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College of Engineering
Civil Engineering Department

Driver Response to Yellow Timing at Selected Signalized Intersections in Karbala City,Iraq

A Thesis Submitted to the Council of the Faculty of the College of the Engineering/University Of Kerbala in Partial Fulfillment of the Requirements for Master Degree in Civil Engineering

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Rajab 1444

بسم الله الرحمن الرحيم

يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ

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Abstract

The city of Karbala in Iraq is one of the most important cities that is witnessing a significant increase in its population. Moreover, due to the importance of the city from a religious perspective, it has a large number of visitors during the year. Therefore, the study of driving behavior at signalized intersections in this city can provide an analytical background for a safer traffic signals design that can reduce the probability of vehicle accidents at intersections. In this context, this work is an experimental study that is aimed at analyzing driving behavior and estimating the driver's decision to move or stop at signalized intersections when the yellow light is presented. In particular, in this period, the driver may not be able to safely stop before the stop line, nor crosses the intersection. This is known as the dilemma zone, which is considered critically important to understand and characterize, yet the estimation of the driver's decision at this zone is considered highly stochastic because the driver's decision can be changed from one driver to another. This is a data-driven approach that ends up providing a model that can be used to estimate the driver's decision from observed measurements. In this experimental study, the input variable x_i consists of four features; speed, headway, TTSL (time to stop line), and vehicle type. The output variable y_i is binary (takes either 0 or 1) that represents the driver's decision to pass ($y_i = 0$) or not pass ($y_i = 1$) the intersection. The data were collected by installing cameras placed at the Al- Dhareeba intersection and Saif Saad intersection for five workdays in Karbala city. The passing and stopping vehicles were calculated for the yellow light, as well as those vehicles violating the traffic signal during traffic intersections for the beginning of the red light. In this context, Red Light Running (RLR) is one of the most dangerous riding behaviors at mixed traffic intersections and one of the most serious safety

issues. In the first set of experiments, RLR violations were measured for five days from 8:00 a.m.-10:00 p.m. According to these measurements, there was a high percentage of RLR violations that occurred in both signalized intersections. During the hours of 8:00-9:00 a.m., the Al- Dhareeba intersection had the highest percentage of RLR violations (67.60%), while Saif Saad intersection had 45.46%. In the second set of experiments, the input and output variables $\{(x_i , y_i)\}$ were measured for five days during rush hours 8:00 am-10:00 a.m. and 5:00 p.m.-7:00 p.m. This set of experiments provided 513 samples (x_i , y_i) for each intersection (a total of 1026 samples for both intersections). A logistic regression binary model is used in this study. To train and test this classifier, SPSS Statistics has been used in this study. The results for Al-Dhareeba intersection indicated that there was an insignificant relationship between the speed and headway and vehicle type with the driver's decision to go or stop at the yellow light, while the TTSL feature is significant with the driver's decision having a p-value of 0.01. The negative sign in the coefficient (β) indicated that the probability of stopping increases with the decrease of the speed and headway. In Saif Saad intersection case, the results indicated a significant relationship between the speed and TTSL with the driver's decision. The negative sign in the coefficient (β) indicated that the probability of stopping increases with the decrease in headway. In the third set of experiments, data were collected using electronic questionnaire questions open to all drivers on the internet, where a statistical analysis has been carried out to provide a qualitative assessment of the effect of gender, age, and education level on the driver's decision.

Undertaking

I certify that the research work titled "Driver Response to Yellow Timing at Selected Signalized Intersections in Karbala City,Iraq" is my work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/referred to.

Signature:

Bushra Fahad Jassim

Date: 25 / 5 / 2023

Dedication

Thanks to Allah first for all his gifts.

To the beloved of the Messenger of God, Mohammad, may God bless him and his family, To the lady of the women of the worlds, To my lady, and role model, ***Fatima Al-Zahra****(peace be upon her).*

To the one who promised to fill the world with the right, hope this research work could server his way, to our beloved imam, ***Al-Imam Al-Mahday*** *(peace be upon him).*

To the one who was supportive of me in this world and, to the soul of my father ***Fahad Jassim*** *(God bless his soul)***.**

To the one who is the reason for my existence in life ***(my dear mother).***

*To my dear Husband (****Ahmad Mohammed****) who helped me and encouraged me.*

To the candles that burn to light up to others to everyone who taught me a letter ***(my teachers)****.*

My supportive and inspiring brothers, especially, ***Mohammed, Falah, and Najah****.*

*To my dear son (****Ali Ahmad)****.*

To everyone who helped and encouraged me, my colleagues, and my friends.

I dedicate this humble research, hopping the Almighty finds acceptance and success.

Bushra Fahad Jassim

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List of Abbreviations

CY	Circular Yellow
DZ	Dilemma Zone
FHWA	Federal Highway Administration
GS	Go-Straight
GES	General Estimates System
ITE	Institute of Transportation Engineers
LT	Left-Turn
P.C	Passenger Car
RLR	Red Light Running
S.E	Standard Error
Sig.	Significant
SPSS	Statistics is a Powerful Statistical Software
SUV	Sport Utility Vehicle
TTSL	Time to Stop Line
USA	United States of America

List of Symbols

β	This is the coefficient for the constant (also called the "intercept") in the null model
Y	Length of the yellow interval
t	Perception-reaction time
$\boldsymbol{v}$	Speed of approaching vehicle
a	Deceleration rate in response to the onset of the yellow indication.
g	Acceleration due to gravity
G	Grade
df	This is the degrees of freedom for the Wald chi-square test
Ý	Predicted
N	Number of samples
Xi	Independent varablie
Yi	Dependent varablie

Chapter One: Introduction

1.1 General Background

Drivers' safety and mobility are jeopardized by signalized intersections in the road traffic network. At signalized intersections, traffic accidents in the yellow period account for more than half of all traffic accidents(Z. Yang et al.,2014) Even though traffic lights are intended to manage traffic and allow for the shared use of road space by pedestrians, bikes, and motorists, congestion and accidents are most common near signalized crossings. The issue is that when the light turns yellow, vehicles are unsure whether they should go or stop. Vehicle crashes caused by dilemma zone problems are commonly related to high-speed signalized junctions (Rakha et al.,2007). A dilemma zone is widely known as an area on the high-speed intersection approach .Here,vehicles neither safely stop before the stop line nor proceed through the interaction during the yellow interval,when drivers are forced to make such a decision. Incorrect driver decisions can result in rear-end collisions if the driver stops when they should have continued and/or right-angle collisions with side-street traffic if they go when they should have stopped (Rakha et al.,2007). In the dilemma zone, the vehicle model and initial vehicle speed will influence the driver's behavior,when the driver decides to accelerate to pass through a signalized intersection, the effect variation tendency appears to be consistent, and the level of variation varies depending on the vehicle model and initial vehicle speed. ,when the driver decides to stop before the stop line, the probability of variance varies depending on the vehicle model and initial vehicle speed. One of the most essential variables in the development of problem zones and the safety of human vehicles in this condition is driver behavior (Li et al.,2021). Figure (1-1) depicts the dilemma zone at a four-armed signalized intersection.

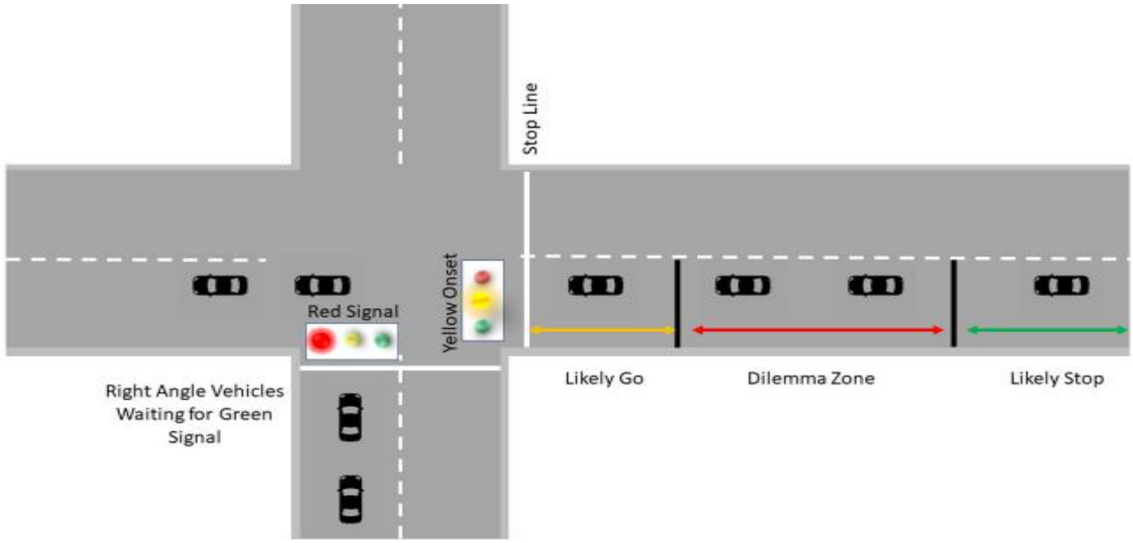


Figure (1-1): Dilemma zone detection in a four-armed signalized intersection (Komol et al.,2022).

Due to the high speed, insufficient vehicle protection in the dilemma zone frequently results in running the red light, which causes severe accidents. A vehicle may be involved in a right-angle collision or a rear-end collision in such a place (Mohammadi et al.,2017).

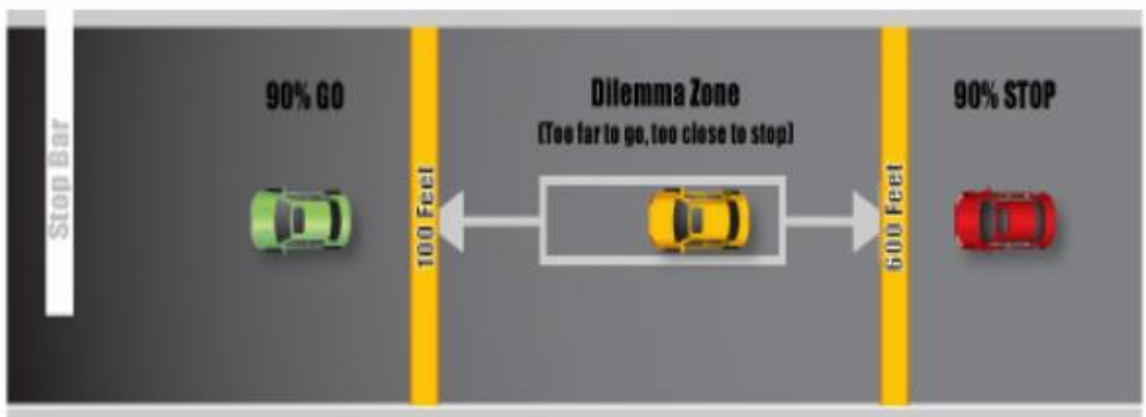


Figure (1-2): Dilemma zone at a high-speed intersection (Mohamadi et al.,2017).

Dilemma zones typically arise at high-speed crossroads in urban areas because people tend to travel faster than other vehicles to get to their destination as soon as possible; they do not exist at low-speed intersections or in school zones. The risk of a right-angled collision increases if the vehicle chooses to proceed quickly through the intersection while the light is still yellow. If they choose to stop first, it could cause a collision or an extension of the delay (Mohammadi et al.,2017). Figures 1-3 and figure 1-4 below show that a right-angled crash and a rear-end crash happened as a result of the problem of red-light-running (RLR). RLR is among the most dangerous riding behavior at mixed traffic intersections and one of the most serious safety issues. RLR accidents at signalized intersections can result in serious injuries or deaths.

