JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

HIGHWAY ENGINEERING STREAM

Investigation on Road Traffic Accident Factors and Possible Countermeasures: A case study from Bonga to Mizan Roadway

A Thesis Submitted to The School of Post Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Highway Engineering.

By:

Adinew G/Michael Mery

December 2019

Jimma, Ethiopia

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Main-advisors: Engr. Elmer C. Agon (Asso. Prof)

Co-adviser: Engr. Melka Amensa (MSc)

December, 2019

Jimma, Ethiopia

DECLARATION

I Adinew G/Michael Mery, hereby declare that this Research entitled "Investigation on Road Traffic Accident Factors and Possible countermeasures: A case study from Bonga to Mizan Roadway" is my own original work that I am the Authorship owner thereof and the work that take from others are acknowledged.

Mr. Adinew G/Michael _____ _____

Student Signature Date

This Research submitted by Mr. Adinew G/Michal entitled "Investigation on Road Traffic Accident Factors and Possible Countermeasures: A case study from Bonga to Mizan Roadway" is approved by us the university supervisors stated bellow.

Engr. Elmer C. Agon (Asso. Prof) _____ _____

Main-Advisor signature Date

Engr. Melka Amensa (MSc). _____ _____

Co-Advisor signature Date

ABSTRACT

Road traffic accident is a worldwide problem, that leading several countries to gather efforts to intervene in the situation currently. It results from a combination of factors related to human behavioral factors, vehicular factors and road geometric factors, due to the way they interacted. Some factors contribute to the occurrence of crashes and others aggravate its effect.

Currently, Ethiopia experienced the highest world's road traffic accident record due to several factors. Road traffic accident severities from Bonga to Mizan roadway are also increasing rapidly, and the most exposed groups are passengers and pedestrians. Unless possible countermeasures are taken, the situation escalates and traffic accidents are continuing per year. This results in fatalities and the number of reported injuries to increase.

The objective of this research is the investigation of road traffic accident factors and possible countermeasures for traffic accidents. Data collection for this research is the qualitative and quantitative method, within a framework of the case study approach. Direct visual observation and review of related literature are done accordingly and presented in terms of tables, charts, and graphs.

The result from analysis show that road traffic accident factors from Bonga to Mizan roadway are frequently occurred due to improper design of cross-sectional elements like narrow carriageways, lack of shoulders, medians, pedestrian crossings, roadside delineators, missing of pavement markings, lack of curve signs, and animal and vehicle mixed traffic flow systems. Blackspots are also identified as 24% traffic accidents in Gimbo at 18+80, 20% in Bong town from 03 kebele to Tesfaye Garage, 10% in Shiishoo-Indee at 53+80, 9% in Chenna at 70+20 and 3% in Mizan-Aman town. It is also concluded from three years analysis period that, 62% of the traffic accident severities are due to driver's error, 37.3% are due to vehicular defects and 0.7% are by others. Finally, it is also recommended to local government authorities in collaboration with traffic Polices to declare road safety as a human rights and interdisciplinary processes requiring institutional cooperation, and governments to play a big role to intervene in the situation for relief.

Key Words: Traffic accidents, Accident Severities, Road geometric design, Blackspots.

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ACRONYMS AND ABBREVIATIONS

DF	Degree of Freedom
ECA	Economic Commission for Africa.
ERA	Ethiopian Road Authority.
FHWA	Federal Highway Administration.
HSIS	Highway Safety Information System.
NRSCO	National Road Safety Coordination Office.
PDO	Property Damage Only
RTA	Road Traffic Accident.
SNNPR	South Nation Nationalities of People Region.
SPSS	Statistical Package software for Social Science
TRL	Transport Research Laboratory
UNDA	United Nations Decade of Action.
UNECA	United Nations Economic Commission for Africa.
UNGA	United Nations General Assembly.
WHO	World Health Organization.

CHAPTER ONE

INTRODUCTION

1.1 Back Ground

People for centuries and periods have been moving from place to place to carry out their day-to-day activities. To ease their movements, they use multiple modes of transportations like road transport, air transport, train transport, and water transport. From all these modes of transportations, road transportation is easily accessible and closest to people, letting them run their business from door-to-door within a short distance and at the most competitive price.

In Africa, over 80% of the goods and people are transported through road transportation while in Ethiopia, it accounts for more than 90% of the freights' and passengers' movement every year, (WHO, 2012).

However, the increase in road transport placed a considerable burden on people's health in the form of road traffic accidents.

Hossain, et al. (2016), stated that road traffic accidents caused about 1.2 million deaths and injuries 10 to 15 million people in a year throughout the world, and more people died than due to malaria. And also, Takahiro, T. (2018) suggested that low and middle-income countries remain the most affected by the road traffic injuries, because, traffic accidents were not only linked to the number of vehicles, to the existing road conditions, to the drivers' behavior and attitude towards the road safety, but also directly or indirectly to one country's level of economic and social structure.

In Ethiopia, the situation is different from developed countries, because of the road traffic accidents are increasing with time and mortality due to various factors. Road traffic accident severities are also increasing from time to time along the highway section from Bonga to Mizan. An implication of this is that factors causing road traffic accidents on the highway section clearly need further empirical attention. The interest of this study under its objective seeks investigation on road traffic accident factors and possible countermeasures to intervene globally alarming road traffic accident situation.

1.2 Statement of the Problem

To the coming 2020, the road traffic accidents are expected to be the third leading cause of fatalities and disabilities throughout the world, (Bisrat, 2017). It is more severe to African continents, particularly to the sub-Saharan countries. In this part of the continents, about 10 % of the global road fatalities take place, despite the fact that only 4% of the global vehicle populations are registered in the region (ERA, 2016).

Road traffic accidents are growing rapidly day today as the vehicle use of developing countries rise. This results in a great impact on economic and social activities. It is causing all kinds of losses, other than loss of life and injuries. Loss to modes of transportations and an item of additional expenditure to purchase new vehicles and repairing damaged ones are one of the main consequences due to road traffic accidents.

Ethiopia, as one of the developing countries experience the world's worst road traffic accident record by the rate of 170 fatalities per 10,000 motor vehicles, (Yayeh. A. 2010). Currently, Ethiopia lost almost 1700 lives each year, 7500 people are seriously injured and 7783 faces property damage only due to road traffic accidents, (Yayeh, A. 2010).

Highway section from Bonga to Mizan roadway is one of the new road networks connecting Kafa and Bench-Sheko Zones. Road transport and development sector of the Zones with traffic police in 2018 reported that the occurrence of road traffic accidents from Bonga to Mizan roadway was increasing for the last three years. And, the most exposed groups were passengers and pedestrians. This implies that, the need for investigation on road traffic accident factors and possible countermeasures to reduce globally escalating situations. The researcher's interest to deal with this topic is that, as Ethiopia relying greatly on road transport and battling with how to control the severities that claiming lives and brought sorrows to families, it must be an agenda that concerns everyone. Due to these reasons, the researcher initiated to play own role in fighting the issue and would like to deem it necessary to look critically into the situation.

1.3 Objective of the study

1.3.1 General objective

The main objective of this study was investigation on road traffic accident factors and possible countermeasures to intervene in the road traffic accidents by considering the highway section from Bonga to Mizan roadway.

1.3.2 Specific objectives

More specifically, this research realized through the following specific objectives.

1. To identify factors causing road traffic accidents from Bonga to Mizan roadway.
2. To assess improper geometric cross-section design elements causing road traffic accidents from Bonga to Mizan roadway.
3. To identify road traffic accident-prone areas wishing an immediate mitigation from Bonga to Mizan roadway.
4. To provide necessary improvement measures to reduce road traffic accident severities from Bonga to Mizan roadway.

1.4 Research Questions

It is the fact that, in order to achieve targeted objects at the end of the day, the researcher is expected to plan a set of designed specific objects answering each research question.

1. Which contributory factors are identified for the occurrence of road traffic accidents from Bonga to Mizan roadway?
2. Which improper geometric cross-section design elements cause road traffic accidents from Bonga to Mizan roadway?
3. Which segment highly experiences road traffic accident occurrence from Bonga to Mizan roadway?
4. What type of improvement measures are provided to reduce road traffic accident severities from Bonga to Mizan roadway?

1.5 Significance of the study

The beneficiaries were: the societies, future related researchers, local government authorities in health, road transport and development sectors, the road traffic polices to their enforcement and strategic enforcement. It is also beneficiary in adding the skill and knowledge on how to intervene traffic accidents relative to investigated risk factors, the

event of the road traffic accidents and related injuries to reduce fatalities along with the regulated Black spots.

Generally, local government authorities who were going to benefit the public at large on the reduction of road traffic accidents along the Bonga-Mizan roadway were among the beneficiaries.

1.6 Scope and Limitation of the study

It was up to investigating the risk factors and their interventions for the road traffic accidents considering the Bonga-Mizan roadway. It extended over 117km length and considered the following study parameters.

- Human behavioral factors
- Vehicle mechanical factors
- Road geometric factors, such as Straight and level, curves, uphill, downhill, and traffic control signs.

The study has a limitation in dealing with drunk drivers, due to the lack of technology measuring instrument to detect how many milligrams of alcohol in the drivers' blood was. And also, considering the Road geometric factors such as super elevation and deflection angle of the road cross-sectional elements were not considered due to lack of design data for evaluation.

1.7 Justification of the study

Ethiopia planned to double the road network in 2020 from extent in 2015. Highway engineers are greatly expected to play their own role in conducting researches on how to lower globally escalating road traffic accidents. The researcher has a confidant about the paper that, it played its own value on reducing accident severities due to road traffic accidents. So, the researcher participated in the success of the government's plan to intervene in the road traffic accident severities. The benefit for the country is to reduce the fast-growing fatalities, serious injuries, and light injuries as well as PDOs. Although the research was conducted from Bonga to Mizan roadway, the result was not area dependent. It can be used in an area with the same issues and for future researches.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Road Traffic Accident (RTA)

According to Ali Aram, (2010), Road traffic accident is understood as any vehicle crash or collision occurring between vehicles and animals, vehicles and pedestrians, vehicles and fixed objects or vehicles and vehicles traveling along with the road network. Road traffic fatalities accounted for 23% of fatal injuries worldwide, (Bisrat, 2017). The widely accepted concept for the RTAs is given by the Economic Commission for Europe (ECE). Road traffic accidents (RTAs) are those accidents occurring on a way or street open to the public traffics, resulting in one or more persons being killed or injured and at least one moving vehicle is involved. Currently, road traffic accidents along the roadway are globally influential, causing more fatalities and injuries. From recent research, road traffic accidents kill 1.2 million victims worldwide and injuries 50 million people each year (Ghazi, 2012). 90% of the road traffic accidents occurre in developing countries and more than half of all sufferers globally are between the ages of 15 and 44, (Ghazi, 2012). Hence, the manner forward is to investigate factors contributing to the crash severities and their possible counter measures to intervene road traffic accidents by considering the highway section from Bonga to Mizan roadway.

2.2 Road Safety and Various causes of road traffic accidents

Road traffic safety can be regarded as the system and strategies to prevent the risk of a person along the road section being killed or seriously injured, including users like pedestrians, cyclists, motorists, and passengers or freights, (Ding Jianmei & PEI Yulong, 2016). The best-practiced road traffic accident intervention focused upon the reduction of fatalities, serious injuries, light injuries and PDOs. Highway segments designed considering road safety are capable of providing the environment that ensuring limited vehicle speeds within the human tolerances for serious injuries and fatalities wherever conflicting points are existing, (Achuta, 2013).

2.3 Highway Safety Information System

Road safety should be the main objective for the highway and traffic engineers to provide an effective, efficient, smooth and comfortable mode of transportation system for road users, (Chen. G, 2014). Road traffic accidents with their end result of fatalities and injuries are strongly related to the factors along the highway section, Downing. A. et al, 200). One of the key measurements for the road traffic accidents along the highway section is the number of factors causing fatalities and injuries along with the road network. Consequently, records and statistics for the factors and road traffic accidents should be available at traffic departments and agencies in each country for their highway network, (Achuta, 2013).

2.4 World's vehicle population and road traffic accidents

According to the report, (WorldBank, 2012), there are about 53 million cars on the world's road and in 1990, the global fleet size rises to 456 million. On average, the fleet is grown by about 9.5 million automobiles per year. However, currently from the World Bank report, there are 737 million cars worldwide. Among these, 70% are found in North America, Western Europe and Japan. Approximately, 162 million cars (22%) are found in Latin America, Asia and Eastern Europe. The rests are distributed to the remaining countries. Globally, road traffic accidents are the leading cause of the death of young people, especially the productive ages from 15–29 years, (WHO, 2015). In addition to fatalities along the road sections, up to 50 million people incur non- fatal injuries each year due to the road traffic accidents caused by different factors, while there are additional health problems associated with disabilities, (Kadiyali. R, 2007).

2.5 The risk of road traffic fatalities in the world

Factors for road traffic accidents and their interventions vary considerably from the region to regions and there is a slight difference in the regional rates by fatalities since 2010, (WHO, 2015). The highest rate of traffic accident is still in African Regions, while European Regions has the occurrence far below the global average (9.3 per 100, 000 populations, relative to the world's rate of 17.4. However, there continued a large imbalance in rates within particular regions, (WHO, 2015). The rate to some of the high-income countries of the Western Pacific Region like Australia is among the lowest in the

world. But, some of the region's middle-income countries are with the high rates, above the global average at 24 per 100,000, (WHO, 2015).

2.6 Overview of road safety in Ethiopia.

Ethiopia as a developing country has the worst issue regarding road traffic accidents, (Yayeh, 2011). The country possessed the road traffic fatality rate of 170 fatal per 10,000 motor vehicles, (Yayeh, 2011) and (95 in 2015/16), (UNECA, Sep.2016). They stated that Ethiopia lost almost about 1700 lives each year, 7500 were injured and further 7783 were PDO, due to road traffic accidents. In the last Ethiopia financial year of 2016, Traffic police reported that, 15,086 accidents which cause losses of 2,161 lives and over 82 million ETB equivalent to US$7.3 million cost estimate of PDOs, (UNECA, 2016). Hence, it was suggested that the economic costs of road traffic accidents were an obviously heavy burden for the national economy, (UNECA, 2016). Road traffic accidents were one of the major problems for road transport in a country without due consideration. Although road traffic accident fatality rate per 10,000 motor vehicles (95 in 2016) was showing a declining trend currently, still it puts Ethiopia extremely on the high rate of the international road safety part. Up to 2015, road traffic accidents and fatalities increased at 17% and 10% per year respectively, (Cansiz. O, 2011).

2.7 Road Traffic Accident Classification

There are no definite and consistent classification strategies for road traffic accidents worldwide. Some of the countries record only simple documents classifying accidents as a serious injury and minor injuries or as a total injury and PDOs. As indicated by (Hobbs, 2014) and cited on (Bitew,2016), the comparison between road traffic accident statistics of the countries made it difficult, because unique definitions are not being used by different countries. For example, death is defined differently in many countries, deaths within 30 days in Britain, at the scene in Portugal, within 24 hours in Spain, within 6 days in France, within 7 days in Italy and within a year in USA. Among these, the definition within 30 days is mainly accepted and the case is true as in Ethiopia. According to suggestion of Chang, I. & Kim, S. W. (2012), road traffic accidents are classified according to the severity of the accidents emphasizing whether a person is killed or injured or as fatalities, serious injuries, light injuries and PDOs.

2.8 Crash Types

2.8.1 Rear-end collision

Rear-end collisions are very common road traffic crash types, which are often caused by unexpected deceleration, slowing down or braking of vehicles. And also, in some cases, another driver is following too closely or accelerates to a higher speed than the car in front of it, (Choi, J., Kim, S., Heo, T. Y., & Lee. J, 2011). The lashing action of the whip was a common injury occurring in a rear-end collision, and usually affects drivers and passengers of the impacted car. The fault was usually attributed to the driver of the car that rear-ends the other vehicles.

2.8.2 Side-impact collision

According to Daigavane, P., & Bajaj. P, (2009), side-impact collision causes serious injuries, often called "T-bone" or "broadside" collisions. Side impact crashes occurred when the side of a vehicle was impacted. It can also be impacted by the front or rear of another vehicle or in some cases due to the fixed objects. Vehicle damages were often severe and drivers or passengers on the impacted side of the vehicle usually sustain far worse injuries than they would in another type of crashes.

