JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

HIGHWAY ENGINEERING STREAM

INVESTIGATION OF ROAD SAFETY MEASURES AROUND SCHOOLS IN ADDIS ABABA

A Thesis submitted to School of Graduate Studies, Jimma University, Jimma Institute of technology, Faculty of Civil and Environmental Engineering in Partial Fulfilment of the Requirements for the Degree of Master of Science in Highway Engineering

By

Abenezer Ewnetu Hailu

July 2021

Jimma, Ethiopia

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Abenezer Ewnetu Hailu

Advisor: Dr. Eng. Lucy Feleke (PhD)
Co-Advisor: Eng. Oluma Gudina (MSc)

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DECLARATION

I, the undersigned, declare that this thesis proposal entitled by: **"INVESTIGATION OF ROAD SAFETY MEASURES AROUND SCHOOLS IN ADDIS ABABA**" is my original work and has not been presented by any other person for an award of a degree in this or any other University, and all sources of material used for this thesis proposal have to be duly acknowledged.

Ms. Abenezer Ewnetu Hailu ____________________ _________

Signature Date

As Master's Research Advisors, I hereby certify that I have read and evaluated this MSc thesis paper prepared under my guidance by Ms. ABENEZER EWNETU HAILU entitled "INVESTIGATION OF ROAD SAFETY MEASURES AROUND SCHOOLS IN ADDIS ABABA" and recommend and would be accepted as a fulfilling requirement for the Degree Master of Science in Highway Engineering.

Dr. Eng. Lucy Feleke (PhD) __________________ _______________

Main Advisor Signature Date

Eng. Oluma Gudina (MSc) _________________ ______________

Co- Advisor Signature Date

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ABSTRACT

This WHO report shows that the traffic accident problem is getting worse that deaths from road traffic crashes have increased to 1.35 million a year. That's nearly 3700 people dying on the world's roads every day. Rising numbers of fatalities on the roads in low and middle-income countries are linked to development and motorization but occur in large part because road safety concerns are not being adequately addressed as the transport systems develop. While road transport is vital to countries' development, maximizing the efficiency of road transport systems without adequate attention to safety leads to loss of life, health and wealth. In developing countries like Ethiopia Road traffic accidents are among the leading and top cause of death and injury. The severity of traffic accident is still at distressing stage in Addis Ababa capital of Ethiopia, in the past five years 137,129 accidents has occurred in Addis Ababa, and 9844(7.1%) occurred with in the school zone, putting kids and road users at risk of serious injury and even death. The main objective of this study was investigating the road safety measure around schools in Addis Ababa. Primary and secondary data were used to achieve this objective, primary data was collected by using checklist to assess road safety measures around school while secondary data collected from Addis Ababa police commission to identify schools with high RTA and Identify accident characteristics. During the study an accident data from 2015/16-2019/2020 was taken and 9844 accidents (152 fatal, 674 serious injury,412 slight injury and 8606 property damage) were occurred around schools in Addis Ababa. Based on the fatal accident number recorded, 30 schools with frequent road traffic accident, in the specified period were identified and descriptive analysis was done by using statistical package for social science spss26.

The result of the study revealed that most of the accident has caused by vehicle type of minibus upto 12 seats (39%) and automobiles(38%) and vehicles with service year greater than 10 years causes 45.94% of the accident. However, all of the vehicles involved in crash doesn't have reported technical defect. Regarding human factor the result confirms that youngest drivers (18-30) years, those with experience less than 5 years and junior high-school level educational background took the highest role in the occurrence of the accident at school zone. Most of the accidents were occurred on weekday and during day time at schools' peak hour highest accident number was recorded.

Therefore, it is concluded that the contributing factors of the accidents occurred in the school zones under this study was found to be, service year of vehicle, age, experience and educational background of the drivers. In addition to the cause identified from police commission report, road and environmental factors around school also had a major contribution based on the chi square test result, more than 80% of the road factors has strong association ($p<0.05$) with accident. With regard to safety measures, Inadequate provision of road safety measures and deteriorated pedestrian facilities was observed.

Finally, Demarcating areas around the schools as school zones, preparing school zone road safety guidelines and including in education system, encouraging roads safety awareness creating campaigns and low-cost solutions like walkway repair and maintenance, removing obstacles, high visibility crosswalks, proper area signing, modified drop-off/pick-up operations, and holding traffic safety days are recommended.

Keywords: Contributing factors, Road safety, School zone, Traffic accident

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ACRONYMS

4E's	Engineering, Education, Enforcement, Encouragement,
AAPCCID	Addis Ababa police commission crime investigation Division
ETB	Ethiopian Birr
MUTCD	Manual on uniform Traffic Control Device
NMTS	Non-motorised transport strategy
RTA	Road Traffic Accident
RTC	Road Traffic Crash
RTI	Road Traffic Injury
SI	Severity Index
SPSS	Statistical Package for the Social Sciences
SUV	Sport utility Vehicles
UNECA	United Nations Economic Commission for Africa
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1. Background

WHO has launched the Global status report on road safety by December 2018, highlights that the number of annual road traffic deaths has reached 1.35 million. Road traffic injuries are now the leading killer of people aged 5-29 years said the report. The burden is disproportionately borne by pedestrians, cyclists and motorcyclists, in particular those living in developing countries. The report suggests that the price paid for mobility is too high, especially because proven measures exist. There continues to be a strong association between the risk of a road traffic death and an income level of a countries. With an average rate of 27.5 deaths per 100000 population, the risk is more than 3 times higher in low-income countries than in high income countries where the average rate is 8.3 deaths 100000 population. The burden of road traffic death is disproportionately high among low and middle income in relation to the size of their population and the number of motor vehicle in circulation. Although only 1% of the world's motor vehicles are in low-income countries 13% of death occur in these countries.

Countries in Africa and South-East Asia have regional rates of road traffic deaths higher than the global rate with 26.6 and 20.7 Death per 100,000 population respectively Organization (2019).
Despite having a very low car ownership level, a total of 1,138,365 vehicles in 2019, Ethiopia has a relatively high rate of crashes. According to the World Health Organization (WHO), road traffic deaths in Ethiopia are estimated at 27,326, amounting to a death rate of 27 per 100,000 population. The main causes of crashes include poor road design, negligence of drivers, and technical faults of vehicles. Vulnerable road users, including pedestrian and cyclists, are the most affected and pay a heavy toll in terms of deaths and injuries. Pedestrians account for the highest proportion of road fatalities in Ethiopia or 37 percent of all deaths (NMTS 2020).

In Ethiopia, pedestrians and passengers of commercial vehicles are the most vulnerable in, whereas in high-income countries crashes involve primarily privately owned vehicles with the driver being the main car occupant injured or killed. According to the Federal Police Commission report, the death rate due to car accident is significantly increasing among pedestrians and passengers from time to time in Ethiopia.

The rate of traffic accidents in the city of Addis Ababa goes up together with the increase in the total number of motor vehicles in use and rapid growth rate in the population size. The ever-increasing rise in the number of automobile ownership together with the poor condition of the existing functional public roads has factually resulted in causing the high level of safety problems.

There is clear evidence in developed countries of an increasing trend for children to be driven to and from school in private motor vehicles, at the expense of other modes, such as walking, cycling and public transport (Pooley, Turnbull et al. 2005). Managing traffic and road safety at schools is a matter for everyone in our community. Children and young people are at risk in road environments around schools and colleges because they are smaller and less visible to drivers and because of the traffic congestion occurs at the peak hours of school. It is difficult to predict their behaviour when compared with adults and they may have a wrong judgement when handling traffic. So that this study will be an input to show the reality concerning road safety around schools and help to point out where the problem lies regarding school zone traffic accident. Progress in reducing road traffic deaths over the last few years varies significantly between the different regions and countries of the world. Additionally this study has done to point out the cause of the RTA s at school and imply the action should be taken to lower the problem as well as meet any future global target that might be set and save lives.

1.2. Statement of the Problem

Pedestrian accidents are on the rise and sadly, far too many of them occur in school zones, putting kids at risk of serious injury or even death. RTA is found to be a leading killer of young peoples aged from 5-29, this could be a serious disaster for a country since more of the productive power is included with in the range of this Age. It is also considered as a serious health problem all over the world and the problem is becoming severe from time to time in developing countries.

In Ethiopia, pedestrian fatalities are the dominant type of road traffic fatalities, accounting for 55%of total deaths (Newnam, Mamo et al. 2014). This statistic demands attention, however child pedestrian safety research in Ethiopia has been relatively rare due to the limitations of resources and institutional capacity in the field. This shows that the productive power and generation of the country is in danger due to the accident which caused at early age death and disability and it directly affects the economy of the country, and this problem is shared by other developing countries.

In addition, the number of traffic accident victims due to lack of proper law enforcement issues, traffic characteristics and improper geometric road designs have become enlarged from time to time. Even some road networks can be regarded as non-functional from the perspective view of their provisional concept.

School zone is vulnerable for accident occurrence because of the congestion occurs at the school vicinity and also Childs may not be developmentally ready to make safe judgments about traffic. At school drop-off and pick-up times, the roads in the immediate area of schools are especially busy and there is usually a high level of vehicle, pedestrian, and cyclist activity. School activities such as Staff arriving and leaving work, school buses transporting students, parents dropping off and taking children, causes congestion and very often leads to frustration from pedestrians and motorists to the apparent confusion. Generally, the road environment, road users and the engineering setting of the road sections are among the main accident-causing aspects.

Therefore, this area needs special concern. Parents, teachers and stakeholders need to be aware of the skills of the children and plan road safety awareness in accordance with the child's development.

1.3. Research questions

1. Which schools in Addis Ababa have the highest road traffic accident?
2. What are the road and environmental risk factors at schools with highest traffic accidents?
3. What engineering and road safety measures have been implemented at the schools with the highest road traffic crashes in Addis Ababa?

1.4. Objective

1.4.1. General Objective

The main purpose of this study is to investigate the roads safety measures around schools with high traffic accident data in Addis Ababa.

1.4.2. Specific Objectives

- To identify schools with the highest road traffic accident in Addis Ababa.
- To assess the major contributing factors of these accidents at schools with highest traffic accident.
- To investigate Engineering road safety measures that has been implemented at the schools with the highest road traffic crashes in Addis Ababa.

1.5 Significance of the study

There is no study done on pedestrian crash around school zone in Ethiopia. Therefore, this study will contribute an important input regarding the magnitude and factors associated with road traffic accidents around school in case of Addis Ababa city.

This study will also help to identify and describe the factors related to pedestrian crash around school in the city. Moreover, this study will access the possible safety measures taken around the selected schools and their effectiveness in order to decrease death and disability resulting from road traffic accidents. Finally, the finding of this study will be an important input for further research on RTA in Addis Ababa and other cities in Ethiopia.

1.6 Scope of the study

The main objective of this study was to investigate the roads safety measures around schools with high traffic accident data in Addis Ababa. The scope of this study was limited in accessing the road traffic accident happened in school zone and identifying schools with highest crash data, take schools with high accident record for further investigation of road safety measure. This is done by taking the recorded accident data from Addis Ababa police commission crime investigation department that has happened from 2015/2016-2019/2020. It only accessed the accident contributing factors and implemented safety measure around selected schools, with in according to MUTCD and ERA geometric design manual standard procedures. Regarding road safety measures only engineering safety measures has been assessed in this study.

1.7 Limitations of the study

The study finding does not represent the whole Addis Ababa school's road safety practice because of the limitation of time and proposed budget. Therefore, the study has considered limited number of schools with highest road traffic crash history and contributory factors from the accident characteristics recorded by police. Since the data was secondary data it may have discrepancies so that the exact cause of those accident cannot be given in this study. It has also selected the schools based on the fatal crash occurred within the school zones it does not access the injuries and property damages occurred at those schools.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of traffic Accident

Traffic is often defined as the movement of pedestrians and goods along a route, and within the 21-century the foremost significant problem and challenge for the traffic engineer is typically an imbalance between the number of traffic and thus the capacity of the route, leading to congestions. Traffic congestions are not a new phenomenon. Roman history recorded that the streets of Rome were so clogged with traffic that at least one emperor was forced to issue a proclamation threatening the death penalty to those whose chariots and cars blocked the way. More recently pictures of our modern cities taken at the turn of the century show clogged with traffic (Samson 2006). The dictionaries define "traffic" as the transportation of goods, coming and going of persons or goods by road, rail, air, etc. Traffic engineering deals with the traffic planning and designs of roads, of frontage development and of parking facilities and with the concern of traffic to provide safe, convenient and economic movement of vehicle and pedestrians. Traffic engineer is used to either improve an existing situation or, in the case of new facility, to ensure that the facility is correctly installed.

A road traffic crash is defined as accident, event, collision or crash between two or more vehicles, a vehicle and a train, a vehicle and a cyclist, a vehicle and a pedestrian, a vehicle and an animal, a vehicle and a tough and fast object, sort of a bridge, building, tree, post, etc., or one vehicle that overturned on or near a public road. A road traffic crash could also be one road traffic incident, regardless of the quantity of vehicles or persons involved in any particular crash (RTMC 2015).

According to world health Organization (2015) report, Factors contributing to road traffic injuries are categorized into four major groups, Road factors Motor vehicle factors; Human factors; and Environment factors.

Studies conducted on this area has shown that the human factor is a major contributor to road traffic injuries. The road user group under investigation in this study, is the child pedestrian and other school community who was a victim of road traffic accident caused around school, in school zone. This research will focus on investigating the child pedestrian crash around schools, as well as the road and environmental contributory factors that result in crashes involving child pedestrians (Behrens, Jobanputra et al. 2013).

2.2 Human Factors

Driver behavior is additionally one among the foremost contributing factors to road traffic accidents because it's shown in several kinds of literature. The drive factors include negligence of following traffic laws like speeding, not using safety equipment like seat belts and child seats for teenagers, drunken driving, substance abuse, poor eyesight, fatigue, poor experienced drivers, age, disease, and disability. Young drivers and male drivers are more likely to be involved in road traffic crashes. According to Petridou and Moustaki (2000) Human driver behaviour factors that contribute to RTI has been classified as follows

- "Those that reduce capability on a long-term basis (inexperience, aging, disease and disability, alcoholism, drug abuse);
- Those that reduce capability on a short-term basis (drowsiness, fatigue, acute alcohol intoxication, short term drug effects, binge eating, acute psychological stress, temporary distraction)
- Those that promote risk taking behaviour with long-term impact (overestimation of capabilities, habitual speeding, habitual disregard of traffic regulations, indecent driving behaviour, non-use of seat belt or helmet, inappropriate sitting while driving, accident proneness and
- Those that promote risk taking behaviour with short-term impact (moderate ethanol intake,
  psychotropic drugs, motor vehicle crime, suicidal behaviour, compulsive acts)".

