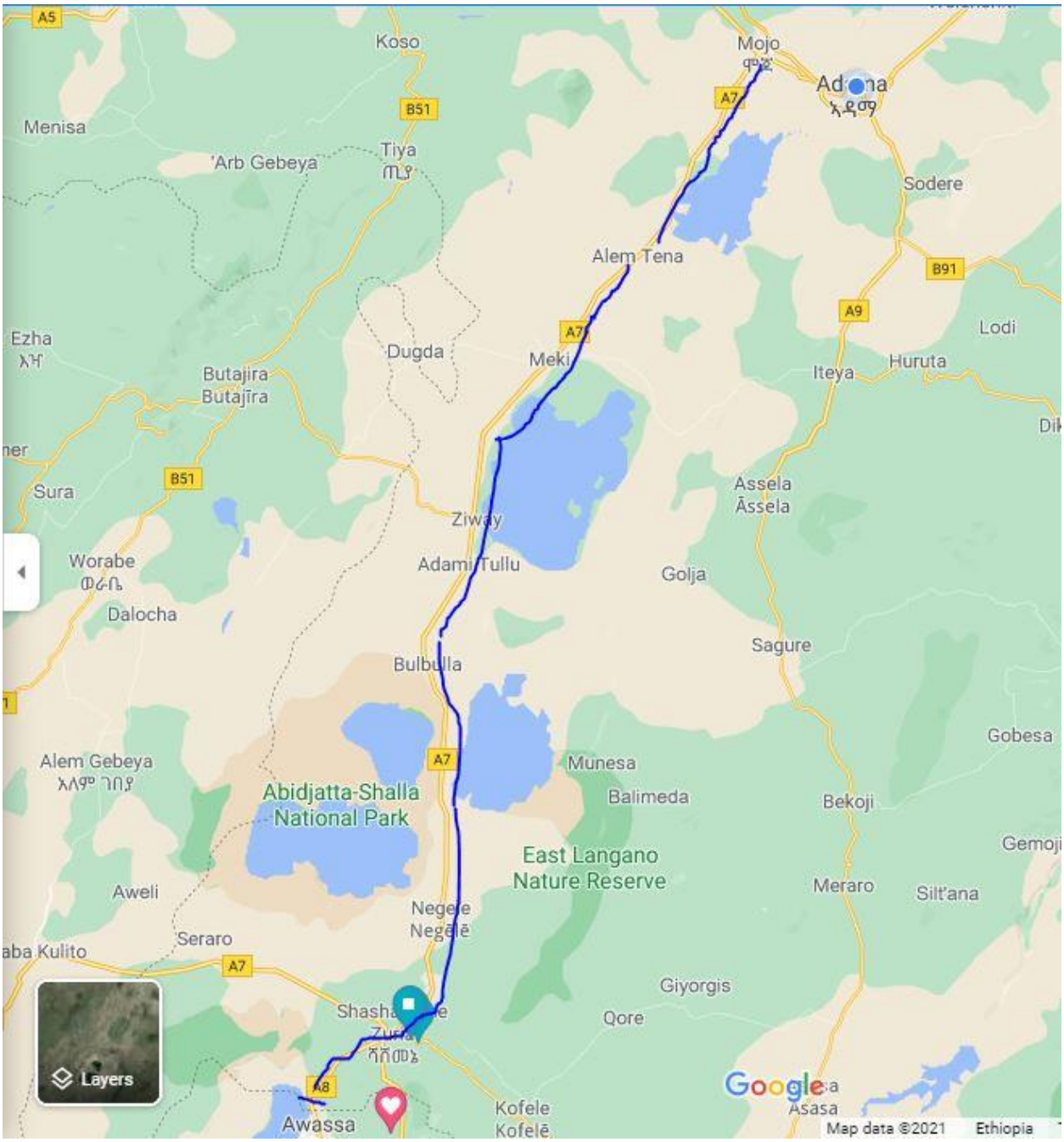


Figure 3-1: Map of the Study Area Modjo-Hawassa study segment.

Source: Google map

3.3 Sampling Method and Sample Size Determination

This study explores the effects of drivers' behaviors, vehicle types and roadway condition characteristics factors affecting traffic crash injury severities. Using database for vehicle involved traffic crashes from the study area a five-year period traffic crash database from July 2014 to July 2019 is collected from East Shewa zone and West Arsi zone Police office, and separate models of traffic crash injury severities (with possible outcomes of fatal injury, severe injury, slight injury, and property damage only) were estimated using a multinomial logit model to obtain potential factors effects of drivers' behaviors, vehicle types and roadway condition characteristics on the traffic crash injury severity. Likelihood ratio tests were accompanied to survey the general stability of model estimates across variable and effects of each exposure variable were also considered to investigate the drivers' behaviors, vehicle types and roadway condition characteristics effect of individual parameter estimates on traffic crash injury-severity probabilities at the area. A wide interval of variables characteristics such as drivers causal factors, time of day, roadway condition, crash specific factors, light conditions, and vehicle characteristics were considered potentially affects traffic crash injury severities. Small sample size could significantly influence model performance. Considering the suggestion made by (Lord, and Mannering, 2010) regarding the sample size requirements for the multinomial logit models, the number of observations for each calendar year traffic crashes in the current study are sufficient to arrive at reliable independent variable parameters estimates by the model.

3.4 Data Collection

The traffic crash database provide comprehensive facts on drivers characteristics (such as education level, driving experience, drivers obeying roadway rule, drivers age, gender), roadway condition, environmental conditions (such as light and road surface conditions), crash attributes (such as manner of crash, cause of crash, events contributing to crash), vehicle characteristics (such as vehicle types, vehicle service year, vehicle defects) and the time of the day. Traffic crash data though suffer from underreporting traffic crash effects, especially for slight injury and property damage only. As a result, traffic crash data sampling can be considered as outcome based sampling method of stratified sampling with unknown population shares of the injury severities.

3.4.1 Roadway Traffic Crash Data Collection

To establish the relationship between drivers' behaviors, vehicle types and roadway condition characteristics factors affecting traffic crash injury severity data were collected. The traffic crash database of the drivers' characteristics, vehicle types and roadway condition characteristics factors affecting injury severities were collected from East Shewa Zone police office and West Arsi Zone city of a five-year period database from July 2014 to July 2019 is collected and separate annual models of traffic crash injury severities (with possible results of fatal injury, severe injury, slight injury, and property damage only).

Table 3-1: The traffic crash database collected from East Shewa and West Arsi Zone police office

		Injury severity type/Level Frequency					Injury severity type/Level Frequency Percentage
No	Year of Traffic Crash	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Total Percentage
1	2007 E.C (2014/2015)	131	98	59	299	587	20.32
2	2008 E.C (2015/2016)	137	100	61	294	592	20.49
3	2009 E.C(2016/2017)	138	91	59	270	558	19.31
4	2010 E.C (2017/2018)	163	84	53	285	585	20.25
5	2011 E.C (2018/2019)	172	83	55	257	567	19.63
	Total	741	456	287	1405	2889	100.00

Detailed database records of fatal injury, severe injury, slight injury, and property damage only have been collected from the East Shewa Zone police office and West Arsi Zone police office of woredas which Modjo-Hawassa roadway pass through. After removing records with missing variables, a total of 2889 traffic crashes were included in the study of which, 741 were fatal injury, 456 were severe injuries, 287 slight injuries and 1,405 were property damage only in five years from July 2014 to June 2019. The explanatory variables included in the multinomial logit model were driver characteristics, roadway characteristics, vehicle type and light conditions variables. Considering the suggestion made by (Ye and Lord, 2011) regarding the sample size requirement

for the multinomial logit models, the number of observations for each calendar-year traffic crash in the current study area are sufficient to arrive at reliable independent variable parameter estimates. The traffic crash injury severity observed variables are categories of four injury severity levels. They are; fatal injury, severe injury, slight injury, property damage only. Fatal injury comprises traffic crashes which results in fatal of occupant within 30 days of traffic crash. Severe injury (Incapacitating) traffic crash injury prevents the injured individual from walking, driving or doing jobs they were skilled of doing before they injured. Obvious slight injury includes vehicle crashes where injury is evident to witnesses at the vehicle crash place. Slight injury is one where occupant complained of pain, but it diminishes rapidly from the time of evaluation at the crash location to the time of examination at the hospital. Finally, property damage only is where the reported vehicle crash does not resulted in any people injury. This method is usually used by researchers to confirm sufficient sample size for model estimation (Chen and Chen, 2011; Milton, Shankar, and Mannering, 2008).

3.4.2 Traffic Volume Data

Traffic volume database were used for the analysis of vehicle type proportion effects on traffic crash injury severity of the study roadway. The database has been obtained from Ethiopian Roads Authority Shashemene District Road Network Management Office and the traffic volume and vehicle type count was conducted based on ERA-2013 (Authority, 2013) manual on the roadway of study area. The drivers' behaviors, vehicle characteristics and roadway condition characteristics were identified and traffic database correlated with the Ethiopian Roads Authority Shashemene Road Network Management Directorate at the study sites along the 201 km section during the period of July 2014 to June 2019.

The counted traffic data were conducted at Shashemene and Bulbula, Batu and Modjo for seven consecutive days (five days 12 hours and 2 days 24 hours) and for three periods in a year such as February, July and November depending on Ethiopian Roads Authority Manual. Depending on the traffic volume and vehicle type collected the traffic volume data of Annual Average Daily Traffic (AADT) were calculated for each year and counting stations.

Steps of calculation of AADT;

- ✓ Seven consecutive days with five days of 12hr and 2days 24hr data (one week day and one at weekend) were collected. The 24hrs data are used for establishing night factor.
- ✓ By founding the average of two days night factor adjustments were made for 24hrs of days with 12hr collected.
- ✓ The average of the seven days count is considered as Average Daily Traffic (ADT) of the subject quarter.
- ✓ The quarterly ADT is then converted to annual average daily traffic (AADT) using seasonal adjustment factor.

3.4.3 Road geometric Data

The roadway geometric design factors, which include number of horizontal curvature, radius of horizontal Curve, roadway Carriage width, shoulder width, and grade of the road were collected and considered in the data analysis..

3.5 Methods of traffic crash data Analysis

3.5.1 Descriptive Statistics

Based on the collected data, characterization and description of the traffic crashes with different aspects was made. These characterizations help to know the factors which have significant contribution for traffic crash injury severity and based on this statistical analysis like correlation between traffic crashes injury severity and identified contributing factors. This helps to know which drivers' behaviors, vehicle type and roadway condition characteristics parameters are the most significant contributing factors and results to solve the problems causing traffic crash on the study location. The sub-populations considered in this research include; male and female drivers older than 18 years old; male and females drivers older than 30 years old; male and female drivers older than 41 years old and male and female drivers older than 51 years old. In addition to this on black spot sections of field observation and interpretations was made to point out the contribution of physical objects like trees, detours, deteriorated pavements, geometric features and other obstacles for traffic crashes. The general flow or steps of the analysis include; drivers' behaviors, traffic crash database, traffic volume, vehicle type data and roadway condition data. Descriptions

and interpretations of the analyzed data were carried out. Based on the database analyzing and investigation of the major causes of traffic crash on the roadway segments were made and correlation analysis was carried out to evaluate the significance of contributing factors for traffic crash injury severity. Finally from factors contributing to traffic crash injury severity level the possible remedial measures were pointed out. Modeling of traffic crash injury severity is very important in roadway traffic crash injury severity analysis, and in the past, researchers have proposed an analytical method for analyzing traffic crash data. The researcher used the analyzing method using STATA 15.0, Excel and other software important to estimate traffic crash injury severity level classifications by multinomial logistic regression model. There have been many researches which studied the association between traffic crash causing factors and traffic crash injury severity results using discrete choice models, such as multinomial logit models, mixed logit models, and ordered logit/probit models (Savolainen et al., 2011). Multinomial logit (MNL) model is particularly subjected to correlation of unobserved effects from one traffic crash injury severity level to the next traffic crash injury severity level. Independent variables whose coefficients were insignificant were analytically deleted from the model through stepwise methods. Statistically significance of the model was evaluated at a p-value less than 5%. After systematically removing all insignificant independent variables of p-value greater than 5%, interpretation for each significant independent variable was made.

3.5.2 Multinomial Logistic Regression Analysis

It should be noted that previous studies have shown that the normal distribution generally provides the best fit for the injury-severity data (Milton et al., 2008; Shaheed et al., 2013). The analysis of this research focuses on estimating the effects of independent variable using the traffic crashes that occurred during each individual year to examine the drivers, vehicle types and roadway characteristics on traffic crash injury severity of the victims' models. One of the studies (Chen and Chen, 2011) recommended starting with all possible variables, then reducing one at a time; however, this is not achievable in some cases, especially for a relatively large number of observations. This approach, having demonstrated its capability through successful use here in, can be recommended fitting a multinomial logit model to facilitate the modeling procedure. In this research, it is proposed that the traffic crashes dependent variable injury severity database can be

divided into four different categories. Using an indication of how important these variable categories are; fatal injury, severe injury, slight injury and property damage only. The method often used to check the appropriateness of distinct models over one collective model is to use likelihood ratio tests (Pahukula et al., 2015). In this study, once the three models were developed, a series of likelihood ratio tests were performed following the procedures articulated in Washington et al. (2003). Specifically, the tests were:(i) the full model for all drivers behaviors traffic crashes for the three separate models (driver age, driver education level, driver driving experience, vehicles service years, vehicle type), (ii) The three separate models developed for vehicle characteristics (Vehicle defects, Vehicle service year, vehicle type), (iii) the full model for all other traffic crashes and the three separate models developed for three variable factors(drivers give priority for pedestrians, drivers obey traffic rule, roadway condition, roadway light condition). In a multinomial logistic model, a severity propensity function determining the injury severity level j for an individual vehicles drivers i is defined as;

$$\mathbf{U_{ij} = \beta_j X_{ij} + \varepsilon_{ij}} \text{----------} 3.1$$

Where $\mathbf{U_{ij}}$ is the injury severity risk propensity function for an individual i of an injury severity level of j; X_{ij} is a vector of explanatory variables, (driver characteristics, vehicle characteristics and roadway factors that impact the injury severity for observation i; ε_{ij} is the error term (assumed to follow a standard logistic distribution), if the disturbances are extreme-value distributed, the multinomial logit model results such that; and β is a vector of estimable parameters for injury-severity outcome i. and $\boldsymbol{\varepsilon_{ij}}$ is the error term that is assumed to accounts for casual noise for unobserved factors influencing traffic crash injury severity level and is assumed to be identically and independently distributed. Then the probability of traffic crash victims i having an injury severity level of j in multinomial logit model has the following model

$$P_{n(i)} = \frac{\exp[\beta i X i j]}{\sum \forall j \exp(\beta i X i j)} \text{----------} 3.2$$

Where $P_{n(i)}$ is the probability of nth victims i having an injury severity level of j. The variations in the outcome categories across different crashes are introduced in multinomial logit model. The probability function for each outcome categories level becomes as follows.

$$P_{n(i)}=\frac{\exp[\beta iXij]}{1+\sum \exp(\beta iXij)} \text{ ----------} 3.3$$

Where the β_i in the injury risk propensity function is then distributed across individuals following certain distributions.

3.5.3 Dependent Variables and Independent Variable Category Label and Value Label

Multinomial logit (MNL) model allows each traffic crash injury severity level results has to have different function in the multinomial logit model making the model structure more flexible. In this research, traffic crashes dependent variable injury severity divided into four categories. These categories are; fatal injury, severe injury, slight injury and property damage only.

Table 3-1: Dependent variables name and category label with value labels

s.no	Dependent variable name and category label	Value labels
1	Fatal	1
2	Severe injury	2
3	Slight injury	3
4	Property damage only	4

The selected independent variables which used in the model are; vehicles types, vehicle ages in year, vehicle defects, drivers not obeying roadway rule and regulations, drivers driving experience, drivers age, drivers' education level, roadway condition and roadway light condition. Goodness-of-fit statistics for the model, including log-likelihood at convergence, log-likelihood at zero, Pseudo R2, are also shown in the same results. The effects also depict the effect of change in a certain independent variable on the probability of an injury severity level. For continuous effect represents the percentage the variable is associated with severe injury occurrence. For this research

Table 3-2: Independent variable name, category label and value label

Independent variable name	Variable category label	Value label
Vehicle defects	Braking failure	1
	Wheel and steering problems	0
Vehicle types	Cars and pickups	1
	Small and Large Buses	2
	Small and Medium Trucks	3
	Heavy Trucks and Trailers	4
	Unknown vehicle type	5
Drivers age	less than 18 years	1
	Between 18-30 years	2
	Between 31-40 years	3
	Between 41-50 years	4
	Above 51 year	5
	drivers age Unknown	6
Drivers not obey traffic rule and regulation	Failure to obey gibe priority sign rule	1
	Failure to give priority for pedestrians	2
	Failure to keep their distance	3
	Not obey roadway rule and regulation	4
	less than 5 years	1
	Between 6-10 years	2

Drivers driving experience in years	Between 11-15 years	3
	Between 16-20 Years	4
	above 20 years	5
	Drivers driving experience unknown	6
Drivers education level	Illiterate	1
	Elementary School	2
	High school	3
	Diploma and Above	4
	Drivers education level unknown	5
Vehicles ages in years	<5 years	1
	Between 5-10 years	2
	Above 10 year	3
	Vehicle service years unknown	4
Roadway condition	Deformed asphalt pavement	1
	Crack and pothole failure road	2
	Good paved roadway	3
Light Condition	Night dark	0
	Day light	1

the vehicle types are categorized in to cars, pickups (5L, dolphin Toyota), small Bus, large Bus, small trucks include (Isuzu, FSR), medium trucks (Sino truck), heavy tracks and truck and trailer. The analysis of this multinomial Logistics Regression model uses three performance measures:

P value: This is a significance test. It is normally tested at a threshold value of 5% or 1%. If the p-value is less than the threshold value, we reject the null hypothesis and accept the test hypothesis to be valid. For these model, the threshold value tested at 5% significance level. Therefore, if the p-value of independent variable is less than 0.05, we can conclude that it is statistically significant.

β-value: The beta coefficients shows the effect of the independent variables on the dependent variable. A positive coefficient for β shows a positive impact on the dependent variable, while a negative coefficient shows a negative impact on the dependent variable. For our analysis, a positive β value shows that the category is more likely to impact category of dependent variable with respect to the reference category. If β-value > 0, it is more likely to influence the dependent variable. If β-value < 0, it is less likely to impact the dependent variable. If β =0, the particular category and the reference category are equally likely to impact the dependent variable.

Exponential Beta value: This value gives us the odds ratio for the independent variables. It is an exponentiation of the regression coefficients (β). The odds ratio shows the change in odds of the dependent variable being in a particular category compared to the reference category, corresponding to one unit change of independent variable. An odds ratio > 1 indicates that the risk of the outcome falling in the comparison group relative to the risk of the outcome falling in the reference group increases as the variable increases. So it is more likely to fall in the comparison group. An odds ratio < 1 indicates that the risk of the outcome falling in the comparison group relative to the risk of the outcome falling in the reference group decreases as the variable increases. In general, if the odds ratio < 1, the outcome is more likely to be in the reference group.

$\chi 2$=-2 [LL (βm2m1)-LL (βm1)] ----------3.4

where LL(βm2m1) is the log-likelihood at convergence of a model containing converged parameters from m2 while using data subset m1, and LL(βm1) is the log-likelihood at convergence of the model using subset m1's data (parameters are no longer restricted to subset data m2's converged parameters as is the case for LL(βm2m1). This test was also reversed such that subset m1 above becomes subset m2 and subset m2 above becomes subset m1 (thus giving two test results for each model comparison).

CHAPTER 4 RESULTS ANALYSIS AND DISCUSSIONS

4.1 The Modjo-Hawassa Road Traffic Crash Injury Severity Characteristics

The traffic crash database of the roadway segment of the study area covers all traffic crashes collected from concerned six woreda and respective cities traffic police record data. As it is written in Table 4-1: below during these periods, a total of 2,889 crashes were reported out of which 741(25.65%) were fatal injuries, 456 (15.78%) were severe injuries, 287(9.93%) were slight injuries and 1405 (48.63%) were property damages only on the study road section. Fatal injury comprises traffic crashes which results in fatal of occupant, pedestrians, drivers and others within 30 days of traffic crash. Severe injury (Incapacitating) when traffic crash injury prevents the injured individual from walking, driving or doing jobs they were capable of doing before they injured. Slight injury includes when vehicle crash is evident to eyewitnesses at the vehicle crash place. Finally, property damage only is where the reported vehicle crash does not resulted in any people injury.

To have better understanding, it is important to see the traffic crash distribution in relation to traffic crash injury severity with time (temporal) condition (hours of the day, year of traffic crashes, days of the weeks, months of the years), drivers characteristics (drivers' gender, drivers' age, drivers' education level, drivers driving experience), road characteristics, crash type, vehicle type and other relationships used to show the characteristics of traffic crashes as follows.

4.2 Traffic Crash Injury Severity with Time (temporal) Condition

In this study, the traffic crash injury severity by time were expressed in happening hour, day of the week, months of the year and by the year. Since traffic crash injury severity have a characteristics of random happening it will be occur at any time and wherever due to different causing factors.

4.2.1 Traffic Crash Injury Severity with Hours of the Day

Generally, from the collected data and indicated in Table 4-1, most of the fatal traffic crashes are 181(24.42%) and 175(23.62%) occur between evening (16:00-19:00) and morning (07:00-10:00) o'clock respectively, and the list fatal traffic crashes are 52(7.01%) at midnight (23:00-02:00). At these time, drivers are strained and tired. During these hours as an outcome of pick hour for any

Table 4-1: Road traffic crashes injury severity by hours of the day

		Injury severity Frequency					Injury severity Frequency Percentage				
No	Traffic crash by Hours of Day	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	07:00-08:00	32	29	19	58	138	4.32	6.36	6.62	4.13	4.78
2	08:00-09:00	45	29	25	70	169	6.07	6.36	8.71	4.98	5.85
3	09:00-10:00	48	20	14	91	173	6.48	4.39	4.88	6.48	5.99
4	10:00-11:00	50	23	8	70	151	6.75	5.04	2.79	4.98	5.23
5	11:00-12:00	25	26	11	64	126	3.37	5.7	3.83	4.56	4.36
6	12:00-13:00	39	23	17	55	134	5.26	5.04	5.92	3.91	4.64
7	13:00-14:00	48	40	22	58	168	6.48	8.77	7.67	4.13	5.82
8	14:00-15:00	32	11	8	52	103	4.32	2.41	2.79	3.7	3.57
9	15:00-16:00	29	34	22	101	186	3.91	7.46	7.67	7.19	6.44
10	16:00-17:00	54	37	17	88	196	7.29	8.11	5.92	6.26	6.78
11	17:00-18:00	57	40	25	131	253	7.69	8.77	8.71	9.32	8.76
12	18:00-19:00	41	34	22	94	191	5.53	7.46	7.67	6.69	6.61
13	19:00-20:00	32	23	14	58	127	4.32	5.04	4.88	4.13	4.4
14	20:00-21:00	25	17	14	40	96	3.37	3.73	4.88	2.85	3.32
15	21:00-22:00	45	23	14	49	131	6.07	5.04	4.88	3.49	4.53
16	22:00-23:00	34	3	3	61	101	4.59	0.66	1.05	4.34	3.5
17	23:00-24:00	11	6	3	34	54	1.48	1.32	1.05	2.42	1.87
18	24:00-01:00	18	6	3	34	61	2.43	1.32	1.05	2.42	2.11
19	01:00-02:00	18	3	3	40	64	2.43	0.66	1.05	2.85	2.22
20	02:00-03:00	5	3	3	27	38	0.67	0.66	1.05	1.92	1.32
21	03:00-04:00	16	6	3	21	46	2.16	1.32	1.05	1.49	1.59
22	04:00-05:00	16	3	3	24	46	2.16	0.66	1.05	1.71	1.59
23	05:00-06:00	11	3	3	27	44	1.48	0.66	1.05	1.92	1.52
24	06:00-07:00	10	14	11	58	93	1.35	3.07	3.83	4.13	3.22

Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

Source: Shashemene City and Woreda, Arsi Nagele City and Woreda, Adami Tulu Jiddo Kombolcha Woreda and Batu City, Dugda Woreda, Bora Woreda and Lume Woreda Police Office. It is prepared by thesis author.

movement of traffic road users and it is sleepy time. Generally, from the compiled data and indicated in Table 4-1: above most fatal traffic crashes

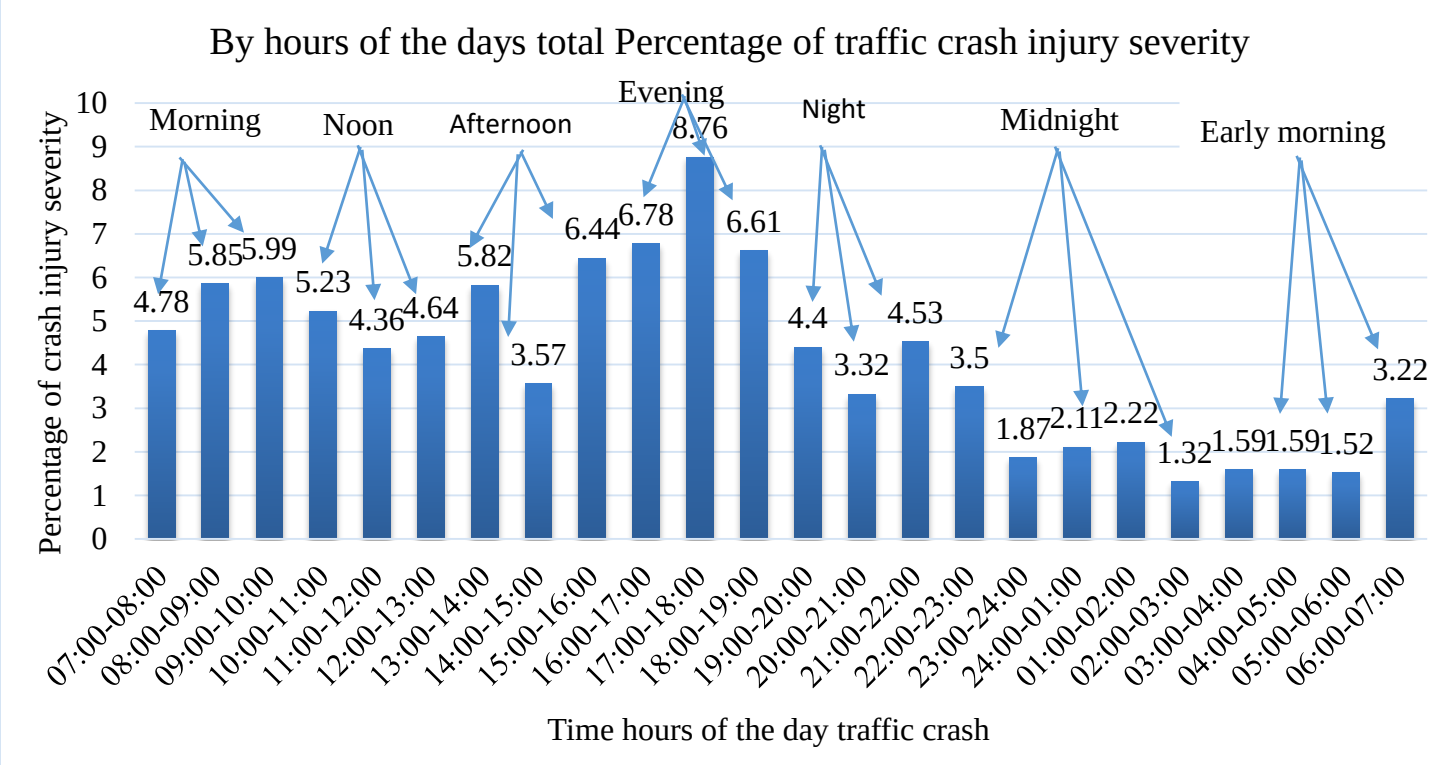


Figure 4-1: Road traffic crashes injury severity distribution by hours of the days

During these hours as an outcome of pick hour for any movement of traffic road users and it is sleepy time. Road traffic crashes injury severity distribution by hours of the days for five years (2007-2011 E.C) are shown by percent and frequency on Figure 4-1: and Table 4-1: above. The most fatal crashes are 181(24.42%) and 175(23.62%) occur during evening (15:00-18:00) and morning (07:00-10:00) o'clock respectively. During the Night hours and the list fatal traffic crashes are 52(7.01%) at midnight (23:00-02:00). Hence, association analysis is made to identify the contribution of drivers' characteristic factors and Figure 4-1: gives the total Percentage of

traffic crash injury severity by hours of the days for traffic crash injury severities and to make comparative evaluation between different independent variables and finding the remedial actions.

4.2.2 Traffic Crash Injury Severity with Year of traffic crashes

From Table 4-2: below, five years traffic crash database is developed and the maximum number of fatal injury traffic crashes are 172 (23.21%) in 2011 E.C (2018/2019). As shown in five years traffic crash occurred, the maximum number of total traffic crash happened was 592 (20.49%) in 2008 E.C (2015/2016) and the list is 558(19.31%) in 2009 E.C (2016/2017). The other years total traffic crashes are 587(20.32%) in 2007 E.C (2014/2015), 585(20.25 %) in 2010 E.C (2017/2018) and 567(19.63%) in 2011 E.C (2018/2019).

