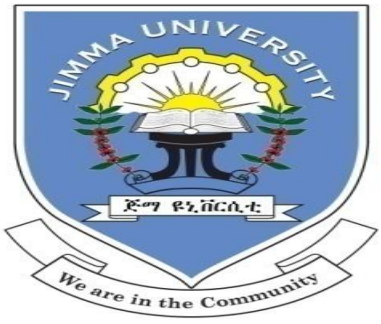

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SCHOOL OF GRADUATE STUDY

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FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

HIGHWAY ENGINEERING STREAM

Investigation on Contributory Factors to Accident Severity and Crash Loss Value: A Case Study on Addis Ababa–Adama Expressway

A Research Thesis Submitted to School of Graduate Studies of Jimma University; In Partial Fulfillment of the Requirement for the Degree of Master of Science in Civil Engineering (Highway Engineering).

By:

Biruk Kebede

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APPROVED BY BOARD OF EXAMINERS

1. Dr. Bikila Teklu	bikila teklu	22/11/17
External Examiner	Signature	Date
2. Engr. Murad Muhammed,MSc	_____	_____/_____/_____
Internal Examiner	Signature	Date
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Main advisor	Signature	Date
5. Engr. Markos Tesgaye, MSc	_____	_____/_____/_____
Co-advisor	Signature	Date

DECLARATION

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

Name: Biruk Kebede

Place: Jimma, Oromia, Ethiopia

Date of submission: _____

Signature: _____

Title of the thesis:

Investigation on Contributory Factors to Accident Severity and Crash Loss Values: A Case Study on Addis Ababa- Adama Expressway.

I have submitted this thesis for examination with my approval as university Adviser for the above mentioned title**.**

Advisor

Name: Prof.Dr.Ing. Alemayehu Gebissa

Signature: _____

Date: _____

Co-advisor

Name:Markos Tsegaye (Msc)

Signature: _____

Date: _____

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ABSTRACT

Road traffic accidents occur due to several factors associated with traffic system. The cause of traffic accident can be group in to four main factors, namely: human factors, vehicle factors, road factors and environmental factors. Road traffic accidents (RATs) are currently serious and major public health problem in developed and developing countries. In developing countries like Ethiopia RTAs are among the leading and top cause of death and injury.

Nowadays in Ethiopia road fatalities and injuries are major killer problem. The expressway that connects Addis Ababa to Adama is one of new and latest among the roads in Ethiopia. But the accident occurred on expressway increase day to day. The occurrence of the accident has many contributory factors. However, among the contributory factors it is vital to select major factors and give measures how prevent the causes. The main objective of the study was to investigate the contributory factors to accident severity and the crash loss values on the expressway.

Primary and secondary data used to meet the objective of the thesis. Primary data collected by questionnaires were distributed to drivers and interview also made. Secondary data was collected from Ethiopian toll road enterprise. During the study period 2014/15 to 2016/2017 total of 1171 reported accidents was collected and out of this 70 fatalities 147 serious, 344 lights and 610 properties damage were reported. To analyze the data descriptive analysis and statistical package for social science was used.

The result of the study showed that higher traffic accident cause by male drivers compared to female drivers. Also the study finds the age groups of 18-30 were mostly affected age of drivers. From the day of the week Sunday was the highest traffic accident were recorded. And also accidents varies throughout the time of the day, hence starting from mid-day (12:00PM) to night time (6:00PM) were the highest accident were recorded. During dry surface condition and straight and level of road character the occurrence of the accident were highest. The reported data on the expressway shows most of accidents occurred by vehicle type of bus (13-65 seats), automobiles and truck (11-40 quintals). Due to this the occurrence of the accident on the expressway an average 32,240,400 birr was loss.

The result shows age of driver, sex of driver, time of day, day of week, road character, surface condition, weather condition and possible causes reported by traffic police (over speed, unethical driving (reckless driving, driving under influence, fatigue, not use seat belts, sleeping, breaking problem, tire problem, animal entrance and technical problem) have statistically significant impact on the occurrence of accidents. Based on reported and surveyed data the cause and contributing factors on the expressway were over speed, unethical driving (reckless driving, driving under influence), fatigue, not use seat belts, sleeping, breaking problem, tire problem, animal entrance and technical problem. Hence to prevent and reduce the occurrence of accident on the expressway the researcher recommended some possible measures. These measures are appropriate driving training program, education, making policy or legislation and enforcement have been forwarded for the responsible government and road users.

Key words: accident severity, contributory factors, road traffic accident, loss values

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ACRONYMS

AACRA	Addis Ababa City Authority
AADT	Annual Average Daily Traffic
ANSI	American National Standard
ERA	Ethiopian Road Authority
ETRE	Ethiopian Toll Road Enterprise
HSM	Highway Safety Manual
HISI	Highway Safety Information System
NRSCO	National Road Safety Coordination Office
PDO	Property Damage Only
RAs	Road Accidents
RTAs	Road Traffic Accidents
RTIs	Road Traffic Injuries
Sig.	Significance
NNECA	United Nations Economic Commission for Africa
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1. Background

Everybody travels from one place to another place weather it is to work or do business. All raw materials must be conveyed from the land or from the place of hoard to the place of manufacturing or usage, and all manufactured goods must be moved from factory to the market place and from the staff to the customer. Transport is the means by which those activities occur; it is the cement that binds together the communities and their day to day activities. Meeting these needs has been, and continues to be, the transport tasks. How people lives and work has changed as a consequence of improvements in life style and in transport capabilities. What can be said with certain about the future is that these interactive changes will continue, and that it will be the task of the transport planner and traffic engineer to cope with them [1].

Road traffic accident is defined as any vehicle accidents occurring on public highway. It includes collision between vehicle and animals, vehicles and pedestrian, vehicles and fixed objects or vehicles and vehicles. Road traffic deaths accounted for 23% of all injury deaths worldwide in 2002 [2].

Road traffic injuries claim more than 1.2 million lives each year and have a huge impact on health and development [3]. They are the leading cause of death among young people aged between 15 and 29 years, and cost of government approximately 3% of GDP [3]. Despite this massive and largely preventable human and economic toll, action to combat this global challenge has been insufficient. Most of these deaths are in low and middle income countries where repaid economic growth has been

accompanied by increased motorization and road traffic injuries. As well as being a public health problem [3].

Accidents are a drain on the national economy and may lead to disablement, death, damage to health and property, social suffering and general degradation of environment. To minimize the number of crashes by any kind of severity expected to occur on the entity during specific period is known as road safety. Accidents and the fatalities on the road are the result of inter-play of a number of factors. Road users in India are heterogeneous in nature ranging from pedestrian ,animals-driven carts, bicycles, rickshaws, hand carts and tractor trolleys, to various categories of two/three wheelers, motor cars, buses, trucks, and multi axels commercial vehicles etc. The vehicle population has been steadily increasing because of change in the style of living f people. Increase in vehicle population with limited road space used by a large variety of vehicles people has heightened the need and urgency for a well thought-out policy on the issue of Road Safety [4].

1.2. Statement of Problem

The problem is more severe when it comes to the African content, particularly the sub-Saharan Africa. In this part of the continents, about 10% of global road deaths take place despite the fact that only 4%of the global vehicle population is registered in the region [5]. In the developing countries, road traffic accident is the major factor that brings about death next to those caused by natural factors. They do have great impact on economic and social activities. Road accidents cause all kind of losses. Other than the loss of life and injured, there is also loss of means of transportation and fresh expenditure for purchasing new vehicles or repairing damaged ones. These scarce resources could be used more profitably elsewhere [6].

Road traffic injuries are growing day to day as the vehicle use of developing countries rises. By 2020, road traffic accidents are expected to be the third leading cause of death and disability throughout worldwide, by some calculation matching the toll of AIDS [2].

Ethiopia as one of the developing countries has one of the world's worst road accident records as a measured by fatality rate of 170 fatalities per 10,000 motor vehicles [7]. Ethiopia currently losses almost 1700 lives each year, another 7500 are injured, and further 7783 face property damage only due to accidents [7]. In the last Ethiopian fiscal year (2007/8), police reported 15,086 accidents which caused the losses of 2,161 lives and over 82 million ETB equivalent to US$7.3 million (cost estimate of property damage by traffic police) [8].

Road crashes have been in on an increasing trend in the last decade or so. This has led the researchers to think of this problem and find possible causes and precautionary measures to prevent crashes [9]. The number of road accidents and the level of accident severity have been extensively applied as the indicators for measuring the efficiency of service provision in road network system of each country.

Nowadays Ethiopia has major problem on road accident. Traffic accident is increased from time to time on expressway that connects Addis Ababa to Adama. Therefore understanding the cause of accident severity and giving the appropriate solution is important. In this research it is tried to investigate the contributory factors to accident severity and crash loss value on Addis Ababa Adama expressway.

1.3 Objective of the Study

1.3.1. General objective

The main objective of this research was to investigate the contributory factors to accidents severity and crash loss values on the Addis Ababa to Adama expressway.

1.3.2. Specific objectives

- To examine the extent and temporal variation of accidents on Addis-Adama expressway.
- To identify the major causes and contributory factors of accident on Addis-Adama express way.
- To estimate the economic loss through accident on Addis-Adama essway.
- To provide the possible measures to minimize the accident on Addis-Adama expressway.

1.4. Research Question

1. What is the extent and temporal variation of accident on expressway?
2. What are the major factors and contributory that cause accidents on expressway?
3. How much is it the economic loss of the accident?
4. What are the possible measures to minimize the accident on expressway?

1.5. Significance of the study

Road transportation is the main vein of the nation and its people by providing the access of movement from one place to another also the movement of their goods but know a day to perform day to day activities is hard because of road traffic accident. Studying the cause and giving the appropriate solution is essential to stop or reduce the problem. Hence the current study has the importance of:-

- Give detail information about the cause of the accident.
- Detail information on the crash loss value on the expressway.
- Increase the knowledge for the road user about the issue.
- Highlight and recommend the possible measurement on the issue for responsible authority.

1.6. Scope of the study

The study focus on investigation of contributory factors and its crash loss values and also countermeasures were proposed for the accident occurred on Addis Ababa Adama expressway. Information and data on accident statistics employed in the study. But some accident data recorded without full information. Due to the shortage of time only direct accident cost was computed.

1.7. Limitation of Study

There are limitations on the thesis; mainly there were incomplete and inconsistent records. The researcher also consider very limited representative sample of respondent in questionnaires an interview to the supplement of data collected from Ethiopian toll road enterprises(ETRE). The study has been limited to analyzing the detail magnitude of traffic accidents occurred by the road factors and environmental factors due to lack of as built and insufficient data.

1.8. Organization of the research

The research organized in five chapters. Chapter one is an introduction of the paper and contains statement of the problem, objectives, significance of the study, scope, limitation and organization of the paper. Chapter two presents an over view of road traffic accident and related topics. Chapter three is containing the methods used to conduct the research were described and detailed methods presented. In chapter four result and discussions were presented, Characterization of the road traffic accident was discussed and analyses of the accident were under taken in order to identify the cause. Finally in chapter five based on the analysis and discussion the paper comes up with conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This part contains the review of previous studies on causes of road traffic accidents and possible counter measures which were contributed by different researchers. The occurrences of traffic accidents are rare and random in space and time. However, road safety and road incident reduction are related to many other fields of activity such as education, driver training, publicity campaigns, police enforcement, road traffic policing, the court system, the National Health Service and Vehicle engineering [10].

2.2. Definition of traffic Accident

2.2.1. What is traffic?

Traffic can be defined as the movement of pedestrians and goods along a route, and in the 21-century the biggest problem and challenge for the traffic engineer is often imbalance between the amount of traffic and the capacity of the route, leading to congestions. Traffic congestions are not a new phenomenon. Roman history recorded that the streets of Rome were so clogged with traffic that at least one emperor was forced to issue a proclamation threatening the death penalty to those whose chariots and cars blocked the way. More recently pictures of our modern cities taken at the turn of the century show clogged with traffic [1].

The dictionaries define “traffic” as the transportation of goods, coming and going of persons or goods by road, rail, air, etc. Traffic engineering deals with the traffic planning and designs of roads, of frontage development and of parking facilities and with the concern of traffic to provide safe, convenient and economic movement of vehicle and pedestrians. Traffic engineer is used to either improve an existing situation or, in the case of new facility, to insure that the facility is correctly and

safely designed and adequate for the demands that will be placed on it [1].

2.2.2. Road traffic accident

Road traffic accident is defined as any vehicle accident occurring on a public highway. It includes collisions between vehicles and animals, vehicles and pedestrians, vehicles and fixed objects or vehicles and vehicles. Road traffic deaths accounted for 23% of all injury deaths worldwide in 2002 [2].

Semarang Government Regulation No. 43 Year 1993 on Infrastructure and Then Cross, which is the translation of Act No. 14 of 1992 regarding traffic and road transport, was born due to the high number of accidents that occur on the road which states that a traffic accident is an event in the way that unexpected - and unintentional thought involving vehicles that are move with or without other road users, resulting in loss of life or loss of property. Crash victims named in this case could be the victim certainly died as a result of traffic accidents in the long within 30 (thirty) days after the accident [11].

Globally, traffic accidents on roads are influential. Traffic fatalities and injuries resulting from road accidents are so high worldwide. According to the most recent estimates, road traffic accidents kill 1.2 million victims worldwide and injure 50 million each year [12]. Ninety percent of them occur in developing countries, and more than half of all victims globally are between the ages of 15 and 44 [12]. [In addition to human suffering which traffic accidents cause, they result in considerable additional costs to societies [12].

The topic of crash severity has been of interest to traffic safety community because of the direct impact on occupants involved. The way forward could be to identify factors contributing to either a more or less severe crash. The approaches used to model

injury severities vary from one to another, depending on the purpose of the study and data availability [13].

As countries develop death rates usually fall, especially for diseases that affect the young and result in substantial life-years lost. Deaths due to traffic accidents are a notable exception: the growth in motor vehicles that accompanies economic growth usually brings an increase in road traffic accidents [14].

2.3. Road Safety and Various Cause of Accident

Road traffic safety refers to methods and measures for reducing the risk of a person using the road network being killed or seriously injured. The users of road include pedestrians, cyclists, motorists, their passengers, and passengers of on –road public transport, mainly buses and trams. Best practice road safety strategies focus up on the prevention of serious injuries and death crashes in spite of human fallibility. Safe road design is now about providing a road environment which ensures vehicle speeds will be within the human tolerance for serious injury and death wherever conflict pints exist [4].

2.4. Highway Safety Information System

Safety is the main goal for highway and traffic engineers that should be provide for drivers, road users and pedestrians. Road traffic accidents with their end results of fatalities and injuries are significantly related to safety on highways. One of the key measures of safety on a highway is the number of traffic accidents occurring on it. Consequently, records and statistics of traffic accidents should be available at traffic departments and agencies in each country for the country's highway network [12].

The Highway Safety Information System (HSIS) was developed by the Federal Highway Administration (FHWA). The FHWA proceeded in the development of this database due to the need for a database that would serve as a tool to assist

highway engineers and administrators in the decision-making process. The need for an understanding of how safety is affected by the geometric design of the roadway, the use of traffic control measures and the size and performance capabilities of the vehicles led to the development of the HSIS [1].

In brief, some of the data files including the flowing information:-

- Crash: contains type of accident, vehicle types, sex and age of occupants, accident severity and weather conditions.
- Roadway Inventory: contains information for types of roadway, number of lanes, lane width, rural urban designation and functional classification.
- Traffic Volume: contains Annual Average Daily Traffic (AADT) data.
- Intersection: contains traffic control type, intersection type, and signal phasing and turn lanes [1].

2.5. World Vehicle Population and traffic accident

According to World Bank [15] cited on Bitew [6] today there are 737 million cars worldwide. Among these 70% of them are found in North America, Western Europe and Japan. Approximately 162 million cars (22%) are found in Latin America, Asia and Eastern Europe. The remaining is spread out in the rest of the world. In 1950, there were about 53 million cars on the world's roads, and in 1990, the global fleet size rose to 456 million. On the average, the fleet has grown by about 9.5 million automobiles per year over this period.

According to world health organization [3] over 1.2 million people die each year on the world's roads, with millions more sustaining serious injuries and living with long-term adverse health consequences. Globally, road traffic crashes are a leading cause

of death among young people, and the main cause of death among those aged 15–29 years.

In addition to deaths on the roads, up to 50 million people incur non- fatal injuries each year as a result of road traffic crashes, while there are additional indirect health consequences that are associated with this growing epidemic [3].