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

a. Driver: All road users have a crucial role within the prevention and reduction of accidents. Although accidents tend to occur not only by Single cause, but road users are the foremost dominant influence. In some cases, the absence of skills or experience to infer things – things that are important from a significant of events cause the incorrect decisions or actions

(WANTIGLI 2013). Alsop, Langley et al. (2001) the common driving errors are lack of observation or ineffectiveness, driving too fast, failure to seem, misperception and panic reaction from the inexperienced. This may be severe if the driving force is impaired thanks to alcohol, drugs, illness, fatigue and emotional stress. In the same study, young and inexperienced drivers were found to be more likely to cause traffic accidents than older and experienced drivers. In the USA, the age group 16-24 years contains 22% of the driver population and this group was involved in 35% of fatal and 39% of all injury accidents (Bitew 2002) .

Speed choice: -The speed of motor vehicles is at the core of the road injury problem. Speed influences both crash risk and crash consequence. The speed drivers prefer to travel at is influenced by many factors. Modern cars have high rates of acceleration and may easily reach very high speeds in short distances. The physical layout of the road and its surroundings can both encourage and discourage speed. Crash risk increases as speed increases, especially at road junctions and while overtaking – as road users underestimate the speed, and overestimate the distance, of an approaching vehicle. Speed has an exponentially detrimental effect on safety (2004).

Sex and Age of drivers: - The risk of a crash with alcohol varies with age and drinking experience. World Health Organization (Organization, Staff et al. 2004) that crash rates of male drivers aged 16–20 years were a minimum of 3 times the estimated crash rate of male drivers aged 25 years and above. With few exceptions, the relative risk of being fatally injured during a single-vehicle crash was found to decrease with increasing driver age for both men and women . Dehuri (2013) studied 680 young driver behavior involvement during a traffic crash in Florida. The result revealed that aggressive violation, in-vehicle distraction, and demographic characteristics were the many factors affecting young drivers' involvement in crashes at the age of 16-17. In-vehicle distraction, attitude towards speeding, and demographics characteristics were the many factors that affect young drivers' crash risk at the age of 18-24. As in other developing countries, males are over-involved in road traffic crashes and account for over 67% of these killed (Samson 2006). This will partly be explained by their greater exposure to traffic as drivers and as frequent travelers in automobiles for work and leisure activities. Females are involved mainly as passengers and pedestrians. In Botswana, as an example, a recent study showed that females accounted for as high as one- third of all pedestrian fatalities and 43 percent of all pedestrian casualties (Samson 2006).

2.3 Vehicle Factors

The vehicle type, design and state of maintenance are among the main contributors to the number and severity of road traffic crashes. The type and design of motor vehicle contributes to the severity of road traffic accidents involving pedestrians. Heavy vehicles such as trucks and sport utility vehicles (SUV) have a higher rate of fatal injuries compared to all other passenger vehicles. (Kim, Ulfarsson et al. 2008). Vehicle manufactures have been urged to review the design of the vehicles and in particular, the front bumper and bonnet as studies show that using softer material on the vehicle bonnet reduces the severity of lower body injuries and head injuries if a victim's head hits the front bonnet during the collision (Organization 2019).

Studies indicate that the use of un-roadworthy vehicles also contribute significantly to RTCs. Moodley and Allopi (2008) highlight defective tires as the main contributor to road vehicle accidents followed by mechanical failure.

2.4 Road and Environmental Factors

The road environment could also be a component of each human being's general environment and forms an area of how citizenry interact with the world. Children are exposed to the road environment whilst conducting their everyday activities, whether it's around their homes, whilst playing, walking or cycling, round the schools and around recreational facilities and as passengers in automobiles and while within the company of adults conducting their day-to-day activities. (Congiu, Whelan et al. 2008). The type of environment that exposes children to traffic injury include:(Petch and Henson 2000).

- Lack of open spaces or playgrounds for children to play;
- On-street parking;
- High traffic volumes and speeds;
- Roads that are straight and those that allow high volumes of through traffic;
- Street frontage access;
- Lack of dedicated pedestrian infrastructure;
- Street vending; and
- Lack of safe public transport

The road environment is often a deadly place for young and under developed countries. It is, therefore, important that child factors be taken into consideration within the design of the built environment that children are exposed to. The built environment factors that increase the danger of road traffic injuries are divided into two categories. The first category includes those factors that are influenced by the selection of road and environment design. The second category are those environment factors that are usually unique to things or environment where the road traffic crash happened, they're influenced by external factors, like state of infrastructure maintenance, weather and lighting conditions. A summary of Category one road factors that increase the risk of road traffic crashes are listed hereunder,(Kim, Ulfarsson et al. 2008):

- Poor road design;
- Road class - which influences the number of lanes, type of intersection and direction of traffic;
- Lack of provision of good quality and accessible pedestrian facilities, such as pedestrian crossings and sidewalks;
- Lack of good traffic control measures, such as traffic signals, traffic signs, road markings, channelling devices and variable message signs; and

•Lack of provision of measures that deal with high traffic speeds and volumes, such as traffic calming and the reduction of posted speed limits. A summary of Category two environmental factors follows hereunder:

•Condition of the road surface;

•Presence of on-street parking and street vendors;

•Lighting conditions;

•Weather conditions; and

•Location of road traffic crash, that is, midblock versus intersection

•Volume of traffic;

•Speed limits;

•Predominant type of dwelling or land use;

•Absence of play areas due to the lack of open spaces;

•Location on roads which also affect road classification;

•Protection provided around the play areas;

- Extent of on-street parking;
- Vehicle speed;
- Shared driveways;
- Types of road;
- Time of day;
- Weather; and
- Lighting.

The road environmental factors are discussed in more detail in the following sections.

2.4.1 Geometric Design

The road alignment plays a task within the number and severity of road traffic crashes. Most crashes happen on roads with a straight alignment compared to curved roads, because straight roads provide good sight distances for drivers and thus encourage speeding. Roads on steep gradients are found to possess higher frequency and severity of road traffic injuries, compared to flat roads because there's a bent for speeding when a motor-vehicle driver travel downhill (Kim, Ulfarsson et al. 2008). Furthermore, the frequency of crashes involving child pedestrians is high on through roads with high traffic volumes, and on children’s trip attractors and generators, like schools, recreational areas, libraries (Elvik and Prevention 2008).

2.4.2 Pedestrian Facilities

The increase in road traffic crashes has demanded a review of the provision of infrastructure for non-motorized modes of transport in 2003, therefore the country issued a first guideline to the design of non-motorized infrastructure. Dedicated infrastructure for non-motorized transport, such as walking and cycling includes sidewalks, dedicated road crossing facilities, footways and cycling paths. Sidewalks and cycle lanes are useful in separating pedestrians and cyclists from motor vehicles, their provision reduces the exposure of pedestrians and cyclists to motor vehicles and thus reduces the rate of road traffic crashes Retting (2011) found that residential roads without sidewalks have twice as many road crashes involving pedestrians compared to those with sidewalks. A pedestrian crossing demarcates the area at which pedestrians and cyclists are allowed to cross the road. Pedestrian crossings are meant to increase the driver’s expectation of pedestrians and cyclists and ensure that drivers are not taken by surprise by the sudden appearance of a pedestrian or cyclist on the road. A pedestrian crossing can either be located at the intersection or away from the intersection. These crossings can be in the form of painted lines, textured paving or raised crossings. Raised crossings have a dual purpose of acting as traffic calming measures. Unfortunately, studies reveal that pedestrian crossings are not effective in reducing road traffic crashes involving pedestrians especially on roads with high traffic volumes. (Zegeer, Richard Stewart et al. 2001).

2.4.3 On street Parking

The presence of on-street parking is particularly problematic to child pedestrians and increases the risk of crashes involving child pedestrians. Older children are less likely to be involved in crashes where there is on street parking compared to younger children, this is because older children are taller, and therefore, have a better view of the road over the parked vehicles compared to younger shorter children. Petch and Henson (2000) Elvik and Prevention (2008) and Kim, Ulfarsson et al. (2008) found that roads with public transport stops have higher crashes compared to routes without public transport. The reasons are the following:

- Temporarily a high volume of pedestrians on the side of the road after disembarkation;
- Children's view of the road is obstructed by taller children; and
- Adults and the public transport vehicle itself that might not have left the bus stop. Furthermore, children lack the training and skills of waiting for the right time to cross the road and choosing the correct location to cross the road.

2.4.4 Road Alignment

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

i. Horizontal Alignments

A different study shows that road accidents on horizontal curves are causes for concern all countries. In France, over 20 percent of fatal crashes occur as a result of dangerous curves in rural areas. Crashes on bends are major problems in many developing countries, although the proportion of such crashes depends on both the topography and demography of every country. A study in Denmark shows that about 20 percent of all personal injuries and 13 percent of all fatalities occur on curves in rural areas (Sweedler and Stewart 2009).

ii. Vertical Alignments

There are three main effects of vertical road alignments. These effects are closely related to the occurrence of traffic accidents. These are excessive speeds and out-of-control vehicles on downgrades, differential speed between vehicles created on both down and upgrades, and low range of visibility that always occurs within the immediate vicinity of steep grades at the crest of vertical curves. Researchers indicated that it's going to be difficult for the driving force to understand the sight distance available on the crust curve and he may overtake when it's insufficient for him to try so safely. this will be extremely expensive to supply safe overtaking sight distances on crust curves. However, an entire ban on overtaking would be difficult to enforce due to the presence of very slow-moving vehicles, the shortage of driver discipline in selecting places, poor maintenance of road markings and signs. Successive short vertical curves on a straight section of the road may produce misleading forward visibility (Fouracre, Kwakye et al. 1994). The effects of the vertical curve in steep grades have higher accident rates than mild ones (Berhanu 2000). Grades of less than 6 percent have little effect, but grades steeper than this are associated with higher accident rates. Downgrades are greater problems, particularly for truck safety than upgrades. A combination of horizontal curves under 450m and grades over 4 percent are not recommended. Poor condition of the horizontal and vertical alignments of a road can result in visual effects, which contribute to accidents and are detrimental to the appearance of the road.

2.4.5. Sight Distance

This is the ability to see ahead in order to stop safely or overtake vehicle or view approach intersection. Sight obstructions on the road, generally occur due to the presence of deep cuts, embankments, vegetation, walls and the like on the inside of the horizontal curves and intersection quadrants, and sharp crest vertical curves. Types of sight distances are: stopping, passing, intersection, and decision sight distance. These sight distances vary with design or operational speeds of road section, perception/reaction time, eye, height, object height and pavement friction. Study made in Sweden indicated that there is a decrease of accident rates with increasing sight distance; especially for single-vehicle accidents at night Study made in British reported that on rural roads sight distances shorter that 200m were relatively more likely to be found at accidents sites through their association with horizontal curves (Berhanu 2000).

2.4.6. Road Cross-Sectional Elements

Various studies revealed that road cross sectional elements are the most important road related features which affect road safety. Road cross-sectional elements comprise lanes, shoulder, side slope, back slope, and clear zone

i. Lane and Shoulder Width

Numerous studies revealed that lane and shoulder width affect run off the road and opposite direction accidents. The rates of these accidents decrease with both increasing lane and shoulder width, but the marginal effect of increasing width on accident rates decrease as either the base lane width or the base shoulder width increases. Lane width of 3.4 to 3.7 meters has the lowest accident rate and represents the balance between safety and traffic flow. The research revealed that for 3.0 meters lane it is recommendable a shoulder of 1.5 meters or greater, and for 3.3 to 3.6 meters lanes shoulders of 0.9 or greater reduces the accident rate significantly. Generally, lane width has greater effect on accident rates than shoulder width (Berhanu 2000).

ii. Road Side Features and Side Slopes

Roadside encroachments begin when the vehicle inadvertently leaves the travel lanes, veering toward the roadside. Most encroachments are quite harmless: the driver is able to regain control of the vehicle on the shoulder and safely return to the travel lanes. When coupled with nearby roadside hazards, however, encroachments can result in roadside accidents (Berhanu 2000).

2.4.7 Traffic speed and Volume

High traffic speed and volume are one of the main contributors to frequency and severity of road traffic crashes. (Petch and Henson 2000). A slight change in speed results in a huge change in the severity of road traffic crashes. A 10% decrease in speed and traffic volume, for example, results in a 37.8% speed and 6.5% volume decrease in fatalities. The fatality risk curves indicate that the risk of death after a crash increase with vehicle speed. The fatality risk increases sharply after vehicle speeds of 40km/h are reached.

The contribution of speed to fatalities, due to crash injury cannot be over emphasized. Unfortunately, only eleven countries in Africa have set a speed limit to less than 50km/h in urban areas. (Peden and promotion 2009). It is, therefore, not surprising that the fatalities linked to road crashes are very high in Africa. Traffic volume is also found to be a significant contributor to road traffic crashes and this poses a risk to child pedestrians. Studies by Petch and Henson (2000) show that doubling the traffic volume results in double the rate of road traffic crashes. The reason for the high road traffic crashes involving child pedestrians is that, on high volume roads, there is a high frequency of vehicles, this poses a risk to child pedestrians since they lack the skill to assess the gap between traffic in order to cross the road safely. Traffic volumes are particularly problematic in and around the school zones. The number of scholars being picked-up and dropped-off at school by private vehicles has increased in recent years. The increase in the number of vehicles during school pick-up and drop-off times has introduced a further risk for child pedestrians (Isebrands 2009). The road infrastructure along schools has not kept up with this change. Facilities, such as off-street parking and vehicle turning facilities are often not provided at schools. Attempts to solve the problem have been made by some schools where safety officers or scholar patrollers have been introduced to guide scholars while crossing the road during the morning and afternoon pick-up- and drop-off times.

2.4.8 Weather and Lighting

Studies indicate that inclement weather, in general, reduces the rate of road traffic crashes. The reason for the decrease in crashes is that drivers and pedestrians are likely to be more cautious in bad weather. Drivers are likely to slow down, due to poor visibility and reduced skid resistance of the road surface. Studies in New York City revealed that most of the road traffic crashes involving children took place in dry, clear weather conditions. **(**DiMaggio and Durkin 2002**)**.

2.5. Road User Information and Traffic Accident

Road users ought to acquire the knowledge needed to travel safely by means of formal training and their own experiences. Nonetheless, insufficient knowledge of traffic regulations, traffic signs, vehicles and other elements may be some of the factors contributing to unsafe behavior and road accidents. Road user information and campaigns are intended to reduce accidents by promoting safer behavior in traffic, by giving road users improved knowledge and more favorable attitudes towards such behavior. Also, most campaigns targeted at road accidents in general have not led to statistically significant changes in the number of accidents (Elvik and Prevention 2008).

2.6. Current Accident Severity Definition in Ethiopia

In Ethiopia, even though a documented definition of different accident severity levels was not obtained for this study, the information obtained from the interview of some patrol and police officers show that:

- A **fatal accident** is the one in which one or more individuals die as a result of traffic accident within the same reporting 30 days of the occurrence of the accident.
- A **serious injury** is one in which a victim sustains severe cuts, bleeding, breaks, and other damages which requires a medical treatment as "in-patient" in hospital.
- A **slight injury** is the one as a result of which the victim sustains only small cuts, scratches, and other small damages which may be treated as an out-patient without requiring admission to a hospital.
- **Property damage only** accident is the one as a result of which no person is injured only one or more vehicles involved in the accident are damaged.