Table 4-2: Road traffic crashes injury severity levels distribution by the Years

		Injury severity type/Level Frequency					Injury severity type/Level Frequency Percentage				
No	Year of Traffic Crash	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	2007 E.C (2014/2015)	131	98	59	299	587	17.68	21.49	20.56	21.28	20.32
2	2008 E.C (2015/2016)	137	100	61	294	592	18.49	21.93	21.25	20.93	20.49
3	2009 E.C(2016/2017)	138	91	59	270	558	18.62	19.96	20.56	19.22	19.31
4	2010 E.C (2017/2018)	163	84	53	285	585	22.00	18.42	18.47	20.28	20.25
5	2011 E.C (2018/2019)	172	83	55	257	567	23.21	18.20	19.16	18.29	19.63
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

Source: Shashemene City and Woreda, Arsi Nagele City and Woreda, Adami Tulu Jiddo Kombolcha Woreda and Batu City, Dugda Woreda, Bora Woreda and Lume Woreda Police Office. It is developed by author.

The result shows that, the study roadway traffic crash injuries are increasing from year to year. It is important to identify that, the drivers who use the study area roadway are not give priority for pedestrian, not drive keeping their distances, drivers' drives without attention, overpassing at curve

roadway, after overpassing suddenly wright turning, driving in excess of speed limit, improper maneuver and disobeying road law and regulation are the most drivers factors that increasing; fatal injuries, severe injuries, slight injuries and property damage only from year to year. Table 4-2: above, it is clearly shown that during the specified five years period from July 2014 to June 2019, a total of 2,889 traffic crashes were recorded on Modjo-Hawassa roadway of which 741(25.65%) are reported as fatality injury (FI), 456(15.78%) severe injuries (SI), 287(9.93%) slight injuries (SI) and the other 1,405(48.63%) are reported as property damage only (PDO) traffic crashes.

4.2.3 Traffic Crash Injury Severity with days of the weeks

Figure 4-2: below indicates the Modjo-Hawassa road traffic crashes injury severity in day's condition based on the Road traffic crash injury severity happened in days for five years (2007-2011 E.C). Based on the day of the week, maximum fatality traffic crashes occur on Monday. The fatality injury crash is 183(24.70%) it is shown in Figure 4-3: below. As shown Figure 4.3: below, 183 (24.70%) on Monday, 144 (19.43%) on Saturday, 137 (18.49%) on Wednesday, 110 (14.84%) on Thursday, 64 (8.64%) on Sunday, 57 (7.69%) on Friday

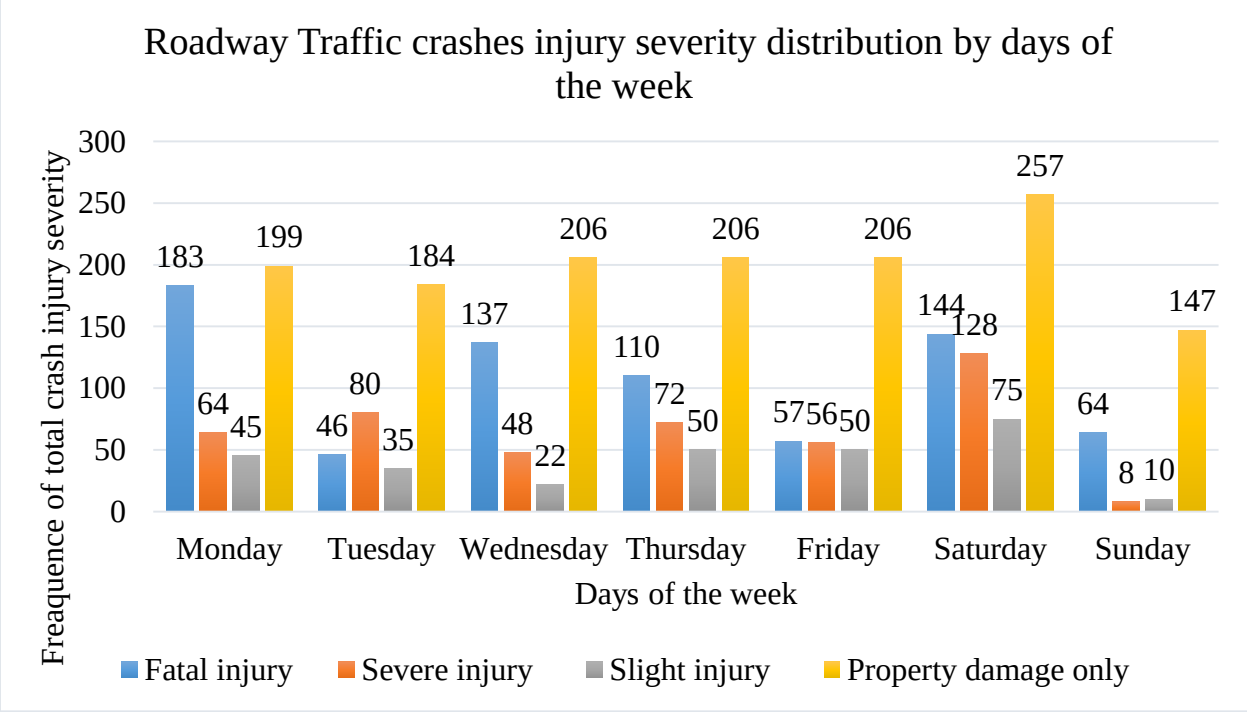


Figure 4-2: Total road traffic crashes injury severity distribution by days of the week

Source: West Arsi and East Shewa zones and woreda police offices. It is developed by author.

Table 4-3: Modjo-Hawassa Road traffic crashes injury severity in day of the week

		Injury severity type/Level Frequency					Injury severity type/Level Frequency Percentage				
No	Day	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	Monday	183	64	45	199	491	24.70	14.04	15.68	14.16	17.00
2	Tuesday	46	80	35	184	345	6.21	17.54	12.20	13.10	17.00
3	Wednesday	137	48	22	206	413	18.49	10.53	7.67	14.66	11.94
4	Thursday	110	72	50	206	438	14.84	15.79	17.42	14.66	14.30
5	Friday	57	56	50	206	369	7.69	12.28	17.42	14.66	15.16
6	Saturday	144	128	75	257	604	19.43	28.07	26.13	18.29	12.77
7	Sunday	64	8	10	147	229	8.64	1.75	3.48	10.46	20.91
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

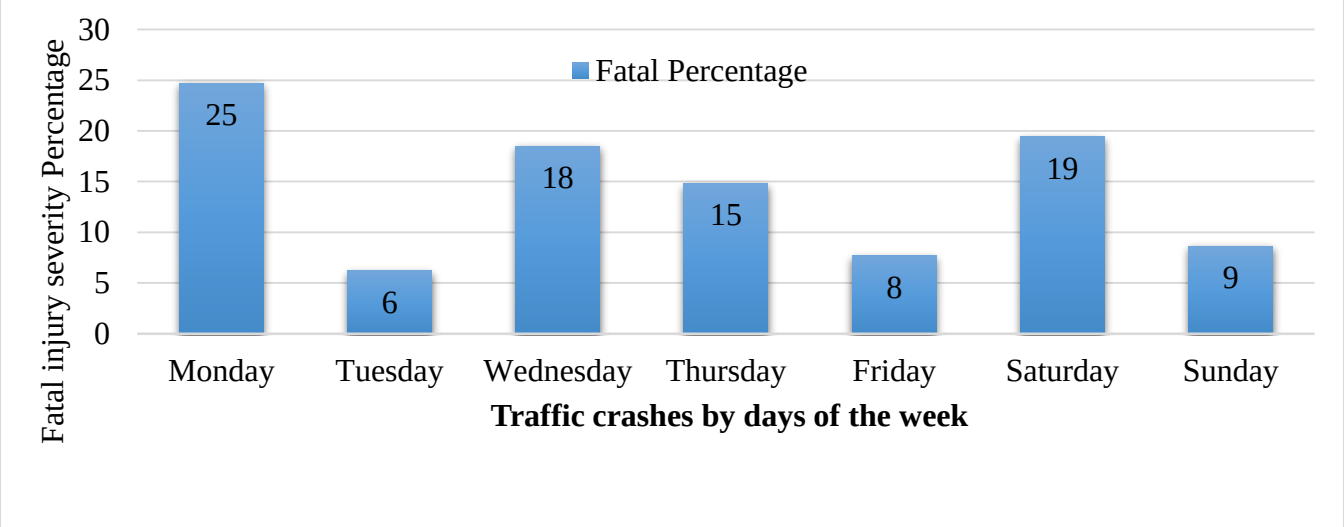


Figure 4-3: Fatal injury severity Percentage of traffic crashes by days of the week for five years (2007-2011) E.C.

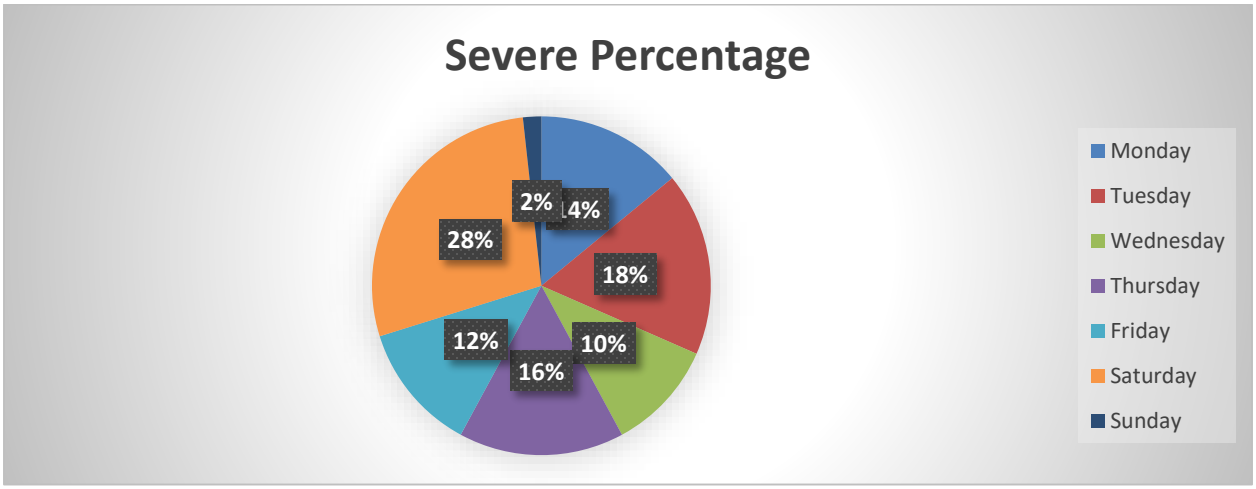


Figure 4-4: Severe injury severity percentage distribution of traffic crashes by days of the week
Source: West Arsi and East Shewa zones and woreda police offices. It is developed by author.
and 46 (6.21 %) on Tuesday are fatal crash injury severity happened on Modjo-Hawassa Road. The highest fatal injury severity is on Monday and Saturday which is due to the start of jobs and market days respectively.

4.2.4 Traffic Crash Injury Severity with Months of the Years

Database shown on Table 4-4: and Figure 4.2 below indicates that Road traffic crashes injury severity in Months of the year happened in months of five years (2007-2011 E.C) are the categories of fatal injuries, severe injuries, slight injuries and property damage only as four response groups. The most fatal injury severity is in June 90 (12.15%) and the total traffic crash injury severities are in June 315(10.9%) and the second most fatal injury severities are in November 87 (11.74%) and the total traffic crash injury severity in November is 261(9.03%). The other traffic crash injury severity are in January 49(6.61%) fatal injuries and 153 (5.3%) is the total traffic crashes. March fatal injuries are 77 (10.39%) and total March traffic crashes injuries are 322 (11.15%), in April fatal injuries are 66 (8.91%) and the total April traffic crashes are 258(8.93%), in May the fatal injuries are 56 (7.56%) and the total May traffic crashes are 291 (10.07%). The list record of fatal injury severity month is February with 35 (4.72%) fatal injuries and 196(6.78%) is the total February traffic crashes in February in five years (2007-2011 E.C). The list record of fatal injury

severity month is February with 35 (4.72%) fatal injuries and 196(6.78%) is the total February traffic crashes in February in five years (2007-2011 E.C).

Table 4-4: Road traffic crashes injury severity in months of the Year

		Injury severity type/Level Frequency					Injury severity type/Level Frequency Percentage				
No	Months of the year	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	January	49	11	14	79	153	6.61	2.41	4.88	5.62	5.3
2	February	35	34	17	110	196	4.72	7.46	5.92	7.83	6.78
3	March	77	61	44	140	322	10.39	13.38	15.33	9.96	11.15
4	April	66	34	14	144	258	8.91	7.46	4.88	10.25	8.93
5	May	56	46	34	155	291	7.56	10.09	11.85	11.03	10.07
6	June	90	57	31	136	315	12.15	12.5	10.8	9.68	10.9
7	July	52	46	27	125	250	7.02	10.09	9.41	8.9	8.65
8	August	73	31	21	106	230	9.85	6.8	7.32	7.54	7.96
9	September	45	31	17	113	206	6.07	6.8	5.92	8.04	7.13
10	October	77	46	24	102	248	10.39	10.09	8.36	7.26	8.58
11	November	87	42	34	98	261	11.74	9.21	11.85	6.98	9.03
12	December	35	15	10	98	159	4.72	3.29	3.48	6.98	5.5
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

Source: West Arsi and East Shewa zones and woreda police office. Shashemene City and Woreda, Arsi Nagele City and Woreda, Adami Tulu Jiddo Kombolcha Woreda and Batu City, Dugda Woreda, Bora Woreda and Lume Woreda Police Office. It is developed by author.

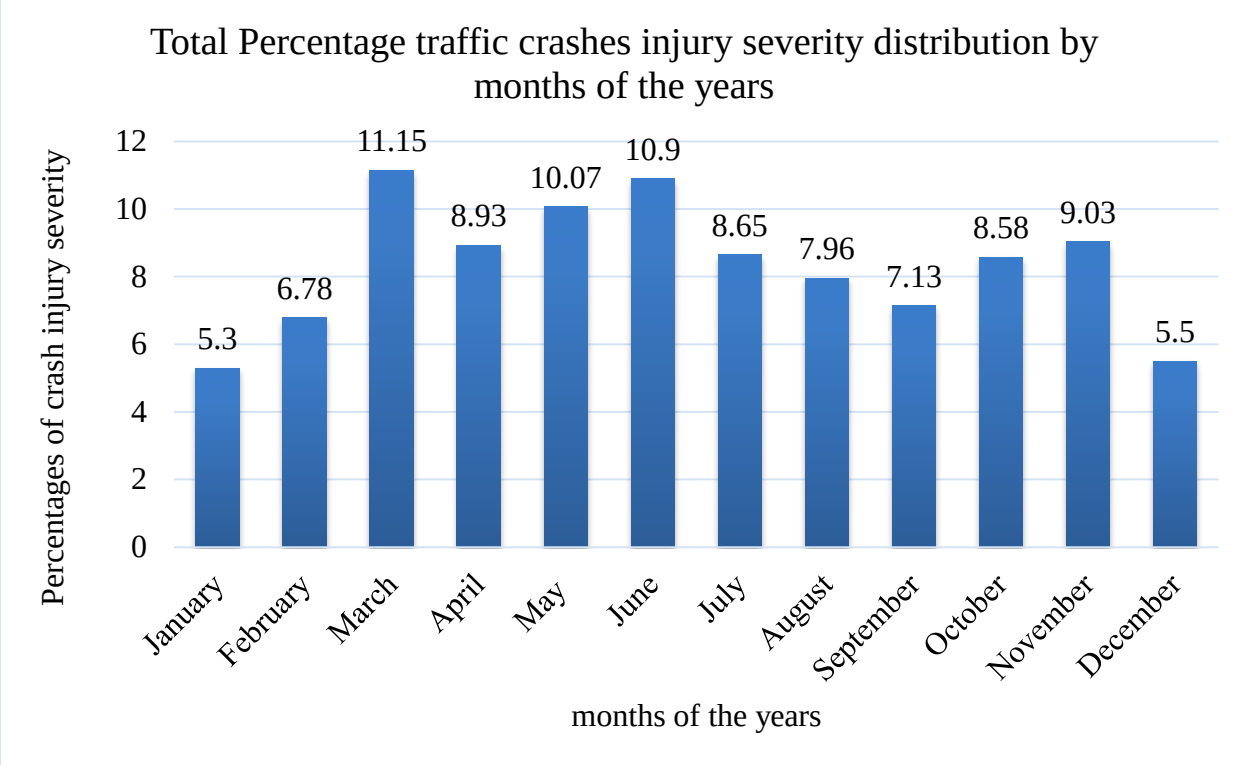


Figure 4-5: Total Percentage traffic crashes injury severity distribution by months of the years

Source: Shashemene City and Woreda, Arsi Nagele City and Woreda, Adami Tulu Jiddo Kombolcha Woreda and Batu City, Dugda Woreda, Bora Woreda and Lume Woreda Police Office. It is developed by author.

4.3 Traffic Crash injury severity with Drivers characteristics

4.3.1 Traffic Crash Injury Severity with Drivers' Gender

Database shown on Figure 4-6: below indicates that road traffic crashes injury severity by drivers' gender happened in five years (2007-2011 E.C) are the categories of fatal injuries, severe injuries, slight injuries and property damage only as by drivers' gender effects contribution on four response groups. The most effect contribution by drivers' gender on fatal injury severity is by male drivers are 502(67.75%) and the total traffic crash injury severity is also by male drivers 2080(72.00%) and the second most fatal injury severity is by gender unknown drivers 228(31.00%). Drivers who's their genders unknowns are the drivers who crash hit and run or go to escape the traffic police and prosecution. This is due to drivers in study roads most of the time hit and escape post-

crash rather than reporting to the Woreda police office. The second shows that, male drivers considers themselves as they have enough experience then female drivers and they drives in excess of speed limit, improper maneuver, crossing traffic police rule and regulation shows their effect contribution of 67.75%) in fatal traffic crash injury severity.

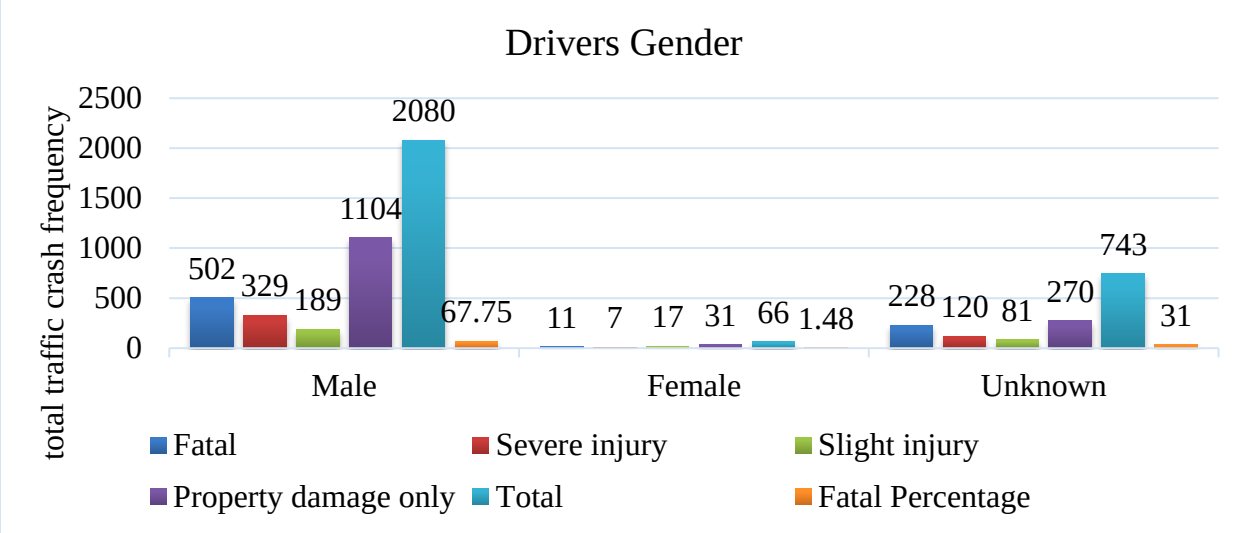


Figure 4-6: Total traffic crashes injury severity distribution by drivers' gender

Source: Shashemene City and Woreda, Arsi Nagele City and Woreda, Adami Tulu Jiddo Kombolcha Woreda and Batu City, Dugda Woreda, Bora Woreda and Lume Woreda Police Office. It is developed by author.

4.3.2 Traffic Crash Injury Severity with Drivers' Age

Database shown on Figure 4.4 and supported by Figure 4.5 below indicates that Road traffic crashes injury severity by drivers' age happened in five years (2007-2011 E.C) are the categories of fatal injuries, severe injuries, slight injuries and property damage only as by drivers' age effects contribution on four response groups. The most effect contribution by drivers' age on fatal injury severity is by drivers' age between 18-30 years 290(39.14%) and the total traffic crash injury severity is also by drivers age between 18-30 years 1429 (49.46%) and the second most fatal injury severity is by drivers their ages are unknown 228(30.77%) and the total traffic crash injury severity is by drivers their ages are between 31-50 years 937(9.03%). The other traffic crash injury severities are by drivers' ages between 31-50 years 191(25.78%) fatal injuries and 345 (11.94%)

is the total traffic crashes by drivers their ages are unknown. Drivers their ages are unknowns are the drivers who crash and go to escape the traffic police and prosecution. This is due to that drivers in study roads most of the time hit and escape post-crash rather than reporting to the Woreda police office. The second show that, drivers during their ages are between 18-30 years and 31-50 years olds considers themselves as they have enough experience and they drives in excess of speed limit, improper maneuver, crossing traffic police rule and regulation shows their effect contribution of 64.92% in fatal traffic crash injury severity. Since driving is a skill which requires repeated training driving experience is the most powerful thing to prevent roadway traffic crash. But, even if driving experience is a good to prevent the traffic crash, the driving environment road is in rural section time hit and escape post-crash rather than reporting to the Woreda police office. The second show that, drivers during their ages are between 18-30 years and 31-50 years olds considers themselves as they have enough experience and they drives in excess of speed limit, improper

Table 4-5: Road traffic crashes injury severity by drivers' age

No	Drivers Age	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	less than 18 year	14	7	9	16	49	1.89	1.54	3.14	1.14	1.70
2	Between 18-30 year	290	210	115	596	1429	39.14	46.05	40.07	42.42	49.46
3	Between 31-50 year	191	101	75	474	937	25.78	22.15	26.13	33.74	32.43
4	Above 51 year	18	18	7	49	129	2.43	3.95	2.44	3.49	4.47
5	Unknown	228	120	81	270	345	30.77	26.32	28.22	19.22	11.94
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

Maneuver, crossing traffic police rule and regulation shows their effect contribution of 64.92% in fatal traffic crash injury severity. Since driving is a skill which requires repeated training driving experience is the most powerful thing to prevent roadway traffic crash. But, even if driving experience is a good to prevent the traffic crash, the driving environment road is in rural section.

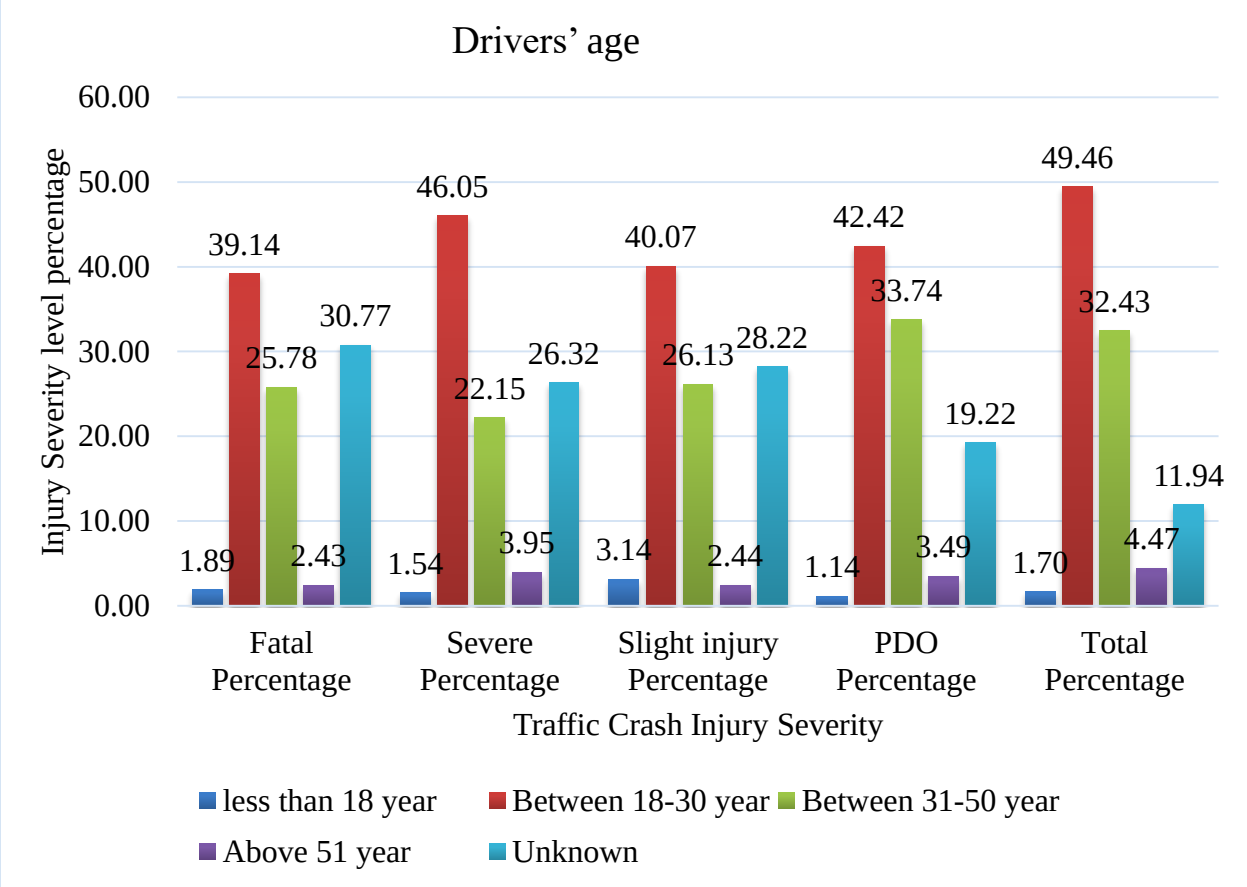


Figure 4-7: Total traffic crashes injury severity level percentage distribution by drivers' age

Time hit and escape post-crash rather than reporting to the Woreda police office. The second show that, drivers during their ages are between 18-30 years and 31-50 years olds considers themselves as they have enough experience and they drives in excess of speed limit, improper maneuver, crossing traffic police rule and regulation shows their effect contribution of 64.92% in fatal traffic crash injury severity. Since driving is a skill which requires repeated training driving experience is the most powerful thing to prevent roadway traffic crash. But, even if driving experience is a good to prevent the traffic crash, the driving environment road is in rural section.

4.3.3 Traffic Crash Injury Severity with Drivers' Education Level

From table 4-6: and supported by figure 4-8: below, high school level drivers have most total traffic Crash injury severity 1209 (41.85%) and fatal injury of 263(35.49%). On the other hand drivers whose education level is unknown are drivers that crash and go to escape the traffic police

and prosecution. Drivers with education level of high school level years have effects of 263(35.49%) fatal injury crash contribution for the crashes recorded on the study period.