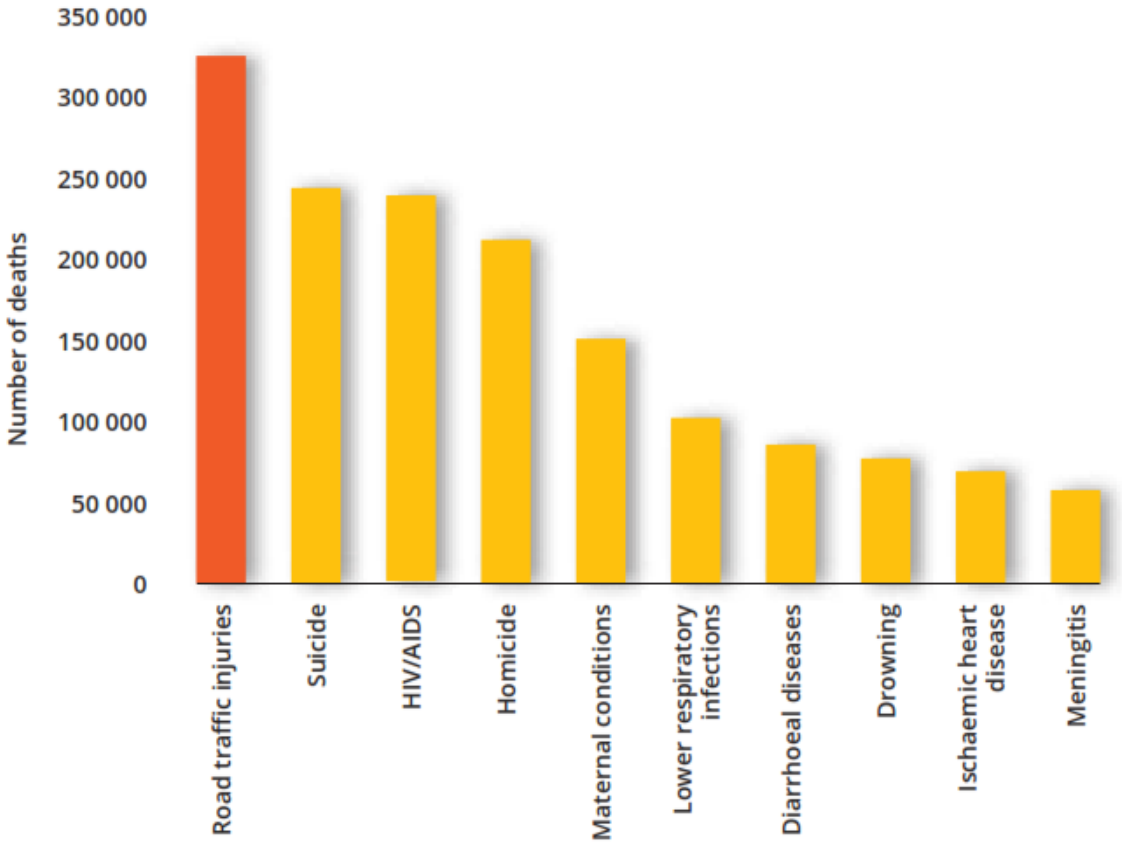


Figure2. 1.Top ten cause of death among people aged 15-29 years, 2012
Source: World Health Organization (2015), Global Status Report on road safety.

There were 1.25 million road traffic deaths globally in 2013 has remained fairly constant since 2007 [3].Despite the increase in global motorization and population, and the predicted rise in deaths. This suggests that interventions to improve global road safety are preventing increases that otherwise would have occurred. the situation is worst in low-income countries, where rates are more than double those in high-income countries and there are a disproportionate number of deaths relative to

the (lower) level of motorization. The African Region continues to have the highest road traffic death rates, while the lowest rates are in the European Region, notably among its high- income countries, many of which have been very successful at achieving and sustaining reductions in death rates despite increasing motorization [3].

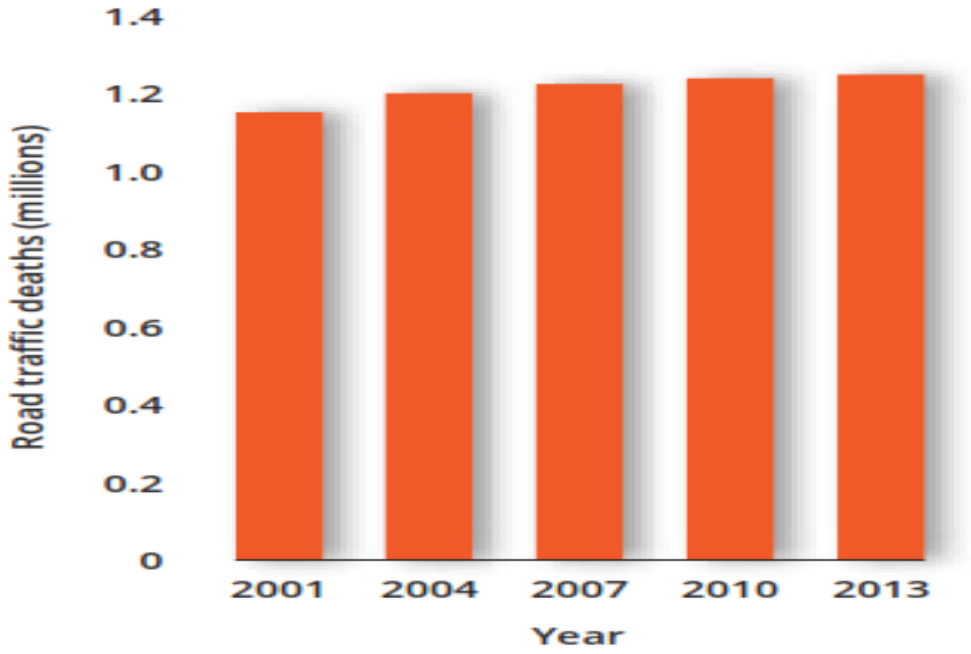


Figure2. 2. Number of road traffic deaths, worldwide, 2013
Source: World Health Organization (2015), Global Status Report on road safety.

2.6. The risk of a road traffic death in world

The risk of a road traffic death varies significantly by region, and there has been little change in the regional rates of death since 2010 [3]. The highest rates are still in the African Region, while the European Region has a rate far below the global average (9.3 per 100 000 population, relative to the global rate of 17.4, however, there continues to be a large disparity in rates within particular regions [3]. For example, rates in some of the high-income countries in the Western Pacific Region (such as Australia) are among the lowest in the world, while some of the region's middle-income countries have rates high above the global average at 24 per 100,000 [3].

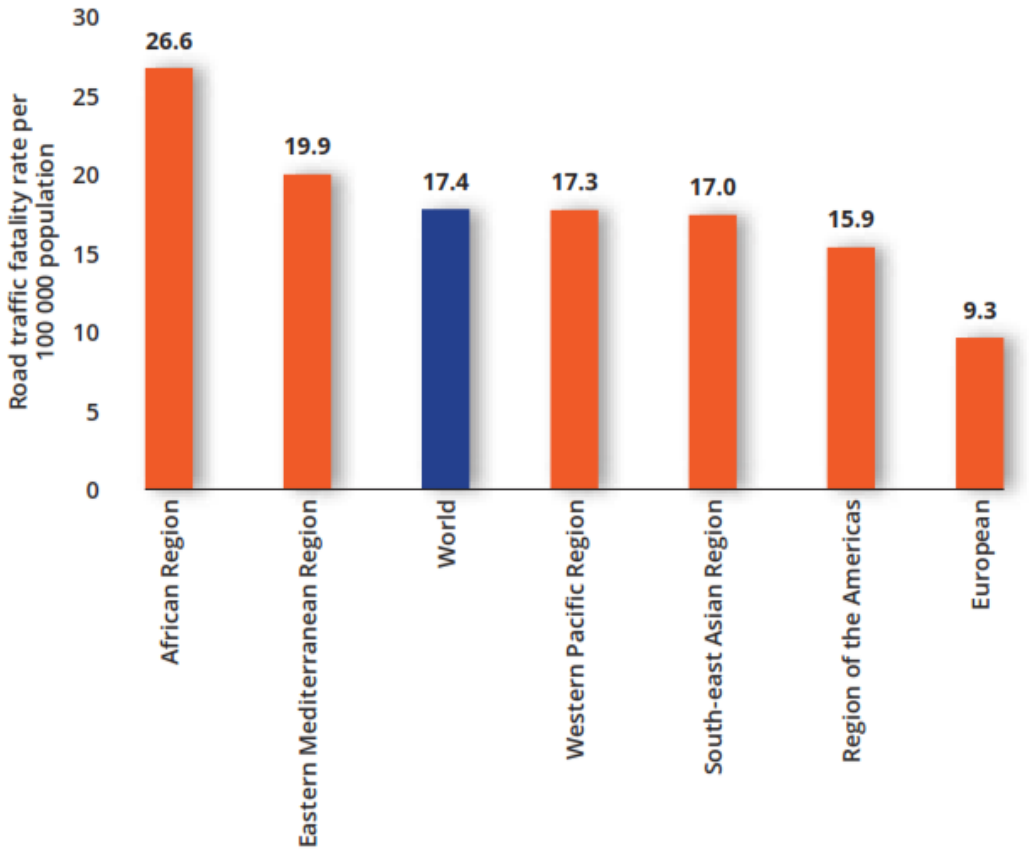


Figure2. 3. Road traffic fatality rate per 10000 populations
Source: World Health Organization (2015), Global Status Report on road safety.

2.7. Overview of Road Safety in Ethiopia

Ethiopia stands as one of the worst countries with respect to road safety performance in terms of traffic accident fatalities per 10,000 vehicles (95 in 2007/8) [8]. However, it is one of the best when the same is expressed in terms of traffic accident fatalities per 100,000 populations (2.84 in 2007/8) [8].

In the last Ethiopian fiscal year (2007/8), police reported 15,086 accidents which caused the losses of 2,161 lives and over ETB 82 million equivalent to US$7.3 million (cost estimate of property damage by traffic police). It would be impossible to attach a value to each case of human sacrifice and suffering, add up the values and produce a figure that captures the national social cost of road crashes and injuries. However, the economic costs of road traffic accidents are, evidently, a heavy burden for the national economy [8].

Road traffic accident remains to be one of the critical problems of the road transport of Ethiopia without due consideration. Although the traffic accident death rate per ten thousand motor vehicles (95 in 2007/8) is showing a decreasing trend in recent years, it still puts Ethiopia on the extreme high side of the international road safety scene. Up to 2005/6, traffic accidents and fatalities increased at 17 % and 10 % per year respectively, but in the recent couple of years there is a sudden drop. The reliability of the recent drop should, however, be evaluated over a longer period of time as it could be due to random variation and/or under reporting [8].

2.8. Road Crashes in Ethiopia – causes and consequences

Ethiopia possesses one of the highest accident records in the world. To reverse this trend, few uncoordinated efforts are being made few organizations including the Ethiopian Road Authority (ERA), National Road Safety Coordination Office (NRSCO), Road Transport Authority, Federal Police and the Association of Ethiopian Insurers. The traffic police collect information on road accidents (RA). Some 30 accident tables are produced quarterly by the Regions and an annual summary of each Region and at national level is compiled. However, RA data is not classified and made available to the public so far [5].

2.9. Road Traffic Accident Classification

There is no definite and consistent classification method of road traffic accidents worldwide. Some countries keep only simple records classifying accident into total serious (heavy) injuries, and minor (light) injuries or as total injury and property damage only. Also as indicated by Hobbs [16] cited on Bitew [6], the comparison of accident statistics between countries is made difficult because common definitions are not used. For example, death is defined differently in different countries. Death within 30 days in Britain, at the scene in Portugal, within 24 hours in Spain, within 6

days in France, 7 days in Italy and within a year in the USA. Among these, the definition within 30 days is mainly accepted and the case is true in Ethiopia. Therefore, accidents are classified according to the severity of the accident emphasizing whether a person is killed or injured into fatal, serious, and slight and damage only accidents.

2.10. Factors cause accident

According to Bhuyan [17] cited on Achuta [4] many factors may exhibit a measurable influence on driving behavior and traffic safety in two-lane highways.

These include, but are not limited to,

i. Human factors such as improper judgment of road ahead and traffic, driving under the influence of alcohol or drugs, driver education and experience, young driver, age and sex.
ii. Traffic factors like speed, volume, density, capacity, traffic mix and variation.
iii. Vehicles deficiencies, such as defective brake, head light, tires, steering and vehicle condition.
iv. Road condition like slippery or skidding road surface, ravels, pothole, ruts etc.
v. Road design such as in adequate sight distance, shoulder width, number of lane, improper curve design, improper lighting and traffic control devices.
vi. Weather conditions like fog, heavy rainfall, dust, snow etc.
vii. Other causes such as enforcement, incorrect signal and sign, service station, badly located advertisement, stray animals etc.

Factors used mixed traffic can lead to increased number of traffic accidents, and of course also an increase in congestion. The cause of the accident can be grouped into four main factors consist of:

- human factor

- Vehicle Factors
- Road Factors
- Environmental factor

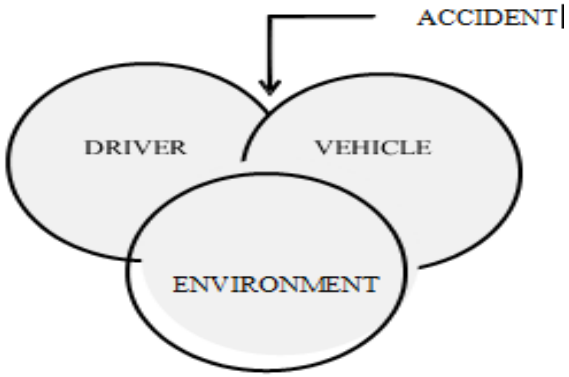


Figure2. 4. Factors related to accident
Source Achuta,2013

Table2. 1.Various Factors Related to Accident
Source Achuta Nanda Dehuri, thesis of Master of Technology

Driver-Related	
Alcohol and drugs	Sickness
Unsafe speed	Cell Phone Use
Drowsing or Fatigue	Distraction
Fatigue	Improper Passing or Turning
Disregard traffic controls	Non Use of Restraint
Vehicle-Related	
Over Loading	Steering defect
Brake defect	tire failure
Light defect	Improper wheel alignment
Environmental- Related	
Road side hazard	Vision obstruction
Ruts	Improper traffic control
Debris or Garbage on the road	Fixed Objects
smoke or fog	Water ponding
Glare	Shoulders defective
Improper/nonworking traffic controls	

2.10.1. Human Factors

The human factor plays a very dominant, because many factors that affect behavior.

a. Driver: all road users have an important role in the prevention and reduction of accidents. Although accidents tend to occur not only by Single cause, but road users is the most dominant influence. In some cases the absence of skills or experience to infer things –things that are important from a serious of events lead to the wrong decisions or actions [11].

According Hobbs [16] cited in Bitew [6] the common driving errors are lack of observation or ineffectiveness, driving too fast, failure to look, misperception and panic reaction from the inexperienced. This will be severe if the driver is impaired due to alcohol, drugs, illness, fatigue and emotional stress. In the same study, young and inexperienced drivers were found to be more likely to cause traffic accidents than older and experienced drivers. In the USA, the age group 16-24 years contains 22% of the driver population and this group was involved in 35% of fatal and 39% of all injury accidents [6].

Speed choice:-The speed of motor vehicles is at the core of the road injury problem. Speed influences both crash risk and crash consequence. The speed drivers choose to travel at is influenced by many factors. Modern cars have high rates of acceleration and can easily reach very high speeds in short distances. The physical layout of the road and its surroundings can both encourage and discourage speed. Crash risk increases as speed increases, especially at road junctions and while overtaking – as road users underestimate the speed, and overestimate the distance, of an approaching vehicle. Speed has an exponentially detrimental effect on safety [18].

Sex and Age of drivers:-The risk of a crash with alcohol varies with age and drinking experience. Zador [19] estimated cited in World Health Organization[18] that crash

rates of male drivers aged 16–20 years were at least three times the estimated crash rate of male drivers aged 25 years and above. With few exceptions, the relative risk of being fatally injured in a single-vehicle crash was found to decrease with increasing driver age for both men and women [18].

Hassan and Aty [20] cited in Achuta [4] studied 680 young driver behavior involvement in traffic crash in Florida. The result revealed that aggressive violation, in vehicle distraction and demographic characteristics were the significant factors affecting young drivers' involvement in crash at the age of 16-17. In vehicle distraction, attitude towards speeding and demographics characteristics were the significant factors effect young drivers crash risk at the age of 18-24.

As in other developing countries, males are over-involved in road traffic crashes and account for over 67% of those killed [1]. This can partly be explained by their greater exposure to traffic as drivers and as frequent travelers in motor vehicles for work and leisure activities. Females are involved mainly as passengers and pedestrians. In Botswana, for instance, a recent study showed that females accounted for as high as one- third of all pedestrian fatalities and 43 per cent of all pedestrian casualties [1].

Drunk driver:-Alcohol and drugs can affect ones driving skills. It causes general impairment of the brain and the function of nervous system. Drivers who drive tired or exhausted are mostly sleepy, agitated and aggressive on the roads. Fatigue can affect their clear thinking if they encounter a glitch on the roads and this can lead to accident. Some drivers disregard road rules since they are more concerned of getting to their destination than of how they would get there especially in the festive seasons as there are always many passengers and they want to travel as many times as they

can to take advantage of the increasing number of passengers. Such drivers would violate road rules and laws just to get to where they are going [13].