2.6.1. Present Accident Situation

I) Motor vehicle involvement

Vehicles which were responsible for road accidents have been collected. Table 2.3 shows that fatal accidents are concentrated on trucks with capacity of 11-40 quintals, and on trucks capacity of 41-100 quintals. Similarly, Station wagons and taxi had major shares in traffic accidents during those years.

Table 0.1 Motor Vehicle Involvement in Road Traffic Accidents in Addis Ababa from 2015/16-2019/20

Description	Automobile	Station wagon	Pick up	Truck 11-40qt	Truck 41-100 qt	Truck with trailer	Taxi	bus
Fatal	365	62	217	164	212	58	276	136
Serious injury	2064	730	1317	427	208	28	1578	432
Slight Injury	1254	483	565	251	139	23	915	157
Property damage	27518	9253	16903	7805	5236	1308	24007	8448
Total	**31201**	**10528**	**19002**	**8647**	**5795**	**1417**	**26776**	**9173**

Source: -AAPCCID, Dec, 2020

2.6.3. Possible Reasons for High Number of Road Traffic Accidents

According to the report provided by the Interim National Road Safety Coordination Office, the reasons for the relatively high number of road traffic accident include

(I) Lack of driving skills;

(ii) Poor knowledge of traffic rules and regulations;

(iii) Violation of speed Limit;

(iv) Insufficient enforcement;

(v) Lack of vehicle maintenance;

(vi) Animal drawn carts and animals frequently using in main highways;

(vii) Lack of safety conscious design and planning of road network;

(viii) Disrespect of traffic rules and regulations;

(ix) Lack of general safety awareness by pedestrians; and

(x) Lack of medical facility in general, which increase the severity of accidents (National Roads Safety Coordinating Office 1997)

However, in case of Addis Ababa police commission crime investigation report the cause for those accident was driver's failure to give way for the pedestrian and to respect traffic rules and regulations, in reality this cannot be the only case since an accident is a combination of several factors in addition to human factors.

2.7 Road Safety Interventions

The interventions required to address road safety and to reduce road traffic crashes involving children, can be divided into four categories, these are;

- Education;
- Engineering measures; and
- Enforcement of traffic rules.
- Modification of vehicle design

Other campaigns include encouragement and evaluation as additional measures to increase road safety for child pedestrians. Education measures could be a variety of teaching methods to increase awareness about road safety as well as attempts to reinforce good behavior of children on the road. Engineering measures involve the proactive or reactive design and manipulation of the built environment to make it safe for children. Enforcement measures are applied to ensure compliance with the road traffic rules; particularly those traffic measures that are applied to reduce the risk of road traffic crashes. Motor vehicle modification measures are those aimed at the modification of motor vehicle design, in particular, the use of softer material on the vehicle bonnet as studies indicate that this measure reduces the severity of lower body injuries and head injuries if a victim's head hits the front bonnet during the collision.(Towner, Dowswell et al. 2001).

Encouragement is a measure applied to encourage school children to use more sustainable modes of transport, such as walking and cycling to school. This type of measure reduces traffic congestion in the school zone caused by motor vehicles dropping off and picking up scholars in the morning and afternoon. Evaluation is the process applied to check the effectiveness of the strategies applied to increase road safety at particular schools. The evaluation allows for continuous improvement of the road safety interventions. This research will use schools with high traffic accident data in Addis Ababa city as a case studies for investigating road traffic injuries involving child pedestrians. The interventions that are going to be investigated in this research are road safety education and engineering measures that have been cited in literature as being successful in reducing road traffic injuries in the school zone.

Engineering measures

Road crashes tend not to be evenly distributed throughout the network. They occur in clusters at single sites, along particular sections of road, or scattered across whole residential neighbour-hoods, especially in areas of social deprivation. While road engineering can greatly help in reducing the frequency and severity of road traffic crashes, poor engineering can contribute to crashes. The road network has an effect on crash risk because it determines how road users perceive their environment and provides instructions for road users, through signs and traffic controls, on what they should be doing. Many traffic management and road safety engineering measures work through their influence on human behavior (WHO 2002).

Negative road engineering factors include those where a road defect directly triggers a crash, where some element of the road environment misleads a road user and thereby creates error, or where some feasible physical alteration to the road that would have made the crash less likely has not been made.

In the planning, design and maintenance of the road network, four particular elements affecting road safety have been identified. These elements are:

- Safety-awareness in the planning of new road networks;
- The incorporation of safety features in the design of new roads;
- Safety improvements to existing roads
- Remedial action at high-risk crash sites.

2.8. Road Safety Management Approaches

There are two main engineering approaches for dealing with traffic safety problems: the proactive a reactive approach. The proactive approach is an accident prevention approach that tries to prevent unsafe road conditions from occurring in the first place. The reactive approach, or retrofit approach, on the other hand, consists of making the necessary improvements to existing hazardous sites in order to reduce accident frequency and severity at these sites. (El-Basyouny and Sayed 2010).

2.8.1. Proactive Approach

The primary objective of the proactive approach is to ensure that road safety aspect is an explicit priority in transportation planning and design. And the stated objective of the approach might seem redundant at first. After all, the most common definition of transportation engineering is that it is the application of science and technology in order to provide for the safe and efficient movement of people and goods. This definition gives the impression that existing transportation planning and design policies and standards lead to the construction of safe roads. (El-Basyouny and Sayed 2010). In addition, the proactive approach is to design roads in such a way that a minimum number of crashes takes place. However, the level of safety that is built into the road system by following these policies and standards is largely unknown. At the planning stage, existing transportation policies call for the preparation of statements assessing the impact of different transportation plans on traffic mobility, air pollution, and noise pollution among other issues However, the impact of these plans on safety is usually neither called for nor addressed. At the design stage, highway and traffic engineers produce designs whose safety consequences are not known. By law, they are required to produce designs that do not violate existing standards and codes. There is no doubt that these standards and codes were written with safety in mind, but the level of safety that they introduce into the road system is largely unknown (Sawalha 2002).

2.8.2 Reactive Approach

The reactive approach to safety management focuses on identifying and remedying safety problems in the existing road networks. Most road authorities have established road safety improvement programs, otherwise known as black spot programs, whose main goal is to identify hazardous locations in road networks and to establish countermeasures for correcting the problems at these locations. In broad terms, road safety improvement involves the following three stages:

- Detection of black spots, otherwise known as hazardous or accident-prone locations.
- Diagnosis of the problems that cause the detected locations to be hazardous.
- Remedy of the diagnosed problems by establishing and implementing countermeasures that are effective in alleviating them. (El-Basyouny and Sayed 2010).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

The study area for this specific research was Addis Ababa, the capital and largest city in Ethiopia. Addis Ababa has the status of both a city and a state. It is where the African Union and their predecessors the AU are based. It also hosts the headquarters of the United Nations Economic Commission for Africa (UNECA) and numerous other continental and international organizations. Addis Ababa is therefore often referred to as "The political capital of Africa" for its historical, diplomatic and political significance for the continent also a home of African Union having important United Nations branches and with nearly every foreign embassy from around the world represented. According to Chart and table of population level and growth rate for the Addis Ababa, Ethiopia metro area, the current metro area population of Addis Ababa in 2020 is 4,794,000, a 4.4% increase from 2019.

Based on Madruga (2012) UNECA report, the city is a cultural mosaic of all Ethiopian ethnic groups due to its position as capital of the country. Addis Ababa contributes a lot to the economic development of the country and it is where most significant changes in the socio-political sphere of the land originate from. Addis Ababa has been manifesting to be the fastest growing city in recent decades and contributes about 40% to the national GDP. Addis Ababa lies at an elevation of 2,300 meters (7,500 ft) and is a grassland biome, located at 9°1′48″N and 38°44′24″E coordinates. This study has conducted on the school located in Addis Ababa by selecting schools with highest traffic accident.

Figure3.1 Study area map

Source: https://www.google.com/maps/place/Addis+Ababa

3.2 Study Design

Although there are endless ways of classifying research design, they usually fall into one of the three general categories: Experimental, Quasi- Experimental, and Non-Experimental. This classification system is based primarily on the strength of designs experimental control. (Madruga 2012). Therefore, in this particular thesis, since there are no extraneous variables as the cause of what is being observed, or no control over the variables and the environments that the study looking for, Non-Experimental designs (i.e., descriptive) is used as a scientific study design. This study design will provide a brief overview of road safety measure around schools which are highly exposed to traffic accident, through the most widely used approaches: Case study.

Case Study: involve in providing an accurate and complete description of the road traffic accident in the city of Addis Ababa, using in depth review of traffic records in the specified period of time.

The study design that will be incorporated in this research has presented on the in the following figure.

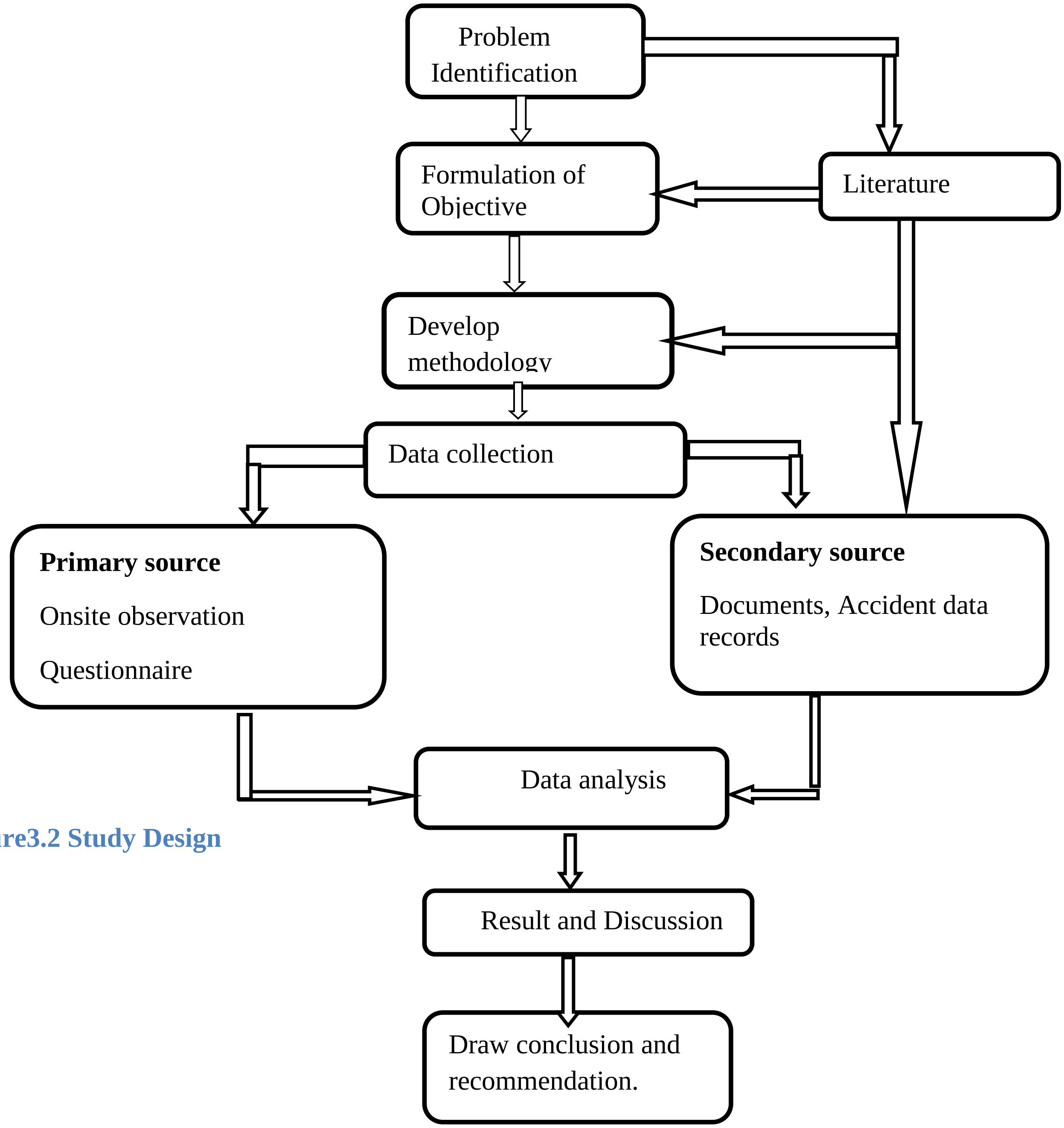


Figure3.2 Study Design

3.3 Study population

Schools in Addis Ababa that has recorded history of traffic accident involves fatal, injury or property damage occurred within the school zone will be considered as population of the study.

3.4 Sample size and Sampling procedure

There are different ways of choosing sample, and the method will depend on the area of research, research methodology and preference of the researcher. Basically, there are two main type of sampling: probability and purposive sampling. The sampling method used for this study is purposive sampling.

Purposive sampling is regarded as a non-probability sampling method where a sample is purposefully handpicked rather than randomly selected. (Sandelowski and health 2000). Criterion sampling is choosing a sample according to their scores according to the predefined criteria. (Sandelowski and health 2000). The criteria going to be used in this research is the number of road traffic crashes. The top ten schools that have the highest road traffic crashes will be chosen as the sample.

3.5 Study variables

The study variables, which consist of the research, contained both independent and dependent variables.

3.5.1 Dependent Variable

- The dependent variable is Road safety in school zone

3.5.2 Independent Variables

Independent variables are:

- Road factors and Environmental factors
- Human factors
- Vehicle factors
- Pedestrian facilities
- Road safety measures

3.6 Data collection Process

There are many different approaches to data collection: desk review, interviewing, global rating, observation, biological measures. Among these approaches, desk review techniques will be used in this thesis, which it provides an accurate and complete description of the traffic accident report; type of injury, place, behavior of drivers, road environment of the selected schools. The second approach of this thesis is observational method of data collection, which it relies on the direct observation, which is also often used in the assessment of highly risky black spot section of the roads. Structured checklist and questionnaire will be used as a data collection tools.

1.6.1 Primary data collection

Structured checklist was prepared for the rod safety measures is given in **Appendix A**

1.6.2 Secondary Data Collection

Road traffic crash data

Crashes are recorded by the traffic police on yearly basis. Secondary data obtained from Addis Ababa police commission crime investigation division was categorized based on the variables considered in the study.

Driver Demographic Factors: The demographic variables related to driver involved in the crash are:

Age: it is categorized as:

- below 18
- 18-30
- 31-50 and
- 51 and above

Educational Background: The maximum education level attained by the driver is recorded under one of the following categories

- primary School
- Junior high School
- Secondary School
- Above Secondary School

Driving Experience: This is the number of years since the driver received a driving license. This information is sometimes recorded by asking the driver since the year the driver received the first license could not be found on the current license if the driver is having higher level driving license. The information obtained from the driver is recorded under one of the following six categories:

- Less than or equal to 1 year
- Greater than 1 year and less than or equal to 5 years
- Greater than 5 years and less than or equal to 10 years
- More than 10 years

Vehicle factors:

Vehicle Type:

- Bus
- Minibus/taxi
- Automobile
- Truck

Vehicle service year:

- Less than or equal to 5 years
- Greater than 5 and less than or equal to10 years
- Greater than 10 years

Other factors

- Time of the day
- Day of week

3.7 Data Processing and Analysis

In this study both qualitative and quantitative methods of research were used for data analysis because combination of both methods is found to be the best way of providing answers to the research question. The purpose of the quantitative component of this study was to identify primary schools with the highest road traffic crashes using road traffic crash data, to analyze the data and identify the common risk factors for road traffic accident.