2.8.3 Sideswipe collision

Sideswipe collisions occurs when two cars that are parallelly touching. In many cases, the damages are only severe, as the cars just "swiped" to each other. Unless one of the drivers loses control of their vehicle as a result of collision, injuries and damages are typically minimal, (Chattaraj, U. & Panda. M, 2010).

2.8.4 Vehicle Rollover

Vehicle rollover crashes are particularly dangerous and frightening. A rollover crashes occurred when a vehicle literally flips over on to its side or roof. Any vehicle can be involved in rollover crashes, but cars with a high center of gravity are especially prone to this type of crashes. Often caused by sharp turns at high speed and rollover crashes can lead to serious injuries including spinal cord injuries and brain trauma.

2.8.5 Head-on collision

This type of collision is often fatal. Head-on collisions are exactly what they sound like - they occurred when the front ends of two vehicles impact each other.

2.8.6 Single car crash

Crash types involving only one vehicle are common. They occurred when a vehicle strikes objects such as poles, trees, fire hydrants and walls. In some cases, they may involve pedestrians and other innocent bystanders. Single car collisions result from drivers and passenger injuries, pedestrian injuries and often extensive property damages.

2.8.7 Multi-vehicle collision

Multi-vehicle collisions are sometimes referred to as "pile-ups", and often occurred along the busy roads, such as highways and freeways. They involve many vehicles and be the most dangerous crash types. The World Road Transport Crash Report-(http://www.Worldlife expectancy .com suggests that, vehicles are impacted multiple times and it may be difficult to escape and to determine faults in these causes.

2.9 Factors causing road traffic accident.

Road traffic accidents are mainly caused by drivers, road users, vehicles, and driving environmental conditions. Studies from American and British reports show that, accidents are occurred due to several factors, like 57% due to driver factors, 27% due to combined roadway and driver factor, 6% due to combined effect of vehicles and deriver factor ,3% due to a combination of road, drivers, vehicles, 2% due to vehicle factors and 1% due to combined effect of vehicle and road users, (Ruman, K. 1985). Currently, road network in Africa is growing fast and similarly, maintenance standards are improved for the safety of road transport. But, in Ethiopia, the contribution of roads and environment to the road traffic accidents are underestimated. Specially, the road network from Bonga to Mizan roadway experiences highest rate of road traffic accident severities due to several factors. Therefore, necessary improvement measures are expected to be implemented to reduce globally escalating road traffic accident severities by considering the roadway from Bonga to Mizan as the study areas for this research.

Generally, factors causing road traffic accidents are classified as human behavioral factors, vehicular factors and road geometric cross-sectional element design factors, including the driving environment, (L.Zheng, K.Ismail, X.Meng, 2014).

2.9.1 Road geometric design factors

The main importance of road geometric cross-section design is to address the prerequisite of the drivers, vehicles, freights and passengers, such as safety, comfort and efficiency, (Peden M. et al, 2014). The features normally considered cross-section elements, sight distance considerations, horizontal curvatures, gradients, and intersections. The design of these features is to a great extent influenced by the driver's behavior and psychology, vehicle characteristics, traffic characteristics, like speed and volume. Proper road geometric design helps for the reduction of road traffic accidents and their severities. Therefore, the objective of road geometric design is providing optimum efficiency for road traffic operation systems and maximizing safety at a reasonable time and cost, (Guyu. F, 2011)

2.9.1.1 Road alignment

One of the main factors for the occurrence of road traffic accident in terms of frequency and severities are due to inconsistent of road alignments. Improper horizontal alignment of road over sharp curves and grades, are known for their considerable and adverse safety impacts, (Winter mute. G, 2014, vol, pp, 223–237).

2.9.1.2 Horizontal alignment

Various studies currently show that, road traffic accident occurs at horizontal curves are in concern throughout the countries. For instance, the study in Denmark founds about 20% of all personal injury accidents and 13% of all fatal accidents occur at curves in rural areas, and in France, more than 20% of the fatal accidents occur at sharp curves. Accidents along bends are one of the major problems in many developing countries. Although the proportion of such accidents are dependent on the topographies of one country. Reviews show that, sharp curve result in higher crash rates than gentle curves. Highway sections with curvature of between 5^0 have at least twice the crash rate of highway sections with the curvature of 1^o and 5^o and also highway sections with curvature of between 10^o and 15^o have the crash rates four times more, (Choueiri. R, 2011). In terms of curve radius, 200 m seems to be the point below which the crash rate greatly increases. Some studies suggest that, curve flattening is highly effective in reducing crash severities. Numerous researches

are also reviewed by Leisch and confirmed that, there are several elements for horizontal alignments, which are associated with curve modifications.

2.9.1.3 Curve radius

According to Ding jianmei & Pei Yulong, (2000) reviewed from the study of Shenda, road traffic accident rate and curve radius are closely related. The road traffic accident rate reduces as the radius of the road increases and the curves with similar radius are safer than with different radiuses. A small radius, which is inserted into a long and straight line, is dangerous and the study concludes modification of horizontal alignment is one of the effective countermeasures for highway road traffic accidents. All being equal, crashes are more likely to occur on highway curves than on tangents (straight sections of road). Glennon (1987) quotes results that suggesting average crash rate for curved road segments is three times that of tangents and average single vehicle's, the run-off-road crash rate is four times higher. Additionally, curved road segments have higher proportions of the severe wet road, icy road crashes and a high rate of pushing the vehicles outward from the center of the carriageways, (Getu, 2014).

The rate of road traffic accidents are high at horizontal curves, at the intersection and at claimed that the average rate of accidents on highway curve is three times that of the average rate of road traffic accidents for highway tangent and as the radius of horizontal curve decreases, the rate of road traffic accident increases, (Brinkman. C.P, 2016).

2.9.1.4 Vertical alignment

Some of the main effect of vertical road alignments closely related to the occurrences of road traffic accidents are: over speeding and out of control vehicles on downgrades, differential speed between vehicles created along at down and upgrades and low range of visibilities, that are regularly occurring at immediate vicinity of the steep grades, at the crest of the vertical curves. Ross Silcock Partnership, (2016) indicates that, it may be difficult for the driver to appreciate the sight distance available on crust curves and drivers may overtake, when it is insufficient to do so safely. Honestly, this may be extremely difficult to provide safe overtaking sight distance at crust curves, because of the presence of very slow-moving vehicles, lack of driver’s discipline for selecting places, poor maintenance of road markings and location of traffic control signs. Successive short

vertical curves along straight section of the road and placement of the traffic control signs can produce misleading forward visibility of the roadway. The effects of vertical curves in such a way that, steep grades cause higher accident rate than mild ones, (Behanu, G. 2000). This researcher also suggests that, grades less than 6% have a little effect, but grades steeper than this percentage are associated with higher road traffic accident rates. Downgrades cause greater problems than upgrades, particularly for truck safety. The combination of horizontal curves under 450m and grades more than 4% are not recommended. Poor condition of horizontal and vertical alignments of road segments can result in visual effects, can easily contribute to road traffic accidents and are also detrimental to the appearance of road sections, (Tewolde, M, 2016).

2.9.1.5 Sight distance

It is the ability of drivers to see ahead, to stop safely or overtake vehicles and view approaching intersections. Sight obstructions along the road alignment generally occurred due to the presence of deep cuts, embankments, growing vegetations, walls and the like from inside of horizontal curves and at the intersection quadrants and sharp crest vertical curves themselves. Sight distances are typically categorized into stopping sight distance, passing sight distance, intersection sight distance and decision sight distances. According to Berhanu, (2000) reviewed several studies that valued and considered uses of sight distance and suggested that, sight distances vary with design or operational speeds along the road sections, perceptions-reaction time, eye height, object height and pavement frictions. Considering reviewed studies in Sweden, decrease in crash rates with increasing sight distance is observed, particularly single-vehicle crash at night. In the British study, it is suggested that, along rural roads, sight distances shorter than 200m are relatively more likely to be found at a crash site, through their association with horizontal curves.

2.9.1.6 Grades

Roy Jorgensen (2017) suggests that, steeper grades are linked in causing higher crash rates. Crash rate and severities increase with increased gradients of upgrades and downgrades. Organization for Economic Co-operation and Development (2011), Hillier, (2010) suggest similarly that, downgrades are the greater problems and Hoban (2012) reviews steep grades above about 6% are associated with higher road traffic accidents.

Christo. J and Jester. M (2015) suggests, steeper grades cause increased road traffic accident rates and traffic accident rates along mountainous terrains are higher than flat terrains. They also suggest, effect of vertical road alignments to road traffic accidents are excessive speed, differential speed between vehicles and difficulty for visibility of the divers at crust curves.

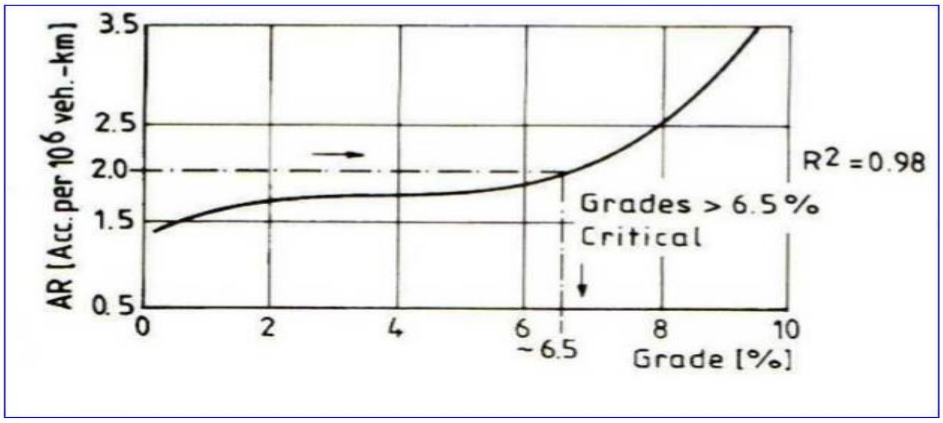


Figure 2. 1: Dependence of relative road traffic accident rates on grades.

Source: Iyinam, A.F., Iyinam, S. and Ergun, M, (2000).

Emergency braking distances along downgrades are longer than braking distances along upgrades. More road traffic accidents occur at downgrades than upgrades.

Unless safety measures be taken along the highway sections, road traffic accident rates are high at upgrades and downgrades, but suggestively higher road traffic accident rates at downgrades than at upgrades. By increasing two directional lanes, remedial measures are taken at upgrades and downgrades, accidents are decreasing and after fixing speed limit signs, road traffic accidents become decreased and keep relatively stable. According to Sarbaz Othman and Robert Thomson (2009) reviewers, effect of grades to road traffic accident rates and reported accident rates at downgrades are slightly higher than at upgrades. And also, upgrades have less effect to road traffic accident rates, while road traffic accident rates increased with increasing downgrades.

2.9.1.7 Cross-section elements

Cross-sectional elements are the main factors considered in highway road design to curb road traffic accident severities. These includes lane width, shoulder width and types. According to the authors, Sarbaz Othman and Robert Thomson (2009) studies, influence

of carriageway width on road traffic accident's rate and suggested, road traffic accident rates decreased with increasing lane width greater than 5.8 m and carriageway width of 5.8 m has the lowest road traffic accident rates along one-lane road section.

2.9.1.7.1 Lane Width

DeLuca (5013) in Miami-Dade shows that, increase in sideswipe crashes occurrs with the decrease in lane width and the study conducted by Zegeer, et al. (2014) also founded, wide lanes had the road traffic accident rates 10 to 39% lower than those at narrow lanes and heavy vehicles overtaking other heavy vehicles remain centered in their lanes, only when lanes are designed 12 feet (3.6 m) wider. Considering the effect of lane width on trucks, they also have concluded that, lane widths have the greatest effect on the probability of truck accidents, and probability for a truck accident increased as the lane width decreased. Thus, the wider the lane, the larger is the average separation between vehicles moving along adjacent lanes. This provided a wider buffer to absorb the small random deviation of vehicles from their intended paths. The other link between safety and lane width is that, a wider lane provids more room for correction in near accident circumstances, (Ding jianmei & Pei Yulong, 2000).

National Association of Australian State Road Authorities (2016) quoted the sealed width on rural highways is widened from 4.9 to 5.5 m, and from 6.7 to 7.3 m, with a casualty crash reduction of 43%. Transportation Research Board in (2010) also indicates, American study where 2.7 m lanes on rural roads are widened to 3.3 m, and 3 m lanes are widened to 3.6 m, with a 22 % of serious injury crash rate reduction. From Iyinam, A.F., Iyinam, S., and Ergun, M. (2000) studies, as the pavement lane width increased, the road traffic accident rates decreased.

2.9.1.7.2 Shoulder width

One of the reasons why shoulder along the highway section needs is, for parking, stopping vehicles, and overtaking crossing vehicles. Width of the shoulders on crashes are less conclusive. However, there are evidence that the crash rate reduced as shoulder width increased up to 3m. From American studies, Zegeer, Deen and Mayes, (2014) founded results which show 21 % reduction in crashes, when the road with without shoulders over the shoulders of 0.9-2.7 m provided width.

The Christo J.Bener and Joster Maki. A, (2010) shows that, shoulders wider than 2.1m have lower road traffic accident rates than those narrower than 2.1m, and roadways without shoulder exhibit relatively low traffic accident rates which are one-lane earth roads where speeds are very low.

2.9.1.7.3 Medians

National Association of Australian State Road Authorities (2012) reported a Victorian study where 42 km of the 2-lane highway is replaced with 4-lane divided highway sections, with a 30 % crash reduction. It also reported an Adelaide study, which compared crash rates for 4-lane roads having wide medians, narrow medians, and painted narrow medians with 4-lane roads without separation lines. Compared to un-divided road segments, it reduced the crash rate by 30% at the narrow-painted median, 48% at a narrow-raised median, and 54% at a wide median. Therefore, separation lines dividing the highway section by a median lead to a significant crash rate reduction. Along with urban area roadways, medians should ideally be wide enough to protect turning or crossing vehicles.

2.9.2 Human behavioral factors

Referring to suggestion of J. Ambros, R.Turek, J. Paukrt, (2014), driving is a complex activity that, several variables are cooperating with each other, but also with varying degrees of dependency. Road traffic accident occurrence may be due to driver's judgment errors, ignorance, incompetence, rule violation, carelessness, age, sex, training, use of alcohol or drug, fatigue, use of crash helmets, safety belts and awareness to apply the design speed. All of these are considered as human errors. Pedestrians account for the highest proportion of road traffic fatalities nearly in all African countries, ranging between 31% in Zimbabwe and 51% in Ethiopia, (WHO, 2016).

Studies in Addis Ababa and Abidjan reported that, extremely high proportion of pedestrian casualties of 90% and 75%, respectively. Passengers rank second, about 32% to 46% of road traffic accidents. Pedestrians and passengers together represent more than 80% of all road traffic fatalities, (Elizabeth. K, 2015).

Among sub-Saharan countries, South Africa has the largest share of driver fatalities (22%), (WHO, 2016). Crash risks are incurred due to pedestrians and cyclists resulted from a complex mix of various factors. Provision for pedestrians and cyclists in low-income

countries is basic or even nonexistent, (WHO, 2017). Reports from several countries like in Kenya, Uganda, Ethiopia, Tanzania, Ghana, South Africa and Zimbabwe shows that, most road traffic crashes are largely due to a range of human behavioral, vehicular and road geometric cross-section design factors, (Achuta,2013).

2.9.3 Vehicular factors

Considering the Jornal article of D.Gettman. L, (2018), vehicules are one of the factors causing human injuries and fatalities. Regarding to vehicles design speed, the greater the mass of the vehicles, the greater would be its force of an impact at collision with pedestrians leading to higher injuries. Hence, it is possible that, drivers of small vehicles, but high speedy are more likely to weave around in traffics, changing lanes, dart ahead of others or even take corners and curves faster. Vehicular accidents can be a factor if it cannot be controlled as it could be a result of technical conditions, that are not feasible road or not in accordance with, (Wantigli. J, 2013).