Alcohol causes deterioration of driving skills even at low levels and the probability of accidents increases with rising blood alcohol levels. Alcohol needs no digestion and is absorbed rapidly into the blood stream; about 10% to15% of alcohol users develops alcohol dependence and become alcoholics [4]. After drinking, the judgment power of the driver gets impaired which is a threat to road safety. Due to its effects, driver tends to talk more risks, became more aggressive and takes a longer reaction time [4].

b. Pedestrians and cyclists

Crash risks incurred by pedestrians and cyclists result from a complex mix of factors. A fundamental factor in high-income countries is the fact that the modern traffic system is designed largely from the perspective of a motor vehicle user. Provision for pedestrians and cyclists in low-income countries is rudimentary or even nonexistent [18].

2.10.2. Vehicle Factors

Vehicle type was found to be an important factor which affects human injury/fatality caused by traffic accidents. For any given speed, the greater the mass of the vehicle, the greater would be its force of impact at collision with the pedestrians leading to higher injury severities. Furthermore, it is possible that drivers of small vehicles but high speedy are more likely to weave around in traffic, change lanes, dart ahead of others or even take corners and curves faster [2].

The main cause for traffic accidents are due to the vehicles' malfunction of the breaking, body, tire, improper inspection and maintenance [21]. Vehicle accident can be a factor if it cannot control as it should be, namely as a result of technical conditions that are not feasible road or use is not in accordance with [11].

a) Brake tension, mechanical failure, flat tire is a condition of vehicle not roadworthy. Steering is not good, or as loose coupling, lights especially on night, slips and so on.

b) Over load or overload is a vehicle that uses not in accordance with the order of the charge.

c) Design vehicle weight can be a factor contributing to accident severity, button - the button on the dashboard of a vehicle could injure people driven for a collision, and the steering column can penetrate the driver's chest during collision. Similarly, the front of the vehicle design can injure pedestrians were hit by a vehicle. Repair vehicle design depends primarily the vehicle manufacturer's recommendation but regulatory or government can give effect to the designer.

d) Vehicle lighting systems that have a dual purpose for the driver to the condition of the road in front of him and be consistent with the velocity distinguish converting the vehicle to observers from all directions without blinding, In recent years, many states have automobile physical changes vehicle design, including the addition of light vehicles, which increases quality of vision of the driver.

2.10.3. Road factors

Relationships road width, curvature and visibility all give effect major accidents. Generally more sensitive when considering factors - these factors together - the same as having a psychological effect on drivers and influence the choice on velocity. For example, widening the road alignment that was narrow is not able to reduce accidents if the speed remains the same after the repair of roads. However, speed is usually greater because of the sense of security, so that the rate increases the accidents. Super

elevation improvement and repair the road surface is implemented isolation also has the same tendency to increase the rate of accident. Of safety considerations, condition assessment should be performed speed that may occur after any type of road repairs and checking the width lines, visibility and road surface are all satisfactory to raise the speed of thought. The selection of materials for lining the road to suit the needs of traffic and accidental slippage is no less important than the election for the purpose of Construction purposes. The place - a place that has a surface with the edge low coefficient of style a few times will easily have an accident slippage than location - other similar locations that have value - the value high. This is important when braking or bending often occurs, for example, the curved road roundabout and the intersection and the intersection when approaching bus stops, pedestrian and on the sloping road, it needs to be suitable road surface [11].

Road Alignment:-An important factor, which affects the occurrence of road traffic accidents in terms of frequency and severity, is road alignment. Inconsistent horizontal alignments of roads, sharp curves and grades are known for their substantial and adverse safety impacts [10].

2.10.4. Environmental factors

Consideration of unfavorable weather and road conditions can affect traffic accidents, but the effect could not be determined. However the driver and pedestrians are the biggest factors in the accident traffic [11]. Most of the accidents occurred in good conditions. Poor light conditions contributed to causing fatal/serious injuries, which indicates that poor light conditions could increase the probability of causing fatalities when a crash occurs. This is possibly due to poor visibility at night in the absence of street light is limited by the range of headlights and glare from oncoming vehicles headlights. In addition, drivers are also unable to distinguish pedestrians from the

shaded surroundings due to their darker outfits. All these can lead to drivers braking later or taking less effective avoidance maneuvers leading to increased risk of crash and serious injury [2].

2.11. Risk Factors

According to Fanuel, 2006 [1] Reports for various countries (Kenya, Uganda, Ethiopia, Tanzania, Ghana, South Africa, and Zimbabwe) show that most of the road crashes are largely due to a range of human error, road and vehicle factors that include:

1) Over speeding, perilous overtaking;
2) Alcohol and drug abuse;
3) Driver negligence, poor driving standards;
4) Vehicle overload;
5) Poor maintenance of vehicles;
6) Bad roads and hilly terrain;
7) Negligence of pedestrians;
8) Distraction of drivers (e.g. speaking on cell phones).

2.12. Crash Contributing Factors

While it is common to refer to the "cause" of a crash, in reality, most crashes cannot be related to a singular causal event. Instead, crashes are the result of a convergence of a series of events that are influenced by a number of contributing factors (time of day, driver attentiveness, speed, vehicle condition, road design etc.). These contributing factors influence the sequence of events (described above) before, during and after a crash [22].

Before-crash events - reveal factors that contributed to the risk of a crash occurring, and how the crash may have been prevented, for example whether the brakes of one or both of the vehicles involved were worn;

During-crash events – reveal factors that contributed to the crash severity and how engineering solutions or technological changes could reduce crash severity for example whether a car has airbags and if the airbag deployed correctly;

After-crash events – reveal factors influencing the outcome of the crash and how damage and injury may have been reduced by improvements in emergency response and medical treatment For example the time and quality of emergency response to a crash [22].

A framework for relating the series of events in a crash to the categories of crash contributing factors is the Haddon matrix provides an example of this matrix. The Haddon matrix helps create order when determining which contributing factors influence a crash and which period of crash the factors influence. The factors listed are not intended to be comprehensive; they are example only [22].

Table2. 2. Haddon matrix of identifying contributing factor

Source: Highway safety manual, 2009

period	human factor	vehicular factor	environmental/road factor
Before Crash Factors contributing to increased risk of crash	distraction, fatigue, inattention, poor judgment, age, cell phone use, deficient driving habits	worn tires, worn brakes	wet pavement, polished aggregate, steep downgrade, poorly coordinated signal system
During Crash Factors contributing to crash severity	vulnerability to injury, age, failure to wear a seat belt, driving speed, sobriety	bumper heights and energy adsorption, headrest design, airbag operations	pavement friction, grade, roadside environment
After Crash Factors contributing to crash outcome	age, gender	ease of removal of injured passengers	the time and quality of the emergency response, subsequent medical treatment

2.13. Data Needed for Crash Analysis

Accurate, detailed crash data, roadway or intersection inventory data, and traffic volume data are essential to undertake meaningful and statistically sound analyses. This data may include:

Crash Data: The data elements in a crash report describe the overall characteristics of the crash. While the specifics and level of detail of this data vary from state to state, in general, the most basic crash data consist of crash location, date and time, crash severity and collision type, and basic information about the roadway, vehicles and people involved [22].

Facility Data: The roadway or intersection inventory data provide information about the physical characteristics of the accident site. The most basic roadway inventory data typically include roadway classification, number of lanes, length, and presence of medians and shoulder width. Intersection inventories typically include road names, area type, and traffic control and lane configurations.

Traffic Volume Data: In most cases, the traffic volume data required for the methods in the HSM are annual average daily traffic (AADT) [22].

2.14. Method of estimating road traffic accident cost

A) Gross Output

The gross output (or human capital) was suggested and used in Ethiopia in relation to the prevailing condition of the country [6]. This method basically requires the estimation of direct and indirect costs incurred to individuals and society as a whole. Generally the cost of traffic are divided into two main categories:(i) the cost due to the loss of current resource, including the cost of vehicle damage, medical treatment, and administrative cost, and (ii) the cost due to the loss of future resource that the victim would have lived to aim which must be discounted back, back to give present

values. Usually, a significant sum is added to reflect the “pain, grief, and sufferings the accident victim and to those who care for [25].

B) The "net output" approach

Unlike the gross output approach the discounted value of the victim’s future consumption is subtracted from the gross output figure. In this approach the difference between an individual’s gross output and future consumption may be regarded as a measure of the rest of society’s economic interest in his continued survival [25].

The major limitation in using this approach is that it could be very difficult to estimate what a person consumes through his/her life time. The second limitation is lack of literatures used this technique in estimating road accident costs and it is not being used in most countries [25].

C) The "life-insurance" approach

According to this method the cost of road accident is directly related to the sums which individuals are willing or are able to insure their lives. This is based on the assumption that insurance cover provides an estimate of the value of his/her life to dependents [25].

To base any analysis on the insured population alone is almost certainly to choose a biased sample. This approach is of particularly limited value in countries like Ethiopia where relatively few people carry life insurance. The second limitation in using this approach is that it says nothing about the value that individuals place on their own lives [25].

D) The "court award" approach

The sums awarded by the courts to the surviving dependents of those killed or

injured are treated as indicative of the cost that society associates with the road accident or the value that it would have placed on its prevention. Real resource costs are then added to this figure to obtain the cost of an accident [25].

E) The "implicit public sector valuation" approach

With this method an attempt is made to determine the costs and values that are implicitly placed on accident prevention in safety legislation or in public sector decisions taken either in favor of or against investment programs that affect safety. As clearly stated in some studies the main drawback of using this method is that there is an enormous variation in „implied values of life", even within the same sector [25].

F) The "willingness to pay" Approach

This method mainly estimates the amount of money people affected would pay to avoid an accident. Each individual has their chance of being involved in a fatal accident reduced by a small margin if a road safety improvement is introduced. Thus the value of preventing one fatality in one accident is defined as the aggregate amount that all the affected individuals in society are willing to pay for these small risk reductions [25].

Estimation of willingness-to-pay costs and values is far from straight forward. Various methods have been used and include an approach where estimates are obtained by observing situations where people actually do trade off wealth or income for physical risk. Another approach uses a complex questionnaire where samples of individuals are asked more or less directly how much money they would be willing to pay in order to obtain a small reduction in their own or other people risk [25].

CHAPTER THREE

METHODOLOGY OF THE STUDY

3.1 study site

The study site of the research was the expressway that connects Addis Ababa and Adama. The road is 3 lanes in two directions each 3.75m wide with 2m tree plant median the roadway width of 31m including 2.5m asphalt shoulder in each side. Ethiopian Roads Authority (ERA) is the developer of the project and Chinese Communications Construction Company (CCCC) is the contractor. The project was completed at an estimated cost of $612m.It has 80 km length. The new road is 20km shorter than the old Addis Ababa Adama road, while the route is fenced on either sides for protection from pedestrians and animals. Two design speeds of 100kmph and 120kmph are used for different sections of the road [23].

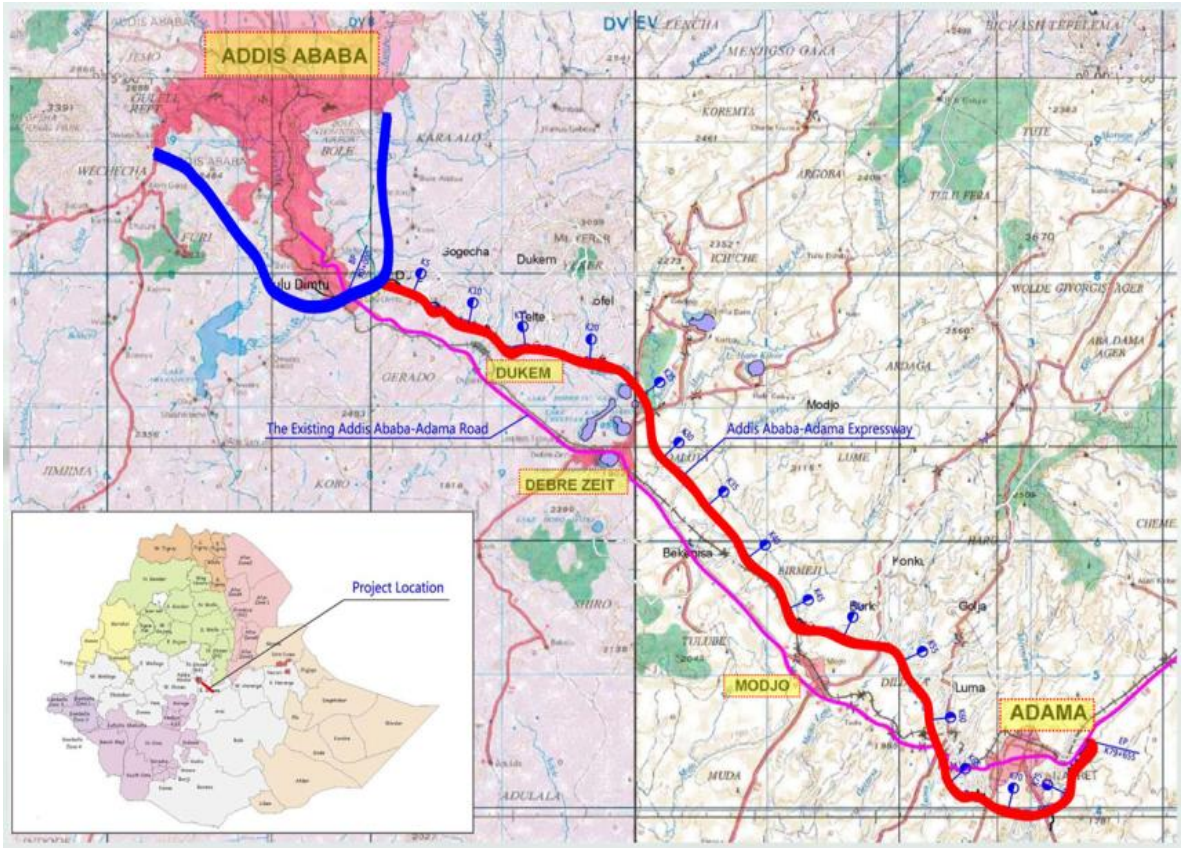


Figure3. 1.Study site
Source: Ethiopian Toll Road Enterprise

3.2. Source of data

Primary and secondary data sources were used to meet the objective of the thesis such as questionnaires, field observation and interview. Secondary data were obtained from Ethiopian toll road enterprise (ETRE) include traffic accident data.

3.3. Sampling techniques

In order to select the samples the researcher assessed the recorded traffic accidents and sampling frame designed from the drivers use the expressway. Thus, drivers were randomly selected.

3.4. Sample size

From the drivers that use the expressway in order to have optimum sample size some sampled driver was taken. From several sampling formula adopted for this study is [24]:

$$n_o = \frac{z_{\frac{\alpha}{2}}^2 \, p(1-p)}{d^2} \quad \text{..... Equation.3. 1Sample size}$$

Where

- n_o= the minimum estimated sample size
- $z_{\frac{\alpha}{2}}^2$=is the critical value of the normal distribution atα/2 (e.g. for confidence level of 95% , α is 0.05 and the critical value is 1.96)
- p=is the estimate of population proportion (take 0.5)
- d=is the margin of error (5%)

If the estimate n_o is greater than 5% of the overall population, make the following correction:

$$n = \frac{n_o}{1+\left(\frac{n_o}{N}\right)} \quad \text{..... Equation.3. 2Correction for sample size}$$

Where:

- n=is the adjusted minimum estimated sample size
- N=is the total population

Based on the formula the sample size is calculated to be 384, these 384 sampled driver were selected based on simple random sampling and well organized and structured questionnaires was distributed.

3.5. Study design

The purpose of the study was to investigate the main causes and contributory factor of accidents. The study design included descriptive, qualitative and quantitative type.

Descriptive research method: collected numerical and text data and analyses in terms of tables, charts and graphs.

Quantitative research method: collected numerical data (data in the form of numbers) and analyses using numerical analysis and manipulating pre-existing statistical data using computational technique.

Qualitative research method: collected qualitative (data in the form of text, image, sounds) drawn from the observations, literature review and interviews, and analyses using qualitative data analysis method.

3.6. Study Variables

3.6.1 Dependent Variables

- Accident severity
- Crash loss value

3.6.2 Independent Variables

- Age and sex
- Speed
- Road character
- Time of accident

- Day of accident
- Weather condition
- Road conditions

3.7. Population

The population that considered in the study was vehicles, drivers, road users, road condition and environmental condition.

3.8. Data collection

To attain the objectives of the study, previous research studies on accident severity were reviewed. The necessary reliable data that were accident data, road data, traffic data and field observation were obtained. And to get additional information questionnaires and interview were made.

3.8.1. Traffic accident data

Road traffic accident data from 2014/15-2016/17 were collected from Ethiopian toll road enterprise reported by police. During that period 1171 accidents were recorded.

Accident data contain

- Age and sex of driver
- Day of week, month of year
- Crash hour
- Weather condition
- Road character
- Type of vehicles

3.8.2. Traffic data

Traffic data were required to undertake the road safety problem on the expressway under consideration and the traffic data were obtained from the Ethiopian toll road enterprise.

