ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

EVALUATING RED-LIGHT RUNNERS AT SIGNALIZED INTERSECTION IN ADDIS ABABA

Thesis for the partial fulfillment of the Master of Science in Road and Transport Engineering

By **SISAY ASRAT**

JUNE 2023

Addis Ababa

A Thesis

Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Road and Transport Engineering

The undersigned have examined the thesis entitled '**EVALUATING RED-LIGHT RUNNERS AT SIGNALIZED INTERSECTION IN ADDIS ABABA**' presented by **SISAY ASRAT**, a candidate for the degree of **Master of Science** and hereby certify that it is worthy of acceptance.

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UNDERTAKING

I certify that the research work titled "**EVALUATING RED-LIGHT RUNNERS AT SIGNALIZED INTERSECTION IN ADDIS ABABA**" is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/referred.

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ABSTRACT

The conduct of red-light-running is widespread and growing in the world. The problem has been explored in different countries with less attention also in Addis Ababa. This paper examines the relationship between violation frequency and influencing factors related to red light running. The data for the current study has been taken from Addis Ababa traffic police; reported traffic rule violations including red light running behavior in Addis Ababa for four years (2018 to 2021) were analyzed using an Excel spreadsheet. Structured questionnaires were also distributed to the willing drivers with 412 rates of participants and analyzed using a chi-square test to demonstrate the rate and contributing factors to red light running. In addition, four signalized intersections namely Shola Gebeya, Legehar, Churchill, and Semen Hotel were randomly selected. Multiple linear regression analysis has been calibrated to assess the effect of the independent variables on the red-light running violations as the dependent variable by SPSS software.

From the statistical analysis made on the collected traffic rule violation data, it can be seen red-light running violation rate is becoming increasing in recent years in the city and it also shows that Bole and Lideta sub-cities have higher rates of violation among the eleventh sub-cities. Gender, age, educational background, and driving experience were found as dominant influencing factors affecting red light running behavior in Addis Ababa. Most drivers were more likely to engage in RLR and would speed up at signalized intersections when they are in a hurry in the morning peak hour on working days they mostly prefer to run the red light to save time. Empirical results exposed that Car, number of lanes, red light time, cross road width and green light time, were found statistically significant at 95% of significance. Green light time, heavy vehicle, and cross road width are negatively related variable with red light running and affects negatively while car, bus, yellow light runners, Pedestrian, number of lanes, grade and red-light time are positively affecting the red light running.

Finally, low-cost engineering countermeasures including optimizing the traffic light, education, and awareness campaign are recommended to reduce the number of red-light running conduct at signalized intersections. The education on red light running offenses must be accompanied by frequent Police enforcement of the traffic law to reduce the degree of violation.

Key words RLR (red light running), Signalized intersection, SPSS, Multiple Linear Regression, Binary logistic regression, driver behavior

ACKNOWLEDGMENT

First of all, I am very grateful to the Almighty God for granting me strength, wisdom, and health during the duration of my studies and for his perfect protection and guidance in my life.

I would like to express my sincere gratitude to my advisor Dr. Getu Segni, for his invaluable guidance and support throughout my master's program. His expertise and encouragement helped me to complete this research and write this thesis.

I acknowledge the Civil Engineering Department of Addis Ababa University in writing co-operation letters for concerned organizations. I also extend my acknowledgment and forward my thanks to the following organization for their help in providing relevant information; the Addis Ababa traffic management agency and the Addis Ababa traffic police office for assisting me by providing important information and documents relevant to my study.

Thanks to all government officers who helped me by giving different documents relevant for this research and any resources available in good will without reservation.

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LIST OF ACRONYMS

Term	Explanation / Meaning / Definition
RLR	Red light Runner
YLR	Yellow light runner
NRLR	Non-Red-light Runner
NYLR	Non-Yellow light Runner
EB	East-bound
NB	North-bound
SB	South bound
WB	West bound
AACRA	Addis Ababa City Road Authority
WHO	World Health Organization
AATMA	Addis Ababa Traffic Management Agency
VZ	Vision zero
AATA	Addis Ababa Transport Authority
AATP	Addis Ababa Traffic Police
GDP	Gross domestic product
RTA	Road traffic accident
SPSS	Statistical Package for the Social Sciences
CDF	Cumulative distribution function

CHAPTER 1. INTRODUCTION

1.1. Background

Road traffic injuries are a global problem affecting all sectors of society. To date, road safety has received insufficient attention at the national and regional levels. This has resulted in part from a lack of information on the magnitude of the problem and its preventability; a fatalistic approach to road crashes; and a lack of the political responsibility and multidisciplinary collaboration needed to tackle it effectively. The number of road traffic deaths on the world's roads remains excessively high. Road traffic damages are the leading killer of children and young adults more than half of universal road traffic deaths are amongst pedestrians, cyclists, and motorcyclists who are still too often ignored in road traffic system design in many countries there is progress being made, however, it is far from uniform across countries Road traffic damages are the 8th leading cause of death for people of all ages. The number of deaths on the world's roads remains unacceptably high with 1.35 million people dying each year (World Health Organization, 2018).

Progress in reducing road traffic deaths over the last few years varies significantly between the different regions and counties of the world. There continues to be a strong association between the risk of road traffic death and the income level of nations. With an average rate of 27.5 death per 100,000 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 per 100,000 population. As shown high among low- and middle-income counties concerning the size of the populations and number of motor vehicles in circulation. Even though only 1% of the world's motor vehicles are in low-income countries, 13% of deaths occur in these countries. (World Health Organization, 2018).

RLR is also a major cause of severe injuries in developing counties; In Ghana, almost two-thirds of (65%) of all road traffic crashes occur in urban areas (Ackaah et al., 2020). For instance, in the year 2018,(Global status report on road safety 2018) the five major cities in the country namely: Accra, Tema, Kumasi, Sekondi-Takoradi and Tamale accounted for over 3605 road traffic crashes with a little over one-third 34% of being fatal or serious (Ackaah et al., 2020). The statistics further indicated that 41% of all the crashes in the urban road setting happened at intersections and this might be due to traffic violations such as running of red light. The red-light running rate of 35% is

generally high because, in more than one-third of all red-light phasing, a driver was observed violating the signal.(Ackaah and Aidoo 2020)

According to research conducted on Red-light-running in a Ghanaian metropolis (Kolawole Ojo et al. 2022) a total of 5,045 motorists were detected at three traffic lights A low degree of RLR 13.3% Pedu Junction traffic lights 15.1%, UCC 12.7%, and Interbeton Junction 10.8% in the metropolis. Drivers entering the UCC Gate-Campus were 1.54 times more likely to involve in RLR than those leaving campus, and vehicles without passengers were 1.27 times more likely to engage in RLR, compared to those with one or more passengers. Motorists were less likely to make an RLR fault on weekdays as compared to weekends.(Kolawole Ojo et al. 2022)

In Malaysia, traffic crashes put up to the leading noteworthy wounds and passing. For the past five a long time, the number of accidents at signalized convergences in Malaysia has been on an upward trend. One of the causes of crashes at intersections is red light running. The number of fatalities due to traffic light-related accidents has steadily increased, leading to 182 fatalities and 757 injuries in 2009. The primary reason of crashes at signalized intersections happened when vehicles pass in the intersection on a red signal.(Jamil and Shabadin, 2012)

In Ethiopia, the situation has been got worse as the number of vehicles has increased accordingly due to increased traffic flow and conflicts between vehicles and pedestrians. Despite government efforts in road development, road crashes remain to be one of the critical problems of the road transport sector in Ethiopia. Every year, many lives are lost and huge property is destroyed due to road traffic accidents in the nation (Tegegne 2019).

1.2. Statement of the Problem

Road security issues are one of the major financial, societal, and health problems, especially in a developing country like Ethiopia. According to the WHO report, an estimated 1.25 million people are killed in road crashes, and up to 50 million are injured global every year, with on average 3,287 deaths a day (World Health Organization, 2015). RTA is becoming the leading cause of death among young people aged between 15 and 29 years, and costs governments nearly 3% of GDP (and up to 5% in low- and middle-income countries). About 90% of the world's fatalities on the roads occur in low-income and middle-income countries, which have only 54% of the world’s registered vehicles (World Health Organization 2015).

The rate of road traffic death is high in Africa and South-East Asia which ranges from 26.6 per 100,000 population of Africa and 20.7 deaths per 100,000 population in South-East Asia respectively. As reports of (Segni Tulu et al. 2013) show more than half of all road traffic deaths are among vulnerable road users: pedestrians, cyclists, and motorcyclists. Africa has the highest proportion of pedestrian and cyclist mortalities with 44% of deaths. In South-East Asia and the Western Pacific, the popular of deaths are among riders of motorized two and three-wheelers, which characterize 43% and 36% of all deaths respectively (Segni Tulu et al. 2013).

Each year, road traffic crash causes a great loss of human and economic resources in Ethiopia. This problem is increasing from year to year at an alarming rate accompanied by the rapid increase in population and the number of vehicles. (Kelacha 2021)

High road traffic crashes statistics in Addis Ababa are attributed to different complex risk aspects such as driver and pedestrian behavior, vehicle and road conditions, and environmental and other related factors (Abebe 2022). There are over 803,000 vehicles in Ethiopia, 553, 938 Cars are available in Addis Ababa (Addis Ababa City Road Traffic Management Agency 2017)..According to the preliminary report by the Addis Ababa City Road Traffic Management Agency in 2017, in recent years for which statistics are available, there were nearly 153056 road traffic rule violations informed to the police in the past seven years and economic losses were estimated at 1,371,688,008. (Addis Ababa City Road Traffic Management Agency 2017).

Running red lights has been reported to be on the rise, along with other aggressive driving habits like speeding, failing to stop, or even slowing down at stop-controlled junctions. This has led to a concern with national safety. In light of this, a study of the elements that contributed to accidents among drivers reveals that, between 2010 and 2017, 226 incidents involving pedestrians and 767 accidents involving vehicles who ran red lights. While all sub-cities in Addis Ababa reported over 256963 red light violations to the traffic police office there between 2018 and 2021, with roughly 38.85% of those offenses occurring in 2021.

According to the national goal report (Abebe 2022), enhancing road safety is a significant addition to research on the subject in low-income nations where the issue of road safety is only getting worse despite efforts to address it with various policies and tactics. There are two popular approaches to road safety. The Safe System approach addresses crashes caused by road system flaws by making changes to the road system. These enhancements may involve better vehicle

design, infrastructure management, and slower speeds. The Safe System strategy consists of five key components: post-crash response, safe roads and roadsides, safe speeds, safe automobiles, and safe road use of the whole RLR offense, (Yao Wu Yanyong Guo and Wei Yin 1 2018) were recorded at 2021.

The long-term objective of Sweden's Vision Zero program is to have no fatalities or serious injuries related to traffic accidents. To better understand how they define road security issues, distribute responsibility for road security, and the nature and type of interventions they advance to address road fatalities and injuries, it is crucial to compare and contrast the road security policies of cities like Addis Ababa with effective road security arrangements like VZ. (Abebe, H G., 2022)

Traffic accidents are more likely to occur when red-light runners violate the law. Assessing red light runners' conduct in Addis Ababa city is crucial to figuring out the main causes and making solutions. As a result, the issue that needs to be solved deserves proper consideration.

1.3. The Objective of the Research

1.3.1. General Objectives

The general objective of this research is to investigate the behavior causes and factors of red-light running at signalized intersections in Addis Ababa.

1.3.2. Specific Objectives

Specific objectives of this research include;

I. To assess the frequency of red light running relative to other traffic rule violations in Addis Ababa
II. To investigate the impact of driver behavior on red light running conduct in Addis Ababa
III. To investigate factors related to red light running in Addis Ababa

1.4. Research Questions

The research questions that this study would like to seek answers are as follows

1. What is the trend, characteristics, and magnitude of red-light running conduct and other traffic rule violation in Addis Ababa?

2. What is the relationship between driver behavior, and red-light running offense in Addis Ababa?
3. What are the major contributing factors of red-light running violations and driver's decision-making at signalized intersections in Addis Ababa?

1.5. Significance of the Study

Upon the completion of the research, it is anticipated that the findings will assist road safety experts in understanding the most frequent causes, characteristics, magnitudes, and trends of running red lights at signalized intersections, in evaluating how red light running rule violations are related to drivers' characteristics and traffic accident history at signalized intersections, and ultimately in assisting the road and transport management agency in implementing interventions to the traffic rule violators. It describes how drivers' actions at red lights in Addis Ababa influence their opinions toward traffic safety.

1.6. Research Scope and Limitation of the Study

1.6.1. Scope of the Study

The scope of the study was limited to Addis Ababa at four signalized intersections based on the area in which there is high traffic and pedestrian flow and congestion to assess red light runner behavior. The collection of data was a challenging task in the research area and two major traffic flow bounds are considered at all intersections.

1.6.2. Limitations of the Study

There will be time limitations for covering all signalized intersections in the city. Due to the limitation of resources and time speed of the vehicle is not considered too in this study.

1.7. Structure of the thesis

There are five chapters in this research thesis, and the following are the contents of each chapter:

The problem description, objectives, research question, significance of the study, scope, report organization, and research limitation are all included in chapter one, which serves as an introduction to the article.

The literature on signalized intersection safety, red light running violations, their magnitudes, trends, and characteristics, associations with various aspects of driver behavior, and their contributing factors are all examined in the following chapter.

The methods employed to achieve the goals of this study is described in Chapter 3. It offers detailed descriptions of the methods used for data analysis and the procedures followed in data collection. Details of the three research techniques have been stated, and the methodology used to perform the study is given.

Results and comments of the study's findings are provided in Chapter 4. The chapter also included the identification of red-light running causes, which is supported by a site visit and comprehensive research.

Chapter 5 contains conclusions and suggestions. This chapter will present the data and conclusions from this investigation. The main findings of the study were emphasized. Recommendations were then put forth for road safety engineers, managers, and planners. Additionally, the study's advantages, and recommendations for further research were discussed.

CHAPTER 2. LITERATURE REVIEW

2.1. Definition of red-light running

Red light runner is an event in which a driver breaks a red-light signal and deliberately run red light at signalized intersection. A red-light runner is identified as one of the major causes of traffic crash and affect traffic flow. (Jantosut et al. 2021)

Stoplights, traffic lights, or traffic signals are signaling tools placed at intersections or pedestrian crossings to manage traffic flow. Typically, traffic lights have three signals, which communicate important information to drivers and passengers using colors and symbols like arrows. Red, yellow (sometimes referred to as amber), and green are the standard traffic signal colors and are arranged vertically or horizontally in that sequence. Although this is internationally defined, there are variances in traffic light sequences and rules at the national and municipal levels.

A red-light running (RLR) accident occurs when a driver intentionally or unintentionally runs a red light at a signalized intersection and collides with a vehicle that is traveling in the opposite direction and has the right-of-way. One of the primary contributing factors to crashes at signalized crossings has been found as RLR violation. Additionally, RLR violations have caused a significant amount of severe injuries, several fatalities, and massive property damage. (Elnashar 2004; Jamil & Shabadin, 2012).

The severity of RLR crashes may vary depending on their type. In the field, three different types of RLR behavior are seen. The driver's first deliberate intention is to speed up through red lights. Second, when a yellow signal appears at a signalized intersection, the driver makes a poor stop-go judgment. Third, either due to attention or inadequate signal visibility, the vehicle misses the traffic light. RLR occurs when a car approaches the stop line after the red light turns on but still drives through an intersection with a traffic signal. (Chen et al. 2019)

In China, the United Kingdom, and the United States (US), RLR is a frequent and serious traffic signal violation that contributes significantly to RTAs each year (Ackaah et al. 2020). The degree of road safety depends on cars obeying the signals, however red-light running by motorists, pedestrians, motorcyclists, and cyclists has raised worries about intersection safety (Retting, Ferguson, & Farmer, 2008). At signalized crossings, for instance, 0.14 percent of drivers in China, 11.3 percent in Jordan, and 12.9 percent in the UK use RLR. (Ackaah et al. 2020)

2.2. Overview on traffic light

Three fundamental subsystems make up a traffic light system: the supporting poles, the electric controller, and the signal lights (red, yellow, and green) in their housing. It is a traffic-controlling signaling device that is put in place at an intersection or pedestrian crossing. British railroad engineer John Peake Knight created the first traffic signal in 1868, which was placed in front of the London Houses of Parliament and manually operated by a traffic officer. In 1918, New York installed the first three-color signal, which was manually operated from a tower in the middle of a roadway. Since then, numerous types of traffic lights have been developed and entered the technological art. (Hsu et al. 2018)

According to Eboli. (Eboli et al. 2017),there are primarily two different types of traffic signal systems: the fixed time system, which is pre-timed, and the traffic-actuated system, which is activated by moving cars or pedestrians utilizing electronic detectors. A fixed time system is always preferable since it is far less expensive to install and run than a traffic-actuated system.

At active crossing places, traffic lights are supposed to advance a safe and effective traffic stream. Whatever the scenario, drivers' compliance to the signals greatly influences the amount of safety attained. Find out if it's true that many drivers disobey red lights, putting themselves and other street pedestrians at risk for real collisions caused by doing so.

2.3. Signalized Intersection characteristics

It was underlined that intersection characteristics, such as flow rate, the number of signal cycles, and phase termination by max-out, relate to red-light runner characteristics. Studies (A Toolbox of Engineering Countermeasures to Reduce Red-Light Running 2003) support the logical conclusion that the number of violations rises as more cars are exposed to the possibility of doing so. the violation rate increases due to;

- *Flow rate or volume*: Every vehicle approaching the intersection at the onset of the yellow is exposed to the potential of red-light running. A choice must be made to stop or proceed through the intersection. As the number of approaching vehicles increases, the number of red-light runners will likely increase.
- *Number of signal cycles:* There is a greater chance of red-light running the more times the yellow phase signal is flashed.

- *Phase termination by max-out:* As long as the method is in use, actuated signal systems run using green extension time. Regardless of whether the approach is occupied, the green could reach its maximum length and end. On the other hand, if the approach is unoccupied for a predetermined amount of time, the signal may gap out. Red light running is more likely to occur when the frequency of max-out rises.
- *Actuated coordination and control:* This aspect is related to driver expectations. Vehicles with activated control systems frequently move in platoons over a network of interconnected signals. Drivers anticipate that the light will stay green until they have passed the intersection. Drivers anticipate that the yellow will last long enough for them to pass through the intersection and continue with the platoon.
- *Approach grade:* Drivers on downgrades are less likely to stop at a given travel time from the stop line than drivers on level or upgrade approaches. Long yellow intervals can violate driver expectancy as drivers that stop are not rewarded with the red signal. In contrast yellow intervals shorter than drivers off guard and resulted in a high number of red-light violations
- *Headway:* Red light runners are more likely to be those that follow closely, with a headway of less than 2 seconds. The following car is attracted into the intersection when a driver makes a little headway because the leading vehicle is receiving more attention than the surroundings and the traffic signal. (A Toolbox of Engineering Countermeasures to Reduce Red-Light Running 2003)

2.3.1. Vehicle Actuated Traffic Signal Control

The intersection's traffic-actuated signal control operates based on traffic volume and demand. When traffic is constrained, green time may be extended. It uses a sensor and user-programmed settings to regulate the length of the signal in response to vehicle or pedestrian demand. Depending on how much traffic movement is felt, actuated traffic signal control can be classified as completely or semi-actuated.. (Chiguma and Kungliga Tekniska högskolan. Avdelningen för trafik och logistik. 2007)

2.3.2. Fully actuated traffic signal Control

Fully actuated controls are better suited for isolated intersections where all traffic movements are dictated by vehicles and all phases are triggered. should choose which phase should operate for the current traffic situation, the law is pre-programmed. Completely operational traffic signal with split, cycle and phase change sequence. Phases may be skipped if there is no traffic, allowing the controller to move the time remaining on the green signal.