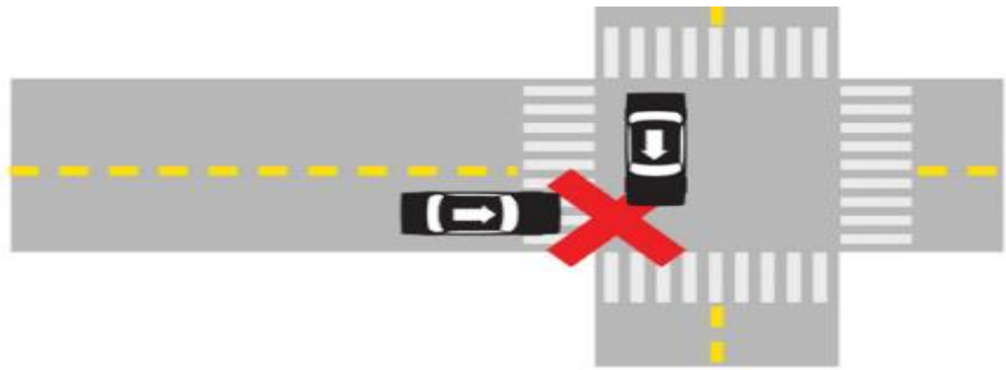


Figure (1-3): Right-angled crash (Mohammadi et al.,2017).

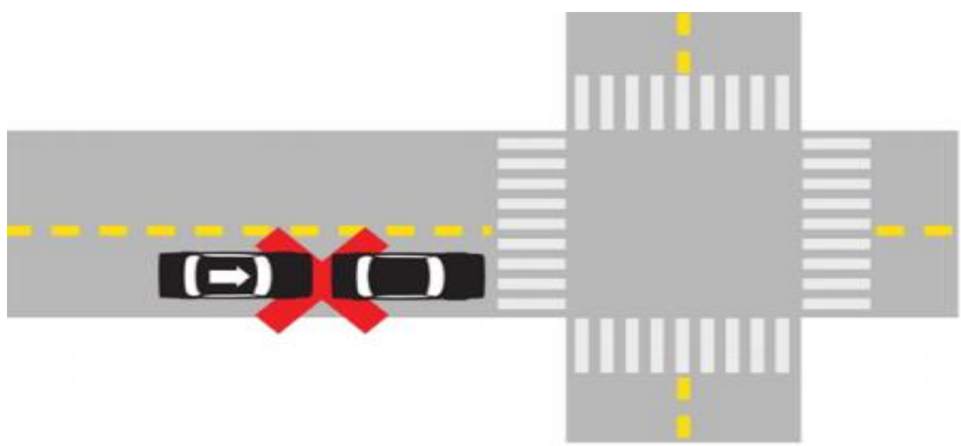


Figure (1-4): Rear-end crash (Mohammadi et al.,2017).

1.2 Statement of the Problem

The high traffic in rush hours as well as the many violations and red light running by drivers at intersections in Karbala city require careful analysis of driving behavior and the driver's decision to go or stop during the yellow indication at the intersections. The main challenge here is the stochasticity and uncertainty of driving behavior at intersections and the dependency of the driver's decision on several parameters.

1.3 Research Objectives

The purpose of the study is to examine driver behavior at the beginning of the yellow indication and determine whether or not drivers in the city of Karbala run red lights. The main objectives of the current study are:

1- Identifying the variables that affect a driver's behavior while a signal is yellow.

2- Determining the proportion of drivers who violate the red light as well as the influences on these decisions.

3-Suggesting solutions and recommendations for reducing aggressive driving behavior in Karbala city.

1.4 Motivation of Work

The results of this experimental study can improve the efficiency and safety of intersection signal design, mitigate traffic, and reduce the probability of vehicle accidents in Karbala city. The proposed statistical and machine learning methods developed in this study can be gainfully used to identify high-risk intersections and optimize the duration of traffic lights to reduce traffic and red light running at intersections.

1.5 Contribution

The contribution of the current study is summarized below:

1. **Statistical analysis of red light running (RLR)**: A set of experiments have been carried out at the two selected intersections in which measurements of RLR have been collected and statistically analyzed.

2. **Data-driven modeling of driver's behavior**: A logistic regression classifier has been developed and experimentally validated to predict the driver's decision to go or stop at an intersection during the yellow indication using four measurable features: speed, headway, TTSL, and vehicle type.
3. **Experimental qualitative analysis of driver's decision**: A set of experiments has been carried out in which answers electronic questionaries have been collected, and qualitative analysis has been implemented to find the relationship between drivers' decisions with demographic variables such as gender, age, education level, driving experience, etc.

1.6 Organization of the Thesis

Chapter one: offers an introduction with a brief idea, a statement of the problem, research objectives, and motivation for work.

Chapter two: offers a review of past research literature and relevant background information.

Chapter three: shows some principles of the research methodology adopted and data collection by the videos and questionnaire.

Chapter four: represents both the analysis of the questionnaire questions provided and the analysis of the data collected from the videos.

Chapter five: includes the conclusions of this study and recommendations for future

Chapter Two: Literature Reviw

2.1 Introduction

This chapter includes highway intersections, types of intersections, traffic control systems, cycle length, factors affecting the drive response to yellow lights, the definition and condition of the dilemma zone (DZ), and previous studies which are related to RLR and driver behavior during the yellow light.

2.2 Highway Intersections

Intersections are areas of highways that produce conflicts among vehicles and pedestrians because of entering and crossing movements. The driver determines when to accomplish the required maneuver based on factors such as distances, velocities, and vehicle performance. (Yang et al.,2017).

2.3 Types of Intersections

At the intersection of two or more roads, there is a risk of vehicle collision (Tamás 2004). Intersections can be classified into three types.

2.3.1 Unsignalized intersection

At least one of the movements is regulated by a stop or yield sign in an unsignalized intersection (Guerrieri et al.,2021). The drivers on the controlled movements (commonly referred to as minor movements) must estimate the size of the gap along the major (or uncontrolled) street and choose an acceptable gap to operate such facilities (Guerrieri et al.,2021).

2.3.2 Uncontrolled intersection

An uncontrolled intersection is a road intersection where no traffic lights, road markings, or signs are used to indicate the right-of-way. They are found in either residential neighborhoods or rural areas. While the intersection itself is unmarked, warning signs or lights may be present to alert drivers to it (Guerrieri et al.,2021).

2.3.3 Signalized intersection

Signalized intersection means an intersection where traffic is controlled by official traffic-control signals. "Street or highway" means the entire width between the property lines of every way publicly owned (Guerrieri et al.,2021).

2.4 Traffic Control System

Isolated signalization systems are those that are not linked to other junctions in the vicinity of an intersection. To put it another way, it's the system that a single intersection manages. It is recommended that periods in isolated systems are kept as short as possible. When traffic volume is large, however, times are automatically lengthened. There are three types of traffic control systems. These control systems are described in the titles below(Tamás 2004).

2.4.1 Fixed-time signalization control system

At a fixed-time signalization control system, the period, phase duration, phase numbers, and range are all predetermined. The right of way is given in the system following pre-determined time schedules based on the vehicle and pedestrian traffic approaching the intersection from various directions. Fixed-time signaling systems can be implemented in two ways: as a single program running throughout the day or as multiple programs running throughout the day. In today's traffic, it's impossible to employ the as, throughout the day (Thunig et al.,2019). It is, however, implemented on a case-by-case basis. Fixed-time signals are recommended in all downtown areas, important business districts, and urban areas where pedestrians are expected or desired and moderate speeds are favored (Thunig et al.,2019).

2.4.2 Semi –actuated and fully- actuated

Except for the mainline, semi-actuated isolated signals detect some or all movements. Non-detected phases are regulated on a pre-set schedule. By altering the observed phase lengths, the cycle length can be altered (Vicky et al.,2018). The percentages of the mainline split are then computed by dividing the fixed mainline phase by the variable cycle duration (Day et al.,2008). Without causing further delays to other movements, sufficient green time for the mainline cannot be ensured. When a call comes in, the non-coordinated phases can be served after the mainline minimum green has been served (with clearance times). The signal generally sits in the mainline phase unless there is a conflicting call. All cycle and phase lengths (and thus splits) are allowed to match traffic flows (Yarger 1993). Fully actuated signal control may be used where vehicle and pedestrian volumes vary considerably throughout the day. Mount delay by being responsive to ongoing shifts and patterns in the traffic system. Semi-actuated control prioritizes the thorough movement of a major road and is not recommended on streets with frequent cross traffic or pedestrian demand from the minor approach unless a low cycle length is used (below 80 seconds) (Urbanik et al.,2007). Any traffic signal with substantial pedestrian delays may discourage crossings and become a travel barrier, especially at congested intersections. A multitude of signalization treatments, including full signalization (of the major and minor approaches) and pedestrian or half-signalization, can be paired with actuated signals (stop sign on the minor approach) (Day et al.,2008).

2.4.3 Adaptive signalization control system

Traffic congestion and delays are exacerbated by poor traffic signal timing. Signal systems in the past relied on daily signal timing schedules that were pre-programmed. The timing of red, yellow, and green lights is adjusted by adaptive signal management technology to meet changing traffic patterns and reduce traffic congestion. The key advantages of adaptive signal control technology over traditional signal systems can evenly divide green light time for all traffic movements continuously. By gradually moving vehicles through the green light, you can improve travel time reliability. Congestion can be alleviated by providing a more fluid flow (Bonneson et al.,2003). Ascertain that the timing of traffic signals is as efficient as feasible (Yang et al., 2017)**.**

2.5 Cycle Length

The amount of time takes to display all phases for each direction of an intersection before returning to the starting point, or the first phase of the cycle is referred to as a cycle length. Cycle lengths are determined by traffic volumes and perform best within a specific range, depending on the intersection's characteristics. The flow of traffic, which includes motor vehicles, motorcycles, bicycles, pedestrians, and other road users, is guided, warned, and regulated by traffic control lights positioned along, beside, or above a route.

2.5.1 Red light

The red signal light indicates that the driver must stop and yield to pedestrians and vehicles in the path. The driver can make a right turn against the red light only after stopping and yielding to pedestrians and vehicles in the path(Tang 2012). If there is a sign that says, do not turn there is a sign posted no turn on red (see figure 2-1).

Figure (2-1): The red signal light and arrow (Google Image)

The red arrow means stop until the green signal or green arrow appears. A turn may not be made against the red arrow (Kullback et al.1984).

2.5.2 Green light

A green light indicates that you may proceed, but you must first allow any remaining vehicles, bicycles, or pedestrians in the intersection to pass before proceeding. You can only turn left if there is adequate room to complete the turn before any oncoming vehicle, bicycle, or pedestrian creates a hazard. Vehicles turning left must always yield to those traveling straight in the other direction. Do not enter a junction unless there is enough space to cross completely before the signal turns red, even if the light is green. You may be cited if you stop traffic due to high traffic. A green arrow indicates that the driver should proceed, but the driver must first surrender to any remaining vehicles, bicycles, or pedestrians in the intersection. A green arrow pointing right or left permits you to make a protected turn; the red light stops oncoming automobiles, cyclists, and pedestrians as long as the green arrow is lighted (see Figure 2-2)(Tang 2012).