Table3.1.Average Annual Daily Traffic (AADT)
Source Ethiopian toll road enterprise

Toll Station	Average Annual Daily Traffic (AADT)				
	Year	2014	2015	2016	2017
Tulu Dimtu (K2)	Entrance	4790	6032	6667	7634
	Exit	5673	6789	7156	8340
Bishoftu North (K16)	Entrance	717	1549	1660	3197
	Exit	1456	1872	2456	3267
Bishoftu South(K33)	Entrance	263	576	645	1697
	Exit	872	1235	1562	2678
Modjo (K52)	Entrance	564	1210	1654	1817
	Exit	1023	1446	1723	2862
Adama West (K60)	Entrance	2041	1478	4563	2513
	Exit	1234	1561	1894	2678
Adama Main (K64)	Entrance	617	1456	1834	1936
	Exit	1263	1456	1678	2689
Total	Entrance	8991	12301	17023	18794
	Exit	11521	14359	16685	22514

3.8.3. Road data

The road data collected from Ethiopian toll road enterprise and contains the information:

- Road way(lane width ,number of lane)
- Shoulder width
- Median width

3.8.4. Interview

Structured interview have been made and interviewed key informants including traffic policeman, Ethiopian toll road payment enterprise authorities and drivers.

3.8.5. Questionnaires

In addition to interview, well organized and structured questionnaires distributed for the drivers and gathered properly.

3.9. Method of analysis

After collecting the necessary data, analyzing data were performed. To analyzing and interpreting the data descriptive in terms of tables, charts, and graphs and statistical package for social science (SPSS) version 23 were used. Chi-square tests of association were used to analyze factors affecting the occurrence of traffic accident.

The chi-square test of independence is calculated by the formula

$$X^2 = \sum_{i=1}^{R} \sum_{j=1}^{C} \frac{(oij - eij)2}{eij} \quad \text{..... Equation.3. 3Chi-square test}$$

Where

x^2= chi-square value

o_{ij}=observed cell count in i^{th} row and j^{th} column

e_{ij}= expected cell count in i^{th} row and j^{th} column

The expected value is computed by:

$$e_{ij} = \frac{\text{row i total} * \text{column j total}}{\text{Grand total}} \quad \text{..... Equation.3. 4Expected value}$$

$$o_{ij} - e_{ij} = \text{residual} \quad \text{..... Equation.3. 5Residual}$$

The calculated x^2 value is then compared to the critical value from the x^2 distribution table with the degree of freedom and chosen confidence level. If calculated x^2 value greater than critical x^2 value, then we reject the null hypothesis.

3.10. Method of estimating road traffic accident cost

Calculating road traffic accidents cost is not a simple task, various studies on accident costs have identified six different methods they are:

i. The gross output method
ii. The net output approach
iii. The life insurance approach
iv. The court award approach

v. The implicit public sector valuation approach

vi. The willingness to pay approach

The gross output (or human capital) was suggested and used in Ethiopia in relation to the prevailing condition of the country [6]. This method basically requires the estimation of direct and indirect costs incurred to individuals and society as a whole.

CHAPTER FOUR

RESULTS AND DISCUSSION

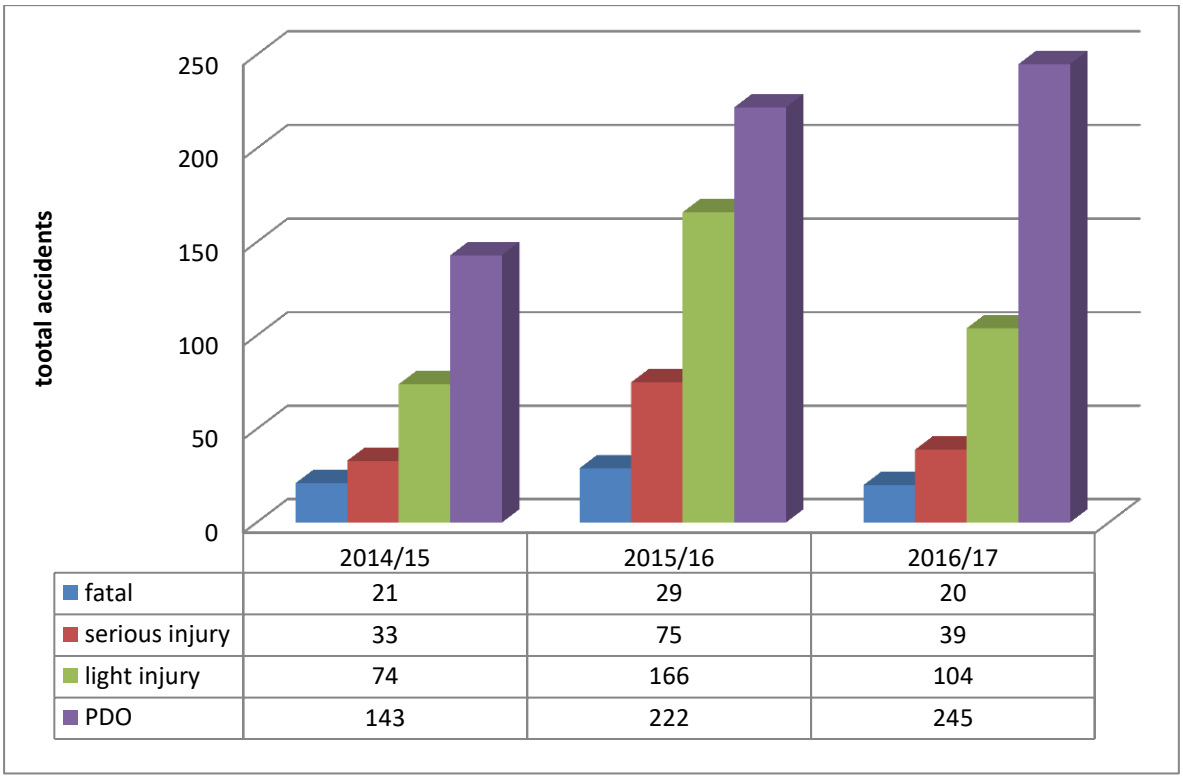
4.1. Road traffic accidents records on Addis Ababa Adama expressway

The road traffic accidents characteristics for the Addis Ababa Adama expressway was summarized for the period of three years (2014/15-2016/17) and presented in table 4.1 below. The crash data grouped into fatal, serious injury, light injury and PDO.

Table4. 1. Road traffic accidents records
Source: Ethiopian toll road enterprises; compiled by researcher

year	Fatal	Serious	light	PDO
2014/15	21	33	74	143
2015/16	29	75	166	222
2016/17	20	39	104	245

The accidents of Addis Ababa Adama express way that were established for this study contain traffic accidents that reported and recorded by the police and responsible parties at the study site. A total of 1171 accidents were reported and out of this 70 were fatal 491 injuries and the remaining 610 were property damage only. However some of the year data is not recorded properly with the required information.



	2014/15	2015/16	2016/17
fatal	21	29	20
serious injury	33	75	39
light injury	74	166	104
PDO	143	222	245

Figure4. 1. Characteristics of accidents on the expressway

4.2 Accident Distribution on Expressway

4.2.1. Driver factor by age

The Age group of casualties was also addressed in the study. Age was classified into four groups of age categories.18-30, 31-40, 41-50 and 50 years and above. The total number of fatalities, serious injuries and light injuries were obtained by age group.

Table 4.2 shows below the age distribution with the level of road accident on Addis Ababa Adama expressway. The reported traffic accidents were 1171 of 70 fatal, 147 serious injuries, 344 light injuries and 610 property damage only. However, from the total 1171 recorded data there were a data of 38 fatal, 74 serious injuries and 157 light injuries recorded without age. As a result the total accident reduced to 32 fatal, 73 serious, 187 light injuries and 610 PDO and totally 902 traffic accidents were recorded properly and used for analysis.

Table4. 2. Accident distribution by age of driver
Source: Ethiopian toll road enterprises; compiled by researcher

driver age		accident level				
		fatal	serious injury	light injury	PDO	Total
18-30	count	20	50	108	308	486
	% total	2.22%	5.54%	11.97%	34.14%	53.89%
31-40	count	8	15	54	192	269
	% total	0.89%	1.66%	5.97%	21.29%	29.82%
41-50	count	4	5	16	96	121
	% total	0.44%	0.55%	1.77%	10.64%	13.41%
>50	count	0	3	9	14	26
	% total	0%	0.33%	1.00%	1.55%	2.88%
total	count	32	73	187	610	902
	% total	3.55%	8%	20.73%	68%	100%

Fig 4.2 shows the age between 18 and 30 had high value of accident severity. It had 2.22 percent fatal, 5.54 percent serious injury, 11.97 percent light injury and 34.14 percent PDO of the total injury. Also it shows the age group of 18-30 causes more road traffic accidents. This is due to the age group of 18-30 are more aggressive and less experienced than the other age group. As a result the age increases the road traffic accidents were decrease. It shows as the driver age increases the experiences of the driver also increase as a result the road traffic accident decrease.

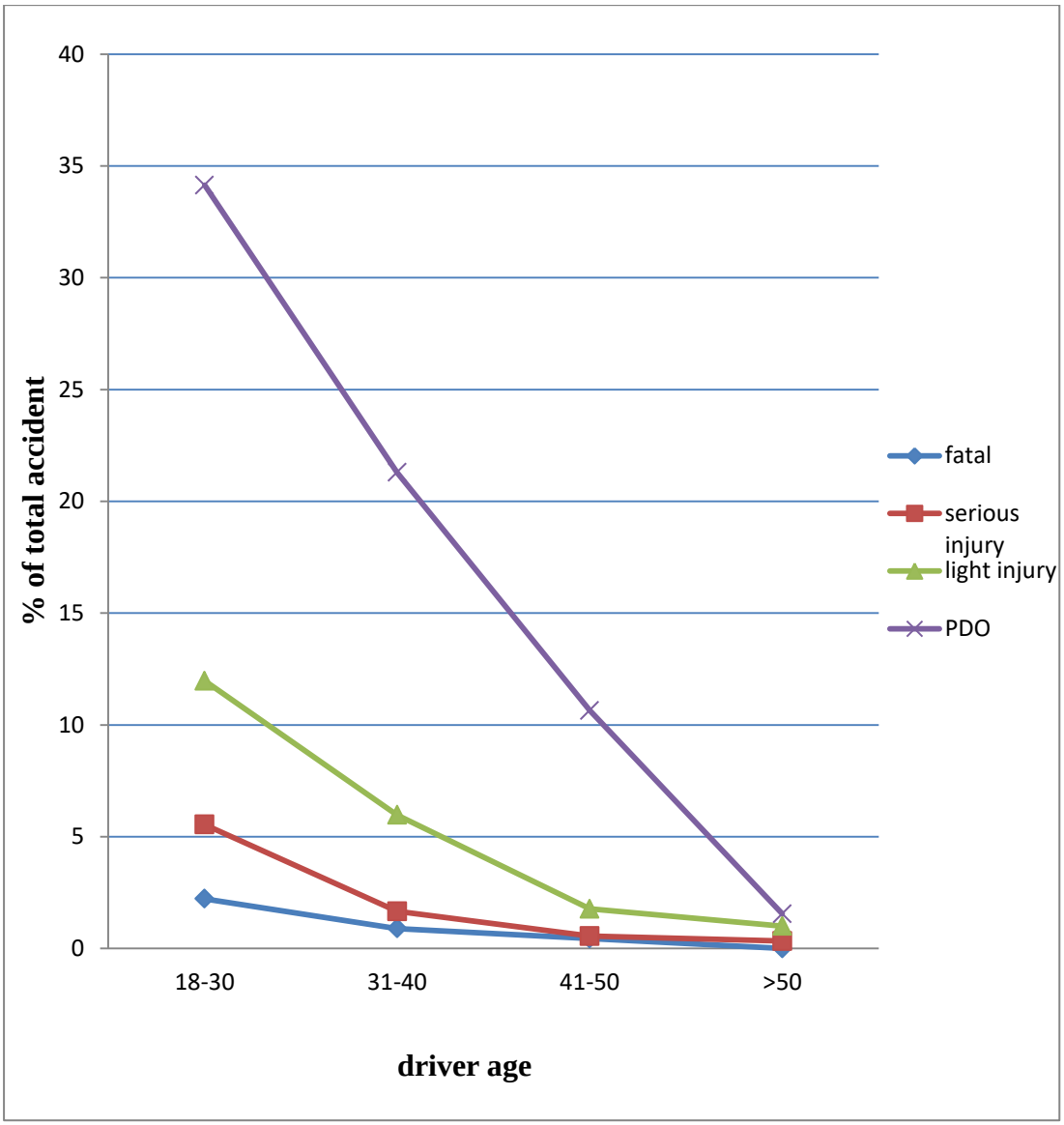


Figure4. 2.Percentile distribution of accident level by age of driver

To investigate whether age group of the driver related or not with the occurrence of accidents chi-square test was made. The table shown below represents the analysis of Pearson chi-square between age of driver and the occurrence of the traffic accident.

Table4. 3. Calculation of chi-square test for age of driver

age of driver	number of accident	df	x^2 critical	x^2 calculated
18-30	486	9	16.92	20.686
31-40	269			
41-50	121			
>50	26			
total	902			
sig.			0.05	0.014

The Pearson chi-square result shows that the p-value (0.014) and the chi square value or calculated value of 20.686 and the critical value of 16.92.Based on the result the p-value (0.014) less than the chosen significance value (α=0.05) also the calculated value (20.686) greater than the critical value (16.92).Therefore the result show the null hypothesis is rejected. There is a statistically significantly associated with the occurrence of traffic accident.

4.2.2. Road traffic accident distribution by sex of driver

Table 4.4 shows the magnitude and percent of accident with the sex of drivers. The analysis in table 4.4 confirm that from the total 1171 accidents 80.70 percent of the accident caused by male drivers and 15.29 percent by female the remaining 4.01 percent accidents was not recorded. Moreover, from 80.70 percent of male drivers 5.55 percent fatal, 11.70 percent serious injuries, 27.84 percent light injuries and 35.61 percent property damage only. Correspondingly from 15.29 percent of female drivers 0.09 percent fatal, 0.51 percent serious, 0.77 percent light injuries and 13.92 percent property damage were recorded. Finally from 4.01percent unrecorded accidents 0.34 percent fatal, 0.34 percent serious injuries, 0.77 percent light injury and

2.56 percent were property damage. Generally the road accident occurred on the expressway caused by male drivers were significant. On the other hand the accidents caused by female drivers were minimal. This is due to more male driver's uses the expressway.

Table4. 4. Accident distribution by sex of driver
Source: Ethiopian toll road enterprises; compiled by researcher

sex of driver		number of accidents				
		fatal	serious injury	light injury	PDO	Total
M	count	65	137	326	417	945
	%total	5.55%	11.70%	27.84%	35.61%	80.70%
F	count	1	6	9	163	179
	%total	0.09%	0.51%	0.77%	13.92%	15.29%
Unrecorded	count	4	4	9	30	47
	%total	0.34%	0.34%	0.77%	2.56%	4.01%
Total	count	70	147	344	610	1171
	%total	5.98%	12.55%	29.38%	52.09%	100%

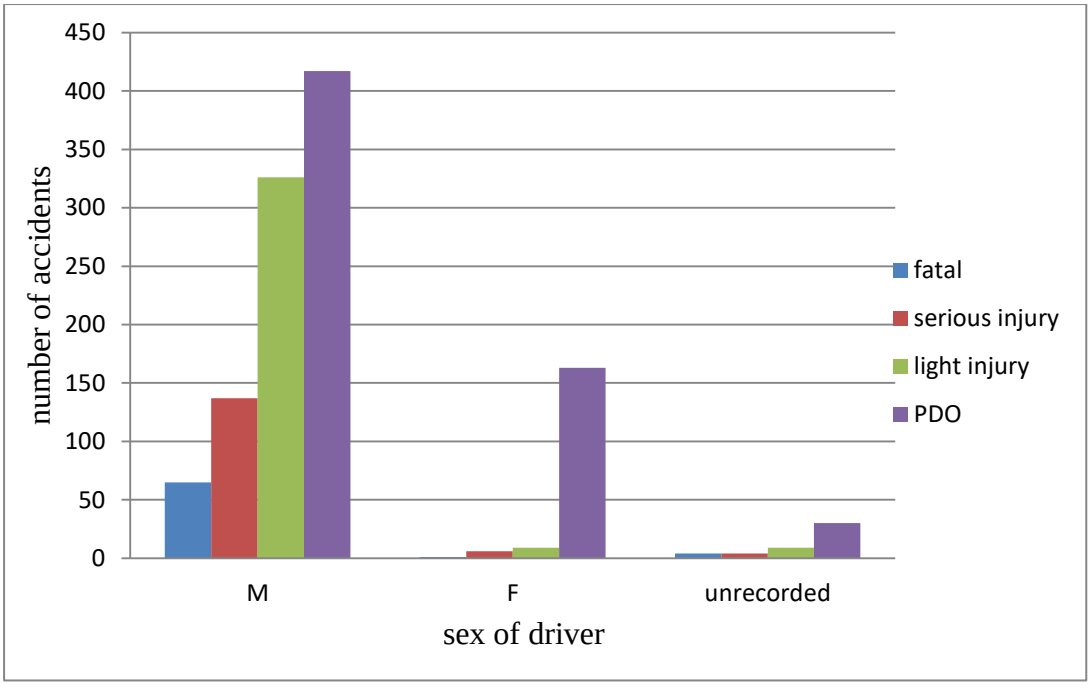


Figure4. 3. Accident distribution by sex of driver

Table4. 5. Chi-square test analysis for sex of driver

Sex of Driver	number of accident	df	x^2 critical	x^2 calculated
M	945	3	7.815	133.02
F	179			
total	1124			
sig.			0.05	0.000

According to above table 4.5 confirm the null hypothesis of independence between sex and accidents is rejected. Because the calculated x^2 value of 133.02 df value of 3 and the critical x^2 value of 7.815 at alpha value of 0.05.As the result, calculated x^2 value is greater than critical x^2value and p-value (0.000) less than chosen alpha value(0.05) so null hypothesis is rejected. There is association between sex of driver and the occurrence of accident.