Fully operational traffic signal controls offer many advantages. In particular, it reduces delay compared to pre-timed control by being highly responsive to traffic demand and changes in traffic pattern, allowing phases to be skipped if there is no call for service, and allowing the controller to reallocate the unused time to a subsequent phase using its detection information.. (Chiguma and Kungliga Tekniska högskolan. Avdelningen för trafik och logistik. 2007)

2.3.3. Semi Actuated traffic signal control

Semi-actuated traffic signals let significant movements to receive green until the car dictator installed on the lesser link warns the signal. Only for the minor movement are vehicle dictators offered; they can also be used for the main movement. It has many benefits, including minimizing the delay experienced by the main road users at times of light traffic and being more efficient when utilized in a coordinated signal system than pre-timed control. The main benefit of a semi-actuated traffic signal is that if the determined green and passage time parameters are not suitable, continuous demand on the phases associated with one or more minor movements causes excessive delay to major road through movements, and detectors must be used on the minor approaches which are associated with one or more minor movements which require installation and ongoing maintenance and Finally it needs more training. (Chiguma and Kungliga Tekniska högskolan. Avdelningen för trafik och logistik. 2007)

2.3.4. Pre-timed traffic signal control.

Pre-timed activity control signal is suited to closely divided crossing points where activity volumes and patterns are standard on day to day additionally such conditions are frequently found in downtown zones. They are moreover superior to convergences where three or less stages are required. Pre-timed activity flag has a few focal points, these are utilized to supply compelling coordination with adjoining pre-timed signals where both the begin and end of green are known and it does not require tyrant. (Chiguma and Kungliga Tekniska högskolan. Avdelningen för trafik

och logistik. 2007). Generally, it requires a least amount of training to set up and maintain. However, this control system cannot compensate for unplanned fluctuations in traffic flows and it tends to be inefficient at isolated intersections where there are traffic arrivals are random. Modern traffic signal controllers do not explicitly support signal timing for pre-timed operation because they are designed for actuated operation. Pre-timed signal operations can be accomplished by specifying a maximum green light set.

2.3.5. Adaptive Traffic Signal Control

Utilizing traffic information from signal dictators, adaptive signal control is a technique used to modify the timing of each intersection's signal. It is a dynamic, online, real-time method for reducing traffic congestion that monitors demand and traffic change patterns continuously. (Chiguma and Kungliga Tekniska högskolan. Avdelningen för trafik och logistik. 2007)

2.4. Influence factors of traffic violations at signalized intersections

The first crucial step in successfully managing traffic violations at signalized crossings is to pinpoint their main causes. Four key components, including pedestrian, vehicle, road, and traffic environment, are identified as the main contributors to drivers running red lights. Red light runners are substantially influenced by human variables including age, gender, and occupancy (Fu and Liu 2020). Red light runners tend to have certain vehicle characteristics, including size, speed, license, load, stopping distance, and approach speed. such as the quantity of approaches, the width of the intersection, the style of the intersection, and the speed. Red light runners are impacted by traffic scenario characteristics such as signal mounting layouts, signal timing, approach volume, and red-light cameras**.**(Fu and Liu 2020)

There is no simple explanation or one factor that explains why drivers disregard red signals. There is a propensity to highlight driver faults that were either intentional or signal-ignorant. Signal visibility doesn't want to stop and purposeful infringement during the yellow signal are the main causes of red-light runners.(Ellison 2014)

Traffic flow moment entrance time on the red light and the propensity of the driver to run the red-light signal are characteristics of red-light runners. The left turn vehicle is forced by geometry to travel through the intersection at a slow speed rate and generally experiences more delay in the intersection relative to the through driver. Traffic movement and flow are the different

expectations and experiences of the left turn driver compared to the through driver. (Bonneson 2002)

A lot of drivers ignore the signals from traffic lights. In the United States, there are more than one million motor vehicle collisions at traffic signals every year, and disobeying traffic signals by drivers is a key contributor to these collisions. Running red lights and other traffic-control devices, like stop signs, are the most common type of collision in urban areas, and occupant injuries occurred in 45 percent of red-light running crashes, compared to 30% for other crash types, according to a review of 4,526 police-reported crashes in four U.S. cities. This suggests that fewer accidents involving people running red lights would be especially helpful in lowering crash fatalities in cities. (Komol et al. 2022)

Time-separated traffic signals are intended to lessen auto accidents at intersections where opposing traffic movements occur. The safety of the road traffic system is seriously hampered by violations of traffic laws. According to a survey on road accidents in France, at least one traffic regulation infringement occurs before 92% of incidents. Traffic accidents are currently one of the leading sources of death and financial damage in the majority of developed countries. (Hassen et al. 2011; Bedada 2011)

2.5. The factor contributing to red light running

There are two types of causes for drivers to run red lights: passive and willful. A driver who drives passively disregards external factors like the weather, their level of experience, or the shape of the road when making decisions. The driver's decision to participate in risky driving behavior, such as aggressive driving, peer pressure, and speeding to a safe distance, constitutes the deliberate factor. This deliberate element frequently results in crashes with higher degrees of injury severity at signalized junctions.(Commons et al. 2019)

Red light running was found to be influenced by the driver's age and gender, the number of passengers in the car, the type of vehicle, the type of junction, the signal's cycle length, and the length of the queue. Targeted public awareness initiatives on the risks of running red lights are required.(Ackaah and Aidoo 2020)

Road safety researchers have focused a lot of attention on driver conduct as one of the key factors to counteract red light runner behavior. Since they integrate driver intention and are used to

measure driving maneuvers, driver attributes, vehicle and driver status, weather condition, and surroundings, road safety researchers have developed machine learning and deep learning models for predicting driver behavior. (Komol et al. 2022)

Traffic volume, cycle length, advance detection for green extension, speed, signal coordination, approach grade, yellow interval duration, proximity to other vehicles, presence of heavy vehicles, delay, intersection width, and signal visibility are just a few examples of the many individual factors that affect the frequency of running red lights for drivers. (Bonneson & Zimmerman, 2004). Male drivers, young people, seasoned drivers, bad weather, extended wait times, lowered credibility/low conflicting traffic flow, proximity to the crossing, and herding (when other cars are running red lights, they are more likely to do the same). together with a few buses and trucks. (Traffic rule violations-Red Light Running 2003)

2.5.1. Driver behavior

Road safety researchers have focused a lot of attention on driver conduct as one of the key elements in preventing red light running. Since they integrate driver intention and are used to measure driving maneuvers, driver attributes, vehicle and driver status, weather conditions, and environment, researchers in road safety have developed machine learning and deep learning models for predicting driver behavior. (Fhwa 2005; A.M Yahia et al. 2017)

Red light running is a result of driver actions like speeding and aggressive driving. If the driver mistakes the timing of the signal change, the driver will enter the junction against the red signal. The vehicle may speed in anticipation of the change in signal indication to make it in the yellow signal. The distance required to stop before entering the intersection and the distance required to stop the vehicle increase when traveling faster than the posted speed limit.(Ellison et al. 2015)

Driver red light violation is also a useful characteristic of the driver as intentional and unintentional Un avoidable intentional red-light runner violation occurs if the driver sees the yellow signal light indication but determines that it is impossible to stop safely before reaching the intersection Another helpful trait of a driver is whether or not they intentionally run red lights. If a driver notices the yellow signal light indication but decides it is unsafe to stop before reaching the intersection, they have committed an unavoidable deliberate red-light runner violation. (Ellison et al. 2015). Unavoidable intentional red-light running may be an indicator of a short yellow interval or of excessive speed, a sign of a poorly visible signal. Entry time relates to the time that the driver

enters the intersection after the onset of the red indication. Drivers entering the intersection after the light has turned red may be an indicator of poor signal visibility or poor sight distance along the intersection approach. If cars enter during the initial few seconds of a red light, it may be a sign of impatience caused by an excessive amount of wait, an insufficient amount of time between yellow lights, or an excessive amount of speed. It may also be a sign that the driver doesn't care about the rules of the road surrounding the red indication. (Fhwa 2005,)

2.5.2. Intersection design and operation

Red light violations would be a result of faults in the layout and construction of signalized junctions. Certain geometrical and design factors, such as grade, low visibility, obstructions along the side of the road, line of sight, and traffic volume, may result in inadequate stopping sight distances, confuse drivers, or limit the visibility of traffic control devices. Engineering improvement can correct these design and configuration issues. (Fhwa 2005)

Additionally, the following are aspects that contribute to red-light running and affect how often crashes occur as a result.

- The flow rate on the approach (exposure factor)
- Number of signal cycles in the intersection (exposure factor)
- Phase termination by max-out (exposure factor)
- Flow rate on the conflicting approach of the intersection (exposure factor).
- Probability of stopping in yellow signal (contributory factor)
- Yellow interval duration (contributory factor),
- All red interval duration (contributory factor) and
- Entry time of the conflicting driver to the intersection (contributory factor)

There are also human factors that can contribute to the occurrence of red-light runner crashes include physical or physiological factors like strength, vision, psychological or behavioral factors like reaction time, emotion, and cognitive factors include attention and decision making. (Bonneson 2002)

Red-light cameras (RLC) can be a crucial factor in motivating drivers to stop rather than run a red light. Studies in two American communities, Oxnard, California, and Fairfax City, Virginia, discovered that during the first year of RLC enforcement, infraction rates fell by about 40%

(Elnashar 2004) Additionally, 75 nations throughout the world are said to deploy automated enforcement systems, which have been shown to reduce speeding offenses by 5 to 60 percent, red-light violations by 40 to 90 percent, and collisions by 15 to 90 percent. (Elnashar 2004). On the contrary, there are a few studies done overseas that show otherwise.(Jamil & Shabadin 2016)

Effect of intersection on traffic safety

In Australia, for example, intersection crashes account for about 33% of serious accidents, making them one of the biggest hazards globally. In China, intersections account for about 30% of all traffic fatalities. Complex interactions among the vehicle, road user behaviors, vehicle variables, road geometry characteristics, and environmental elements lead to intersection-related collisions. Accidents are primarily caused by traffic offences, particularly red light running at signalized junctions. According to data collected from China between January 2012 and October 2012, red light runners had specifically caused 4,227 severe injury crashes and 789 fatalities.Traffic offenses at signalized intersections may be effectively controlled and reduced, which would reduce the corresponding serious injuries and fatalities. (Mccrea 2015)

Count down signalized intersection

Count down signalized intersections are intersections where the amount of time until the next red or green light is displayed along with the signal lights. This sort of signal is utilized for both drivers and pedestrians. The majority of pedestrian countdown signals are present in European nations, particularly Japan, and they show the amount of waiting and remaining time for pedestrians. Countdown signals for cars have not yet been adopted in the nation. When compared to other nations, such as European or American nations, the length of the Japanese traffic light signal cycle is relatively long.. (Mccrea 2015)

If drivers are not given information about how much time is still green or red, they may have trouble accurately calculating when the signal will turn red during a green light. A proper traffic signal can lessen drivers' stress and blunders by making it appear as though they are waiting for the green light for a longer period of time than they actually are. This can make drivers make poor decisions since they are under stress. A countdown signal is one of the best ways to lessen driving stress and weariness since it allows drivers to gauge the appropriate timing for maneuvers at intersections, resulting in a smoother flow of traffic and increased safety.. (Mccrea 2015)

Based on their research on a field survey conducted in Turkey and Japan, Ke Yu and Huapu Lu examined how drivers behaved when given a countdown signal while waiting at a red light. The rate of premature start is quite high in Japan, where the signal counts down the display number until just a few seconds before the signal is changed. However, if the number displayed stopped earlier and the startup delay becomes longer on the other hand the rate of premature start can be reduced. In Turkey several factors influence on startup delay from this signal countdown system can shorten startup, especially for large vehicles when the startup delay is originally quite long. The rate of premature start is rather high if there is no camera installed together with the countdown signal and finally countdown signal can reduce stress. (Mccrea 2015)

Yellow Interval Timing on the Frequency of Red-Light runner

Driver choice type, driver expectation, and entry time of the red-light runner driver onto the signalized intersection are features of red-light runner violations. The relationship between these qualities is illustrated below. This classification is based on the Bonneson study, and the driver decision type outlines the rationale behind the motorist's choice to proceed through a red light. When a driver can safely stop but chooses to proceed through the red light, this is known as an avoidable red-light runner event. However, an unavoidable red-light runner event occurs when the driver either believes that they cannot safely stop and chooses to proceed through the red light or is unaware of the need to stop. Most of the time avoidable red-light runner may be an indication of excessive delay or unwillingness of the driver to respect the traffic laws. (Mccrea 2015)

2.6. Crash types related to red light runner

All red-light running crash features have been evaluated in Florida, United States of America, in three categories of risk factors relating to the traffic environment, driver traits, and vehicle type. The findings indicate that a number of factors, including driver age, alcohol and drug usage, physical impairment, and place of residency, are significantly associated with the likelihood of a crash caused by running a red light. According to the data, 6 lane highways have a higher red-light running crash risk than 2 lane and 4 lane highways. The ratio of crashes during the night is 27% greater than during the day, when it is 63.6%, and the ratio of crashes during the weekend is higher than during the week. Cloudy weather increases the likelihood of a crash by 6.5% when compared to wet weather's 17.2%. The outcome also showed that older and younger drivers (55 years and over) are more frequently engaged in red-light accidents. According to a global survey of

researchers, older drivers take longer to process information and make decisions than younger drivers. However, aggressive driving style, careless driving, and speeding are more frequently associated with younger drivers. These actions add to the frequency of crashes and the running of red lights. (A Toolbox of Engineering Countermeasures to Reduce Red-Light Running 2003)

Red light running accidents include at least two vehicles, but they can also involve just one car and a pedestrian or a bike using a different form of transportation. The opposite legal driver or the running the red violator may take evasive measures to avoid the other and crash into a fixed object, such as a signal post, in a single car hit crash. A driver that runs a red light might also strike a cyclist or pedestrian who is legally in the crosswalk. (Accident rate due to motorcycle driver 2021)

Angle and turning crashes are the two most common crash types involving numerous cars. Usually, in an angle crash, the offending car strikes or is struck by a vehicle that is legally approaching the intersection from the opposite direction. When a left-turning car collides with an oncoming vehicle coming from the opposite way, either vehicle may have been running a red light. The majority of studies reveal that three collision kinds were the focus of research on how cameras or other programs affect red light runners. This covers the two s mentioned above, as well as turning and rear-end crashes. Red light running does not cause rear-end incidents; rather, it is the outcome of vehicles waiting for a signal at a junction while others are behind them. (A Toolbox of Engineering Countermeasures to Reduce Red-Light Running 2003)

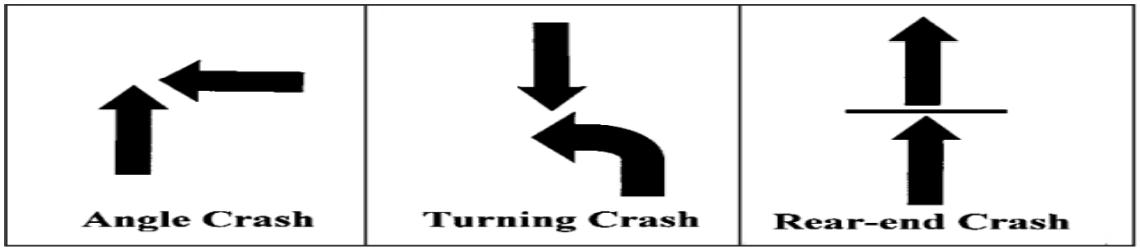


Figure 1 Common Crash Types Associated with red light running

The figure displays the three crash types in developing a red-light camera effectiveness study Persaud and Council noted that the following crash types could be possible target crashes for a red-light runner Right-angle or side impact crashes (Yan 2004)

1. Left turn two vehicles turning or one vehicle oncoming

2. Rear end at straight ahead or while turning
3. Other crashes specifically identified as red light running

Impact of red-light camera on traffic crash

The Urban Transit Institute at North Carolina University presented a recent study on red lights in September 2003. Angle, rear-end, and side-swipe collisions, as well as accident severity, were used to examine the effect of red-light cameras on crashes at signalized junctions. The study lasts 45 months, with cameras being inserted during the first 27 of those months.(Jantosut et al. 2021)

Red light cameras reduce collisions the model suggests that the presence of RLCs may actually be associated with marginal increases in total crash 11 %, angle crashes 8 % and decreases for rear end collisions by -1%. Total collisions did increase from a mean of 16.428 to 16.638 accidents per month per million ADT. Angle collisions also increased with a mean changing from 4.8 to 6.1. However, rear end collisions contradicted the model showing a change in the mean from 5.036 to 5.28.

Comparisons were made between red light camera sites to all other intersections in the data. The fact that red light camera sites are usually selected based on high accident rates or dangerous sites usually those with multiple lanes and high traffic volumes bias the model because the remaining comparison sites are likely less dangerous.(Jantosut et al. 2021)

In one of the most widely reported studies of red-light cameras, the United States Institute for Highway Safety examined four Californian cities—Bakersfield, Oxnard, Santa Barbara, and San Bernardino—before and after installing red-light cameras. Three cities served as comparisons in the study, with Oxnard serving as the treatment site. There were eleven intersection approaches with red light cameras. Data were gathered for both the before and after periods for a total of 29 months. According to the study's findings, installing a red-light camera decreased collisions by 7%, with injury-related collisions decreasing by 29%; right-angle collisions decreased by 32%, with injury-related right-angle collisions decreasing by 68%; and rear-end collisions increased by 3%. (Richard A. Retting, Allan F. Williams, And Michael A. Greene no date) It was concluded as that red-light camera likely reduces collisions, especially injury crashes, at intersections with signals. The study compares the total collisions of every signalized and non- signalized intersection in both the treatment and control sites thus assuming that the effects of the red-light camera are dispersed throughout the city of Oxnard.(Jantosut et al. 2021)

2.7. Research Gap

Red light running was investigated with less attention in Ethiopia which had only a few previous studies on signalized intersection in Addis Ababa.

The study by (Mosisa 2018) characterizes and identifies the most common traffic violations, patterns and magnitude of traffic violations in the Arada sub-city over 3 years. The study also explores the differences between traffic offences by driver and vehicle characteristics. Finally, this study reveals offender attitudes towards unsafe driving behavior with less focus on red lights. According to research by (Bedada 2019), the driving behavior of offenders in Addis Ababa rarely complies with traffic controls. The main objective of this research was to identify which drivers' personal characteristics played prominent roles in drivers' understanding of traffic control devices and to investigate driver compliance to signalized and two-way stop control intersections. A study conducted on evaluating the performance of a signalized intersection and the Associated economic impact of congestion: A case study on Ras Mekonnen Street of Addis Ababa, Ethiopia by: (Gashaw Abate and Teklu Wodajo 2018) Abate was focused on the performance of signaling system along with the cost of congestion results from travel time lost, extra fuel consumption and environmental pollution costs. And the other thesis conducted on the assessment and modeling of driver Behavior in dilemma zone of signalized intersection by Solomon Tsegaye Mengestie (Mengestie 2022) accordingly, the driver becomes indecisive about whether to pass or stop at the intersection on the yellow onset, which is called dilemma zone. The main motive of the study was to investigate the factors that influence driver behavior in dilemma zone at signalized intersections using questioner survey and binary logit model the study is limited in that it doesn't consider much influencing factors other than some.

There is limited scientific literature identifying the rate, conduct, magnitudes, trends, and characteristics, of red-light running behavior at signalized intersections in Addis Ababa. Understanding the most common drivers' behavior, magnitudes, trends, and characteristics during a red light, and identifying the influencing factors and other variables related to driver conduct helps in making interventions toward reducing the number of red-light traffic offenses. So, this study analyzes the safety level of signalized intersections in Addis Ababa by identifying influencing factors from field surveys and drivers' behavior at red lights using questioner survey to spot the perception of drivers about this violation So, this study was motivated by the researcher

to fill the gap on the evaluating red light running conduct by using different methodological approaches and focuses on the way of the drivers understanding about red light running conduct and compliance of traffic signal devices rules and by evaluating signalized intersection characteristics

CHAPTER 3. RESEARCH METHODOLOGY

3.1. Research approach

This chapter discusses the methodology used to achieve the objectives of the study and deals with a clear overview of the study area, the method of data collection, and how the data was selected and organized. Provides a framework in which this research was carried out and presented with emphasis on red light runners at signalized intersections through field survey traffic count, questionnaire analysis, and traffic accident report from the traffic management office. The research finding used to emphasize red light runner frequency and quantity. This could be best analyzed by studying the characteristics of red-light runners

3.2. Research design

Research design is the overall structure of the research study. It is a strategy for answering the research question. The quantitative methodology has been utilized in this research to get and understanding of the cause, and any other related information on the red-light running behavior of the drivers at signalized intersections. This will enable the researcher to grasp the perceived behavioral study from the participant's own red-light running experience. Measure different types of variables and describe frequencies, averages, and correlations. The study also employs these quantitative research methods for the analysis of the magnitude of red light running in Addis Ababa from primary and secondary data sources. visual observations have been undertaken to collect the nature of the signalized intersection, geometric features, and finally traffic count taken.