Figure (2-2): The green light and arrow (Google Image)

2.5.3 Yellow light

The yellow signal light warns the driver that the red signal is about to appear. Drivers should stop when they see the yellow light if it is safe to do so (see Figure 2-3)(Tang 2012).

Figure (2-3): The yellow light and arrow (Google Image)

If drivers can't stop,they have to look out for vehicles that may enter the intersection when the signal changes.

2.5.3.1 Definitions of dilemma zones

An initial proposal for the dilemma zone was made by Gazis, Herman, and Maradudin (1960). The dilemma zone is an area between two points on approaching a signalized intersection, generally starting where approaching drivers will likely stop at the stop line when shown the yellow indication and ending where drivers can cross the intersection safely before the red indication displays. There is a dilemma for drivers between these two points - whether to stop or continue (ITE 2010). The yellow light dilemma zone is widely known as an area on the high-speed intersection approach here vehicles neither safely stop before the stop line nor proceed through the intersection during the yellow interval. Within such an area, vehicles might be involved in a right-angle crash or rear-end crash. There are two types of dilemma zones that drivers can experience when approaching an intersection and encountering a circular yellow (CY) indication. Type I dilemma zones are those where the driver either continues through the intersection because he or she is too close to stop or go because it is safe to do so (Bonneson et al.,2002). In other words, a type I dilemma zone describes the situation in which the driver approaching a signalized intersection may not be able to stop safely before the stop line when presented with the yellow light or safely pass through the intersection because of its physical characteristics (Knodleret al.2009). These physical parameters can refer to timing and phasing, detector layout and operation, or geometry. The cause of these errors can be poor signal timing (excessively short the yellow change intervals) as well as detector placement (detector setbacks are too short). Furthermore, site-specific factors such as approach grade, speed, and available sight distance can contribute to these errors (Knodler et al.2009). Figure 2-4 shows the type I dilemma zone which corresponds with the timing of the change period.

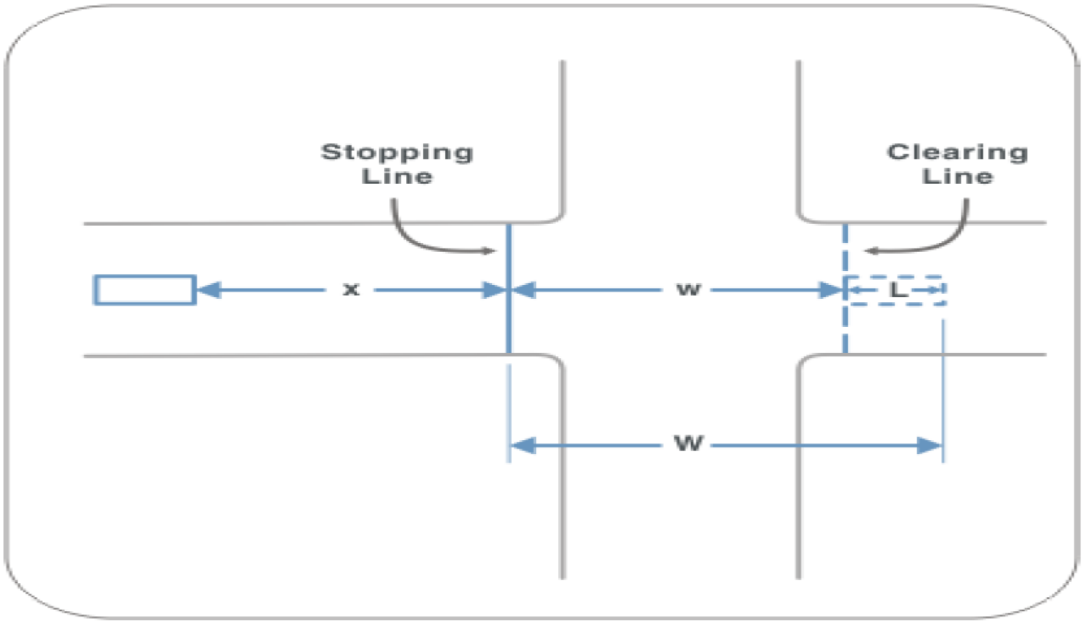


Figure (2-4): Stopping and clearing dilemma zone type I
(Bonneson et al.,2002)

Type I dilemma zone does not exist due to the assumed parameters, a vehicle can either safely stop or clear the intersection. In this case, drivers are not placed in a dilemma caused by a short yellow plus red clearance (Bonneson et al.,2002)**.** There are a few crucial considerations to keep in mind when dealing with the Type I problem. The formula is based on well-known physical rules. The formula, however, is only as good as the parameters that are assumed. The problem arises because drivers' abilities differ differences in human elements can change the scenario, leading to the second type of situation. This has resulted in the wide variety of opinions and practices presently employed regarding signal timing for Type I dilemma zones (see figure 2-5).

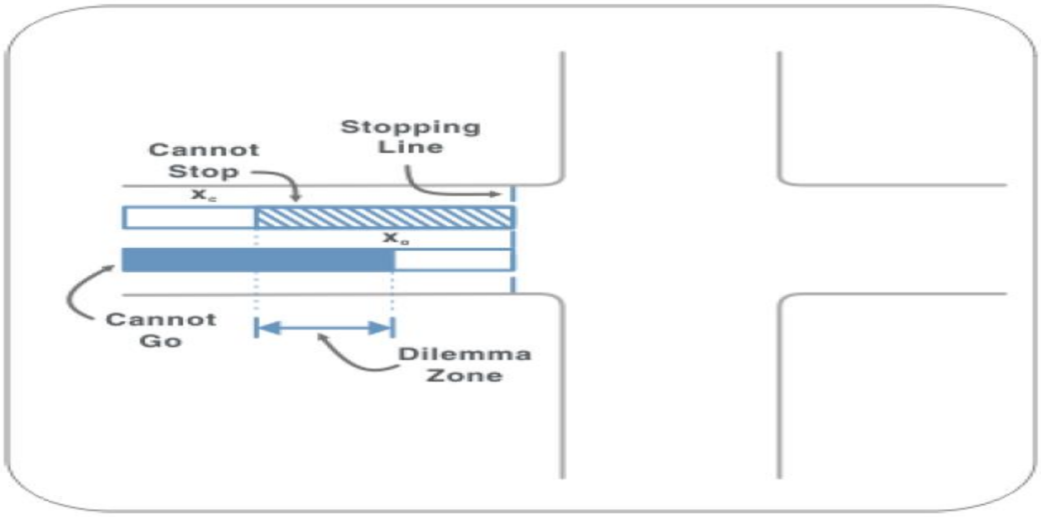


Figure (2-5): Type I dilemma zone (Bonneson et al.,2002)

Type II dilemma zones have also been called “indecision zones” and “option zones,” reflecting their probabilistic nature. As a group, drivers within a few seconds of traveling time of the intersection tend to be indecisive about their ability to stop at the onset of the yellow indication. This conduct creates a "zone of indecision" ahead of the stop line, where some drivers may choose to continue while others choose to stop figure 2-6 depicts the type II dilemma zone's position (Bonneson et al.,2002)

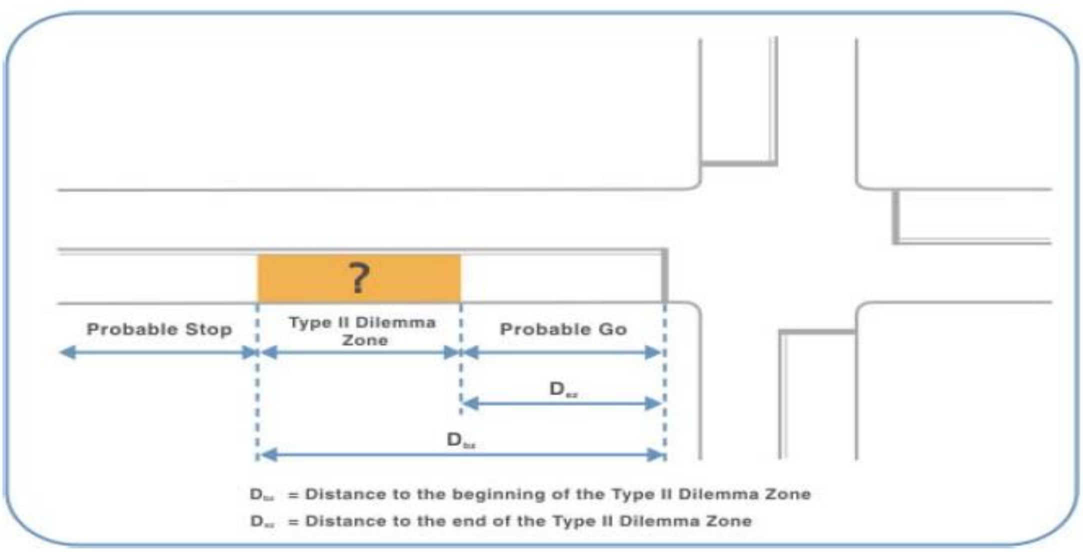


Figure (2-6): Type II dilemma zone (Bonneson et al.,2002)

The type II dilemma zone has been defined in several ways. In terms of distance from the stop line, Zegeer defined it (Zegeer 1977). He defined the start of the Type II dilemma zone as the distance beyond which 90% of all drivers would stop if faced with a yellow light. He defined the zone's end as the distance within it. Only 10% of all drivers would pull over. The distance from the start of the race Zegeer recommends a Type II dilemma zone that lasts roughly 5 seconds. As stated in the instructions, the Type II dilemma zones begin at the beginning of travel time ranges from 4.2 to 5.2 seconds, with greater numbers corresponding to higher speeds. The type II dilemma zone has also been defined as the observed travel time to the stop line. (Chang et al.1985) discovered that if the driver was more than 3 seconds from the stop line, regardless of speed, 85 percent of drivers stopped. Similarly, vehicles that were less than 2 seconds from the stop line almost often continued through the intersection, according to the study (Bonneson et al.,2002). The beginning and end of the Type II dilemma zone are roughly 5.5 seconds and 2.5 seconds, respectively, from the stop line, according to research data collected at least 20 years ago. These times correspond to the 90th and 10th percentile drivers' decision times, respectively**.** A driver's decision to proceed or stop at a signalized intersection is influenced by the following factors: signal phasing sequence; cycle length; the yellow signal duration and all the period; position in a platoon (platoon leader or follower); vehicle speed; distance from stop line; and drivers characteristics (Papaioannou 2007).