Table 4-6: Road traffic crashes injury severity by drivers' Education Level

No	Education level	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	Illiterate	38	3	3	34	79	5.13	0.66	1.05	2.42	2.73
2	Elementary School	152	108	59	339	657	20.51	23.68	20.56	24.13	22.74
3	High school	263	203	131	624	1209	35.49	44.52	45.64	44.41	41.85
4	Diploma	27	12	3	56	88	3.64	2.63	1.05	3.99	3.05
5	Degree	12	6	4	72	88	1.62	1.32	1.39	5.12	3.05
6	Above Degree	21	3	6	9	25	2.83	0.66	2.09	0.64	0.87
7	Unknown	228	120	81	270	743	30.77	26.32	28.22	19.22	25.72
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

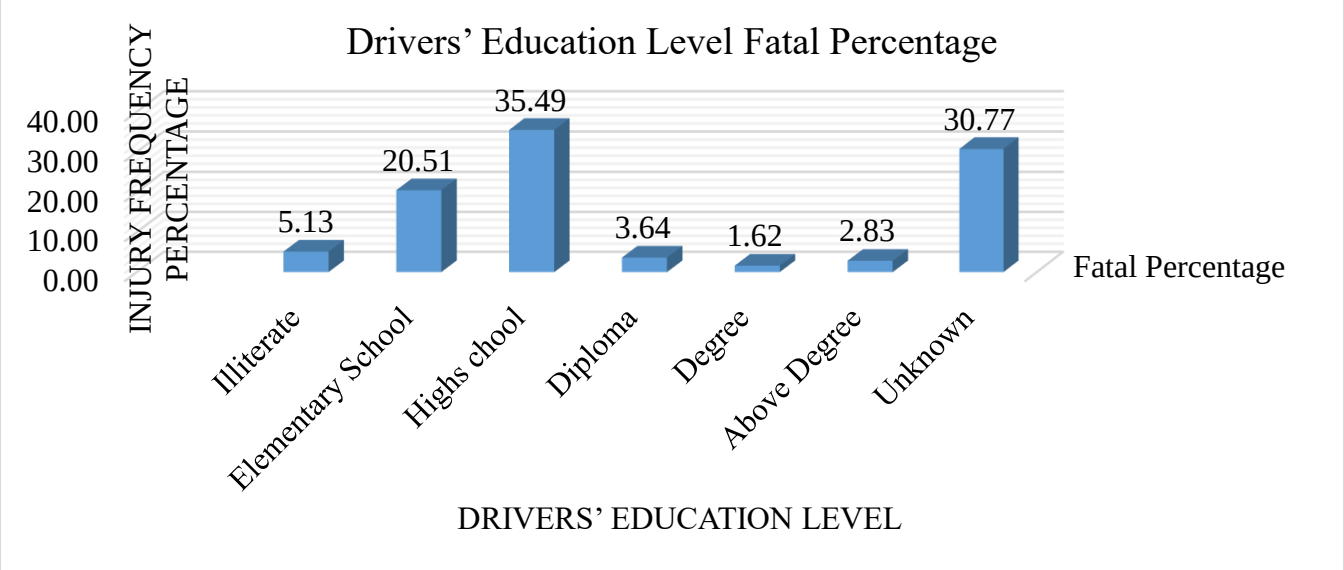


Figure 4-8: Fatal injury severity of traffic crashes distribution by drivers' education level percentage

This is due to the roadway traffic crashes injury severity distribution by drivers' Education Level shows the drivers in study roads most of the time hit and escape post-crash rather than reporting to the Woreda police office. The second show that, speed during between high school level of driving experience and when they think that, they have enough experience and they drives in excess of speed limit, improper maneuver, crossing traffic police rule and regulation that increased traffic crash injury severity

4.3.4 Traffic Crash Injury Severity with Drivers Driving Experience

From table 4-7: and supported by figure 4-9: below, unknown drivers have most total traffic crash injury severity 882(30.53%) and fatal injury of 228(30.77%). On the other hand drivers whose driving experience is unknown are drivers that crash and run or go to escape the traffic police and prosecution. Drivers with driving experience of 3-5 years have effects of 145(19.57%) fatal injury crash contribution for the crashes recorded on the study period. This is due to that drivers in study roads most of the time hit and escape post-crash rather than reporting to the Woreda police office.

Table 4-7: Road traffic crashes injury severity by drivers' driving experience

No	Driving experience	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	Has no license	2	22	29	95	129	0.27	4.82	10.1	6.76	4.47
2	less than 1 year	63	22	37	109	209	8.5	4.82	12.89	7.76	7.23
3	Between 1-2 Year	59	27	37	98	193	7.96	5.92	12.89	6.98	6.68
4	Between 3-5 year	145	77	15	310	528	19.57	16.89	5.23	22.06	18.28
5	Between 6-10 Year	82	114	22	166	375	11.07	25	7.67	11.81	12.98
6	Year 11-15	43	33	22	111	168	5.8	7.24	7.67	7.9	5.82
7	Year 16-20	68	31	22	145	267	9.18	6.8	7.67	10.32	9.24
8	Year 21-35	38	5	1	54	68	5.13	1.1	1.1	3.84	2.35
9	Above 36 year	13	5	22	47	69	1.75	1.1	7.67	3.35	2.39
10	Unknown	228	120	81	270	882	30.77	26.32	28.22	19.22	30.53
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

The second show that, speed during between 3-5 years of driving experience and when they think that, they have enough experience and they drives in excess of speed limit, improper maneuver, crossing traffic police rule and regulation that increased traffic crash injury severity.

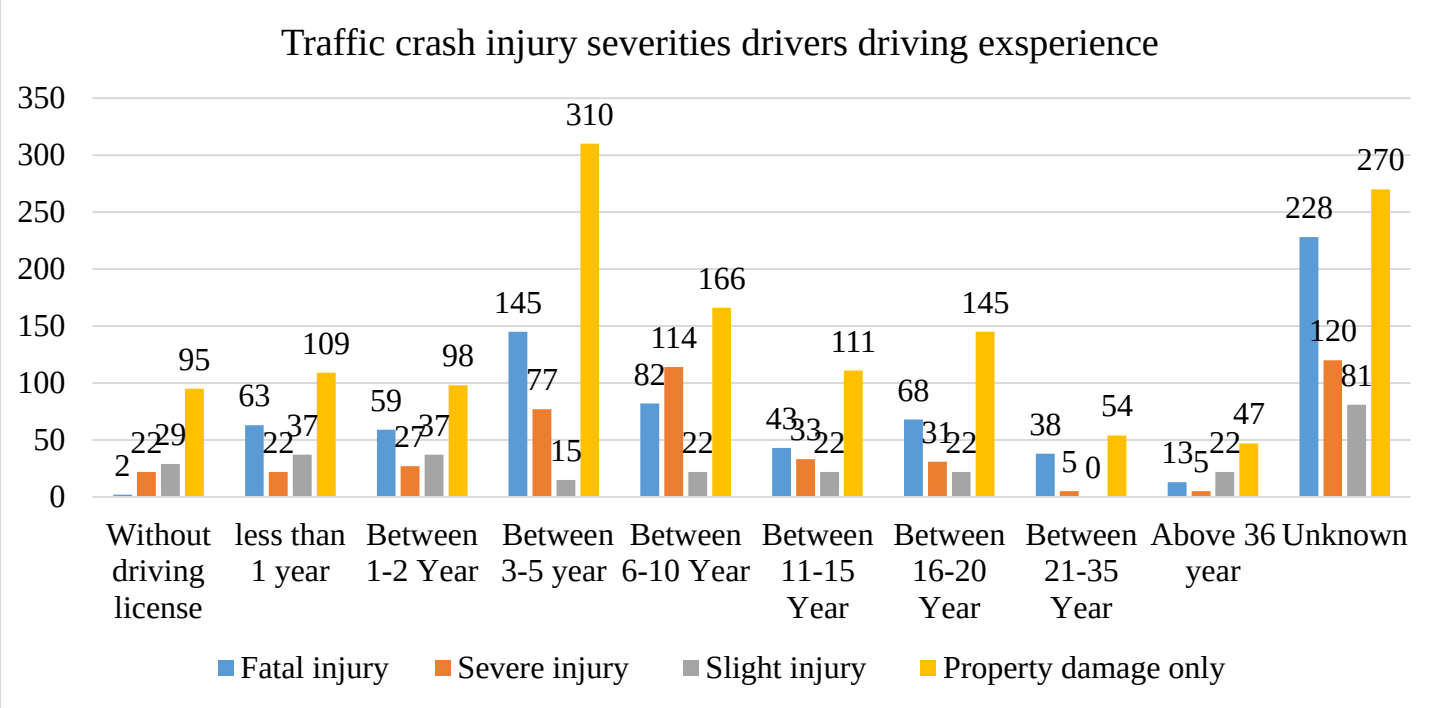


Figure 4-9: Total roadway traffic crashes injury severity by drivers' driving experience

4.4 Traffic Crash Injury Severity with Vehicles Characteristics

4.4.1 Traffic Crash Injury Severity with Types of Vehicles

The table 4-8: below and supported by figure 4-10: below, shows the types of vehicles involved in traffic crash in the study region and from the collected traffic crash database vehicles most frequently involved in total traffic crashes were small trucks such as freight Isuzu and Isuzu FSR trucks. The total traffic crashes injury severity they engaged in are 731(25.30%) and the fatality traffic crashes are 182(24.56%). As indicated in table 4-8:, small bus, large bus, small trucks, medium trucks, heavy trucks, trucks and trailers are heavy vehicles which involved in fatal traffic crash of 313(42.24%) in these five years of traffic crash. The result shows that the drivers of the heavy vehicles type travel long distances, drives for long hours of time and are not easily understand the study area roadway. These condition make drivers; failure to keep their distances,

failure to giving priority for pedestrian, driving in excess of speed limit, improper maneuver, driver fatigue and

Table 4-8: Road traffic crashes injury severity by vehicle type

Vehicle Type	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
Cars	107	94	67	105	373	14.44	20.62	23.34	7.48	12.91
Pickups	189	108	30	383	710	25.51	23.68	10.45	27.26	24.58
Small Bus	7	16	6	34	63	0.94	3.51	2.09	2.42	2.18
Large Bus	5	10	10	22	47	0.67	2.19	3.48	1.57	1.63
Small Trucks	182	102	77	370	731	24.56	22.36	26.83	26.34	25.30
Medium Trucks	75	35	26	157	293	10.12	7.68	9.06	11.17	10.14
Heavy Trucks	19	24	17	105	165	2.56	5.26	5.92	7.47	5.71
Trucks and Trailers	25	15	11	116	167	3.37	3.29	3.83	8.26	5.78
Unknown	132	52	43	113	340	17.81	11.40	14.99	8.04	11.77
Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

Sleeping which trigger the increment of traffic crash injury severity of study roadway. The second and third most frequently involved in total traffic crashes were; pickups 710(24.58%), Cars 373(12.91%), and unknown vehicle types 340(11.77%). Pickups 710(24.58%) are mostly operated by younger drivers with less driving experience, improper (careless manner) of driving, driving out of their Lane, failure to giving priority for pedestrian, failure to keep their distances, failure to drive keeping their distance, over passing at curve and drive between woreda and other neighbor woreda. They create competition between each other and this enforce to drive in excess of speed limit. On the other hand unknown vehicle types are operated by drivers that crash and go to escape the traffic police and prosecution. In addition to these, improper maneuver, crossing traffic police rule and regulation are the main causes for traffic crashes injury severity in these types of vehicles.

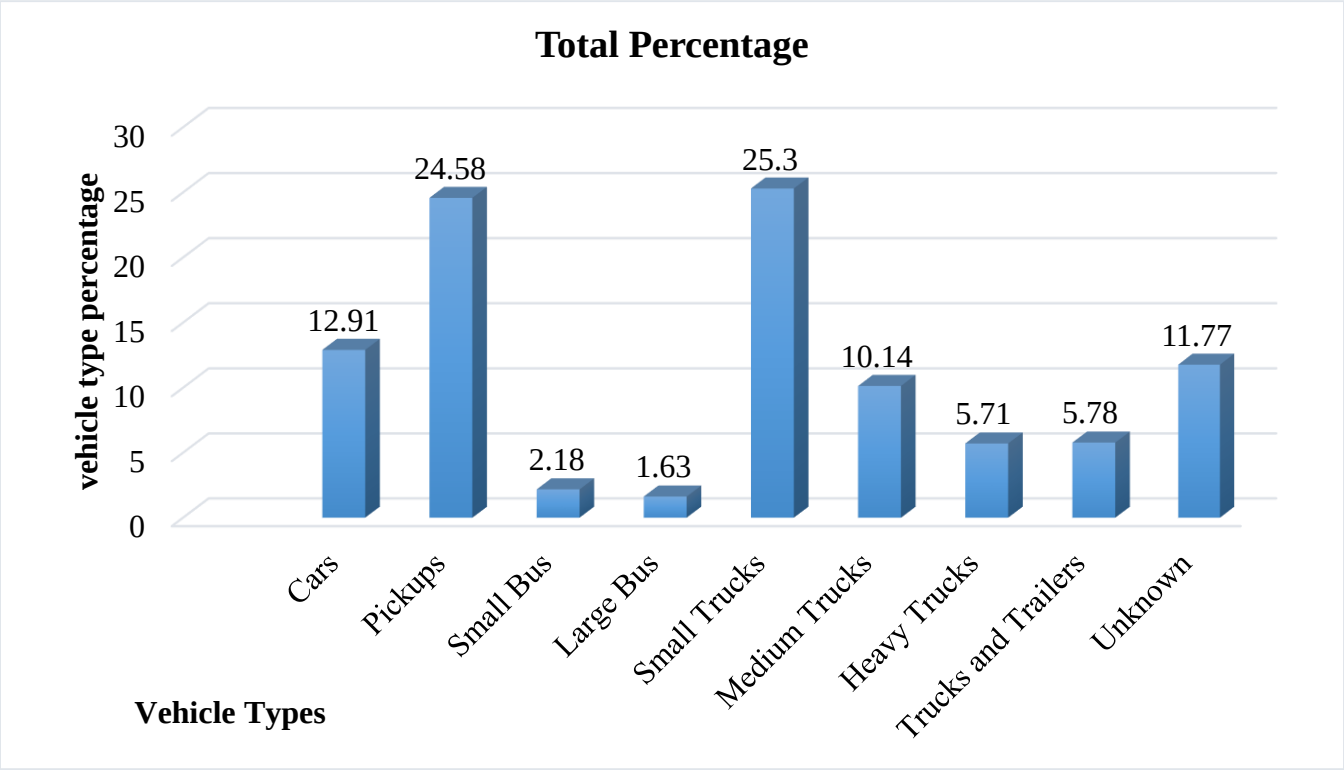


Figure 4-10: Total roadway traffic crashes injury severity by vehicles type

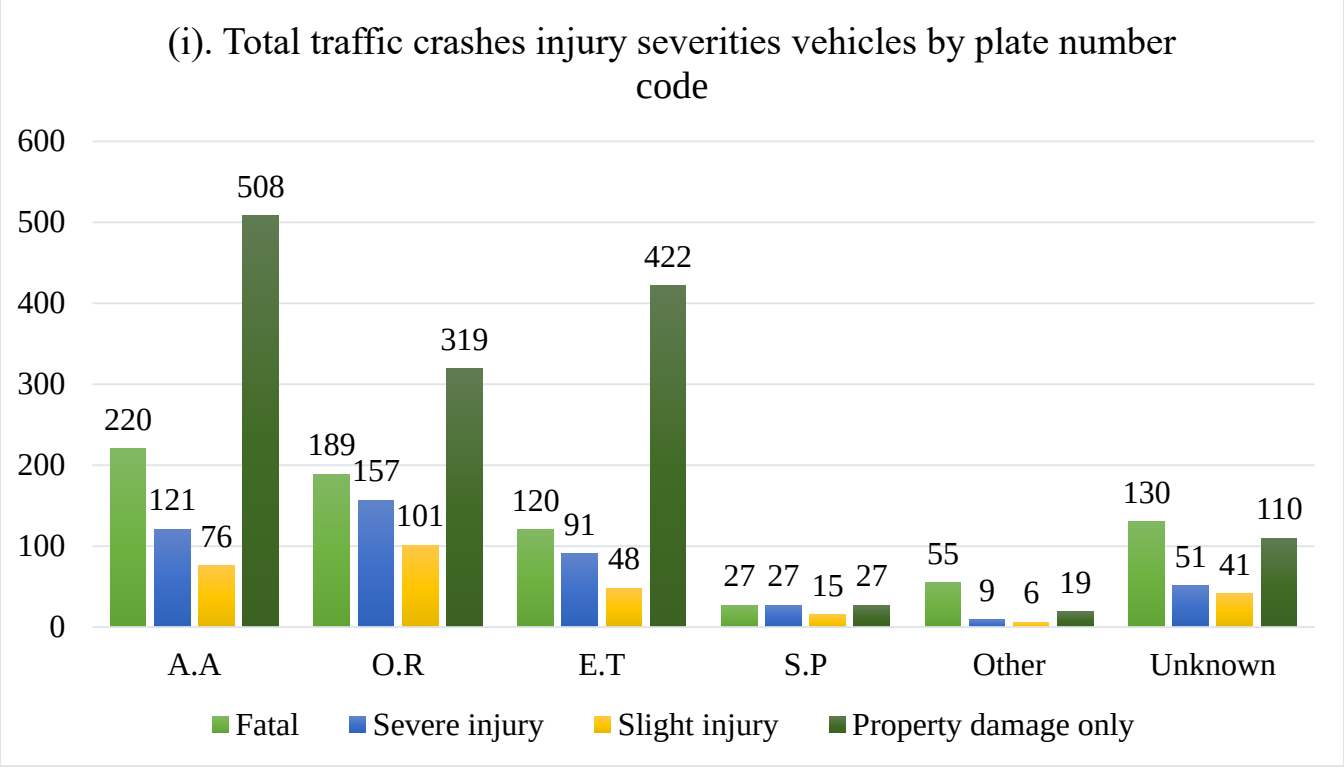
4.4.2 Traffic Crash Injury Severity with Vehicles by Plate Number Code

Traffic crash injury Severity classification of the Vehicles by plate number code is important to show how the drivers driving for long time and long distance are effects on the crash injury severity. It also used to predict the drivers driving for long time and long distance are less familiar with roadway geometry and condition, local road users' condition when compared with local drivers. In table 4-9: and supported by figure 4-11: (i) and (ii) below, 130(17.54%) are fatal injury of vehicles with unknown plate number codes are the vehicles, which the drivers are Hit and run after the traffic crash is happened to escape the traffic police and prosecution. Vehicles with A.A vehicles plate number code have effects of 220(29.69%) on the fatal injury crash contribution for the crashes recorded on the study period. The other effects of vehicles with different vehicles plate number code is, O.R 189(25.51%) are fatal injury, E.T with 120(16.19%) fatal injury effect on traffic crash, S.P with 27(3.64%) fatal injury effect on traffic crash and others with 55(7.42%) are

vehicles with plate number codes different from plate number codes which are written in table 4-9: below. These result shows most fatal injury is caused by A.A plate number code types of

Table 4-9: Road traffic crashes injury severity by vehicles plate number code

No	Vehicles by Plate Number code	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	A.A	220	121	76	508	951	29.69	26.54	26.48	36.16	32.92
2	O.R	189	157	101	319	790	25.51	34.43	35.19	22.7	27.35
3	E.T	120	91	48	422	696	16.19	19.96	16.72	30.04	24.09
4	S.P	27	27	15	27	109	3.64	5.92	5.23	1.92	3.77
5	Other	55	9	6	19	98	7.42	1.97	2.09	1.35	3.39
6	Unknown	130	51	41	110	246	17.54	11.18	14.29	7.83	8.52
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00



vehicles. Most of the time the vehicles which attached A.A type of plate number codes are; Cars, Isuzu Trucks, FSR Truck other vehicles travel throughout Ethiopian city using the study roadway. The second most is O.R which is the local vehicles such as 5L, Dolphin and High-roof Minibus and others which have contribution effects on injury severity of traffic crash to be increased. Drivers of these types vehicles with unknown plate number codes in the study roads; most of the

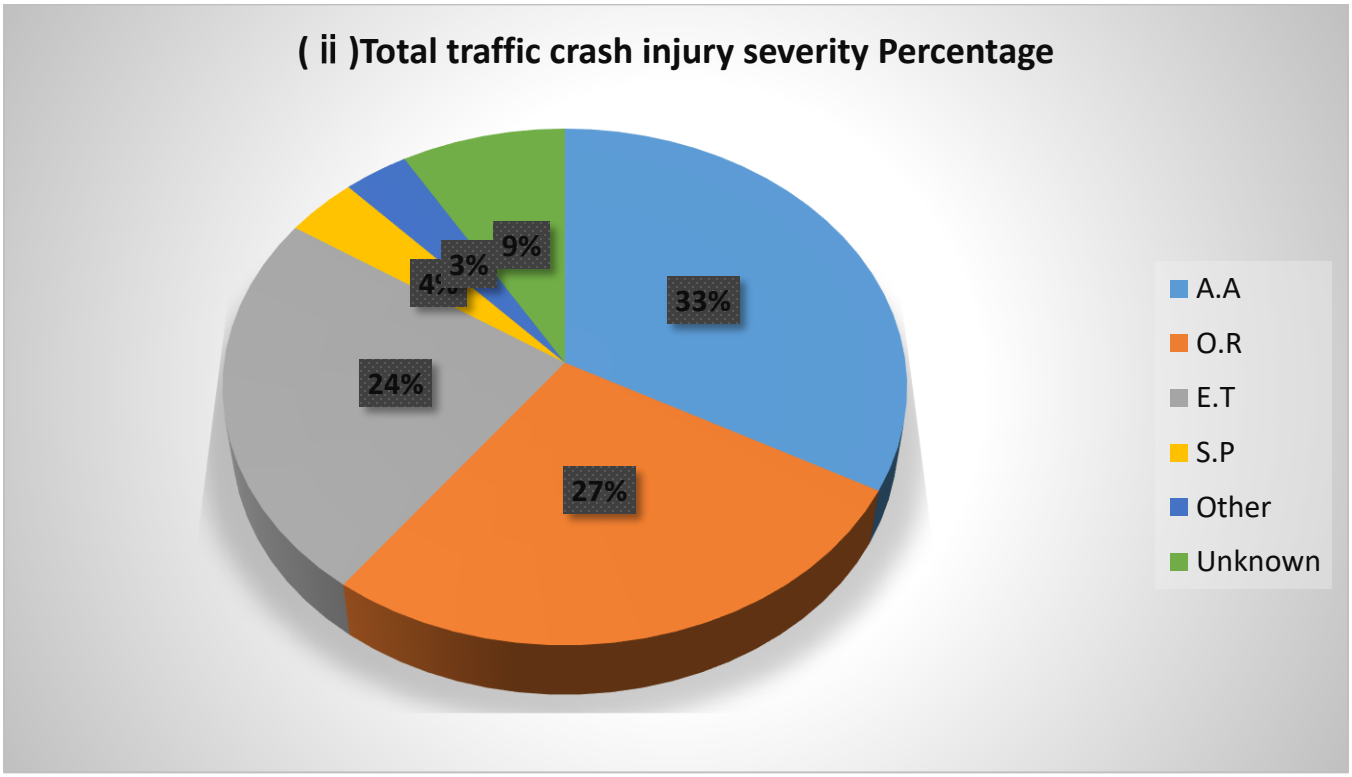


Figure 4-11: (i) and (ii) Road traffic crashes injury severity by vehicles plate number code

time hit and run or escape post-crash rather than reporting to the Woreda police office. The result shows the factors which increase effects on the injury severity of traffic crashes are drivers considers themselves as they have enough experience and they drives in excess of speed limit, failure to keep their distances, driving without attention, improper maneuver, crossing traffic police rule and regulation that increased traffic crash injury severity on the study segments.

4.4.3 Traffic crash injury severity with vehicles Ages

From table 4-10: and supported by figure 4-12: below, the road traffic crash injury severity by vehicles age for five years (2007-2011E.C) are summarized and supported by the summary of the

fatal percentage by figure 4-12: below. Vehicles of age between 4-5 years have most effects on fatal injury of 221(29.82%), Vehicles of unknown age years have the second most effects on fatal injury severity of 130(17.54%) and the vehicles of age years between 0-1 year have the effects on fatal injury severity of 121(16.33%) contribution for the crashes recorded on the study period.

Table 4-10: Road traffic crash injury severity by vehicles age in year

No	Vehicles age in year	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	0-1 year	121	44	21	127	313	16.33	9.65	7.32	9.04	10.83
2	Between 2-3 Year	119	53	31	130	333	16.06	11.62	10.8	9.25	11.53
3	Between 4-5 year	221	169	118	541	1049	29.82	37.06	41.11	38.51	36.31
4	Between 6-10	72	95	73	334	574	9.72	20.83	25.44	23.77	19.87
5	Above 10 year	78	44	3	163	288	10.53	9.65	1.05	11.6	9.97
6	Unknown	130	51	41	110	332	17.54	11.18	14.29	7.83	11.49
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

The vehicles of unknown ages in year increased due to that drivers in study roads most of the time hit and run to escape post-crash rather than reporting to the Woreda traffic police office. There is no Woreda traffic police office emergency care access number post-crash for reporting the crash happened. These is due to the post-crash emergency contact address is limited through the study roadways in short time especially for the traffic crash at the rural roads. These problems opens the roads for the divers to escape (hit and go) by driving their vehicle post-crash which conducted the crash and increased numbers of unknown drivers and vehicle characteristics which caused the traffic crash. Ethiopia has only one number which is used post-crash as countrywide emergency attention contact number (WHO 2018). These is due to the post-crash emergency contact address is limited through the study roadways in short time especially for the traffic crash at the rural roads. These problems opens the roads for the divers to escape (hit and go) by driving their vehicle post-crash

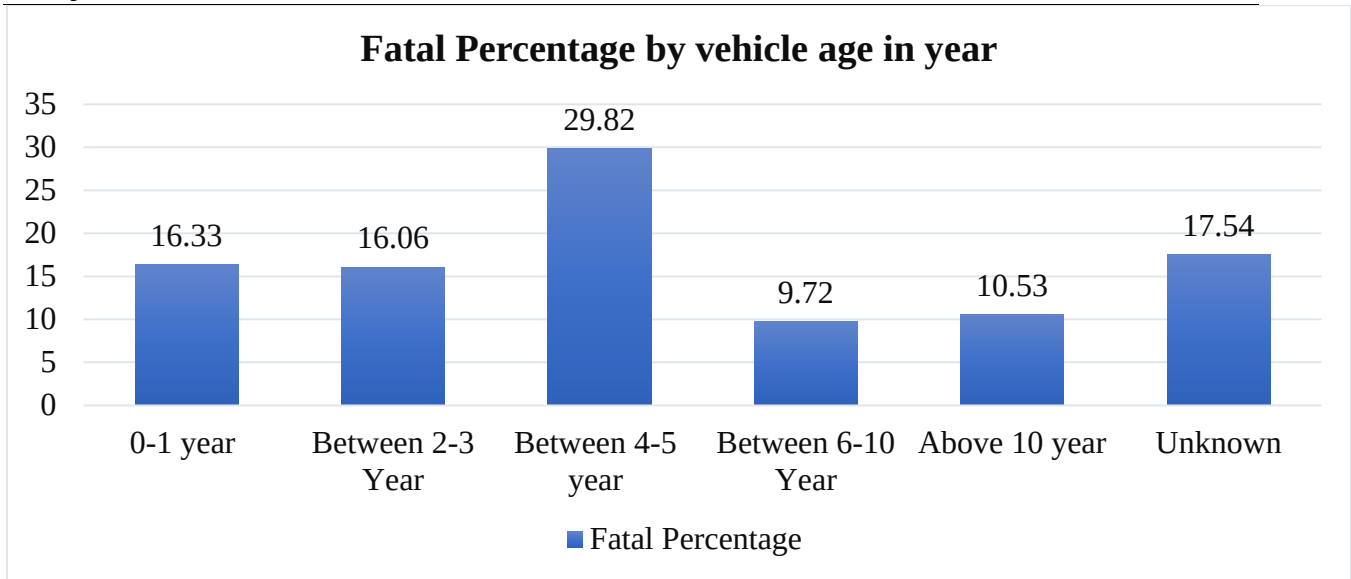


Figure 4-12: Fatal roadway traffic crashes injury severity percentage by vehicles ages in year

Which conducted the crash and increased numbers of unknown drivers and vehicle characteristics which caused the traffic crash.

4.4.4 Traffic Crash Injury Severity with Vehicles Movement action during crashes

As shown in table 4-11: and supported by figure 4-13: below, the majority of fatal injury severity of the traffic crash is caused by straight moving vehicles 387(52.23%), which is the result of the drivers who uses the road without attentions. Severe injury severity of traffic crash resulted also is caused by straight moving vehicle crashes 206(45.18%), slight injury severity of traffic crash resulted by drivers driving vehicles straight forward roadway are 91(31.71%). The straight forward movement of crash causing vehicles also caused the maximum property damage of 615(43.77%) share from all the traffic crash occurred on the study roadway. The unknown type of vehicle movement traffic crash injury severity is also high which caused these type of traffic crash injury severity like; fatal injury of 147(19.83%), 56(12.28%) severe injury of traffic crash, 49(17.08%) slight injury of traffic crash, 171(12.17%) property damage of traffic crash and 679(23.51%) total unknown vehicle movement condition of traffic crash is identified from traffic crash database of study roadway. These unknown vehicle movement condition of traffic crash is the crash causing drivers hit and escape after crash occurred. Vehicles moving out of intersections fatal injury crashes are 19(2.56%), vehicles turning left and wright fatal injury crashes are 52(7.01%) and "**U**"

shape turning fatal injury crashes are 35(4.72%) shows percentage of their effect contributions on traffic crash injury severity. This result showed us in in the study area, there is no proper pedestrian facilities, drivers drive in excess of speed limit and improper usage of the roadway by drivers like failure to giving priority for pedestrian, failure to keep their distances and failure to obey give priority traffic sign rule. These result showed that, most of straight moving vehicles and unknown type of vehicle movement traffic crash results are fatal injuries. The straight moving vehicles and unknown type of vehicle movement traffic crash fatal injuries increased due to; drivers' failure to giving priority for pedestrian, failure to keep their distances, driving without attention, lack of driving experience at the crash location and overpassing at curve roadway. Most of the time the unknown type of vehicle movement and vehicle types are crash with pedestrians, animal cart drivers and cyclists at the rural area, night, early morning and evening time..