4.2.3. Road traffic accident distribution by hour of a day

When addressing traffic safety severity of traffic accident, number of fatalities and number of injuries by time also important measures. The time of accidents that the accident occurred on expressway were also addressed in the study. The recorded accident data were distributed over throughout 24 hours. The following table shows the distribution of accident over the time of the day.

Table4. 6. Accident distribution by time of day
Source: Ethiopian toll road enterprises; compiled by researcher

day time		Number of accident				
		fatal	serious injuries	light injuries	PDO	Total
6:00AM-12:00PM	count	36	68	103	205	412
	% total	3.09%	5.84%	8.84%	17.6%	35.36%
12:00PM-06:00PM	count	23	52	145	243	463
	% total	1.97%	4.46%	12.45%	20.86%	39.74%
6:00PM-12:00AM	count	8	12	51	104	175
	% total	0.69%	1.03%	4.38%	8.93%	15.02%
12:00AM-06:00AM	count	3	15	39	58	115
	% total	0.26%	1.29%	3.35%	4.98%	9.87%
Total	count	70	147	338	610	1165
	% total	6.01%	12.62%	29.01%	52.36%	100%

The difference in the distribution of the road traffic accidents recorded for the 24 hours of the day that is 12 hours day time and 12 hours night time. According table 4.6 and figure 4.4 shows a total of 1171 were reported out of 70 is fatal, 147 serious, 344 light injury and 610 property damage only. However 6 light injuries were recorded without time. As the result the total road accidents reduce to 1165.According to the table fatalities and serious injury were higher during morning to mid-day with the value 3.09% and 5.84% of the total accident. On the other light injury and

property damage had higher value during mid-day to sunset with 12.45% and 20.86% of the total value.

Generally the analysis confirm that the road traffic accident occurs during mid-day to sunset were higher with 39.74 % and during day time were higher than the night time with 75.1% and 24.89% of the total accident. It seems during the night time the visualization is less and low illumination, which may affect the driver perception of the appropriate speed choice and drivers give attention while they driving. But in day time there is no lack of visualization. And also the traffic volume varies through the day and night time. In day time the traffic was high. Due to those factors the traffic accidents were high during day time than night time.

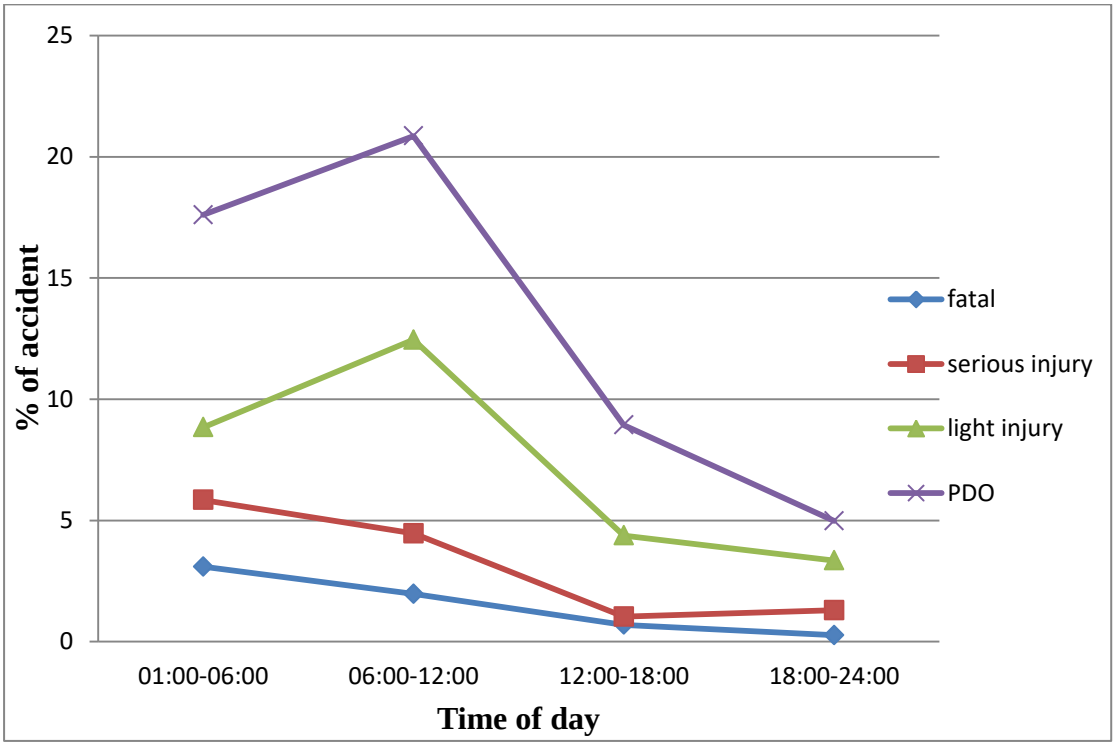


Figure4. 4. Percentile distribution of accident level by time of day

Fig.4.4 shows the time of accidents observed that the numbers of accidents were peaked during the time period from 6:00o'clock (mid-day time) to 12:00o'clock (sun set time). And the time period between from 6:00o'clock (mid-day time) to 12:00

o'clock (sun set time) is considered a critical time period in terms of traffic safety on expressway.

Table4. 7. Result of chi-square test for crash hour distinction

crash hour	number of accident	df	x^2 critical	x^2 calculated
6:00AM-12:00PM	412	9	16.92	25.387
12:00PM-6:00PM	463			
6:00PM-12:00AM	175			
12:00M-6:00AM	115			
total	1165			
sig.			0.05	0.003

The above table shows the chi square tests of the crash hour and the calculated x^2 value of 25.385 for the df value of 9.The critical x^2 value of 16.92 at alpha value of 0.05. Since calculated x^2 value is greater than the critical x^2 value. Therefore, the null hypothesis independency between the crash hour and the number of accidents is rejected at the p-value of (0.003) <0.05.There is a statistically significantly association between crash hour and the occurrence of accidents.

4.2.4. Road traffic accident by day of week

Fig. 4.5 presents the accident variation on expressway by the day of week. From the figure Sunday, Wednesday and Tuesday had higher fatal reported from the other week of day with the value of 27, 16 and 13 respectively. And also from serious injury Sunday, Tuesday and Thursday had higher reported value of 50, 34 and l7. From light injury Tuesday, Sunday and Friday had significant value of 90, 66 and 47.

Finally Sunday, Tuesday and Monday had 110, 91 and 88 of property damage only. Generally the analysis confirms that from the day of the week Sunday and Tuesday

had the higher road traffic accidents. This is due to most of the driver go out for recreation during the week end.

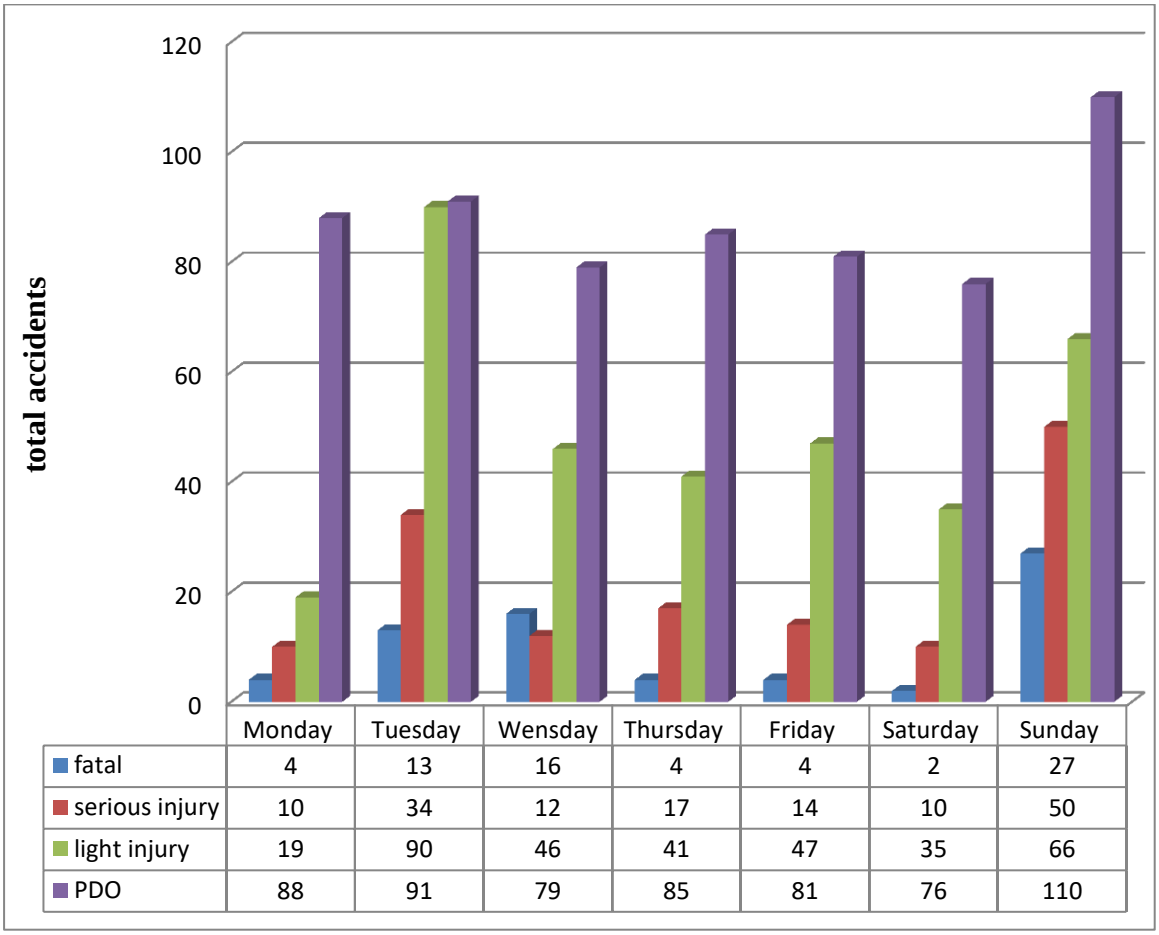


Figure4. 5. Road accident distributions by day of week

Table4. 8. Chi-square test result for week of day

week of day	number of accident	df	x^2 critical	x^2 calculated
Monday	121	18	28.87	84.592
Tuesday	228			
Wednesday	153			
Thursday	147			
Friday	146			
Saturday	123			
Sunday	253			
total	1171			
sig.			0.05	0.000

The chi-square test result shows that the calculated x^2value of 84.592 for df value of 18 and critical x^2value at the alpha level of 0.05 is 28.87.As the result calculated x^2 value is greater than the critical x^2 value. Therefore the null hypothesis rejected and week of day statistically significantly associated with the occurrence of traffic accident.

4.2.5. Road traffic accident by month of year

When the month of the year is also considered, traffic accidents data obtained for Addis Ababa to Adama expressway shows that the highest numbers of traffic accidents indeed occur during the months of January, June and April 136,134 and 119 accidents actually occurred in these months respectively. On the other hand, 118,109and 97accidents occurred during August, May and September respectively. Similarly in July, November, March, February, October and December of 90, 80, 80, 78,77and 53 accidents were recorded.

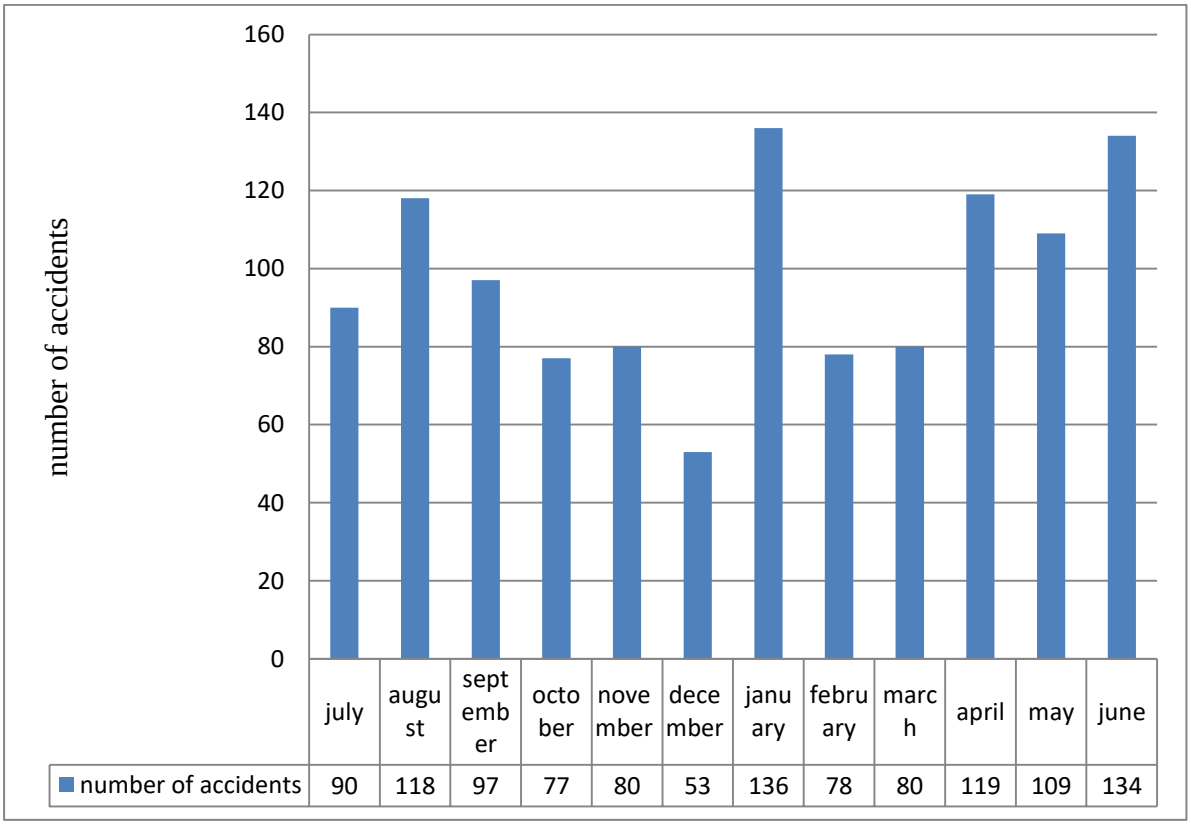


Figure4. 6. Road traffic accidents by month of year

4.2.6. Road traffic accident by road characteristics

Road character are affected the occurrence of road traffic accidents in terms of frequency and severity. Road character had psychological effect on drivers and influence the choice on velocity. Table 4.9 below shows the distribution of road character with road traffic accidents occur on expressway. The result shows the highest accidents recorded at straight and level, in 2014/15,135 accidents, in 2015/16 and 2016/17, 255 and 164 accidents respectively. It seems the straight and level road characteristics affect the behavior of driver and influence the choice of speed. Since the speed increases the crash risk also increase by reducing the reaction time and the available distance to see and respond to hazards.

Table4. 9. Accident distribution by road character
Source: Ethiopian toll road enterprises; compiled by researcher

road character	number of accidents				
	2014/15	2015/16	2016/2017	total	% total
straight and level	135	255	164	554	47.31
down hill	77	182	111	370	31.6
Curve	38	29	74	141	12.04
Uphill	12	16	59	87	7.43
Un recorded	9	10	0	19	1.62
Total	271	492	408	1171	100

Table4. 10. Calculation of chi-square test accident distribution by road character

road character	number of accident	df	x^2 critical	x^2 calculated
straight and level	554	9	16.92	36.102
Uphill	87			
Downhill	370			
Curve	141			
Total	1152			
sig.			0.05	0.000

Table 4.10 shows the result of chi-square test with the calculated x^2 value of 36.102 for df value of 9.Moreover,a critical x^2 value of 16.92 at the alpha level of 0.05.The result confirm calculated x^2 value greater than the critical x^2value as a result a null hypothesis is rejected at a p-value(0.001)< 0.05. There is a statistically significance difference and it is evident that the road character highly related with the occurrence of accidents.