Department of Transportation in 2017 suggested that 5% of the Vehicle defects cause road traffic accidents and 13% of defect-related road traffic accidents are considered in correlation with either human factor or the driving environment.

2.10 Blackspot Identification

According to Guyu Ferede Daie (2013) suggestion, prone areas are determined as dangerous accident sites when its priority value (P), calculated by using the following formula, equals 15 or more and the Flemish government analyses method applied for accident data analysis process as

P = X + 3*Y + 5*Z, where

X = total number of light injuries

Y = total number of serious injuries

Z = total number of fatalities

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study area

This research was conducted in Southern Regional State of South West Ethiopia, starting from Kafa zone of Bonga town longitude of 7.2672^0N & latitude of 36.2468^0 E to Bench-Sheko Zone of Mizan-Aman town longitude of 6.9963^0N & latitude of 35.5822^0E. It considered 115.7 km length of the road segment constructed by KEANGNAM PLC contractor under the consultancy of ERA. Highest length of this highway road crosses dense forests in Kafa Zone. Both towns were populated by people from different ethnic groups and nationalities speaking various languages belonging to a wide variety of religious communities. Kaffa and Bench-Sheko were the home of Bonga and Mizan-Tepi Universities respectively.

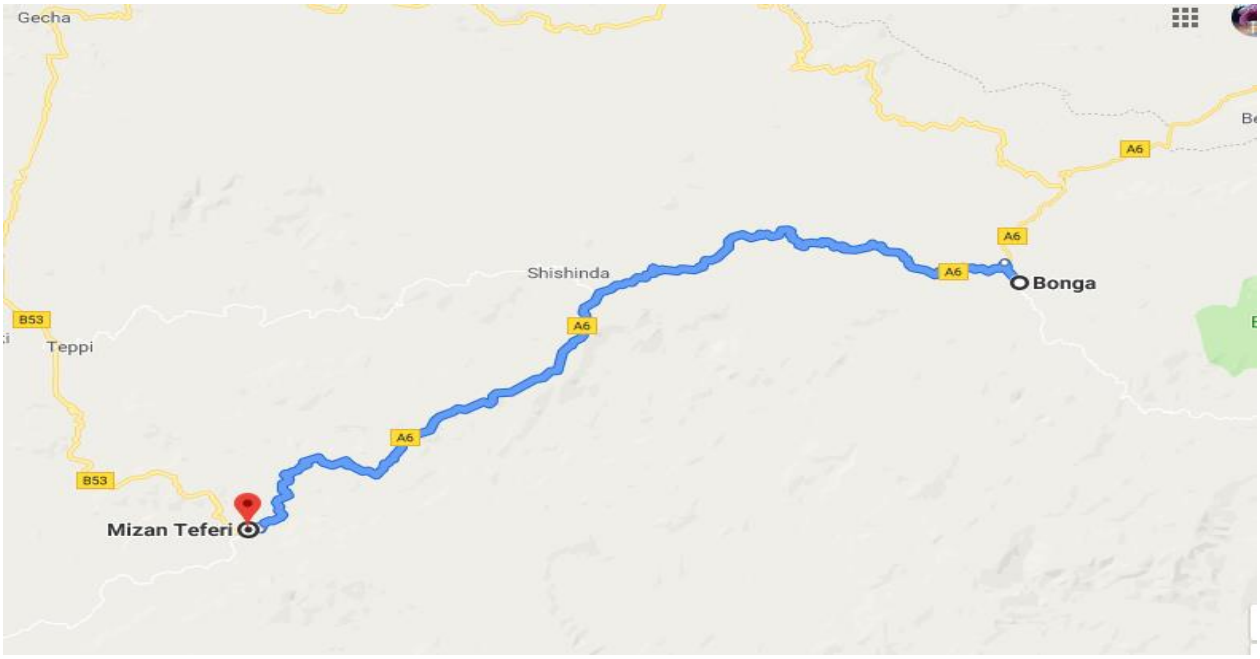


Figure 3. 1: Study segment from Bonga to Mizan roadway (source: google map).

3.2 study Period

Study period indicates the time at which this research was started up to it finished.

This study was conducted from June to November of 2019.

3.3 Study design:- indicates each procedures followed by the researcher from problem identification up to final documentation.

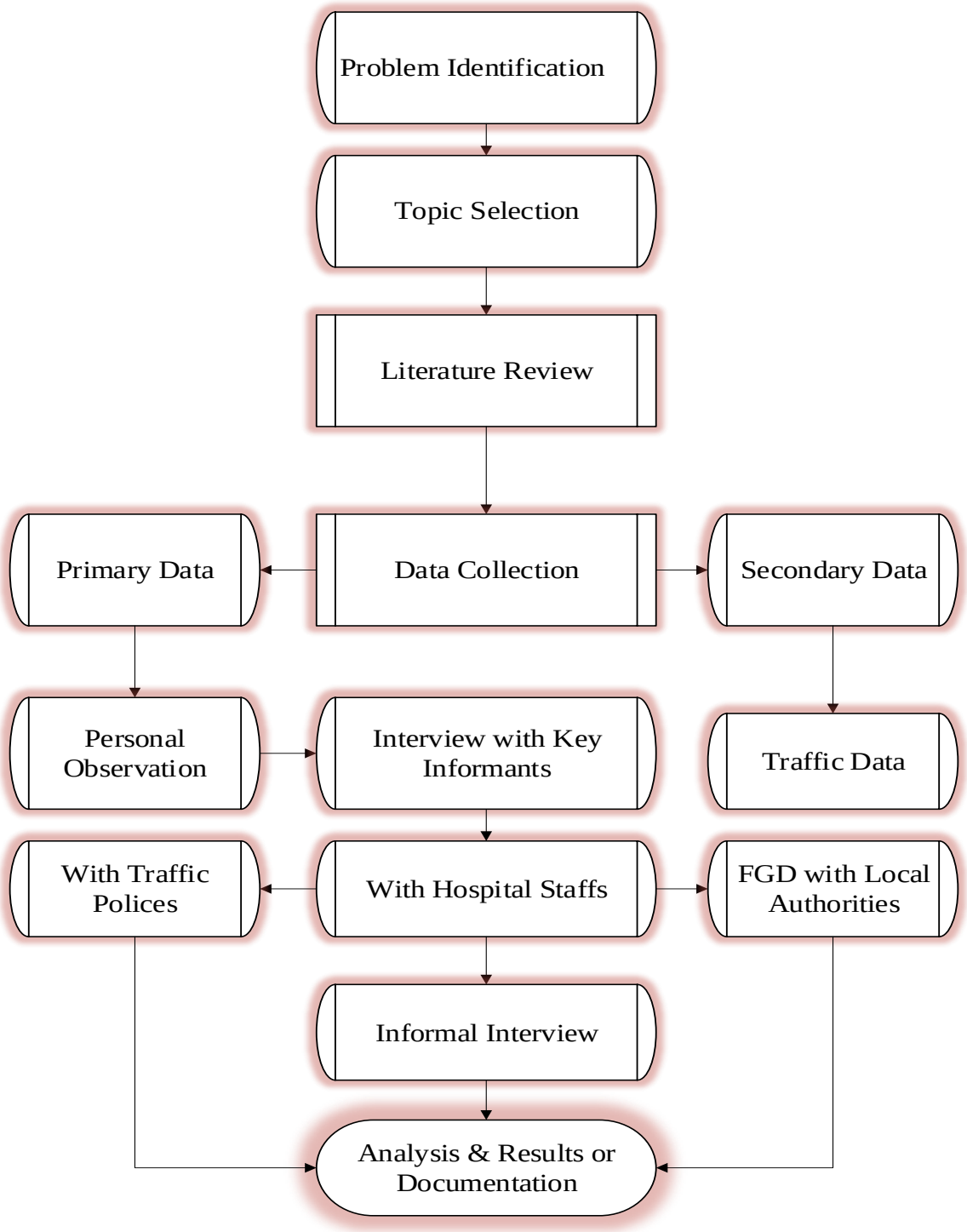


Figure 3. 2: study design flow chart.

3.4 Population

Populations considered for this research were road users like vehicles. drivers, pedestrians and road geometric cross-sectional elements.

3.5 Sample size and sampling procedures

Sample sizes were selected by using Purposive sampling method by considering different techniques and procedures for gathering relevant data. In order to select relevant samples, the researcher assessed the existing road traffic accident records from the annual road traffic report and designed sampling frame accordingly. Areas with high traffics characterized by dense vehicle, pedestrians, road design problems, and improper construction of roads were considered. Thus, 130 sample sizes were considered. This was because of, population of the study area was not known, so that, sample sizes were randomly stratified considering data proportion satisfied.

Table 3. 1: Stratifying simple size for data proportion.

No	Questioners with	Interview with	FGD with	Number of respondents
1	20 drivers	20 drivers	4 traffic police	44
2	30 Pedestrians	30 Pedestrians	8 Road transport.	68
3	8 Hospital staffs	8 Hospital staffs		
4	3 Mechanics	3 Mechanics		6
5	2 Religious leaders	2 Religious leaders		4
6	4 NGOs	4 NGOs		8
7	Total respondents			130

3.6 Study variables

Two types of variables were considered under this research. These were dependent and independent variables.

3.6.1 Dependent variable

The dependent variable for this research was the road traffic accident.

3.6.2 Independent Variables

Independent variables under consideration were human behavioral factors, vehicular factors and road geometric factors, including driving environment.

3.7 Source of Data

Data for this research were sourced from the Primary and secondary data sources.

3.7.1 Primary data sources

The first part of data collection was based on a qualitative technique through applying data collection tools like interviews, direct personal observation of the existing highway section and focus group discussions with concerned local authorities.

3.7.1.1 Direct personal observation

Information and awareness about the phenomenon were obtained through direct visual observation of the road segment from Bonga to Mizan. It involved the process whereby the researcher visited an area along the road and observed visually how people uses the roads. This was because of, to enable the researcher to relate and crosscheck information obtained from the questionnaires, interviews and FGD and to provide necessary information background on the problem being studied. Observation was therefore, a vital qualitative method used during data collection for this research.

In direct personal observation of the site from Bonga to Mizan roadway, the researcher together with the road traffic polices identified places at which the road traffic accidents frequently occurring. Those identified prone areas were named by kilometers per vehicle and name of the local areas at which the road traffic accidents occurred. By using the Flemish government analysis method. Each segment within the last three years or more road traffic accidents occurred were selected and the site was considered as the Blackspot, when its calculated priority value (P) equals or more than 15. Analysis was done by using the Flemish government analyses method.

$P = X + 3*Y + 5*Z$, Where:

P = Priority value

X = total number of light injuries

Y = Total number of serious injuries and Z = Total number of fatalities.

Since number accident severities for fatalities, light injuries, severe injuries and PDOs were properly determined at each identified prone areas, priority value of Flemish government formula was used to rank the Blackspot locations to prioritize for intervention. The next step was the cause of accidents determination and the preparation of road safety audit checklist to provide countermeasures based on the site inspection. After identifying Blackspots, direct personal observation along the road section by using the Road Safety Audit Checklist of ERA Manual was applied, and possible improvement measures were recommended by ranking the Blackspots relative to their crash rate severities calculated.

3.7.1.2 Interview with key respondents.

The interview was done to listen what people were saying about their lives, views, and opinions in their own words and to learn from their view side of daily life experiences. Qualitative research interview was attempted to understand the world from the subject point of view, to unfold the meaning of people's experiences and to uncover their lived world prior to once scientific explanation. In view of the this, and given nature of the study, the researcher needs to hear from the responsible officials, their views and opinions about the road traffic factors and possible countermeasures to intervene in road traffic accidents. During interviews, the researcher introduced once together with explaining who he was and what the purpose of the visit was. Due to these reasons, the researcher received a warm welcome from the respondents and made the respondents free to air their views and share their life experiences. This also helped to be free in giving out their views without being doubtful. This research considered randomly selected population respondents for interview. This was because of, these respondents satisfy the sample size gathered for data quality assurance and sample size was determined considering data saturation.

3.7.1. 2 Interviews with hospital staffs

Five officials from Bonga G/tsaddik-Shawo hospital and three from Mizan-Tepi University Teaching hospitals were interviewed. These were the hospital secretary, Matron of the hospital, Doctor in-charge of casualty, Laboratory technician in charge of the blood transfusion unit and the Radiologist in-charge of the X-ray department. (See in Appendix C). Each key informant interviewed separately on different day of times, following the scheduled appointment. Each interview took between 10 to 15 minutes and conducted

using semi-structured interview guides. The reason for interviewing officials from these hospitals was that, these were the only hospitals from Bonga to Mizan roadway that providing emergency services for road traffic accident victims.

3.7.1.3 Interviews with traffic police staffs

There was also one interview with the Zone traffic police officer. Although it was planned to interview three or more respondents with the preference of the road traffic polices and licensing departments, unfortunately, the Zonal traffic commander decided that, he can be interviewed on behalf of the other police officers, this was due to the fact that, he was the only person authorized to serve as the spokesman of the traffic polices. Their responses were taken as representing the opinions of the traffic police officers. The interview was done with the zonal police commander and was accompanied by two professional road traffic polices. The interview took almost 20 minutes. It was also conducted by using a semi-structured interview guiding line, and additional probing questions were also asked. The guiding questions aimed at getting information on how policemen collecting the road traffic accident data, and what problems were encountered in working with the road traffic accidents and victims, how rules and regulations were controlled. It also had a provision for them to give opinions on how risk factors and road traffic accidents can be prevented along the Bonga-Mizan roadway, (See in Appendix C).

3.7.1.4 Focus group discussion with government officials

Focus group discussion was highly efficient qualitative data collection technique, providing some quality controls for data collection. Participant tends to provide checks and balances to each other and it was fairly easy to assess the extent to which there was a relatively consistent shared view among the participants. With this concept, focus group discussion was held at the office of the zone Commissioner in the meeting room, six government officials were attended. From which, two were from the Department of Social welfare, two drivers from the office of the zone Commissioner, one from woreda administrative secretary and one from the department of discipline and labor. The officials were actually very open and willing to share their idea freely, and the meeting took almost 20 minutes.

3.7.1.5 Informal interviews

Despite using the formal interviews with individuals and officials, the researcher conducted informal interviews by talking to people from different places within and outside the study area, including professionals, and community-based organizations, without an interview guideline.

This was because of, informal interviews as insight information which can verify the trend and reality of what was searched for and it can be in form of talk, friendly discussions, listening to other people's discussions and narrations.

3.7.2 Secondary data sources

Secondary data was obtained from the monthly and annual reports of three-year period from 2016 to 2018 of traffic accidents police officers, hospital staffs in emergency room, road transport and develop sectors of the Zones.

3.8 Writing and analysis

Data were entered into the computer using the statistical tool SPSS. The standard statistical tables were generated to examine the relationship between variables and causes of fatalities, serious injuries, light injuries and PDOs. The results were also summarized to show trends and patterns of road traffic accidents from the year 2016 to 2018 using tables, charts, and graphs.

3.9 Data collection process

Primary data: Collected by visual observation of identified Blackspots along the asphalt road segment from Bonga to Mizan highway section considered only feasible factors. Field data collection was based on both qualitative and quantitative methods within a framework of a case study approaches. Interviews with government officials, road traffic polices and focus group discussions with local authorities was done.

Secondary data: Collection was through related literature review about casualties from journal articles, monthly and annual traffic police reports, hospital staffs at emergency records and road transport and development sectors by using the prepared checklists.

3.10 Data presentation and analysis

Data were analyzed using the Pearson Chi-square test analysis method. Chi-square test analysis is useful in making statistical inferences about categorical data in which the categories are two and above. Data were presented in terms of tables, charts, and graphs.

3.11 Ethical consideration

Before data collection, the purpose of the study was clearly described to the organizations and each concerned individual respondents. Data collected were corrected based on the willingness of the organizations to give feasible information. It was also kept with confidence and only used for targeted purposes.