Drivers in the 65 years of age and older group are more likely to stop at the onset of a yellow-phase trigger (74 percent compared to 66 percent for drivers less than 65 years old). Younger drivers are approximately 20 percent more likely to attempt to run the yellow light when compared to older drivers. We hypothesize that the driver's conduct is the most important component in the driver stop/go decisions if we simply take into account light-duty vehicles because the drivers all drove the same test vehicle, which we feel allows the results to be generalized for several reasons(Rakha et al.,2007). Many options, such as traffic-responsive signal timing, advance signal warning, and problem zone protection methods, have been explored and applied to prevent red light running crashes. However, human error or behavior is the most common cause of redlight running accidents. Based on theoretical and logical reasoning, new traffic rules to prevent redlight running are proposed (Awadallah 2009). Due to the two sorts of dilemma zone scenarios, there are three basic failure conditions. This study focuses on the two types of failures related to through traffic in a Type II dilemma zone (rear-end collision on the approach and right-angle collision in the intersection)(Hurwitz et al.,2012). The dilemma zone is a broad concept that represents a region (length) of roadway where vehicles may encounter the yellow dilemma difficulty at the commencement of the yellow indicator(Wu et al.,2013). All or part of the yellow and all-red intervals are not used or needed for a significant portion of traffic signal operation. In addition, increasing the green interval for the typical "dilemma zone" protection does not affect safety when terminated via the "max-out" option, although it does increase latency for minor approaches (Awadallah 2013)**.** The dilemma zone for trucks, as shown in this study, begins far further back than the dilemma zone for regular passenger automobiles. If the yellow times were raised to give this protection at all times, the system's delay would result in a noticeable reduction in the level of service at junctions(Katz 2013). With vehicle-to-infrastructure communications an intersection will be able to know when a truck is approaching and is at risk of being caught in a dilemma

zone and can adjust the yellow times accordingly for that situation, thus avoiding introducing is unnecessary delay when there are no trucks present (Katz 2013)**.** It should be noted that other factors, like the intersection's design, the driver's familiarity with the signal phases, the signal's visibility, its height, and the driver factors such as age and gender among many others, frequently affect how drivers' behavior there(Pathivada et al.2017).In the dilemma zone, the vehicle model and initial vehicle speed will influence the driver's behavior. When the driver decides to accelerate to pass through a signalized intersection, the effect variation tendency appears to be consistent, and the level of variation is dependent on the vehicle model and initial vehicle speed. When a motorist decides to stop before the stop line, the likelihood of variance varies depending on the vehicle model and initial vehicle speed (Li et al.,2021).
The yellow Change Interval is computed using the ITE formula**:** (Papaioannou 2007).

$$Y = t + \frac{1.47v}{2(a+Gg)} \qquad (2-1)$$

Where:

Y= length of the yellow interval, sec.

t = perception-reaction time, sec.

v = speed of approaching vehicles, in mph.

a = deceleration rate in response to the onset of the yellow indication (use 10 ft/sec2).

g = acceleration due to gravity (use 32.2 ft/sec2).

G = grade, with uphill positive and downhill negative (percent grade /100).

2.6 Red Light Running (RLR)

Drivers may run the red light if they are too far from the stop line of the intersection and chooses not to stop (Elmitiny et al.,2010). Road accidents and the deaths they cause are one of the main causes of the 1.3 million people who die every year from road traffic accidents worldwide (Komol et al.,2022). In 2019, RLR crashes caused 846 fatalities and 143,000 injuries (Mohammed et al.,2022). RLR infractions can happen for several reasons. The following are significant contributing factors: (1) intersection characteristics, such as cross-street width, traffic control signal type, traffic volume, the yellow change interval, and approach grade; (2) the driver's background and educational level; and (3) the level and impact of enforcement (Mohammed et al.,2022). RLR collisions frequently result in fatalities and severe injuries. RLR crashes involving riders can be fatal in emerging Asian nations (Jantosut et al.,2021). RLR infractions at high-speed signalized intersection approaches can be caused by a variety of circumstances. The human factor (speeding and aggressive driving), the vehicle factor (larger-sized vehicles), the intersection factor (traffic volumes, approach grade, signal control type, signal cycles frequency, and timing of the yellow interval), and the demographic factor (age, gender, and occupancy) are some of these factors (Mohammed et al.,2022). Efforts to lengthen the yellow intervals or slow down drivers are likely to be beneficial in reducing red-light violations.Nonetheless, they are more likely to have a minor impact on red-light-related collisions (only crashes that are left-turn-related are likely to be reduced). Efforts to enhance the driver's attention (and hence minimize unintended red-light infractions) are more likely to lower the frequency of red-light-related crashes (Bonneson et al.,2003).Five thousneds one hundred twelve observations of drivers entering six traffic-controlled crossings in three cities were reported by the study. In total, 35.2% of the light cycles that were observed contained at least one red-light runner before opposing traffic started (Galatioto et al.,2012). There are ten times more violations than in the USA and Australia—32 violations per 1000 vehicles—on average(Al-Atawi 2014). RLR crashes of type 1—which make up 66.72% of all RLR crashes—involve a GS RLR vehicle and a GS non-RLR vehicle. RLR crash type 2 (representing crashes involving a GS RLR vehicle and an LT non-RLR vehicle, accounting for 24.99%), and RLR crash type 3 (representing crashes involving an LT RLR vehicle and a GS non-RLR vehicle, accounting for 8.28%) (Zhang et al.,2018). Shows the three types of red-light running (RLR) crashes. Figure 2-7 shows the three types of red-light running (RLR) crashes that were found in the GES database.

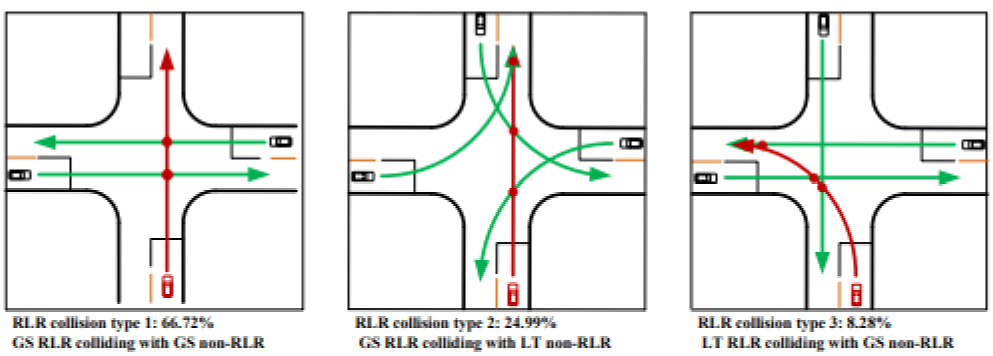


Figure (2- 7): Types of red-light runnings (RLR)s

Note that the red line denotes the approach of an RLR vehicle, whereas the green line denotes the approach of a non-RLR vehicle. GS and LT stand for a vehicle's straight-ahead and left-turning movements, respectively (Zhang et al.,2018). The results of statistical analysis are in good agreement with traffic engineering practice. For instance, RLR is most likely to occur during weekday rush hours when there is high traffic volume and longer signal cycles, and a total of 95.24% of RLR events happened within the first 1.5 seconds of the red phase beginning (Zhang et al.,2018).

2.8 Previous Studies about Responses of Drivers to Yellow Indications

Author	Year	Previous Studies
Papaioannou	2007	A signalized intersection in Thessaloniki, Greece, driving behavior to obeying or disobeying yellow signals was evaluated as a contributing element to intersection safety. The study's findings resulted in the conclusion that aggressive drivers account for a significant portion of all drivers, necessitating improved driving practices and/or slower vehicle speeds.
Rakha et al	2008	Created models that describe driver perception reaction times, braking timings, and stop/go choices at the beginning of the yellow indication during a high-speed signalized intersection approach. The study showed that the only factor affecting driver perception-reaction times is the driver's time-to-intersection (TTI) at the beginning of the yellow signal.

Li	2009	Used probabilistic methods to address several dilemma zone protection-related challenges. He created a model of how drivers make decisions and behave when they see a yellow onset.
Wei et al	2010	Analyzed drivers' yellow stopping patterns related to problem zones at the OH-4 and Seward Road crossing in Fairfield, Virginia. They looked at several variables with a view toward how they might affect driving behavior, stopping the behavior, and distributions of the dilemma zone.
Elmitiny et al	2010	Used a video-based system with three cameras for their field data collection to recorded drivers' actions as the light turned yellow. They used classification tree models to examine the relationships between the traffic parameters and the probability of making a stop-or-go decision and running a red light.
Sharma et al	2011	Found the speed to be a significant factor in drivers' decision-making. According to

		the research, research has examined some factors that may not directly apply to mixed traffic conditions but have an impact on the dilemma zone problem for homogenous traffic conditions. Under different traffic conditions, a variety of additional influencing factors may need to be taken into account to effectively understand the intricacies of drivers' decision-making processes. This research represents an effort in that direction.
Chang et al	2012	Have developed an evaluation model to describe driver behavior and found that aggressive driving is more common during yellow periods among drivers who drive greater than the average stream speed
Yang et al, and Long et al	2014, 2013	Found that the probability of stopping was greater for intersections without the countdown timer than that with the countdown timer.

Qu et al	2014	Driver behavior, for example, is typically influenced by the type of vehicle, with heavier vehicles less probable than passenger cars to halt when stranded in a dilemma zone. Heavy vehicles have slower stopping speeds than passenger cars, which increases their operating costs. Additionally, in emergencies, heavy vehicle drivers attempt to employ softer deceleration rates to prevent cargo from shifting.
Gates et al, Gates et al,Abbas et al,and Gates et al	2007, 2010, 2016	Accidents at signalized intersections are caused in part by drivers' impossibility to make smart decisions in the stressful dilemma zone.
Abbas et al,Rakha et al,Bonneson et al,and Mohammed et al.	2016, 2007, 2002, 2021	Driver behavior and decision-making are affected by the following factors at the beginning of a CY indication: (1) driver characteristics (such as perception-reaction time, age, and gender); (2) intersection characteristics (such as type of intersection control, time to the intersection at the beginning of the CY indication, signal coordination, approach

		grade, pavement, and environmental conditions); (3) vehicle characteristics (such as classification, approach speed, and safe speed rates); and (4) sig (e.g., headway and travel time)
According to Mohammed et al	2021	A driver's stop/go decision was influenced by the amount of time it took to get to the stop line, the distance between the car in front of it and the one behind it, and the speed of the vehicle when the CY was displayed.

2.9 Previous Studies about RLRs

Author	Year	Previous Studies
Chang et al, Mohamedshah et al, and Bonnesonet al.	1985, 2000, 2001	Studies the RLR grows as traffic volume, vehicle closeness to the intersection, and approaching speeds to increase.
Fitzsimmons et al	2007	Red light running crashes make for 21% of all crashes generally and more than 35% of crashes at signalized intersections that resulted in deaths or severe accidents, according to research conducted

		nationwide in 1999 and 2000 on fatal collisions at signalized intersections, 20% of the vehicles involved did not follow the signals. .
Fitzsimmons et al	2008	observed that, on average, intersection approaches without red light running cameras experienced 25 times more red light running violations than approaches with cameras. It was also noted that, at intersections where red light running cameras were in place, there was 44 percent decrease in overall crashes.
Johnson et al	2011	From October 2008 to April 2009, a video recording camera was used to record cyclists at ten locations in urban Victoria, Australia, for a cross-sectional observational study. At ten locations along the main on-road commuter paths in urban Victoria, cyclists were observed. Each site had two forward lanes, four cross lanes, a pedestrian crossing, and a tram line running parallel to the right vehicular lane. They were all less than five kilometers

		from the CBD. Location, rider characteristics, and other road users were the three sets of predictor variables that were noted.
Williams et al,kamyab et al, and Al-Atawi ,	1998, 2000, 2013	In the United States, there are 1.3 red light running violations for every 1000 vehicles or three violations per hour, According to another study, there are 0.45 to 38.5 violations for every 1000 vehicles. the probability of making a stop-or-go decision and running a red light.
Al-Atawi	2014	By completing a thorough field Questionnaire at 38 intersections with video camera records, researchers were able to determine the features of RLR violations in Tabuk, Saudi Arabia.
Wang et al	2016	RLR was the subject of a field investigation at four intersections in Shanghai, China. In these investigations, video cameras were deployed to capture how vehicles operated as they approached the intersection.
Abu Ali et al	2016	Some external and internal characteristics must be taken into account in line with traffic models. However, this field needs to be greatly improved to handle many,

		complicated lane changes. Studies of the implementation of technical algorithms, sensors, and evaluation approaches for data collecting and experimentation with effective intersection management have been made.
Gazis et al, and Majhi et al	1960, 2019	An effort to cross the intersection in this situation is ineffective since the red signal will activate before the intersection area is clear, which will result in a right-angle collision with vehicles traveling oppositely. .
Tang et al	2020	Analyze statical methods and machine learning algorithms for clearance time prediction, and a methodological review was carried out.
Mohammed et al	2022	Were conducted utilizing a driving simulator to examine the response of drivers to circular yellow and circular red warnings. 1,272 observations from 53 participants were included in the data, with a 3.7% red-light running violation rate. vehicle characteristics (such as

		classification, approach speed, and safe speed rates); and (4) sig (e.g., headway and travel time)

2.10 Summary

This chapter shows the importance of the yellow light in an intersection and includes a general overview of the types of intersections, the traffic control system, and the length of the cycle, as well as talks about the definition of a dilemma zone and its types. studies the dilemma zone, and shows the driver's reaction to the yellow light and the safety implications at signalized intersections. As well as previous studies about the responses of drivers to yellow indications and RLR.