4.2.7. Road traffic accident by surface condition

The road pavement surface condition influence the occurrence of traffic accidents. Subsequently, different pavement surface conditions were considered in the study to investigate the effect of surface condition on traffic accidents they included dry and wet surface. Figure 4.7 shows that 180,383 and 306 accidents occurred in 2014/15, 2015/16 and 2016/17 in dry surface condition. Consequently, in 2014/15, 2015/16 and 2016/17 the accidents of 86, 97 and 102 were occurred during wet surface condition. Hence, the analysis confirms that the higher road accident occurred during dry surface than wet surface.

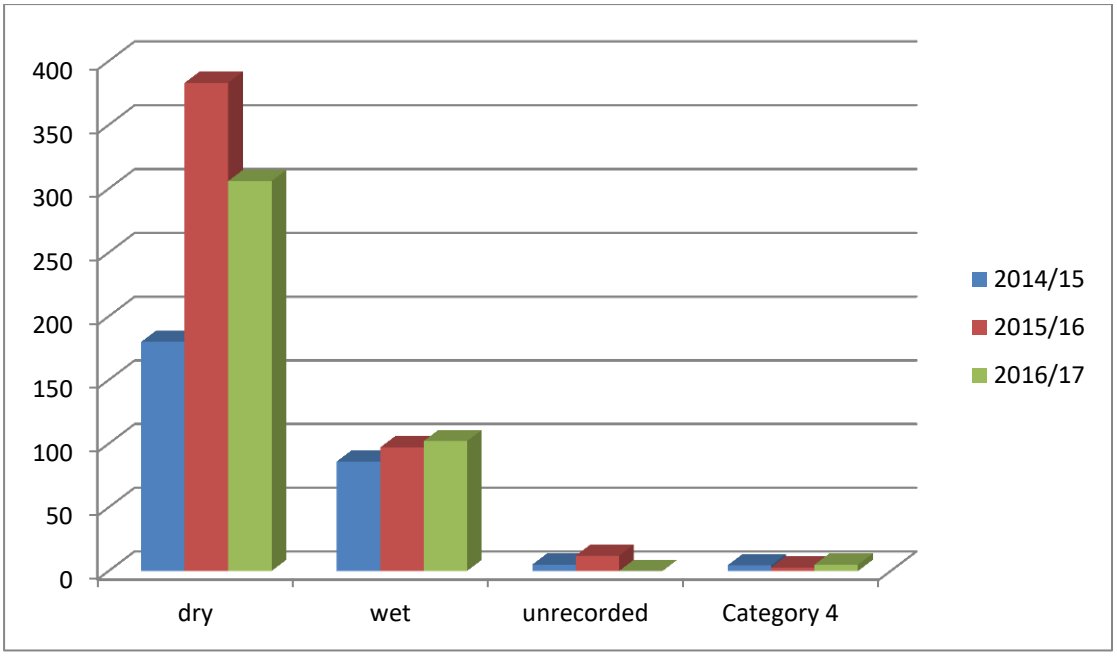


Figure4. 7. Road traffic accidents by surface condition

Figure 4.7 shows the higher road traffic accident occurred during dry surface condition than wet surface condition. This is due to during wet pavement surface condition the friction between the road and the vehicle decrease and it's affected the speed choice of the drivers. So the drivers give more attention while they driving. But in dry surface condition the friction is normal the drivers drive without paying attention.

Table4. 11.Calculation of chi-square for surface condition

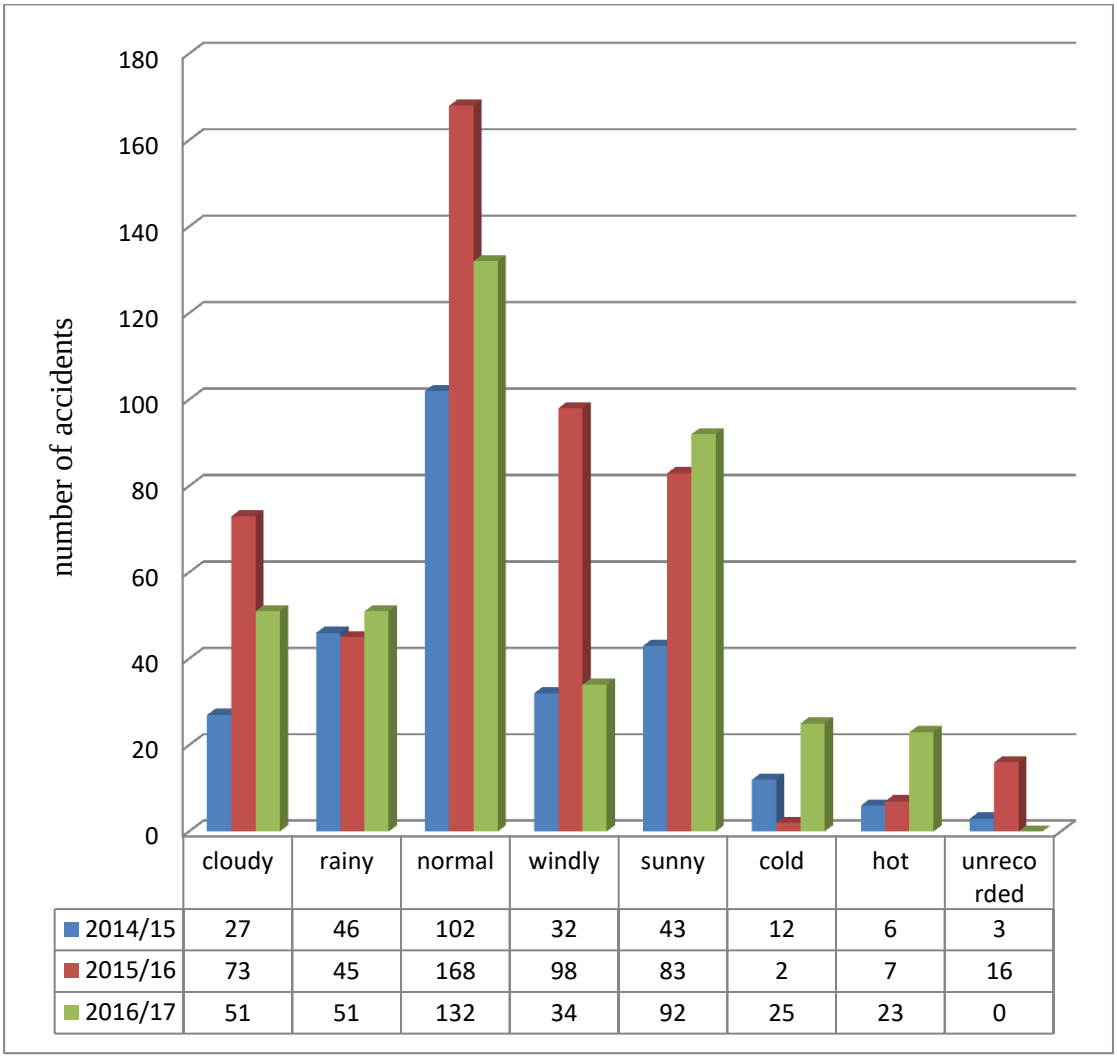
surface condition	number of accident	df	x^2 critical	x^2 calculated
wet	302	2	5.99	12.122
dry	869			
total	1171			
sig.			0.05	0.002

Result in above table 4.11 confirms that the null hypothesis is rejected, and concludes that there is a presence significance difference between road surface and accidents at the probability level of p (0.002) and with chi-square value of 12.122 and the critical value 5.99 for df value of 2 and alpha value of 0.05.

4.2.8. Road traffic accident by whether condition

Figure 4.8 shows the distribution of accidents with the weather condition. From the figure 102,108 and 132 accidents were recorded with normal weather (good weather condition) condition in 2014/15, 2015/16 and 2016/17 respectively. The remaining

weather condition had medium level of accidents. The analysis confirms that higher accidents were occurred in normal weather condition from the others.



	cloudy	rainy	normal	windly	sunny	cold	hot	unrecorded
2014/15	27	46	102	32	43	12	6	3
2015/16	73	45	168	98	83	2	7	16
2016/17	51	51	132	34	92	25	23	0

Figure4. 8. Road traffic accidents by weather condition

The weather conditions influence the driver behavior. During bad weather or uncomfortable weather condition the drivers' acknowledge the need to reduce their speed choice. Also visibility decrease during bad or uncomfortable weather condition. Due to this reason the speed of vehicle decreases. But in normal (good) weather condition drivers feel safe and comfort and not considered the speed choice. Therefore, during normal (good) weather condition the traffic accident were higher than the other weather condition elements.

To investigate the effect of weather condition on traffic accidents statistical data over study period (2014-2017) were obtained and analyzed.

Table4. 12. Calculation of chi-square for weather condition

weather condition	number of accidents	df	x^2 critical	x^2 calculated
cloudy	151	18	28.87	236.611
rainy	142			
normal	402			
windy	164			
sunny	218			
cold	48			
hot	46			
total	1171			
sig.			0.05	0.000

Analysis of traffic data obtained for expressway shows that weather condition contributes significantly in the occurrence of traffic accidents. Table 4.12 indicate that calculated x^2 value for the degree of freedom (df) value of 18 is 236.11.And also the critical x^2 value for 0.05 alpha level is 28.87.the result shows the significance value of (0.000) less than the critical p-value of 0.05 this suggests that the null hypothesis is rejected.

4.2.9. Road traffic accident distribution by types of vehicles

The severity of accidents occurred on the road is depend on the type of vehicles. The reported data on the expressway shows in figure 4.9 most of accidents occurred by vehicle type of bus (13-65 seats), of 28 percent, automobiles 21 percent and truck (11-40 quintals) of 18 percent were recorded.

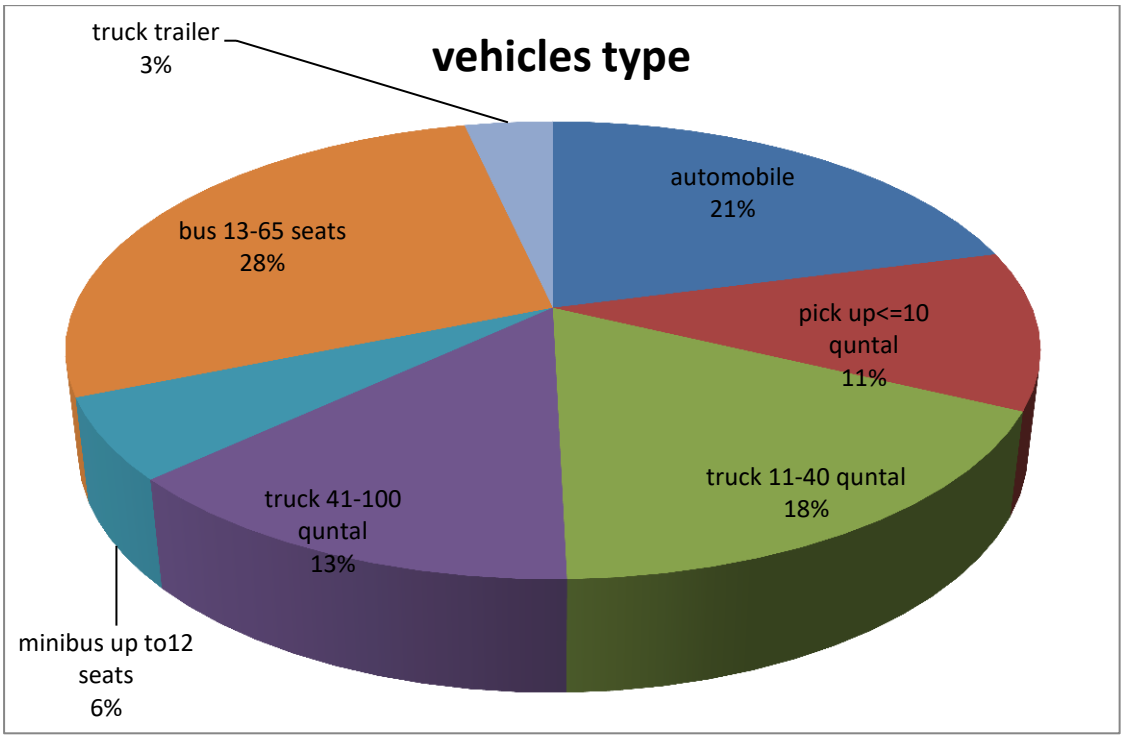


Figure4. 9. Road traffic accidents by vehicle type

4.3. Road traffic accident by possible causes

Accidents commonly occurred by different causes. Factors used mixed traffic can lead to increased number of traffic accidents, and of course also an increase in traffic volume. There are many causes and contributing factors reported by traffic police and extracted from questionnaires.

4.3.1. Causes reported by the traffic police

The Ethiopian toll road enterprise (ETRE) and the police together identify the multiple main causes of accidents on the expressway. Starting from opening of the expressway that is from 2014/15 to 2016/17 a total of 1171 accidents was recorded. From this 62 percent of accidents were caused by drivers error, 37.3 percent and 0.7 percent were due to vehicular defects and others respectively.

Table4. 13.Causes reported by the traffic police
Source: Ethiopian toll road enterprises; compiled by researcher

accidents cause	total number of accidents	
	number of accidents	total percent
drivers error	727	62
vehicular defects	436	37.3
Others	8	0.7
Total	1171	100

From the analyzing the accidents recorded from2014/15-2016/17 it was found from 1171 total accidents ,30.7 percent of accidents were caused by un ethical driving (reckless driving ,driving under influence (alcohol ,chat and drugs),fatigue ,not use seats belt) ,25.3 percent accidents caused by over speed and 18.3 percent of accidents were caused by tire problem. Generally unethical, over speed and breaking problems are appears to be serious problem and cause of accidents on the expressway. The analysis of road accidents in terms of possible casualties' factors reveals that high speed is the single most important factors responsible for accidents it takes higher proportion from others factors.

Table4. 14. Accident distribution by possible causes
Source: Ethiopian toll road enterprises; compiled by researcher

causalities	number of accident			total	% of total
	2014/15	2015/16	2016/17		
over speed	78	93	125	296	25.3
un ethical driving	99	148	113	360	30.7
sleeping	7	29	35	71	6
breaking problem	49	42	46	137	11.7
tire problem	31	129	54	214	18.3
animal	0	4	4	8	0.7
technical	7	47	31	85	7.3
total	271	492	408	1171	100

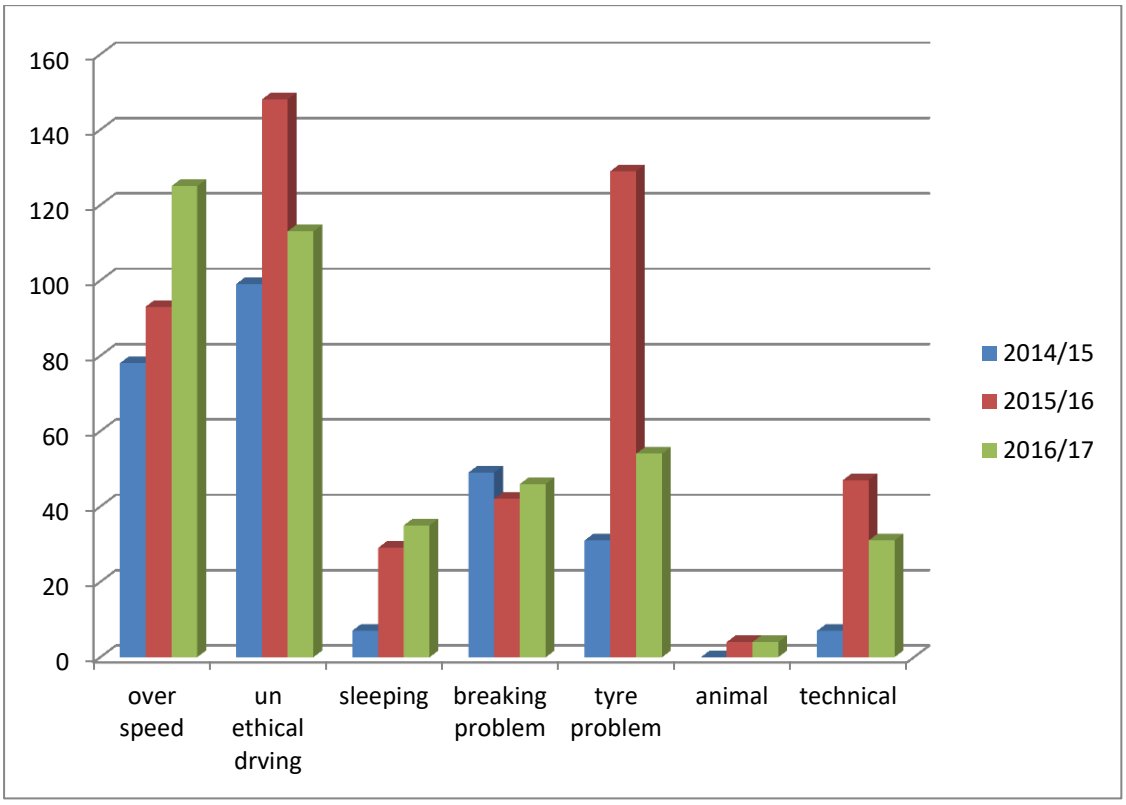


Figure4. 10.Accident distributions by possible causes

Table4. 15.Calculation of chi-square for possible cause

Possible cause	number of accidents	df	x^2 critical	x^2 calculated
over speed	296	18	28.87	54.67
Unethical driving	360			
sleeping	71			
Breaking problem	137			
Tire problem	214			
animals	8			
Technical problem	85			
total	1171			
sig.			0.05	0.000

The chi-square test is used to determine if there is statistically significant relationship between the two variables. Hence the result ($p<0.001$) shows they are statistically significant.