3.2.1. Study Design

A framework, or the set of methods and procedures used to collect and analyze data on variables specified in a particular research problem Several types of research were reviewed to find the parameters that are used to study the effect of red-light runners in signalized intersections. To study red light running conduct, the above-mentioned factor was studied at the field survey by observation at signalized intersections and from questionnaires.

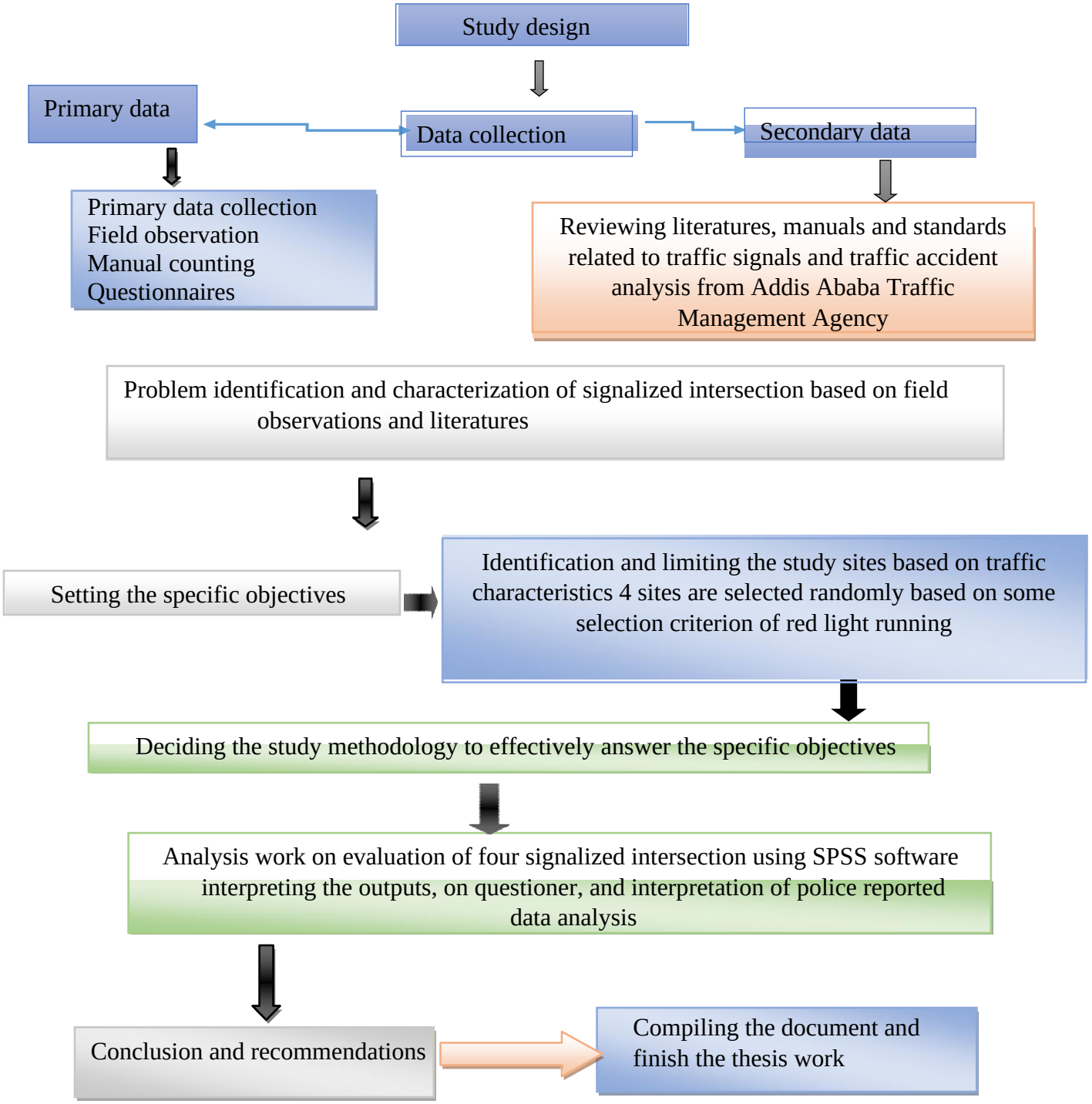


Figure 2 Study processes flowchart

3.3. Study location

Four signalized intersection approaches are selected to collect data for this study in Addis Ababa, Ethiopia. The selected approaches allow for collection of driver behavior data. The identification of an intersection with a red-light-running problem is typically based on consideration of several criteria. Intersection approaches are selected in such a way;

1. Moderate to high volumes of traffic flow (flow of traffic)
2. There are high pedestrian interventions (high intervention of pedestrian i.e. market area)
3. Geometric characteristics of the road (i.e. grade, number of lanes, crossroad width)

The selected intersections which are located in Addis Ababa

- ✓ Shola Gebeya signalized intersection
- ✓ Legehar signalized intersection
- ✓ Churchil Eliana signalized intersection
- ✓ Semen Hotel signalized intersection

3.3.1.1. Description of the Study Area

Addis Ababa is the capital city of the Federal Democratic Republic of Ethiopia (FDRE) and a seat for heads of the African Union which is also a seat for the United Nations Economic Commission for Africa (UNECA) as well as a center of economic and political activities of the country. The total population of Addis Ababa is more than 5,460,591 million (a.a population source.2023)

3.3.1.2. Selected signalized intersections

This section contains information on each of the sites that were chosen. In Addis Ababa, there are 85 available intersections; four intersections were chosen for investigation and evaluation of red light runner behavior based on the aforementioned criterion, and they had the following traffic flow characteristics.

1. **Shola signalized intersection;** this signalized intersection were selected due to its location. The field analysis revealed that this intersection likewise has a signalized interaction with a significant pedestrian movement and intervention on the green. The British Embassy Approach, Minarol Tower, Shola Market Road, and BITS Collage are the four approaches to the Shola signalized intersection. This particular signalized crossroads was chosen because it is close to the "Shola Gebeya" large market in order to evaluate the influence of market areas on red light running behavior where there is increased traffic and pedestrian flow.

Figure 3The plan view of Shola signalized intersection

2. **Semen Hotel Intersection**; there is a road network of two-way, and four-way lanes there is a downhill road. Semen Hotel signalized Intersection has four approaches namely Malawi street approach, Senegal street approach, Instituto Italiano de culture approach, and Addisu Gebeya approach.

Figure 4. The plan view Semen Hotel signalized Intersection

3. **Legehar signalized intersection** There is very high traffic flow at this specific signalized intersection. The flow from Mexico to Bole, from Ras Hotel to Legehar, and from Legehar to Ras Hotel; has high traffic flow toward Bole and Mexico. Legehar Signalized Intersection has

four approaches namely Mexico approach, Beherawi approach, Stadium approach and old Addis Ababa train station approach.

Figure 5 Plan view Legehar signalized intersection approach

4. **Churchill Street signalized intersection**; the street has also high traffic flow toward pissa and stadium. Churchill street signalized intersection has four approaches this are General Winget approach, Wawel Street and Churchill Avenue approach. This signalized intersection has high traffic volume and steep gradient.

Figure 6 The plan view of Churchill Street signalized intersection below

3.4. Methods of data collection and equipment

The process of obtaining, measuring, and analyzing precise data from a range of pertinent sources so as to address issues in research, provide answers to queries, assess results, and predict trends

and probability. Quantitative data gathering techniques from both primary and secondary data sources were employed to meet the study's objectives.

3.4.1. The primary data

The process of gathering primary data consists of two steps. The first steps involved gathering data from a field survey. Observation sheets were made, and observed and measured data were entered on the sheet. The second activity involved handing out questionnaires to drivers in a few key locations and gathering their responses. Specific questions were developed, converted to the federal language of Amharic, duplicated, distributed, and collected, and then evaluated using an Excel spreadsheet.

3.4.1.1. Manual traffic volume counts

The field survey data collection can be used to assess how various pedestrians and drivers behave in an uncontrolled environment. This technique makes it simple to gather information on traffic volume, vehicle categorization, and turning proportions, and the data may be used immediately.
Prior to gathering field measurement data, preliminary studies were carried out at each signalized intersection to survey the area and determine which day would be more effective for demonstrating the behavior of vehicles who ran red lights. On Monday and Friday, there is a lot of traffic and congestion, and on the weekends, signalized intersections are not working and there is also less traffic flow. In order to capture the true behavior of red-light runners at signalized intersections, traffic counts will be taken on the three days of the week—Tuesday, Wednesday, and Thursday. Additionally, the teams of researchers and observers recorded signal timing and phasing, evaluated geometrical intersections of the road, and physically observed pedestrian crossing behavior.
The field survey data collected for this study include;

- ✓ Traffic volume count violation rate (red light runners) and respecting rate of drivers (green and yellow light runners)
- ✓ Pedestrian count (who are crossing on the green light phases)
- ✓ Crossroad width
- ✓ Number of lanes
- ✓ Signal cycle time (green, yellow, and red)
- ✓ Grade

Data collection format was prepared which allows the observer team to collect, and filter the required variables for the study. Counts were collected on selected signalized intersections using pen and paper. By assigning four persons two are responsible to count through vehicle pass from one bound and the other Pearson is responsible for the opposite direction bound. The count was showed to determine the number of vehicles that violated the red light and respected as well as pedestrians who have violated during the green light.

Typical count periods are 15-minute intervals. Data for this study were collected starting from March 1, 2023, G.C. to March 15, 2023, G.C. The traffic volume count was made starting on the morning from 7:45am to 12:15 pm. It was taken for through vehicles and a manual count with in a signal cycle could be used to obtain the traffic volume data. The vehicles were counted in the category of Car, Bus, and heavy vehicle.

The study focused on collecting the following data which are relevant to the nature of the research:

- Intersection engineering characteristics. These include the type of intersection (number of legs in each intersection), the number of lanes, grade of the road, the width of the road, and the signal time.
- Traffic characteristics of the intersection. these include total volume of traffic at the intersection.
- Red light running violation. This includes the number of vehicles that passes during the green light phase, yellow light, and the red-light runners as compared to the number of cars allowed to pass the intersection.

Collecting cross-sectional width and grade

During field measurement, alignment of the legs, the width of traffic lanes, crosswalks, number of lanes, median, and the method of treating and channelization of turning movements have been measured on each approach for the selected intersection. The width of the traffic lane and median measurement is done manually using a tape meter. The rest of the data were collected by visual observation

To gather the cross-sectional width and grade of the road I have used SW Map. SW Maps is a free GIS and mobile mapping app for collecting, presenting, and sharing geographic information. Right

now, AACRA is using this software to collect data like crossroad width, grade, land feature, and other geometric features of the road.

The field survey count for each approach and the geometric feature is summarized in Tables 1 and 2 below.

Intersection Characteristics	**Lagahare**	**Churchile**	**Shola Gebeya**	**Samene Hotel**
Target approach	EB, WB	NB, SB	EB &WB	NB & SB
Median type	Raised	Raised	Raised	Raised
Waring sign	Yes	yes	yes	Yes
Crossection width	33	29.75	34.6	14.9
Pedestrian light	No	No	No	No

Table 1 Intersection characteristics

Signalized intersection	Direction	Yellow light time(S)	Green light time(s)	Red light time(s)	Cycle Length	Number of lanes	Speed limit	Grade (%)
Legahare	WB	3	80	100	183	3	No	-4.1
	EB	3	80	100	183	4	No	4.1
Churchile	NB	3	85	110	198	4	50	8
	EB	3	85	110	198	4	50	-8
Shola Gebeya	WB	3	70	100	173	4	50	-9.1
	EB	3	70	100	173	4	50	9.1
Semen Hotel	NB	3	130	50	183	3	30	5.1
	EB	3	100	80	183	3	30	-5.1

Table 2 Selected signalized intersections each bound characteristics

3.4.1.2. Questionnaires

Surveys offer a comprehensive viewpoint from sizable populations. Based on the investigation of data from all Addis Ababa drivers that was conducted in accordance with the aforementioned objectives. Instead of asking respondents about their beliefs about running red lights, the survey focused on what drivers reported about their red-light running behaviors.

The sample size used for the Attitudinal survey

Sample size determination for traffic offenders Number of traffic offenders involved in traffic offenses was calculated by the sample size determination of Cochran's formula for the unknown population because the exact number of drivers that were traffic offenders was not accurately known. (Scott & Smith, 2015). It was assumed that the common and traditional confidence level, 95%, +/-5% (e) standard error for precision, and (p=0.5), assumed standard deviation) and hence q=1-p=0.5. A 95 % confidence level to determine the appropriate sample size, level of precision, level of confidence, and degree of variability has to be taken under consideration

$n = \frac{Z^2(P)(1-P)}{W^2}$ Equation 1 sample size required for attitudinal survey

Where,

Z= confidence interval N= total population

n= sample size W= margin of error

P= proportion of the population in the previous study

Determine the critical standard score (z)

To find this score some assumption has to be considered with normal distribution. Level of precision e=±5%

Z at confidence interval 95%=1.96

Degree of variability p=1-0.5=95%, z^2

$$n = \frac{1.96^2(0.5)(1-0.5)}{0.05^2} = 385$$

> 385 respondents were considered having included a non-respondent rate of 10%, the final sample size reached 422.

Data Collection Procedures

Questionnaires were distributed randomly around at four taxi terminal stations namely; Megenagna taxi station, Stadium taxi station, Churchil taxi station and at Giorgis taxi and bus terminal to drivers of taxis, private car owners and public transport drivers to gather information

on their behaviors during red light at signalized intersections. Before starting the delivery of the questionnaires to the respondents, they were asked whether they are willing to participate or not, then it was carried out. In this study, 412 drivers were willing to answer the prepared questions excluding those unwilling and who failed to finish all the questions. And the questionnaire was distributed to 412 vehicle drivers who were around and willing to complete the questionnaires

3.4.2. Secondary data's

Secondary data are gathered from various sources and organizations. Data on violations of the road traffic signal in Addis Ababa city was gathered by two organizations. The Addis Ababa traffic police management and Addis Ababa traffic management office are the first concerned body to gather traffic collisions. Data is gathered in PDF and Excel files as well as on paper. The eleven sub-cities are in charge of collecting the data (driver information, passenger or pedestrian information, location, weather information, road geometry information reason for the accident, and the accusation reason) regarding serious injury, slight injury, and property damage in their sub-cities in detail. The whole gathered data is documented in paper form.

3.5. Variables of the study

Dependent Variable

Red light running is the dependent variable of this study.

Independent Variables

Several independent variables were examined in this study. These included sociodemographic factors such as age, gender, marital status, degree of education, and years of driving experience that were associated with traffic offenders. Additionally, there are the characteristics of the traffic light area, such as the number of legs, slope, lanes, vehicle type, and signaling time. The following table provides a summary of these factors;

Variables	Definition	Categorical Values
Age	Indicates the driver's age of the respondents. Four groups are divided in this study.	18–30 31–41 42–52 ≥53

Gender	Indicates the sex of drivers who have involved in RLR	Male Female
Driving Experience	Indicates driving experience of the respondent. Four groups are divided in this study.	1-5 5-10 10-15 More than 15
Types of vehicle	Indicates a classification of vehicles based on ERA classification	Car Bus Heavy Vehicle
Number of lanes	Indicates the number of travel lanes.	One Two Three Four Six Others
Days of the week	Days of the week when red light running occurring	Day of the week i.e. Monday, Tuesday, etc. Weekend Saturday and Sunday
Time of day	Time of day when most red light running occurs	12:01 a.m. – 6:00 a.m. 6:01 a.m. – 12:00 p.m. 12:01 p.m. – 6:00 p.m. 6:01p.m – 12:00 am
Traffic police	Indicates whether drivers run the red light at rush hour with the presence of traffic police around the signals	Yes No

Slop Grade	Indicates whether red light running is related to the grade of the road	Upward Downward
Yellow light	Indicates whether yellow light is influencing the occurrence of red light running	+ve influence -ve influence
Cycle time	Indicates whether cycle length is influencing the occurrence of red light running	+ve influence -ve influence
Crossection road width	Indicates whether Crossection road width is influencing the occurrence of red light running	+ve influence -ve influence
Red cycle time	Indicates whether Red cycle length is influencing the occurrence of red light running	+ve influence -ve influence

Table 3. Independent variables

3.6. Methods of Analysis

The information gathered for this investigation was analysed using several statistical techniques. The t-test and the Chi-square test are also used in this study to analyze the independent variables and the other variables. The magnitude of the independent variable's influence on the dependent variables was determined using regression analysis. The descriptive and statistical analyses' results were obtained using the SPSS program. The independent t-test in SPSS can be used to evaluate the hypothesis of homogeneity of variance. An F statistic and a significance level (p-value) are provided by this test for homogeneity of variance. The variances of the two groups can be treated equally if the significance level exceeds a pre-determined critical value of significance (for instance, 0.05).

To examine the differences in the mean values of the dependent variable associated with the effect of the controlled independent variables by taking the null hypothesis that there is no significant difference between the means of different populations. A dependent variable that is measured is required for an analysis of variance. A single or more independent variables are also required. All

of the independent variables must be continuous or categorical. Depending on the amount of independent variables taken into consideration for the study's objective, the sort of analysis would be made for looking at variances.

Data analysis involves computing particular indicators and looking for any possible patterns of correlations between dependent and independent variables. The data were evaluated in accordance with the goals of the study and their nature. Data analysis, presentation, and interpretation were done using descriptive analysis, which was done prior to the analysis. Excel software was used to process the data obtained from the Addis Ababa City Traffic Police Office. In regard to this, the information was arranged and displayed as column bar charts. Data analysis for an investigation was done, and descriptive analysis was performed.

Driver behavior at a signalized intersection is determined by the relationship between red light runner and behavior using an Excel sheet, and chi-square. Regression analysis was used to identify the size of the effect of the independent variable on the dependent variables. Data collected from the field observation were processed using descriptive statistics, multiple linear regression models in the Statistical Package IBM SPSS Statistics 23 software, and Advanced Excel.

3.6.1. Multiple linear regression and assumptions

Data that has been observed in the study geographical area, such as the analysis of traffic flow, the number of pedestrians crossing at intersections, and the total number of red-light runner cars, are included in the analysis of survey data. The total number of vehicles moving through a signalized intersection in a research area is referred to as the analysis of traffic flow. Multiple Linear Regression was used to examine the data in order to describe the relationship between the dependent variable and one or more independent variables.

Data on the number of vehicles passing through this intersection is analyzed based on the intersection, vehicle class, cross-road width, vehicles that pass through a yellow light, and the number of lanes.

The dependent variable that is linearly related to k independent or explanatory variable X_1, X_2...Xk through the parameter β_1, β_2…….βk and we write

$Y= \beta_0+X_1\beta_1+X_2\beta_2+\ldots\ldots\ldots\ldots...X_k\beta_k+\varepsilon$

- ✓ Y Dependent Variables red light runner
- ✓ X_1, X_2, X_3…...Xn = independent variables include vehicle type, yellow light runner, red light cycle, pedestrian, cross road width, and number of lanes
- ✓ β_0 = Constant
- ✓ β_1, β_2, β_3, and βn are the regression coefficients
- ✓ ε= represents regression residua

This is called the multiple linear regression model. The parameter β_1, β_2……. βk is the regression coefficients associated with X_1, X_2……Xk

After the regression equations are constructed, a process of testing was used. The testing process aims to find out the best suitable model that represents the given data. The analysis procedure was based on three main statistical regression tests, which are:

1. Test of hypothesis (T-test).
2. Coefficient of multiple determinations (R2)
3. Analyze of Variance Test (ANOVA – Test)

The T-test of the hypothesis is incorporated to study the relationship between each of the regression coefficients (β0, (β1, and β2 … βn)) and the response variable at a certain degree of confidence (assumed 95% in this study). Hence the test was conducted for all of the regression coefficients in the regression model.

The effectiveness of a fitted regression model was demonstrated using the coefficient of multiple determination (R^2). The R^2 is a figure that represents the percentage of variability in the response variable that the regression model can account for. The coefficient accepts values between 0 and 100, where 100 indicates perfect correlation between the variables.

The Analysis of Variance test (ANOVA) is a potent tool for determining the relationship between the independent variables (vehicle, yellow light, crossroad width, grade, pedestrian, red light cycle, number of lanes, and heavy vehicle) and the response variable (red light running in this study). To determine the accuracy of the regression line, the ANOVA test expands the t-test for a broader null hypothesis. This demonstrates the crucial evidence to accept or reject the regression model.

3.6.1.1. Pearson correlation analysis

Pearson r is designed for interval/ratio level (continuous) variables. It can also be used if you have one continuous variable and one dichotomous variable. The correlation is expressed in the form of a coefficient. Symbolized as *r*, a correlation coefficient is normally reported as a decimal number somewhere between +1.00 and -1.00.