Chapter Three: Methodology and Data Collection

3.1 Introduction

This chapter provides an overview of the study area and methodology, describing the intersections selected in the city of Karbala. Then, the stage of data acquisition, data collection techniques, abstraction, and processing were then described. In addition, conducting an electronic Questionnaire (questionnaire) to learn how drivers behave during the yellow indication at signalized intersections. The area of the study consists of two intersections in the governorate of Karbala. Where cameras were placed at two signalized intersections. The first site was SaifSaad intersection where cameras were placed for five workdays from Sunday to Thursday. This intersection is one of the important intersections in the city, linking Najaf-Karbala Street (Haider Al-Karar Street), Al-Iskan Street, Al-Abbas Street heading towards the city center, and Al-Tawun Street. The second site was Al-Dhareeba intersection where cameras were placed for five workdays. This intersection connects Saif saad Street, the center of the Holy city, and the Ramadan neighborhood highway, the center business area (Center Street), Al-baladea. The data were collected every day, starting at 7 am and ending at 10 pm. The cameras were set on December 19/12/2021 for five workdays. Due to the presence of numerous centers of activity, including schools, government offices, commercial malls, and religious facilities, traffic congestion in this area has developed along with rising traffic demand in the study area as shown in figure (3-1).

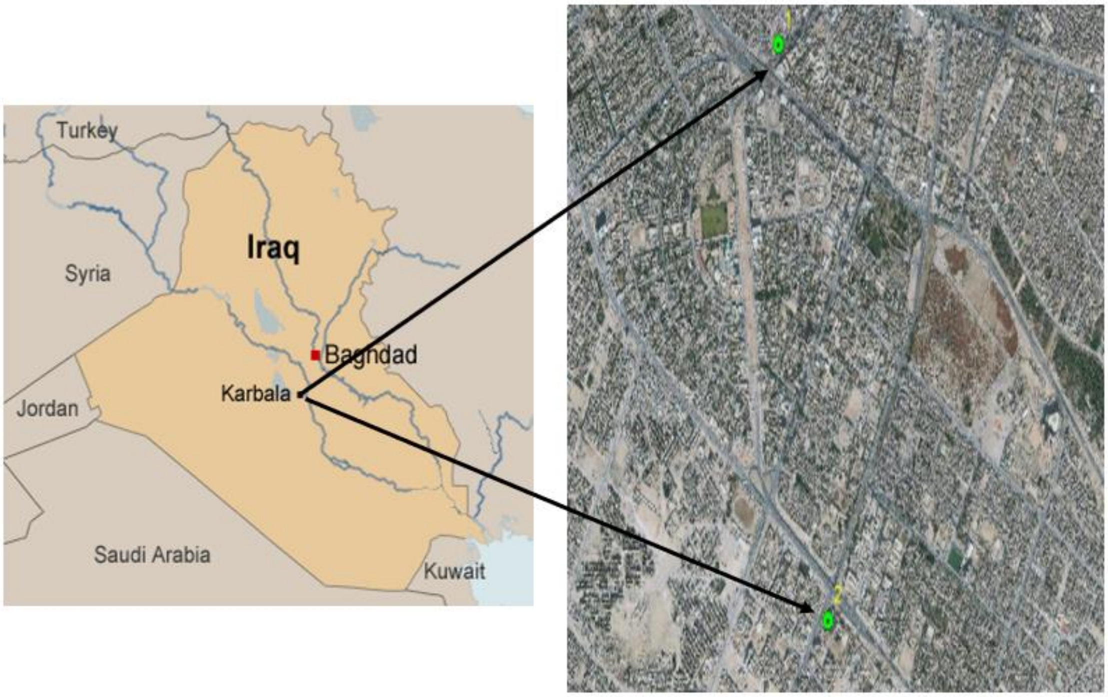


Figure: (3-1): Intersections locations in Karbala (Google Erth and Map)

3.2 Location of Study Area

3.2.1 Al- Dhareeba intersection

It is a four-legged, signalized crossroads that is one of the most significant intersections in Karbala city. The north way connects to the area's center, while the west direction leads to the University of Kerbala. It has a bridge that is (432) meters long. It was built in the direction of Fatima Al- Zahraa Street, and it was built to reduce traffic congestion at the intersection, particularly those caused by heavy left turns. This intersection is shown in figure (3-2).

Figure (3-2): Location ofAl-Dhareeba intersection (Google Earth)

3.2.2 Saif Saad intersection

Saif Saad intersection is one of the crucial intersections in the holy governorate of Karbala. This intersection is one of the important intersections in the city, linking Najaf-Karbala Street (Haider Al-Karar Street), Al-Iskan Street, Al-Abbas Street heading towards the city center, and Al-Tawun Street. Figure (3-3) shows the location of this intersection.

Figure (3-3): Location of Saif Saad intersection(Google Earth)

3.3 Method of Data Collection

At Al-Dhareeba intersection, where the cameras were positioned on Al-Baladiyah Street across from the traffic signal, cameras were mounted. Where the camera was positioned on 12/19/2021 for five days so that they could capture both vehicles and traffic signals as shown in figure (3-4).

Figure (3-4): Camera installation

The traffic flow data for Saif Saad intersection were collected by using a video camera from Karbala police on 16/1/2022 for five days. Characteristics of the selected intersection approaches are shown in table (3-1).

Table (3-1). Characteristics of the selected intersection approaches

Intersections	Location 1	Location 2
Intersection name	Saif Saad	Al-Dhareeba
Cycle length	156 s	120 s
Yellow phase duration	3 s	3 s
Green phase duration	54 s	29 s
Red phase duration	99 s	88 s
Number of lanes	3	3
Street width	10 m	10 m
Cameras site	Al-Tawun Street	Al-Baladiyah Street
Type of intersection	4- Legged	4 - Legged

3.3.1 Camera properties

The cameras installed at the intersection are a camera HIKVISION. The HIKVISION camera's most crucial characteristics and features are that it uses an infrared light sensor for automated night vision, has high-quality lenses, and has a sturdy metal casing for long-term use. The duration of recording for four hours, following which the camera is installed and recharged by connecting it to an electricity.2TB hard drive up to storage capacity.

3.4 Traffic Data

From Sunday to Thursday, from 7:00 am to 10:00 Pm, data were gathered forAl-Dhareeba intersection and SaifSaad intersection, and the following calculations were made:

3.4.2 RLR

The number of vehicles passing within this 3-second period, which begins when the yellow light turns on, is counted. We count the number of violating vehicles between the end of the yellow and the start of the red light. Every hour, data calculations from Sunday to Thursday, from 7 am to 10 pm computation is performed in the shape of the subsequent law:

$$\% RLR = \frac{Violating\ Vehicles}{Violating\ Vehicles + Vehicles\ passing\ when\ the\ yellow\ light\ runs} \times 100\% \qquad (3\text{-}1)$$

3.4.3 Speed

The speed was computed for two hours in the morning and two hours in the evening. From Sunday to Thursday, the peak hour in the morning, from 8 to 10 am, and the two hours of low traffic, from 5 to 7 pm, were both selected. We selected a specific location from the videos already available, which is the electricity pole. We measured the distance between the electricity pole and the pedestrian crossing line, and using the time it took the vehicle crossing line e from the electricity pole to the stop line through, we calculated the speed using the laws of both intersections.

$$Speed = \frac{distance(km)}{time(hour)} \qquad (3-2)$$

3.4.4Headway

It is determined during the appearance of the yellow light and is the time between the first vehicle's front beam and the second vehicle's front beam, or between the first vehicle's rear beam and the second vehicle's rear beam. It was also calculated to allow for two hours in the morning and two hours in the evening, from seven in the morning to nine in the evening, respectively. An imaginary line is drawn to cross the first vehicle as part of the process of calculating headway using a camera located at the aforementioned crossings. The phone clock is then set to match the movement of the vehicle and the time is recorded. The time is taken from the front beam of the first vehicle to the front beam of the second vehicle as shown in figure 3-5.

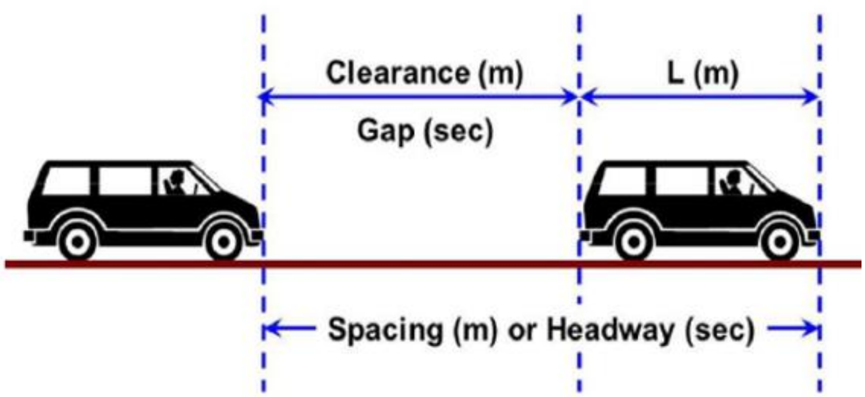


Figure (3-5): Headway in traffic flow (Mohammadi et al.,2017)

3.5 Questionnaire

There are some things that we can calculate through the camera placed at the intersections, such as the vehicle's speed, as well as the headway, RLR, and other things. However, there are some things that we cannot calculate through the camera placed at the intersections, such as the driver's gender, and age, as well as predicting the driver's actions and other things. Therefore, we put a set of questions in an electronic questionnaire. These questions are electronically shown in table (3-2). data were collected using electronic questionnaire questions open to all drivers on the internet, where a statistical analysis has been carried out to provide a qualitative assessment of the effect of gender, age, and education level on the driver's decision. Six hundred figures participated in the Questionnaire.