The purpose of the qualitative component of the research was to complement the quantitative study by collecting data on the observations, opinions and factual information about the common causes of road traffic crashes, and the effectiveness of the applied measures. The onsite observations were also conducted to supplement information on the road environment factors that contribute to road traffic crashes within the school zone. Those onsite observations has been accessed based on MUTCD and ERA geometric design manual standards.

The data obtained has checked and edited manually, then coded and entered into the computer using the Statistical Package for the Social Sciences (SPSS) version 26.00. Frequencies generated and presented by graphs, pie charts and tables.

CHAPTER FOUR

RESULT AND DISCUSSIONS

There are 2100 schools in Addis Ababa starting from kindergarten to secondary and preparatory school. The road traffic crash statistics indicate that over a period of five years, commencing in 2015/16 to 2019/20, The total recorded road traffic crashes around schools in the city is 9844. The severity of the injuries resulting from the recorded crashes ranged from property damage 8606, slight injury 412, serious injury 674 and fatal injury 152. The five years detail accident record occurred around school were given in the following table 4.1.

Table4.1 Five years Accident data at Addis Ababa schools

	Fatal	Serious injury	Slight injury	Property Damage	Total
2015/16	40	134	100	2093	2367
2016/17	29	94	66	1254	1443
2017/18	37	172	91	1731	2031
2018/19	22	118	81	1805	2026
2019/20	24	156	74	1723	1977

Source: AAPCCID

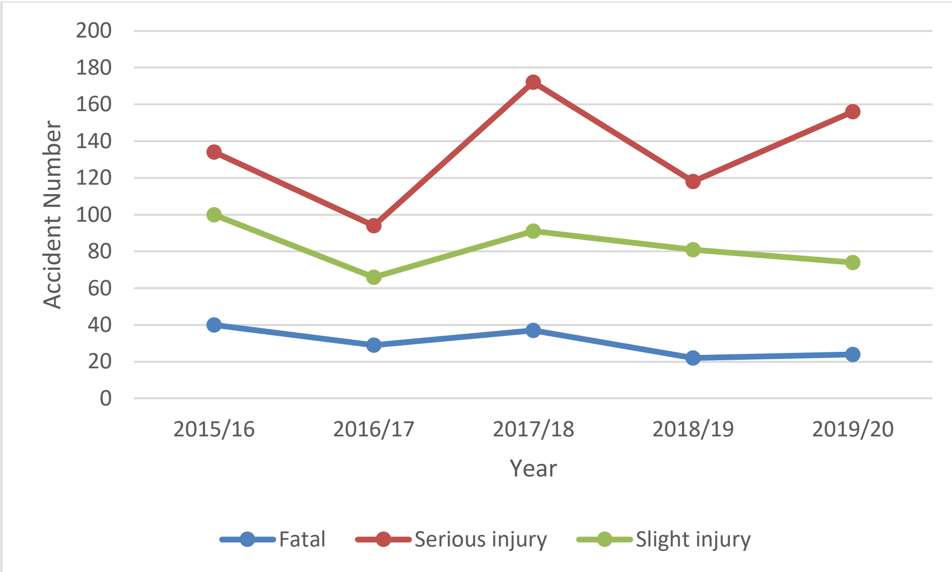


Figure 4.1 Five years Accident data at school

Source: AAPCCID

4.1 Schools with highest Fatal accident

The schools with highest crash data were identified based on number of fatal injuries recorded by Addis Ababa police crime investigation division. 30 schools were identified based on the frequency of accident occurred there, from the recorded 152 fatal crash 74 were occurred at those schools. From the identified schools Felegeyordanos primary school (Kirkos sub-city) and school of tomorrow (Yeka sub-city) takes the leading having 4 fatal injuries with the specified five years period. From the recorded fatal accident data 152 accidents were occurred in school zone and 30 schools with high number of fatal were identified and given in the **Appendix B**.

From the above finding it is summarized that the accident was distributed in all sub-cities, thus the location of the school doesn't have any significant relation ship with the sub-city rather it may depend on specific location of the school. Those schools' characteristics that may associated with the occurrence of accident has studied.

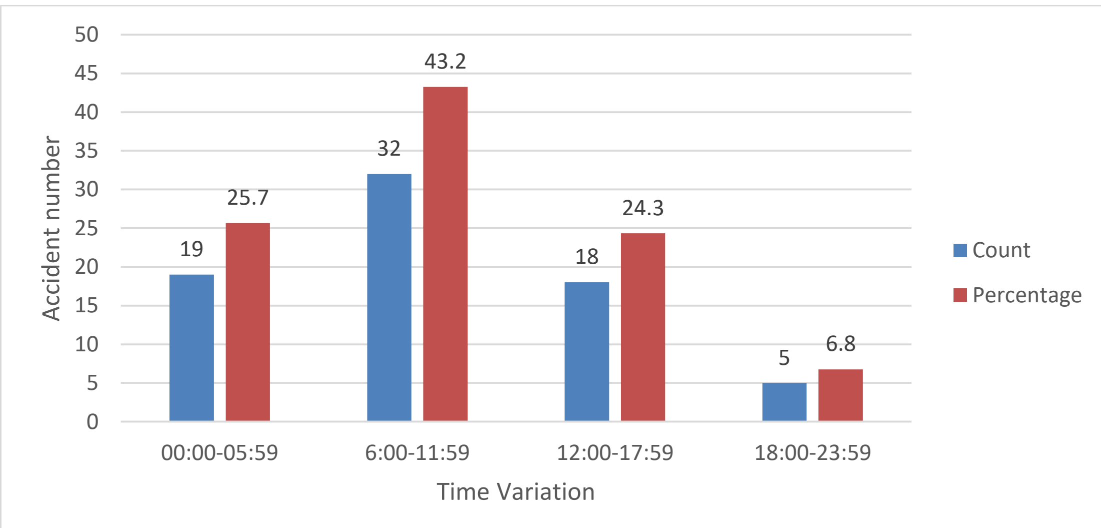
4.2 Accident contributing factors

To have better understanding, it is important to see the accident distribution in relation to road sections. Accordingly, accident frequency analysis is made to identify the characteristics of the accidents and identify which variable is more responsible for the occurrence of crash relative to total accident frequency.

Accident frequency provides rough estimation for exhibiting crash promoting factor. However, it cannot provide which parameter is severely contributing for road crash relative to the rest variables, so the chi-square test is used to determine if there is statistically significant relationship between the environmental and road condition and the accident occurrence around those school and the result was presented.

4.2.1 Variation Time of Accident

When addressing traffic safety severity of traffic accident, number of fatalities time also important measures. The time of the day that the accident occurred at schools were also addressed in the study. The recorded accident data were distributed over throughout 24 hours. The difference in the distribution of the road traffic accidents recorded for the 24 hours of the day that is 12 hours day time and 12 hours night time. The following table shows the distribution of accident over the time of the day.



Source: AAPCCID

Figure 4.2 Time variation of the Accident by Time

Generally, the analysis confirm that the road traffic accident occurs. and during day time (00:00-11:59) were higher (68.94%) than the night time with 31.06% of the total accident. It seems during the night time the visualization is less and low illumination, which may affect the driver perception of the appropriate speed choice and drivers give attention while they driving. But in day time there is no visibility problem and also, there is high traffic flow around schools through the day than night time. Due to those factors the traffic accidents were high during day time than night time.

There is a clear trend of an increased number of crashes in the afternoon and morning peak periods for all schools, 43.24 %, and 25.2% respectively. The afternoon peak has most crashes this is due to the fact that school children are released at the same time after schools whereas, in the morning, children's arrival is distributed.

On the other hand, Figure 4.3 shows accident variation occurred around the schools on days of the week, it depicts that the week days has the highest value than weekend. This is due to the school areas are more congested during the weekdays because the traffic flow increases on those days, which necessarily leads to accident occurrence.

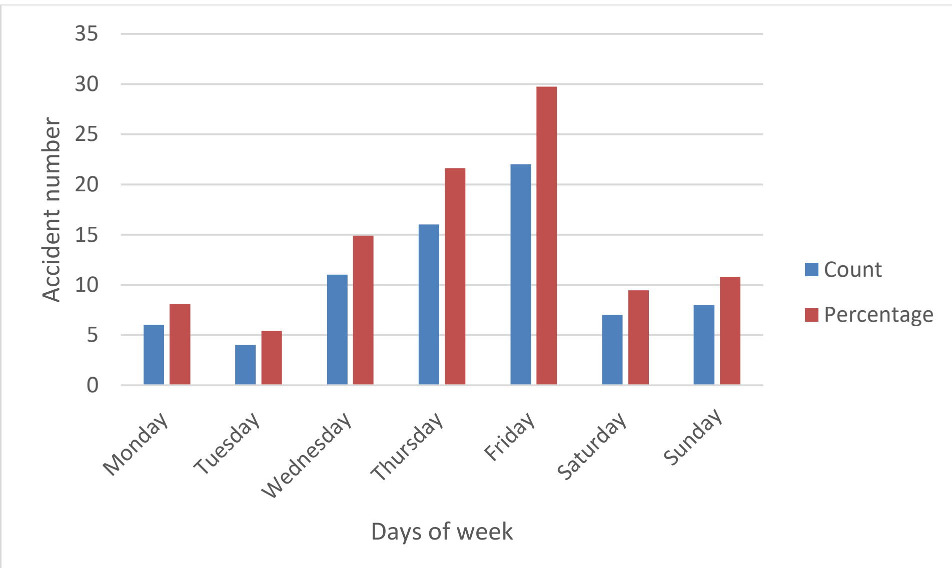


Figure 4.3 Accident variation by days of week

Source: AAPCCID

ii. Drivers' Age

A study on drivers killed in road crashes estimated that teenage drivers had more than five times the risk of a crash compared with drivers aged 30 and above, at all levels of BAC. Drivers in the 20–29 years age group were estimated to have a three times higher risk than drivers aged 30 years and above, at all BAC levels (WHO 2002). The finding of this study regarding the age range of drivers involved in fatal crash is shown Table 4.2. also support this fact. Among these categories, drivers with in the age group 18-50 are responsible for the larger number of fatal injuries (45.9%) followed by those which are between 31-50 which took 33.7% of the injuries. However, drivers with age 18 and below has less involvement with regards to the total percent of crash.

Table 4.2 Drivers' Age

Driver's Age	**Frequency**	**Percentage**
Less than 18	2	2.7%
18-30	34	45.9%
31-50	25	33.7%
Above 51	9	12.1%
Undefined	4	5.6%
Total	74	100

Source: AAPCCID

Among age groups, driver's aged fewer than 18 accounts for only 2.7% of total crash although they make up more than half the population, such that the 18-30 and 31-50 age groups account for more than three-fourth of total crashes. This age group is most active in the economy and most of them are hired drivers. In this regard, about 70 per cent of the drivers are hired or employed as professional drivers. This is consistent with WHO reports that indicate that Road traffic injuries are now the leading killer of people aged 5-29 years.

On the other hand, only 12.1% of the fatal injury caused by the drivers aged above 51 which shows there was strong and direct relationship between increasing driver age and decreasing risk of moderate to fatal injury. It shows as the driver age increases the experiences of the driver also increase as a result the road traffic accident decrease. Drivers older than 50 years had more than 50% lower risk than those aged from 18-30. This is due to the age group of 18-30 are more aggressive and less experienced than the other age group.

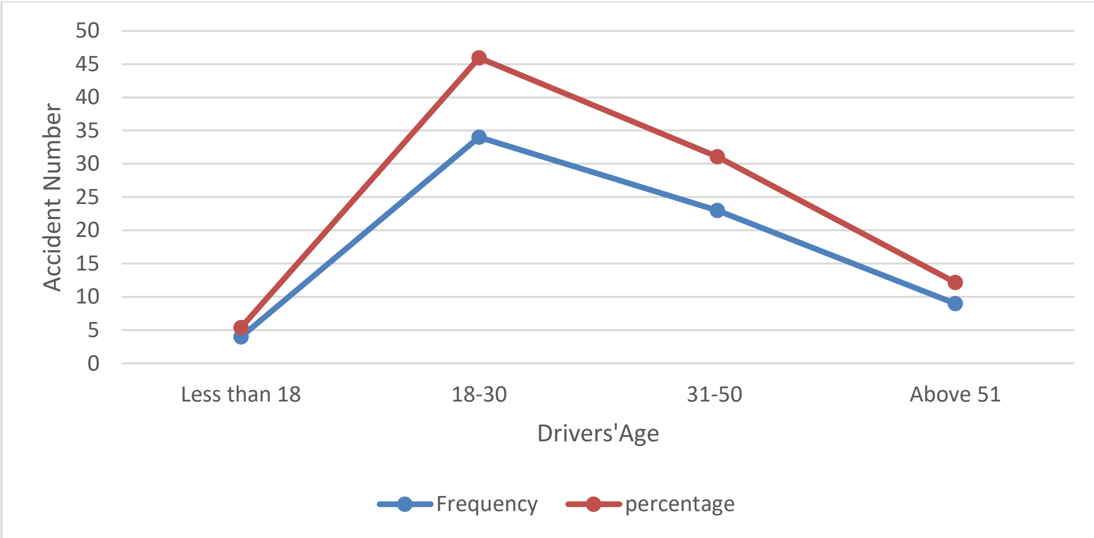


Figure 4.4 Drivers' Age

Source: AAPCCID

iii. Driving Experience

Table depicts that drivers whose experiences were more than 10 years represented only 17.56% of fatally injury crashes while those who has the experience less than five years accounts the highest percentage (56.75%) of accidents. Similarly, finding indicated that drivers whose experiences were greater than 5 year or less than or equal to 10 years indicated 14.86% of total crash. Crashes were analyzed in terms of driver experience, and findings indicated that no driving licenses were involved in 6.75% of fatalities.