Positive, Negative, or Zero Correlation

Positive and negative signs denote correlations that are positive and negative, respectively. A positive correlation means that as one variable rises, the other rises as well, whereas a negative correlation means that as one variable rises, the other falls. However, the value alone reveals how strong a connection is. It's crucial to remember that correlation doesn't reveal anything about cause and effect. The correlation does not describe how one variable affects another. The coefficient of correlation is typically interpreted verbally to provide a response. The relationship the following Table makes interpreting coefficient simple. 4 (Walter A. Shewhart And Samuel S. Wilks, 2004).

Size of Correlation	Interpretation
1	Perfect Positive/Negative Correlation
± .90 to ± .99	Very High Positive/Negative Correlation
± .70 to ± .90	High Positive/Negative Correlation
± .50 to ± .70	Moderate Positive/Negative Correlation
± .30 to ± .50	Low Positive/Negative Correlation
± .10 to ± .30	Very low Positive/Negative Correlation
± .0 to ± .10	Markedly Low and Negligible Positive/Negative Correlation

Table 4. Person correlation interpretation

CHAPTER 4. RESULTS AND DISCUSSION

4.1. Introduction

This chapter focuses on: a) To assess the frequency of red light running relative to other traffic rule violations through the data from the concerned office b) To investigate the impact of driver behavior on red light running violation variation emphasized on descriptive analysis of driver's violation of RLR. This part describes an analysis of questionnaires by using tables, graphs, and chi-square analysis methods including the frequency of the respondent's RLR offense trend and. c) Finally, the analysis of factors affecting RLR in Addis Ababa city is also discussed in this chapter to assess the impact of signalized intersection location on traffic light offense by considering some independent variables which have an impact on the red light running the detailed correlation analysis between RLR and independent variables using multiple linear regression analysis, person correlation analysis on SPSS software.

4.2. Characteristics of police-reported road traffic violation in Addis Ababa over eleven Year Period

All road accidents, even property damage accidents, are required to be reported. Yet, the traffic police officials of different office readily acknowledged during the discussion that not all accidents are reported to them and their statistics greatly underestimates the extent of the true accident situation

The main task of this section is to quantify, characterize, and interpret trends in traffic rule violations including red light running conduct reported to police over an eleven-year period in Addis Ababa. The characteristics considered in the paper include the magnitude, where traffic rule violations occurred, and when violations occurred.

The data for each sub-city was collected from the Addis Ababa traffic police office for the period from 2018 to 2021for (four years) which was the latest data available at the time and the reasons for the penalty of driver's road traffic rule violation.

4.2.1. RLR distribution in Addis Ababa

The RLR in each sub-city of Addis Ababa for the past four-years distribution is collected. The frequency of red light running in Addis Ababa varies from one sub-city to the other. This variation in the frequency of red-light running violations has led to the need for the identification of

influencing variables and factors for taking appropriate policy measures at relevant accident locations by considering each sub-city. Figure 7 shows the distribution of several respective accidents including red light running offenses in each sub-city. Accordingly, Bole (26.03%), Kirkos (18.97%), and Lideta (15.96%) sub-cities were the three leading sub-cities in the frequency of RLR being the 1st, 2nd, and 3rd ranked. Nifas-Silk/Lafto (15.3%), Kolfe (7.85%), and Yeka (6.74%) Arada (4.77%) sub-cities followed with 4th, 5th, 6th, and 7th ranked respectively. Therefore, the following figure is devoted to present the distribution of RLR in each of the sub-cities in Addis Ababa

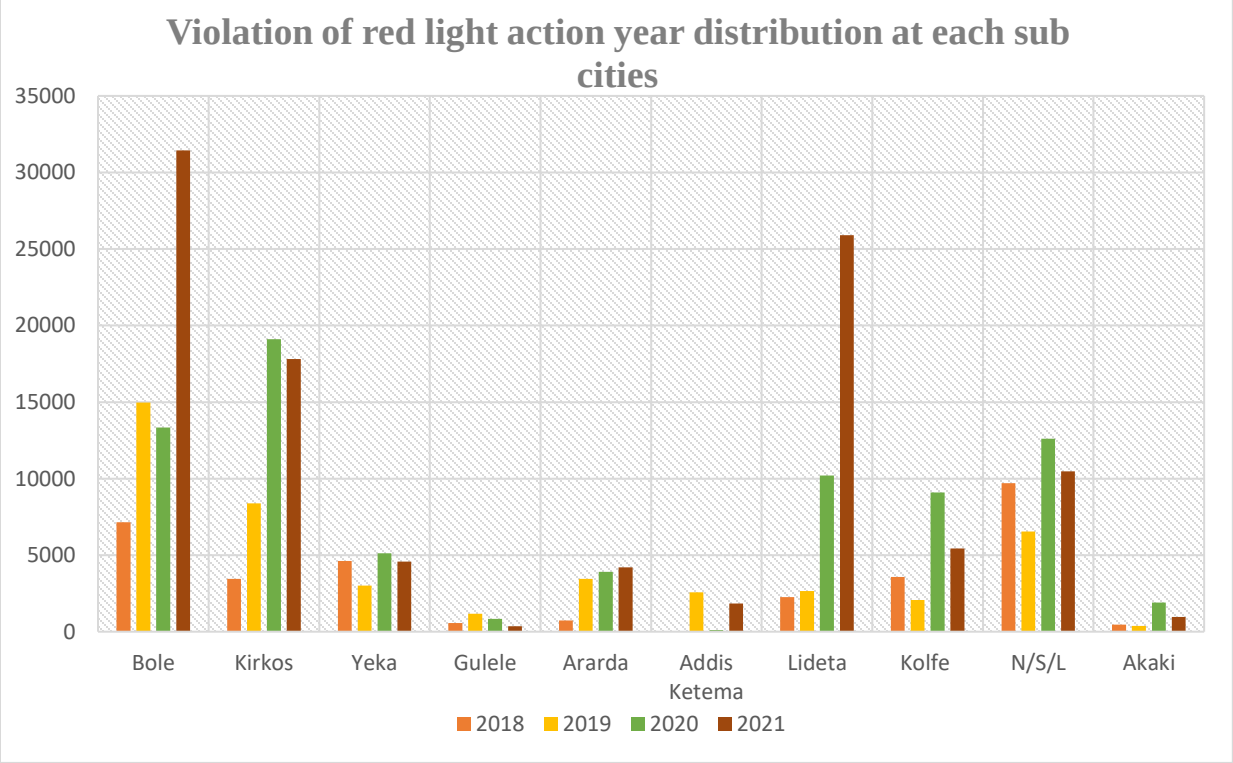


Figure 7 Red light running violation distribution at each sub-city

According to the recorded data shows in recent years it is seen that the rise of red light running is a vital problem in the city; for instance in 2021 in Bole sub-city red light running conduct frequency reaches 31450 it accounting for about 12.23% of the total red light running violation record in 2021 only in Bole sub city and 25912 which is 63.15% of total violation recorded at Lideta Sub city at this specific year (2021), while the least violation was recorded at Addis Ketema sub city in 2018 there is no any red light running reported according to the data gathered.

4.2.2. Distribution of traffic rule Violations by year in Addis Ababa

The following Figure 8 shows traffic rule violation data distribution that occurred in the past four years in each sub-city. According to this chart, there are a large number of red-light running violations occurring in Addis Ababa in the past four-year.

It can be seen from the following figure red light violations is become rapidly increasing and it is the leading violation among other reasons of accusations of drivers by comparing the frequency of violations on action taken on drivers, namely action taken on drivers without permission at all, action taken on drivers driving with technical defects, action taken on driving without a belt, action taken on drivers without permission at all and action taken on red light runners.

Among the four-year traffic rule violation distribution, red light running comprised 335946 (44.40%) of all traffic rule violation types, while driving without a belt accounted for 98904 (13.07%).it is the second-ranked violation among the five traffic rule offenses.

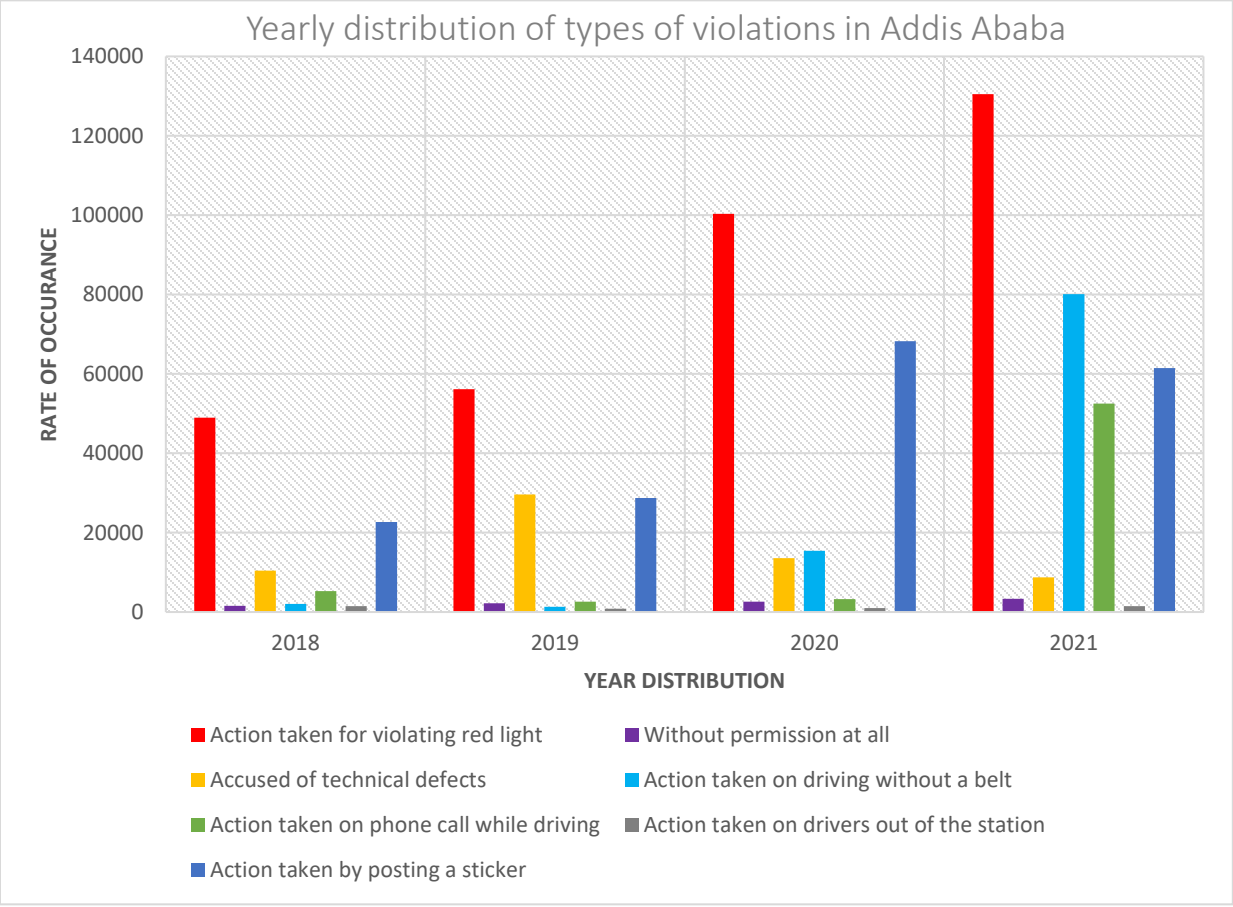


Figure 8 Traffic rule violation statistics including red light running in Addis Ababa

4.3. Descriptive Statistics

Demographic characteristics of the driver who participated in the attitudinal survey conducted to see their understanding of red traffic light at the signalized intersection were presented as follow. Out of 422 questionnaires distributed to the drivers' 412 questionnaires were responded to with a return rate of 97.63%.

4.3.1. Drivers factor by gender

From among the participants, males and females were compared to determine male drivers participated in attitudinal survey was contributed 374 (90.77%), and the rest, 38 (9.22%), were female.

Variable	Category	Frequency	Percent
Gender	Male	374	90.77%
	Female	38	9.22%

Table 5. Frequency and Percentage of drivers‟ gender

Table 6 shows among the questioned drivers (60.67%) did not run red traffic lights, and the remaining drivers have run red lights and those drivers are about (39.32%) All categories of individuals run red lights. Overall, 39.32% of the respondents reported running red lights.

Comparisons	Frequency	Percent (%)
No	250	60.67
Yes	162	39.32

Table 6. Drivers' RLR participation frequency

By considering a 95% level of significance, the critical chi-square value is 3.843. The calculated chi-square values were greater than the critical value. Consequently, in agreement with the below analysis, the chi-square test result confirms the presence of statistically significant differences among male and female drivers in RLR in the city. The chi-square value greater than the critical value of 95% confidence interval i.e., 3.843, shows the presence of effects between the driver's gender and RLR conduct at signalized intersection.

Category	Observed violation value	expected value	Observed non-violation	Expected non-violation	Chi-square	Calculated X^2
Male	156	147.05	218	226.94	3.841	4.3820
Female	6	14.94	32	23.05		

Table 7. The chi-square test result of driver's gender and violation

Some groups reported significantly more red light running. Younger drivers and those with lower driving experience tended to report more red light running., unmarried respondents interestingly, were more likely to run red lights than married does.

4.3.2. RLR frequency factors by Age

The distribution of red-light running rate varies with age distribution. The respondents' age ranged from 18 to 52 and above

Variable	Category	Frequency	Percent
Age	18-30	156	37.86%
	31-42	127	30.82%
	43-52	84	20.38%
	>52	40	9.7%

Table 8. Frequency and Percentage of drivers‟ age category

The following table 9 shows there is a higher number of red-light running rates by younger people age group of 18-30 years among 156 respondents 101 drivers conducted red light running in this age group this accounts that 62.34% of the total red light running conduct, most of the young people participate in a red-light violation and due to this high activity and movement they will put their lives in hazard younger people could be a cause of a traffic accident. A chi-square test was conducted to observe age participation in red light violations. The result is presented on table 17.

	RLR Frequency Observed Values				
Age	Never	Rarely	Sometimes	Often	Always
18- 30	55	12	63	21	5
31-42	100	11	6	6	4

43-52	55	12	17	0	0
>52	40	5	0	0	0

Table 9. Frequency and Percentage of drivers‟ age category and RLR violation

4.3.3. RLR Frequency of drivers factor by Educational background

Table 10 below shows the rate of educational background among which Primary school (28.15%), and High school (42.71%) educational level were committing high rate towards running the red light. Similarly, the Vocational (11.65%), and Degree and above (17.47%) levels violated lesser. Accordingly, as the driver's educational level increased the driver's violation towards traffic lights decreased.

Variable	Category	YES	NO	Percent
Educational Background	Primary school	73	43	28.15%,
	High school	131	45	42.71%
	Vocational	28	20	11.65%
	Degree and above	48	24	17.47%

Table 10. Driver's RLR frequency based on educational background

In Table 11, the association using chi-square was tested for the association of education level of drivers conducted towards red light running was tested and showed an association. Since the p-value (0.038) critical chi-square (7.815), then it rejects the null hypothesis. The null hypothesis of independence between the educational background level of the drivers and red-light running frequency is rejected at p-value <0.05 [It is evident that the RLR rate is related to the educational background of the drivers in Addis Ababa city.]

Category	Observed value	Expected value	Observed non-violation	Expected non-violation	Chi-square Critical Value	Calculated X^2
Primary school	49	44.0388	63	69.96	7.815	8.5845
High school	53	66.058	115	101.94		
Vocational	36	25.165	28	41.83		
Degree Above	24	26.737	44	44.26		

Table 11.Chi-square results of driver's educational background and RLR frequency

4.3.4. Drivers factor by Marital status

The following Table 12 shows that 31.06% of respondents have no parents or they are Unmarried whereas out of the total respondents (68.93%) drivers are unmarried

Marital status	Variable		Frequency	Percent %
	Violation	Non-violation		
Married	58	222	284	67.96 %
Unmarried	104	28	128	32.03%

Table 12. Driver's RLR frequency based on marital status

In the association analysis of the marital status of the respondents and the red-light running frequency, the result is given below in Table13 by considering a 5% level of significance, the critical chi-square value is 3.841. The calculated chi-square values (36.36) were greater than the critical value. Consequently, in agreement with the below analysis, the chi-square test result confirms the presence of statistically significant differences among married and unmarried drivers in red light running conduct in the city. Meaning, the chi-square value greater than the critical value of 95% confidence interval i.e., 3.841, shows the presence of significant effects between the driver's marital status and violation of traffic lights

	Observed married	Observed unmarried	Expected married	Expected unmarried	O - E (Violation)	$(O-E)^2$	$(O-E)^2/E$	Chi square (Critical X^2)	Calcula-ted -ed X^2
Violation	58	104	108.9	50.1	-50.9	2590	23.790		
Non-violation	222	28	175.08	78.91	46.92	2201.	12.574	36.36	3.841

Table 13. Chi-square results of driver's marital status

4.3.5. Drivers factor by Experience of driving

Frequency distribution of the respondents according to their response rate based on driving experience is listed in Table 14. As driving experience increased the red-light running frequency decreased and vice versa this relationship is shown in Table 15

Variable	Category	Frequency	Percent

Driving Experience	1- 5	155	37.62%
	5-10	129	31.31%
	10-15	119	28.88%
	> 15	9	2.18%

Table 14. Drivers' non-compliance frequency based on the driving experience

By considering a 5% level of significance, the critical chi-square value is 22.46. The calculated chi-square values of all the RLR frequencies evaluated were larger than the critical value indicating that there are reasons to believe that the variables are dependent. According to the table, the null hypothesis of independence between the driving experience and red-light running frequency device is rejected at p-value <0.05. Is red light running highly related to the driving experience. Since the tabular value (7.815) is smaller than the calculated value (12.66), reject the null hypothesis, meaning that the characteristics i.e. driving experience and red-light running rate is dependent on each other. This output is shown in Table 15

Category	YES	Expected violation	NO	Expected non-violation	SUM	Critical ^{2}	Calculated x^2
1- 5	43	60.9466	112	94.0534	155	7.815	12.66
5-10	56	50.7233	73	78.2767	129		
10-15	54	46.79126	65	72.20874	119		
> 15	9	3.538835	0	5.461165	9		
SUM	162			250	412		

Table 15. Chi-square result of drivers' experience and non-compliance frequency

4.3.6. Variation of accidents by days of the week and by hours

The results show in the following figure that drivers were most likely to run red lights on weekday mornings while going to work or school. Given in the next findings that being in a rush predicted their behavior, it makes sense that these times of day and destinations would predict red light running. According to the result from the questionnaire based on the perception of the drivers most red-light running violations.

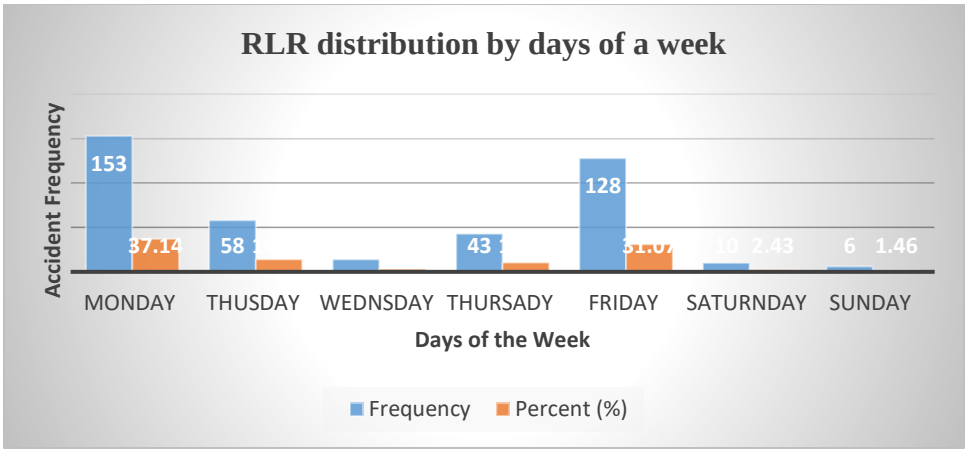


Figure 9. Distribution of RLR by days of the week

Figure 9 presents RLR violation variation by day of the week. This shows that there is a significant variation between days of the week as the driver's perception. However, a higher value is depicted on the graph during the weekdays i.e. Monday, and Friday this is because of the likelihood of a higher rate of traffic flows on these days likewise there is a higher amount of congestion around signalized intersections.