4.3.2. Observed and Questioned Survey Based Factor

Accidents statistics from the Ethiopian toll road payment enterprise provided all information with regard to accidents and causes. But the reported accidents were not gave all the main accident generation or association between factors related to accidents. That is why field observation, interview and questionnaires were performed.

From the sampled drivers the majority of the drivers are male which accounted for 314 (90%) and the remaining 34 (10%) drivers are female. Thus, most of the drivers 39 percent are the aged between 18 and 30, 35 percent aged between 31-40 and 21 percent of aged between 41 and 50 and the remaining 5 percent are greater than 50 years old.

The educational levels of the respondent are 19 percent of primary and above, 49 percent secondary and 32 percent sample drivers were above secondary. Regarding the driving experience the most drivers have the driving experience less than 5 years around 55 percent and the least 13 percent sampled drivers have greater than 10 years driving experience the remaining 35 percent have between 5 and 10 years driving experience. The vehicles of 62 percent that use the expressway were used without service for 2 to 5 years and 40 percent vehicles have less than 2 years and the remaining 8 percent greater than 5 years driving on the expressway without giving service for the vehicles.85 percent of the sampled driver were follow the driving rule and regulation while they driving. Most of the driver around 55 percent always uses stimulants and 45 percent of drivers not use stimulants while they driving.

From the sampled driver 87 percent use the speed limit allow on the expressway there is also 8 percent and 5 percent drivers use speed above and below speed limit respectively. Furthermore, 95 percent of drivers believe the road way has effect on the speed choice and 69 percent of drivers feel safe while they driving on straight and level road geometry.42 percent of the drivers faced accidents on the expressway. From the driver that faced accident 40.48 percent of the accidents caused by over speed, 28.57percent by driving under influence, 14.29 percent reckless driving and ego, 9.52 percent fatigue and the remaining 7.14 percent caused by other factors.83 percent of the drivers use seat belts while they driving and 13 percent not use seat belts. More drivers never observed animal on the expressway. Around 72 percent of the driver observed animal on the expressway.

4.4. Life and Damage cost

Life and Damage cost calculated based on the information collected from the insurances like Awash insurance and Africa insurance company cost of paid to third parties for fatalities, serious injuries, light injuries and vehicle repairing costs for motor vehicle. The information collected on 123 motor vehicles claims from the insurance company to the third parties in March 23 to June 22 of 2017.The data contain information like accident severity and claim paid.

Table4. 16. Claim paid to motor vehicles

type of vehicle	accident severity				total	claim paid(birr)			
	fatal	serious injuries	slight injuries	PDO		Fatal	serious injuries	slight injuries	PDO
motor vehicle	18	19	26	60	123	1,229,400	1,140,000	795,600	798,000

The information is generalized as for all vehicle types collected on 123 accidents and claim paid money for three months in 2016/17. And average claim paid money was computed for each severity level. This done by dividing the claim paid birr for each of accident severity to number of accident for each of accident severity. The result presented below.

Table4. 17. Average claim paid /vehicle

type of vehicle	average claim paid /severity type			
motor vehicles	fatal	serious injuries	light injuries	PDO
	68,300	60,000	30,600	13,300

The accident data collected from Ethiopian toll road payment enterprise for the year 2014/15-2016/17 with respect to accident severity.

Table4. 18.Accident severity data

year	fatal	serious	light	PDO
2014/15	21	33	74	143
2015/16	29	75	166	222
2016/17	20	39	104	245
total	70	147	344	610

Having the total accident statistics and average claimed birr the life and damage cost were calculated by multiplying the average claim paid birr and the number of each accident severity and the result are tabulated below.

Table4. 19. Life and property damage cost

year	life and property damage cost(birr)				Total
	fatal	serious injuries	light injuries	PDO	
2014/15	1,434,300	1,980,000	2,264,400	1,901,900	7,580,600
2015/16	1,980,700	4,500,000	5,079,600	2,952,600	14,512,900
2016/17	1,366,00	2,340,000	3,182,400	3,258,500	10,146,900
total	4,781,000	8,820,000	10,526,400	8,113,000	32,240,400

As the result shows in the above table the analysis found that the cost value 4,781,000 birr for fatal, 8,820,000 birr for serious injuries, 10,526,400 birr for light injuries and 8,113,000 birr for property damage cost. And the total life and property damage cost 32,240,400 birr was lost due to traffic accident occurred on the expressway.

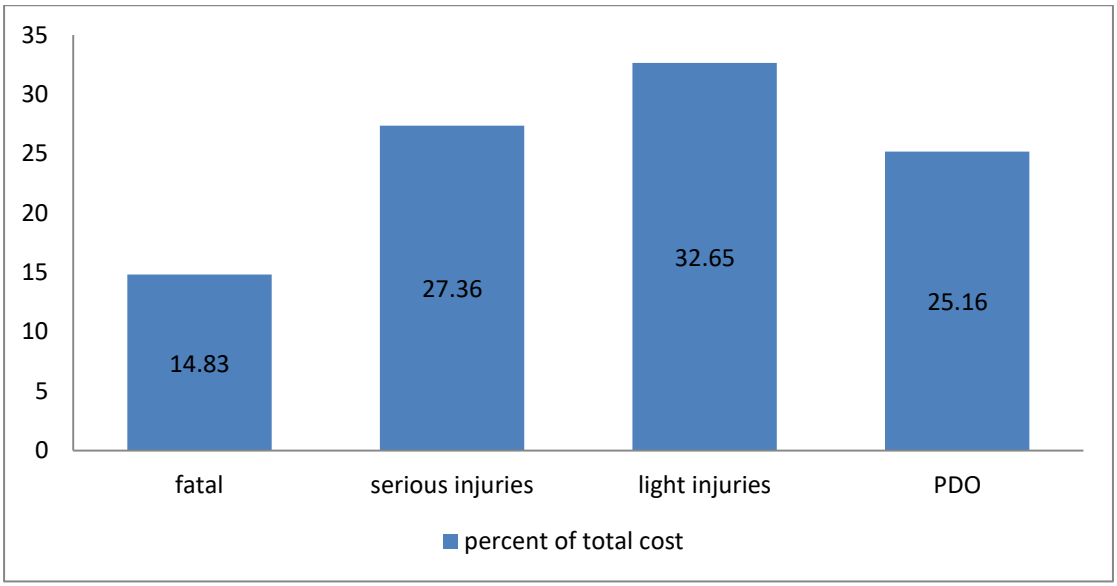


Figure4. 11. Cost distribution by accident severity

From the chart it can be shown that fatal accounted around 20.96 percent of the total cost, 23.04 percent of serious injuries, 19.69 percent of light injuries and 36.31 percent of the total cost loss due to PDO on the expressway.

4.5. Possible Proposed Remedies

Based on the analysis the following remedies were proposed to minimize road traffic accident on the expressway.

- The analysis of the study confirms that the casualties of the driver were higher and less experienced drivers cause more accident. There for the government should be educate younger driver and revise the driver testing and training program.
- Most of the accidents occur due to vehicular deficiencies. Therefore to solve the problem pre-trip inspection and post-trip inspection should be made.
    1. Pre-trip inspection: before beginning a travel the driver should be check the status of the vehicle. If there were defects, the driver should repair the defects. Before driving the vehicle satisfied or in good condition of the following parts and accessories;-
        - Tires
        - Horn
        - Rear vision mirror
        - Wheels and ring
        - Braking
        - Lightening device and reflectors
    2. Post-trip inspection: after the completion each day's work or travel the driver should check the status of the vehicle.
- Accidents occurred on straight and level road condition was high and this road character influence speed choice of drivers. Long tangent section increases the danger from heading glare and usually leading excessive speed. The maximum

tangent, measured in meters, of 20 times the design speed in km/hr [26]. Therefore the length of the straight section should be decrease.

- Over speeding is the single most important factor on the expressway. The driver that doesn't use the speed limit they should be enforcing to use the limit. This done by deploying patrolled traffic police on expressway.

  Over speeding can be reduced by using new technology such as

  1. Intelligent speed adoption (ISA): it is a system used to informs or provide feedback when the driver exceeded the speed limit or actual vehicles speed.
  2. Speed camera: automatic camera enforcement results in a crash reduction of 15 to 20% [27].
- The drinking and driving restriction should be followed on the drivers by checking the alcohol limit in their blood using breathalyzer or checking the blood. If no breathalyzer can be performed, an officer must determine if there are any outward signs of drug impairment, such as physical appearance, erratic driving, incriminating statement etc.
- Reckless driving is caused by one or more poor decisions made by the driver. To prevent or reduce accidents caused by reckless driving driver should be drive safely and as per the rule and regulation of road.
- According to the report of the traffic police one of the causes of the traffic accident was fatigue and sleeping due to long driving. To get out from sleeping problem the driver uses stimulants like chat. So the driving time should be limited and followed by government authorities. This limitation work by restrict the driving hours and the length of journey.

- Almost all public vehicles don't have seat bealts.so, an installment of seat belts on the vehicles is important and there should be the enforcement of wearing seat belts.
- In general by considering the contributory factors that contribute to the occurrence of accident severity on the expressway crash reduction strategies must take and work on. Some of are:-
    1. **Education: -** This is done by influencing the behavior of drivers and road users by public awareness, campaign, and structured driver training programs. For example educations like road safety
    2. **By making policy or legislation: -** This reduces crash severity by influencing the human behavior, design of road way and vehicle technology. This policy must be restricted and the road user must be corporate with the traffic regulation and rule. For example laws prohibit using chat, drug and drinking alcohol while driving. If the drivers did not follow this type of rule and regulation the road user like passengers must be report to the traffic police.
    3. **Enforcement:-**The traffic police should be penalizing illegal drivers appropriately like slow and excessive driving speed.
    4. **Using technology advance**:-This may reduce the outcome of crash severity. For example while the driver take the driving training program using driving simulation.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The result obtained from the assessment of the data get from Ethiopian toll road enterprise, traffic police and from the questionnaires indicate that the extent of accident on the expressway were high and a serious problem.

According to the finding on the Ethiopian toll road enterprise accident data the following conclusion were drawn

- The total accident occurred on the expressway were 1171 out of this 70 fatal, 491 injuries and the remaining 610 property damage only were recorded. Most of the accident regarding to fatal, serious injuries and light injuries caused by male drivers. The road traffic accident occurred on the expressway were also grouped in to age categories. From the result the total accidents higher RTAs occurred by the age group of 18-30 and the least accidents were recorded age group of greater than 50 years old. The age group of driver increase the road traffic accident occurred on the expressway decreased. The road traffic accidents were vary throughout the day and the night time, according to accidents report most of the accidents were occurred on the day time. That is from the mid-day to the night time that means 12:00PM-6:00AM (6 o'clock day time -12 o'clock night time at local time) that of 463 accidents and the leas accident occurred at 12:00AM-6:00AM (18:00-24:00 o'clock).Accidents distributed throughout the day of the week. Sunday was the day registered high accidents from the day of the week. The studies also identify the road character and road traffic accident occurred. The most accident occurred on straight and level of road character. And the least road traffic accidents

occurred at uphill road character. Moreover, most of the road traffic accident occurred during normal weather condition and fewer accidents recorded on hot weather condition. Different types of vehicle are used the expressway and they are involved in road traffic accidents. From the vehicle types the most of road traffic accidents occurred by bus (13-65) seats and the least traffic accident occurred by truck (11-40 quintals).

- Generally The cause and contributing factors on the expressway were over speed, unethical driving (reckless driving, driving under influence, fatigue, not use seat belts, sleeping, breaking problem, tire problem, animal entrance and technical problem.
- The study shows that the national economic losses resulting from road traffic accident occurred on the expressway are high. Based on the data and computed the minimum average estimate cost of road accident crash were 32,240,400 birr.
- Finally to minimize the accidents occurred on expressway there should be appropriate driver testing and training, inspection of vehicles, enforcement of speed limit, drunk driving, reckless driving and wearing seatbelts.

5.2. Recommendation

Based on the finding and conclusion the following recommendations were drawn.

To prevent or decrease road traffic accident the government should be approved road national safety. The policy should outline

- ✓ Promoting awareness
- ✓ Establishing road safety information data base
- ✓ Application of intelligent transport enforcement of safety laws
- ✓ Emergency care

Also to reduce or minimize the current high frequency of traffic accident on expressway the following recommendation should be implemented

- ✓ Strict traffic police enforcements and speed control
- ✓ Limiting driving time
- ✓ Improve accident data collection and processing system
- ✓ Strengthening the technical inspection of vehicles
- ✓ Use seatbelts
- ✓ Implement drink drive measures
- ✓ Enforcement of speed limit
- ✓ Provide public awareness
- ✓ Improve traffic regulation and enforcement
- ✓ Standardized drivers' training and license

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APPENDICES

Appendix 1: Actual and Compiled Data of expressway

Table A- 1.Average annual daily traffic

Data source: Ethiopian toll road enterprise

Toll Station	Average Annual Daily Traffic (AADT)				
	Year	2014	2015	2016	2017
Tulu Dimtu (K2)	Entrance	479	6032	6667	7634
	Exit	**567**	**6789**	**7156**	**8340**
Bishoftu North (K16)	Entrance	71	1549	1660	3197
	Exit	**145**	**1872**	**2456**	**3267**
Bishoftu South(K33)	Entrance	26	576	645	1697
	Exit	**87**	**1235**	**1562**	**2678**
Modjo (K52)	Entrance	56	1210	1654	1817
	Exit	**102**	**1446**	**1723**	**2862**
Adama West (K60)	Entrance	204	1478	4563	2513
	Exit	**123**	**1561**	**1894**	**2678**
Adama Main (K64)	Entrance	61	1456	1834	1936
	Exit	**126**	**1456**	**1678**	**2689**
Total	**Entranc**	8991	12301	17023	1879
	Exit	**1152**	**1435**	**1668**	**2251**

Table A- 2. Traffic accident by age of driver

Data source: Ethiopian toll road enterprise compiled by researcher

age of driver	traffic accident								
	Year								
	2014/15			2015/16			2016/17		
	fatal	serious injury	light injury	fatal	serious injury	light injury	fatal	serious injury	light injury
18-30				11	32	56	9	18	52
31-40				3	7	22	5	8	32
41-50				3	1	7	1	4	9
>50				0	0	6	0	3	3
blank	21	33	74	12	35	75	5	6	8

Table A- 3. Traffic accident by sex of driver

Data source: Ethiopian toll road enterprise compiled by researcher

sex of driver	traffic accident								
	Year								
	2014/15			2015/16			2016/17		
	fatal	serious injury	light injury	fatal	serious injury	light injury	fatal	serious injury	light injury
M	19	30	65	29	73	166	17	34	95
F	1	3	6	0	2	0	0	1	3
unrecorded	1	0	3	0	0	0	3	4	6

Table A- 4. Traffic accident by crash hour

Data source: Ethiopian toll road enterprise compiled by researcher

crash hour	traffic accident											
	Year											
	2014/15				2015/16				2016/17			
	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO
6:00AM-12:00PM	14	15	15	34	14	39	58	81	8	14	30	90
12:00PM-6:00PM	4	7	28	61	10	28	86	88	9	17	31	94
6:00PM-12:00AM	1	2	13	26	5	5	13	35	2	5	25	43
12:00AM-6:00AM	2	9	18	22	0	3	9	18	1	3	12	18
blank	0	0	0	0	0	0	0	0	0	0	6	0

Table A- 5. Traffic accident by day of week

Data source: Ethiopian toll road enterprise compiled by researcher

day of the week	traffic accident											
	Year											
	2014/15				2015/16				2016/17			
	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO
Monday	0	2	4	25	3	4	9	37	1	4	6	26
Tuesday	1	7	23	19	10	20	38	35	2	7	29	37
Wednesday	6	2	15	20	4	5	18	23	6	5	13	36
Thursday	0	3	7	18	3	11	22	28	1	3	12	39
Friday	0	3	6	15	3	8	22	31	1	3	19	35
Saturday	1	1	11	18	1	5	17	26	0	4	7	32
Sunday	13	15	8	28	5	22	40	42	9	13	18	40

Table A- 6.Traffic accident by road geometry

Data source: Ethiopian toll road enterprise compiled by researcher

Road character	traffic accident											
	Year											
	2014/15				2015/16				2016/17			
	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO
straight and level	14	19	35	67	13	38	87	117	12	23	49	80
uphill	1	2	3	6	2	4	5	5	4	7	4	44
down hill	4	9	24	40	10	27	71	74	2	5	35	69
curve	2	3	4	29	4	6	3	16	2	4	16	52
unrecorded	0	0	8	1	0	0	0	10	0	0	0	0