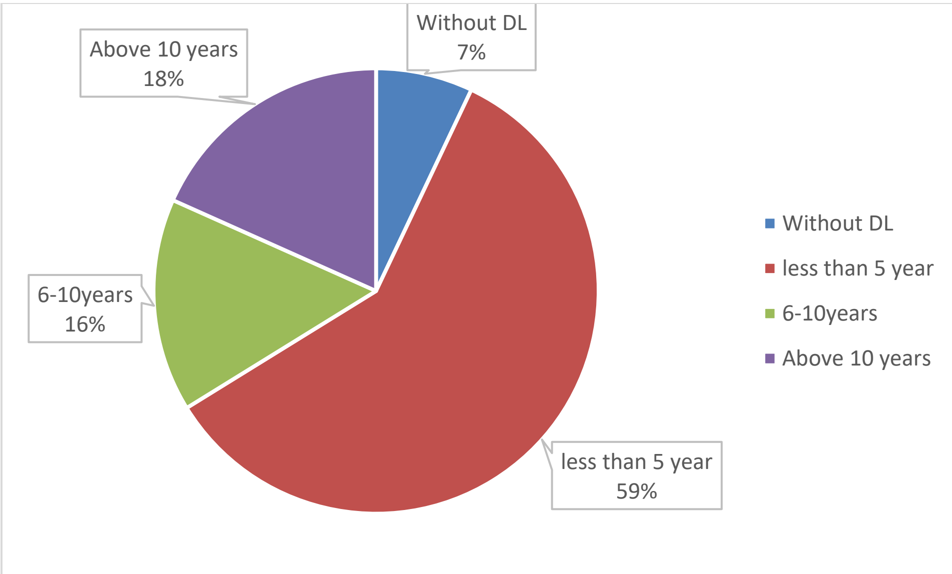


Figure 4.5 Drivers’ experience

Source: AAPCCID

iv. Educational Background

Among the four categories of educational background shows, those drivers with Junior High-School level of education are responsible for the largest share of injuries (32.43%) followed by those with primary school (29.73%). However, drivers with secondary and higher education level accounts 20.27% and 13.5% respectively. The finding shows that number of fatal crash decreases as the educational level of driver’s increase, so it can be said that crashes are necessarily occurred from lack of good educational background.

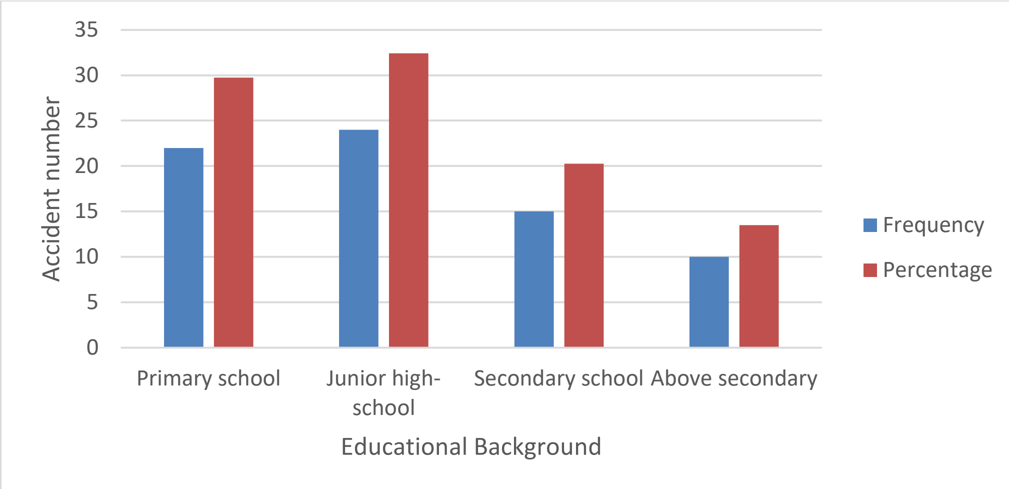


Figure 4.6 Drivers' Educational background

Source: AAPCCID

v. Accident distribution by type of Vehicle

This variable has four categories. Among the four categories, Minibus/taxis and Automobiles are responsible for the largest number of crashes with values 39.2% and 37.8 % respectively. In Addis Ababa it is visible that there is higher traffic congestion because of higher mobility of, commercial vehicles, minibus taxis, automobiles and buses with in the city which become more considerable at school leaving time that might be the reason for their involvement in the crashes occurred within the school's zone.

In terms of collision types, the majority of accident severity resulted in pedestrian hit accidents , other collision types like head on, nose-tail, side, side with angle collision, roll over, fall from vehicle, collision with animals, collision with static objects and collision with parked vehicles had minor contributions to these accidents.

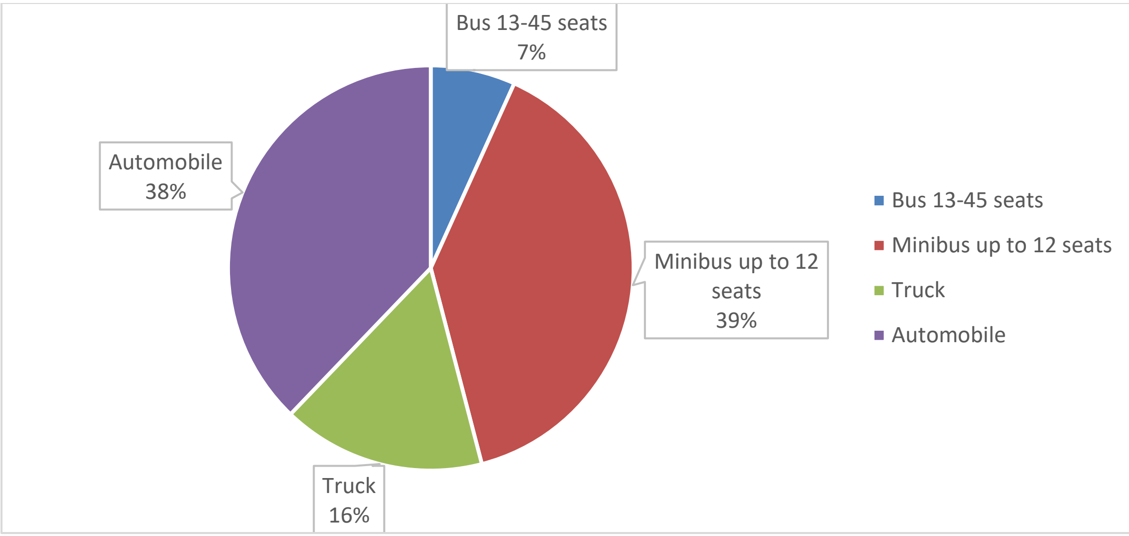


Figure 4.7 Types of vehicle involved in an Accident

Source: AAPCCID

vi. Service year

Given these figures, vehicles aged over 10 years were involved in the majority of crashes, 45.94%, followed by who has service year of 6-10 years in Addis Ababa. This is highly likely that these vehicles travel more kilometers per annum contributes to a high number of crashes.

Table 4.3 Service year of Vehicles involved in Accident

Service year	**Count**	**Percentage**
Less than 5	17	23%
6-10 years	21	28.4%
Above 10 years	34	45.94%
Undefined	2	2.7%
Total	74	100

Source: AAPCCID

vii. Roadway alignment

Road characters affects the occurrence of road traffic accidents in terms of frequency and severity. Road character had psychological effect on drivers and influence on the choice of speed. Horizontal curves, steep grades, and vertical curves bring additional challenges to drivers, resulting in increased risk of collisions.

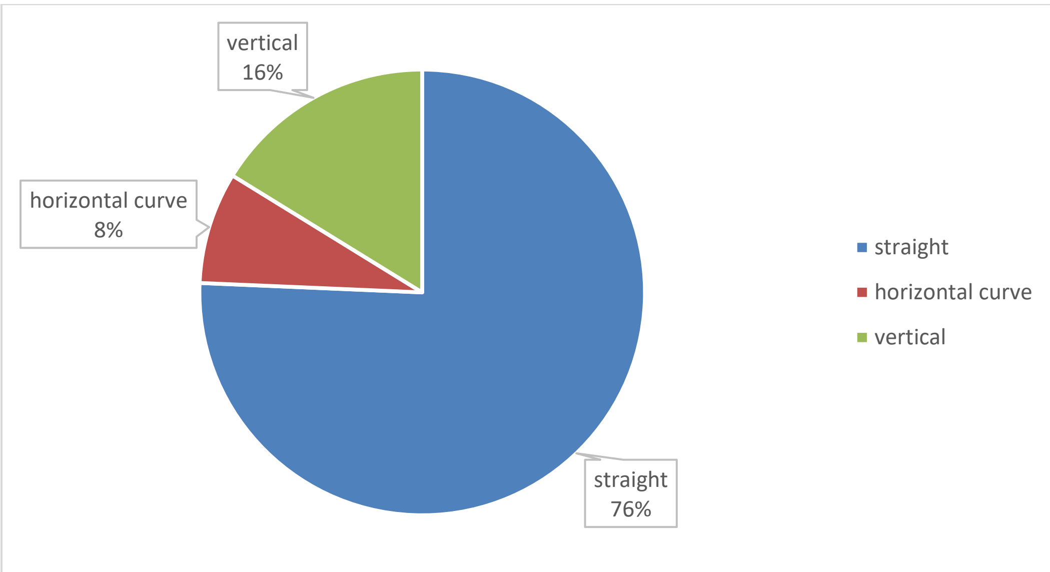


Figure 4.8 Road layout at which accident occurred

Source: AAPCCID

The result shows that During the five years period, from the number of accidents occurred on school the highest percentage of the accident occurred on straight section while only horizontal curves and vertical was less than that of tangent sections. This study also revealed that from the accident occurred more than 80% occurred vehicle pedestrian hit and from the percentage 66.2% of the fatal crush was occurred while pedestrian crossing the street,16.4% was occurred on the side of the road.

viii. Surface condition

The road pavement surface condition influences the occurrence of traffic accidents. Subsequently, different pavement surface conditions were considered in the study to investigate the effect of surface condition on traffic accidents they included dry and wet surface, 88% of the accidents occurred on dry surface, while only 12% occurred on wet surface of the pavement.

Hence, the analysis confirms that the higher road accident occurred during dry surface than wet surface. This is due to during wet pavement surface condition the friction between the road and the vehicle decrease and it’s affected the speed choice of the drivers. So, the drivers give more attention while driving, But, in dry surface condition the friction is normal, the drivers drive without paying attention.

In addition to the data obtained from Addis Ababa police commission crime investigation division, to identify the road and environmental factor of the accident the road and environmental condition of the school were assessed based on the given manuals and engineering judgement of the researcher. In order to identify the statistical significance of the environment and road traffic accident occurrence, the chi square test was done and variable which has strong relationship with accident occurrence were identified (those with p value less than 0.05).

Engineering Road safety measures and Accident occurrence

There are many causes and contributing factors reported by traffic police and extracted from environmental and road condition at which accident has occurred. With regard to road safety measure, in addition to those schools which has highest road traffic accident, other 30 schools with no accident have randomly chosen to check road safety measures implemented. chi square test has done to show the statistical association of the selected road factors with accident occurrence. Among those variables presence of pedestrian facilities such as footpath, pavement marking, crossing has been statistically significant as shown on the result, as they decrease pedestrian-vehicle conflict, so that accident might not be occurred as those streets without those facilities. According to the result on this study kerb and gutter (p=0.076) has no significant relationship with occurrence of road traffic crash.

Table 4.4 statistical association of road factor and accident

Variables	Category	Accident Status		X^2	P value
		Yes	No		
Kerb and gutter	Yes	27(90%)	30(100%)	3.15	.076
	No	3(10%)	0		
Footpath	Yes	16(53.3)	30(100%)	4.286	.038
	No	14(46.7%)	0		
Pavement marking	Yes	9(30%)	19(63.3%)	6.696	.010
	No	21(70%)	11(36.7%)		
Signalized crossing	Yes	0(0%)	9(30%)	10.588	.001
	No	30(100%)	21(70%)		
Pickup/drop off	Yes	0(30%)	8(26.7%)	9.231	.002
	No	30(100%)	22(73.3%)		
On-street Parking	Yes	23(76.7%)	8(26.7%)	15.017	0.001
	No	7(23.3%)	22(73.3%)		
Streetlight	Yes	18(60%%	30(100%)	15.00	.001
	No	12(40%)	0(%)		

On the other hand, traffic calming devices such as traffic light, speed break, median also tested and the result has shown except median presence and status of those has a strong association with road traffic crash. Road layout on which the schools found has a relationship with the occurrence of accident because the curve might obstruct the visibility and leads to an accident. There might be different factors around schools that hinders the sight of drivers, this also has a noticeable association with accident (p=0.001). Another important factor was speed break/hump with p value 0.001 helps to control an erratic behavior of a driver so that so it will decrease the chance of pedestrian being hit while crossing the road.

Table 4.5 statistical Association Traffic calming and Accident

Variables	**category**	**Accident status**		X^2	**P value**
		Yes	No		
Median	Yes	24(80%)	25(83.3%)	0.111	0.739
	No	6(20%)	5(16.7%)		
Road layout	H.curve	6(20%)	6(20%)	11.077	.004
	straight	15(50%)	24(80%)		
	V.curve	9(30%)	0(0%)		
Sight obstruction	Yes	22(73.3%)	6(20%)	17.143	0.001
	No	8(26.7%)	24(80%)		
Speed break	Yes	1(3.3%)	17(56.7%)	20.317	0.001
	No	29(96.7%)	13(43.3%)		
Traffic light	Yes	4(13.3%)	12(40%)	5.455	0.020
	No	26(86.7)	18(60%)		

4.3 Engineering Road safety measures

The most appropriate solution for a particular school may involve a combination of engineering, education, enforcement and encouragement measures (the Four Es to achieve the desired result) as mentioned on different studies Road safety measures that have been implemented was accessed under those four major categories.

Regardless of the school location, the best way to achieve effective traffic control is through the uniform application of realistic policies, practices, and standards developed through engineering judgment or studies. Pedestrian safety depends upon public understanding of accepted methods for efficient traffic control. This principle is especially important in the control of pedestrians, bicycles, and other vehicles in the vicinity of schools. Neither pedestrians on their way to or from school nor other road users can be expected to move safely in school areas unless they understand both the need for traffic controls and how these controls function for their benefit. Procedures and devices that are not uniform might cause confusion among pedestrians and other road users, prompt wrong decisions, and contribute to crashes. To achieve uniformity of traffic control in school areas, comparable traffic situations need to be treated in a consistent manner (guideline).

A. Footpath

Pedestrian footpaths and pavements are used more in high-income than in low-income countries and tend to be in urban rather than rural areas. The risk of a crash on roads without pavements separating pedestrians from motorized traffic is twice that on a road with a pavement. Pavements in poor condition or obstructed by parked vehicles may force pedestrians to walk on the street, thus significantly increasing crash risk. Studies in low-income and middle-income countries have shown that even where pavements exist, they are often blocked – for instance, by street vendors' stalls (WHO 2002).

Major streets in all cities and rural centers need high-quality footpaths. Well-designed footpaths provide continuous space for walking and they also support other activities such as street trade and comfortable waiting spaces at bus stops.

However, As observed during the study time most of the area does not have proper pedestrian facilities and road users are not well aware of traffic rules and regulation in the city. In major area of the study road sections specially in school area, carriageways or the edge of carriageways are used as footways due to the absence of well-designed footpath. From the studied 30 schools only 16(53.3%) has footpath so it is common to observe pedestrian and vehicle conflicts at school peak hours around those schools this also may be a major risk factor for traffic accident.

The status of the facilities was rated based on their visibility, placement and state of use and most of the pedestrian facility were not in a good condition footpath were deteriorated and overcrowded by street market. Therefore, consideration should be given in developing safe pedestrian access in school zones.

B. Traffic Sign

The main functions of traffic signs and road markings are to provide warnings, regulations, and guidance information for road users. The report on traffic signs and road markings revealed that road signs and markings are important to regulate the use of a road, warn of dangerous situations and guide road users to their destinies in a uniform and safe way.