Figure 10. Shows an hourly variation of RLR rate and the peak frequency corresponds with morning traffic volume peaks 12:01 a.m. – 6:00 a.m. This is due to there being the highest amount of traffic congestion at the morning peak hour. However, more rate of RLR occurred during 12:01 p.m. – 6:00 p.m. hours which is in the evening. Most probably, drivers are stressed and fatigued during these hours and relatively 6:01 a.m. – 12:00 p.m. and 12:01 p.m. – 6:00 p.m. had the lowest RLR rate.

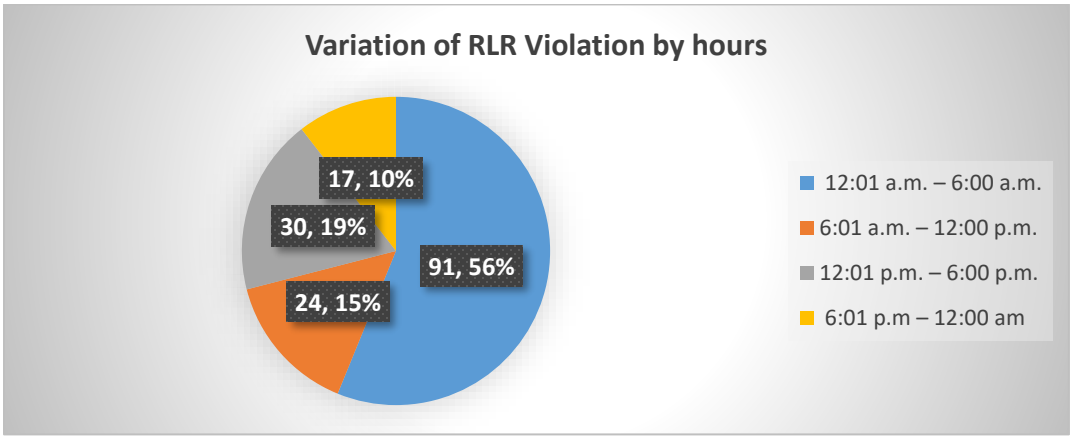


Figure 10. Distribution of RLR by Hour of a day

4.4. Perceptions of the drivers about red light running and their frequency distribution

As described in the above section, the last part of the questionnaire includes questions directly related to the occurrence of RLR behavior at signalized intersections the following section provides a summary of the frequency of the violation and the principal reason for committing the violation for the case. While drivers gave very specific reasons for each category

As can be seen in Table 16 most drivers 218 (52.91%) prefer to stop driving when they normally face red traffic light at signalized intersections despite 10 (2.43%) running the red light the remaining drivers when they face red light drivers decide based on the condition they come into during the red traffic light these accounts about 176 (42.72%) of the total respondents

Conduct of the drivers	Frequency	Percent (%)
Run the red traffic light	10	2.43
Slow down and try to stop	218	52.91
It depends on the condition	176	42.72
Other…. (please explain)	8	1.94

Table 16. Drivers act at the signalized intersection facing the red light

Table 17 shows the choice each respondent gave to the question asking “How many times do you try to go through an amber light and end up running through a red light? “

By considering a 5% level of significance, the critical chi-square value is 29.66. The calculated chi-square values of all the RLR Frequency evaluated were larger than the critical value indicating that there are reasons to believe that the variables are dependent. According to the table, the null hypothesis of independence between the age of the driver and the red-light running frequency device is rejected at a p-value <0.05. Compliance is highly related to the age of the driver. Since the tabular value (21.03) is smaller than the calculated value (29.66), reject the null hypothesis, meaning that the characteristics i.e. age of the driver and red-light running rate are dependent on each other.

	RLR Frequency Expected values					Chi-square	Calculated X^2
Age	Never	Rarely	Sometimes	Often	Always		
18- 30	94.66	15.15	32.56	10.22	3.41	21.03	29.66
31-42	77.06	12.33	26.51	6.47	2.77		
43-52	50.97	8.16	17.53	5.50	1.83		
>52	27.31	4.37	9.39	2.95	0.98		

Table 17. The chi-square test result of the driver's age and RLR violation frequency

It is concluded that the driver's age and red-light violation rate are dependent. All drivers commit red light running violations at least once in their driving experience and younger drivers committed to red light running more frequently than older drivers.

Table 18 also provides information on the percentage of respondents who had been involved in red light running crashes or had been ticketed for red light running. A significant number of respondents 101 (62.34%) had been involved in red light running but neither ticketed nor crash involved, while fewer 9(5.55%) had been ticketed for the behavior. As one would expect, more red-light runners had been ticketed than people responding that they had never run red lights. Some of the respondents that they were involved in crash accounts 52 (32.09%)

Category	Frequency	Percent (%)
Red light running but neither ticketed nor crash involved	101	62.34
RLR crash	52	32.098
Has been ticketed for RLR.	9	5.55
None	0	0

Table 18.Frequency distribution of driver's involvement in RLR

Table 19 shows the choice of each respondent given to the question asked "What type of traffic crashes do you face? " According to their response, the majority of drivers (51.92%) have faced Property damage and about 32.69 % of respondents responded they have faced slight accident the others 9.61 and 5.77% faced fatal and Serious accidents are ranked crashes types

Respondents' perception	Frequency	Percent (%)
Serious	3	5.77
Slight	17	32.69
Fatal	5	9.61
Property Damage	27	51.92

Table 19. Type of traffic crashes respondents face due to red light running

In addition, 54 (33.33%) of the respondents run the red light because the red light is too long to wait for whereas the absence of traffic police at a signalized intersection is also one reason for the drivers to run the red light and these drivers are about 49 drivers (30.25 %) the third leading factor of the reason for red light runners to run the red light when they are in a hurry is 41 (25.31%) also some drivers 10 (6.17%) tends to run the red light when they are not paying attention and the remaining respondents 8 (4.94%) have others reasons according to the conducted survey and this analysis is discussed in Table 20

Respondent's reason why they were running the red light	Frequency	Percent (%)
In hurry	41	25.31
No traffic around me	49	30.25
Not paying attention	10	6.17
The red light is too long to wait for	54	33.33
Other	8	4.94

Table 20. Reason for drivers to run the red light

In answering the question, “How do you think driving above the speed limit around signalized intersection is serious?”, about 63.51% of drivers consider driving above the speed limit around signalized intersection is extremely serious, and also there are small groups, 7.58%, 11.61, and 1.90% considers that very serious, moderately serious and slightly serious respectively drivers don’t think that driving above speed have no any serious accident at signalized intersection this analysis is summarized in figure below Figure 11

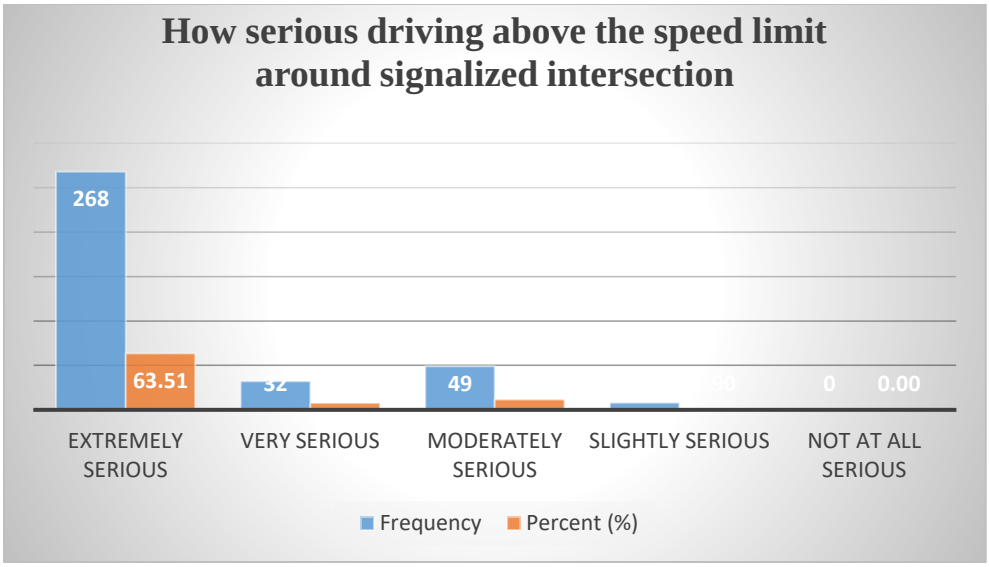


Figure 11. Impact of speeding at the signalized intersection by the perception of the drivers

When asked why they would speed up at signalized intersections, the most common responses were to save time and the least reason is being in a rush. Drivers who slowed down typically did so for safety reasons. The following Table 21 shows that Saving time is the primary reason for drivers to run the red light these drivers account for about 41.26% of the respondents and the second reason 40.53% run a red light is some drivers are frustrated with having to stop again and some drivers 18.20% run the red light when they are in rush drivers they tend to run the traffic light these drivers account around 7.58% of the total respondents but no one enjoyed the thrill of beating the red traffic light

Reason to run the red light	**Frequency**	**Percent (%)**
To save time	170	41.26
I was in a rush	75	18.20
I was frustrated with having to stop again	167	40.53
I enjoy the thrill of beating the light	0	0.00

Table 21. Reason for speeding around signalized intersection

As can be seen from the figure below inspecting the overall percentages for each idea, it was clear that the largest solution type was education. Combining police enforcement, increased fines, and photo enforcement strategies, 20% suggested greater legal enforcement for red light runners.

Education was the second most-mentioned solution type of the respondents suggesting either more education or driver improvement clinics as their first ideas.

Most drivers (33%) recommended that educating drivers about the red-light running risk at the signalized intersection will prevent red-light running violations next to this another way to prevent this violation is changing signal timing this is the second-ranked (28%) prevention method according to the perception of drivers, police enforcement is also third important prevention these respondents are about 20% of all respondents these can be seen in Figure 12

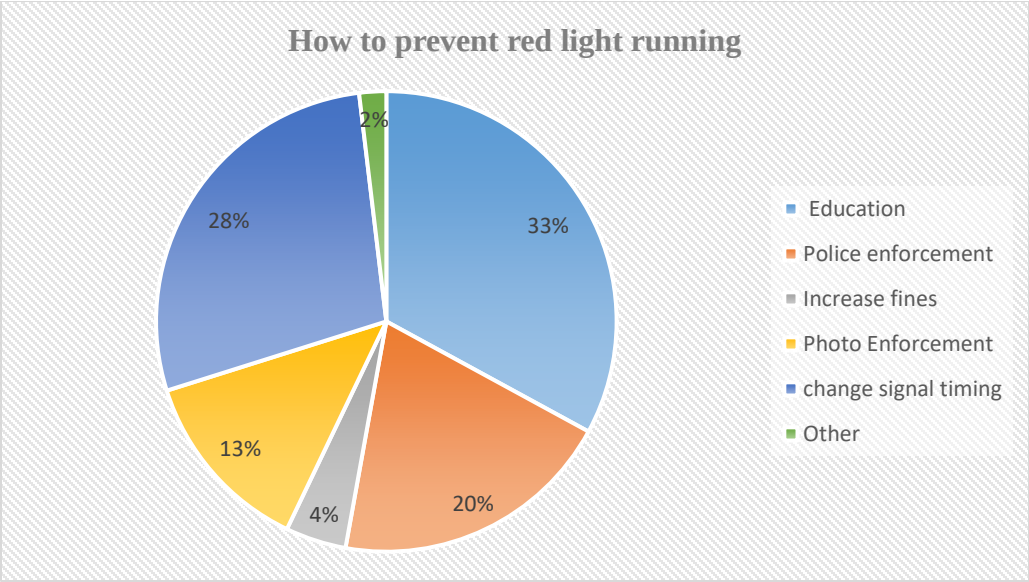


Figure 12.Driver's perception of how to reduce (prevent) red light running

Figure 13 below shows the summary of why would drivers slow down and prepare to stop during red light at signalized intersection drivers think that it is too risky to run the red light and wants to save things to do by deciding not to run the red light at signalized intersection most respondents responded that this is the main reason drivers slow down and prepare to stop during red light at signalized intersection this choice is responded by 237 (56.16%) of the respondents the second 63 (14.93%) of the respondents reason why they prefer to stop at a signalized intersection is that they are afraid of getting hurt in the crash involvement also 61 (14.45%) drivers think that it is their responsibility to stop at red light despite only few drivers 51(12.09%) think that they should follow the low.

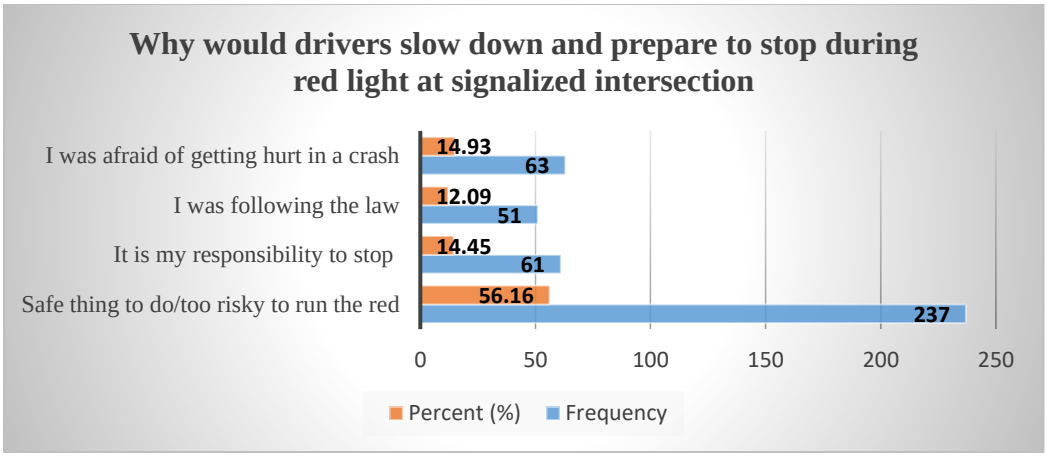


Figure 13. Perception of the drivers that the reason why not to run red lights

The following Table 22 summarizes the response to the question "The traffic light has just turned red. At this time, you notice that there is no traffic near you. Which of the following would you likely do?" According to the response of the drivers; most drivers 262 (63.59) would like to stop at the red and wait until the light turns green whether there aren't traffic police near them but some drivers 114(27.67%) prefer to slow down but proceed directly through the red light since there is no traffic police around the signalized intersection whereas few drivers 36(8.74%) choose to stop at the red, but then proceed through the red light. Accordingly, this shows that drivers would like not to run the red-light weather in the absence or presence of a traffic police

The act of the driver when they face Red traffic light	Frequency	Percent (%)
Stop at the red, and wait until the light turns green.	262	63.59
Stop at the red, but then proceed through the red light.	36	8.74
Slow down but proceed directly through the red light	114	27.67

Table 22. Driver's perception to run or stop with the presence of traffic police around the signals

Several survey questions assessed respondents' concerns about time. Late and approaching intersection that is about to have a red-light question Table 23 shows one of these results, demonstrating most notably that a large number of drivers, 314(76.21%) although not a majority, are willing to speed up to beat a red light that is oncoming. When asked why they would speed up, the most common responses were to save time and be in a rush. Drivers who slowed down typically

did so for safety reasons. Drivers are mostly influenced by the state of activity and next activities whether they are in a hurry, or the presence of several traffic lights these will impact the driver's perception to violate the red traffic light law.

Comparisons	Frequency	Percent (%)
Slow down and prepare to stop at the red light.	98	23.79
Speed up to beat the red light	314	76.21

Table 23. Driver's perception of being in a hurry and having approaching intersections whether to run or stop at a red light

4.5. Pilot-Testing (Validation)

The pilot test of the questionnaire was conducted on 40 car drivers. In the Amharic version instrument administered to car drivers, the participants were 26 (65 %) males and 14 (35 %) females. The time taken to complete the instruments ranges from 20 to 30 minutes. The Cronbach"s alpha for the newly adapted instrument of .593 after pilot testing few, modifications were made for the final instrument. The final instrument of the study contained 19 items.

4.6. Correlation analysis of red-light runners and independent variables

4.6.1. Analysis of Factor Effects

This section's findings are focused on those variables that were found to strongly correlate with the frequency of red-light violations. Each variable utilized in the study represents the events observed during a site observation and traffic count. multiple linear Regression analysis was used to quantify the influence of the independent variable on the dependent variance. The strength of the relationship between the number of lanes and the type of vehicle is also assessed, as well as the correlation between dependent and independent variables using Pearson correlation. Red light runners' and "Red Light Time"

4.6.2. Red Light Running Frequency and Rate

Frequency of the overall number of red-light running violations is one indicator of the extent of the problem. The table below (table 24) provides some indication of the extent of red light running at the intersections. The overall average rate for a typical approach is 39.8 red light runners per 100 cycles and 7.2 red light runners per 1,000 vehicles. Shola Gebeya and Semen Hotel signalized intersections exceed the average rate of red-light runners per 1000 vehicles. Whereas the other two

intersection approaches on the other tend to be below the average rate. The total number of red-light violations at the sample intersections during the surveyed period is 249 violations, with an average of 56 violations per intersection. The highest number of violations observed was 47 and the lowest number was 11

Signalized intersection	Direction	Total Observation				RLR PER 1000 Vehicle	RLR per 100 Cycle
		Total Vehicle	Cycle	RLR	Pedestrians		
Legahare	WB	5290	80	26	45	4.9	32.5
	EB	4377	80	11	52	2.5	13.8
Churchile	NB	4390	80	33	48	7.5	41.3
	EB	4226	80	25	61	5.9	31.3
Shola Gebeya	WB	4757	73	47	151	9.9	64.4
	EB	4591	72	37	144	8.1	51.4
Semen Hotel	NB	3210	80	37	34	11.5	46.3
	EB	3607	80	33	89	9.1	41.3
Total		34448	625	249	624	7.2	39.8

Table 24.Summary of observation result and red-light running rate

4.6.2.1. Red light runner by vehicle type

To gain insight as to whether drivers of certain vehicle types may be more prone to running red lights, the red-light running rate was much high for car-type vehicles. The following figure 14 presents these rates of RLR distribution by vehicle type at each intersection. This is not a surprising result for buses and trucks, given the heavy loads, capabilities, and length. In general Car riders can be considered to be more willing to take risks; thus, a likely greater propensity to run red lights. who overall probably have less respect for traffic control devices than bus and truck drivers.

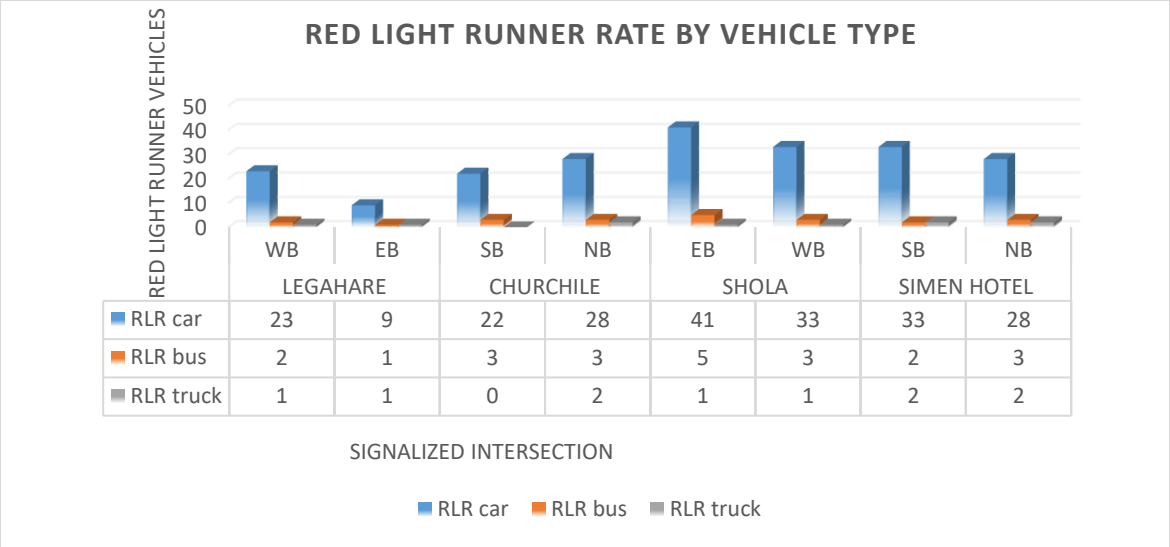


Figure 14.Vehicle type and red-light running relationship

4.6.3. Model Development and Analysis of Relationship

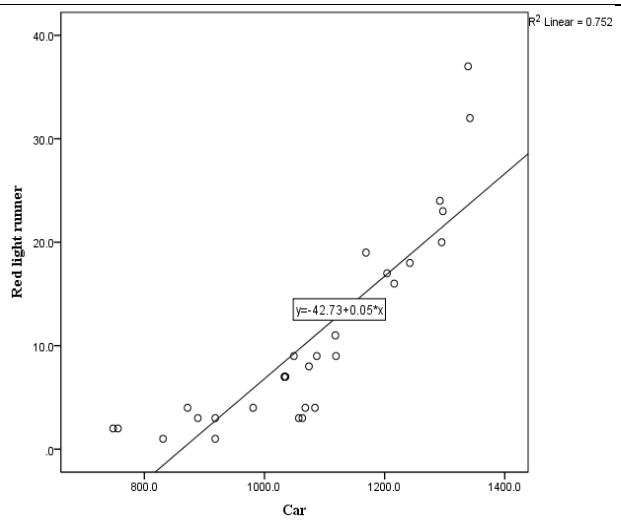
The data were randomly sorted and divided into two parts, one part for analysis of model development and the other part for validation. The Red light running (dependent variables) and Total vehicle, Pedestrian, Number of lanes, and red cycle time, green light time (independent variables).