Table A- 7.Traffic accident by weather condition

Data source: Ethiopian toll road enterprise compiled by researcher

weather condition	traffic accident											
	Year											
	2014/15				2015/16				2016/17			
	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO
cloudy	0	6	4	17	5	7	22	39	1	6	9	35
rainy	3	7	2	34	1	5	8	31	4	5	12	30
normal	10	16	35	41	13	39	50	66	12	15	44	61
windy	0	0	23	9	0	22	76	0	1	6	9	18
sunny	7	4	10	22	8	0	0	75	1	5	20	66
cold	0	0	0	12	0	1	1	0	1	2	6	16
hot	1	0	0	5	2	1	4	0	0	0	4	19
unrecorded	0	0	0	3	0	0	5	11	0	0	0	0

Table A- 8.Traffic accident by causalities

Data source: Ethiopian toll road enterprise compiled by researcher

causalities	traffic accident											
	Year											
	2014/15				2015/16				2016/17			
	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO
over speed	3	5	22	48	5	12	23	53	12	14	37	62
un ethical driving	16	15	23	45	7	15	49	77	8	20	32	53
sleeping	0	0	1	6	0	2	7	20	0	0	5	30
breaking problem	1	11	17	20	1	2	16	23	0	2	9	35
tire problem	1	2	11	17	13	26	50	40	0	3	11	40
animal	0	0	0	0	0	2	2	0	0	0	4	0
technical	0	0	0	7	3	16	19	9	0	0	6	25

Table A- 9.Traffic accident by vehicle type

Data source: Ethiopian toll road enterprise compiled by researcher

vehicles type	number of accidents											
	2014/15				2015/16				2016/17			
	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO	fatal	serious injury	light injury	PDO
automobile	1	5	32	36	2	13	24	46	3	9	27	47
pick up<=10 quintals	1	0	3	14	2	2	13	27	2	14	12	41
truck 11-40 quintals	5	7	25	42	4	4	19	40	3	2	14	40
truck 41-100 quintals	1	4	6	31	2	5	10	43	1	3	13	39
minibus up to12 seats	0	0	0	0	0	0	3	21	1	2	10	30
bus 13-65 seats	13	13	8	20	19	50	91	40	10	7	20	33
truck trailer	0	4	0	0	0	1	6	5	0	2	8	15

Table A- 10.Traffic accident by surface condition

Data source: Ethiopian toll road enterprise compiled by researcher

surface condition	number of accident			
	2014/15	2015/16	2016/17	total
wet	86	97	102	285
dry	180	383	306	869
blank	5	12	0	17
total	271	492	408	1171

Appendix 2: SPSS out put

Chi-square test for age of driver

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
age of driver * accident severity	902	77.0%	269	23.0%	1171	100.0%

age of driver * accident severity Crosstabulation

			accident severity				
			fatal	serious injury	light injury	PDO	Total
age of driver	18-30	Count	20	50	108	308	486
		Expected Count	17.2	39.3	100.8	328.7	486.0
		Residual	2.8	10.7	7.2	-20.7	
	31-40	Count	8	15	54	192	269
		Expected Count	9.5	21.8	55.8	181.9	269.0
		Residual	-1.5	-6.8	-1.8	10.1	
	41-50	Count	4	5	16	96	121
		Expected Count	4.3	9.8	25.1	81.8	121.0
		Residual	-.3	-4.8	-9.1	14.2	
	>50	Count	0	3	9	14	26
		Expected Count	.9	2.1	5.4	17.6	26.0
		Residual	-.9	.9	3.6	-3.6	
Total		Count	32	73	187	610	902
		Expected Count	32.0	73.0	187.0	610.0	902.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	20.686[a]	9	.014
Likelihood Ratio	22.116	9	.009
Linear-by-Linear Association	6.947	1	.008
N of Valid Cases	902		

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.151	.014
	Cramer's V	.087	.014
N of Valid Cases		902	

The chi-square test is used to determine if there is statistically significant relationship between the two variables. Hence the result ($p<0.05$) so they are statistically significant. And the systematic measures cramer's v shows strength of the relationship and the value is .087 the effect is small.

Chi-square test for causalities

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Per cent
possible causes * accident severity	1171	100.0%	0	0.0%	1171	100.0%

possible causes * accident severity Cross tabulation

			accident severity				
			fatal	serious injuries	light injuries	PDO	Total
possible causes	over speed	Count	20	31	82	163	296
		Expected Count	17.7	37.2	87.0	154.2	296.0
		Residual	2.3	-6.2	-5.0	8.8	
	unethical driving	Count	31	50	104	175	360
		Expected Count	21.5	45.2	105.8	187.5	360.0
		Residual	9.5	4.8	-1.8	-12.5	
	Sleeping	Count	0	2	13	56	71
		Expected Count	4.2	8.9	20.9	37.0	71.0
		Residual	-4.2	-6.9	-7.9	19.0	
	breaking problem	Count	2	15	42	78	137
		Expected Count	8.2	17.2	40.2	71.4	137.0
		Residual	-6.2	-2.2	1.8	6.6	
	tire problem	Count	14	31	72	97	214
		Expected Count	12.8	26.9	62.9	111.5	214.0
		Residual	1.2	4.1	9.1	-14.5	
	Animals	Count	0	2	6	0	8
		Expected Count	.5	1.0	2.4	4.2	8.0
		Residual	-.5	1.0	3.6	-4.2	
	technical problem	Count	3	16	25	41	85
		Expected Count	5.1	10.7	25.0	44.3	85.0
		Residual	-2.1	5.3	.0	-3.3	
Total		Count	70	147	344	610	1171
		Expected Count	70.0	147.0	344.0	610.0	1171.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	54.670[a]	18	.000
Likelihood Ratio	64.610	18	.000
Linear-by-Linear Association	.395	1	.529
N of Valid Cases	1171		

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.216	.000
	Cramer's V	.125	.000
N of Valid Cases		1171	

The chi-square test is used to determine if there is statistically significant relationship between the two variables. Hence the result ($p<0.001$) so they are statistically significant. And the systematic measures cramer's v shows strength of the relationship and the value is .125 the effect is medium.

Chi-square test for road geometry

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
road geometry * accident severity	1152	98.4%	19	1.6%	1171	100.0%

road geometry * accident severity Cross tabulation

			accident severity				
			fatal	serious injuries	light injuries	PDO	Total
road geometry	straight and level	Count	39	80	171	264	554
		Expected Count	33.7	70.7	161.6	288.1	554.0
		Residual	5.3	9.3	9.4	-24.1	
	uphill	Count	7	13	12	55	87
		Expected Count	5.3	11.1	25.4	45.2	87.0
		Residual	1.7	1.9	-13.4	9.8	
	downhill	Count	16	41	130	183	370
		Expected Count	22.5	47.2	107.9	192.4	370.0
		Residual	-6.5	-6.2	22.1	-9.4	
	curve	Count	8	13	23	97	141
		Expected Count	8.6	18.0	41.1	73.3	141.0
		Residual	-.6	-5.0	-18.1	23.7	
Total		Count	70	147	336	599	1152
		Expected Count	70.0	147.0	336.0	599.0	1152.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	39.393[a]	9	.000
Likelihood Ratio	41.817	9	.000
Linear-by-Linear Association	10.636	1	.001
N of Valid Cases	1152		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.29.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.185	.000
	Cramer's V	.107	.000
N of Valid Cases		1152	

The chi-square test is used to determine if there is statistically significant relationship between the two variables. Hence the result ($p<0.001$) so they are statistically significant. And the systematic measures cramer's v shows strength of the relationship and the value is .107 the effect is medium.

Chi-square test for sex of driver

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Sex of driver * accident severity	1124	96.0%	47	4.0%	1171	100.0%

Sex of driver * accident severity Cross tabulation

			accident severity				Total
			fatal	serious injury	light injury	PDO	
Sex of driver	male	Count	65	137	326	417	945
		Expected Count	55.5	120.2	281.7	487.6	945.0
		Residual	9.5	16.8	44.3	-70.6	
	female	Count	1	6	9	163	179
		Expected Count	10.5	22.8	53.3	92.4	179.0
		Residual	-9.5	-16.8	-44.3	70.6	
Total		Count	66	143	335	580	1124
		Expected Count	66.0	143.0	335.0	580.0	1124.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	133.026[a]	3	.000
Likelihood Ratio	153.609	3	.000
Linear-by-Linear Association	93.474	1	.000
N of Valid Cases	1124		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.51.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.344	.000
	Cramer's V	.344	.000
N of Valid Cases		1124	

The chi-square test is used to determine if there is statistically significant relationship between the two variables. Hence the result ($p<0.001$) so they are statistically significant. And the systematic measures cramer's v shows strength of the relationship and the value is .344 the effect is medium.

Chi-square test for time of accident

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
time of accidents * accident severity	1165	99.5%	6	.5%	1171	100.0%

time of accidents * accident severity Cross tabulation

			accident severity				
			fatal	serious injuries	light injuries	PDO	Total
time of accidents	6:00AM-12:00PM	Count	36	68	103	205	412
		Expected Count	24.8	52.0	119.5	215.7	412.0
		Residual	11.2	16.0	-16.5	-10.7	
	12:00PM-6:00PM	Count	23	52	145	243	463
		Expected Count	27.8	58.4	134.3	242.4	463.0
		Residual	-4.8	-6.4	10.7	.6	
	6:00PM-12:00AM	Count	8	12	51	104	175
		Expected Count	10.5	22.1	50.8	91.6	175.0
		Residual	-2.5	-10.1	.2	12.4	
	12:00AM-6:00AM	Count	3	15	39	58	115
		Expected Count	6.9	14.5	33.4	60.2	115.0
		Residual	-3.9	.5	5.6	-2.2	
Total		Count	70	147	338	610	1165
		Expected Count	70.0	147.0	338.0	610.0	1165.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25.387[a]	9	.003
Likelihood Ratio	25.955	9	.002
Linear-by-Linear Association	8.870	1	.003
N of Valid Cases	1165		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.91.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.148	.003
	Cramer's V	.085	.003
N of Valid Cases		1165	

The chi-square test is used to determine if there is statistically significant relationship between the two variables. Hence the result ($p<0.05$) so they are statistically significant. And the systematic measures cramer's v shows strength of the relationship and the value is 0.085 so effect size is small.

Chi-square test for surface condition

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
surface condition * accident per year	1154	98.5%	17	1.5%	1171	100.0 %

surface condition * accident per year Cross tabulation

			accident per year			Total
			2014/15	2015/16	2016/17	
surface condition	wet	Count	86	97	102	285
		Expected Count	65.7	118.5	100.8	285.0
		Residual	20.3	-21.5	1.2	
	dry	Count	180	383	306	869
		Expected Count	200.3	361.5	307.2	869.0
		Residual	-20.3	21.5	-1.2	
Total		Count	266	480	408	1154
		Expected Count	266.0	480.0	408.0	1154.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	13.556[a]	2	.001
Likelihood Ratio	13.303	2	.001
Linear-by-Linear Association	2.976	1	.085
N of Valid Cases	1154		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 65.69.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.108	.001
	Cramer's V	.108	.001
N of Valid Cases		1154	

The chi-square test is used to determine if there is statistically significant relationship between the two variables. Hence the result ($p<0.05$) so they are statistically significant. And the systematic measures cramer's v shows strength of the relationship and the value is .108 the effect is medium.

Chi-square test for weather condition

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
weather condition * accident severity	1152	98.4%	19	1.6%	1171	100.0%

weather condition * accident severity Cross tabulation

			accident severity				
			fatal	serious injuries	light injuries	PDO	Total
weather condition	cloudy	Count	6	19	35	91	151
		Expected Count	9.2	19.3	44.4	78.1	151.0
		Residual	-3.2	-.3	-9.4	12.9	
	rainy	Count	8	17	22	95	142
		Expected Count	8.6	18.1	41.8	73.5	142.0
		Residual	-.6	-1.1	-19.8	21.5	
	normal	Count	35	70	129	168	402
		Expected Count	24.4	51.3	118.3	208.0	402.0
		Residual	10.6	18.7	10.7	-40.0	
	windy	Count	1	28	108	27	164
		Expected Count	10.0	20.9	48.3	84.8	164.0
		Residual	-9.0	7.1	59.7	-57.8	
	sunny	Count	16	9	30	163	218
		Expected Count	13.2	27.8	64.2	112.8	218.0
		Residual	2.8	-18.8	-34.2	50.2	
	cold	Count	1	3	7	28	39
		Expected Count	2.4	5.0	11.5	20.2	39.0
		Residual	-1.4	-2.0	-4.5	7.8	
	hot	Count	3	1	8	24	36
		Expected Count	2.2	4.6	10.6	18.6	36.0
		Residual	.8	-3.6	-2.6	5.4	
Total		Count	70	147	339	596	1152
		Expected Count	70.0	147.0	339.0	596.0	1152.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	230.414[a]	18	.000
Likelihood Ratio	239.228	18	.000
Linear-by-Linear Association	3.389	1	.066
N of Valid Cases	1152		

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.447	.000
	Cramer's V	.258	.000
N of Valid Cases		1152	

The chi-square test is used to determine if there is statistically significant relationship between the two variables. Hence the result ($p<0.001$) so they are statistically significant. And the systematic measures cramer's v shows strength of the relationship and the value is .258 the effect is medium.

Chi-square test for week of day

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
day of week * accident severity	1171	100.0%	0	0.0%	1171	100.0%

day of week * accident severity Cross tabulation

			accident severity				
			fatal	serious injuries	light injuries	PDO	Total
day of week	Monday	Count	4	10	19	88	121
		Expected Count	7.2	15.2	35.5	63.0	121.0
		Residual	-3.2	-5.2	-16.5	25.0	
	Tuesday	Count	13	34	90	91	228
		Expected Count	13.6	28.6	67.0	118.8	228.0
		Residual	-.6	5.4	23.0	-27.8	

	Wednesday	Count	16	12	46	79	153
		Expected Count	9.1	19.2	44.9	79.7	153.0
		Residual	6.9	-7.2	1.1	-.7	
	Thursday	Count	4	17	41	85	147
		Expected Count	8.8	18.5	43.2	76.6	147.0
		Residual	-4.8	-1.5	-2.2	8.4	
	Friday	Count	4	14	47	81	146
		Expected Count	8.7	18.3	42.9	76.1	146.0
		Residual	-4.7	-4.3	4.1	4.9	
	Saturday	Count	2	10	35	76	123
		Expected Count	7.4	15.4	36.1	64.1	123.0
		Residual	-5.4	-5.4	-1.1	11.9	
	Sunday	Count	27	50	66	110	253
		Expected Count	15.1	31.8	74.3	131.8	253.0
		Residual	11.9	18.2	-8.3	-21.8	
Total		Count	70	147	344	610	1171
		Expected Count	70.0	147.0	344.0	610.0	1171.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	84.592[a]	18	.000
Likelihood Ratio	84.842	18	.000
Linear-by-Linear Association	5.910	1	.015
N of Valid Cases	1171		

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.269	.000
	Cramer's V	.155	.000
N of Valid Cases		1171	

The chi-square test is used to determine if there is statistically significant relationship between the two variables. Hence the result ($p<0.001$) so they are statistically significant. And the systematic measures cramer's v shows strength of the relationship and the value is .155 the effect is medium

Appendix 3 questionnaires

1. Sex _____

2. Age _____

3. Education level

   A. Primary and above
   B. Secondary
   C. Above secondary
   D. Other

4. How many years stay while you driving?

   A. Less than 5 years
   B. 5-10 years
   C. Greater than 10 years

5. How many total years did the vehicle uses without services?

   A. Less than 2 years
   B. 2-5 years
   C. Greater than 5 years

6. Do you follow driving rule and regulation while you driving on the expressway?

   A. Yes
   B. No

7. When you driving do you use stimulants like chat, alcohol, drugs?

   A. Yes
   B. No

8. What is your average driving speed on the expressway

A. Less than 100km/hr

B. 100km/hr-120 km/hr

C. Above 120km/hr

9. When you driving on the expressway which of road geometry affect you?

A. Straight and level

B. Uphill

C. Down hill

D. Curve

10. While you driving on the expressway road factors have effect on the speed choice?

A. Yes

B. No

11. Are you faced accident while driving n the expressway?

A. Yes

B. No

12. If the answer of question 11 is yes what is the cause?

A. Over sped

B. Driving under influence

C. Reckless driving and ego

D. Fatigue

E. Other

13. When you drive do you use seat belts?

A. Yes

B. No

14. Are you observe animals on the expressway?

A. Always

B. Sometimes

C. Never

15. Suggest some possible solution to prevent and reduce accident on the expressway.

_____

_____

_____

_____.

Appendix 4.Interviw for Driver and Road User

1. What do you think the reason for variation of accident during time of day?
2. What is the reason vary road traffic accident vary by road characteristic?
3. What is the effect of road surface condition on driver behavior and road users?
4. What is the effect of weather condition on driver behavior and road users?