Table 4-11: Road traffic crash injury severity by vehicle movement during crashes

No	Vehicle movement actions during crash	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	Entering intersection	59	55	30	93	258	7.96	12.06	10.45	6.62	8.93
2	Moving out of intersection	19	15	17	74	103	2.56	3.29	5.92	5.27	3.57
3	Turning Left	17	6	3	115	23	2.29	1.32	1.05	8.19	0.8
4	Turning Wright	35	58	28	92	171	4.72	12.72	9.76	6.55	5.92
5	"U" Shape Turning	35	22	14	62	122	4.72	4.82	4.88	4.41	4.22
6	Moving Back	21	33	22	97	150	2.83	7.24	7.67	6.9	5.19
7	Straight Moving	387	206	91	615	1056	52.23	45.18	31.71	43.77	36.55
8	Crash stopped vehicle	21	5	33	86	327	2.83	1.1	11.5	6.12	11.32
9	Unknown	147	56	49	171	679	19.83	12.28	17.08	12.17	23.51
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

These condition make the vehicle movement condition to been unknown post traffic crash data recording by woredas traffic police. Most of the time the unknown type of vehicle movement and

vehicle types are crash with pedestrians, animal cart drivers and cyclists at the rural area, night, early morning and evening time. These condition make the vehicle movement condition to been unknown post traffic crash data recording by woredas traffic police

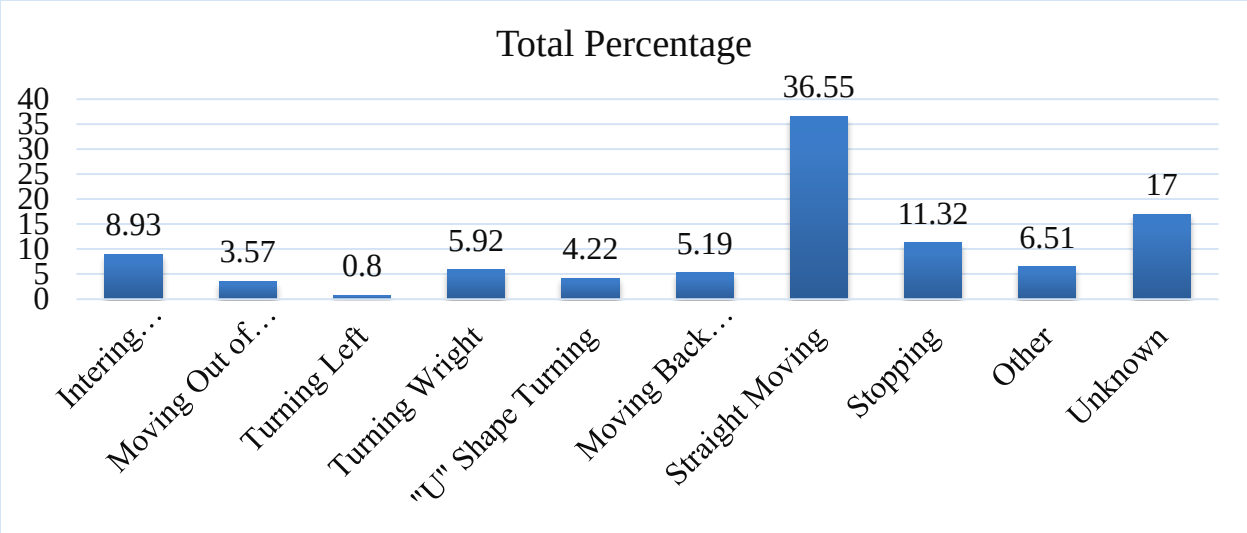


Figure 4-13: Total road traffic crashes injury severity percentage by vehicles movement

4.5 Traffic Crash injury severity with traffic Crash characteristics

4.5.1 Vehicle Body of Crash with other Vehicle, pedestrian or objects

As shown in table 4-12: and supported by figure 4-14: below, the majority of fatal injury severity of the traffic crash is 360(48.58%), which is result of vehicle crashes with pedestrian Severe injury severity of traffic crash resulted also on pedestrian crashes 99(21.71%), slight injury severity of traffic crash resulted by vehicle Over turning 158(14.63%), the total Unknown type of traffic crash injury severity is also high 332(11.49%), which is drivers escape after crash occurred. Front and front crash are 242(8.38%) and front and back crash are 259(8.97%). Other traffic crash types like, front and side crash 248(8.58%), side and side swipe traffic crash 248(8.58%), animal cart crash 192(6.65%), falling from vehicle 104(3.60%), stopped vehicles crash 117(4.05%), road side objects crash 187(6.47%), had minor contributions to traffic crash injury severity. Other type of crash which type of crashes are different from what is written in table like during exciting from residence area. This result showed in the study area, there is no proper pedestrian facilities, drivers drive in excess of speed limit and improper usage of the roadway by drivers like failure to giving

Table 4-12: Road traffic crashes injury severity by vehicle Crash with other body or vehicle parts

No	Types of Crash	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	Front and Front	45	37	23	137	242	6.07	8.11	8.01	9.75	8.38
2	Front and Back	28	42	20	149	259	3.78	9.21	6.97	12.03	8.97
3	Front and Side	37	29	31	151	248	4.99	6.36	10.80	10.75	8.58
4	Side swipe	15	20	11	113	159	2.02	4.39	3.83	8.04	5.50
5	Over Turning	35	49	42	158	284	4.72	10.75	14.63	11.25	9.83
6	Pedestrian Crash	360	99	39	109	607	48.58	21.71	13.59	7.76	21.01
7	Animal Cart Crash	45	39	25	83	192	6.07	8.55	8.71	5.91	6.65
8	Falling From veh-	6	15	11	72	104	0.81	3.29	3.83	5.12	3.60
9	Stopped Vehicles	9	19	8	81	117	1.21	4.17	2.79	5.77	4.05
10	Road side objects	22	31	11	123	187	2.97	6.80	3.83	8.75	6.47
11	Other	9	25	25	99	158	1.21	5.48	8.71	7.05	5.47
12	Unknown	130	51	41	110	332	17.54	11.18	14.29	7.83	11.49
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

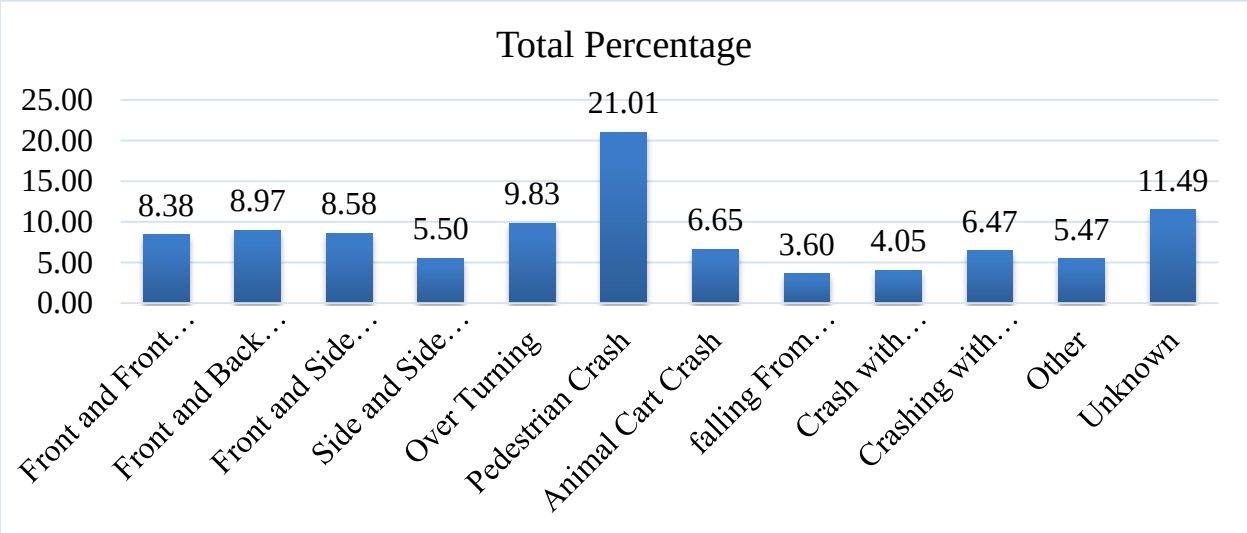


Figure 4-14: Total roadway traffic crashes percentage injury severity by types of crashes

priority for pedestrian, failure to keep their distances and failure to obey give priority traffic sign rule.

4.5.2 Traffic Crash Injury Severity Distribution with Crash Causing Factors

As shown in table 4-13: and supported by figure 4-16: below, the majority of traffic crash injury severity of traffic crash resulted by drivers' crash causing factors. These traffic crash causing factors are; drivers driving in excess of speed limit caused fatal injury of 164(22.13%). Drivers driving without attention caused fatal injury of 131(17.68%) and drivers who are unknown caused fatal injury of 113(15.25%).

Table 4-13: Road traffic crash injury severity by types of crash causing factors

No	Types of Crash causing factors	Fatal injury	Severe injury	Slight injury	PDO	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	PDO Percentage	Total Percentage
1	Alcohol influence	2	2	4	12	20	0.27	0.44	1.39	0.85	0.69
2	Mobile destruction	6	2	1	24	33	0.81	0.44	0.35	1.71	1.14
3	Drivers not obey law	354	198	113	775	1442	47.77	43.44	39.37	55.15	49.93
4	No drive experience	6	2	1	6	16	0.81	0.44	0.35	0.43	0.55
5	Over speed limit	164	85	51	166	466	22.13	18.64	17.77	11.81	16.13
6	Roadway geometry	36	57	38	279	407	4.86	12.49	13.3	19.85	14.09
7	Driver sleeping	2	2	2	5	10	0.27	0.44	0.70	0.36	0.35
8	Driver fatigue	10	7	1	13	32	1.35	1.54	0.35	0.93	1.11
9	Lighting condition	2	9	5	8	25	0.27	1.97	1.74	0.57	0.87
10	Vehicle defects	16	31	31	27	101	2.15	6.81	10.82	1.92	3.5
11	Roadway condition	10	6	10	22	49	1.35	1.32	3.48	1.57	1.70
12	Pedestrian problem	10	15	8	14	48	1.35	3.29	2.79	1.00	1.66
13	Unknown Vehicles	123	40	25	54	242	16.60	8.78	8.71	3.84	8.38
	Total	741	456	287	1405	2889	100.00	100.00	100.00	100.00	100.00

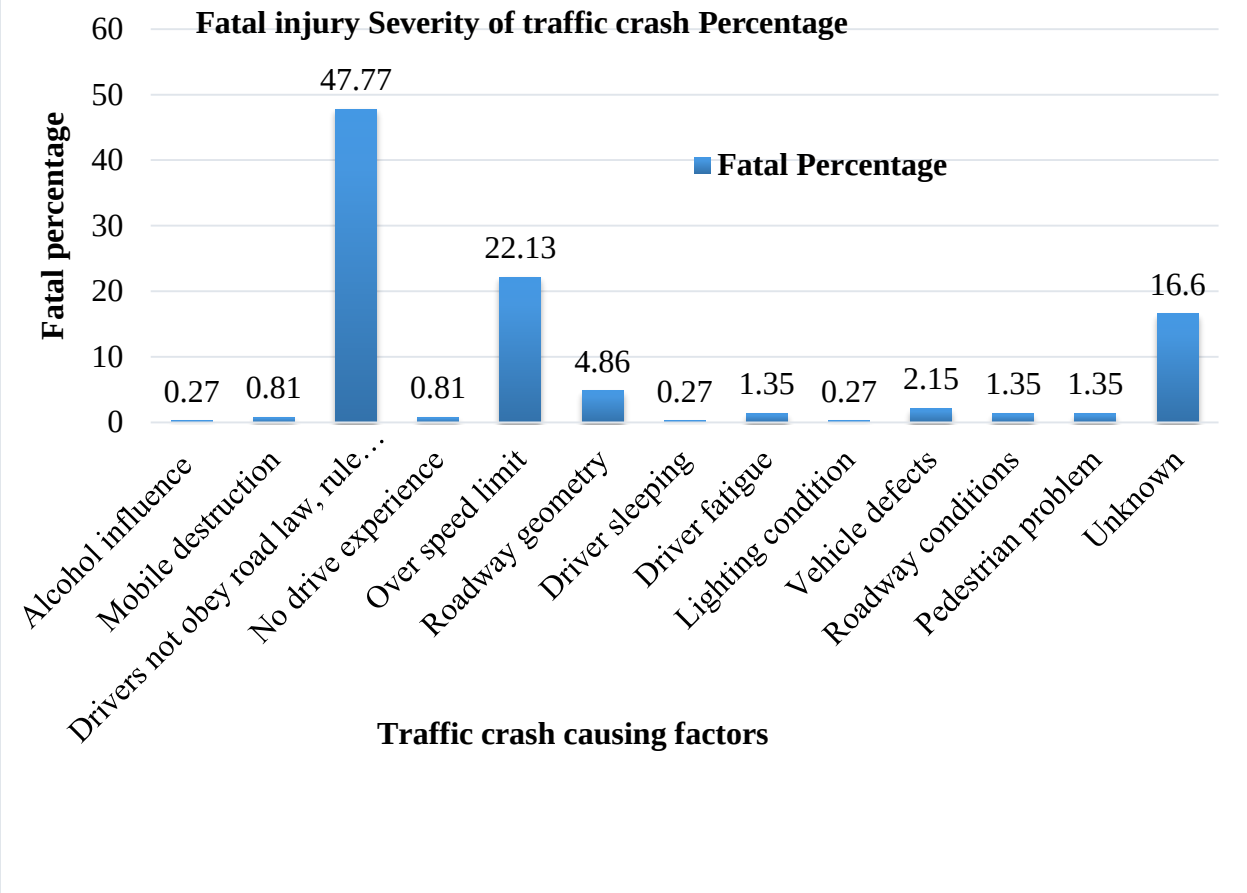


Figure 4-15: Roadway fatal traffic crashes percentage by types of crash causing factors

Drivers who are failure to give priority for pedestrian caused fatal injury of 107(14.44%) and drivers who drive improperly (careless manner) caused fatal injury of 53(7.15%) and drivers driving in excess of speed limit caused severe injury of 85(18.64%) more than the drivers driving in excess of speed limit caused slight injury of 51 (17.77%). Drivers who are unknown caused slight injury of 43(17.32%) and drivers driving without attention 44 (15.33%) and drivers failure to obey stop sign rule caused property damage only traffic crash of 360(25.62%) are the leading traffic the result shows that the drivers of the heavy vehicles type travel long distances, drives for long hours of time and been new for the study area roadway. These condition make drivers; to drive in excess of speed limit, drivers to drive without attention, failure to keep their distances, failure to giving priority for pedestrian, improper maneuver, driver fatigue and sleeping which trigger the increment of traffic crash injury severity of study area roadway. These condition make

drivers; to drive in excess of speed limit, drivers to drive without attention, failure to keep their distances, failure to giving priority for pedestrian, improper maneuver, driver fatigue

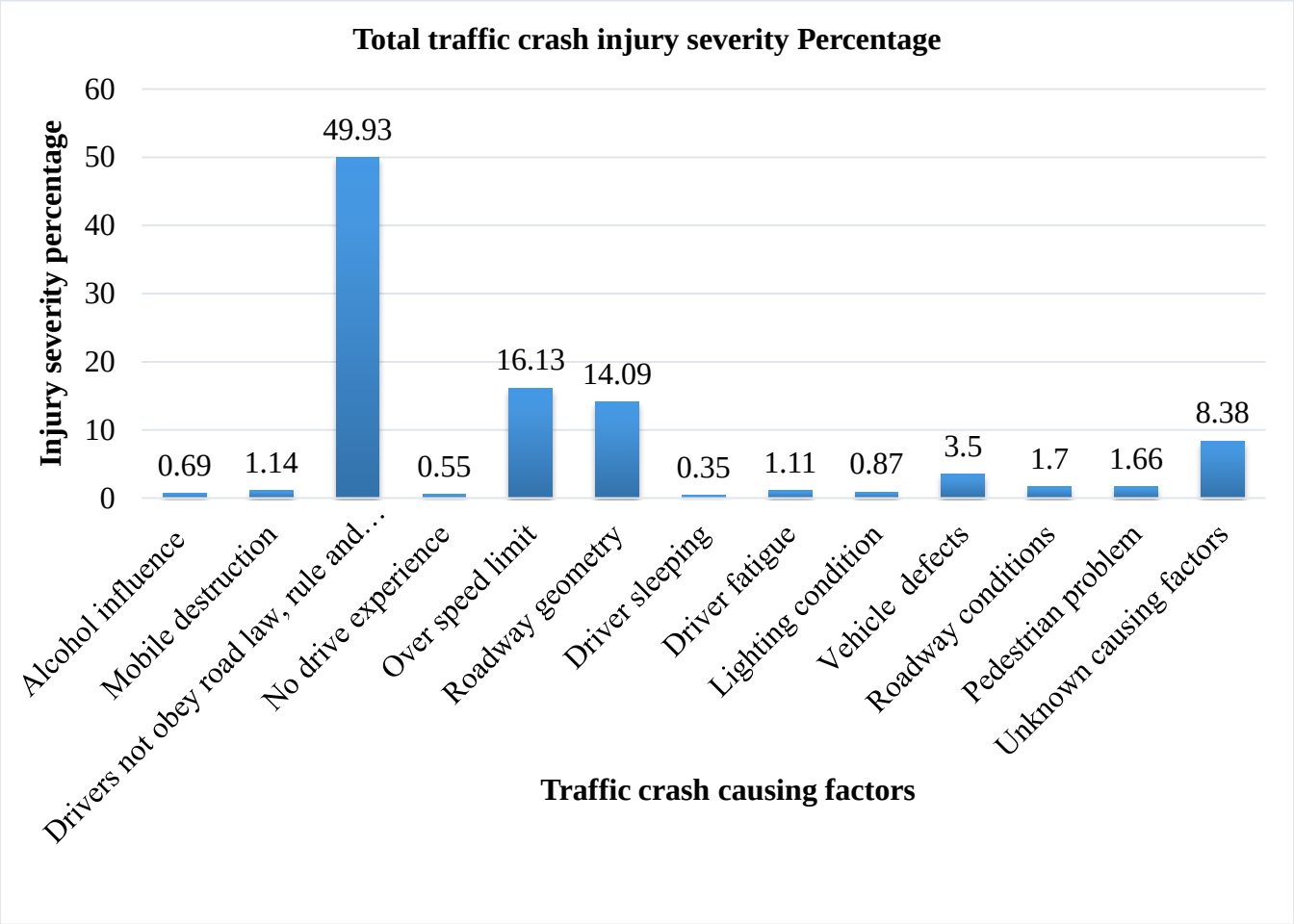


Figure 4-16: Total road traffic crashes injury severity percentage by crash causing factors

and sleeping which trigger the increment of traffic crash injury severity of study area roadway. Drivers who are unknown caused slight injury of 43(17.32%) and drivers driving without attention 44 (15.33%) and drivers failure to obey stop sign rule caused property damage only traffic crash of 360(25.62%) are the leading traffic Crash causing factors. The result shows that the drivers of the heavy vehicles type travel long distances, drives for long hours of time and been new for the study area roadway. These condition make drivers; to drive in excess of speed limit, drivers to drive without attention, failure to keep their distances, failure to giving priority for pedestrian, improper maneuver, driver fatigue and sleeping which trigger the increment of traffic crash injury

severity of study area roadway. These condition make drivers to drive in excess of speed limit, drivers to drive without attention, failure to keep their distances, failure to giving priority for pedestrian, improper maneuver, driver fatigue and sleeping which increase traffic crash injury.

4.5.3 Traffic Crash Injury Severity with Injured (victims) Peoples

As shown in Table 4-14: below, the major total crash victims occurred in passengers which

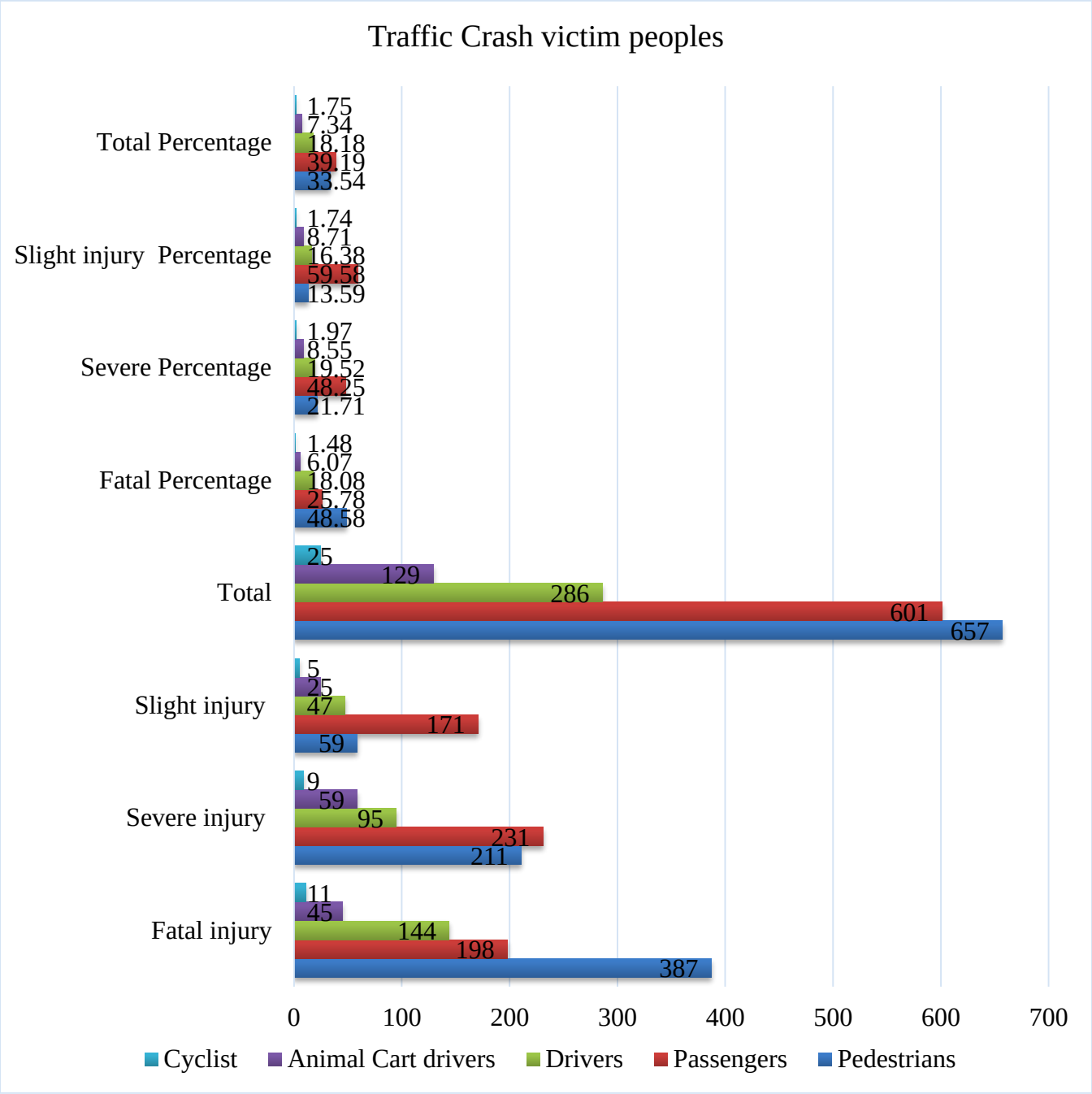


Figure 4-17: Total road traffic crashes injury severity by crash injured (victims) peoples

accounted for about 582(39.19%). The pedestrian and drivers accounted about 498(33.54%) and 270(18.18%) respectively with total number of crash victims. But in terms of fatal crash victims pedestrians placed on the first stage with a number of 360(48.58%) fatal and passengers are about 191(25.78%) people died. These result showed that, the likelihood of current with live after crash

Table 4-14: Road traffic crash injury severity by crash victim peoples

No	Crash victim people	Fatal injury	Severe injury	Slight injury	Total	Fatal Percentage	Severe Percentage	Slight injury Percentage	Total Percentage
1	Pedestrians	387	211	59	657	48.58	21.71	13.59	33.54
2	Passengers	198	231	171	601	25.78	48.25	59.58	39.19
3	Drivers	144	95	47	286	18.08	19.52	16.38	18.18
4	Animal Cart drivers	45	59	25	129	6.07	8.55	8.71	7.34
5	Cyclist	11	9	5	25	1.48	1.97	1.74	1.75
	Total	785	605	307	2889	100.00	100.00	100.00	100.00

Occurred is too low for pedestrians related to passengers. The study area pedestrian crashes results are less when compared with Addis Ababa City pedestrian crash account approximately about 85% (Tulu, et al., 2017). When severe and slight injuries compared between passengers and pedestrian crash victims were increasing with opposite order for fatal, series injury and slight injuries respectively. Animal Cart drivers and Cyclist fatal injuries are 45(6.07%) and 11(1.48%) respectively. These result showed that, most of pedestrians and vehicle crash results are fatal injuries. The pedestrians' fatal injuries increased due to; drivers' failure to giving priority for pedestrian, failure to keep their distances, driving without attention, lack of driving experience at the crash location and overpassing at curve roadway. Most of the time the unknown drivers and vehicle types are crash with pedestrians, animal cart drivers and cyclists at the rural area, night, Early morning and evening time.

4.6 Traffic Crash injury severity with Roadway characteristics

Road features is geometric elements of the study area roadway which includes, horizontal and vertical curves, cross sectional elements (carriage way width and surface condition, shoulder width, median width, side slopes etc.) grade, junctions, site distance, intersection and others. As

Table 4-15: Road traffic crash injury severity by roadway geometry

No	Roadway geometry	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage	Severe Percentage	Total Percentage
1	Straight and level road	235	102	39	212	587	31.71	21.49	20.31
2	Grade up slope road	121	220	171	252	614	18.49	21.93	21.28
3	Escarpment road	134	89	47	288	555	18.62	19.96	19.22
4	Slight horizontal curve road	132	39	25	392	585	22.00	18.42	20.28
5	Downhill road	119	13	9	261	528	23.21	18.20	18.29
	Total	741	456	287	1405	2889	100.00	100.00	100.00

shown in table 4-15, an amount of 235(31.71%) of the fatal injury of traffic crash occurred on straight and level road of the study road segment and others contribution is 614 (21.28%) for grade up slope road, 555(19.22 %) for escarpment road, 585(20.28%) for slight horizontal curve road and 528 (18.29 %) of crushes occurred on downhill road of the road segments. These result showed that, most of traffic crash results are fatal injuries on the road geometry of straight and level roads.

shown in table 4-16, below an amount of 265(35.76%) of the fatal injury of traffic crash occurred on good pavement roadway of the study road segment and fatal injury of traffic crash by fatigue cracked pavement is 124 (16.73%), 121(16.33%) fatal crash is by pothole surface defects, 111(14.98%) traffic crashes are on edge break surface defected roads and 89 (12.00%) of crushes occurred on new rehabilitated pavement roadway segments. These result showed that, most of traffic crash results are fatal injuries on the good pavement roads. The fatal injuries increased at good pavement roadway, new rehabilitated pavement roadway which has escarpment and slight curve roadway types when drivers suddenly wright turn after overpassing and driving in excess of speed limit, improper maneuver, drivers' failure to giving priority for pedestrian, failure to keep

their distances, driving without attention, lack of driving experience at the crash location and overpassing at curve roadway.

Table 4-16: Road traffic crash injury severity by roadway pavement condition

No	Roadway pavement condition	Fatal injury	Severe injury	Slight injury	Property damage only	Total	Fatal Percentage
1	Deformed asphalt pavement	31	46	47	77	201	4.18
2	Edge break surface defects	111	38	21	251	421	14.98
3	Fatigue Cracked pavement	124	83	26	231	464	16.73
4	pothole surface defects	121	89	57	257	524	16.33
5	Good pavement roadway	265	135	81	297	778	35.76
6	New Rehabilitated pavement roadway	89	65	55	292	501	12.00
	Total	741	456	287	1405	2889	100.00

4.7 Traffic Crash injury severity with Light condition characteristics

From the Table 4-1: Road traffic crashes injury severity by hours of the day above, most fatal traffic crashes are 181(24.42%) and 175(23.62%) occur between evening (15:00-18:00) and morning (07:00-10:00) o'clock respectively, and the list fatal traffic crashes are 52(7.01%) at midnight (23:00-02:00). At these midnight time, pedestrians, drivers, passengers and other roadway users are on the rest and sleeping time at home. These traffic crash result show that, night time is dark for traffic movement and has positive effects on decreasing the traffic crash injury severities.

4.8 Cost of the traffic crash property damage only in ETB

Figure 4-18: below is the example of traffic crash database recordings booklet. The blue color circled is the traffic crash property damage only injury severity levels. Traffic crashes are one person fatality injury severity, five occupant severe injury, nine occupant slight injury and 500,000.00(five hundred thousand) EBR estimated as property damage of traffic crash injury

severity are occurred between two vehicle crash at East shewa zone Bora Woreda in rural kebele on Monday morning at 4:00 30/08/2011 E.C. Vehicle type is small bus 28 seat Isuzu welded bus. The detail of occupant injury severities are written by hand at the bottom booklet format by blue and red pens due to the shortage of booklet format in the body of the format. The researcher collected and summed up the summary of cost estimated in each traffic crash if there is the property damage costs are estimated and recorded on the traffic crash recording booklet from each six woreda and each respective city like Shashemene and Batu city. The traffic or other personnel who estimate the cost of property damage are trained specifically on the vehicle body crash cost estimation by zone level consideration of vehicle crash damage cost estimation in Technical and vocational Education collage for four months and then they certified to estimate the vehicle crash property damage. They have autonomous department of traffic crash investigators at each woreda level in police offices. From the study area estimated cost of traffic crash property damage only and life injuries bring economic degradation and halts development. Yearly estimated cost of property damage only in ETB shares are in 2007, 12,464,000.00(5.18%), 2008, 10,284,000.00(4.27%), 2009, 29,098,720.00(12.09%), 2010, 28,528,150.00(11.85%), and 2011, 48,180,000.00 (20.01%). Here the total cost of the traffic crash over five years was estimated to be 240,730,870.00 ETB, of properties damage on the study roadway.