Table (3-2): Questionnaire of drivers

Number	Questions
1	Is the driver man or a woman
2	Driver's age
3	Number of years driving
4	Academic achievement
5	The personal vehicle that you use in your daily life
6	What is the function of the yellow light in the traffic lights
7	How long is the yellow light duration
8	Are you trying to speed up your vehicle when you see the traffic light change from green to yellow light

9	When you are close to the pedestrian crossing line at the intersection (1-2 seconds) and the signal changes to yellow light, what is your decision?
10	When you are close to the pedestrian crossing line at the intersection (2-3 seconds) and the signal changes to yellow light, what is your decision?
11	When you are close to the pedestrian crossing line at the intersection (3-4 seconds) and the signal changes to yellow light, what is your decision?
12	When you are close to the pedestrian crossing line at the intersection (4-5 seconds) and the signal changes to yellow light, what is your decision?
13	When you are close to the pedestrian crossing line at the intersection (more than 5 seconds) and the signal changes to yellow light, what is your decision?
14	Did you ever find it difficult to decide to stop or cross the intersection when the yellow light appears?
15	Do you prefer the yellow light to be longer?
16	How much is the distance between your vehicle and the vehicle before you inside the traffic intersection when the yellow light appears?
17	In your opinion, do motorists put safe distances between their vehicles and the vehicles before them when the yellow light appears?
18	Do you hesitate to cross when the yellow light appears?

19	Have you ever encountered when you are near the crossing line and the traffic signal changes from yellow light to a red light?
20	Have you violated the traffic light because of the change in traffic signal from yellow light to a red light?
21	Did you happen to stop suddenly when the yellow light appeared? Is it more abiding by traffic light laws?
22	In your opinion, who is the most committed to traffic light laws?

3.6 The Driver Behavior Model

The decisions the driver makes about numerous observable variables' characteristics can be used to model the driver's behavior. A binary logistic regression model can describe the drivers' behavior as a function of the numerous explanatory factors given that the driver confronting the yellow light has just two options (stop or go). The functional form of an alternative is represented as, the probability of selecting an alternative (stop or go) is based on this (Pathivada et al.,2017):

$$U_{ij} = \beta_0 + \beta_{j1} x_{ij1} + \beta_{j2} x_{ij2} + \ldots\ldots\ldots\ldots\ldots + \beta_{jn} x_{ijn} \quad (3\text{-}3)$$

Where:

U_{ij} = Utility of driver i choosing alternative j;
j = Alternative (Stop or go);

n = Number of independent variables;

$\{\beta_{jk}\}$ = Model coefficients.

The probability of the driver stopping at the intersection is given by (Pathivada et al.2017):

$$P_i(stop) = \frac{1}{1+e^{(-U_i)}} \quad (3\text{-}4)$$

3.6.1 Binary logit model

A linear model can be used for a data set as shown in figure (3-6 A), where the data are labeled either 0 for a go of x or 1 for the stop; however, the results should be either 1 or 0 for a binary classification problem, and thus the upper and lower sections (marked with blue circles in the figure) can be trimmed as shown in figure (3-6 B). The plot is shown in figure(3-7) which results in the application of the sigmoid function to the linear model,where p = prediction probability, permitting the setting of a threshold (such as 0.5) where y is equal to 1, if p has crossed this point, and otherwise it is equal to zero.

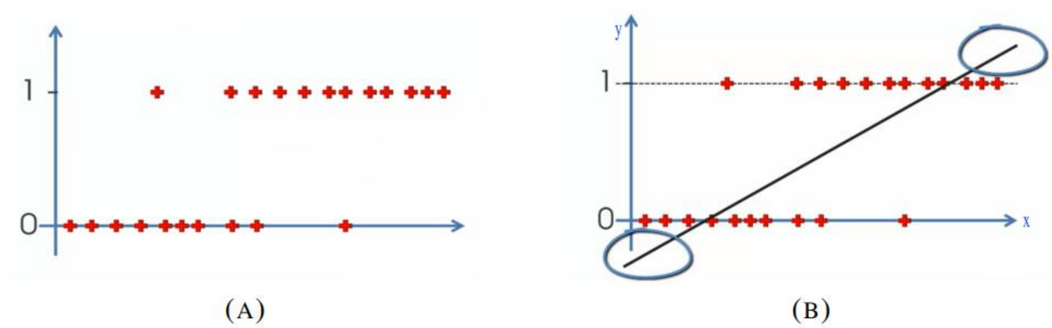


Figure (3-6): Linear model

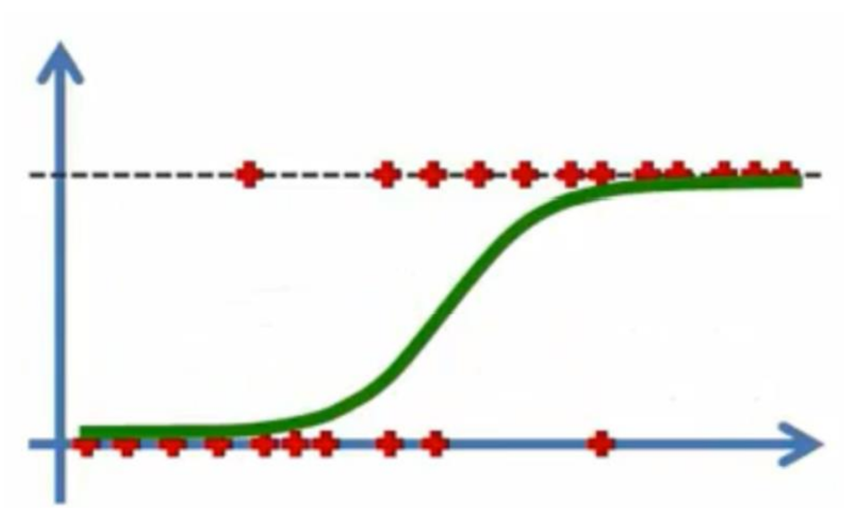


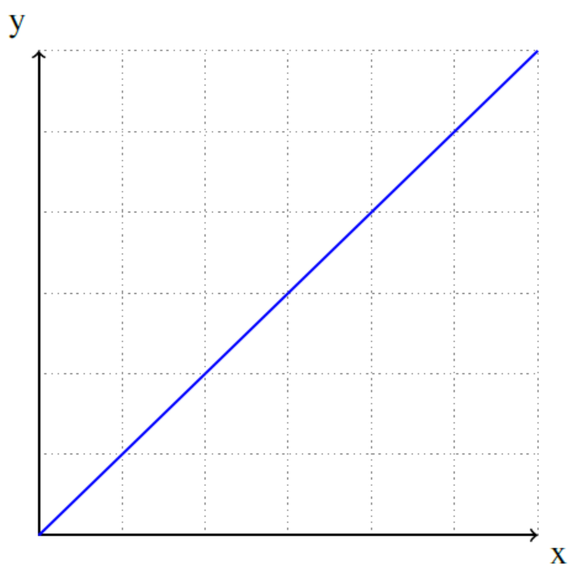
Figure (3-7): Logistic regression model

3.6.2 Feature selection Bertomeu

Feature selection is a preprocessing step in the machine learning field. Feature selection reduces the number of features required to build the statistical model and get the most effective features on the built model. Reducing the redundant features will increase the created model performance, and the time required to build the statistical model will be reduced. Feature selection is broadly divided into three approaches: wrapper model (Hall et al.1999) filter model (Sebbna et al.1999) and hybrid model (Bertomeu et al.2016). The wrapper model uses all possible feature elimination cases and measures the performance with each case; the case of features with the highest model performance is considered the best feature to build the model. The wrapper model is a time-consuming process, and it is increased drastically with the increment of the dataset. The filter method reduces the number (0) features independently from the chosen model based on several criteria such as distance, consistency, and information. The linear correlation method is used in this work to select the best-correlated features. Correlation is a known measure that measures how well the used variables are reduced. The correlation coefficient equals (± 1)if the used variables are fully correlated and equal to 0 if the used variables are not correlated. The correlation coefficient for the two variables is as shown in equations (3-5).

$$r = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{[n\sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2]\,[n\sum_{i=1}^{n} y_i^2 - (\sum_{i=1}^{n} y_i)^2]}} \quad (3\text{-}5)$$

To have a good understanding of what the correlation coefficient value means? Consider a linear function such as y(x) = x. Such a function has a correlation coefficient equal to a positive one where y has a fully positive correlation with x, as shown in Figure (3-7).



Figur e (3-8): Fully positive correlation

Thus, we have a fully negative correlation if we have y(x) = -x, as shown in Figure (3-8).

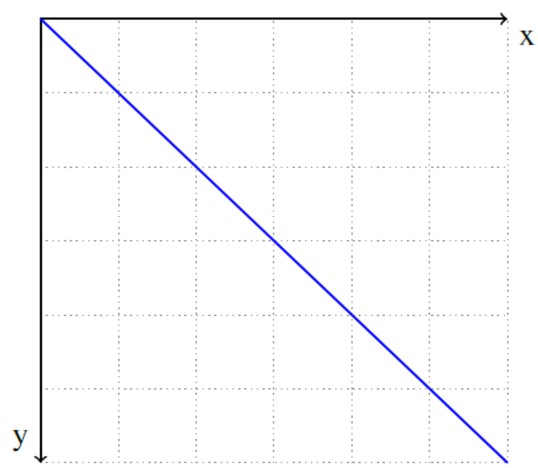


Figure (3-9): Fully negative correlation

If we have y(x) = c, we have a zero correlation between the y and x variables, as shown in Figure (3-9).

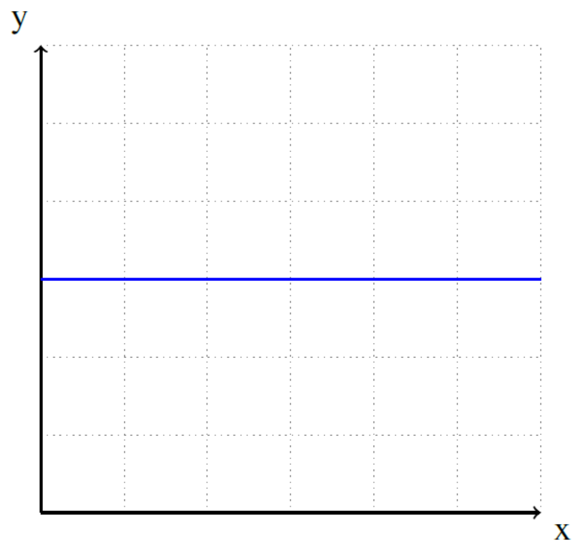


Figure (3-10): Zero positive correlation

3.7 Summary

The third chapter comprises a methodology section, data collection from the camera positioned at the two selected intersections, questionnaire questions, information and images of the intersections that were analyzed, as well as an investigation of various factors that influence the decision of the driver.

Chapter Four: Results and Discussion

4.1 Introduction

This chapter involves analysis and discussion of the results obtained from three sets of experiments. The first set of experiments includes the measurement of RLR violations. The second set of experiments includes the driver's behavior during the yellow indication and measurement of speed, headway, TTSL, classification of vehicles, and driver decision. The third set of experiments includes the collection of answers from electronic questionnaires regarding the driver's gender, age, and education level, and the analysis of their relation to the driver's decision.