Traffic signs provide a safe environment to road users by guiding drivers to directions for route finding; controlling the use of road with mandatory signs; warning drivers of any substandard or unusual features with warning signs, aiding road users to identify the situation ahead and anticipate hazards; providing consistency within the road signing system, with similar situations receiving the same treatment; providing night-time and day-time visibility; informing services rendered to users and emergencies (Sandra V,2005).

However, in the result of this study illustrates that even though the traffic sign available at most of the school, its visibility was obstructed by a lot of things like street market, on-street parking and different advertisements.

Table 4.6 Road safety measures

Variable	Count	Percentage
Kerb and gutter	21	70
Street light	18	60
Footpath	16	53.3
pavement marking	9	30
Signalized crossing	0	0
Crosswalk	26	86.7
Dropoff/pickup	0	0
Speed break	1	3.3
Traffic light	4	13.3
Speed limit	23	76.7
School sign	30	100
Median	24	80

Source:AAPCCID

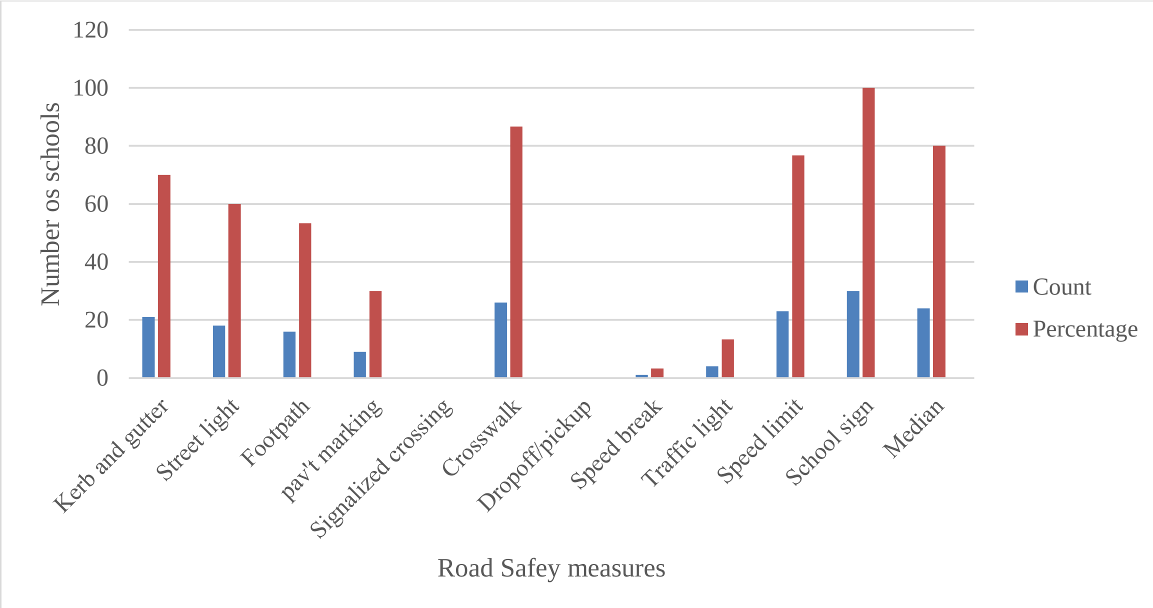


Figure 4.9 Use of road safety measure around school

Source: AAPCCID

C. **Pavement marking**

Regarding to road markings, different studies has shown the requirement of pavement marking and delineation systems installed on road pavements.

- Vehicle position and movement control through visual information that identifies the legal and, safety limits of roadway;
- Driving direction regulation, changing lane and overtaking;
- Zone or lane identification, where maneuvers are allowed, forbidden or mandatory;
- Lane discipline increment, particularly during night periods and adverse weather conditions; and

Dangerous zones identification aid, like obstacles or pedestrian crossings. By use of reflective stud on pavement road marking, average accident reductions of 10 to 40 per cent may be achieved (Sandra V,2005). This measure is particularly effective in roads without any marked limits, and is able to improve from 30 to 40 per cent in accident reductions. In case of this study only 30% of the school has the pavement marking, the left does not have pavement marking provided.

D. Street Lights

Road lights are intended to provide enough lighting for drivers to travel with comfort and safety during night periods or under low visibility conditions. This solution is commonly applied where there is the possibility of conflicts between vehicles and pedestrians or cyclists. In rural roads, the implementation of lighting on unlit roads may lead to a 64 per cent reduction in fatal accidents and 20 to 50 per cent of total accident reduction (Gomes, Geedipally et al. 2012).

Among the schools studied in this paper 60% has the street light, the rest don't have the road light in order to reduce road traffic crash expansion of street lighting into those streets with no traffic light and maintenance of defective street lights has to be done.

E. Traffic calming measure

It is a safety device that alerts and let the drivers to make a change on the driving operation. It consists of some repeated pattern on pavement surface, that creates vibration on vehicles when tires role over on it. Rumble strip is used to tip or alert drivers in changing geometric of the road or driver approaches to any unusual dangerous road sections or spots. The application of rumble strips on rural areas has been associated with 20 to 60 per cent of accident reductions (Gomez 2005). In Europe, there has been much experimentation with these measures and crash reductions of between 15% and 80% have been achieved (WHO 2002).

With regard to speed reducing facilities 76.7% has speed limit sign some of them were not visible so speed break should be available but almost all of the school does not have speed break.

F. Sight obstruction

Another problem observed during school-zone visit was sight obstruction, there were a lot of things such as advertisements on the side of the street, street market, on-street parking and curves which keeps the school vicinity out of sight. It also obstructs the school-zone and speed limit signage this make it difficult for drivers to reduce their speed and give way for pedestrian.

Street market not only provides employment for many citizens, but it is also an important function in street environments. But it should be eliminated from school areas and should have clearly marked location otherwise it will put road safety in to question.

On-street parking should be provided only after adequate provisions have been made for higher priority transport modes, including walking, cycling, and public transport.

G. Median

Centre pedestrian refuge islands that are raised and medians can be used to reduce lane width, forcing drivers to slow down and improving safety of pedestrians according to nonmotorized transport strategy. The road at which the accident occurred were divided by median most of the median (43.3%) were flat and 36.7% are raised and the rest don’t have visible road division. The reason more accidents recorded on roads flat median with less visibility could be the drivers inappropriate overtaking of the lane which leads to road traffic crash. So that it is essential to construct a new roads with appropriate road safety measure and maintain those on existing roads to minimize accidents occurred due to road factors.

F. **Pedestrian crossings (zebras)**

Pedestrian crossings (zebras) are full-time facilities which give priority to pedestrians over vehicles. This type of crossing is usually considered appropriate at schools with and where there is a strong concentration along a pedestrian desire line.

Thus, pedestrian crossing is provided for all the schools but majority 53.3% of it was at poor status which is not visible it might make it harder to drivers to reduce speed and give way to pedestrians as well as pedestrians to know the exact location of crossing. and needs to be recoated.

Signalized pedestrian crossing has signals that can give priority alternately to pedestrians and vehicles on a timed basis. They are usually considered for installation at locations where a crossing on an arterial road adjacent to a school, or the volume of students and passing vehicles is high and a pedestrian (zebra) or children’s crossing is likely to cause delays in traffic flow but in case of the schools included in this study there was no signalized crossing provided for schools adjacent to main road.

H. Drop-off and pick-up areas

Drop-off and pick-up areas utilize existing ‘No Parking’ and regulated parking areas at schools. The area, always on the school side of the road, provides a facility that is suitable for drivers and safe for students. Dropoff and pickup areas helps parents/careers to drop-off or pick-up students during the peak period at the beginning and end of the school day without breaking the traffic law. However, none of the schools under this study has specified drop off and pickup zone so that is also the reason for the overcrowding of the roads and accident occurrence during school peak hours.

CHAPTER FIVE

CONCLUSION AND RECCOMENDATIONS

5.1 Conclusions

The result obtained from the assessment of the data taken from Addis Ababa police commission and from the checklist indicate that the extent and provision of road safety measures around the selected schools. According to the finding following conclusion were drawn to address the objectives of the study.

- In the past five years, 2015/16-2019/20,152 fatal accident was occurred around schools in Addis Ababa. Top 30 schools which takes 48.7% of these accidents were identified based on the frequency of accident occurred.
- The major accident contributing factor was assessed for this study, vehicle factor was assessed in terms vehicles service year and technical status, all the vehicles involved in the accident does not have reported defect and technical problem. However,45.94% of the fatal accident occurred by the vehicles aged grater than 10 years,28.4% with 6-10 years, and 23% less than 5 years. Thus, vehicles service year found to be one of the reasons for road traffic accident in school zones.
- Regarding human factor youngest drivers (18-30) years, those with experience less than 5 years and junior high-school educational background took the highest role in the occurrence of the accident at school zone.
- As reported by traffic police at the accident time the main cause of all accident was failure to give way to the pedestrian. This is due to inexperienced driver and failure to follow traffic law.
- The result of the chi-square test shows Accident occurred and the given road safety measure variables has strong statistical relationship with P-value less than 0.05, therefore, road and environmental factors found to be the leading cause of crashes.
- Inadequate provision and poor visibility of pedestrian facilities on all roads within the school zone is also another cause identified in this study.

- There is a significant Sight obstructions problem observed around school, there is no demarcation of Schools zones and it cannot be easily identified because signs are covered by different factors such as street market and roadside parking's.
- With regard to road safety measures, there is a poor provision of engineering measures.

5.2 Recommendations

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

- Demarcating areas around the schools as school zones to notify drivers and provide traffic calming devices
- Preparing school zone road safety guidelines to be applied nationwide around all schools and including in to education system, so that the students will have a better understanding of proper road use, signage, use pedestrian facilities.
- Encouraging Students and road users' campaign performed around school to create awareness.
- Providing proper pedestrian facilities for school zone and maintaining deteriorated facilities
- Improve traffic regulation and enforcement.
- Strengthening the technical inspection of vehicles and Standardize drivers' training and license.
- Enforcement of speed limit around school, there is posted speed limit in school zone but there should be an enforcement on the drivers to follow the speed limit rule.
- Limiting driving time, to reduce overcrowding around school it is better to limit the traffic flow on school peak hours.
- Provision Warning sign of pedestrian crossing ahead of zebra crossing.
- Eliminating school gates from main road to reduce the overcrowding.
- Further studies on road safety interventions in the country including education, enforcement and encouragement.
- Generally, a due consideration should be given to those schools and urgent solutions including walkway repair and maintenance, removing obstacles, high visibility crosswalks, proper area signing, modified drop-off/pick-up operations, and holding traffic safety days can be applied.

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WHO 2002

Appendix A check list

<table>
<tr><td colspan="3">Investigation of road safety measure around schools In Addis-Ababa</td><td colspan="3">Date:</td></tr>
<tr><td colspan="6">Name of the school:</td></tr>
<tr><td>Sub-city</td><td colspan="2">Wereda</td><td colspan="3">Remark</td></tr>
<tr><td colspan="6">Engineering</td></tr>
<tr><td rowspan="2">kerbs and gutter</td><td colspan="2">Availability</td><td rowspan="2" colspan="3"></td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td rowspan="2">Street light</td><td colspan="2">Availability</td><td rowspan="2" colspan="3"></td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td rowspan="2">Footpaths</td><td colspan="2">Availability</td><td rowspan="2" colspan="3"></td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td rowspan="2">Traffic lights</td><td colspan="2">Availability</td><td rowspan="2" colspan="3"></td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td>pavement markings</td><td colspan="5"></td></tr>
<tr><td rowspan="2">Speed break</td><td colspan="2">Availability</td><td rowspan="2" colspan="3"></td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td rowspan="2">School zone sign</td><td colspan="2">Availability</td><td colspan="3">Status/Visibility</td></tr>
<tr><td>Yes</td><td>No</td><td>Good</td><td>Fair</td><td>Poor</td></tr>
<tr><td rowspan="2">Signalized pedestrian crossing</td><td colspan="2">Availability</td><td rowspan="2" colspan="3"></td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td>Number of lanes</td><td colspan="5"></td></tr>
<tr><td rowspan="2">Cross walks</td><td colspan="2">Availability</td><td colspan="3">Status/visibility</td></tr>
<tr><td>Yes</td><td>No</td><td>Good</td><td>Fair</td><td>Poor</td></tr>
<tr><td rowspan="2">Drop-off and pick-up areas</td><td colspan="2">Availability</td><td rowspan="2" colspan="3"></td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td>On-street parking</td><td colspan="5"></td></tr>
<tr><td rowspan="2">Speed limit</td><td colspan="2">Availability</td><td rowspan="2" colspan="3"></td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td>Sight obstruction</td><td colspan="2">Signs</td><td>Trees</td><td>buildings</td><td>Others</td></tr>
<tr><td>Road Layout</td><td colspan="2">Straight segment</td><td>Vertical curve</td><td colspan="2">Horizontal curve</td></tr>
<tr><td rowspan="2">Median</td><td colspan="2">Availability</td><td rowspan="2" colspan="3"></td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td>Median type</td><td colspan="2">Flat</td><td colspan="2">Raised</td><td>Flushed</td></tr>
</table>

Appendix B schools with highest number of fatal traffic accident

Sub-city	Wereda	School name	Count(fatal)

kirkos		Felegeyordanos primary school	4
Kolfe keraniyo		Repi secondary and preparatory school	3
		UMER	3
		Comprensive	3
		Ayertena	2
		Dej. Geneme	2
Gulelle		Medhanialem preparatory school	3
		Teferimokonin	3
		Dilbetigil primary school	2
		Menen	2
Akakikality		Bulbula	2
Yeka		School of tomorrow	4
		Kokebtsibah	3
		Zenebe werk	3
		Karallo	2
Nifassilk lafto		Kefitegna 23	2
Adisketema		Adisketema	3
		Edget primary school	2
		Haleluya	2
		Shaweldema	2
Bole		Beshale	2
		Zerfeshwal	2
		Misrak dil	2
Arada		Tikur Ambesa	2
		Kelemewerk	3
		Arbegnoch	3
		Belay zeleke	3
		Lycee G/mariam	2
		Kedamawi miilik	2

Appendix C Accident Characteristics

Table C-1 Age of Drivers involved in the accident

Driver's Age	Frequency	Percentage
Less than 18	4	5.4

18-30	34	45.9
31-50	23	31.1
Above 51	9	12.2
Undefined	4	5.4
Total	74	100

Table C-2 Driver's Experience

Experience	**Frequency**	**Percentage**
Without DL	5	6.8
less than 1 year	11	14.9
1-5 years	31	41.9
6-10years	11	14.9
Above 10 years	13	17.6
Undefined	3	4.1
Total	74	100

Table C-3 Educational Background of the drivers

Educational Background	**Frequency**	**Percentage**
Illitrate		0
Primary school	22	29.7
Junior highschool	24	32.4
Secondary school	15	20.3
Above secondary	10	13.5
Undefined	3	4.1
Total	74	100

Table C-4 Type of vehicle

Type	count	Percentage
Bus	4	5.4
Minibus/Taxi	29	39.2
Truck	12	16.2
Automobile	28	37.8
Undefined	1	1.4
Total	74	100