4.6.4. Multiple linear regression analysis for red light runner

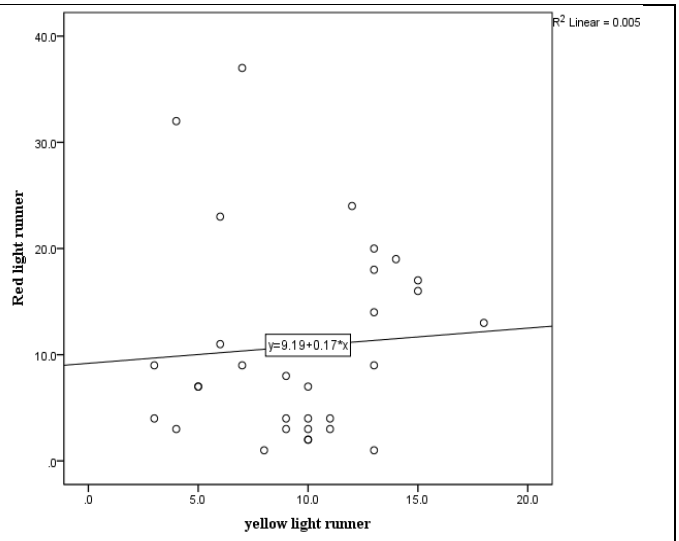
Analysis of survey data includes data that has been observed in the study area such as the analysis of the flow of traffic, and the total number of RLR vehicles analysis of traffic flow refers to the total number of vehicles passing through a signalized intersection in a study area. Data were analyzed with two methods that are Pearson Correlation and Multiple Linear. Multiple regression considers the effect of more than one explanatory variable on some outcome of interest. It evaluates the relative effect of these explanatory, or independent, variables on the dependent variable when holding all the other variables in the model constant. A dependent variable is rarely explained by only one variable. In such cases, an analyst uses multiple regression, which attempts to explain a dependent variable using more than one independent variable. The model, however, assumes that there are no major correlations between the independent variables. The dependent variable (the variable of interest) needs to be using a continuous scale it is counted in terms of running of vehicles on signalized intersections per signal light cycle, and vehicles running through signalized intersections collected data were measured per cycle.

4.6.4.1. Checking Linearity of variables

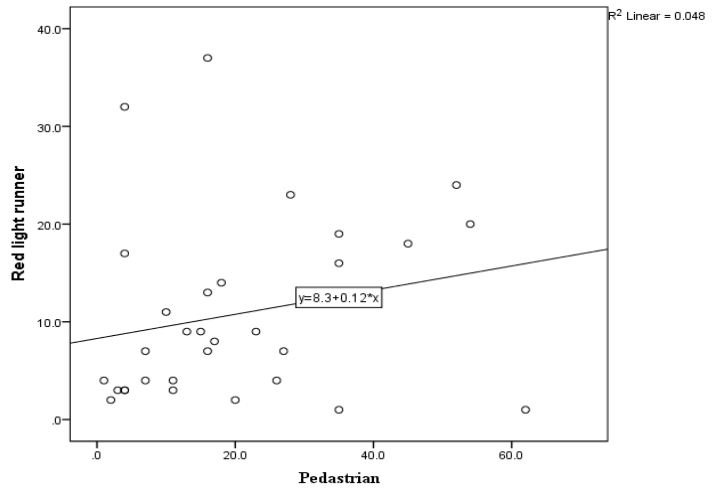
Whilst there are a number of ways to check whether a linear relationship exists between two variables, creating a scatterplot using SPSS Statistics where plotting the dependent variable against your independent variable and then visually inspect the scatterplot to check for linearity. The following output graph, concluded that there is a linear relationship between the red light running and total vehicle, and red light running and pedestrian the result is shown on Figure15.



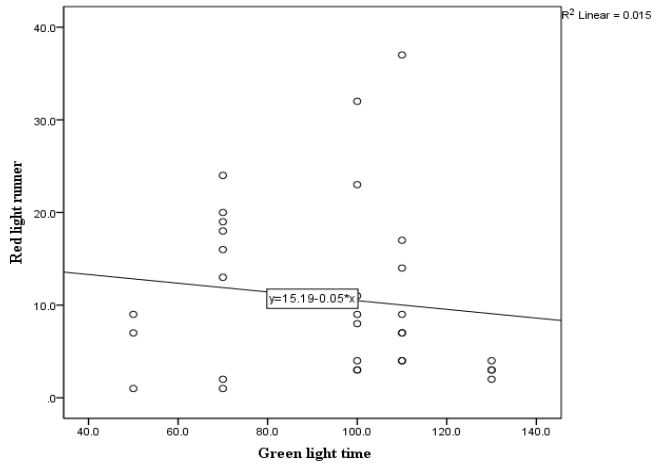
a. Linearity graph between car and red-light runner



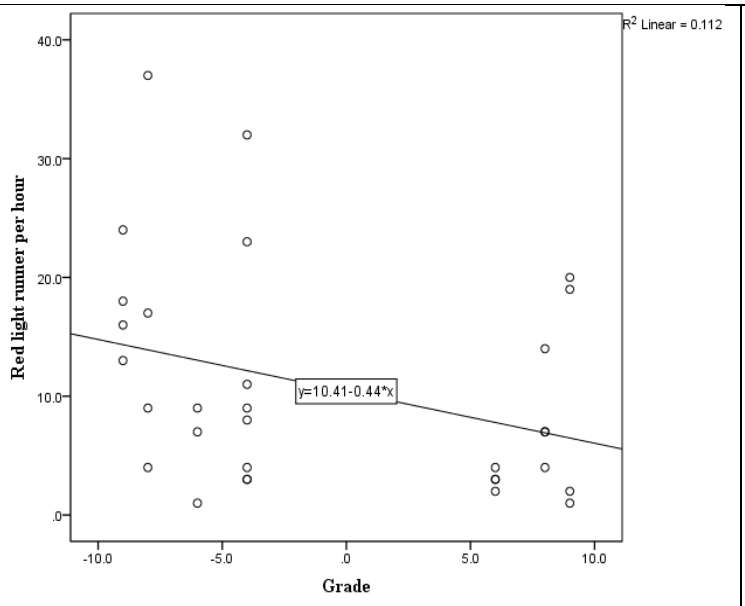
b. Linearity graph between yellow light runner and red-light runner



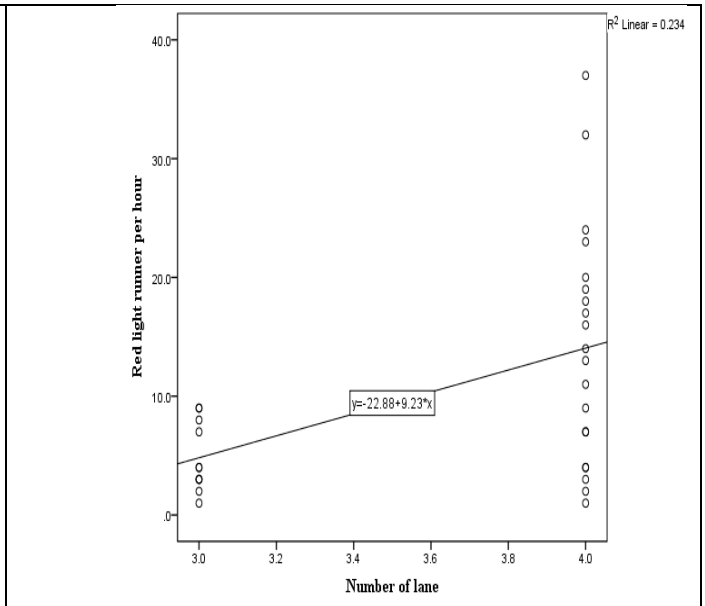
c. Linearity graph between pedestrian and red-light runner



d. Linearity graph between green light time and red-light runner



e. Linearity graph between grade and red-light runner



f. Linearity graph between number of lanes and red-light runner

Figure 15. Linear relationship graph

4.6.4.2. Multicollinearity

Correlation between independent variables shows that shifts in one variable are connected to changes in the other. It is more challenging to modify one variable without also changing another when there is a strong correlation between the two. Estimating the link between each independent variable and the dependent variable separately becomes challenging for the model. Variance inflation factor (VIF) evaluates multicollinearity. The absence of severe multicollinearity in the model is shown by VIF values less than or equal to 10 (or a tolerance value greater than 0.1). Table 25 clearly demonstrates that this model has no multicollinearity between the independent variables, which results in moderate correlation between the variables and no multicollinearity that needs to be adjusted.

Coefficients[a]			
Dependent variable	Independent Variable	Collinearity Statistics	
		Tolerance	VIF
Red light runner	(Constant)		
	Car	.663	1.508

	Bus	.918	1.089
	Heavy vehicle	.971	1.030
	Yellow light runner	.981	1.019
	Green light time	.798	1.253
	Grade	.784	1.275
	Number of lanes	.452	2.215
	Pedestrian	.911	1.097
	Cross road width	.442	2.263
a. Dependent Variable: Red light runner	Red light time	.099	1.139

Table 25 Collinearity Statistics output

4.6.1. Pearson correlation for red light runner and independent variables

The most popular method for determining the linear relationship is the Pearson correlation coefficient (r). The intensity and direction of the relationship between two variables is expressed as a number between -1 and 1. A method for analyzing the relationship between two quantitative or continuous variables is correlation. Table 26 shows the result of Pearson Correlation Analysis based on the independent variable pedestrian, red light time, number of lanes, grade, and green light time.

The analysis shows a significant moderate relationship between number of lane and car (r (623) =0.440, p<.01). It also shows car and red-light runner have a moderate relationship (r (623) =0.693, p<.0.01 and green light time and pedestrians (r (623) =.0.239, p<. 001.

	Correlations											
NO	Variable	A	B	C	D	E	F	G	H	I	J	K
1	Car											
2	Bus	.136**										
3	Heavy vehicle	.037	.090*									

4	Yellow light runner	.030	-.006	-.016								
5	Red light time	-.193**	-.151**	-.134**	-.062							
6	Green light time	.209**	.144**	.100*	.021	-.936**						
7	Grade	-.295**	-.067	-.025	.048	.284**	-.316**					
8	Number of lanes	.440**	.244**	.068	.045	-.033	.091*	.027				
9	Red light runner	.693**	.096*	-.015	.028	-.065	.260	-.148**	.292**			
10	Pedestrian	.103**	.098*	.075	.051	-.297**	.239**	.004	.146**	.088*		
11	Cross road width	.489**	.169**	.106**	.096*	-.075	.031	-.123**	.701**	.245**	.139**	
	**. Correlation is significant at the 0.01 level (2-tailed).											
	*. Correlation is significant at the 0.05 level (2-tailed).											

Table 26 Result of Pearson correlation analysis.

4.6.2. The statistical validity of red light running

4.6.2.1. R-square (R^2)

which can be used to determine how well a regression model fits the data: also known as the Coefficient of determination is a commonly used statistic to evaluate model fit. R-square is 1 minus the ratio of residual variability. The model must fulfill the requirement of p-value ≤ 0.1 (Confident level 90%) and the coefficient of determination is close to 1 ($R2 \approx 1$).

The coefficient of determination is a commonly used statistic to evaluate model fit. R-square is 1 minus the ratio of residual variability. Table 27 shows the model summary the multiple correlation coefficient the R square result is 71.6% and the adjusted R square is 51.2 %. The value of R-square (R2) showing that the model obtained is satisfied with the value of .504.

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.716[a]	.512	.504	.574
a. Predictors: (Constant), Red light time, Number of lanes, Yellow light runner, Heavy vehicle, Bus, Grade, Pedestrian, Car, Cross road width, Green light time				
b. Dependent Variable: Red light runner				

Table 27.Regression statistics of red-light runner

4.6.2.2. ANOVA Output

It can also be seen from Table 28 that the Standard Expected Error between the observed and predicted RLR values is 64.520. Analysis of Variance, i.e. ANOVA in SPSS, is used for examining the differences in the mean values of the dependent variable associated with the effect of the controlled independent variables, after considering the influence of the uncontrolled independent variables. From the ANOVA results of the model presented, it can be observed that the value of "Significance F" is less than 0.05, which shows that the developed model is significant. indicates that, overall, the regression model statistically significantly predicts the outcome variable and the regression model is a good fit of the data.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	212.867	10	21.287	64.520	.000[b]
	Residual	202.573	614	.330		
	Total	415.440	624			
a. Dependent Variable: Red light runner						
b. Predictors: (Constant), Red light time, Number of lanes, Yellow light runner, Heavy vehicle, Bus, Grade, Pedestrian, Car, Cross road width, Green light time						

Table 28 Analysis of variance

4.6.3. The Relationship between independent variables and RLR

As shown in the table 29 that Green light time, heavy vehicle, and cross road width are negatively related variable with red light running and affects negatively while car, bus, yellow light runners, Pedestrian, number of lanes, grade and red-light time are positively affecting the red light running.

- Car; The following table reflects the existence of a statistically found to be significant at 95% level of significance variance between the number of the violation and car. Similarly, it shows evidence of statistical significance of cars on the red-light violations. Whereas, bus and heavy vehicles have no significant relationship between red light runners. Also, red light runner increases with the increase in car, bus, but red-light runners decreases as in increase in heavy vehicle.
- Yellow light runners; Result presented also shows there is no statistical significance of yellow light runners on the red-light violations. The result also shows the significance value is less than the critical value. The model further reveals that red-light violations increase with the increase of yellow light runners
- Number of lanes; Result presented in the following Tables 29 shows there is significant relationship between number of lanes and the red-light violations. The result shows the significance value is less than the critical value. The model further reveals that red-light violations increase with the increase of number of lanes.
- Green light; as the result shows that there is a significant relationship between green light time and red-light runners, further it presents that as green light time increases the likelihood of red-light runner decreases they are negatively related with each other
- Grade; the output further presented also shows there is no statistical significance of grade on the red-light violations. The result also shows the significance value is less than the critical value. The model further reveals that red-light violations increase with the increase of yellow light runners.
- Cross road width; as the result shows that there is a significant relationship between cross road width and red-light runners, further it presents that as cross road width increases the likelihood of red-light runner decreases they are negatively related with each other
- Pedestrian; Result presented in tables 29 shows no statistical significance of Pedestrian on the red-light violations. The result also shows the significance value is greater. The model further reveals that red-light violations increase with the increase of pedestrians.

- Red light time; Result presented shows there is significant relationship between red light time and the red-light violations. The result shows the significance value is less than the critical value and therefore; the model further reveals that red-light violations increase with the increase of red-light time.

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-1.490	.551		-2.704	.007	-2.572	-.408
	Car	.063	.003	.772	22.301	.000	.057	.068
	Bus	.008	.019	.012	.398	.691	-.030	.046
	Heavy vehicle	-.020	.020	-.029	-.993	.321	-.060	.020
	Yellow light runner	.015	.034	.012	.433	.665	-.052	.081
	Green light time	-.010	.003	-.269	-3.002	.003	-.017	-.004
	Grade	.002	.004	.014	.430	.668	-.006	.009
	Number of lanes	.205	.076	.122	2.701	.007	.056	.354
	Pedestrian	.017	.015	.034	1.115	.265	-.013	.046
	Cross road width	-.024	.005	-.225	-5.032	.000	-.033	-.014
	Red light time	.006	.003	-.176	-1.966	.050	-.012	.000
a. Dependent Variable: Red light runner								

Table 29.Statistical analysis output of the model

Estimated model coefficients

To assess the effect of the independent variables on the number of red-light running violations as the dependent variable at the sampled intersections, a multiple linear regression model has been calibrated. The general form of the equation to predict red light runner from total vehicle, pedestrian, green light time and red-light time, is:

$Y = -1.49+.772X_1-.269X_2+.122X_3-.225X_4+.176X_5$

Where Y number of red-light runner violations at a signalized intersection

X_1	Car
X_2	Green light time
X_3	Number of lanes
X_4	Cross road width
X5	Red light time

Unstandardized coefficients indicate how much the red-light runners varies with an independent variable when all other independent variables are held constant. The regression coefficient provides the expected change in the red-light runners for a one-unit increase in the independent variable. Referring to the coefficients Table 30 below the unstandardized coefficient for car, bus and heavy vehicle is .063, .008-.020. This means for every unit increase car, bus, and heavy vehicle there is .063, .008-.020 respectively increase in red light runners, yellow light runners is 015 increase in red light runners for every unit increase in yellow light runners ,green light time there is -.010 increase in red light runners for every unit decreases in green light time, grade; there is .002 increase in red light runners for every unit increase in grade of the road, Number of lanes red light runner there is also .205 increase in for every unit increase in number of lanes, Pedestrian, there is. .017 increase in red light runners for every unit increase in pedestrians (one pedestrian), for every unit increase in red light time there is an increase in red light runners by 017, and there is .006 increase in red light time will also increase the red-light running occurrence. But each one-increase in cross road width causes reduction (the negative sign of the coefficient) in red light runners by-.024

Standardized coefficients are called beta weights, given in the “beta” column. The beta weight measure how much the outcome variable increases (in standard deviations) when the predictor variable is increased by one standard deviation assuming other variables in the model are held constant. These are useful measures to rank the predictor variables based on their contribution (irrespective of sign) in explaining the outcome variable. Hence in this case, car is the highest contributing (.772) predictor to red light runners, and the next is green light time (-.269).

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-1.490	.551		-2.704	.007	-2.572	-.408
	Car	.063	.003	.772	22.301	.000	.057	.068
	Green light time	-.010	.003	-.269	-3.002	.003	-.017	-.004
	Number of lanes	.205	.076	.122	2.701	.007	.056	.354
	Cross road width	-.024	.005	-.225	-5.032	.000	-.033	-.014
	Red light time	.006	.003	.176	-1.966	.050	-.012	.000
a. Dependent Variable: Red light runner								

Table 30. Significant Statistical data for RLR at 95.0% Confidence Interval

4.6.3.1. **Reliability Statistics**

Internal consistency is the measurement accuracy of a field survey for red light runners. The survey's reliability can be more confidently assumed to be higher the internal consistency. The method that is most frequently used for evaluating internal consistency is the Cronbach's Alpha statistic, which computes the pairwise. Pairwise comparisons are techniques for examining the means of numerous variables in pairs to see if they significantly differ from one another or if there are correlations between survey items. The following Table 31 summarizes the Cronbach's Alpha result, which is.723, indicating that the survey's internal consistency is greater and the result is reliable.

Reliability Statistics	
Cronbach's Alpha	N of Items
.723	11

Table 31. Reliability Statistics output

CHAPTER 5. CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

In this research, adequate traffic data were collected to achieve the stated objectives, and behavioral characteristics and influencing factors are well studied. Three methodologies were used to answer the research questions. Primary data on traffic rule violations, intersection geometric design (road width, number of lanes, grade), traffic light design characteristics (cycle length, red light time, yellow interval, green light intervals), and number of red-light violators were collected at 4 intersections through filed survey and the questioner was used to assessing drivers behavioral characteristics about red light running whereas secondary data were collected from Addis Ababa traffic office to assess quantity and frequency of red light running conduct in past years.