3.12 Data quality assurance

Data quality was ensured during data collection, coding, entry, and analysis process. Questionnaires were tested and necessary measurements were done on time before data entry. The researcher recorded only feasible data to avoid the bias of information.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

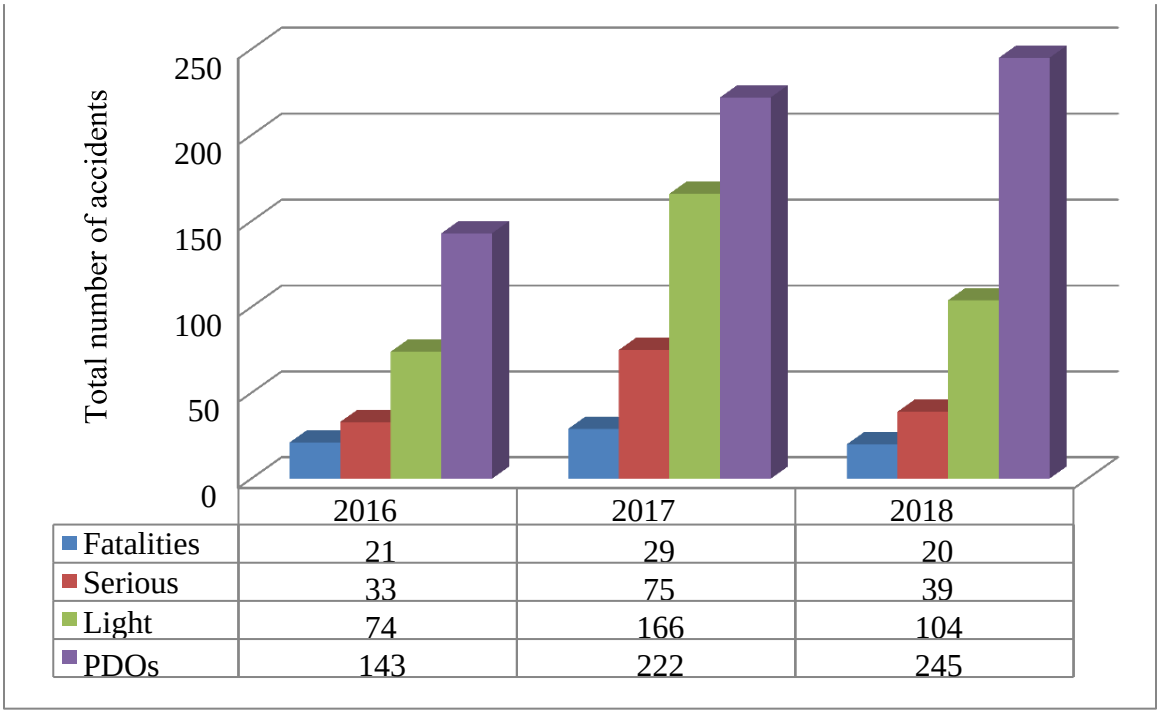
Investigation on Road Traffic accident Factors and Possible countermeasures to provide suggestion for intervention in road traffic accidents from Bonga to Mizan roadway was discussed by considering the study parameters as road geometric design factors, human behavioral factors, and vehicular factors. Road traffic accident characteristics along the Bonga-Mizan highway section was summarized from its opening time to the service, from 2016 to 2018.

Accident severity data were also grouped into fatalities, serious injuries, light injuries and PDOs, based on the annual report of the road traffic polices.

Table 4. 1: Traffic accident severities from 2016 to 2018 (source, Traffic police report).

Years	Fatalities	Serious injuries	Light injuries	PDOs	Total
2016	21	33	74	143	271
2017	29	75	166	222	492
2018	20	39	104	245	408
Total	70	147	344	610	1171

Road traffic accident severities indicated in Table 4.1 were obtained from the road traffic accident police annual report, from hospital records in emergency rooms and from department of road transport and development sectors of the Zones. A total of 556 road traffic accident occurrences were reported from 2016 to 2018. From these traffic accident occurrences, a total of 1171 traffic accident victims were reported. Out of these, 70 fatalities, 147 severe injuries, 344 light injuries and 610 PDOs were recorded under three years annual report. Also, it was observed that, road traffic polices reported a total loss of $631,835,905, due to road traffic accidents.



	2016	2017	2018
Fatalities	21	29	20
Serious	33	75	39
Light	74	166	104
PDOs	143	222	245

Figure 4. 1: Accident distribution characteristics from Bonga to Mizan roadway.

Considering figure 4.1, 1171 accident severities were distributed over three years of the analysis period. From the chart, it was concluded that, the number of years and traffic exhibit influence on road traffic accident situation. Therefore, the significance relation of the chart indicated the number of road traffic accidents in the subject area seems to be increasing as the years went by. The researcher concluded that, as years went by, number of vehicles also increased and number of traffic accidents increased accordingly. Therefore, number of people who were likely to be killed by road traffic accidents surely increased along the Bonga-Mizan highway section.

Generally, factors causing road traffic accident severities from Bonga to Mizan highway section were observed as the combination of multiple factors grouped under three categories as human like driver, vehicular and vehicular related factors (see in figure 4.2 & Table 4.2).

Figure 4. 2: Observed factors for the occurrence of road traffic accidents.

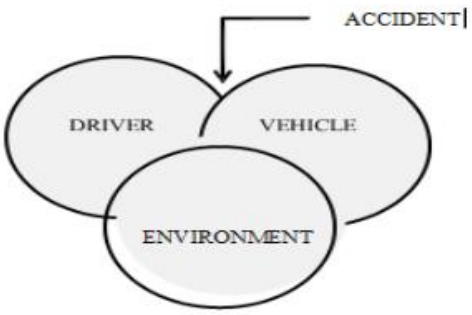


Table 4. 2:Various factors related to road traffic accidents.

Driver-Related Factors	
Alcohol and drugs	Sickness
Excessing speeding	Cell Phone use
Drowsing or sleepy	Distraction
Fatigue	Improper Passing or Turning
Vehicle-Related Factors	
Violation of traffic control signs	Non-use of Restraint
Over Loading	Steering defect
Brake defect	tire failure
Light defect	Improper wheel alignment
Environmentally Related Factors	
Roadside hazard	Vision obstruction
Ruts	Improper traffic control sign
Debris or Garbage on the road	Fixed Objects
smoke or fog	Water ponding
Glare	Shoulders defective

4.1 Traffic accidents due to improper road geometric design

The observed fact was that, geometric design elements from Bonga to Mizan roadway affects traffic operations, due to cross-sectional element design. These played an essential role in the operational traffic efficiency of this highway section. Factors investigated under

geometric design of the road along this roadway included existing road conditions and its built environment, checking cross-sectional geometric design like, road width, presence and absence of shoulders, road barriers, medians, sight distance, pavement marking, road lights, number and width of lanes, road alignments and provision of horizontal and vertical curves. These were investigated by using the Safety Audit Checklist of the ERA standard. The road safety inspection was started after having certain information about the road segments along with both traffic directions. Regarding to driving environment of the road geometric design, it was investigated that, the researcher directly observed the existing road segments to cross-check the actual road conditions at identified black spots by using field measurements and cross-checked actually visualized observations with ERA road geometric design manual as the reference.

Table 4. 3: Some of the observed Road Design Problems from Bonga to Mizan roadway

Observed road geometric design problems	Blackspot Location
In Kafa Zone	
Lack of Median	Gimbo
Lack of traffic control signs	At 51+20 At 54+80 At 58+650
Improper fixing of traffic signs	
Missing shoulder	
Narrow lane width & shoulders	
Too narrow roadside walkway	Bonga town At 58+300 At 64+500 At 67+000 At 37+000 At 40+000
Lack of curve markings	
Improper cross-drainage design	
Narrow traffic rotary	
Lack of traffic control signs and pavement markings	
Absence & missing shoulders	
Absence of Zebra for pedestrian crossings	Shiisho-Indee
Insufficient sight distance	31+648.7 31+648.7
Narrow right of way	
Narrow lane width	
Narrow traffic rotatory	Chena 64+298.3 64+350.8
Narrow right of way	
Insufficient sight distance	
In Bench-Sheko Zone	
Dangerous pedestrian crossings	Mizan-Aman
Missing shoulders and roadside walkways	56+103.8 56+163.5 56+182.9 56+423 56+182.9 56+423
Missing Road sign and pavement marking	
Missing shoulder	
Dangerous pedestrian crossings	
Missing guardrails, but necessary	
Missing traffic control signs and pavement markings	
Missing shoulders	55+889.9 55+973 55+973
Too narrow roundabout and illegal roadside parking	
Using road sideway for personal business	
Insufficient sight distance	Temenjaj
Narrow roundabout	56+705.7
Pavement grooving's and striping	56+752.3
Insufficient sight distance	57+472.8
Narrow right of way and lack of traffic Light	57+611.4

Table 4. 4: Observed Road Design Problems from Bonga to Mizan roadway.

Observed road geometric design problems	Blackspot Location
Dangerous pedestrian crossings	Mizan-Aman 55+603.7 55+581.9 55+698.6 55+878.8
Missing shoulders and roadside walkways	
Missing Road sign and pavement marking	
Missing shoulder	
Dangerous pedestrian crossings	
Missing guardrails, but necessary	55+495.3 55+588.2
Missing traffic control signs and pavement markings	
Missing shoulders	Beyemmo 55+279.8 55+472.2
Too narrow roundabout and illegal roadside parking	
Using road sideway for personal business	
Insufficient sight distance	Temenjaj 51+103.9 51+581.9 52+250.2 52+318.2
Narrow roundabout	
Pavement grooving's and striping	
Insufficient sight distance	
Narrow right of way and lack of traffic Light	

Table 4. 5: Observed values compared with ERA standard cross-section design elements.

Roadway elements	ERA Standard Value	Observed Value
Number of lanes	2 lanes	2 lanes
Design Speed	50km/hr. -85km/hr. Depending on terrain	80-140 km/hr.
Shoulder width	0.5-3.5m depending on terrain	0-1.1m
Carriageway width	7m	3.5m
Bridge Width	At least full approach traveled way width of 0.6m clearance on each side	2/3 of traveled way width
Right of way	50m	35-45
Pedestrian Crossing	Controlled	Un-controlled
Alignments	Adequate and smooth alignment	Poor alignments

As it was concluded from Table 4.3, Table 4.4 & Table 4.5, factors associated with road traffic accidents from Bonga to Mizan roadway were the technical elements of the highway

construction. This highway section was constructed below its standard and not well equipped with traffic safety measures like traffic separation lines, medians, lanes, appropriate roadsides traffic control signs and pavement markings. It was also observed that, it was not designed with the facilities to accommodate the characteristics and behavior of road users, vehicles, traffics, environment, visual guidance, alignment standards and poorly controlled and uncontrolled intersections in Bonga and Mizan-Aman town. Access along the roadway was also identified as the main factor related to road traffic accidents. Lack of traffic separation line also accounts for the highest possibility of being exposed to road traffic accident risks. From personal observation of this highway section, the following cross-sectional geometric design problems were also identified as the contributory factors for the occurrence of the road traffic accidents at each Blackspots identified. Such investigated cross-sectional elements as a factors for the road traffic accidents were, narrow carriageways, lack of shoulders, medians, pedestrian crossings, roadside delineators, and missing of pavement markings, traffic control signs, roadside guard rails improper roadside parking, side drainage systems, absence of centerlines and edge line markings, lack of curve signs, and curves being too narrowness, presence of animal and vehicle mixed traffic flow system were the main factors identified for the occurrence of the road traffic accidents from Bonga to Mizan roadway. The researcher also observed that, most cars were in hurry and they overtake each other unnecessarily, speed limit was not followed, at the beginning of most villages there was a sign showing speed limit of 50km per hour or 30km per hour, but it was not followed by drivers, Most sheets used to put signs were filched by natives, hence there were only polls without signs and the drivers were taking an advantages. Another interesting observation was that, most pedestrians along the segment choose to cross the road at no zebra crossings, even when zebra crossing was available. This helped the researcher to lean or rely on people's behavior in risk-taking and their attitude towards the factors and road traffic accidents from Bonga to Mizan roadway.

Therefore, these identified factors were expected to be solved by implementing necessary improvement measures relative to those identified factors in order to intervene in the situation at each Blackspots. Like by fixing the design speed, implementing pedestrians'

priority, and enforcing the rule and regulation by governments. Basically, it is also expected to provide zebras crossings horizontally marked and the vertical traffic warning signs placed along the roadsides to minimize traffic collisions. Medians should also be provided with visible paints to intervene in the situation.

4.1.2 Traffic accidents due to the driving environments

Road traffic accidents that occurred along the Bonga-Mizan roadway were not uniformly distributed over the existing road network. They were occurred in clustered at single sites, along with the particular section of the road segments. Highway engineering can greatly help in reducing the frequency and severity of road traffic accidents. It can also contribute to the crash severities. As it was observed that, the existing road network constructed along the Bonga-Mizan roadway has an effect for the road traffic accident risks because, it determines how road users perceived their environments and provided instructions for road users through fixed traffic control signs and on what they were expected to do. And it was also observed that, the highway section along the Bonga-Mizan roadway was constructed with more of curves provided along the route length. This was due to the existing topographic features. Highway engineering factors observed along the highway section also included the road defects directly activating road traffic accidents. Some elements of the road environment lead the road users and forms error. During planning, designing, and maintenance of the road network along the Bonga-Mizan roadway, some of the following particular elements affecting the road safety were also identified through visual observation.

- Safety awareness in planning relative to the pedestrians' walkway.
- Incorporation of safety features for the design of shoulders and Zebra crossings
- Safety improvement measures for the existing road segments and
- Remedial actions at high-risk blackspots.

4.1.3 Traffic accidents due to sight distance

It was also observed that, inadequate visibility was the main factor for the following road traffic accident types along the Bonga-Mizan roadway.

- Moving vehicles running towards the rear or side of slowly moving or stationary vehicles ahead along the roadway during night-time

- Angled collisions or head-on collisions during the day time.
- Rear-end collisions due to fog, during the day time and at night time.

As it was also observed Bonga to Mizan roadway that, the phenomenon of pedestrians and vehicles was frequently a serious problem. The highway section was constructed without adequate lightings and even in towns, some were not be lit at all. It was more common for vehicles to have no lights or reflectors and for the road spaces to be shared by fast-moving and slow-moving road users along the roadway at Bonga and Mizan-Aman towns. And also, most segments of the highway section were covered with a dense forest from all directions. This easily resulted in inadequate visibility, causing road traffic accidents. According to the observation from an interview with the key respondents, construction of this highway section did not involve the local person participation specifically, for road safety measures. The road designers and construction engineers seem to have no legal and formal obligations to be responsible for the road traffic safety consequences for their acts as the infrastructure providers. Unlike the highway engineers who are legally brought to account for the faults under their works, transport planners and construction engineers who created the road traffic accidents at Blackspots for the built environment were not in the principle, prosecuted for road traffic accidents occurring due to their negligence. Instead, the built environment was technically assumed to be good and any of the road traffic accidents that occurred along the roadway were blamed either on faults by humans or the vehicles. Safety considerations for the pedestrians along Bonga-Mizan roadway seem as being not a part of their contractual terms of the reference.

Generally, traffic accidents due to road characteristics along the Bonga-Mizan roadway was analyzed as follow.

Table 4. 6: Road traffic accident severities due to road characters from 2016 to 2018.

Road character	Number of accidents				
	2016	2017	2018	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

Table 4. 7: Chi-square test result due to road characters.

Road characteristics	Number of accidents	df	χ 2 critical	χ 2 calculated
Straight and level	554	9	16.92	36.102
Uphill	87			
Downhill	370			
Curve	141			
Total	1125			
Sig.			0.05	0.000

Considering Chi-square test analysis result in Table 4.7, the χ 2-calculated value 36.102 with the df value of 9 and the χ 2 critical value of 16.92 was at the alpha value of 0.05 considering 95% confidence interval. Hence, the researcher concludes that, the χ 2- value calculated greater than the χ 2 critical value suggesting the road geometric cross-section elements were significantly related as the factor for the road traffic accidents from Bonga to Mizan roadway. Therefore, those road cross-section elements investigated for the analysis were significantly related as a factor in causing road traffic accidents.

4.1.4 Traffic accidents due to surface condition

Pavement surface conditions observed along the Bonga-Mizan roadway were one of the factors for the occurrence of road traffic accidents. Subsequently, different pavement surface conditions were considered under this study to investigate the effect of surface conditions for road traffic accidents. Dry and wet pavement surfaces conditions were considered (see in figure 4.3).