Table C-5 Vehicles service year

Service year		
Less than 5	17	23.0

6-10 years	21	28.4
Above 10 years	34	45.9
Undefined	2	2.7
Total	74	100

Table C-6 Accident Variation by days of week

Date	Count	Percentage
Monday	6	8.1
Tuesday	4	5.4
Wednesday	11	14.9
Thursday	16	21.6
Friday	22	29.7
Saturday	7	9.5
Sunday	8	10.8
Total	74	100.0

Table C-7 Accident variation by time of the day

Time of day	Count	Percentage
6:00AM-12:00PM	19	25.7
12:00PM-6:00PM	32	43.2
6:00PM-12:00AM	18	24.3
12:00AM-6:00AM	5	6.8
Total	74	100.0

Table C-8 Road condition at time of accident

Road condition	Count	Percentage
Dry	65	88
Wet	9	12
Muddy	0	0
Total	74	100

Table C-9 Light Condition

light condition	Count	Percentage
Daylight	49	66.2
Night time well road light	8	10.8
Night time not well road light		0
Night time no road light	17	23.0
Total	74	100.0

Table C-10

Accident spot	Count	Percentage

while crossing	52	70.3
on right side	5	6.8
on left side	7	9.5
Undefined	2	2.7
Passenger	8	10.8

Kerb and gutter

Total	74	100

Appendix D SPSS output of engineering measures around schools with highest traffic accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	9	30.0	30.0	30.0
	Yes	21	70.0	70.0	100.0
	Total	30	100.0	100.0	

Street light

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	12	40.0	40.0	40.0
	Yes	18	60.0	60.0	100.0
	Total	30	100.0	100.0	

Footpath

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	14	46.7	46.7	46.7
	Yes	16	53.3	53.3	100.0
	Total	30	100.0	100.0	

Footpath status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		14	46.7	46.7	46.7
	Fair	4	13.3	13.3	60.0
	good	4	13.3	13.3	73.3
	poor	8	26.7	26.7	100.0
	Total	30	100.0	100.0	

Traffic light

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	26	86.7	86.7	86.7
	Yes	4	13.3	13.3	100.0
	Total	30	100.0	100.0	

Pavement marking

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	21	70.0	70.0	70.0
	Yes	9	30.0	30.0	100.0
	Total	30	100.0	100.0	

Speed break

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	29	96.7	96.7	96.7
	Yes	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

School sign

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	30	100.0	100.0	100.0

Visibility

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fair	5	16.7	16.7	16.7
	good	15	50.0	50.0	66.7
	poor	10	33.3	33.3	100.0
	Total	30	100.0	100.0	

Signalized crossing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	30	100.0	100.0	100.0

Lanes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	15	50.0	50.0	50.0
	2.00	13	43.3	43.3	93.3
	3.00	2	6.7	6.7	100.0
	Total	30	100.0	100.0	

Zebra crossing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	4	13.3	13.3	13.3
	Yes	26	86.7	86.7	100.0
	Total	30	100.0	100.0	

Status of Zebra Crossing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Good	4	13.3	13.3	13.3
	Fair	10	33.3	33.3	46.7
	poor	16	53.3	53.3	100.0
	Total	30	100.0	100.0	

Drop off/pickup zone

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	30	100.0	100.0	100.0

On street parking

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	7	23.3	23.3	23.3
	Yes	23	76.7	76.7	100.0
	Total	30	100.0	100.0	

Speed limit

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	7	23.3	23.3	23.3
	Yes	23	76.7	76.7	100.0
	Total	30	100.0	100.0	

Sight obstruction

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	8	26.7	26.7	26.7
	Yes	22	73.3	73.3	100.0
	Total	30	100.0	100.0	

Type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		7	23.3	23.3	23.3
	Advert	5	16.7	16.7	40.0
	Curve	3	10.0	10.0	50.0
	Parking	7	23.3	23.3	73.3
	Street market	8	26.7	26.7	100.0
	Total	30	100.0	100.0	

Road layout

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Horizontal curve	6	20.0	20.0	20.0
	Straight	15	50.0	50.0	70.0
	Vertical curve	9	30.0	30.0	100.0
	Total	30	100.0	100.0	

Median

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	6	20.0	20.0	20.0
	Yes	24	80.0	80.0	100.0
	Total	30	100.0	100.0	

Median type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		6	20.0	20.0	20.0
	Flat	13	43.3	43.3	63.3
	raised	11	36.7	36.7	100.0
	Total	30	100.0	100.0	

Appendix E Output of engineering measures around schools with no traffic accident

Statistics

gutter

N	Valid	30

Missing	0

Gutter

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	30	100.0	100.0	100.0

Street

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	30	100.0	100.0	100.0

Foot

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	30	100.0	100.0	100.0

Footpath status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	fair	8	26.7	26.7	26.7
	good	16	53.3	53.3	80.0
	poor	6	20.0	20.0	100.0
	Total	30	100.0	100.0	

Traffic

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	22	73.3	73.3	73.3
	yes	8	26.7	26.7	100.0
	Total	30	100.0	100.0	

Pavement marking

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	11	36.7	36.7	36.7
	yes	19	63.3	63.3	100.0
	Total	30	100.0	100.0	

Speed break

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	13	43.3	43.3	43.3
	yes	17	56.7	56.7	100.0
	Total	30	100.0	100.0	

School sign

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	30	100.0	100.0	100.0

Visibility

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	fair	12	40.0	40.0	40.0
	good	14	46.7	46.7	86.7
	poor	4	13.3	13.3	100.0
	Total	30	100.0	100.0	

Signalized crossing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	21	70.0	70.0	70.0
	yes	9	30.0	30.0	100.0

		Frequency	Percent	Valid Percent	Cumulative Percent
	Total	30	100.0	100.0	

Lanes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	10	33.3	33.3	33.3
	2.00	17	56.7	56.7	90.0
	3.00	3	10.0	10.0	100.0
	Total	30	100.0	100.0	

Crossing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	30	100.0	100.0	100.0

Status of crossing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	fair	11	36.7	36.7	36.7
	good	15	50.0	50.0	86.7
	poor	4	13.3	13.3	100.0
	Total	30	100.0	100.0	

Dropoff/pickup areas

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	22	73.3	73.3	73.3
	yes	8	26.7	26.7	100.0
	Total	30	100.0	100.0	

On street parking

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	22	73.3	73.3	73.3

	yes	8	26.7	26.7	100.0
	Total	30	100.0	100.0	

Speed limit

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	30	100.0	100.0	100.0

Sight obstruction

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	24	80.0	80.0	80.0
	yes	6	20.0	20.0	100.0
	Total	30	100.0	100.0	

Type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		24	80.0	80.0	80.0
	advert	1	3.3	3.3	83.3
	parking	2	6.7	6.7	90.0
	streetma	3	10.0	10.0	100.0
	Total	30	100.0	100.0	

Road Layout

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	hcurve	6	20.0	20.0	20.0
	straight	24	80.0	80.0	100.0
	Total	30	100.0	100.0	

Median

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	5	16.7	16.7	16.7
	yes	25	83.3	83.3	100.0
	Total	30	100.0	100.0	

Median type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		5	16.7	16.7	16.7
	flat	14	46.7	46.7	63.3
	raised	11	36.7	36.7	100.0
	Total	30	100.0	100.0	

Appendix F Chi-square test output

Kerb and gutter * accident occurrence Crosstabulation

			Accident status		Total
			No	yes	
gutter	No	Count	0	3	3

		% within accident	0.0%	10.0%	5.0%
	Yes	Count	30	27	57
		% within accident	100.0%	90.0%	95.0%
Total		Count	30	30	60

Chi-Square Tests[c]

	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.158[a]	1	.076	.237	.119
Continuity Correction[b]	1.404	1	.236		
Likelihood Ratio	4.317	1	.038	.237	.119
Fisher's Exact Test				.237	.119
N of Valid Cases	60				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.50.

b. Computed only for a 2x2 table

c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

Streetlight * accident occurrence Crosstabulation

			Accident		
			No	Yes	Total
street	No	Count	0	12	12
		% within accident	0.0%	40.0%	20.0%
	yes	Count	30	18	48

	% within accident	100.0%	60.0%	80.0%
Total	Count	30	30	60
	% within accident	100.0%	100.0%	100.0%

Chi-Square Tests[c]

	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	15.000[a]	1	.000	.000	.000
Continuity Correction[b]	12.604	1	.000		
Likelihood Ratio	19.668	1	.000	.000	.000
Fisher's Exact Test				.000	.000
N of Valid Cases	60				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.00.

b. Computed only for a 2x2 table

c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

Foot * accident occurrence Crosstabulation

			Accident		
			no	Yes	Total
Foot	No	Count	0	14	14
		% within accident	0.0%	46.7%	23.3%
	yes	Count	30	16	46
		% within accident	100.0%	53.3%	76.7%
Total		Count	30	30	60
		% within accident	100.0%	100.0%	100.0%

Chi-Square Tests[c]

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	18.261[a]	1	.001	.000	.000
Continuity Correction[b]	15.745	1	.000		
Likelihood Ratio	23.737	1	.000	.000	.000
Fisher's Exact Test				.000	.000
N of Valid Cases	60				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.00.

b. Computed only for a 2x2 table

c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

Traffic light * accident occurrence Crosstabulation

			Accident		
			No	Yes	Total
Traffic	no	Count	18	26	44
		% within accident	60.0%	86.7%	73.3%
	yes	Count	12	4	16
		% within accident	40.0%	13.3%	26.7%
Total		Count	30	30	60
		% within accident	100.0%	100.0%	100.0%

Chi-Square Tests[c]

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.455[a]	1	.020	.039	.020
Continuity Correction[b]	4.176	1	.041		
Likelihood Ratio	5.649	1	.017	.039	.020
Fisher's Exact Test				.039	.020
N of Valid Cases	60				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.00.
b. Computed only for a 2x2 table
c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

pavement * accident occurrence Crosstabulation

			Accident		
			no	yes	Total
pavement	no	Count	11	21	32
		% within accident	36.7%	70.0%	53.3%
	yes	Count	19	9	28
		% within accident	63.3%	30.0%	46.7%
Total		Count	30	30	60
		% within accident	100.0%	100.0%	100.0%

Chi-Square Tests[c]

	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.696[a]	1	.010	.019	.010
Continuity Correction[b]	5.424	1	.020		
Likelihood Ratio	6.829	1	.009	.019	.010
Fisher's Exact Test				.019	.010
N of Valid Cases	60				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 14.00.
b. Computed only for a 2x2 table
c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

break * accident occurrence Crosstabulation

			Accident		
			no	Yes	Total
break	no	Count	13	29	42

		% within accident	43.3%	96.7%	70.0%
	yes	Count	17	1	18
		% within accident	56.7%	3.3%	30.0%
Total		Count	30	30	60
		% within accident	100.0%	100.0%	100.0%

Chi-Square Tests[c]

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	20.317[a]	1	.001	.000	.000
Continuity Correction[b]	17.857	1	.000		
Likelihood Ratio	23.481	1	.000	.000	.000
Fisher's Exact Test				.000	.000
N of Valid Cases	60				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.00.

b. Computed only for a 2x2 table

c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

Signalized pedestrian crossing * accident occurrence Crosstabulation

			Accident		
			no	Yes	Total
spcrossing	no	Count	21	30	51
		% within accident	70.0%	100.0%	85.0%
	yes	Count	9	0	9
		% within accident	30.0%	0.0%	15.0%
Total		Count	30	30	60
		% within accident	100.0%	100.0%	100.0%

Chi-Square Tests[c]

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.588[a]	1	.001	.002	.001
Continuity Correction[b]	8.366	1	.004		
Likelihood Ratio	14.073	1	.000	.002	.001
Fisher's Exact Test				.002	.001
N of Valid Cases	60				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.50.

b. Computed only for a 2x2 table

c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

Dropoff/pickup area * accident occurrence Crosstabulation

			Accident		
			no	Yes	Total
dropoff	no	Count	22	30	52
		% within accident	73.3%	100.0%	86.7%
	yes	Count	8	0	8
		% within accident	26.7%	0.0%	13.3%
Total		Count	30	30	60
		% within accident	100.0%	100.0%	100.0%

Chi-Square Tests[c]

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.231[a]	1	.002	.005	.002
Continuity Correction[b]	7.067	1	.008		

Likelihood Ratio	12.326	1	.000	.005	.002
Fisher's Exact Test				.005	.002
N of Valid Cases	60				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.00.

b. Computed only for a 2x2 table

c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

On street parking * accident occurrence Crosstabulation

			Accident		
			No	Yes	Total
onstreet	no	Count	22	7	29
		% within accident	73.3%	23.3%	48.3%
	yes	Count	8	23	31
		% within accident	26.7%	76.7%	51.7%
Total		Count	30	30	60
		% within accident	100.0%	100.0%	100.0%

Chi-Square Tests[c]

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	15.017[a]	1	.001	.000	.000
Continuity Correction[b]	13.081	1	.000		
Likelihood Ratio	15.720	1	.000	.000	.000
Fisher's Exact Test				.000	.000
N of Valid Cases	60				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 14.50.

b. Computed only for a 2x2 table

c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

Sight obstruction * accident occurrence Crosstabulation

			Accident		
			no	Yes	Total
sighto	no	Count	24	8	32
		% within accident	80.0%	26.7%	53.3%
	yes	Count	6	22	28
		% within accident	20.0%	73.3%	46.7%
Total		Count	30	30	60
		% within accident	100.0%	100.0%	100.0%

Chi-Square Tests[c]

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	17.143[a]	1	.001	.000	.000
Continuity Correction[b]	15.067	1	.000		
Likelihood Ratio	18.092	1	.000	.000	.000
Fisher's Exact Test				.000	.000
N of Valid Cases	60				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 14.00.

b. Computed only for a 2x2 table

c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

layout * accident occurrence Crosstabulation

			Accident		
			no	Yes	Total
layout	hcurve	Count	6	6	12
		% within accident	20.0%	20.0%	20.0%
	straight	Count	24	15	39

		% within accident	80.0%	50.0%	65.0%
	vcurve	Count	0	9	9
		% within accident	0.0%	30.0%	15.0%
Total		Count	30	30	60
		% within accident	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Df	Asymptotic Significance (2-sided)	Monte Carlo Sig. (2-sided) Significance	95% Confidence Interval Lower Bound	Upper Bound
Pearson Chi-Square	11.077[a]	2	.004	.003[b]	.002	.004
Likelihood Ratio	14.572	2	.001	.002[b]	.001	.003
Fisher's Exact Test	11.916			.003[b]	.002	.004
N of Valid Cases	60					

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 4.50.

b. Based on 10000 sampled tables with starting seed 2000000.

median * accident occurence Crosstabulation

			Accident No	Accident Yes	Total
median	no	Count	5	6	11
		% within accident	16.7%	20.0%	18.3%
	yes	Count	25	24	49
		% within accident	83.3%	80.0%	81.7%
Total		Count	30	30	60
		% within accident	100.0%	100.0%	100.0%

Chi-Square Tests[c]