- The finding from this study revealed that red light running conduct is at an increasing rate it reaches 31450 in the year of 2021 at Bole sub city
- And pedestrians are also affected by the red-light running offense in the city and this traffic offence is becoming worse in Bole and Lideta sub cities.
- In another finding under this study, the Driver's characteristics i.e. age, gender, educational background, driving experience, and marital status were tested if each of the factors significantly affects the driver's red-light running behavior based on the questionnaire data, the typical red-light runner is younger male driver (with 18–30) age groups were involved in more frequent number of violation rate.
- The main contributing factors that lead drivers to run the red light are being in a rush to work or school in the morning hours on weekdays to save time for their trip purpose, and if no traffic police around.
- The study identified factors that were likely correlated with the levels of red light running at the intersections. These included red light time, Grade, cross road width, green light time, Pedestrian, Number of lanes, car, bus and heavy vehicle.
- Based on the result of Multiple Linear Regression Analysis for RLR; findings from this study also reveals that car, green light time, number of lanes, cross road width and red-light time were found to be statistically significant at a 95% level of significance.
- Red light violations increase with the increase of car, bus, yellow light runners, grade, number of lanes, pedestrians and red-light time.
- The model further reveals that red-light violations decrease with the increase of heavy vehicle, green light time, and cross road width.

- The Pearson correlation the analysis shows a significant moderate relationship between number of lane and car (r (623) =0.440, p<.01). It also shows car and red-light runner have a moderate relationship (r (623) =0.693, p<.0.01 and green light time and pedestrians (r (623) =.0.239, p<. 001.

5.2. RECOMMENDATION

This study aimed at investigating the factors influencing the driver's decision-making that could be observed from the data obtained from the field observation and through the attitudinal survey. Based on this study, the following recommendations are provided for further enhancement and improvement:

Based on the finding of the study and conclusion, the following recommendation was listed for the concerned body.

- A solution needs to be found to reverse these trends. The solution could be by raising awareness of drivers and more educational measures should be introduced as well as more vigorous enforcement measures should be implemented.
- Of course, the difficulties of manual enforcement (e.g., police) and its short-term influence are well known. The best long-term solution at this point appears to be automated enforcement. When drivers know that they will be penalized for their illegal behavior, they will be much more likely to abide by the law. Of course, there will still be the occasional red-light runner due to inattentiveness, but the number of deliberate red-light runners should be significantly reduced.

The following measurement was recommended as an engineering measurement to minimize red lights running an offense

- Engineering improvement for controlling red light runner includes providing pre-yellow information. Several kinds of control information have been used to supplement the yellow indication by giving drivers a warning. The schemes include advance active warning signs, flashing green indication before solid yellow indication.
- Providing a signal count-down timer that displays the time remaining for a particular signal indication and provides time for the driver to make a decision and control the vehicle

Proposed future work.

This section provides a set of recommendations on the possible extensions of this research as follows:

- The researcher recommends detailed research on the investigation of the impact of speed on the likelihood of red light running.
- red light running varies by time of the day and day of the week. The researcher recommends the investigation of red light running by considering the influencing factors like time of the day, day of the week, traffic volume, etc. using the installed camera to collect all traffic data for a longer period

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Appendix 1. QUESTIONNAIRE Questions for Drivers (English)

Hello, my name is Sisay Asrat. I am from Addis Ababa institute of technology and I am gathering information about red light runners in Addis Ababa City. You have been chosen randomly, and I would like to ask some questions about driving behavior, red light running and red-light running crash on the signalized intersection.

You were not asked your name, address, or other personal information that can identify you. You do not have to answer any question you do not want to, and you can stop the questions at any time. If you have any questions about the study you can ask me.

Section -I Personal Questions

Please Tick on the box which contains your answer

1. What is your age range?

☐ 18-30 ☐ 31-42 ..... ☐ 42-52 ☐ Over 52

2. Are you

☐ Male ☐ Female

3. Do you have a parent?

☐ Yes ☐ Children <20

☐ No ☐ Children >20

4. What is your driving experience?

☐ 1-5 ☐ 10-15

☐ 5-10 ☐ More than 15

5. Education level:

☐ Some High School ☐ Vocational Training

☐ College Diploma or Certificate ☐ Bachelor's Degree

☐ Graduate Degree ☐ Other: (please specify)

Section II: General Driving Questions

6. Have you ever had a crash during red light running?

☐ No ☐ Yes

7. How many times do you try to go through amber light and end up running through a red light?

☐ Very often ☐ Rarely

☐ Sometimes ☐ Never

8. What do you normally do when you face a Red traffic light at signalized intersection?

☐ Run the red traffic light ☐ Slow down and try to stop

☐ It depends on the condition ☐ Other…. (please explain)

9. Which one did you involved in Red light running (RLR?)

☐ Red light running but neither ticketed nor crash involved

☐ RLR crash

☐ Has been ticketed for RLR.

☐ None

11. If you answered yes to question number 7 what type of traffic crashes do you face

☐ Slight ☐ Serious

☐ Fatal ☐ Property Damage

12. What are some of the "bad" reasons for which you have run a red light?

☐ In hurry ☐ The red light is too long to wait for

☐ No traffic around me ☐ Not paying attention

☐ Other

13. when did of day is red light running occurring?

☐ Weekday (Monday, Tuesday etc.….) ☐ Weekend (Saturday, Sunday)

Please circle your answer among the following choices

14. Time of day when most red light running occurs

A. 12:01 a.m. – 6:00 a.m.

B. 6:01 a.m. – 12:00 p.m.

C. 12:01 p.m. – 6:00 p.m.

D. 6:01–12:00 am

15. Which one did you recommend to prevent red light runner

A. Education

B. Police enforcement

C. Increase fines

D. Photo Enforcement

E. change signal timing

F. Other

16. Do you think driving above the speed limit around signalized intersection is

A. Extremely serious

B. Very serious

C. Moderately serious

D. Slightly serious

E. Not at all serious

17. The traffic light has just turned red. At this time, you notice that there is no traffic near you. Which of the following would you likely do?

A. Stop at the red, and wait until the light turns green.

B. Stop at the red, but then proceed through the red light.

C. Slow down but proceed directly through the red light

18. You are late for work, school, or an appointment and have been stopped by several red lights in a row. You are approaching another intersection that has had a yellow light for several seconds, but you know it is about to turn red. Which of the following would you likely do?

A. Slow down and prepare to stop at the red light.

B. Speed up to beat the red light.

19. If you slow down and stops: Why would you slow down and prepare to stop? mark all that apply

A. Safe thing to do/too risky to run the red

B. It is my responsibility to stop

C. I was following the law

D. I was afraid of getting hurt in a crash

20. If you speed up to beat the light: Why would you speed up to beat the red light? mark all that apply

A. To save time

B.I was in a rush

C.I was frustrated with having to stop again

D. I enjoy the thrill of beating the light

Appendix 2. QUESTIONNAIRE Questions for Drivers (Amharic version)

መጠይቅ

በቅድሚያ ሰላምታዬን እያቀረብኩ ስሜ ሲሳይ ሲሆን የአዲስ አበባ ቴክኖሎጂ ተቋም ተማሪ ነኝ። አሁን በአዲስ አበባ ከተማ ውስጥ ቀይ የትራፊክ መብራት ከበራ በኋላ ስለሚያሽከረክሩ አሽከርካሪዎች በተመለከተ ጥናት እያካሄድኩኝ ነው። እርስዎ የተመረጡት በጥቅሉ ሲሆን ስለ ማሽከርከር ባህሪ፣ ቀይ የትራፊክ መብራት ከበራ በኋላ ስለማሽከርከር እና ቀይ የትራፊክ መብራት ከበራ በኋላ በማሽከርከር ምክንያት በመስቀሊኛ መንገድ ላይ ስለሚደርሱ ግጭቶች በተመለከተ አንዳንድ ጥያቄዎችን ልጠይቅዎ እፈልጋለሁ።

ስምዎን፣ አድራሻዎን ወይም ሌላ ማንነትዎን ለይቶ የሚያሳውቅ የግል መረጃዎን እንዲገልጹ አይጠየቁም። ማንኛውንም መመለስ የማይፈልጉትን ጥያቄ አለመመለስ የሚችሉ ከመሆኑም ባለፈ ጥያቄዎቹን በየትኛውም ጊዜ ማቆም ይችላሉ። ስለ ጥናቱ በተመለከተ ማንኛውም ጥያቄዎች ካሉዎ እባክዎ ያነጋግሩኝ።

ክፍል -I የግል ጥያቄዎች

መልስዎን በሚይዘው ሳጥን ውስጥ ምልክት ያድርጉ

1. የዕድሜ ምድብዎ የትኛው ነው?

☐ 18-30 ☐ 31-42 ☐ 42-52 ☐ ከ52 በላይ

2. ጾታዎ

☐ ወንድ ☐ ሴት

3. ወላጅ አሉዎት?

☐ አዎ
☐ አይ

4. የማሽከርከር ልምድዎ ምን ያክል ነው?

☐ 1-5 ☐ 10-15
☐ 5-10 ☐ ከ15 በላይ

5. የትምህርት ደረጃ

☐ የተወሰነ ሁለተኛ ደረጃ ትምህርት ☐ የሙያ ስልጠና
☐ የኮሌጅ ዲፕሎማ ወይም የምስክር ወረቀት ☐ የመጀመሪያ ዲግሪ

☐ ከዲግሪ በታች ☐ ሌላ (እባክዎ ይግለጹ)

ክፍል II: ጠቅላላ ማሽከርከርን የተመለከቱ ጥያቄዎች

6. ቀይ መብራት ከበራ በኋላ በማሽከርከርዎ ምክንያት ተጋጭተው ያውቃሉ?

☐ አይ ☐ አዎ

7. ምን ያክል ጊዜ ቢጫው መብራት ሲበራ ለማለፍ እና ቀዩ መብራት ሲበራ ማሽከርከርዎን ለማቆም ይሞክራሉ?

☐ በጣም በአብዛኛው ☐ አልፎ አልፎ

☐ አንዳንድ ጊዜ ☐ በጭራሽ

☐

8. በተለምዶ ምልክት በተደረገበት መስቀሊኛ መንገድ ላይ እያሉ ቀይ የትራፊክ መብራት ሲበራብዎ ምን ያደርጋሉ?

☐ ቀዩን መብራት እያሽከረከርኩ አልፈዋለሁ ☐ ዝግ በማድረግ ለማቆም እሞክራለሁ

እንደ ሁኔታው ይወሰናል ☐ ሌላ (እባክዎ ይግለጹ)

☐

9. ቀይ መብራት ከበራ በኋላ በማሽከርከርዎ ምክንያት የትኛው አጋጥሞዎት ያውቃል?

☐ ቀይ መብራት ከበራ በኋላ በማሽከርከሬ ተቀጥቼ ወይም ተጋጭቼ አላውቅም
☐ ቀይ መብራት ከበራ በኋላ በማሽከርከሬ ምክንያት ተጋጭቻለሁ
☐ ቀይ መብራት ከበራ በኋላ በማሽከርከሬ ምክንያት ተቀጥቻለሁ
☐ መልስ የለም

10. ለጥያቄ 7 መልስዎ አዎ ከሆነ ምን አይነት የትራፊክ አደጋ አጋጠመዎ?

☐ ቀላል ☐ ከባድ

☐ ሞት ☐ የንብረት ጉዳት

11. ቀይ መብራት ከበራ በኋላ የሚያሽከረክሩባቸው ጥቂት ‹‹**መጥፎ**›› ምክንያቶች ምንድን ናቸው?

☐ መቸኮል ☐ ቀዩ መብራት ለረጅም ጊዜ ስለሚቆይ መሰላቸት

☐ አጠገቤ ትራፊክ አለመኖሩ ☐ ትኩረት አለመስጠት

☐ ሌላ

12. ቀይ መብራት ከበራ በኋላ የሚያሽከርከር አጋጣሚ ያጋጠመዎ መቼ ነበር?

☐ በስራ ቀን (ሰኞ፣ ማክሰኞ፣ ወዘተ) ☐ የእረፍት ቀናት (ቅዳሜ፣ ዕሁድ)

እባክዎ ከሚከተሉት ምርጫዎች መካከል መልስዎ ላይ ያክብቡ

13. አብዛኛው ቀይ መብራት እየበራ ማሽከርከር የሚያጋጥምዎ
የቀኑ ጊዜ
ሀ) ከጠዋቱ 12፡00 - ቀኑ 06፡00 ሰዓት
ለ) ከቀኑ 06፡00 - ምሽት 12፡00
ሰዓት ሐ) ከምሽቱ 12፡00 - ምሽቱ
06፡00 ሰዓት መ) ከምሽቱ 06፡00 -
ጠዋት 12፡00 ሰዓት

14. ቀይ መብራት እየበራ ማሽከርከርን ለመከላከል
የትኛውንይመክራሉ?

ሀ) ትምህርት

ለ) በፖሊስ ማስፈጸም

ሐ) የገንዘብ ቅጣት መጠኖችን መጨመር

መ) ፎቶ ማንሳትን ተግባራዊ ማድረግ

ሠ) የምልክት መስጫ ጊዜውን መቀየር

ረ) ሌላ

15. ምልክት በተደረገባቸው መስቀሊኛ መንገዶች ላይ ከፍጥነት ገደብ በላይ ስለማሽከርከር ምን ያስባሉ?
ሀ) እጅግ በጣም አደገና ነው
ለ) በጣም አደገና ነው
ሐ) በመጠኑ አደገኛ ነው
መ) በትንሹ አደገኛ ነው
ሠ) ምንም ጉዳት የለውም

16. ቀዩ የትራፊክ መብራት በርቷል እንበል። በዚህ ጊዜ በአቅራቢያው ምንም የትራፊክ ፖሊስ አለመኖሩን ያያሉ። ከሚከተሉት መካከል የበለጠ የሚያደርጉት የትኛውን ነው?

ሀ) ቀዩ መብራት ሲበራ እቆምና አረንጓዴው መብራት እስኪበራ እጠብቃለሁ

ለ) መጀመሪያ ቀዩ መብራት ላይ እቆምና ወዲያውኑ ቀዩ እንደበራ ማሽከርከሬን እቀጥላለሁ

ሐ) መጀመሪያ ቀዩ መብራት ላይ ዝግ እልና ቀዩ እንደበራ ማሽከርከሬን እቀጥላለሁ

17. ወደ ስራ፣ ትምህርት ቤት ወይም ቀጠሮዎ ቦታ ለመድረስ ዘግይተው እያለ በተከታታይ በቀይ መብራት ምክንያት ከአንድ ጊዜ በላይ ቆመዋል። አሁን ደግሞ ቢጫው መብራት ከበራ ብዙ ሴኮንዶች ወዳለፉት ቀይ መብራት እየተጠጉ ነው፣ ነገር ግን ቀዩ መብራት በራ። ከሚከተሉት መካከል የበለጠ የሚያደርጉት የትኛውን ነው?

ሀ) ፍጥነት እየቀነስኩ ቀዩ መብራት ጋር ለማቆም እሞክራለሁ

ለ) ቀዩን መብራት ፍጥነቴን ጨምሬ አልፈዋለሁ

18. ፍጥነት እየቀነሱ መጥተው ካቆሙ፡ ፍጥነት ቀንሰው ለመቆም የሚዘጋጁት ለምንድን ነው? ሁሉም መልስ የሆኑት ላይ ምልክት ያድርጉ

ሀ) ይህን ማድረግ ለደህንነት ተገቢ ነው/ ቀዩ እየበራ ማሽከርከር በጣም አደገኛ ነው

ለ) ማቆም ኃላፊነቴ ስለሆነ ነው

ሐ) ህጉን ለማክበር ነው

መ) እጋጫለሁ በሚል ስጋት ነው

19. ፍጥነት ጨምረው ቀዩን መብራት ካለፉ፡ ፍጥነት ጨምረው ቀዩን መብራት ጥሰው ያሽከረከሩበት ምክንያት ምንድን ነው? ሁሉም መልስ የሆኑት ላይ ምልክት ያድርጉ

ሀ) ጊዜ ለመቆጠብ

ለ) ቸኩዬ ስለነበር

ሐ) እንደገና መቆም ስላበሳጨኝ

መ) መብራት ጥሶ ማለፍ ስለሚያስደስተኝ

Appendix 3. Field survey data collection at each selected intersection

LEGAHARE SIGNALIZED INTERSECTION EAST BOUND

cycle	Total vehicle during green and yellow	Red light runner			
		Pedastrian	Car	bus	heavy vechile
1	62	3	0	0	0
2	53	0	0	0	0
3	57	0	2	0	0
4	50	0	0	0	0
5	67	1	0	0	0
6	59	0	0	0	0
7	54	0	1	0	0
8	55	0	0	0	0
9	48	0	0	0	0
10	68	2	0	0	0
11	54	0	0	1	0
12	50	0	0	0	0
13	44	0	0	0	0
14	53	0	1	0	0
15	61	1	0	0	0
16	52	0	0	0	0
17	50	0	0	0	0
18	49	0	1	0	0
19	58	2	0	0	0
20	69	2	1	0	0
21	51	0	0	0	0
22	56	1	0	0	0
23	59	1	1	0	0
24	47	0	0	0	0
25	57	0	0	0	0
26	52	0	0	0	0
27	53	1	0	0	0
28	49	0	1	0	0
29	52	2	0	0	0
30	60	3	0	0	0
31	49	0	0	0	0
32	53	2	0	0	0
33	49	0	0	0	0
34	53	0	0	0	0
35	57	1	0	0	0
36	54	0	0	0	0
37	48	0	0	0	0
38	50	1	0	0	0
39	52	0	0	0	0
40	58	1	0	0	0
41	52	0	0	0	0

42	56	0	0	0	0
43	45	1	0	0	0
44	53	1	0	0	0
45	55	0	0	0	0
46	55	2	0	0	0
47	58	3	0	0	0
48	55	0	0	0	0
49	52	1	0	0	0
50	58	0	0	0	0
51	53	3	0	0	0
52	50	0	0	0	0
53	55	2	0	0	0
54	42	2	0	0	0
55	53	3	0	0	0
56	56	0	0	0	0
57	48	0	0	0	0
58	45	0	0	0	0
59	58	0	1	0	0
60	58	0	0	0	0
61	57	0	0	0	0
62	54	0	0	0	0
63	51	0	0	0	0
64	54	3	0	0	0
65	56	0	0	0	0
66	56	0	0	0	1
67	49	0	0	0	0
68	48	4	0	0	0
69	51	0	0	0	0
70	55	0	0	0	0
71	60	0	0	0	0
72	51	0	0	0	0
73	51	0	0	0	0
74	55	3	0	0	0
75	65	0	0	0	0
76	62	0	0	0	0
77	64	0	0	0	0
78	68	0	0	0	0
79	68	0	0	0	0
80	73	0	0	0	0

LEGAHARE SIGNALIZED INTERSECTION EAST BOUND

cycle	Total vehicle during green and yellow	Pedestrian	Red light runner		
			Car	bus	heavy vehicle
1	85	2	1	0	0

2	78	0	0	0	0
3	75	0	0	0	0
4	72	0	0	0	0
5	75	1	1	0	0
6	76	0	0	0	0
7	72	0	0	0	0
8	74	0	0	0	0
9	72	0	0	0	0
10	79	0	1	0	0
11	67	0	0	0	0
12	74	0	0	0	0
13	71	0	0	0	0
14	74	0	0	0	0
15	68	0	0	0	0
16	67	0	0	0	0
17	60	0	0	0	0
18	70	0	0	0	0
19	67	0	0	0	0
20	67	0	1	0	0
21	70	0	0	0	0
22	65	0	0	0	0
23	59	0	0	0	0
24	64	0	0	0	0
25	65	1	1	0	0
26	70	0	0	0	0
27	62	0	0	0	0
28	62	0	0	0	0
29	66	0	1	0	0
30	60	0	2	0	0
31	68	0	0	0	0
32	59	0	0	0	0
33	61	0	0	0	0
34	64	0	0	0	0
35	64	1	1	0	0
36	55	0	0	0	0
37	50	0	0	0	0
38	44	0	0	0	0
39	56	0	0	0	0
40	64	2	2	0	0
41	57	0	0	0	0
42	50	0	0	0	0
43	55	1	0	0	0
44	54	0	0	0	0
45	47	0	0	0	0
46	58	0	0	0	0
47	51	2	0	0	0