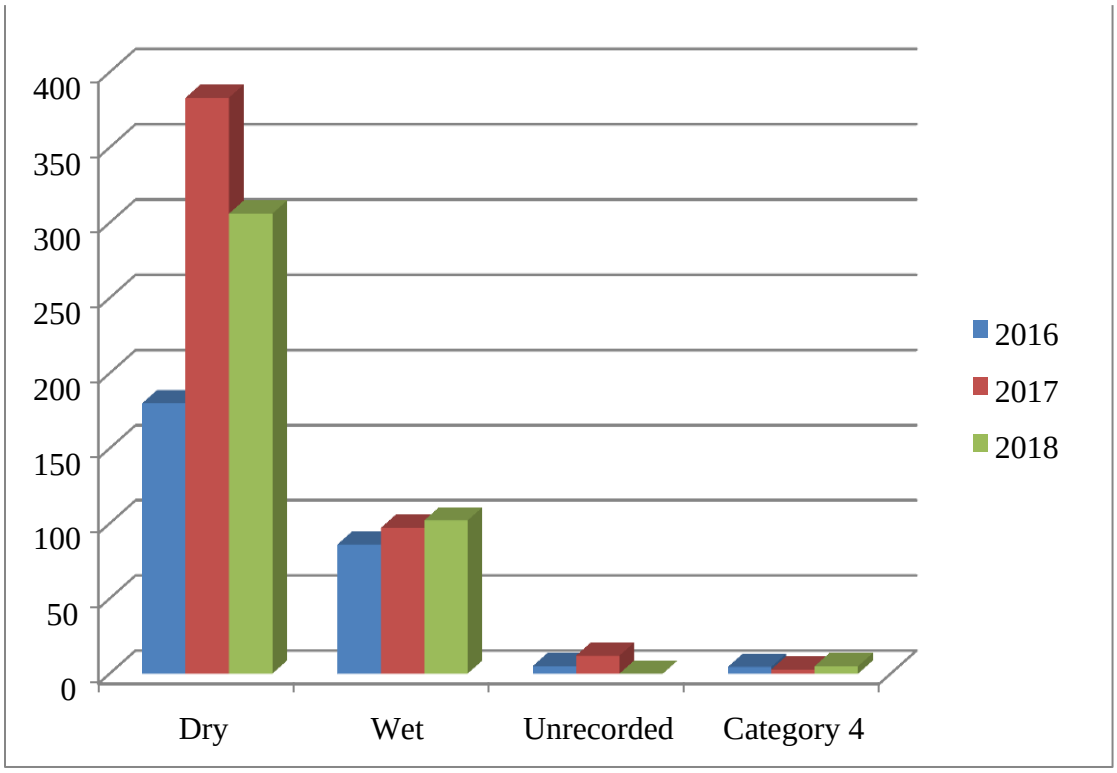


Figure 4. 3: Road traffic accidents due to surface conditions.

It was investigated that, road traffic accidents were observed in 2016, 2017 and 2018, due to the dry surface conditions. Consequently, in 2016, 2017 and 2018, the road traffic accidents equivalent to 86, 97 and 102, respectively also occurred during wet surface condition. The analysis confirmed that higher road traffic accidents were occurred during dry surface than wet surface condition.

Table 4. 8: Chi-square test result due to surface conditions.

Surface condition	Number of accidents	df	χ 2 critical	χ 2 calculated
Wet	302	2	5.99	12.122
Dry	869			
Total	1171			
Sig.			0.05	0.002

From the Chi-square test result in Table 4.8, we conclude that, the p=0.002 and the χ 2 calculated value=12.122 with χ 2 critical value=5.99 relative to the df=2 at α=0.05 was analyzed. Hence, it was concluded that, the significant difference between the road surface conditions and the road traffic accidents at α=0.05 of 95% confidence interval indicated the dry surface condition of the pavement is the main factor than the wet surface condition. Therefore, road traffic accident occurrence is high during driving on dry pavement surfaces than on wet pavement surface condition.

4.1.5 Traffic accidents due to weather condition

It was observed that, weather conditions along the Bonga-Mizan roadway affected the driver's behavior.

Table 4. 9: Traffic accident severities due to weather conditions from 2016 to 2018.

Weather condition	Number of accidents	df	χ 2 critical	χ 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	0.002

When it was bad weather conditions, the drivers need to reduce speed choice and also visibility decreased. This lead, the speed of moving vehicles to be decreased. However, while driving with normal weather condition, the drivers feel safe, comfortable and not think about the speed choice for moving vehicles. This easily resulted in higher road traffic accidents during driving with normal weather condition than others.

Figure 4. 4: Traffic accidents due to weather conditions

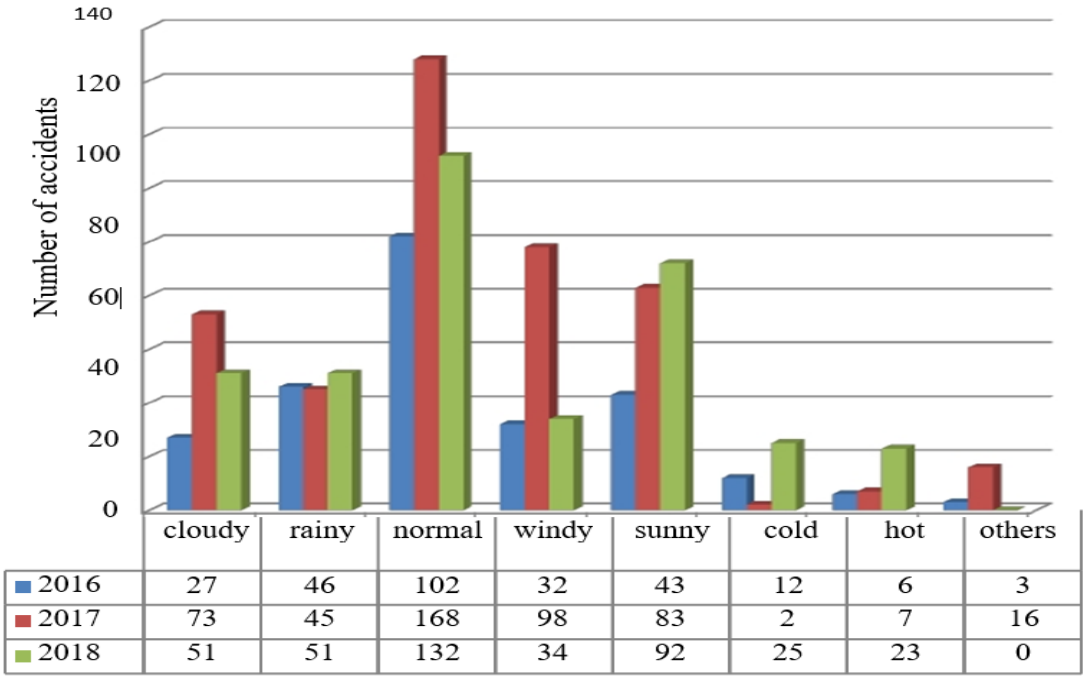


Table 4. 10: Chi-square test result due to weather condition

Weather condition	Number of accidents	df	χ 2 critical	χ 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	0.002

Based on the Chi-square test results in Table 4.10, χ 2 calculated value=236.11 and the χ 2 critical=28.87 with a df=18 at α=0.05 concluded that, the significance value of 0.002 less than the p=0.05. Therefore, weather condition is significantly related as contributary factor for the occurrence of road traffic accidents along this roadway.

4.2 Traffic accidents due to human behavioral factors

It was observed that, human behavioral factors require guidance and control for appropriate interaction with the components of the roads like vehicles and the built environment. The observed fact was that, human behavioral factors constituted about 80% of road traffic accidents and the only small proportions were directly or indirectly contributed to the vehicle performance, including defects and roads themselves with their geometric design and maintenance. Road transport and development sector of the Zones declared that; it was true to say, road traffic accidents don't just happen, but left to happen. Those factors investigated for the road traffic accidents along Bonga-Mizan roadway weighed significantly to prolonged traffic accident occurrences.

Most informants mentioned that, using a cell phone while driving was one of the factors causing road traffic accidents along this roadway. And, it was also the fact that, various tasks entailed in using mobile phone require a different amount of time, mental energy and coordination, leading to potentially different complications of the driving task and resulting risk for collision. The use of mobile phones while driving was a common application of their technology for drivers along the Bonga-Mizan roadway. When talking in to a mobile phone, driver performance was affected in maintaining the correct lane position and headway between two vehicles traveling one behind the other, in keeping an appropriate speed, in judging and accepting safe gaps in the traffic flow.

This confirms that, there was a high risk associated with being involved in road traffic accidents due to the tendency of the drivers using a mobile phone while driving the vehicles. Driving without license was another risk factor identified along the Bonga-Mizan roadway. The driver's error was the most prevalent factor for the occurrence of road traffic accidents. Similarly, most drivers who were involved in road traffic accidents have an illegal driving license and they never trained legally. One of the drivers who interviewed mentioned that, many drivers involved in road traffic accidents have the driving license before they know how to drive the vehicles from Gambella region, and the Bonga-Mizan roadway was mostly used to learn driving informally. This was because of the road traffic polices assigned along the high way section lets them to drive by corruption.

Therefore, there was an existing risk of being involved in road traffic accidents along the Bonga-Mizan roadway due to the existing situation of driving without being legally licensed.

According to an investigation from hospital findings, passengers and pedestrians were the most vulnerable road users. It was also identified by road traffic police reporters that, unguided pedestrians along the roadway increased the risk for road traffic accidents to occur by causing confusion and misleading other road users. Their movement towards the use of road remain inconsistent, since they were unprotected. Pedestrian behaviors were widely variant quite inconsistent, difficult to control and were linked to many other related and unrelated factors. Lack of traffic safety education, poverty, illiteracy, and unemployment were some of the associated factors affecting the behavior of pedestrians in risk-taking for road traffic accidents. It was very common to pedestrians crossing the road without proper attention for the vehicular traffic accidents. Here it was concluded that, pedestrian behavior towards using the roadway was also one of the risk factors contributing to road traffic accidents along the Bonga-Mizan roadway.

An interview with the road traffic polices also indicated that, driving profession seems possessed by less educated drivers. The quality of the driver was one of the factors for road traffic accidents. It was observed that, most drivers along the Bonga-Mizan roadway were driving at a speed higher than design speed and not paying attention to the needs of non-motorized traffics and other road users. Drivers were also exposing themselves to road traffic accidents, while under the influence of alcohol and drugs. These and other human behavioral factors contribute to road traffic accidents.

4.2.1 Traffic accidents due to age of the drivers

Age group fatalities were analyzed by classifying age categories into four groups, 18-30, 31-40, 41-50 and >50 years for fatalities, serious injuries, light injuries and PDOs as indicated in Table 4.11.

Table 4. 11: Traffic accidents for the driver's casualties from 2016 to 2018.

Categories for the driver's casualties		Number of accidents and Levels				
		Fatal	Serious injury	Light injuries	PDO	Total
18-30	Count	20	50	108	308	486
	%	2.22	5.54	11.94	34.14	53.89
31-40	Count	8	15	54	192	269
	%	0.89	1.66	5.97	21.29	29.82
41-50	Count	4	5	16	96	121
	%	0.44	0.55	1.77	10.64	13.41
>50	Count	0	3	9	14	26
	%	0	0.33	1	1.55	2.88
Total	Count	32	73	187	610	902
	%	3.55	8	20.73	68	100

Road traffic accident distribution in Table 4.11 relative to the age of drivers show that, between 18 and 30 has high accident severity value with 2.22% fatalities, 5.54 % serious injuries, 11.97 % light injuries and 34.14 % PDOs for the driver's casualties. This was due to the driver's apathy and less experience. Hence, it was concluded that, the drivers' experience increased when their age increased. This resulted the road traffic accident to be decreased. To investigate either this concept was significantly related or not as a factor for the road traffic accidents, the chi-square test applied (see in Table 4.12).

Table 4. 12: Chi-square test result due to age groups along the Bonga-Mizan roadway.

Age categories	Number of accidents	df	χ 2 critical	χ 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

Chi-square test results in Table 4.12 indicates the significant difference in the level of road traffic accidents relative to given age categories. The effect of age on traffic accident severities changed by the age of the drivers. The magnitude of drivers suffering in RTAs for fatal and serious injuries was high between 18-30 years. Hence, the analysis result confirms that, as the age of the drivers increased, the road traffic accidents conversely decreased and the fatalities and serious injuries for the road traffic accidents associated with similar driver age categories to begin in risky reduction. Therefore, aged drivers were more experienced and probably much more responsible than youths. Pearson Chi-square analysis calculated in Table 4.12 confirm that, the p-value=0.014 calculated chi-square value of 20.686 and the critical value of 16.92 considering the degree of confidence interval at 95% at α=0.05 suggests, the p-value=0.014 less than the significance value of α=0.05 and the calculated value =20.686 greater than the critical value=16.92 was significantly related as a factor for road traffic accidents due to the age of the drivers.

4.2.2 Traffic accidents due to Gender of the drivers.

Table 4. 13: Gender of driver * Accident level Cross tabulation from 2016 to 2018

Driver's age group		Number of accidents and Levels				
		Fatal	Serious injury	Light injuries	PDO	Total
Male	Count	65	137	326	417	945
	%	5.55	17.70	27.84	35.61	80.70
Female	Count	1	6	9	163	179
	%	0.09	0.51	0.77	13.92	15.29
Unrecorded	Count	4	4	9	30	47
	%	0.34	0.34	0.77	2.56	4.01
Total	Count	70	147	344	610	1171
	%	5.98	12.55	29.38	52.09	100

Considering Table 4.13, 80.70% road traffic accidents caused due to male drivers, 15.29% due to female drivers and the remaining 4.01% were occurred due to unknown factors. From 80.70% road traffic accidents caused by male drivers in three years, 5.55 % fatalities, 11.70% serious injuries, 27.84% light injuries and 35.61% PDOs were reported along the

Bonga-Mizan roadway. Similarly, from 15.29% of the road traffic accidents due to female drivers, 0.09% fatalities, 0.51% serious injuries, 0.77% light injuries and 13.92% PDOs were reported. Finally, from 4.01% traffic accidents due to unrecorded causes, 0.34% fatalities, 0.34% serious injuries, 0.77% light injuries and 2.56% PDOs were also obsrved. Generally, road traffic accident severities occurred along the Bonga-Mizan roadway due to male drivers were more significantly related as factors, and female drivers were the minimal factors.

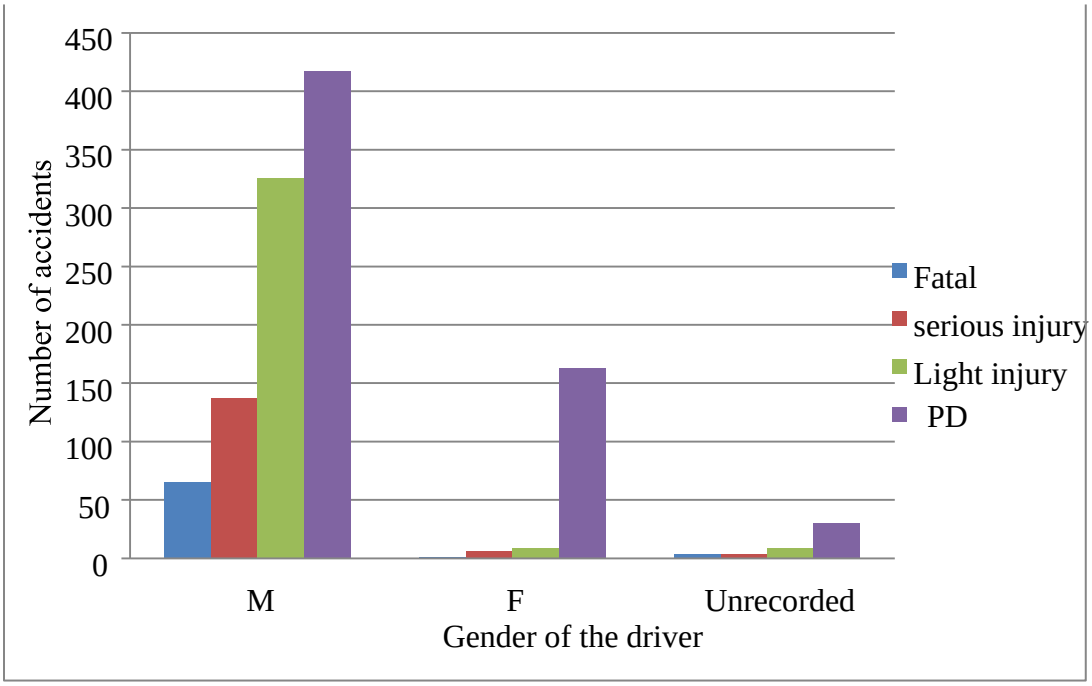


Figure 4. 5: Road traffic accident distribution due to drivers' gender.