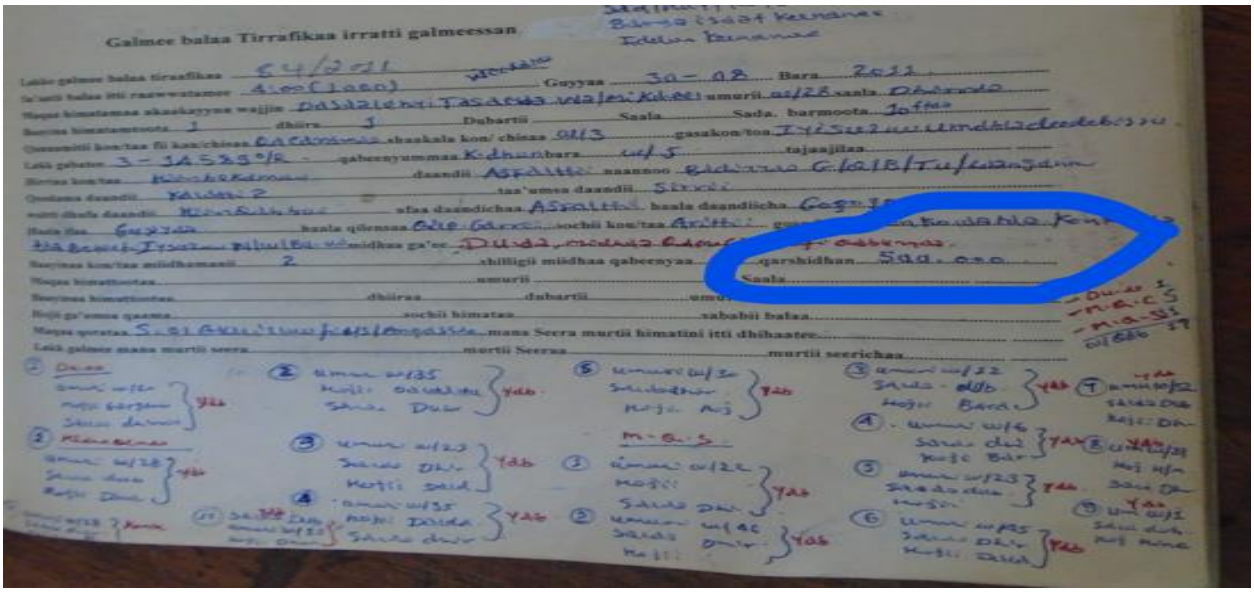


Figure 4-18: photo Sample of traffic crash database recording format booklet

Source: East Shewa; Bora Woreda traffic police office

4.9 Stata multinomial Logistic Regression Analysis Results Interpretations

The model fitting information table, which gives the -2 log likelihood for the intercept and final models, can be used in comparisons of multinomial logistic regression models. The statistically significant chi-square statistic (**p<0.05**) indicates that the final model gives a significant improvement over the baseline intercept on model. This tells us that the model gives better predictions than if we just guessed based on the marginal probabilities for the outcome categories. Therefore, the final model (with factors that affect road traffic crashes injury severity as a predictor) is significantly better than the road traffic crashes severity model. Pearson has the null hypothesis of the model is adequately fit if **p<0.05** we reject null hypothesis. Marginal effects of each explanatory variable, which capture the effect that a one-unit change in any specific explanatory variable has on the probability an injury-severity outcome, will also be calculated to investigate the effect of individual parameter estimates on injury-severity probabilities. On multinomial logistic regression it is tried how to show the dependent (response) variables are related with the independent (explanatory) variables. The explanatory variables have been chosen from police daily recorded archive. From the analysis we can observe that how the independent variables interrelated with the types of traffic crash injury severity. The parameters of the model has been selected from parameters estimated in Table 4-16: shown below from out puts of STATA 15.0 software. Table 4-16: contains the estimated coefficients for the model. The likelihood ratio chi-square of 5852.28 with a p-value less than 0.0001 tells us that our model as a whole fits data significantly and those hatched yellow.

4.9.1 Fatal injury relative to property damage only

Intercept (_Cons) this is the multinomial logistic regression estimate for fatal injury relative to property damage only when the predictor variable in the model are evaluated at zero. For give priority, day time, attention (drivers driving with attention or not), alcohol (yes if drink and drive, no otherwise), driver gender, driving over speed limit, vehicles service year, vehicle type, vehicle defects, road rule, driving experience, driver age, drivers education level, pedestrians' problem, light condition, roadway conditions scores the multinomial logit to cause fatal injury relative to property damage is 17.71754. Drivers giving priority for pedestrians was found a negative and

Table 4-16: Stata 15.0 Multinomial logistic regression model analysis

Injury Severity	Coef.	Std. Err.	Z	P>z	[95% Conf. Interval]	
Fatal injury						
Drivers not obey traffic rule and regulation	4.2289	.6886518	6.14	0.000	2.87916	5.5786
Vehicle defects	6.34752	2.767535	2.29	0.022	.92325	11.771
Vehicle type	-3.078102	.8917008	-3.45	0.001	-4.8258	-1.330
Drivers driving experience in years	-.9215557	.2774839	-3.32	0.001	-1.4654	-.37769
Roadway condition	4.507505	1.914753	2.35	0.019	.75465	8.2603
Vehicles ages in year	-3.911251	.27246	-14.36	0.000	-4.4452	-3.3772
Drivers age	-2.666303	2.395439	-1.11	0.006	-7.3612	2.0286
Drivers education level	-9.57844	2.141	-4.47	0.000	-13.770	-5.383
Light Condition	10.99183	3.109032	3.54	0.000	4.8982	17.0854
_cons	2.3475	3.7536	0.63	0.531	-5.001	9.6963
Severe injury						
Drivers not obey traffic rule and regulation	14.63537	2.728826	-5.36	0.000	-19.983	-9.2869
Vehicle defects	2.866431	.9232392	-3.10	0.002	-4.6759	-1.0569
Vehicle type	9.753996	2.777181	3.51	0.000	4.3108	15.197
Drivers driving experience in years	-2.350774	.2912872	-8.07	0.000	-2.9216	-1.7798
Roadway condition	9.708418	2.117237	4.59	0.000	5.5587	13.858
Vehicles ages in year	-2.962092	.7127688	-4.16	0.000	-4.3590	-1.5650
Drivers age	1.767149	.1820496	9.71	0.000	1.4103	2.1239

Drivers education level	2.875564	.4719885	-6.09	0.000	-3.8006	-1.9504
Light Condition	8.432928	1.567286	-5.38	0.000	-11.504	-5.3611
_cons	22.54509	6.007711	3.75	0.000	10.7702	34.3199
Slight injury						
Drivers not obey traffic rule and regulation	18.74313	3.177867	5.90	0.000	12.5146	24.9716
Vehicle type	-.3763128	2.12948	-0.18	0.001	-4.5500	3.7973
Vehicle defects	-3.402828	.9939703	-3.42	0.001	-2.8790	10.5250
Drivers driving experience in years	-1.468	.2751	-5.34	0.000	-2.007	-.9288
Roadway condition	9.6999	1.958	4.95	0.000	5.860	13.53
Vehicles ages in year	-1.039216	.2056526	-5.05	0.000	-1.4422	-.6361
Drivers age	2.367602	.4434684	5.34	0.000	1.4984	3.23678
Drivers education level	.89015	.3782	2.35	0.000	.1487	1.631
Light Condition	-14.65182	3.011668	-4.87	0.000	-20.554	-8.74905
_cons	-17.4508	4.112042	-4.24	0.000	-25.510	-9.39139

Significantly associated with traffic crash injury severity in to fatal injury at p-value=0.000 which is less than 0.005. Interpretation of log odds implies that if other factors of independent variable in the model are held constant, a unit increase in drivers giving priority for pedestrians, the multinomial log-odds of traffic crash being fatal injury relative to property damage would be expected to decrease by 5.79 units by keeping all other independent variables in the model constant. This finding is concurrent with study identified that drivers' failure to give priority to pedestrians and incorrect overtaking is a major cause to traffic crash injury severity. Moreover young drivers in the age category 18-30, particularly in professional driving are riskier in their behavior (Miranda et al., 2011; Russo, et al., 2014). Drivers' education level has found negative and significantly ($p < 0.01$) association with fatal traffic crash injury severity. Interpretation of log

odds implies that if other factors of independent variable in the model are held constant and a unit increase in variable drivers not obeying road rule then the multinomial log-odds of being fatal injury relative to property damage would be expected to increase by 4.23 units by keeping all other independent variables in the model constant. A driver's driving experience is also another crucial factor that influences traffic crash injury severity in the study area. The driver's driving experience was found negatively associated with fatal injury severity in traffic crash injury and significant at p value less than 0.001. The result of the multinomial logit log odds shows that, keeping other factors constant and a unit rise in driver's driving experience is associated with 0.92 shrinks in fatal injury of traffic crash injury severity. Vehicle type is also a crucial factor that influences traffic crash injury severity. The finding of the study found out that vehicle types were negatively and significantly correlated with fatal injury at p-value less than 0.001. A unit change in the variable vehicle type is associated with a 3.08 decrease in fatal injury. This revealed that a unit change in vehicle type is leads to decrease in fatal injury by 3.08. (Wu et al. 2014; Cantillo, Márquez and Díaz, 2020) vehicle defects have found positive and significant ($p < 0.05$) relationship with traffic crash injury severity into fatal injury. The results of the multinomial logit log odds depicts that, keeping other factors of independent variable constant, a unit increase in the independent variable vehicle defects are associated with increases by 6.34 units in fatal injury. Vehicle defects have found positive and significant ($p < 0.05$) relationship with traffic crash victims into fatal injury. The results of the multinomial logit log odds shows that, keeping other factors of independent variable constant, a unit increase in the independent variable vehicle defects is associated with 6.35 increases in fatal injury severity. Roadway condition is also most critical factor that affects traffic crash injury severity. When roadway is damaged is was found that have a positive association with fatal injury severity and significant at p value less than 0.01. The result of the log odds shows that, keeping other factors constant, a unit increase in the variable roadway condition damage is interrelated with increases by 4.51 units fatal injury severity of traffic crash.

4.9.2 Severe injury relative to property damage only

Drivers giving priority for pedestrians was found a positive and significantly associated with traffic crash injury severity in to severe injury at p-value=0.003 which is less than 0.005. Interpretation of log odds implies that if other factors of independent variable in the model are held constant, a

unit increase in giving priority for pedestrians, the multinomial log-odds of being severe injury relative to property damage would be expected to increase by 7.15 units by keeping all other independent variables in the model is held constant. A drivers obeying road rule has found positive and significantly ($p < 0.01$) association with severe traffic crash injury severity. Interpretation of log odds implies that if other factors of independent variable in the model are held constant, a unit increase in the independent variable when drivers obeying road rule the multinomial log-odds of being severe injury relative to property damage would be expected to increase by 14.63 units by keeping all other independent variables in the model constant. The finding study is similar with Observational studies undertaken in Ethiopia indicate that disobeying traffic control devices (disobeying in road rule) is a major problem. This noncompliant behavior of drivers also extends to other causes of crashes (Tulu, G.S., 2014; Miranda-Moreno, Morency; El-Geneidy, 2011). Drivers' age is also another most important driver's characteristic that influence traffic crash injury severity in the study area. Drivers' age plays a vital role in increasing traffic crash injury severity of crash victims. Drivers' age was found to have a positive association with severe injury of traffic crash injury severity and significant at p value less than 0.05. The result of the multinomial logit log odds describes that, keeping other factors constant; a unit increase in the variable drivers' age in one year is related with increase by 1.767 units in severe injury of traffic crash. Drivers' education level is also another most important driver's characteristic that influence traffic crash injury severity in the study area. Drivers' educational level plays a vital role in increasing crash victims. Drivers' educational level was found to have a positive association with severe injury of traffic crash injury severity and significant at p value less than 0.01. The result of the multinomial logit log odds describes that, keeping other factors constant; a unit increase in the variable drivers' education level in one year is related with increase by 2.88 units in severe injury of traffic crash. A drivers driving experience is also another crucial factor that influences traffic crash injury severity in the study area. The driver's driving experience was found negatively associated with severe injury severity in traffic crash injury and significant at p value less than 0.001. The result of the multinomial logit log odds shows that, keeping other factors constant and a unit rise in driver's driving experience is associated with being expected to decrease by 2.35 in severe injury of traffic crash injury severity. A Vehicle service year is also another crucial factor that influences traffic crash injury severity in the study area. The vehicle service years was found negatively

associated with severe injury severity in traffic crash injury and significant at p value less than 0.001. The result of the multinomial logit log odds shows that, keeping other factors constant and a unit increase in vehicle service years is expected to be decreased by 2.962 in severe injury of traffic crash injury severity. The finding of this study is consistent with study by (Anarkooli, Hosseinpour, and Kardar, 2017) vehicle service years is the factor that influence severe injury, where the more old vehicles, the greater the severe injury severity. It will be interesting to examine if the vehicle defects affects the likelihood of injury severity of traffic crashes. Vehicle defects have found positive and significant ($p < 0.05$) relationship with traffic crash victims in to severe injury. The results of the multinomial logit log odds shows that, keeping other factors of independent variable constant, a unit increase in the independent variable vehicle defects is associated with 9.75 increases in severe injury severity. Vehicle type is also a crucial factor that influences traffic crash injury severity. The finding of the study found out that vehicle types were positively and significantly correlated with severe injury at p-value less than 0.001. A unit change in the variable vehicle type is associated with a 2.866 increase in severe injury. This revealed that a unit change in vehicle type is leads to decrease in severe injury by 2.866 units. This finding is similar with the study done on effects of over speed limit and a sleeping of drivers by (Chang and Chien, 2013; Abegaz, et.al. 2014). Roadway condition is also most critical factor that affects traffic crash injury severity. When roadway is damaged it was found that have a positive association with severe injury severity and significant at p value less than 0.01. The result of the log odds shows that, keeping other factors constant, a unit increase in the variable roadway condition damage is interrelated with increases by 9.71 units of severe injury severity of traffic crash, which is supported by conclusions from previous studies (Wu, et al., 2014).

The roadway light condition is also another critical factor that influences traffic crash injury severity. The road lighting condition was positive and significantly associated with severe injury of traffic crash injury severity at p value less than 0.001. The result of the multinomial logit log odds illustrates that, keeping other factors of independent variable constant then severe injury severity of traffic crash injury severity increased by a factor of 8.43, as the road lighting condition change by one unit from the dark night to the daytime.

4.9.3 Slight injury relative to property damage only

A driver's driving experience is also another crucial factor that influences traffic crash injury severity in the study area. The driver's driving experience was found negatively associated with slight injury of traffic crash injury and significant at p value less than 0.001. The result of the mlogit log odds shows that, keeping other factors constant, a unit rise in drivers driving experience is associated with 1.46 shrinks in slight injury severity of traffic crash injury severity. Drivers' education level was found positive and significantly associated with severe injury at p value less than 0.001. The result of the log odds shows that, keeping other factors constant, a unit increase in the variable drivers' education level by one year is associated with a 0.89 increase in slight injury severity. The finding of this study is consistent with study by (Wang et al., 2013) drivers' education level is the factor that influence slight injury, where the more educated drivers, the greater the slight injury severity. These means educated drivers decrease odds of higher degree of injury severity from fatal and severe injury to slight injury severity by taking all possible traffic crash safety actions.

Vehicle type is also a crucial factor that influences traffic crash injury severity. The finding of the study found out that vehicle types were negatively and significantly correlated with slight injury at p-value less than 0.001. A unit change in the variable vehicle type is associated with a 2.46 decrease in slight injury. This revealed that a unit change in vehicle type is leads to decrease in slight injury by 2.46 units. Cerwick (2014) also found vehicle type to have an influence on the level of injuries severity sustained by heavy vehicle involved traffic crashes. Vehicle defects have found positive and significant ($p < 0.05$) relationship with traffic crash injury severity into fatal injury. The results of the multinomial logit log odds depicts that, keeping other factors of independent variable constant, a unit increase in the independent variable vehicle defects is associated with increases by 6.34 units in fatal injury. Roadway condition is also most critical factor that affects traffic crash injury severity. Roadway condition was found to have a positive association with slight injury severity and significant at p value less than 0.05. The result of the log odds shows that, keeping other factors constant, a unit increase in the variable roadway condition damage is interrelated with 9.69 increases in slight injury severity of traffic crash injury severity. The result that Roadway condition was statistically associated with traffic crash injury severity for crash victims was consistent with previous studies (Chen et al., 2016; Kaplan and Prato, 2012).

4.10 Drivers and road factors which influences crash victims on the study road.

As it is shown in the above result and discussion parts of this chapter the following are the assessed factors which influences the severity degree of traffic crashes victims on the study roadway Modjo-Hawassa case. Assessed factors which influences the traffic crash injury severity to been fatal injury are the factors related to drivers characteristics. When drivers given priority for pedestrians the fatal and severe injury was decreased. As drivers driving experience increased the fatal, severe and slight injury was decreased. When drivers obeyed roadway rule and regulations the fatal injury were decreased. When roadway condition is damaged or roadway is injured the fatal, severe and slight injury was seen increased. When vehicle had defects/failure the fatal and severe injury was increased. When drivers given priority for pedestrians the injury was decreased. As drivers driving experience increased the fatal injury was decreased. When drivers obeyed roadway rule and regulations the fatal injury were decreased. When roadway condition is damaged or roadway is injured the fatal injury was seen increased. When vehicle had defects/failure the fatal injury was increased. As drivers' age increased the severe injury was increased. When drivers' education level increased the severe and slight injury was increased. As vehicle ages in years was increased the severe injury decreased this shows that younger vehicles caused more severe injury. When the road light condition changes from dark night to day light the severe injury was increased.

4.11 Drivers' and vehicles Factors which cause and increase traffic crashes injury severity

Drivers' education level, drivers not obey traffic rule and regulation, roadway condition and Light Condition was found positive and significantly associated with fatal injury severity. A drivers not obey traffic rule and regulation was found positive and significantly association with severe injury of traffic crash injury severity. The finding of the study is similar with observational studies undertaken in Ethiopia indicate that disobeying traffic control devices (disobeying in road rule) is a major problem. This noncompliant behavior of drivers also extends to other causes of crashes (Tulu, 2014; Miranda-Moreno, Morency; El-Geneidy, 2011). A vehicles ages in year, drivers age, vehicle type and drivers driving experience in years was found negative and significantly association with fatal traffic crash injury severity. The finding of the study found out that vehicle types were negatively and significantly correlated with slight injury at p-value less than 0.001. The road lighting condition was positive and significantly associated with severe injury of traffic crash

injury severity. Vehicle defects have found positive and significant at (p-value < 0.05) relationship with traffic crash victims into severe injury. Based on a the five year (2007 to 2011 E.C) crash dataset in Modjo-Hawassa traffic crash used in this paper applies multinomial logistic regression models to predict pedestrians, drivers and passengers injury severity outcomes in traffic crashes and investigated the likelihood influences of causal factors concerning traffic crash, vehicle and driver information on pedestrians, drivers and passengers injury severity patterns.

4.12 Effects of the Drivers, Vehicles and Road Characteristics on the Traffic Crash Injury Severity in the Study Areas

The effects of the drivers' characteristics on the traffic crash injury severity in the study areas are as follows. When drivers given priority for pedestrians the fatal and severe injury was decreased. As drivers driving experience increased the fatal, severe and slight injury was decreased. When drivers obeyed roadway rule and regulations the fatal injury were decreased. When roadway condition is damaged or roadway is injured the fatal, severe and slight injury was seen increased. When vehicle had defects/failure the fatal and severe injury was increased. As drivers driving experience increased the fatal injury was decreased. When drivers obeyed roadway rule and regulations the fatal injury were decreased. When roadway condition is damaged or roadway is injured the fatal injury was seen increased. When vehicle had defects/failure the fatal injury was increased. As drivers' age increased the severe injury was increased. When drivers' education level increased the severe and slight injury was increased. As vehicle service year increased the severe injury decreased this shows that younger vehicles caused more severe injury. Kim et al. (2013) also found vehicle service year to have an effect on the level of injury severity sustained by heavy vehicle involved traffic crashes. When the road light condition changes from dark night to day light the severe injury was increased.

4.13 Proposed remedial actions for drivers, vehicle and roadway characteristics

The remedial actions of the drivers' characteristics on the traffic crash injury severity in the study areas are as follows.

4.13.1 Remedial Actions for Drivers Factors Effects

- ✓ Enforcing the road rule and regulations by law and giving the education campaigns and training for the road users to obey roadway rule and regulations to decrease the fatal injury. The evidenced of 149 countries that have designed principal organizations with responsibilities that included enforcing and evaluating traffic rule and regulations by law and strengthening lawmaking to mitigate the main risk factors is accepted by the majority of governments as an important strategy to improve road safety (WHO, 2018). Generally 22 other countries have revised their rule and regulations by law on one or more risk factors to improve their road safety.
- ✓ Giving the training for the drivers to give priority for pedestrians to decrease traffic crash injury severity of the fatal, severe and slight injury. Drivers might wear seat belts at every times while driving, stop drink-driving, motorcyclist use helmet, applying child restraint scheme, applying speed limits and follow to all guidelines and ways of governing the operation of the vehicles, appreciation of safe drivers and maintaining safe driving to been applied at all times. In the world about 45 countries applied best practice on drink-driving regulations, 49 countries applied on motorcycle helmet use, 33 countries applied child restraint methods, 105 countries applied seat-belts and less improvement has been applied on speed limits unless speed is a key cause of fatal and severe injury (WHO, 2018).
- ✓ To decrease fatal, severe and slight injury the drivers might be more experienced to drive.
- ✓ Traffic safety management office might use banning drivers who have caused the fatal and severe injury from driving for determined time as punishment.

4.13.2 Remedial Actions for Road Conditions Factors Effects

- ✓ Road maintenance and rehabilitation might be done when the roadway condition is damaged or roadway is injured to decrease fatal, severe, slight injury and property damage only of traffic crash injury severity level. The study done in United States of America in county of Florida shows for more effective and safer management of roadway systems pavement condition management might include roadway safety (Lee, Nam, and Abdel-Aty, 2015).
- ✓ Providing the separated road lanes for animals and carts on the main roadway sides to reduce the road blockage due to speed differences where the road main lanes are used by animal carts. The speed of vehicles are higher than the speeds of animals and carts. It is important for

the roadway management to establish a harmony between all the three factors (roadway, vehicles and roadway users' people) at the design stage of the roadway.

- ✓ Damaged roadway traffic signs, signals, pedestrians crossing painting color and removed roadway lane division color painting might be maintained to decrease the traffic crash of small trucks such as small trucks like Isuzu, FSR and medium trucks like Sino Truck most of the time engaged in pedestrian fatal crash injury severity level due to drivers' failure to give priority for pedestrians when they are unfamiliar with roadway geometry condition such as curve, sloped roadway and pedestrians crossing painting color removed.

4.13.3 Remedial Actions for Vehicles Factors Effects

- ✓ Banning defected/failure vehicle using the roadway to decrease the fatal, severe, slight injury and property damage only of traffic crash injury severity level.
- ✓ Distance and time per day which one driver to drive might be limited by law to decrease drivers who drive in excess of speed limit, improper maneuver, driver fatigue and sleeping, decrease the crash of fright small trucks such as Isuzu, FSR and medium trucks like Sino Trucks.
- ✓ Recording vehicles plate number, time of entrance and drivers address might be done to minimize unknown drivers and vehicles which hit and run post traffic crash.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Ethiopia accompanied by sharing fatal traffic crash problem from 1.35 million people die each year as Worldwide (WHO, 2018). The general objective of the study is to analyze the effects of drivers', vehicle and roadway condition characteristics on Modjo-Hawassa roadway traffic crash injury severity and proposing its remedial actions. The traffic crash injury severities are aggregated as a four level categorical dependent variables: fatal injury, severe injury, slight injury and property damage only (PDO). The study used descriptive and Multinomial logistic regression methods to analyzed traffic crash of 2007-2011 E.C or July 2014 to June 2019 G.C of five years database.

Explanatory variables such as drivers not obey traffic rule and regulation, when drivers ages are between 18-30 years, drivers education levels are high school level, vehicle types are small truck such as Isuzu and FSR and medium trucks like Sino trucks, when roadway conditions are damaged or failure, vehicles was defects, day light conditions are night dark are identified as factors increasing fatal, severe, and slight injury severity of pedestrians, passengers, drivers and cyclists. Explanatory variable factors such as higher drivers driving experience in years, lower vehicles ages in year, when drivers' age increase, when drivers' education level above high school, when vehicle types are trucks and trailers and light conditions are day light decreased fatal, severe, and slight injury severity of study area traffic crashes.

Drivers of small trucks such as fright Isuzu, FSR and medium trucks like Sino Truck, which do not obey the roadway rule and regulation most of the time engaged in pedestrians' fatal crashes and crashes with cars which results in fatal and severe injury severity of traffic crashes. Most of the time the unknown drivers and vehicle types (drivers hit and runs) are drivers which hit and run post crashes and they crashes with pedestrians, animal cart drivers and cyclists at the rural area, night, early morning and evening time. The result showed in the study area, there is no proper pedestrian facilities, drivers do not obey the roadway rule and improper usage of the roadway by drivers like failure to giving priority for pedestrian and failure to obey give priority traffic sign rules.

The proposed remedial actions for traffic crash injury severity are giving the training on road rule, regulations and guidelines for the drivers. Regularly doing road maintenance and rehabilitations for damaged roadway, traffic signs, signals, pedestrians crossing painting color. The other is distance and time per day one driver to drive might be limited by law. The findings of the study on the analyzing effects of factors results and evaluations of remedial actions significance are compared with the results of developed country scholar's researches. The addressed remedial actions will helps the traffic police, road administrations, road transport planners and designers to consider during planning, designing and implementations for the enhancements of the road traffic safety. The details evaluations of the significance of remedial actions for the effects of explanatory variable factors are the research gap of this study and it is recommended as future study. Also comparing the results of multinomial logistic regression model with mixed logit model, ordered logistic models and factoring independent variable method are the research gap recommended as future research points.

5.2 Recommendations

According to the findings of the study on the analyzing effects of drivers characteristics on injury severity of crash victims the followings are the key recommendations which will helps the traffic police, road administrations, road transport planners and designers to consider during planning, designing and implementations for the enhancements of the Road Traffic Safety.

- ✓ Giving the training for the drivers to give priority for pedestrians and other vehicles to decrease the traffic crash injury severity.
- ✓ Giving the training for the drivers to obey roadway rule and regulations where there is no traffic police to decrease the fatal injury and enforcing the roadway rule and regulations by law.
- ✓ Distance and time per day which one driver to drive might be limited by law to decrease the crash of small trucks such as Isuzu, FSR and medium trucks such as Sino trucks effects.
- ✓ Traffic safety management office might use banning drivers who have caused the fatal and severe injury from driving for determined time as punishment.
- ✓ Recording vehicles plate number, time of entrance and drivers address to minimize unknown drivers and vehicles post traffic crash.

- ✓ Transport authority who is awarding the driving license to the drivers might consider more practical driving experience before giving the driving license to decrease fatal, severe, slight injury and PDO for light vehicles drivers.
- ✓ Road transportation rule and regulation which allow the penalty receipt replacement for driving license and vehicle plate number when the driving license and vehicle plate number is taken off by traffic police and transportation controller officers after they finished the started trip might be amended by law.
- ✓ Roadway traffic safety awareness campaigns for speed limit enforcement for drivers, traffic police and roadway transport traffic controllers.
- ✓ Traffic crash database recording format and system might be improved.
- ✓ Proper facilities might be provided for pedestrians and other non-motorized roadway users.
- ✓ Road maintenance and rehabilitation might be done when the roadway condition is damaged or roadway is injured to decrease fatal, severe and slight injury of traffic crash.
- ✓ Damaged road traffic signs and road centerline color painting might be maintained.
- ✓ Speed breakers might be constructed where there is no the traffic police assess.
- ✓ At least two calling centers might be established for public communication with woreda transport and police office to report post road traffic crash is happened.
- ✓ Ethiopian university might teach and award driving license to increase license quality.
- ✓ Banning defected/failure vehicles using the roadway to decrease the traffic crash.
- ✓ As future research comparing the results of multinomial logistic regression model with mixed logit model, ordered logistic models and factoring independent variable method are recommended.