4.2 Average RLR Violations

Red light running (RLR) is one of the most dangerous riding behaviors at mixed-traffic intersections and one of the most serious safety issues. RLR accidents at signalized intersections can result in serious injuries or deaths. Many factors can contribute to an increase in RLR violations in these signalized intersections. First, traffic laws are not enforced against violators, encouraging other drivers to run the red lights. In addition, there are no stringent regulations and laws governing the age of drivers who are under the age of 18 years. Moreover, the yellow light's duration is only 3 seconds, which is considered short. The results showed that RLR violations were found to be 67.60% inAl-Dhareeba intersection and 45.46% in SaifSaad intersection during early hours (8-9 am.). These results were not significantly different from afternoon measurements that indicated that RLR violations were 67.05% inAl-Dhareeba intersection during (12-1 p.m.) and 42.47% in the Saif saad intersection during (1-2 p.m.) as shown in Table (4-1). Figures (4-1) and (4-2) show two examples of RLR violations that occurred in both signalized intersections. As shown in figures (4-3) and (4-4), the findings revealed that

RLR violations differed by vehicle type. Thus, RLR violations have been classified according to the type of vehicle. Figures (4-5) and (4-6) show the RLR violations by vehicle type, with the PC having the highest number of violations as compared to other vehicle categories.

Table (4-1): Average RLR violations in two signalized intersections.

Time (hr)	% RLR violations in Al-Dhareeba intersection	% RLR violations in Saif Saad intersection
7:00-8:00 am	51.01	42.87
8:00-9:00 am	67.60	45.46
9:00-10:00 am	50.45	42.35
10:00-11:00 am	51.59	25.09
11:00am-12:00 pm	52.44	38.16
12:00-1:00 pm	67.05	39.27
1:00-2:00 pm	62.74	42.47
2:00-3:00 pm	66.11	32.18
3:00-4:00 pm	51.19	42.22
5:00-6:00 pm	58.53	27.43
6:00-7:00 pm	56.51	15.66
7:00-8:00 pm	55.48	12.50
8:00-9:00 pm	57.49	12.50
9:00-10:00 pm	61.65	16.67