Table 4. 14: Chi-square test analysis results due to drivers' gender

Gender of the drivers	Number of accidents	df	χ 2 critical	χ 2 calculated
Male	945	3	7.815	133.02
Female	179			
Total	1124			
Sig.			0.05	0.000

The Chi-Square test results in Table 4.14 indicated that, the significant difference among male and female drivers for causing road traffic accidents from Bonga to Mizan roadway

at a probability level of p=0.000 with chi-square test value 133.02. This indicates, the more probability level approaching to 0.000 and the chi-square value greater than the critical value at 95% confidence interval. So that, 7.815 χ 2 critical shows the presence of significant effects between the cross-tabulated variables for road traffic accidents due to the gender of drivers, (see in Table 4.14, Table 4.15 and Figure 4.12 for more detail).

4.2.3 Road traffic accidents due to the hour of the day

In addressing traffic accident severities, number of fatalities and injuries by the time of the day was an important consideration under this study. The time of the day that the road traffic accidents occurred was investigated by distributing traffic accident severities over a period of 24 hours.

Table 4. 15:Traffic accident percentage distribution over time of the day from 2016 to 2018.

Time of the day		Number of accidents and Levels				
		Fatal	Serious injury	Light injuries	PDO	Total
6:00AM-12:00PM	Count	36	68	103	205	412
	%	3.09	5.84	8.84	17.6	35.36
12:00PM-6:00PM	Count	23	52	145	243	463
	%	1.97	4.46	12.45	20.86	39.74
6:00PM-12:00AM	Count	8	12	51	104	175
	%	0.69	1.03	4.38	8.93	15.02
12:00AM-06:00AM	Count	3	15	39	58	115
	%	0.26	1.29	3.35	4.98	9.87
Total	Count	70	147	338	610	1165
	%	6.01	12.62	29.01	52.36	100

Variation in percentage distribution for the road traffic accidents in 24hrs of the day was, 12 hours during day time and 12 hours during night time. Considering Table 4. 15, 70 fatalities, 147 serious injuries, 344 light injuries and 610 PDOs were reported from the total of 1171 road traffic accident victims. But no time was recorded for 6 light injuries occurred under the Bench-Sheko zone of annual road traffic report. This lead reducing the total number of road traffic accidents to 1165. From Table 4.15, it was concluded that, the

fatalities and serious injuries along the Bonga-Mizan roadway were higher during the morning time to the mid-day time by the percentage distribution value P=3.09 and 5.84 from the total road traffic accidents reported. And also, light injuries and PDOs were higher during mid-day up to the sunset time by 12.45% and 20.86% respectively.

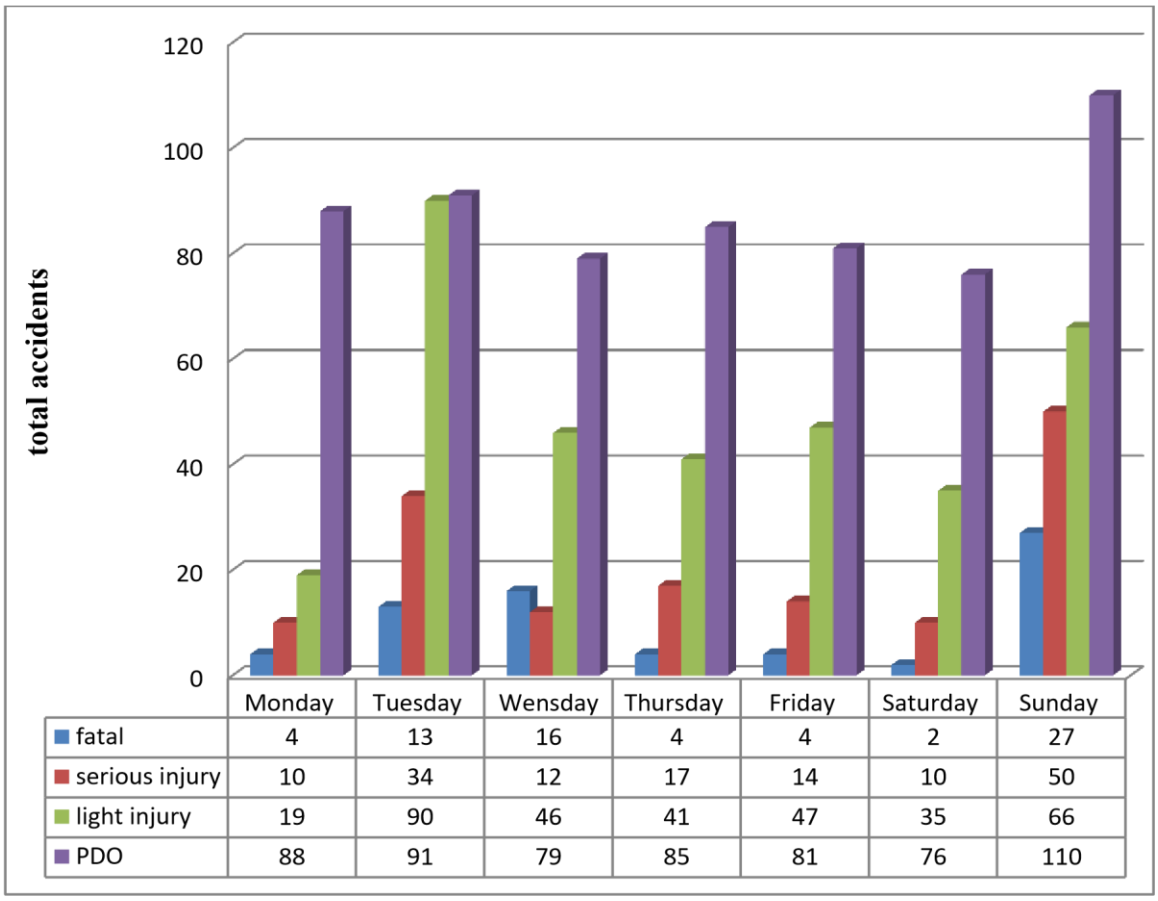
Generally, the researcher concluded that, road traffic accidents from mid-day to sunset were higher by 39.74 %, during day time higher than night time by 75.1% and 24.89% from the total traffic accidents. Hence, during night time the visualization was less and low illumination that affecting the driver's perception of an appropriate speed choice and they give attention while their driving task was at night. However, during the day time, there was enough visualization, this makes the drivers to drive carelessly. And also, traffic volume varies during the day and night time. During the day time, the traffic was high that causing road traffic accident occurrences. Therefore, road traffic accident severity is high during the day time than night time.

Table 4. 16: Chi-Square test results due to the hours of the day.

Hour of the day	Number of accidents	df	$\chi 2$-critical	$\chi 2$ 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 Chi-Square test result for the road traffic accident distribution over the hour of the days in Table 4.16 indicates that, the calculated $\chi 2$=25.387 for df=9 and the critical $\chi 2$-value= 16.92 at alpha value =0.05. Hence, the calculated $\chi 2$- value greater than the χ 2 critical value at the p-value of 0.003<0.05 indicates the road traffic accidents along the Bonga-Mizan roadway were not uniformly distributed over the hours of the days. Higher

percentage of the road traffic accidents were during the day time from 6:00 AM to 6:00 PM. This coincides with the period when people were more active and mobile along the roadway. At these time intervals, the peak time was identified between 12:00 PM to 6:00 PM at which it was the busiest as there was the heavy rush of travelers from schools, offices, factories, and business places. And, between 6:00 AM and 12:00 PM, there was high number of RTAs observed, (see in Table 4.16). During these periods, the ways of the roads were opened for heavy vehicular movements.



	Monday	Tuesday	Wensday	Thursday	Friday	Saturday	Sunday
fatal	4	13	16	4	4	2	27
serious injury	10	34	12	17	14	10	50
light injury	19	90	46	41	47	35	66
PDO	88	91	79	85	81	76	110

Figure 4. 6: Road traffic accident severities over the day of the week.

Traffic accident variation over the day of the weeks indicated that, Sunday, Tuesday, and Wednesday experienced higher fatality rate than another week of days with the equivalent value of 27, 13 and 16 respectively. And, Sunday, Tuesday and Thursday were higher for serious injuries from the day of the weeks, by 50, 34 and l7 accident severities respectively.

Similarly, Tuesday, Sunday and Friday were also the significant day of the weeks for the occurrence of light injuries by 90, 66 and 47 respectively.

Finally, Sunday, Tuesday and Monday were the days of the weeks at which the PDOs observed with the equivalent value of 110, 91 and 88 traffic accidents along the Bonga-Mizan roadway. Lastly, the analysis indicated that, from the days of the weeks, Sunday and Tuesday experienced higher traffic accident severities for road traffic accidents. This was because of these days were the market days at which the people along the roadway running their businesses from most parts of the villages surrounding.

Table 4. 17: Chi-square test result over the week of the day from 2016 to 2018

Week of the day	Number of accidents	df	χ 2 critical	χ 2 calculated
Monday	21	18	28.87	84.592
Tuesday	228			
Wednesday	153			
Thursday	147			
Friday	146			
Saturday	123			
Sunday	253			
Total	1171			
Sig.			0.05	0.000

Chi-square test result in Table 4.17 indicated the calculated χ 2-value=84.592 for the df=18 and the critical χ 2-value=28.87 at alpha value=0.05, suggested the calculated χ 2-value= 84.592 greater than the critical χ 2-value=28.87. Therefore, the week of the days were significantly related as a factor for the occurrence of road traffic accidents.

4.2.4 Traffic accidents due to the month of the year from 2016 to 2018

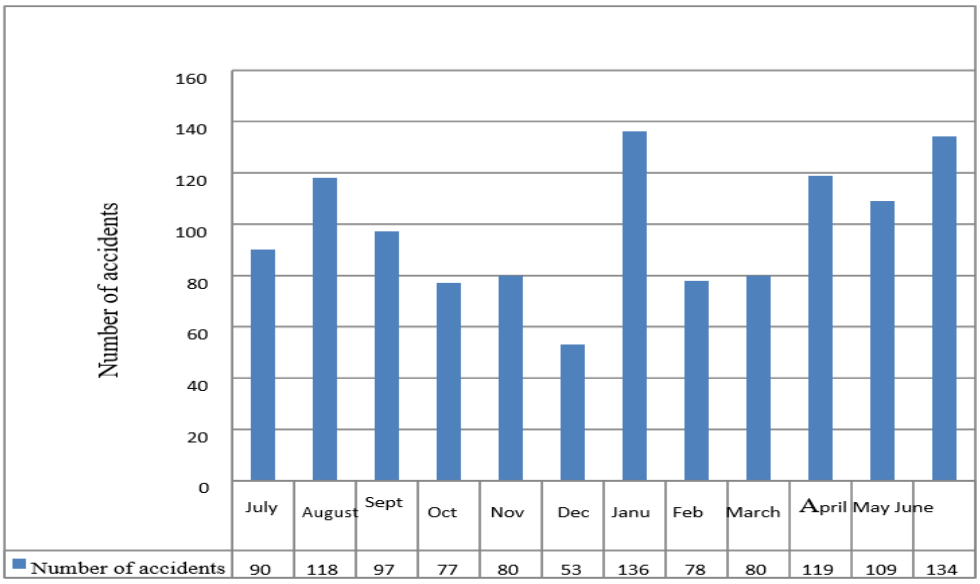


Figure 4. 7: Road traffic accidents due to the month of the years

Considering the month of the year indicated in figure 4.7, road traffic accidents were observed with the highest numbers during the months of January, June, and April by 136,134 and 119 respectively. And also, 118, 109 and 97 road traffic accidents were occurred during the month of August, May, and September of the years respectively.

Moreover, in July, November, March, February, October, and December of the months, road traffic accidents were observed with 90, 80, 80, 78, 77 and 53 respectively.

Hence, it was concluded that, those months with the highest severity of the traffic accidents were the seasons with high traffic volume, due to the last of rainy season and the beginning of sunny seasons along with the study area, and work flow to run business from door to door was also high at these months of the year.

4.3 Traffic accidents due to vehicle factors

It was also noted that, vehicle populations along the Bonga-Mizan roadway were considerably increased, while the road infrastructure remained the same. Most of the vehicles traveling along the roadway were in bad condition regarding to their maintenance because of the vehicles were very used with varying ages from 5 to 15 years. Those vehicles along the Bonga-Mizan roadway were used to the extent that, almost all were not road

worthily. This was due to the fact that majority of the vehicle owners were not afforded their vehicle's maintenance. This easily resulted operational cost to be always on the higher side, leading to mishandling of the vehicle's maintenance and fleets in the traffic system in poor condition.

Although it was observed that, about 80% of road traffic accidents from Bonga to Mizan roadway were caused due to human behavioral factors, it was also identified that human errors coupled with a vehicle mechanical factors resulted in a disaster, when there were any of the road traffic accident causation factors. Increased number of vehicles resulted the corresponding increase of road traffic accidents leading to loss of life and PDOs. It was also observed that, the current vehicle inspection carried out by road transport and development sector was primarily through a visual examination. This was inadequate and not professional to address the present situation. This was one of the risk factors contributing to prolonging road traffic accidents from Bonga to Mizan roadway like braking and maintenance problems. Conditions stated above were quite alarming taking into consideration that, even though there were many responsible factors for road traffic accident causations, road traffic accidents were caused by the combination of several factors.

4.3.1 Road traffic accidents due to types of vehicles

The severity of road traffic accidents along the Bonga-Mizan roadway was dependent on the type of vehicles moving along the segment. Most of the road traffic accidents reported were due to buses, by 28%, automobiles by 21% and trucks by 18 %.

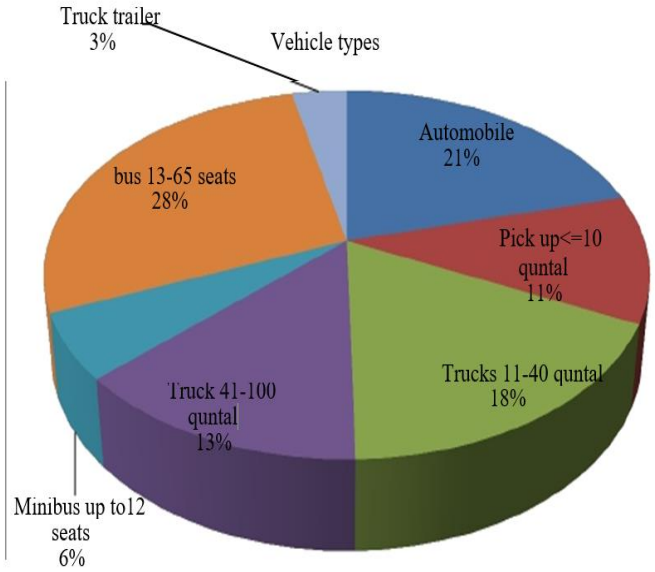


Figure 4. 8: Road traffic accidents due to the vehicle types.

4.3.2 Identified collision types at Blackspots.

Collision types were identified as head-on collisions, rear-end collisions, sideswipe collision, rollover, collision with pedestrians, collision with animals, and collision with roadside objects. These collision types were identified from a period of 2016 to 2018 at identified Blackspots, and the significant difference among the types of collisions were also observed accordingly. From the total of 70 fatalities occurred at Blackspots, about 62 were collisions with pedestrians and also the remaining collision types were not frequent fatal accidents. However, the trend for serious accidents dramatically increased in all collision types, except, collision with roadside objects.