48	54	2	0	0	0
49	64	1	0	0	0
50	48	3	0	0	0
51	64	1	0	0	0
52	58	1	0	0	0
53	60	3	2	0	0
54	52	0	0	0	0
55	68	3	1	0	0
56	68	1	0	0	0
57	61	1	0	0	0
58	72	1	0	0	0
59	71	3	1	0	0
60	60	5	0	0	1
61	74	0	1	0	0
62	69	0	0	0	0
63	72	0	0	0	0
64	77	0	0	0	0
65	66	0	1	0	0
66	79	3	0	2	0
67	73	0	0	0	0
68	71	0	0	0	0
69	70	1	1	0	0
70	56	1	1	0	0
71	73	1	1	0	0
72	74	0	0	0	0
73	73	0	0	0	0
74	71	0	0	0	0
75	66	1	1	0	0
76	76	2	1	0	0
77	75	0	0	0	0
78	77	1	1	0	0
79	73	0	0	0	0
80	82	0	0	0	0

Table 32 Traffic Count Data of Legehar signalized intersection west and east bound within 15 min interval

CHURCHILE SIGNALIZED INTERSECTION EAST BOUND

cycle	Total vehicle during green and yellow	Pedastrian	Red light runner		
			car	bus	heavy vechile
1	64	0	0	0	0
2	58	0	0	0	0
3	49	0	0	0	0
4	49	0	0	0	0
5	45	5	0	0	0
6	55	0	0	0	0

7	51	0	0	0	0
8	45	0	0	0	0
9	55	0	0	0	0
10	64	4	1	0	0
11	53	0	1	0	0
12	49	0	0	0	0
13	47	0	0	0	0
14	55	0	0	0	0
15	55	0	0	0	0
16	51	0	0	0	0
17	46	6	0	0	0
18	53	0	0	0	0
19	52	0	0	0	0
20	59	1	2	0	0
21	54	0	1	0	0
22	52	0	0	0	0
23	46	0	0	0	0
24	59	0	2	0	0
25	55	0	0	0	0
26	52	0	1	0	0
27	52	0	0	0	0
28	53	1	2	0	0
29	60	0	2	0	0
30	52	0	0	0	0
31	43	0	0	0	0
32	53	0	0	0	0
33	40	0	0	0	0
34	54	0	0	0	0
35	73	1	0	1	0
36	50	1	1	0	0
37	45	0	0	0	0
38	37	0	0	0	0
39	51	1	2	0	0
40	45	0	0	0	0
41	40	0	0	0	0
42	38	0	0	0	0
43	46	0	0	0	0
44	41	1	0	0	0
45	56	1	1	0	0
46	54	1	0	1	0
47	53	0	0	0	0
48	50	0	0	0	0
49	54	2	3	0	0
50	47	0	0	0	0
51	52	1	0	0	0
52	55	3	0	0	0

53	52	0	0	0	0
54	46	0	0	0	0
55	50	1	0	0	0
56	58	0	0	0	0
57	50	0	0	0	0
58	52	1	0	0	0
59	50	1	0	0	0
60	63	3	1	0	0
61	53	0	0	0	0
62	61	2	1	0	0
63	54	0	0	0	0
64	47	0	0	0	0
65	60	5	0	0	0
66	57	0	0	0	0
67	55	1	0	0	0
68	51	0	0	0	0
69	63	7	0	1	0
70	50	0	0	0	0
71	60	0	0	0	0
72	52	1	0	0	0
73	55	0	0	0	0
74	65	0	0	0	0
75	52	2	0	0	0
76	50	1	0	0	0
77	59	0	0	0	0
78	64	3	1	0	0
79	62	0	0	0	0
80	68	4	0	0	0

CHURCHILE SIGNALIZED INTERSECTION NORTH BOUND

cycle	Total vehicle during green and yellow	Pedestrian	Red light runner		
			car	bus	heavy vehicle
1	67	1	1	0	0
2	60	0	0	0	0
3	57	0	0	0	0
4	65	0	0	0	0
5	56	0	0	0	0
6	58	0	0	0	0
7	51	2	0	0	0
8	58	0	0	0	0
9	54	0	0	0	0
10	60	0	0	0	0
11	61	0	0	0	0
12	48	0	2	0	0
13	58	0	0	0	0

14	54	0	0	0	0
15	56	0	0	0	0
16	60	1	0	0	0
17	63	0	0	0	0
18	55	0	0	0	0
19	52	0	0	0	0
20	49	3	0	0	0
21	58	2	1	0	0
22	51	0	0	0	0
23	44	0	0	0	0
24	51	2	0	0	0
25	60	3	1	0	0
26	46	0	0	0	0
27	41	4	0	0	1
28	43	2	0	0	0
29	44	0	0	0	0
30	40	3	2	0	0
31	58	0	0	0	0
32	51	0	0	1	0
33	50	1	1	0	0
34	52	0	0	0	0
35	50	0	2	0	0
36	52	1	0	0	0
37	54	0	0	0	0
38	49	0	1	0	0
39	45	0	0	0	1
40	49	0	0	0	0
41	55	1	0	0	0
42	51	1	0	0	0
43	48	1	2	0	0
44	61	0	0	0	0
45	46	0	1	0	0
46	51	3	0	1	0
47	61	1	1	0	0
48	52	0	0	0	0
49	47	3	2	0	0
50	51	1	0	0	0
51	58	0	0	0	0
52	53	0	0	0	0
53	42	3	2	0	0
54	57	2	0	0	0
55	65	0	0	0	0
56	60	0	0	0	0
57	56	0	0	0	0
58	53	0	0	0	0
59	61	0	0	0	0

60	51	0	2	0	0
61	53	0	0	0	0
62	50	0	0	0	0
63	53	0	0	0	0
64	66	0	1	1	0
65	57	0	0	0	0
66	60	4	0	0	0
67	53	0	0	0	0
68	60	3	2	0	0
69	53	0	0	0	0
70	51	0	0	0	0
71	58	0	0	0	0
72	60	0	0	0	0
73	60	0	0	0	0
74	63	0	1	0	0
75	59	0	0	0	0
76	62	0	0	0	0
77	63	0	0	0	0
78	68	0	0	0	0
79	61	0	0	0	0
80	71	0	3	0	0

Table 33, Traffic Count Data of Churchile signalized intersection North and South bound within 15 min interval

SIMEN HOTEL SIGNALIZED INTERSECTION SOUTH BOUND

cycle	total vehicle during green and yellow	Pedestrian	Red light runner		
			car	bus	heavy vehicle
1	52	0	1	0	0
2	48	0	0	0	0
3	41	0	0	0	0
4	39	2	0	0	0
5	42	3	0	0	0
6	45	3	1	0	0
7	42	0	0	0	0
8	40	0	0	0	0
9	43	0	2	0	0
10	42	2	0	0	0
11	45	1	0	0	0
12	47	0	1	0	0
13	37	0	0	0	0
14	44	0	1	0	0
15	48	0	2	0	0
16	44	0	0	0	0
17	36	1	0	0	0
18	50	2	0	0	0
19	47	3	1	0	0

20	37	6	2	0	0
21	45	0	0	0	0
22	42	2	1	0	0
23	49	4	1	0	0
24	46	2	0	0	0
25	48	4	0	0	0
26	55	0	0	0	0
27	45	0	0	0	0
28	49	0	0	0	0
29	51	2	0	0	0
30	49	3	0	0	0
31	50	0	0	0	0
32	46	0	1	0	0
33	51	0	1	0	0
34	56	2	1	0	0
35	41	2	0	0	0
36	47	0	0	0	0
37	42	2	0	0	0
38	45	0	0	0	0
39	38	0	0	0	0
40	33	4	2	0	0
41	31	2	0	0	0
42	44	6	0	0	0
43	50	2	1	0	0
44	50	2	1	0	0
45	55	0	1	0	0
46	48	0	1	0	0
47	43	4	0	0	0
48	44	4	0	0	0
49	57	2	1	0	0
50	51	2	0	0	0
51	51	0	0	1	0
52	41	0	0	0	0
53	48	5	0	0	0
54	46	0	0	0	1
55	53	4	0	0	0
56	55	0	0	0	0
57	56	0	0	1	0
58	42	0	0	0	0
59	60	0	0	0	0
60	49	2	0	0	0
61	43	0	0	0	0
62	49	0	1	0	0
63	41	1	0	0	0
64	43	1	0	0	0
65	45	0	2	0	0

66	44	1	1	0	0
67	40	0	1	0	1
68	38	1	0	0	0
69	30	0	0	0	0
70	39	0	0	0	0
71	31	0	0	0	0
72	37	0	0	1	0
73	38	0	0	0	0
74	35	0	0	0	0
75	32	0	0	0	0
76	42	0	0	0	0
77	45	0	0	0	0
78	51	0	0	0	0
79	55	0	0	0	0
80	58	0	0	0	0
SIMEN HOTEL SIGNALIZED INTERSECTION NORTH BOUND					
	Total vechile during green and yellow		Red light runner		
cycle		Pedastrian	car	bus	heavy vechile
1	52	0	0	0	0
2	50	1	1	0	0
3	51	0	0	0	0
4	47	0	0	0	0
5	41	0	0	0	0
6	42	0	0	0	0
7	44	0	0	0	0
8	33	0	0	0	0
9	34	0	0	0	0
10	45	3	0	0	0
11	38	0	0	0	0
12	37	0	0	0	0
13	37	4	0	0	0
14	32	0	0	0	0
15	44	0	1	0	0
16	34	0	0	0	0
17	36	0	3	0	0
18	35	0	0	0	0
19	31	0	0	0	0
20	45	3	0	0	0
21	41	0	1	0	0
22	39	0	0	0	0
23	35	0	0	0	0
24	30	0	0	0	0
25	43	0	1	0	0
26	42	0	2	0	0
27	39	0	0	0	0
28	39	0	0	0	0

29	34	0	0	0	0
30	44	0	1	0	0
31	37	0	0	0	0
32	39	0	0	0	0
33	36	0	0	0	0
34	42	1	2	0	0
35	40	0	0	0	0
36	36	0	0	0	0
37	38	0	0	0	0
38	36	0	3	0	0
39	34	0	0	0	0
40	42	0	0	0	0
41	31	0	0	0	0
42	32	0	0	0	0
43	37	0	2	0	0
44	35	0	1	0	0
45	46	0	2	0	0
46	34	0	0	0	0
47	37	0	0	0	0
48	36	0	0	0	0
49	39	0	0	0	0
50	44	2	2	0	1
51	35	0	0	0	0
52	38	0	0	0	0
53	37	0	0	0	0
54	42	0	1	0	0
55	46	0	2	0	0
56	44	0	0	0	0
57	40	0	0	0	1
58	43	0	0	0	0
59	36	0	0	0	0
60	45	0	0	1	0
61	40	0	0	0	0
62	40	0	0	0	0
63	43	0	3	0	0
64	37	0	0	0	0
65	46	0	2	0	0
66	43	0	0	0	0
67	41	3	0	0	0
68	45	0	0	0	0
69	40	0	0	0	0
70	44	0	0	0	0
71	41	1	0	0	0
72	38	0	0	0	0
73	41	0	0	0	0
74	43	4	0	0	0

75	47	5	0	1	0
76	46	0	0	0	0
77	43	3	0	0	0
78	43	0	0	0	0
79	43	0	1	0	0
80	55	4	2	0	0

Table 34 Traffic Count Data of Semen Hotel signalized intersection North and South bound within 15 min interval

SHOLA GIBAYA SIGNALIZED INTERSECTION WEST BOUND

cycle	Total vechile during green and yellow light	Pedastrian	Red light runner		
			car	bus	heavy vechile
1	73	3	0	0	0
2	75	5	0	0	0
3	76	2	0	0	0
4	78	3	0	0	0
5	80	1	1	0	0
6	81	2	0	0	0
7	74	4	2	0	0
8	73	2	1	0	0
9	75	2	0	0	0
10	72	1	3	0	0
11	65	1	1	0	0
12	68	1	2	0	0
13	65	3	0	0	0
14	62	4	1	0	0
15	67	5	2	0	0
16	68	7	1	0	0
17	64	3	0	0	0
18	76	7	2	0	0
19	66	3	2	0	0
20	60	3	1	0	0
21	64	7	0	0	0
22	62	0	0	0	0
23	61	2	1	0	0
24	66	0	2	0	0
25	64	0	0	0	0
26	67	2	2	0	0
27	63	0	0	0	0
28	71	4	0	0	0
29	62	2	1	0	0
30	60	0	0	0	0
31	61	2	1	0	0
32	66	3	2	0	0
33	61	2	0	0	0

34	61	3	1	0	0
35	59	3	1	0	0
36	56	2	0	0	0
37	61	0	0	0	0
38	59	0	0	0	0
39	62	0	0	0	0
40	63	3	2	0	0
41	57	4	0	0	0
42	61	2	0	0	1
43	59	2	1	0	0
44	63	3	0	0	0
45	58	4	0	1	0
46	61	2	0	0	0
47	56	5	0	0	0
48	54	3	0	0	0
49	58	2	0	0	0
50	57	1	2	0	0
51	54	2	0	1	0
52	60	5	0	0	0
53	56	5	0	0	0
54	57	6	1	1	0
55	56	0	0	0	0
56	64	4	0	0	0
57	58	2	2	0	0
58	62	0	0	0	0
59	65	0	0	0	0
60	65	0	0	0	0
61	63	0	1	1	0
62	68	0	0	0	0
63	66	0	0	0	0
64	64	2	0	0	0
65	68	0	0	0	0
66	70	0	0	0	0
67	72	0	0	0	0
68	68	0	2	1	0
69	76	0	0	0	0
70	71	0	0	0	0
71	75	0	0	0	0
72	74	0	0	0	0
73	74	0	0	0	0

SHOLA GIBAYA SIGNALIZED INTERSECTION EAST BOUND

cycle	total vehicle during green and yellow light	Pedestrian	Red light runner		
			car	bus	heavy vehicle
1	73	2	0	0	0

2	69	0	0	0	0
3	68	2	0	0	0
4	72	2	0	0	0
5	74	3	1	0	0
6	72	2	0	0	0
7	71	1	1	0	0
8	68	2	0	0	0
9	67	1	2	0	0
10	71	4	1	0	0
11	67	4	2	0	0
12	66	0	0	0	0
13	65	2	1	0	0
14	66	3	0	0	0
15	68	1	2	0	0
16	64	4	0	0	0
17	68	8	1	0	0
18	65	6	0	0	0
19	69	1	1	0	0
20	63	1	1	0	0
21	57	0	0	0	0
22	66	0	0	0	0
23	60	1	2	0	0
24	71	7	1	0	0
25	67	0	0	0	0
26	66	0	0	0	0
27	68	0	0	0	0
28	68	4	1	0	0
29	69	2	0	0	0
30	61	2	1	0	0
31	58	0	0	0	0
32	64	8	0	0	0
33	53	0	0	0	0
34	69	3	0	0	0
35	60	4	1	1	0
36	54	5	4	0	0
37	53	4	2	0	0
38	52	2	0	0	0
39	50	2	3	0	0
40	54	0	0	0	0
41	55	0	0	0	0
42	53	6	0	0	0
43	55	0	0	0	0
44	55	0	0	0	0
45	51	0	0	0	0
46	53	3	0	0	1
47	59	7	0	0	0

48	59	7	0	0	0
49	64	0	0	0	0
50	62	0	0	0	0
51	61	0	0	0	0
52	63	7	2	0	0
53	56	8	0	1	0
54	53	5	0	0	0
55	65	2	0	0	0
56	58	2	0	0	0
57	65	4	2	0	0
58	68	0	0	0	0
59	61	0	0	0	0
60	65	0	0	0	0
61	64	0	0	0	0
62	62	0	0	0	0
63	59	0	1	0	0
64	69	0	0	0	0
65	63	0	0	0	0
66	71	0	0	0	0
67	68	0	0	1	0
68	73	0	0	0	0
69	78	0	0	0	0
70	74	0	0	0	0
71	71	0	0	0	0
72	72	0	0	0	0

Table 35Traffic Count Data of Shola signalized intersection West and east bound within 15 min interval

Appendix 4. Normality of regression standardized residuals with Red light Running

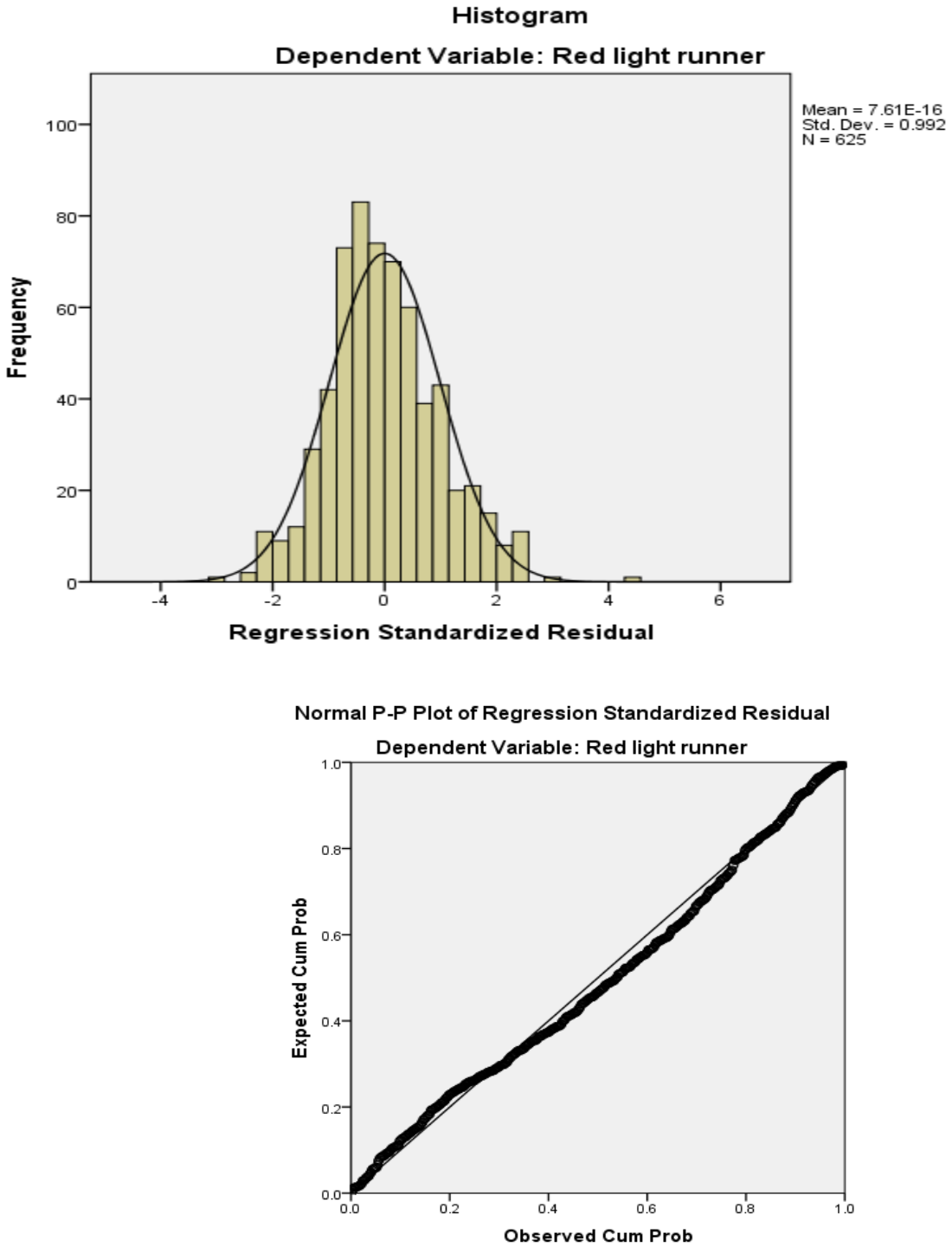

Figure 16.p-p plot of regression analysis

Appendix 5. Exponential function of the model

One-Sample Kolmogorov-Smirnov Test								
		RLR	Total vehicles	Number of lanes	Pedestrian	Red light time	Green light time	Grade
N		594[c]	594	594	594[d]	594	594	594[e]
Exponential parameter.[a, b]	Mean	1.41	57.63	3.60	2.64	114.41	84.98	6.4630
Most Extreme Differences	Absolute	2.552	.436	.566	1.634	.583	.475	.495
	Positive	2.552	.202	.329	1.634	.294	.244	.245
	Negative	0.000	-.436	-.566	0.000	-.583	-.475	-.495
Kolmogorov-Smirnov Z		33.953	10.625	13.790	24.994	14.203	11.582	8.523
Asymp. Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000
a. Test Distribution is Exponential.								
b. Calculated from data.								
c. There are 417 values outside the specified distribution range. These values are skipped.								
d. There are 360 values outside the specified distribution range. These values are skipped.								
e. There are 297 values outside the specified distribution range. These values are skipped.								