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APPENDIX A: Modjo-Hawassa road traffic crashes injury severity level statistical figure charts

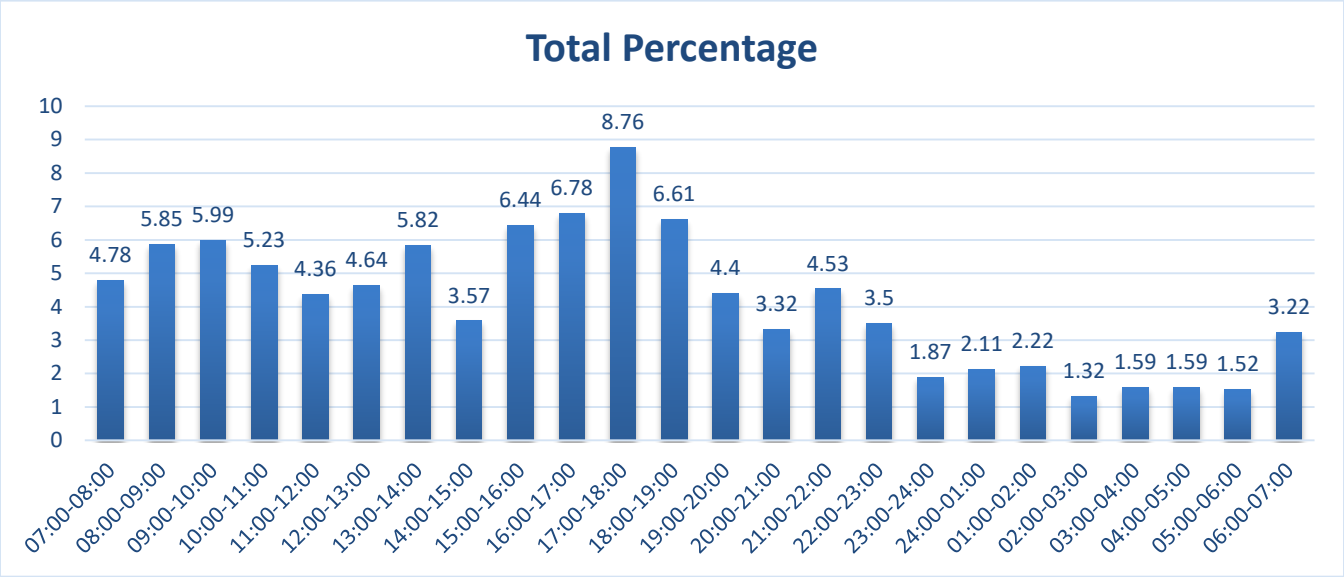


Figure AA1 Road traffic crashes injury severity distribution by hours of the days for five years (2007-2011 E.C). Source: West Arsi and East Shewa zones and woreda police office. It is developed by thesis author.

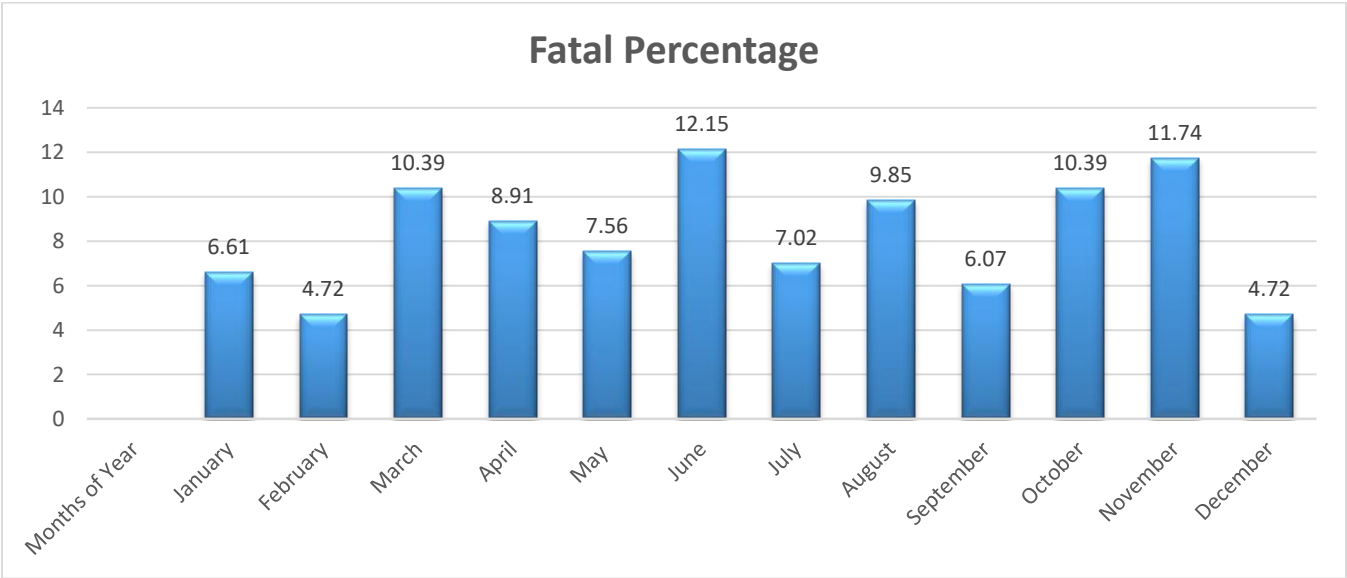
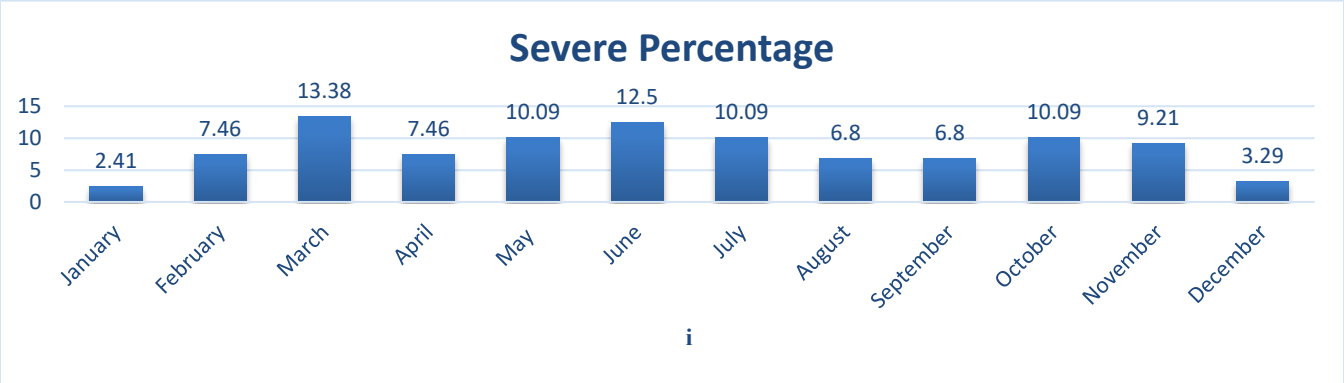
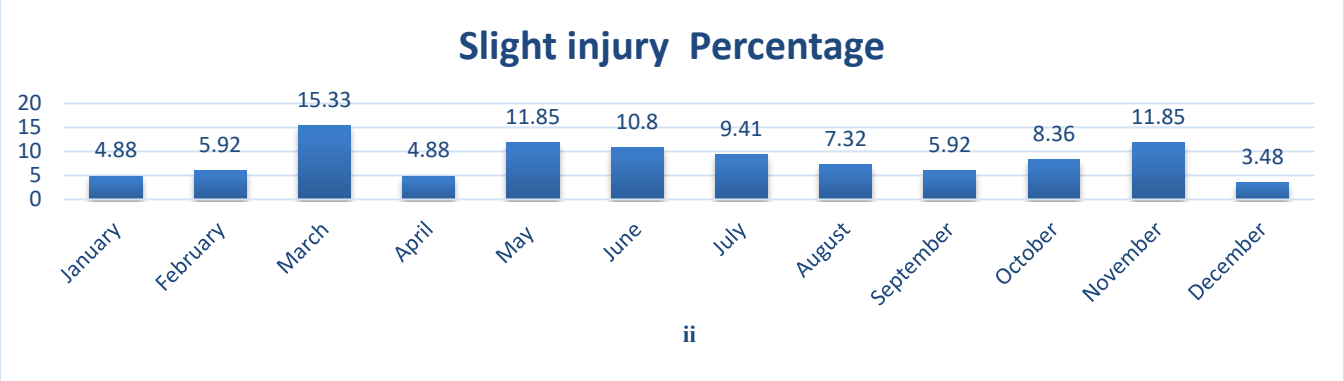


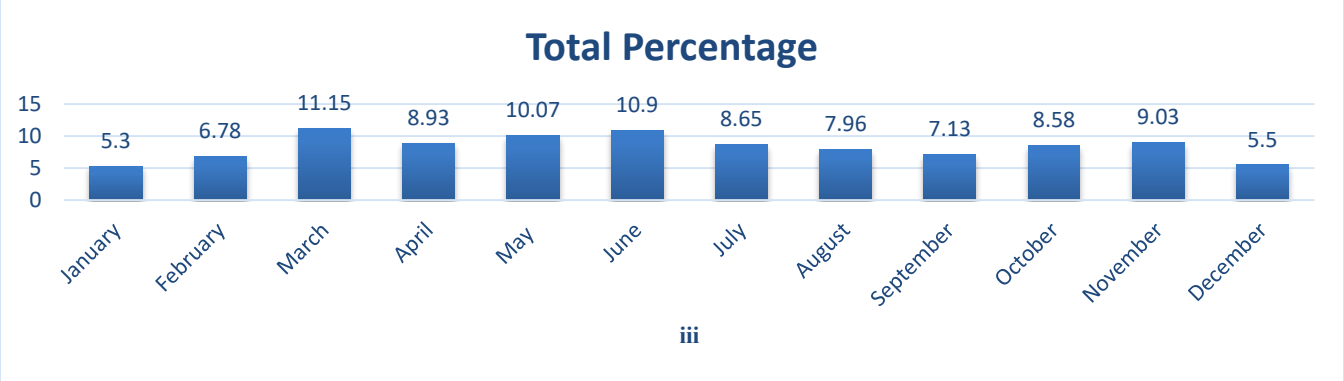
Figure AA5 Road traffic crashes fatal injury severity percentage distribution per months for five years (2007-2011 E.C).



i



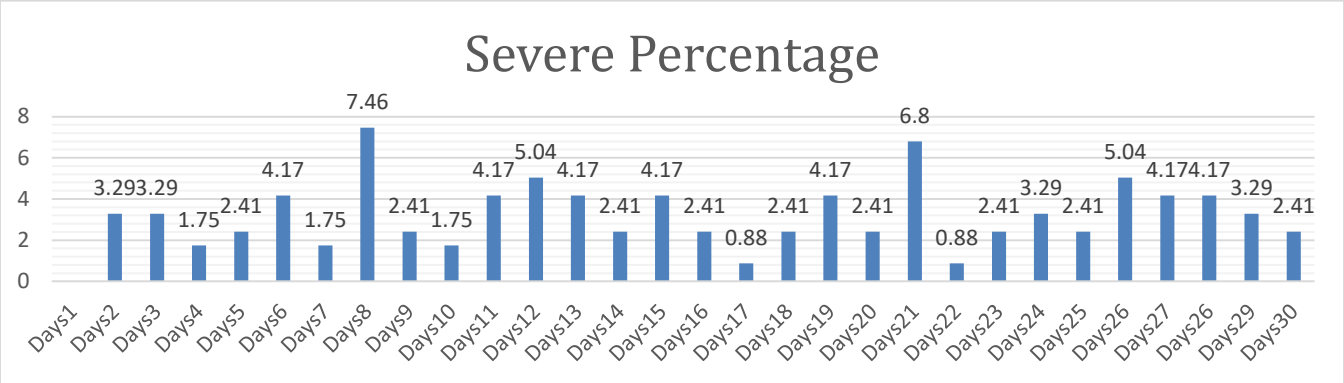
ii

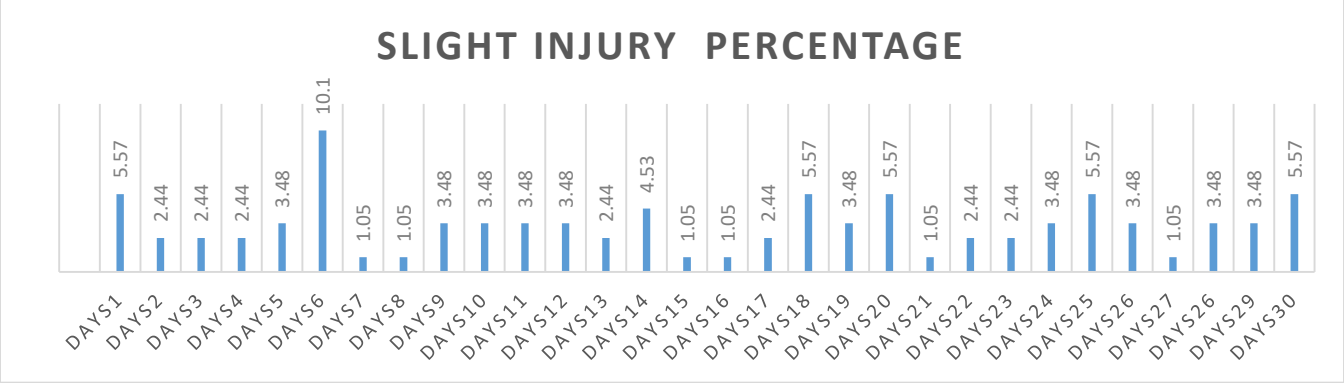


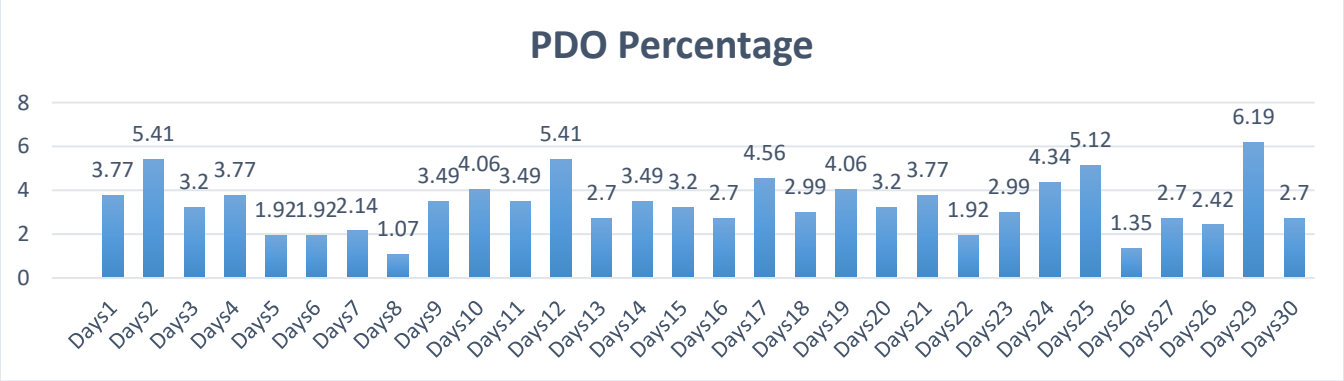
iii

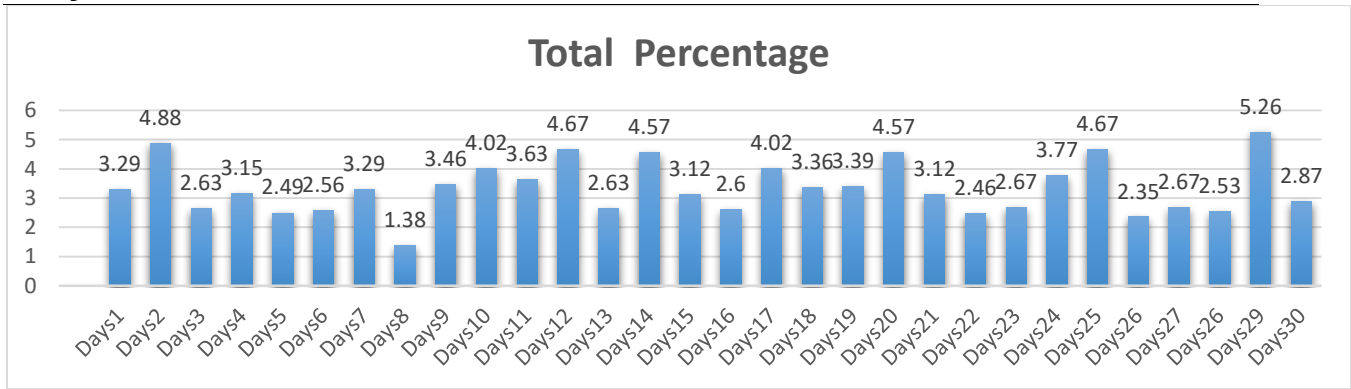
Road traffic crashes i. Severe ii. Slight and iii. Total injury severity percentage distribution per months for five years (2007-2011 E.C).

Modjo-Hawassa Road traffic crashes injury severity in days of the months for five years (2007 E.C-2011 E.C)








Total Percentage
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5
4
3
2
1
0
3.29
4.88
2.63
3.15
2.49
2.56
3.29
1.38
3.46
4.02
3.63
4.67
2.63
4.57
3.12
2.6
4.02
3.36
3.39
4.57
3.12
2.46
2.67
3.77
4.67
2.35
2.67
2.53
5.26
2.87
Days1
Days2
Days3
Days4
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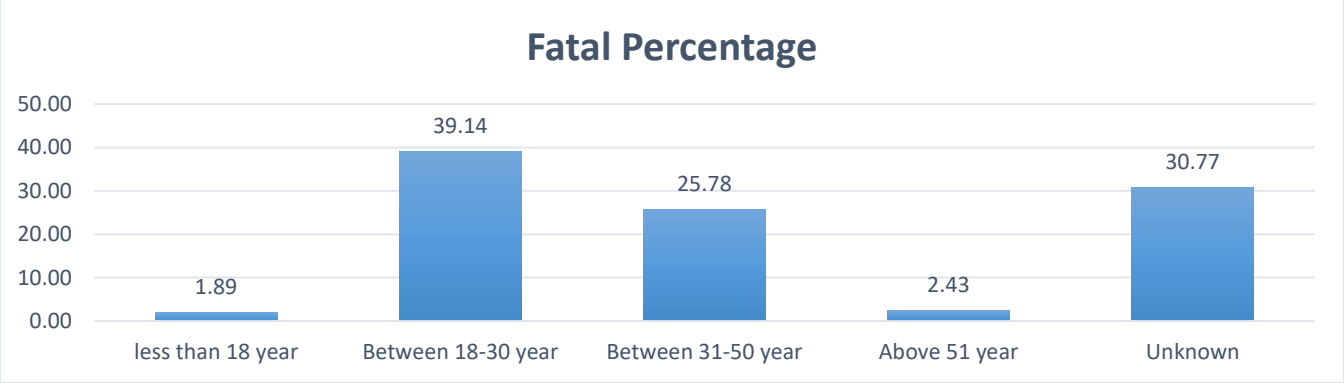
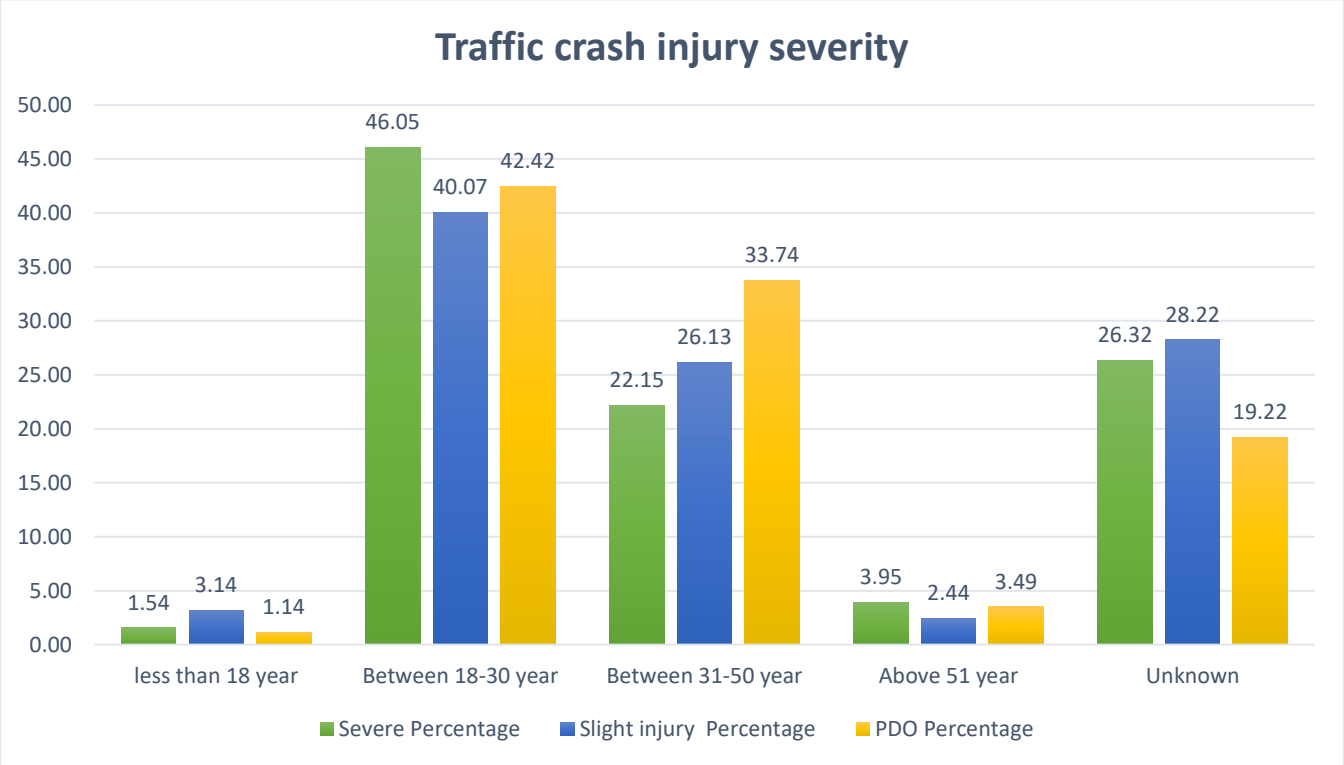
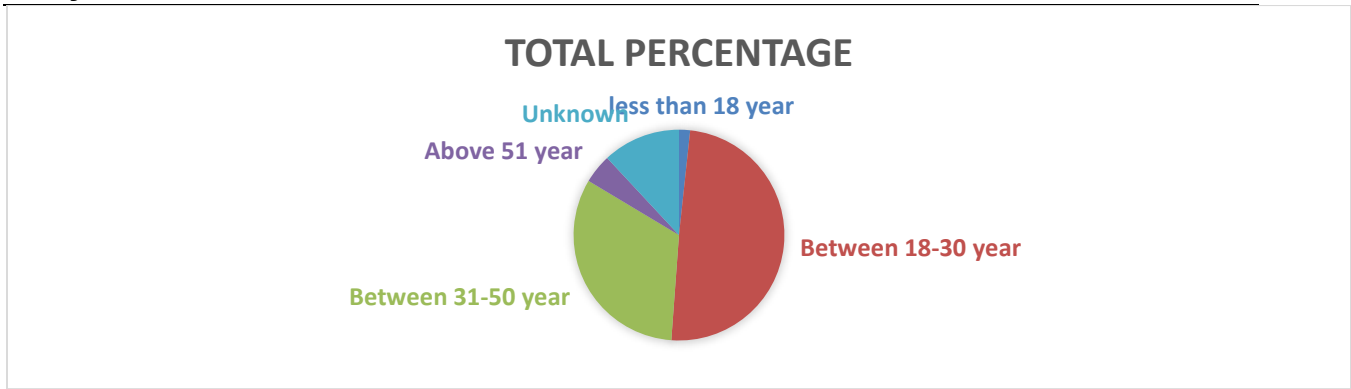
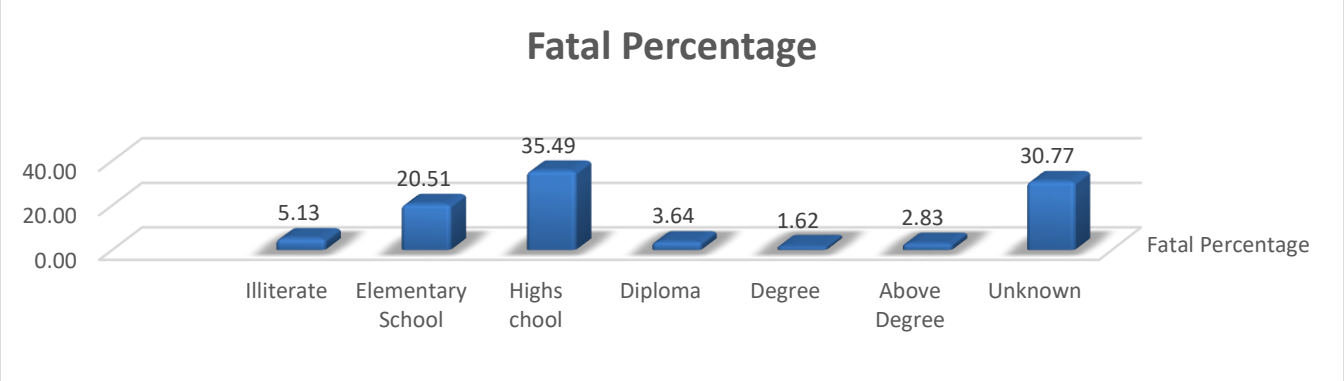
Days26
Days29
Days30

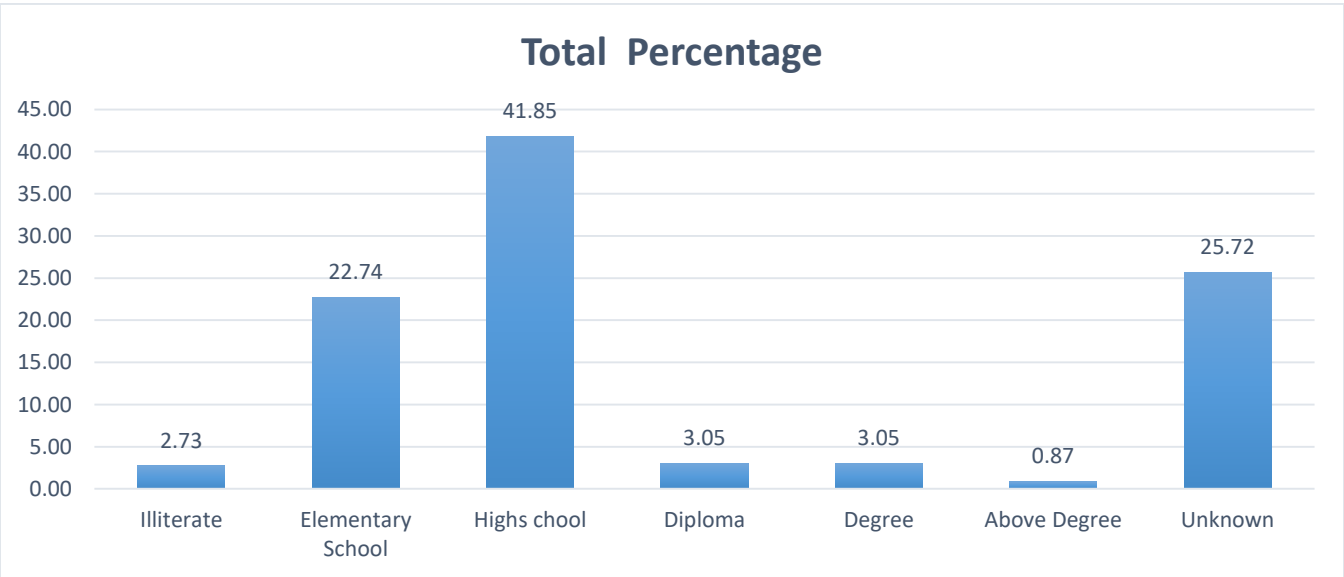

Fatal Percentage
50.00
40.00
30.00
20.00
10.00
0.00
1.89
39.14
25.78
2.43
30.77
less than 18 year
Between 18-30 year
Between 31-50 year
Above 51 year
Unknown

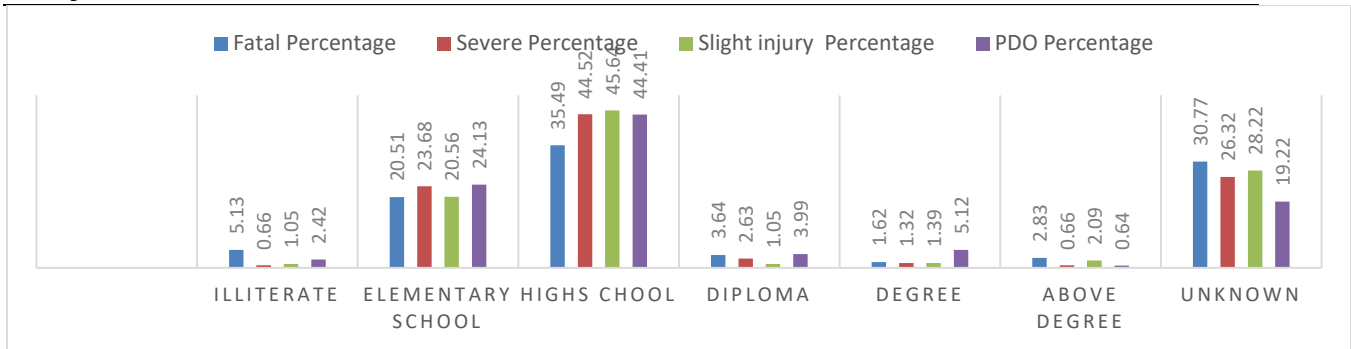

Traffic crash injury severity
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1.54
3.14
1.14
46.05
40.07
42.42
22.15
26.13
33.74
3.95
2.44
3.49
26.32
28.22
19.22
less than 18 year
Between 18-30 year
Between 31-50 year
Above 51 year
Unknown
Severe Percentage
Slight injury Percentage
PDO Percentage