Particularly, collision with pedestrians increased more than three times and other collision types like a head-on collision, rear-end collisions and sideswipe collisions increased compared to the fatal accidents. Similarly, the magnitude of light injuries due to head-on collisions, rear-end collisions, sideswipe collisions and collisions with pedestrians indicate, decreasing traffic trend than the serious injuries. But it was still higher than the fatalities. Degree of property damage collision types were also very dramatic. Hence, 919, 867, 428,103, and 46 property damages were recorded because of collision with sideswipe collision, rear-end, broadside collisions, head-on collisions, and rollover collisions respectively. The researcher from the study confirmed that, majority of the fatalities were

collision with pedestrians and others were moderate. Also, serious injuries, light injuries and PDOs occurred, due to collision with sideswipe collision, rear-end collisions, head-on collisions and rollover collisions.

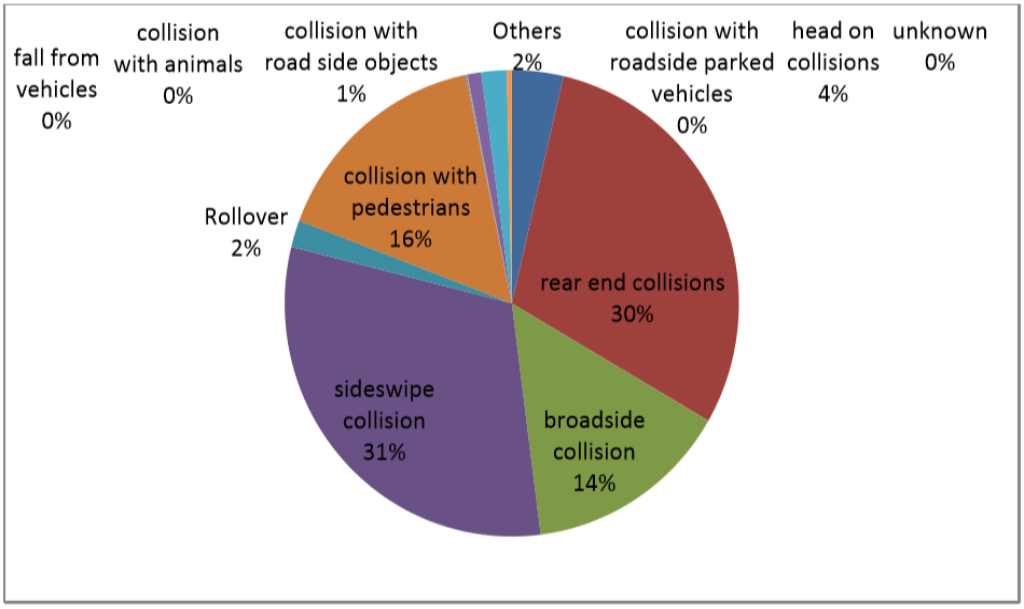


Figure 4. 9: Collisions types at Black spots along the Bonga-Mizan roadway

These identified collusion types relative to their degree of severities depend on the time of the action that were under taken to save the victim's life. Factors contributing the crash severities were dependent on the period at which the road traffic accidents occurred. As it was observed from the interview with hospital staff doctor Yohanis, time to save the life of accident victims was difficult. This was because of hospitals being farness from the place at which road traffic accidents happened & lack of patrol vehicles to give hurry services.

Before-crash- cause factors that contribute to the risk of a crash occurrence and how the crash was prevented or reduced. Whether the brakes of one or both of the vehicles involved were worn or not.

During-crash- cause the factor contributing to the crash severity and how engineering solutions might reduce crash severity. for example, whether a car was equipped with an airbag or if this airbag was used correctly.

After-crash-cause factors influencing the outcome of the crash and how damage and injury were reduced through improvements from the emergency response and medical treatments. For example, the time and quality of emergency responses to an accident

Table 4. 18: Types of crashes and related factors identified from Bonga to Mizan roadway.

Period	Human behavioral factor	Vehicular mechanical factor	Environmental factors
Before Crash Factors contributing to the increased risk of crashes.	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 the 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 the crash outcome	Age, gender	Ease of removal of injured passengers	Time and quality of the emergency response, subsequent medical treatments.

4.4 Identified Blackspots from Bonga to Mizan roadway

It was also investigated that, area at which the road traffic accidents frequently occurring were identified as Blackspots, when its priority value (P) equals 15 or more. The method incorporated was the Flemish government analysis method for traffic accident severity prioritization to decide which Blackspot was wishing an immediate mitigation for intervention.

Formula applied for ranking at each Blackspots was,

$P = X + 3Y + 5Z$, Where, P= priority value

X = total number of light injuries

Y = total number of serious injuries

Z = total number of fatalities.

Table 4. 19: Blackspots identified from Bonga to Mizan roadway from 2016 to 2018.

No	Black spots	From a period of 2016 to 2018			
		Fatalities	Serious	Lights	PDO
1	Gimbo at 18 80 km-25km	9	43	13	147
2	Bonga town from 1-1.6 km at 03 kebele & Tesfaye garage.	9	52	23	269
3	Dimbira at 45+ km.	15	5	2	86
4	Chenna woreda, kennech kebele, bobaballa at 70 km	1	3	4	186
5	Beyyemmo, at 20 km.	1	4	4	147
6	Locally 460, at 25 km.	4	7	8	113
7	Diri, at 28 km	3	27	20	316
8	Shiishoo Indee woreda, at 58 km.	5	16	2	130
9	Grawech and Dukura Woshi, at 35 km.	6	10	19	162
10	Koda kebele, kulishi, at 83 km	2	47	15	199
11	Gojeb, at 35 km.	7	20	14	254
12	Semen Bench, Indekil kebele, at 19 km	9	26	10	102
13	Gabuka, at 10 km.	7	24	12	96
14	Mizan-Aman town	13	38	20	116

Table 4. 20: Blackspot ranking for intervention.

Blackspot locations	Fatalities	Serious Injuries	Light Injuries	PDO	Priority value(P)	Rank
Gimbo	28	137	78	1321	573	1
Bonga	9	52	22	269	205	2
ShiishooIndee	13	38	20	116	173	3
Chenna	9	43	13	147	169	4
460	2	47	22	199	169	4
Mizan town	9	34	11	120	140	5
Gabuka	3	27	20	316	110	6
Temenjaj	7	24	14	254	107	7

4.4.1 Gimbo at 18+80 km from Bonga town

Possible improvement measures identified to intervene in the road traffic accidents from Bonga to Mizan highway section were recommended considering the road traffic accident factors at each Blackspots and the actual features investigated were indicated. The criteria adopted for evaluation was based on the ERA road safety manual and the road safety Audit guiding manual for rural roads. Feasible improvement measures to intervene in the road traffic accidents at each Blackspots were provided directly by investigating an area together with two of the road traffic Police officers, assigned from Kafa Zone traffic polices. Feasible investigations from Bonga to Mizan roadway were done and the sample images were captured at each accident-prone area. Improvement measures for each Blackspots for intervention was recommended according to their severity ranked.

Site description: Location for this Blackspot area is more populated area and surrounded by many residentials, commercials, administrative settlements, church, public market and private schools existing. Number of heavy vehicles use the road, especially during early in the morning and late at the evening time. It experienced highest road traffic accidents compared to other Blackspots.

Figure 4. 10: Blackspot at 18+80 (Source: Adinew G/michael).

Improvement measures: To reduce road traffic accident severities at this identified Black spot, it was recommended that, implementation of the edge side and central traffic marking with visible paints, (paint material cooked at 100 degree). Zebras are also expected to be provided at pedestrian crossing segments with sufficient pedestrian walkways properly

designed and posted speed limits directly visible to the drivers. At 25km, it was also recommended that, obstructions around the curve need to be removed and curve widenings are expected to be implemented to accommodate the existing traffic flow and for the emergency vehicles stopping. Centerline pavement markings have to be provided since the existing paint was already faded out. To protect the pavement markings from fading out, it was also recommended to cook the paint material at 100 degrees. It was also observed that, the road section at this segment was with the steep gradients, proper speed limit posts need to be installed and the roadside delineators guiding moving vehicles at the curves also to be installed and shoulder lines still need to be rehabilitated.

4.4.2 Bonga town from 1-1.6 km

Site description: It was observed that the road section at 03 kebele, in front of the governmental complex and locally in front of Tesfaye garage were more populated and urban areas. It was the place where the private and governmental schools like primary, secondary and high schools, teaching college, Tvt college and most of the government working offices existing. This easily resulted in high traffic volume, when market and holidays. Regarding the existing road geometry, the stretch was also flat and downhill from Bonga to Mizan and uphill from Mizan to Bonga. Horizontal and vertical curves were not smoothly provided for the efficient transition of the vehicles traveling along. Road traffic control signs, parking areas, zebra for crossings, pedestrian walkways, side drainages, shoulders, super-elevations, edge line and centerline pavement markings, guardrails, turning points towards schools and collage, speed limits, curve widenings to stop the vehicles at emergency, and almost all other road geometric parameters to be considered during design phase were seems like to be not properly taken in to account, considering the future traffic volume. These resulted the occurrence of road traffic accidents to be recorded so many times for a year from a period of 2016 to 2018 at the Blackspot.

Figure 4. 11: Blackspot in Bonga town in front of Tesfaye garage (Source: Adinew G/mi).

Improvement measures: Since the longitudinal length of the road segment at this section was long and flat at which the vehicles always speed up to overtake other vehicles so that, speed limit needs to be properly fixed at correct places at which they are visible to the drivers. Original pavement markings have to be rehabilitated through repainting, by using the paint materials cooked at the specified standard of ERA specification and even it violated the rule of road safety, rather than losing life and properties, it was recommended to construct humps to lower over speeding vehicles along downhills. Climbing lane should have to be also provided that supporting slow-moving vehicles and give-way for faster moving vehicles to pass along.

Preparation and construction of separate parking areas were also expected either by the governments or collages.

Generally, considering all the above-observed drawbacks at Blackspots, it was basically recommended that, necessary implementations to achieve these parameters have to be done to reduce road traffic accidents through design revision.

4.4.3 Shiishoo Indee woreda at 53+40

Site description: This was at 53+40 from Bonga town. As it was identified that, there were three Black spots in the woreda, which were in Dukura-Woshi at 35 km, in Dimbira at 45+60 and in Grawech at 58+40 km from Bonga town. Considering the road configuration along these segments, there was more curves too narrow, the tangent line between the curve

was too sharp. The Speed limits posted at these highway segments were not fixed directly visible to drivers, long trees around the curves that shading the vision of the drivers and the existing concrete roadside delineators and guardrails were totally damaged, due to the road traffic accidents.

Figure 4. 12: Identified Blackspot in shishinda at 58+40 (Source: Adinew G/Michael).

Improvement measures: It was recommended that, it needs design revision at this road segment and for the effective transition of the moving vehicles as well as for the passenger's safety travelling along the highway sections smoothly constructed horizontal curves need to be provided and designed traffic control signs need to be installed directly visible to the coming drivers from front. Those long trees around the curves that shading the vision of the drivers have to be removed to clear the surroundings along the roadway. Concrete roadside delineators and guardrails were also expected to be re-established and modification of the roadside objects still needed to be implemented.

4.4.4 Chena woreda at 70+20

Site description: The black spot area was at kennech and bobaballa kebele, 70 km distance from Bonga town. It was actually observed that, the road section at the segment was constructed with a broken back type of curve and half lane of the pavement was totally deteriorated. This made the drivers to make their vehicles to leave their path for searching of the half lane of the pavement and even the asphalt was not deteriorated, its width was not enough and proper road traffic control signs were not installed. The route was also so steep in gradient, with a large horizontal curve radius and it was seen that, the width of the existing shoulder too narrow with side drainages just left as opened.

Figure 4. 13: Identified Blackspot in Chena at 70+20 (Source: Adinew G/michael).

Improvement measures: Pavement segment need to be maintained and the pedestrian walkway lane must be provided. Speed limits were still expected to be fixed directly visible to the drivers and guard rails also need to be installed along the road segment. These can avoid peoples sharing carriageways safely. Enough shoulder width along too narrow shoulders expected to be provided along the road. So that, road traffic accidents could be easily reduced or controlled after all these strategical recommendations being implemented and monitored efficiently.

4.4.5 460 at 25+80

This was the local name of the place at 25 km length from Bonga town. The road section was more forest area and the stretch were steeper in gradient and the existing curve was too sharp.

Figure 4. 14: Identified Blackspot in 460 at 25+80 (Source: Adinew G/michael).

Improvement measures: Countermeasures recommended to reduce the road traffic accident at this Black spot is, proper-provision of the roadside delineators to guide vehicles

negotiating the horizontal curves. It was better if guardrails provided at sharp curves and the removal of obstructions from roadsides were still expected.

4.4.6 Temenjaj 19+60

This prone area was in indekil kebele at 19+60 from Mizan-Aman town.

It was observed that, road segment at this section was totally disintegrated and constructed with a sharp curve and it was broken following the path of the vehicles, so that, most of the road traffic accidents recorded in this zone indicated this place as the main black spot area. Information from various respondents indicated that the road segment at this section was maintained many times up to its life, but it was not working effectively as it has been rehabilitated. Direct observation at this road section also indicated that the top surface of the pavement was totally deteriorated, due to water ejecting upward to the asphalt surface.

Figure 4. 15: Identified Blackspot at 19+60 (Source: Adinew G/Michael).

Improvement measures: the recommended strategical measurement that could reduce the occurrence of the road traffic accident at this black spot needs either the re-alignment of the road direction at this section or re-construction of the pavements with the selected materials, in order to achieve the strength of subgrade that should be constructed at its specified depth above water table and curve widening was still required.

4.4.7 Mizan-Aman town

Site description: This was at the urban section of Mizan-Aman town, 556 km from the capital Addis Ababa, which transported the highest intensity of the freight's and

passenger's vehicular traffic with a design speed of 30 km/h passing along the road. It also practiced the highest rate of fatalities than other road segments. Rear-end collision, sideswipe collision, and collision with pedestrians were highest at this black spot. It was also observed that no properly constructed walkways and pavement marks were faded without traffic control signs and parking of vehicles along the roadside shoulders.

Improvement measures: It was also recommended that, in addition to the existing roadway, widening of pavement, bus bays, passenger shed, traffic control signs, intersection improvements need to be constructed.

It also needs zebra crossings to need to be marked with a vertical traffic control signs, horizontal markings, and warning signs at pedestrian crossings still need to be placed along both sides, in order to minimize traffic collisions. Medians should also be identified by paints.

Figure 4. 16: Identified Blackspot in Mizan-Aman (Source: Adinew G/Michael).

4.4.8 Gabuka at 10+60 from Mizan-Aman town

Site description: The main factor observed and reported for the occurrence of the road traffic accidents at this black spot was; lack of the road traffic control signs, narrow pavement lanes, shoulders, and the tangent line between the curve was not provided efficiently for the smooth transition of the vehicles.

Improvement measures: It was recommended that the road section needs to be provided with traffic control signs, proper pavement lanes, large curve lengths, and tangent lines as well as deflection angles provided efficiently for the smooth flow of the vehicles.

Figure 4. 17: Identified Blackspot in Gabuka at 10+60 (Source: Adinew G/Michael).

4.5 Life and PDOs cost analysis

It is the fact that, some amount of money be paid for the third parties, due to fatalities, serious injuries, light injuries and for repairing the damaged ones. Life and Damage cost was investigated based on the information of the road traffic polices. They mentioned that, it was paid for third parties due to fatalities, serious injuries, light injuries, and for the vehicle repairs. Information was collected considering 123 motor vehicle claims from the insurance company to the third parties on March 23 to June 22 in 2018 about the road traffic accident severity and claims paid.

Table 4. 21: Claims paid to the motor vehicles, due to the road traffic accidents.