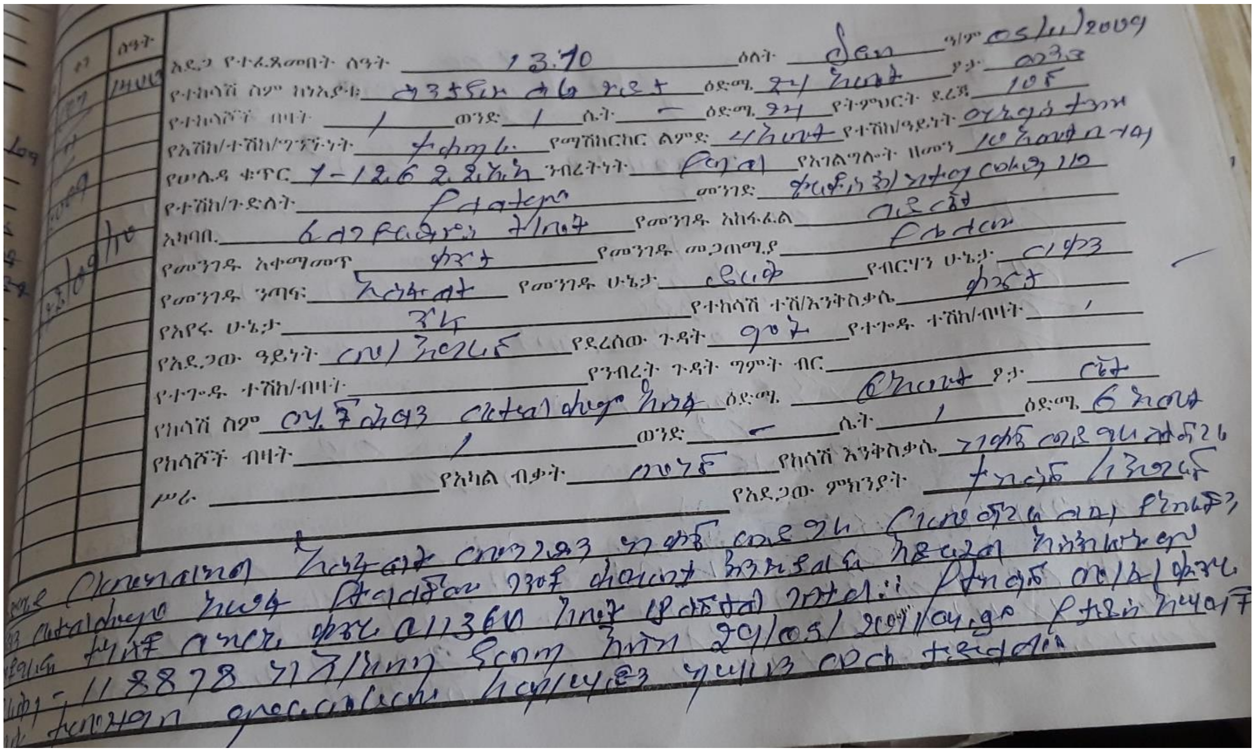
	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.111[a]	1	.739	1.000	.500
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.111	1	.739	1.000	.500
Fisher's Exact Test				1.000	.500
N of Valid Cases	60				

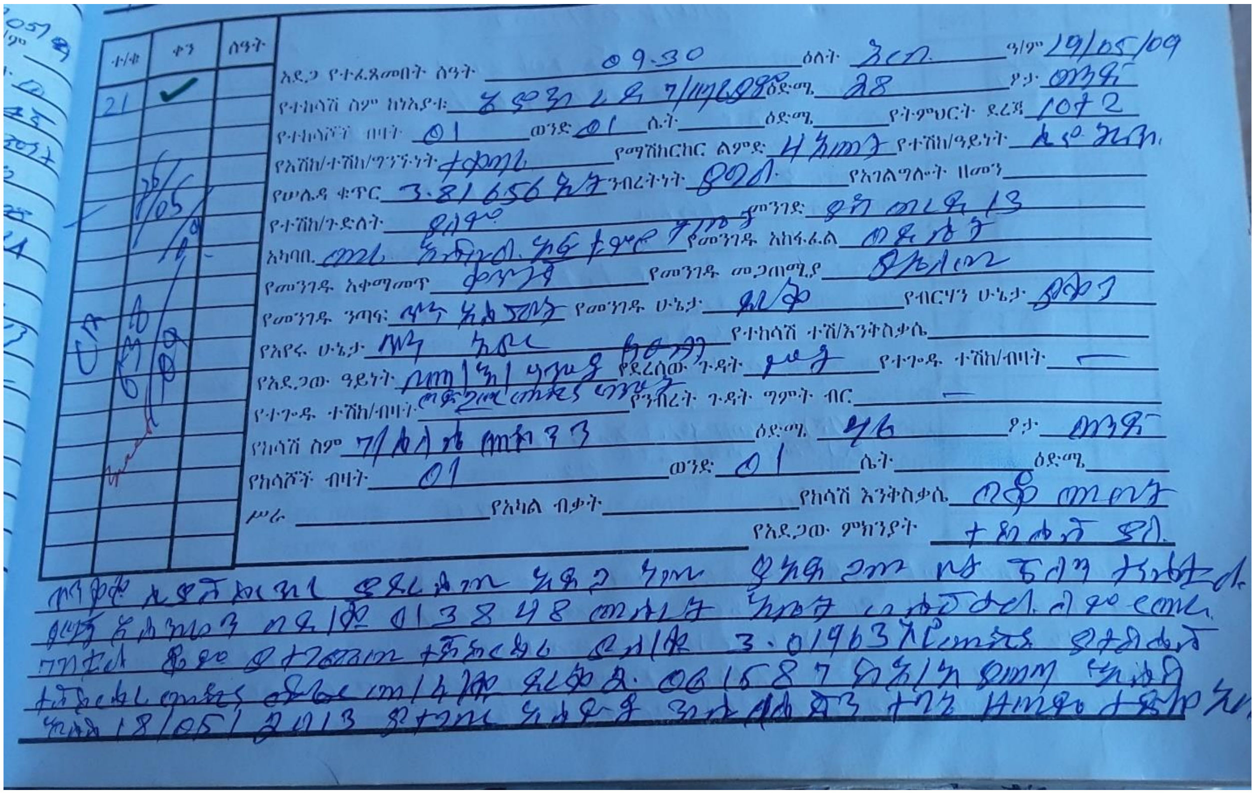
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.50.

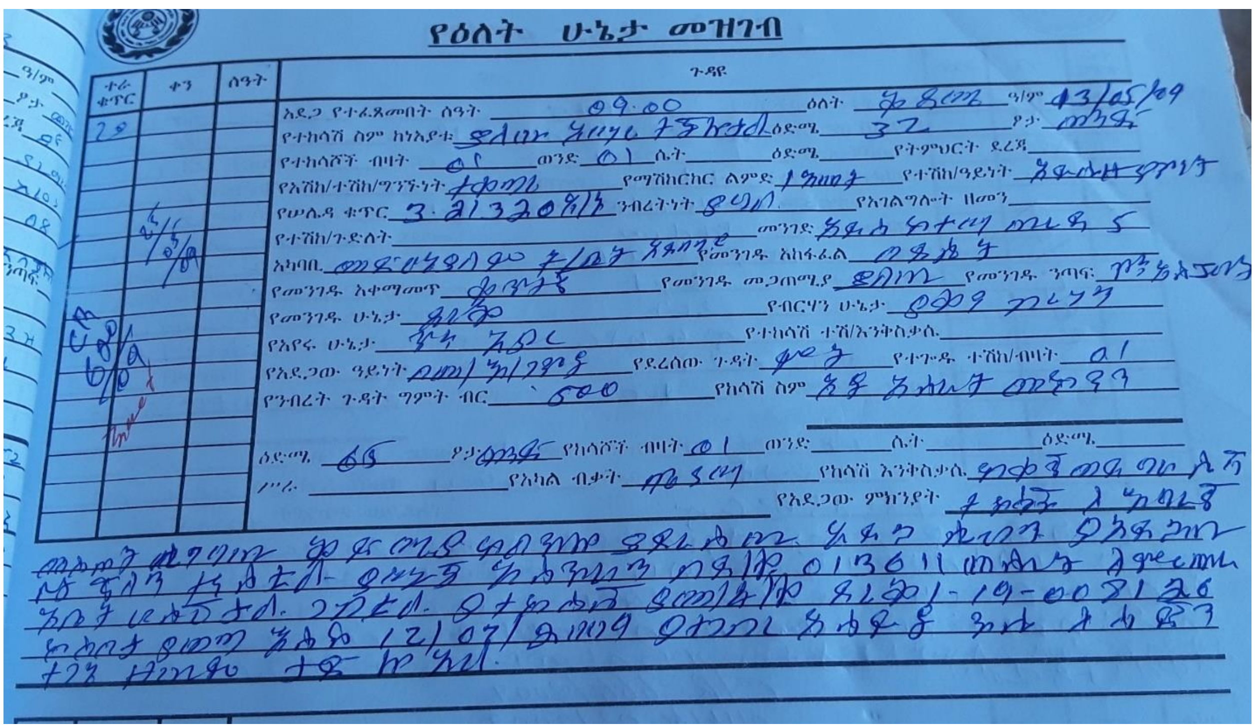
b. Computed only for a 2x2 table

c. For 2x2 crosstabulation, exact results are provided instead of Monte Carlo results.

Appendix G Sample traffic accident data record



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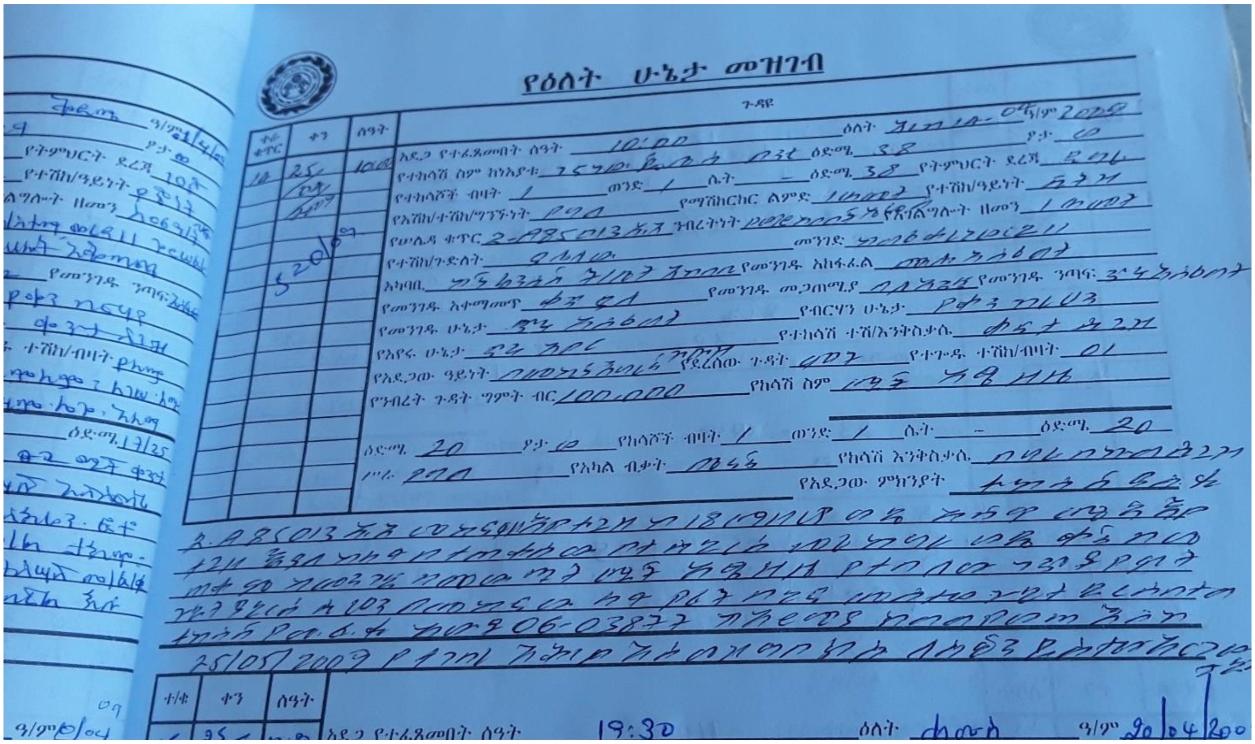
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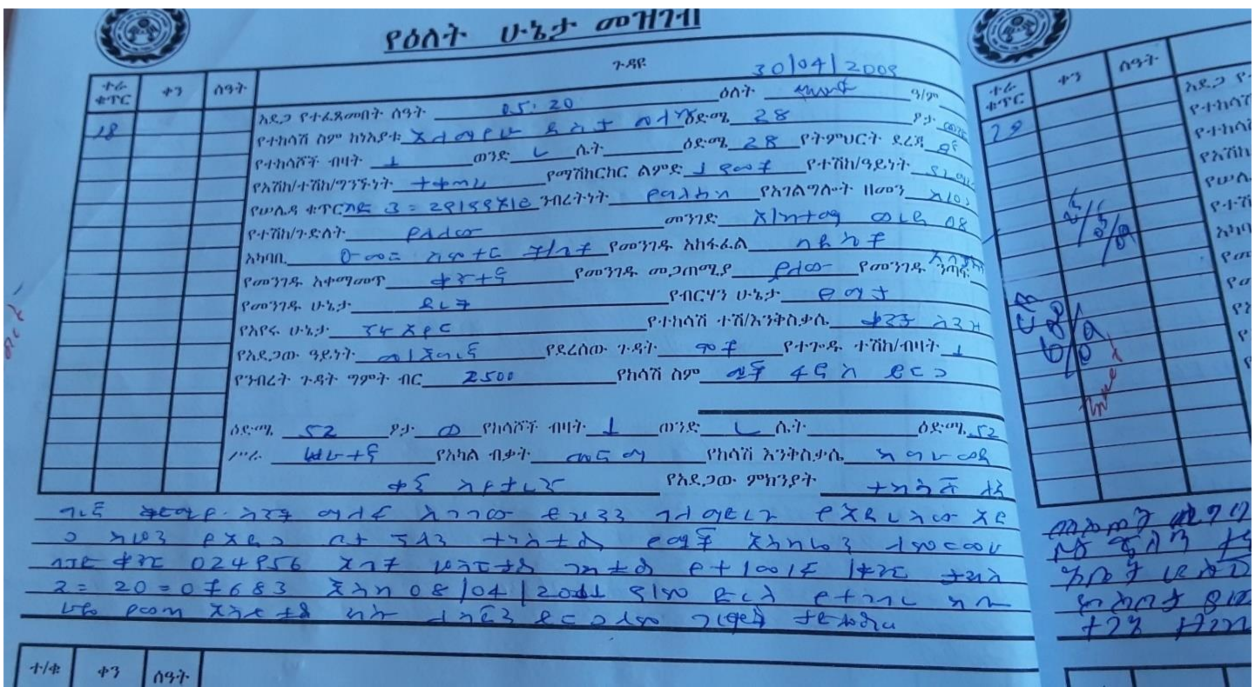
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