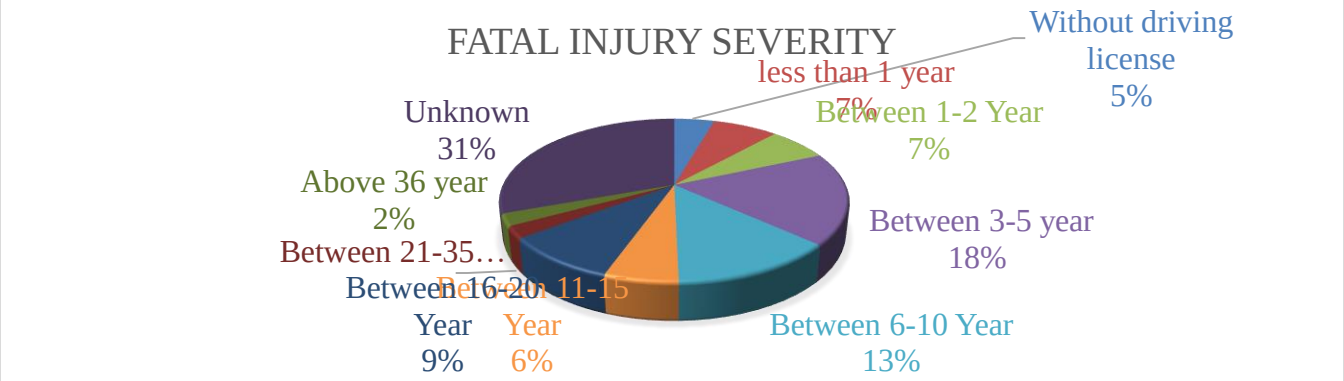
Road traffic crashes injury severity by education level for five years (2007-2011 E.C)

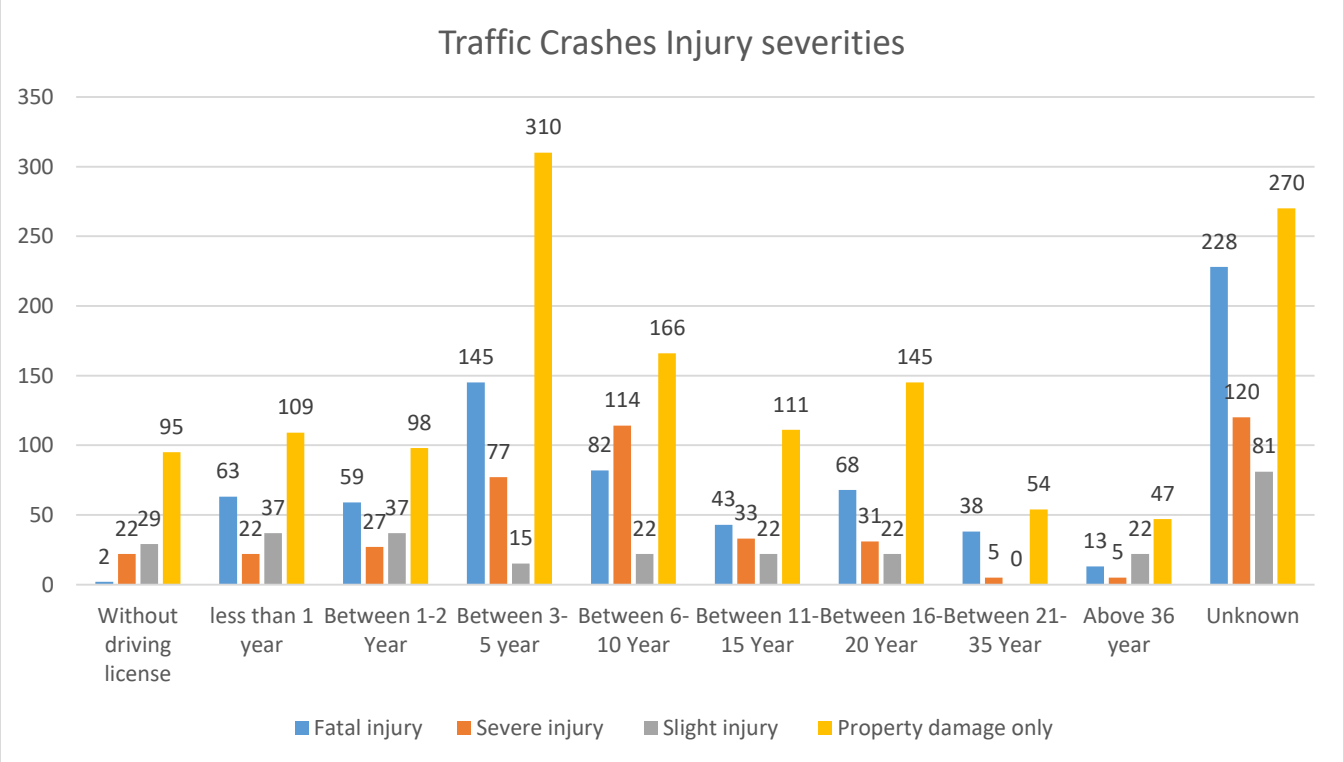


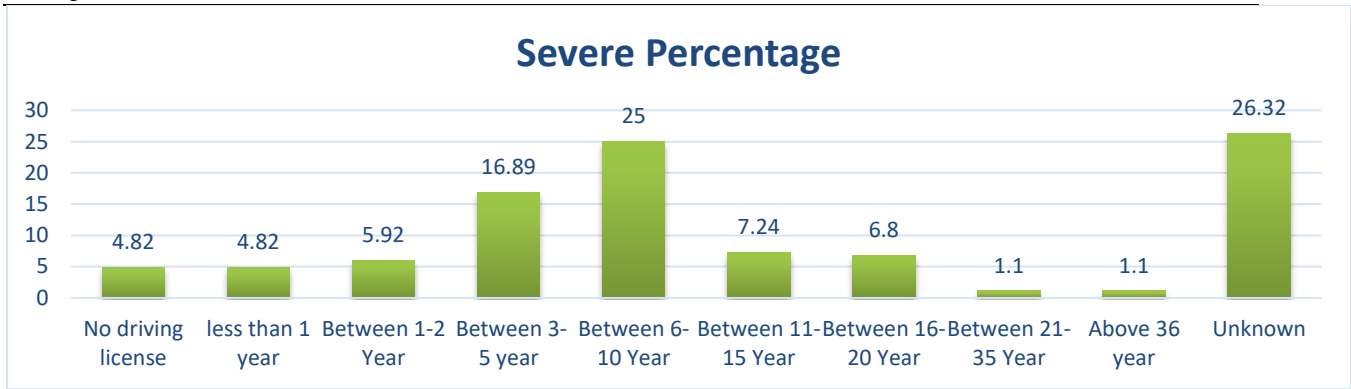


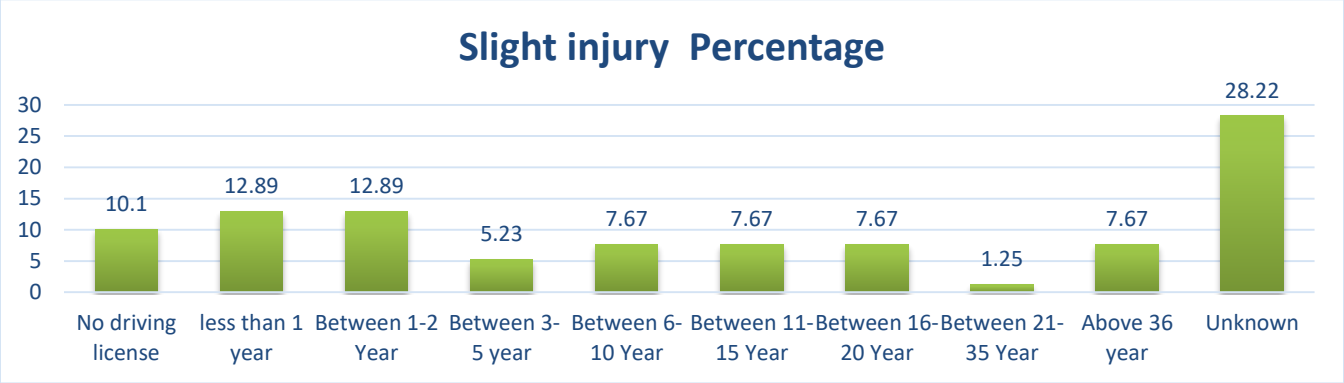


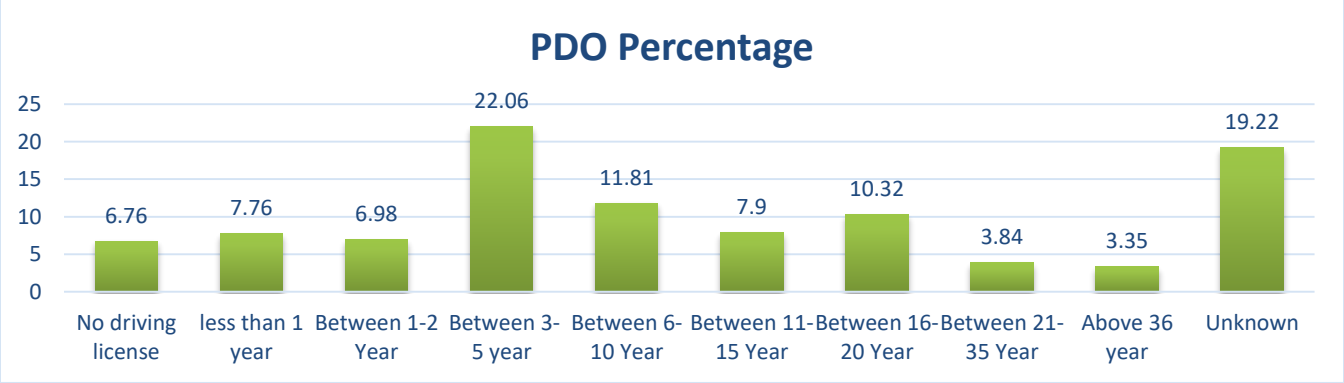
Road traffic crashes injury severity by drivers driving experience for five years (2007-2011 E.C)

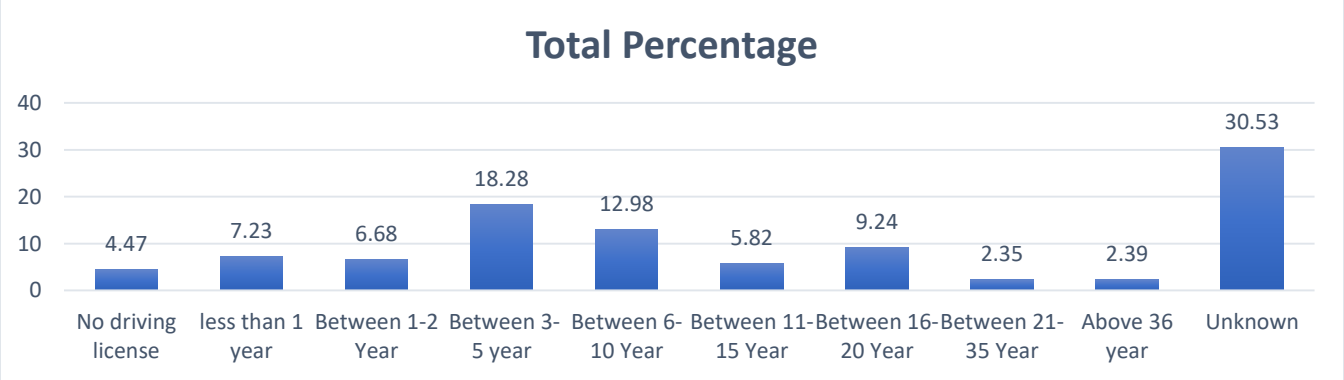




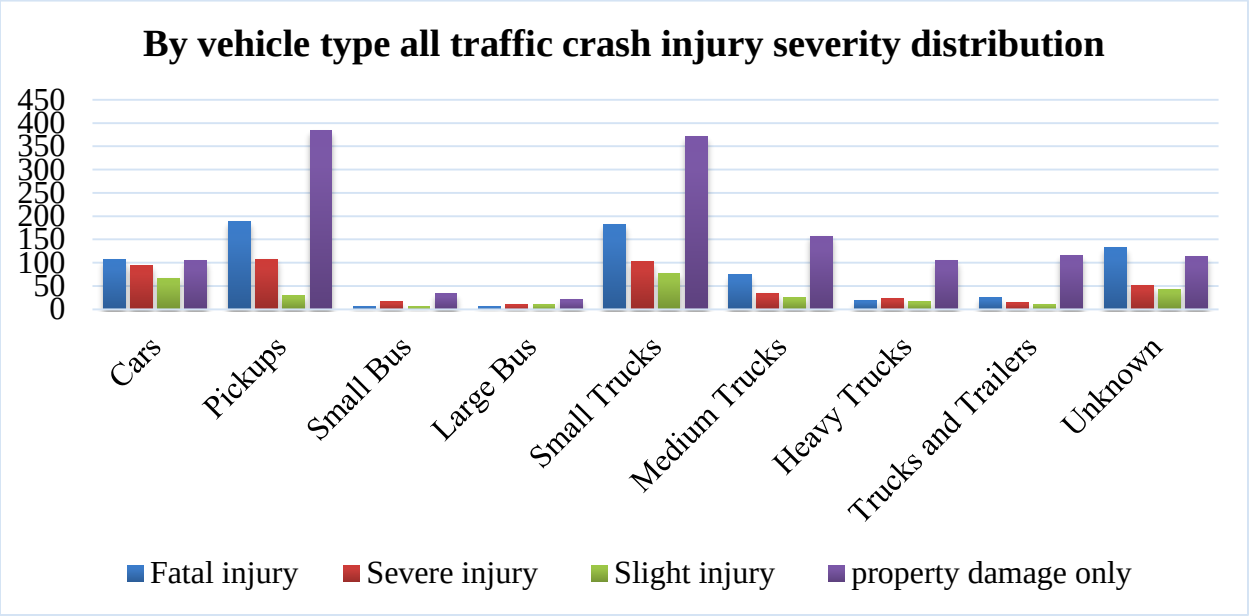

Severe Percentage
30
25
20
15
10
5
0
4.82
4.82
5.92
16.89
25
7.24
6.8
1.1
1.1
26.32
No driving license
less than 1 year
Between 1-2 Year
Between 3-5 year
Between 6-10 Year
Between 11-15 Year
Between 16-20 Year
Between 21-35 Year
Above 36 year
Unknown


Slight injury Percentage
30
25
20
15
10
5
0
10.1
12.89
12.89
5.23
7.67
7.67
7.67
1.25
7.67
28.22
No driving license
less than 1 year
Between 1-2 Year
Between 3-5 year
Between 6-10 Year
Between 11-15 Year
Between 16-20 Year
Between 21-35 Year
Above 36 year
Unknown

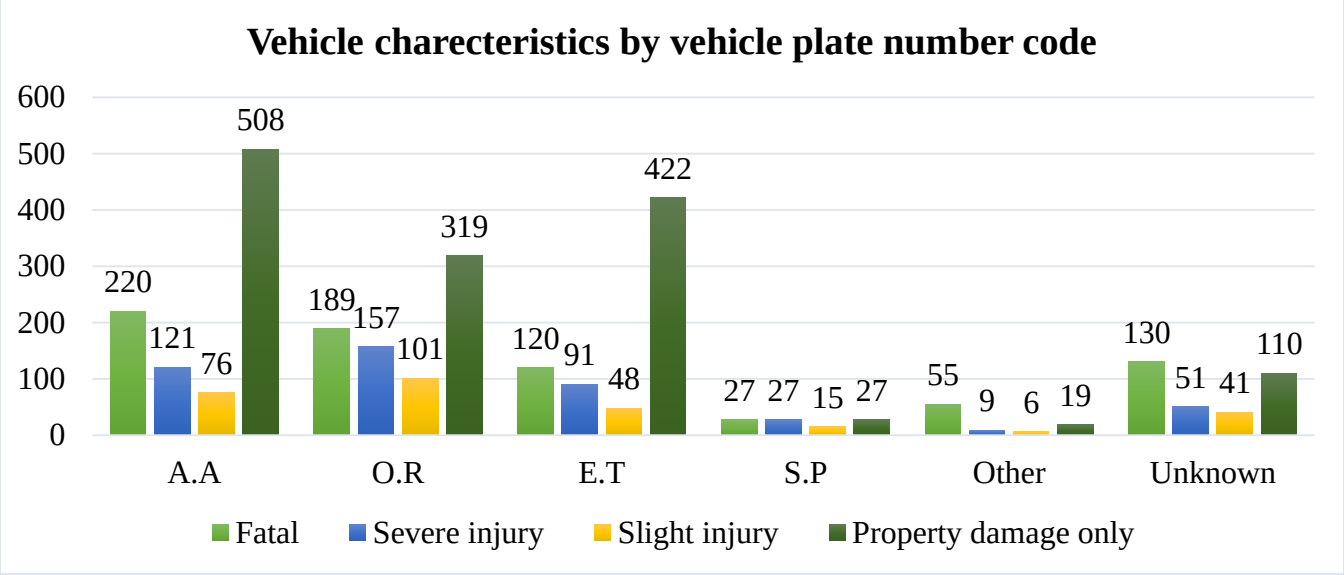

PDO Percentage
25
20
15
10
5
0
6.76
7.76
6.98
22.06
11.81
7.9
10.32
3.84
3.35
19.22
No driving license
less than 1 year
Between 1-2 Year
Between 3-5 year
Between 6-10 Year
Between 11-15 Year
Between 16-20 Year
Between 21-35 Year
Above 36 year
Unknown

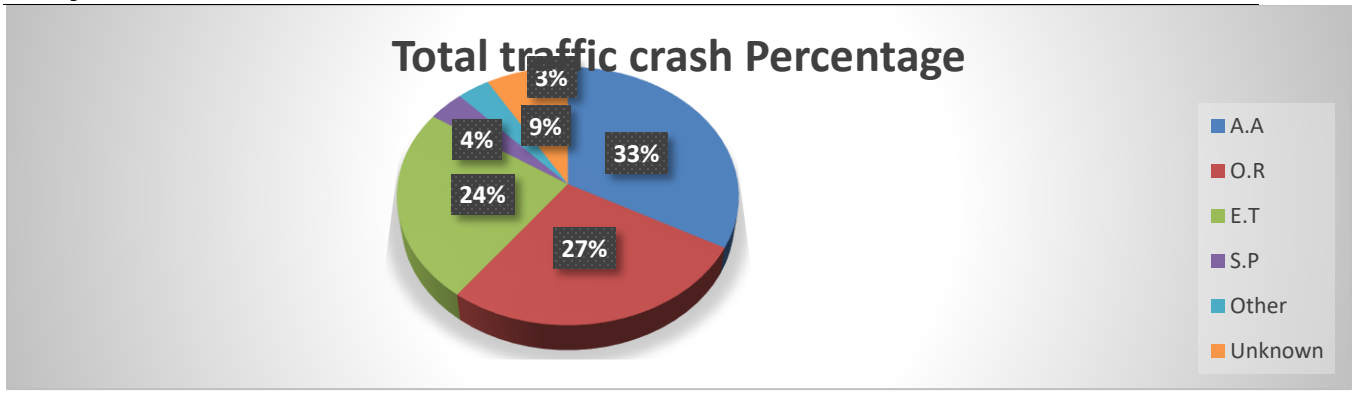

Total Percentage
40
30
20
10
0
4.47
7.23
6.68
18.28
12.98
5.82
9.24
2.35
2.39
30.53
No driving license
less than 1 year
Between 1-2 Year
Between 3-5 year
Between 6-10 Year
Between 11-15 Year
Between 16-20 Year
Between 21-35 Year
Above 36 year
Unknown

Road traffic crashes injury severity by vehicle type for five years (2007-2011 E.C)

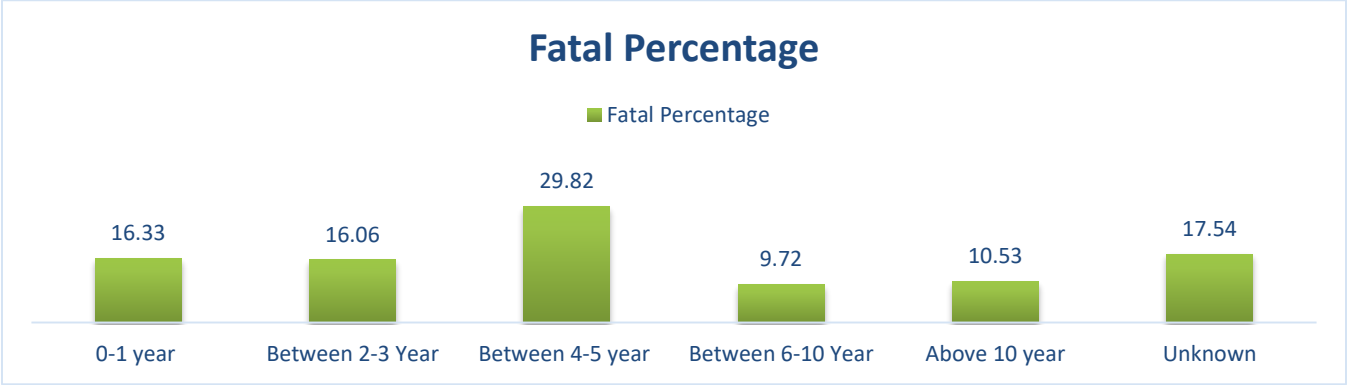


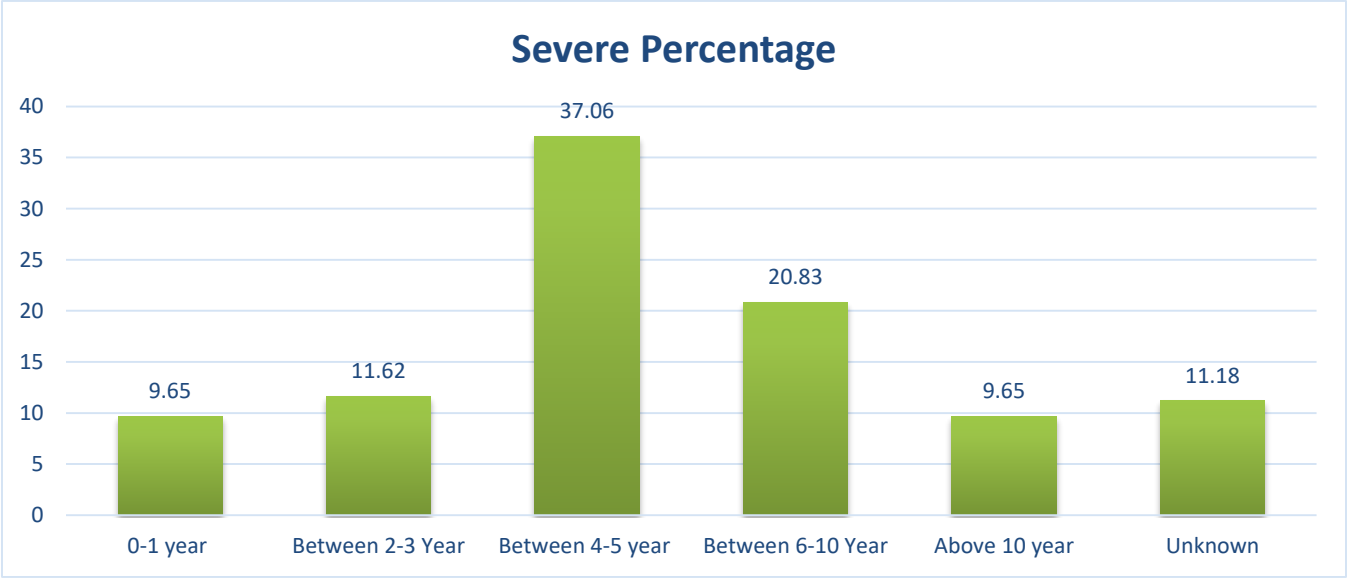
Road traffic crashes injury severity by vehicles by plate number code for five years (2007-2011 E.C)

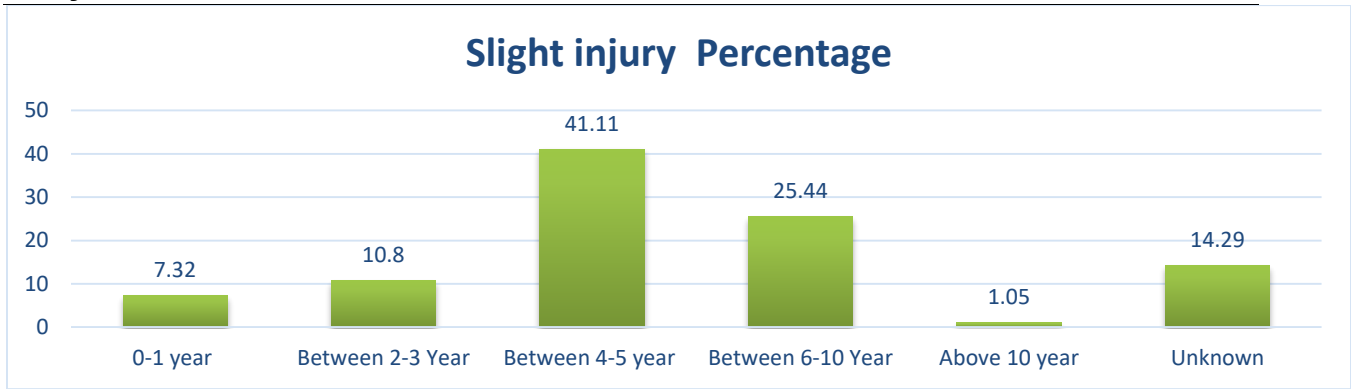


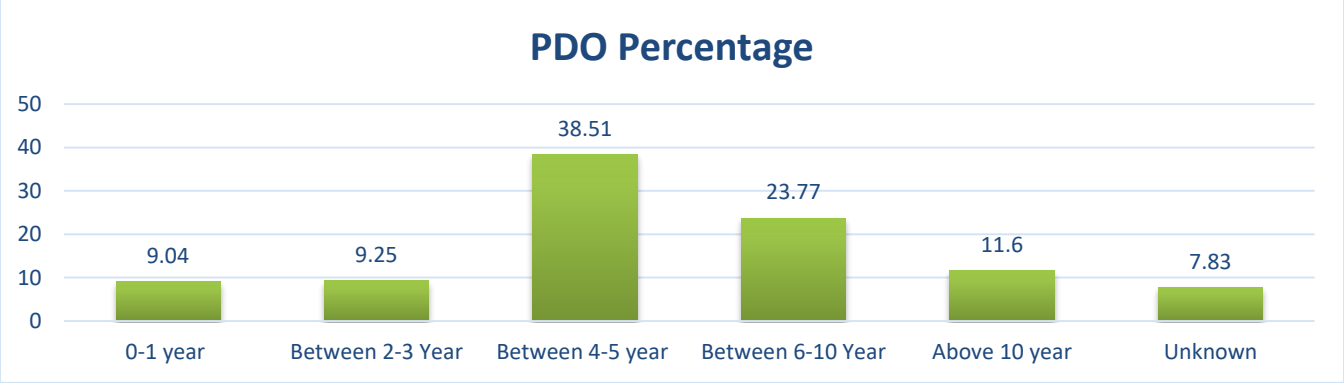


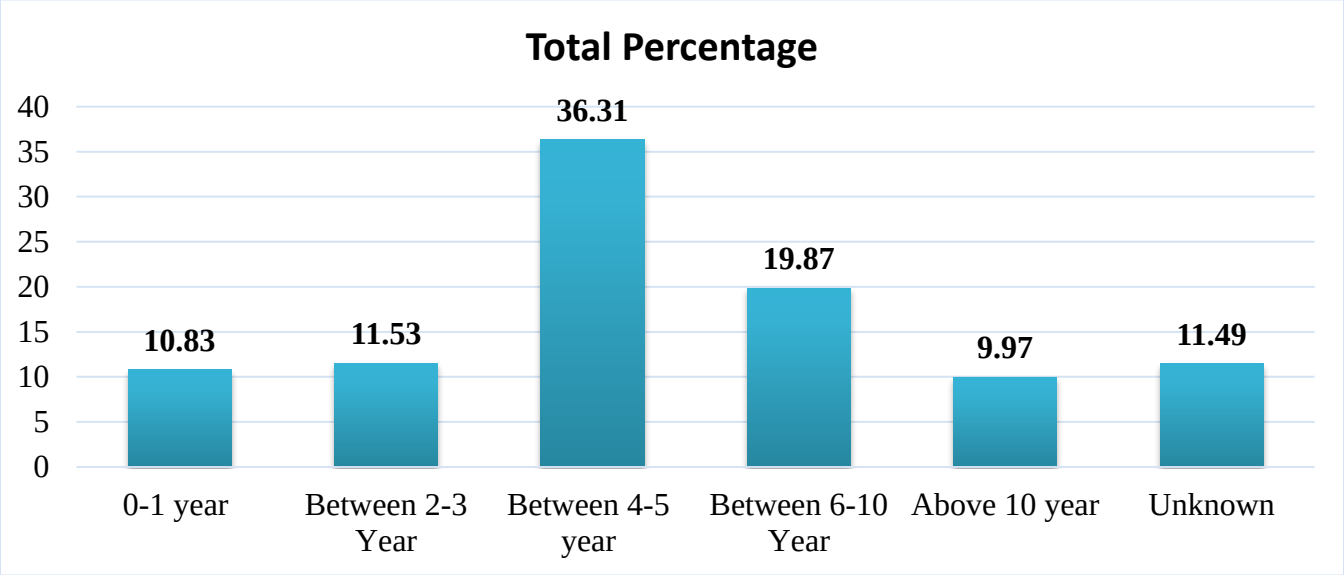
. Road traffic crashes injury severity by vehicles service year for five years (2007-2011 E.C)