Type of vehicle	Accident severity				Claim paid in $			
	Fatal	Serious injuries	Slight injuries	PDO	Fatal	Serious injuries	Slight injuries	PDO
Motor vehicle	18	19	26	60	$35652600	$4060000	$23072400	$23142000
Total	123				$65099200			

The result indicated in Table 4.21 confirmed that, each vehicle types collected considering 123 road traffic accidents and claim paid money for three months in 2018. The average

claim paid money was computed for each severity level indicated in Table 4.21, by dividing the claim paid $ for each traffic accident severities (in Table 4.22).

Table 4. 22: Average claim paid.

Type of vehicle	The average claim paid / type severities			
Motor vehicles	Fatal	Serious injuries	Light injuries	PDO
	$1980700	$1740000	$887400	$385700

Table 4. 23: Accident severity data

Year	Fatal	Serious injuries	Light injuries	PDO
2016	21	33	74	143
2017	29	75	166	222
2018	20	39	104	245
Total	70	147	344	610

Considering the total road traffic accident statistics and the average claimed $, the life and damage cost was calculated by multiplying the average claim paid $ and the number of each accident severities (see in Table 4.24).

Table 4. 24: Life and property damage cost from 2016 to 2018.

Year	Life and property damage cost in $				
	Fatal	Serious injuries	Light injuries	PDO	Total
2016	$41594700	$57420000	$65667600	$55155100	$219837400
2017	$57440300	$130500000	$147308400	$85625400	$420874100
2018	$3961400	$67860000	$92289600	$94496500	$258607500
Total	$102996400	$255780000	$305265600	$235277000	$899319000

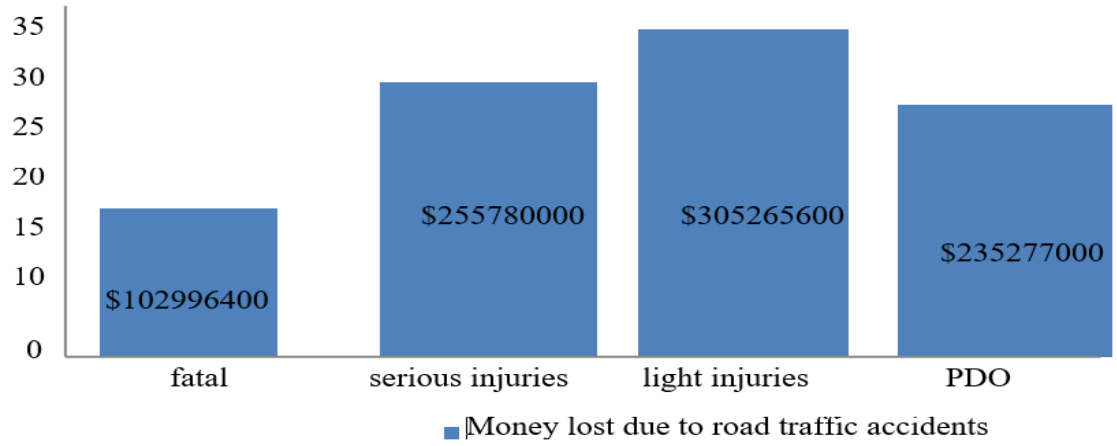


Figure 4. 18: Cost distribution due to accident severities from 2016 to 2018.

Considering the analysis result in Table 4.22, the cost value $102996400 for the fatalities, $255780000 for serious injuries, $305265600 for light injuries and $235277000 for PDOs were lost, due to road traffic accidents along Bonga-Mizan roadway. This resulted the total life and property damage cost of $899319000 loses.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The following conclusion was allowed to be seen based on research findings relative to each specific objective.

Road traffic accidents from Bonga to Mizan roadway frequently occurred due to several factors of mixed traffics leading to the increased number of traffic accidents. Co-existence of high-speed motors and low-speed pedestrian traffics cause road traffic accidents unavoidable in area of intense pedestrians. One of the factors associated with prolonged road traffic accidents observed was weaknesses in traffic regulation enforcement by traffic polices forces as an authorized body to govern and implement traffic safety measures as per regulation. This was the crucial issue identified to be sorted out. Over speeding the vehicles was another identified factor for the occurrence of road traffic accidents along this highway section. This causes both the crash risk and its consequences. Crash risks increased as the speed of moving vehicles increased. This was because of the road users underestimate the speed and overestimate the distance of being approaching vehicles while overtaking.

Technical elements of the highway construction were also one of the factors associated with the occurrence of the road traffic accidents from Bonga to Mizan roadway. This road section was constructed below its standard and it accommodates the traffics without being equipped with road traffic safety measures, like traffic lane separation lines, pedestrian lanes, appropriate traffic control signs, zebra crossings, pavement defects, curves, shoulders and roadside walkways. The highway section was constructed without adequate lightings and even in towns, some were not be lit at all. It was more common for vehicles to have no lights or reflectors and for the road spaces to be shared by fast-moving and slow-moving road users along the roadway at Bonga and Mizan-Aman towns.

Road segments from Bonga to Mizan highway section were also identified as Blackspot segments those wishing an immediate mitigation for intervention in road traffic accident

severities in Gimbo at 18+80, Bonga town from 1-1.6 km at 03 kebele and Tesfaye garage, Shiishoo-Indee at 58+40, Chenna woreda in kennech and Bobaballa at 70+20, 460 at 25+80, Mizan-Aman town, Beyyemmo at 20+80 and Temenjaj, at 19+60, and possible improvement measures were suggested based on their accident severities calculated to rank which Blackspots were wishing an immediate mitigation, and it was also concluded that, considering the analysis period from 2016 to 2018, 62% of road traffic accident severities are due to driver's error, 37.3% are due to vehicular defects and 0.7% are by others

5.2 RECOMMENDATION

The following recommendations were suggested based on the findings.

If new technologies like intelligent speed adoption (ISA) and the speed camera implemented to vehicles, drivers can reduce over speeding. So that, unexpected road traffic accidents can be minimized along the roadway.

It is also better if drunk drivers' restriction is followed by checking the alcohol limit in their blood, using breathalyzer that detecting how many milligrams of the alcohol they drunk. And also, installing and enforcement of the freights to wear seat belts during traveling through vehicles is good.

Those improper road geometric design factors for road traffic accidents are expected to be solved by implementing necessary improvement measures relative to those identified factors to intervene in the situation at each Blackspots. Like by fixing the design speed, implementing pedestrian's priority and enforcing the rule and regulations. Basically, it is also expected to provide zebras crossings horizontally marked and the vertical traffic warning signs placed along the roadsides to minimize traffic collisions. Medians should also be provided with visible paints to intervene in the situation.

It is also imperative that, if systematic inspection of the vehicles through pre-trip and post-trip inspections let and allow roadworthy vehicles under traffic systems like, through detailed station inspection, insurance of roadworthy certificate, roadside vehicle inspection and prosecution of the offenders implemented for mediations, and if also local governments authorities in collaboration with the executive directors of the Zones, organized the

broadcast information by setting the period through FM radio program about the requirements like proper use of roads, the responsibility and rights of road users, riding a bicycle, road accidents, first aid in road accident situations, enforcement of road safety rules, regulations and how to be legally licensed. Through these strategies road traffic accidents can be reduced easily.

Generally, Bonga-Mizan roadway like other highways expected to organize its own special road safety committee dealing with the road traffic accident interventions by coordinating various activities. So that, these committees are expected to provide a conducive environment for other organizations to participate in implementing the road traffic accident interventions, and to declare the road safety as a human right and interdisciplinary process requiring institutional cooperation. Thus, it can be intervened and governments should also play a big role to remedy the situation for relief. Also, each community are expected to take the responsibility and accountability in taking part on the matters of the road safety in order to reduce globally alarming road traffic accidents.

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APPENDIXES

Appendix A Checklist format

Date			
The name of the site to be investigated will be Bonga to Mizan highway section.			
List of site inspections for the identified risk factors and road traffic accidents.			
No	Type of Measures	Comment	
1		Is needed (√)	Not needed (x)
2			
3			
4			

Appendix B Road traffic accidents' record format

No	Kebele /Town	Number of			values (%)		
1		Fatality	Injury	Total Road accident			
2							
3							
4							

Appendix C interview guide lines

a) Interview guide questions with Bonga and Mizan-Tepi university teaching hospital informants

Date of an interview----------

Personal particulars: Age---------- Sex---------- Rank---------- Profession--------

Working experience ----------

a. Do you think motor traffic accident injuries are an important problem in this Hospital?

---

b. What problems do you get in receiving motor accident victims? ……..

c. Do you have enough treatment rooms to accommodate all injured people?

---

d. From your experiences, do you think people fear traffic accidents in this area?

---

e. What risk factors do you think to facilitate the occurrence of the road traffic accident in this area?

1. In terms of Vehicles ----------

2. In terms of (environment) road network----------

3. In terms of Peoples behavior----------

4. In terms of legislation and regulations----------

5. In terms of others(justify) ----------

f. What kind of measures should be taken to reduce traffic accidents along the segment?

---

g. Who do you think should be responsible for the traffic accident? ----------

---

h. What is your recommendation/opinion on how to improve medical service to Motor traffic accident victims in this hospital? ----------

b) Interview Guide Questions with Police Traffic Officers

Personal particulars Date---------- Age---------- Sex---------- Rank----------

Working experience----------

1. Do you think motor traffic accidents are an important problem from the Bonga-Mizan roadway? ----------

2. How do you compare the magnitude of motor traffic accidents from BongaMzian to those of other areas? ----------

3. How do you normally get information after the motor accident has occurred?

---

4. Are there any problems in getting immediate information after the motor accident has occurred? What are those problems? ----------

5. How do you transport injured people from the site of the accident to the hospital?

1) By police vehicle.

2) By ambulance. 3) By requesting other motorists to help.

4) Accident victims hire vehicles themselves.

(5) Others (specify)----------

6. Where do you send dead bodies of persons who die at the site of accidents?

7. Is there any problem with getting valid reports/information on motor accidents occurring from Bonga to Mizan roadway? ----------

8. Do you face any problem in keeping motor traffic accident reports in your office?

---

9. What are your recommendations and opinion on strategies of reducing the motor accident along this roadway? ----------

10. What measures do you take to reduce traffic accidents along the segment?

---

11. Are there any problems with implementing traffic safety measures from Bonga to Mizan roadway? ----------

12. Who do you think should be responsible for traffic accidents? ----------

13. Do you think the available traffic rules and regulations can reduce road traffic accidents? ----------

14. what are the factors do you think to facilitate the occurrence of road traffic accidents in this segment?

Appendix D SPSS output

Chi-square test result due to the age of the drivers

Case Processing Summary

			Cases			
Age of driver * accident severity	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
	902	77.00%	269	23.00%	1171	100.00%

Age of driver * Accident severity crosstabulation

Age of the driver	Accident severities				Total
	Fatal	Serious injury	Light injury	PDO	
18-30	20	50	108	308	486
31-40	8	15	54	192	269
41-50	4	5	16	96	121
>50	0	3	9	14	26
Total	32	73	187	610	902

Chi-Square Test result

Pearson Chi-Square test	Value	df	Asymptotic Significance (2-sided)
	20.686[a]	9	0.014
Likelihood Ratio	22.116	9	0.009
Linear-by-Linear Association	.947 902	1	0.008
N of Valid Cases			

Symmetric Measures

Nominal by Nominal		Value	Approximate Significance
N of Valid Cases	Phi	0.151	0.014
	Cramer's V	.087 902	0.014

Case Processing Summary

possible causes * accident severities	Cases						
N	Valid			Missing		Total	
			Percent	N	Percent	N	Per cent
	1171		100.00%	0	0.00%	1171	100. 0%

Possible causes * Accident severities Cross tabulation

Possible causes	Accident severities				Total
	Fatal	Serious injuries	Light injuries	PDO	
Due to over speeding	20	31	82	163	296
Due to unethical driving	31	50	104	175	360
Due to breaking problem	2	15	42	78	137
Due to tire problems	14	31	72	97	214
Due to Animals	0	2	6	0	8
Due to technical problem	3	16	25	41	85
Total	70	147	344	610	1171

Chi-Square Tests

Value	df	Asymptotic Significance (2sided	
Pearson Chi-square	54.670	18	0
Likelihood Ratio	64.61	18	0
Linear-by-Linear Association	0.395	1	0.529
N of Valid Cases	1171		

Symmetric Measures

Nominal by Nominal	Value	Approximate Significance
Phi	0.216	0
Cramer's V	0.125	0
N of Valid Cases	1171	0

Chi-square test for road geometry

Road geometry * Accident severities		Cases			
Valid		Missing		Total	
N	Percent	N	Percent	N	Percent
1152	98.40	19	1.60	1171	100.00

Road geometry * Accident severity Cross tabulation

Road geometry	Accident severities				Total
	Fatal	Serious	Light	PDO	
Due to straight and level	39	80	171	264	554
Due to uphill	7	13	12	55	87
Due to downhill	16	41	130	183	370
Due to curves	8	13	23	97	141
Total	70	147	336	599	1152

Chi-Square Tests

	Value	df	Asymptotic Significance (2sided)
Pearson Chi-Square	39.393	9	0
Likelihood Ratio	41.817	9	0
Linear-by-Linear Association	10.636	1	0.001
N of Valid Cases	1152		

Symmetric Measures

Value			Approximate Significance
Nominal by Nominal	Phi	0.185	0
	Cramer's V	0.107	0
N of Valid Cases		1152	

Chi-square test due to gender of the driver

Gender of the drivers	Accident severity				Total
	Fatal	Serious injury	Light injury	PDO	
Male	65	137	326	417	945
Female	1	6	9	163	179
Total	66	143	335	580	1124

Chi-Square Test results

Value		df	Asymptotic Significance (2sided)
Pearson Chi-Square	133.026	3	0
Likelihood Ratio	153.609	3	0
Linear-by-Linear Association	93.474	1	0
N of Valid Cases	1124		0

Chi-square test result due to the time of the day

Time of accidents occurred	Accident severity				Total
	Fatal	Serious injuries	Light injuries	PDO	
6:00AM-12:00PM	36	68	103	205	412
12:00PM-6:00PM	23	52	145	243	463
6:00PM-12:00AM	8	12	51	104	175
12:00AM-6:00AM	3	15	39	58	115
Total	70	147	338	610	1165

Case Processing Summary

Surface condition * Accident per year	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
	1154	98.50	17	1.50	1171	100

Surface condition * Accident per year Cross tabulation

Due to surface condition	Accident per year			Total
	2016	2017	2018	
Wet	86	97	102	285
Dry	180	383	306	869
Total	266	480	408	1154

Chi-Square Test results

Value		df	Asymptotic Significance 2-sided
Pearson Chi-Square	13.556	2	0.001
Likelihood Ratio	13.303	2	0.001
Linear-by-Linear Association	2.976	1	0.085
N of Valid Cases	1154		

Symmetric Measures

Values			Approximate Significance
Nominal by Nominal	Phi	0.108	0.001
	Cramer's V	0.108	0.001
N of Valid Cases		1154	

Weather condition * Accident severity Cross tabulation

Due to weather condition	Accident severities				Total
	Fatal	Serious injuries	Light injuries	PDO	
Cloudy	6	19	35	91	151
Rainy	8	17	22	95	142
Normal	35	70	129	168	402
Windy	1	28	108	27	164
Sunny	16	9	30	163	218
Cold	1	3	7	28	39
Hot	3	1	8	24	36
Total	70	147	339	596	1152

Chi-Square Test result

Value		df	Asymptotic significance 2-sided
Pearson chi-Square	230.414	18	0
Likelihood Ratio	239.228	18	0
Linear-by-Linear Association	3.389	1	0.066
N of Valid Cases	1152		

Symmetric Measures

Value			Approximate Significance
Nominal by Nominal	Phi	0.447	0
	Cramer's V	0.258	0
N of Valid Cases		1152	0

Chi-square test result due to the week of the day

Day of week * accident severities	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
	1171	100	0	0.00	1171	100

Day of week * Accident severities cross-tabulation

Due to day of week	Accident severities				Total
	Fatal	Serious injuries	Light injuries	PDO	
Monday	4	10	19	88	121
Tuesday	13	34	90	91	228
Wednesday	16	12	46	79	153
Thursday	4	17	41	85	147
Friday	4	14	47	81	146
Saturday	2	10	35	76	123
Sunday	27	50	66	110	253
Total	70	147	344	610	1171