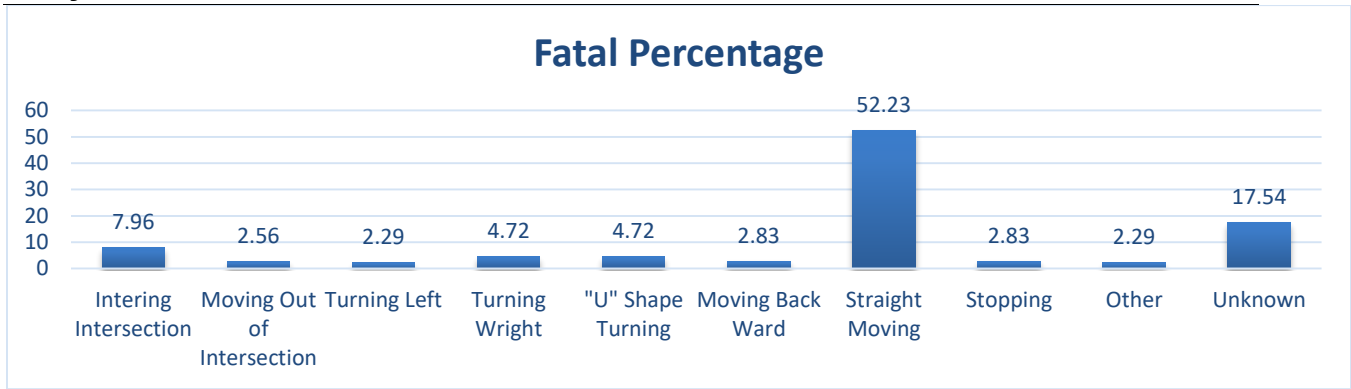


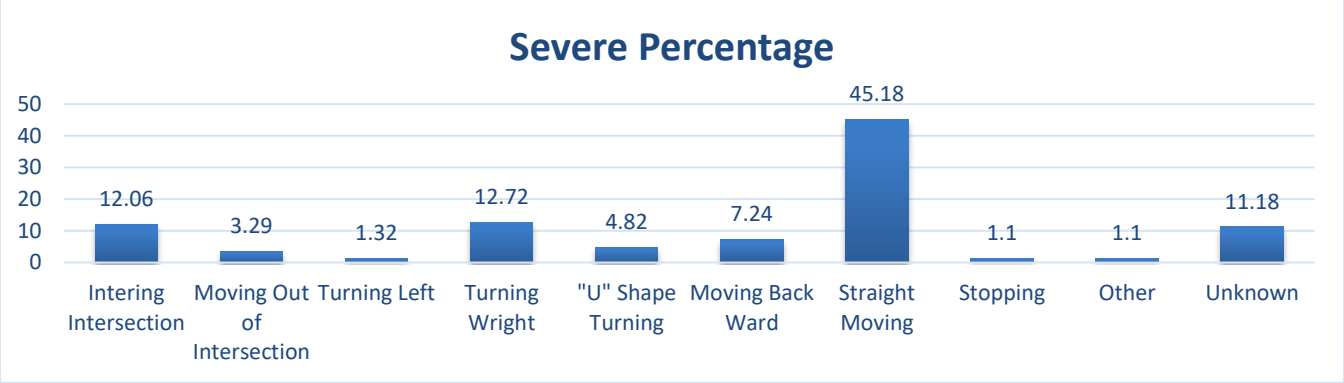


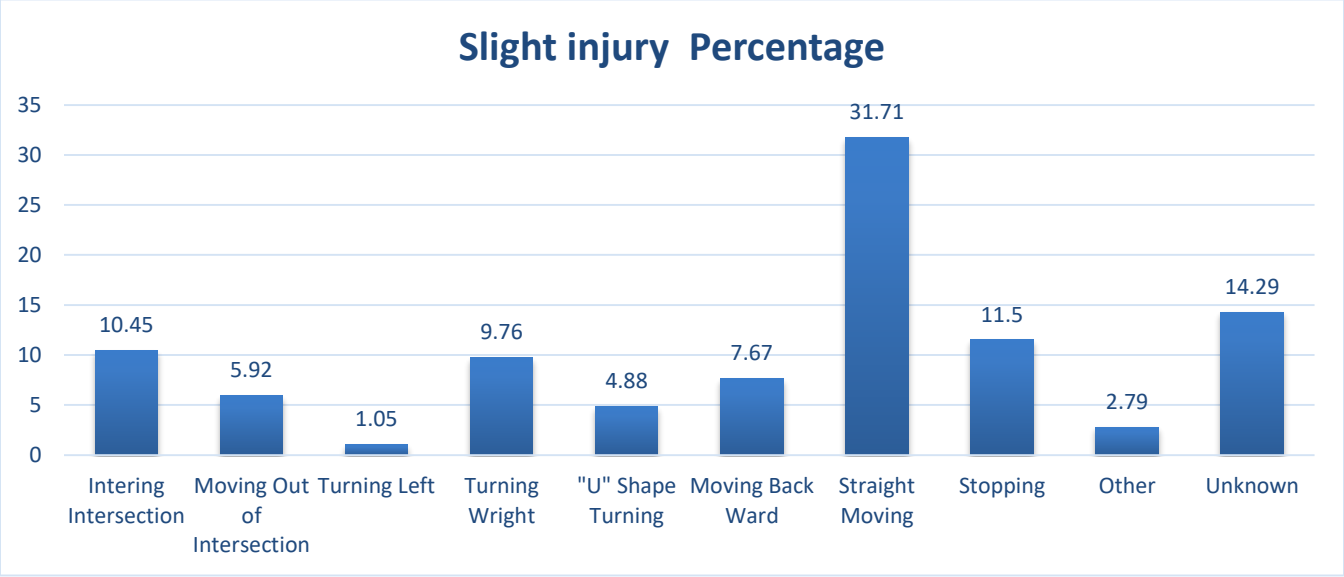


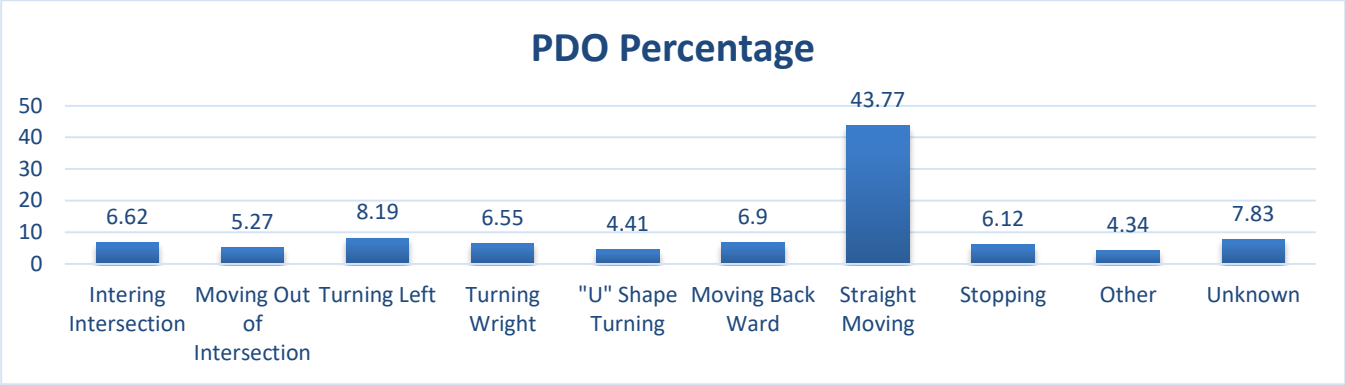


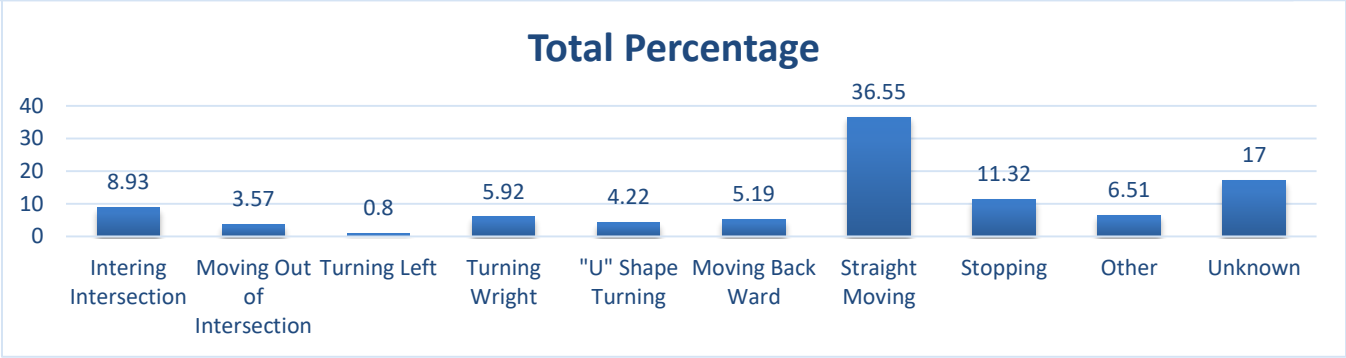
Road traffic crashes injury severity by Crash Causing Vehicle Movement for five years (2007-2011 E.C)


Fatal Percentage
60
50
40
30
20
10
0
7.96
2.56
2.29
4.72
4.72
2.83
52.23
2.83
2.29
17.54
Intering Intersection
Moving Out of Intersection
Turning Left
Turning Wright
"U" Shape Turning
Moving Back Ward
Straight Moving
Stopping
Other
Unknown

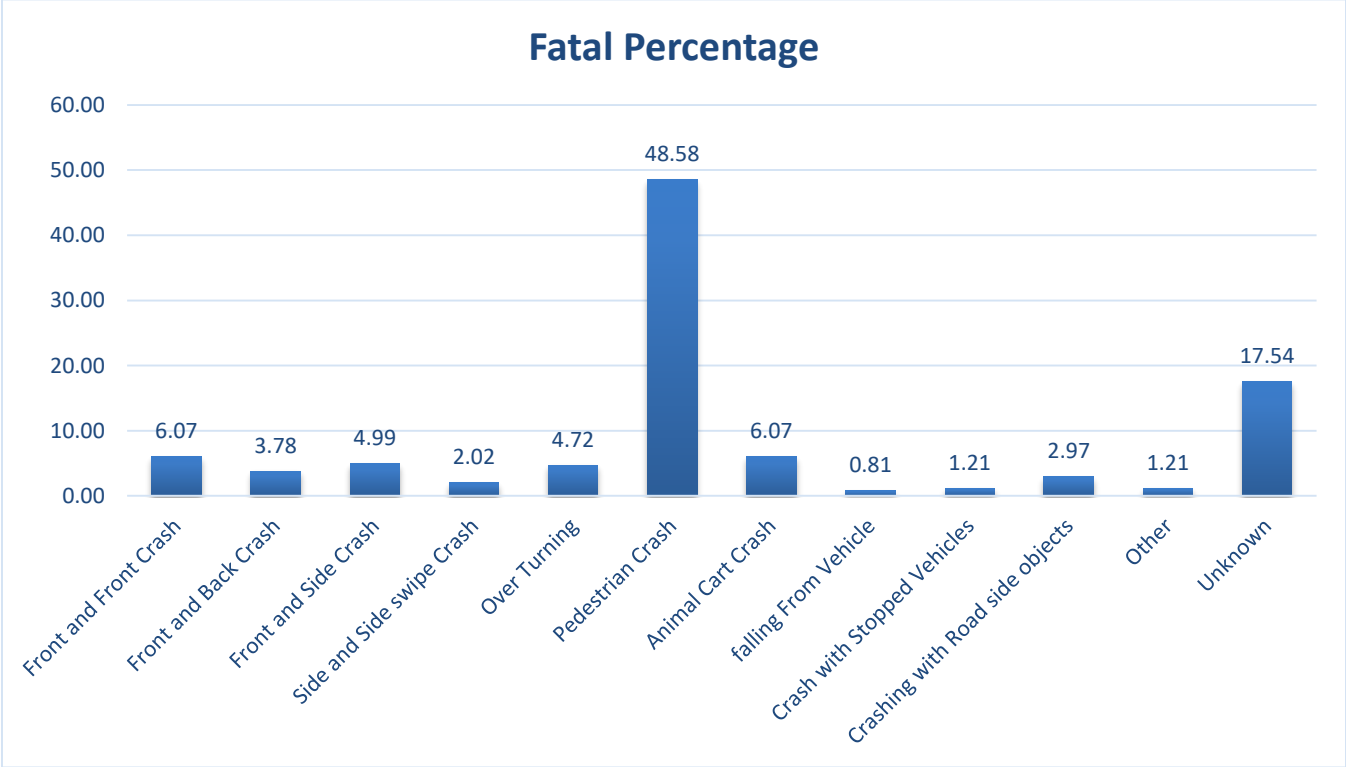

Severe Percentage
50
40
30
20
10
0
12.06
3.29
1.32
12.72
4.82
7.24
45.18
1.1
1.1
11.18
Intering Intersection
Moving Out of Intersection
Turning Left
Turning Wright
"U" Shape Turning
Moving Back Ward
Straight Moving
Stopping
Other
Unknown

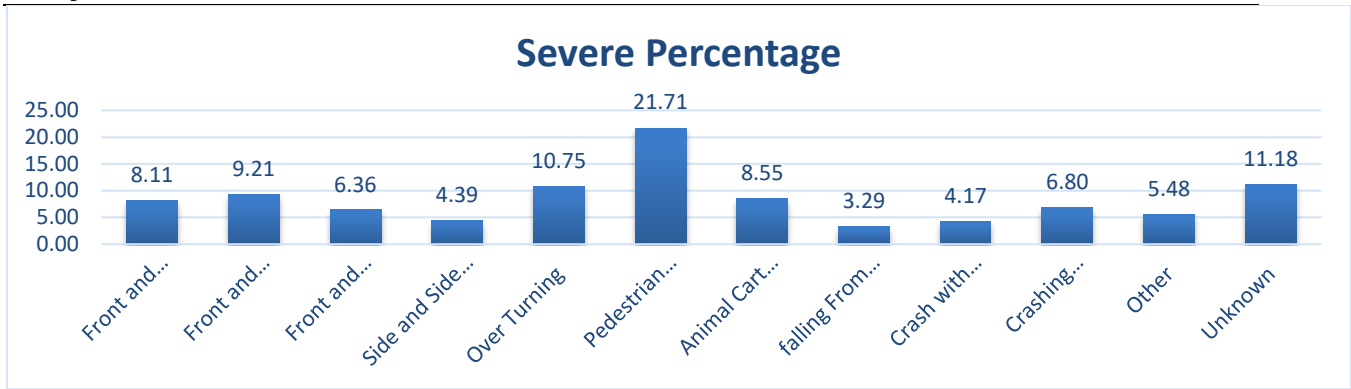

Slight injury Percentage
35
30
25
20
15
10
5
0
10.45
5.92
1.05
9.76
4.88
7.67
31.71
11.5
2.79
14.29
Intering Intersection
Moving Out of Intersection
Turning Left
Turning Wright
"U" Shape Turning
Moving Back Ward
Straight Moving
Stopping
Other
Unknown

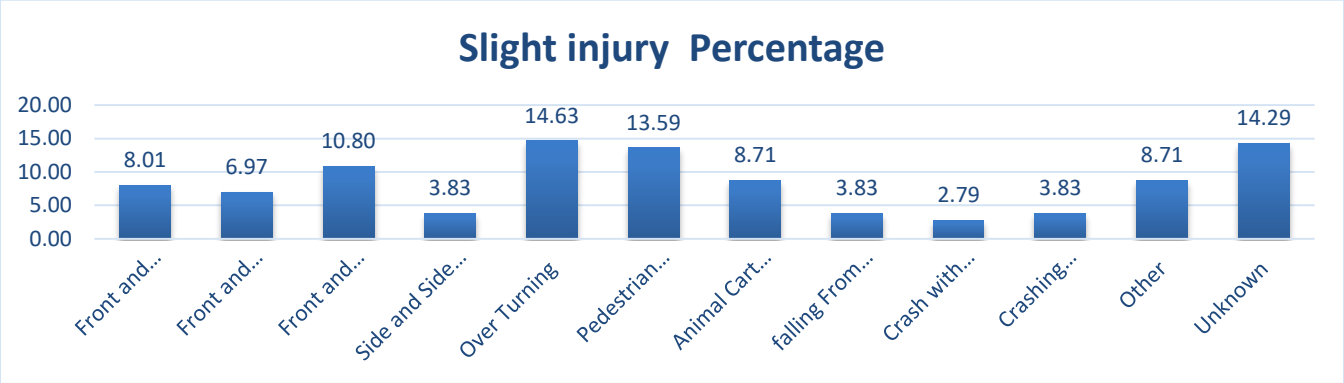


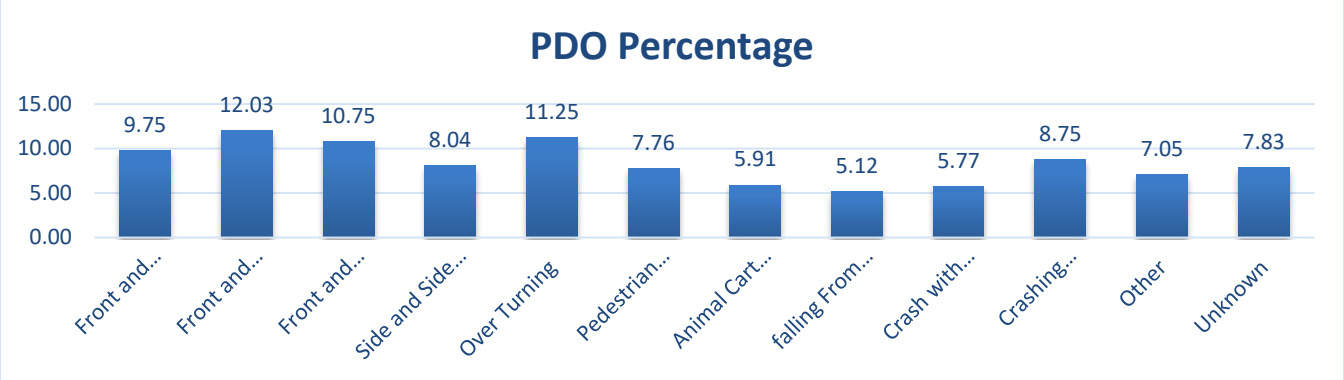


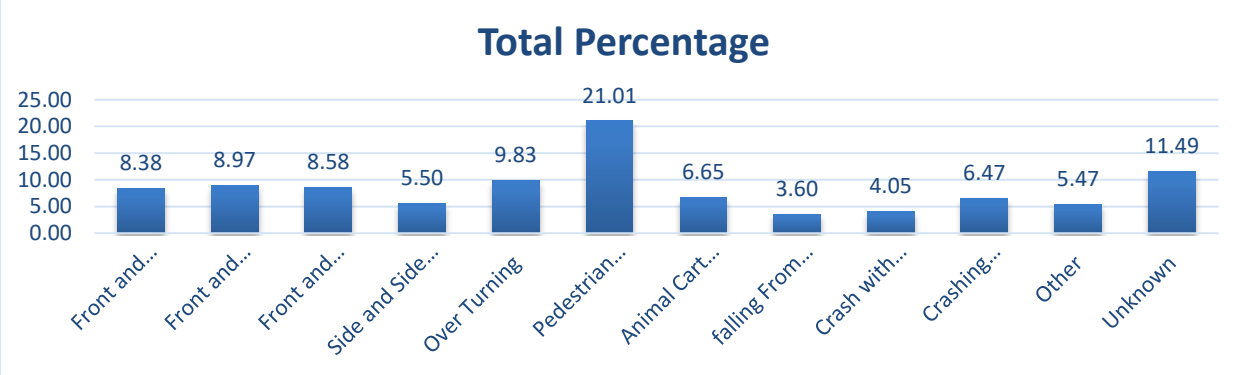
Road traffic crashes injury severity by types of vehicle crash for five years (2007-2011 E.C)



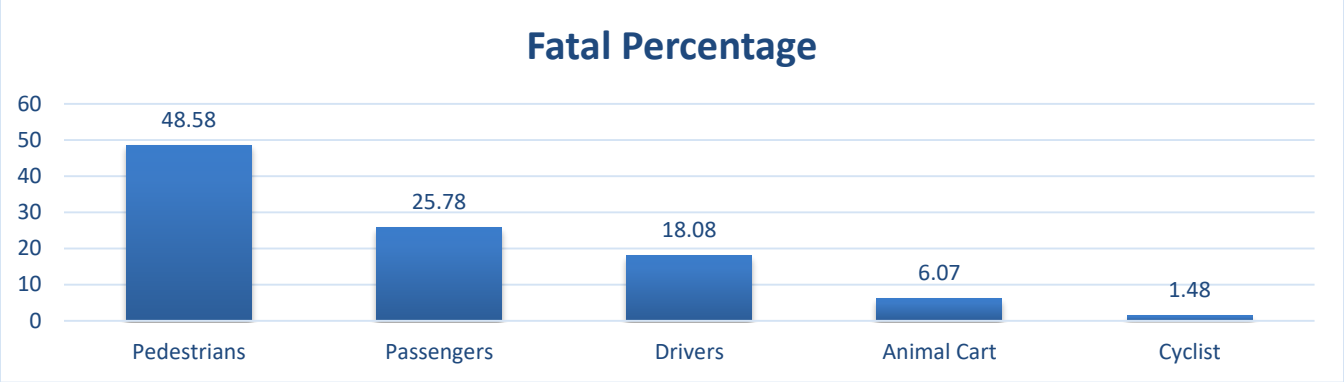

Severe Percentage
25.00
20.00
15.00
10.00
5.00
0.00
8.11
9.21
6.36
4.39
10.75
21.71
8.55
3.29
4.17
6.80
5.48
11.18
Front and...
Front and...
Front and...
Side and Side...
Over Turning
Pedestrian...
Animal Cart...
falling From...
Crash with...
Crashing...
Other
Unknown

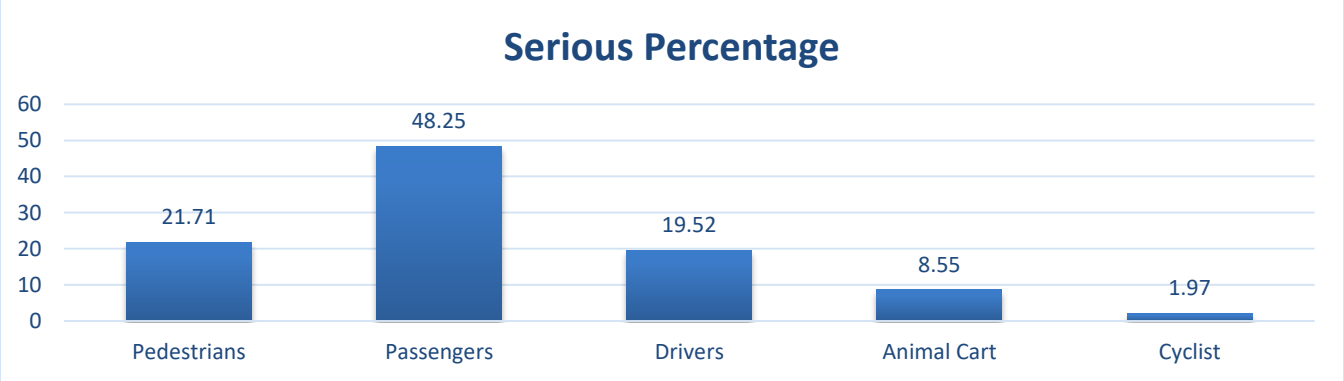

Slight injury Percentage
20.00
15.00
10.00
5.00
0.00
8.01
6.97
10.80
3.83
14.63
13.59
8.71
3.83
2.79
3.83
8.71
14.29
Front and...
Front and...
Front and...
Side and Side...
Over Turning
Pedestrian...
Animal Cart...
falling From...
Crash with...
Crashing...
Other
Unknown

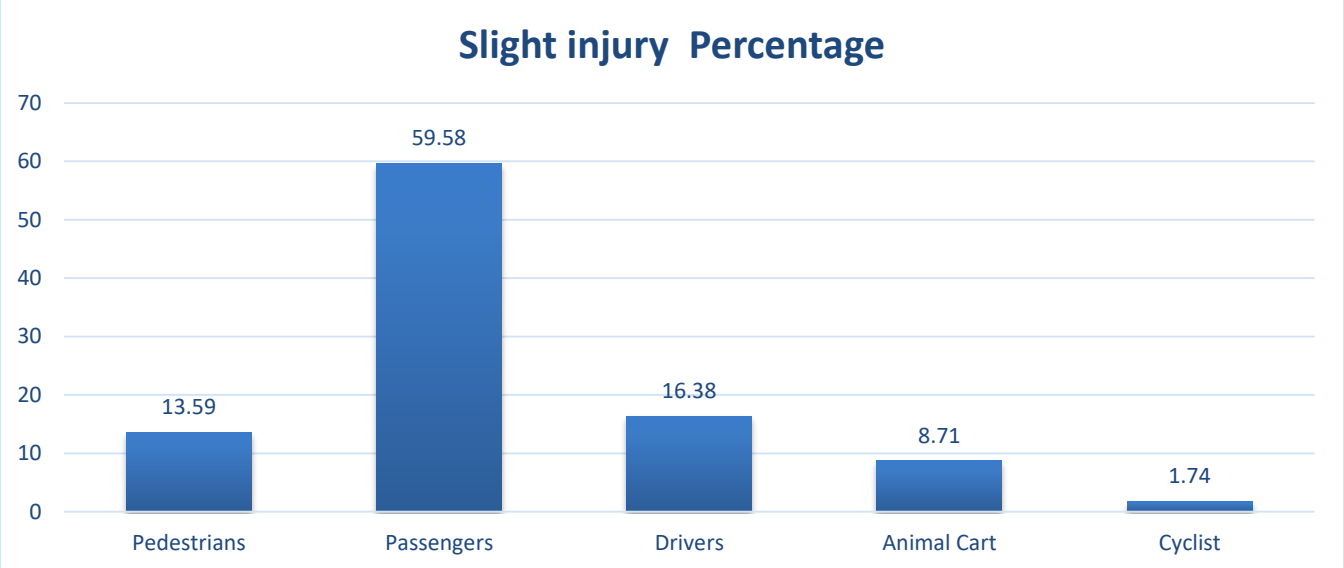

PDO Percentage
15.00
10.00
5.00
0.00
9.75
12.03
10.75
8.04
11.25
7.76
5.91
5.12
5.77
8.75
7.05
7.83
Front and...
Front and...
Front and...
Side and Side...
Over Turning
Pedestrian...
Animal Cart...
falling From...
Crash with...
Crashing...
Other
Unknown


Total Percentage
25.00
20.00
15.00
10.00
5.00
0.00
8.38
8.97
8.58
5.50
9.83
21.01
6.65
3.60
4.05
6.47
5.47
11.49
Front and...
Front and...
Front and...
Side and Side...
Over Turning
Pedestrian...
Animal Cart...
falling From...
Crash with...
Crashing...
Other
Unknown

Road traffic crashes injury severity by crash victim peoples for five years (2007-2011 E.C)







APPENDIX B1: ETHIOPIA ROADWAY TOTAL TRAFFIC CRASHES PER REGIONS

Table AB1. Ethiopia Roadway total traffic crashes per regions and two city for five years (2007-2011 E.C)

No	Regions	2007	2008	2009	2010	2011	Total	Percentage
1	Tigray	1267	1447	1391	1807	2223	8135	3.54
2	Afar	257	309	374	505	711	2156	0.94
3	Amara	3449	3915	4215	4731	5322	21632	9.40
4	Oromia	7357	4949	4485	5144	5958	27893	12.13
5	Somali	236	352	961	1755	2291	5595	2.43
6	B/gumz	205	487	652	1136	1815	4295	1.87
7	South	1808	2037	2561	3125	3950	13481	5.86
8	Gambella	148	172	155	406	6230	7111	3.09
9	Hareri	370	256	460	613	906	2605	1.13
10	AA	20432	22939	26942	28364	29546	128223	55.75
11	D/Dawa	325	345	352	598	7261	8881	3.86
	Total	35854	37208	42548	48184	66213	230007	100.00

Source: Addis Ababa City and Ethiopian federal traffic police commissions

APPENDIX C1: SAMPLE TRAFFIC COUNT DATA

ROAD VEHICLE COUNT SUMMARY SHEET

Date	car	L/Rover	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	T/Truck	Total
1/7/2016	140	1139	158	116	127	133	145	149	2107
2/7/2016	163	183	198	114	168	182	171	176	1355
3/7/2016(i)	208	210	222	116	210	196	195	185	1542
3/7/2016(ii)	82	86	110	52	82	134	78	114	738
4/7/2016	316	227	254	162	251	208	164	181	1763
5/7/2016	228	235	252	164	233	231	238	237	1818
6/7/2016(iii)	87	95	88	50	77	132	119	122	770
6/7/2016(iv)	181	223	235	194	205	193	183	222	1636
7/7/2016	195	205	232	114	197	209	200	193	1545

Source: ERA Shashemene district. Note. i. Working day ii. Night iii. Weekend iv. Night these collection also consider market day and non-market day for full day traffic data collection

Enumerators

Location: Children Amba 1. 91597 Name: Kelil Gelgalu

Direction: Bulbula 2. 17855 Name: Gebita Wariyo