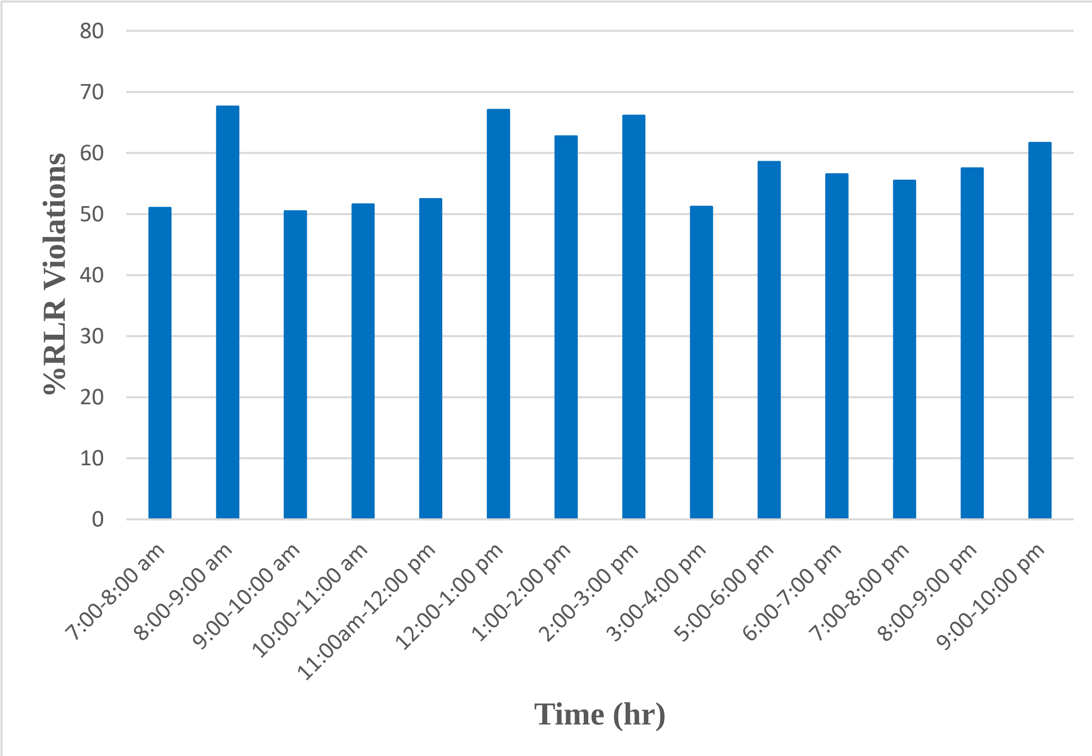


Figure (4-1): Average RLR violations in Al-Dhareeba intersection

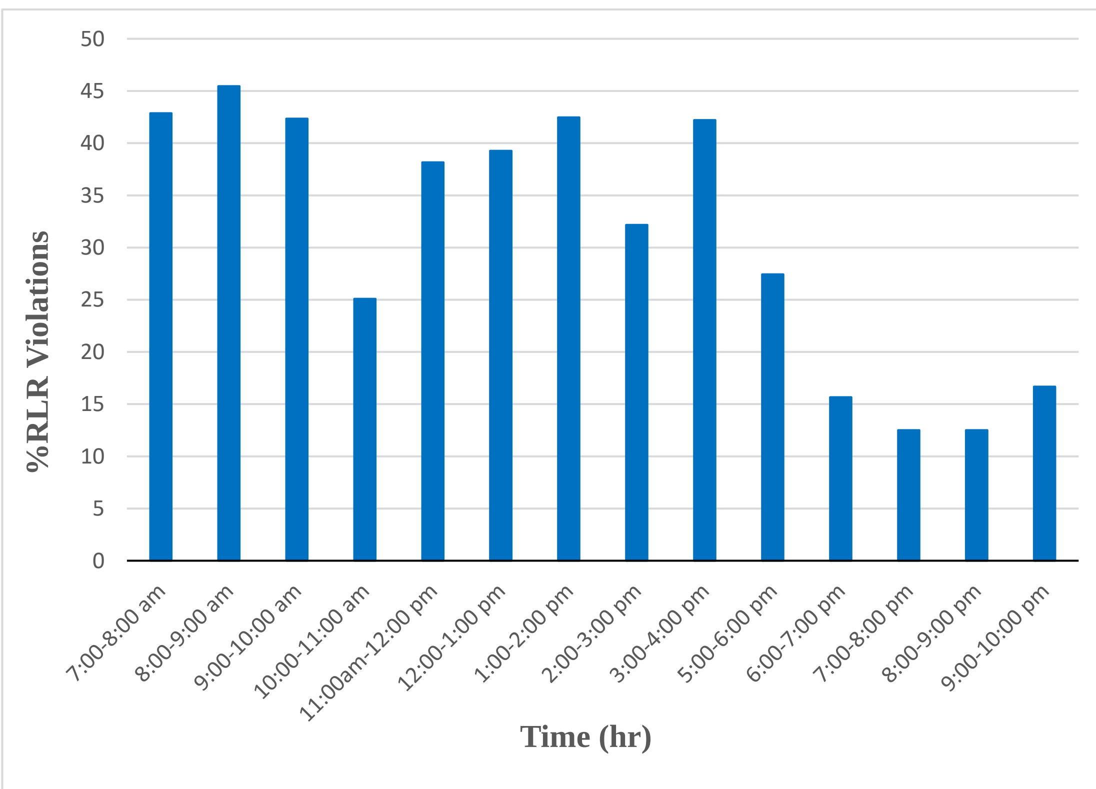


Figure (4-2): Average RLR violations in Saif Saad intersection

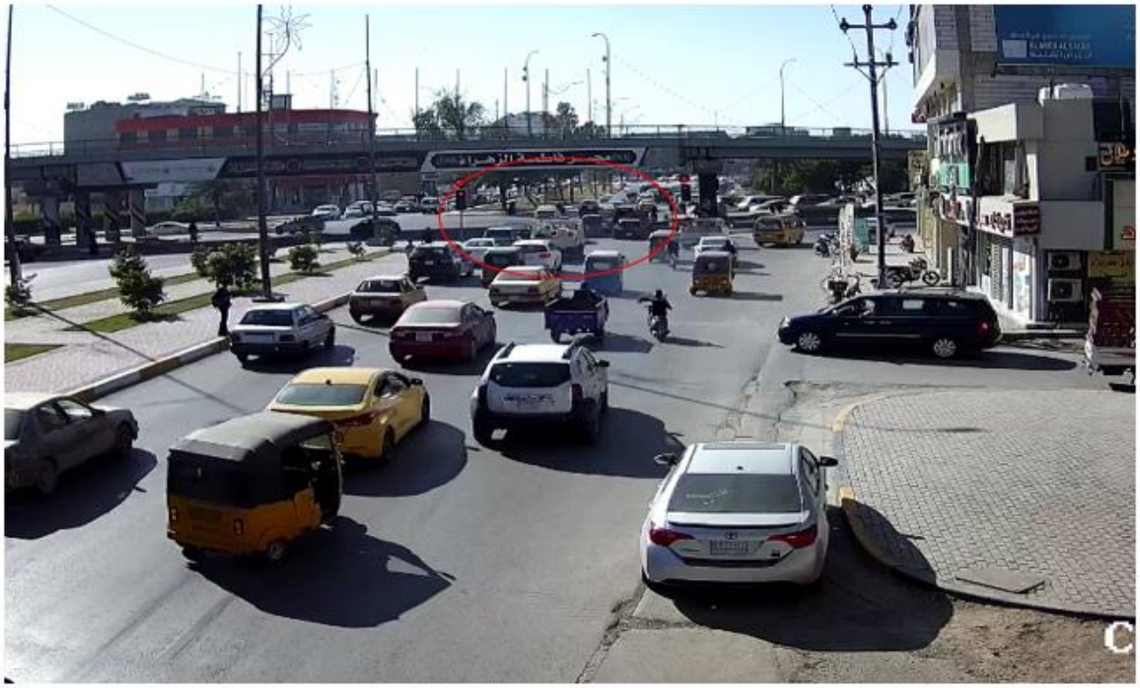


Figure (4-3): Example of RLR violations in Al-Dhareeba intersection

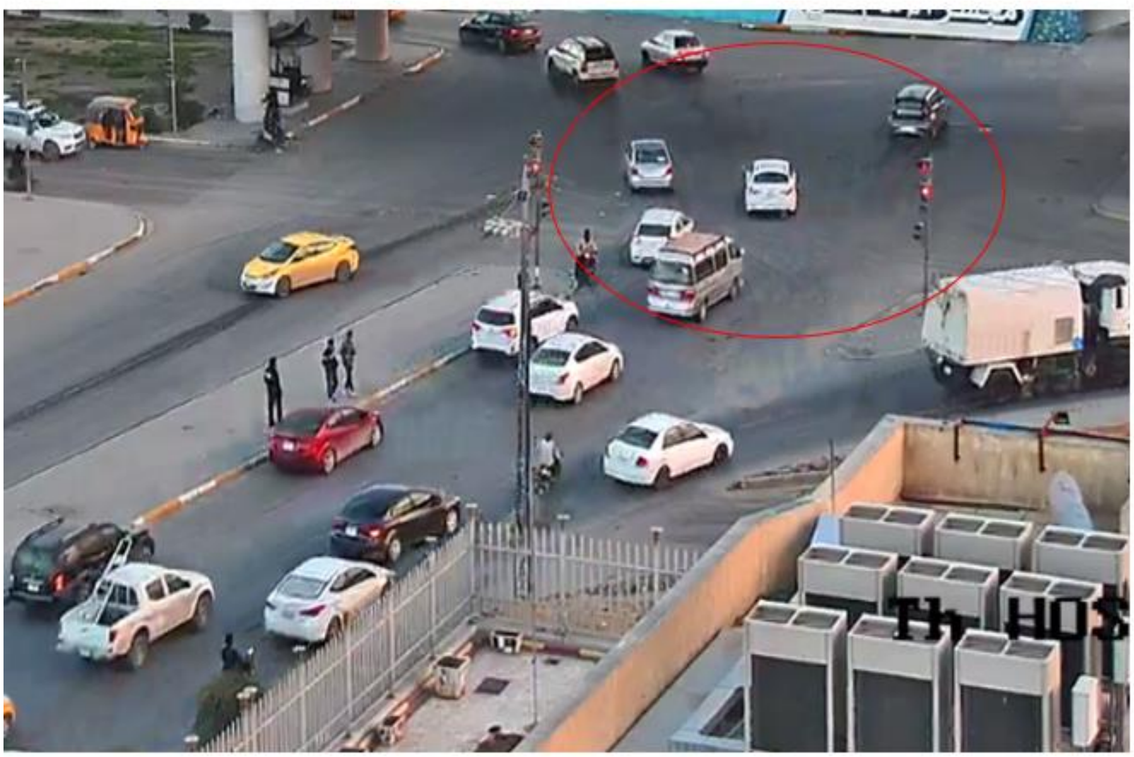


Figure (4-4): Example of RLR violations in Saif Saad intersection

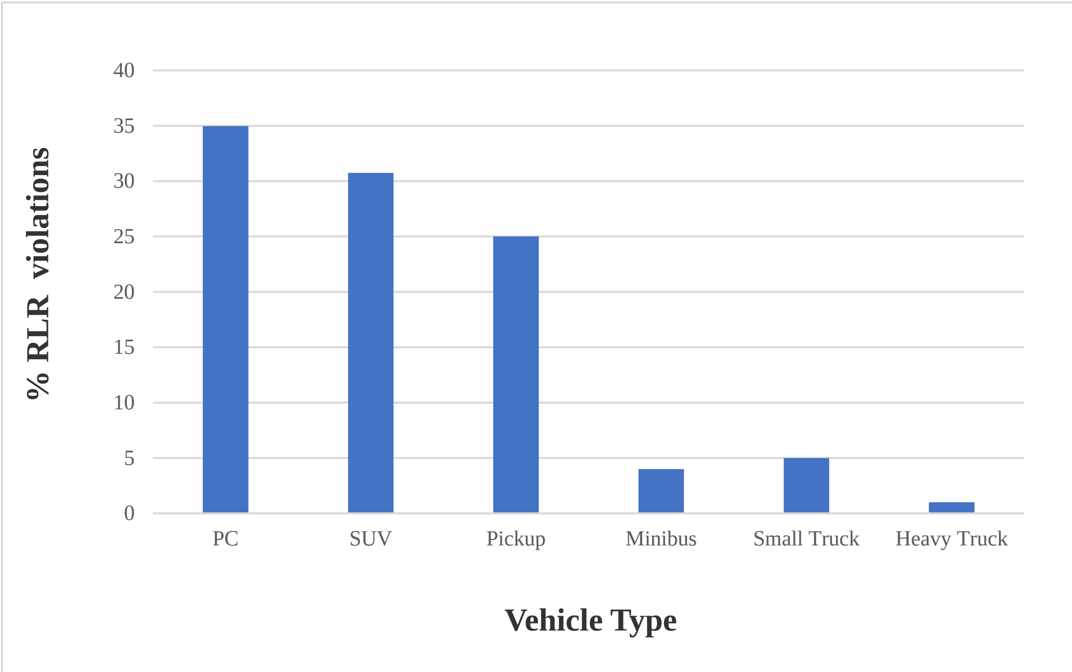


Figure (4-5): Classification of violated vehicles in Al-Dhareeba intersection for five workdays

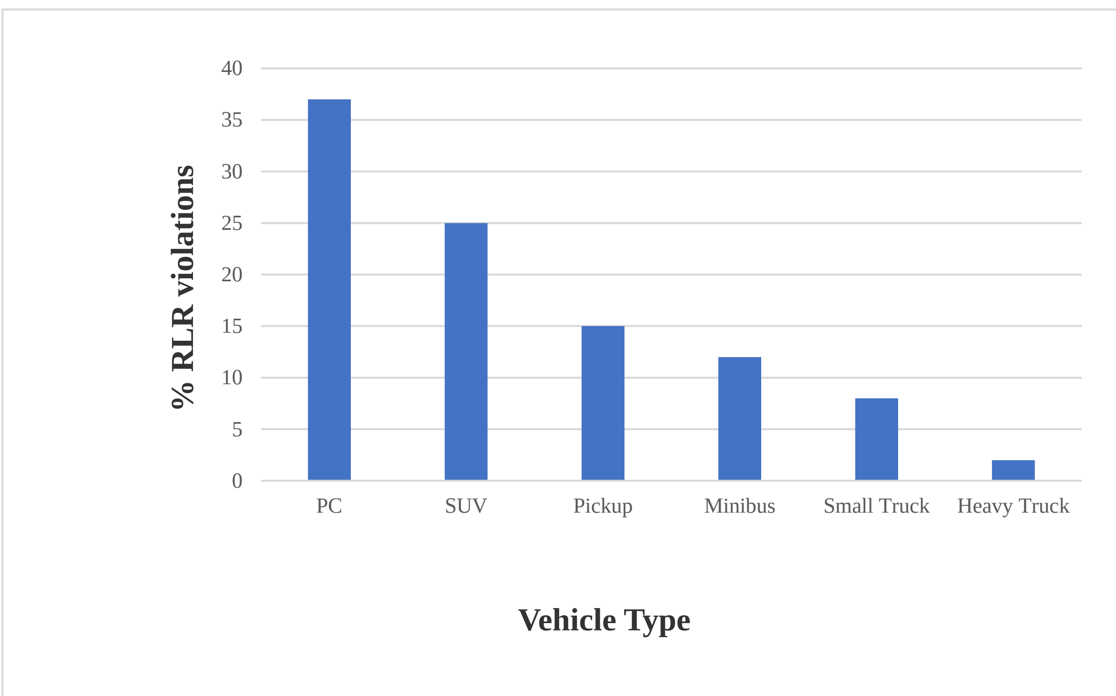


Figure (4-6): Classification of violated vehicles in Saif Saad intersection for five workdays

4.3 The Driver's Behavior in Response to the Yellow Light

Driving behavior in response to the yellow signal has been recognized. The decision of whether to stop or pass at a traffic intersection with traffic lights is influenced by several factors. Speed is one of these factors, as headway, TTSL, the type of vehicle, as well as other factors such as age, gender, and other personal information.

4.3.1 Speed

The distance between the camera and the traffic lights at Al-Dhareeba intersection was 70 meters, making it possible to measure the speed of the driver through footage taken at the intersections. The other camera was positioned on the general authority for the distribution of petroleum products, which looked out over Al-Taawun and Najaf-Karbala roads. The speed is calculated by dividing distance by time, where the distance is calculated as following. In Al-Dhareeba intersection, the distance between the lighting pole and the pedestrian crossing line is 33 meters, at in Saif Saad intersection, the distance between the lighting pole and the pedestrian crossing line is 40 meters. The speed was determined using the speed formula and was equal to the distance in kilometers over the time in hours. The speed measurement was collected during the time intervals (9:00-10:00) a.m. and (5:00-7:00) p.m. Due to constant congestion atAl-Dhareeba intersection, we observed that the speed there was lower than the speed at SaifSaad intersection which has significantly less traffic. We also observed that the speed was higher in the evening than it was in the morning for both intersections. The five-day average speed at Al-Dhareeba intersection between 8:00 a.m. and 10:00 a.m. was roughly 28.96 km/h, while between (5:00-7:00) p.m. it was 43.49 km/h. Between (8:00-10:00) a.m. the average speed at SaifSaad intersection was roughly

39.59km/h, while from (5:00-7:00) p.m the average speed was 54.82 km/h. table (4-2) shows the speeds of the five days averaged on the vehicles for the given time.

Table (4-2): Average speed in two signalized intersections

Day	**Average speed (km/h) in Al-Dhareeba intersection**		**Average speed (km/h) in Saif Saad intersection**	
Time (hour)	(8:00-10:00) a.m.	(5:00-7:00) p.m.	(8:00-10:00) a.m.	(5:00-7:00) p.m.
Sunday	28.96	41.63	34.38	54.82
Monday	23.09	49.06	38.64	52.76
Tuesday	18.30	44.68	27.16	57.43
Wednesday	23.54	39.78	54.92	51.10
Thursday	28.32	42.31	42.84	54.05

*Note:- Speed data were gathered during the yellow indication

4.3.2 Headway

As defined earlier in this thesis, headway is the time taken from the front beam of the first vehicle to the front beam of the second vehicle. In this study, we consider the headway when the first vehicle departs the stop line at the intersection. The headway measurements were collected for the same days and time as the speed measurements, as shown in table (4-3).

Table (4-3): Average headway in two signalized intersections

Day	Average headway (sec.) inAl-Dhareeba intersection		Average headway (sec.) in Saif Saad intersection	
Time (hour)	(8:00 -10:00) a.m.	(5:00-7:00) p.m.	(8:00-10:00) a.m.	(5:00-7:00) p.m.
Sunday	2.60	2.62	1.69	1.79
Monday	2.55	2.58	1.79	1.70
Tuesday	2.46	2.49	1.73	1.70
Wednesday	2.28	2.48	1.97	2.63
Thursday	2.07	1.94	1.84	1.79

*Note:- Headway data were gathered during the yellow phase

4.3.3 Time to stop line (TTSL)

TTSL is the time taken by the vehicle from a certain initial position to travel the distance to the stop line as shown in figure (4-7), where the initial position is specified by time (t) before the red light starts, where t = 2, 2.5, 3, 3.5, 4, 4.5, 5, and 5.5 seconds have been used here.

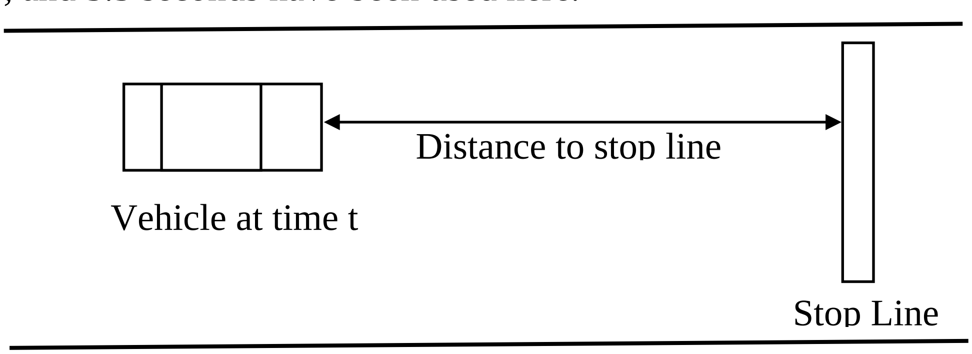


Figure (4-7): Time to stop line

TTSL measurements were collected for the same days and times used for speed and headway. Figures (4-8) and figure (4-9) show the average driver's decision in response to the yellow indication for five workdays in Saif Saad and Al-Dhareeba intersections.

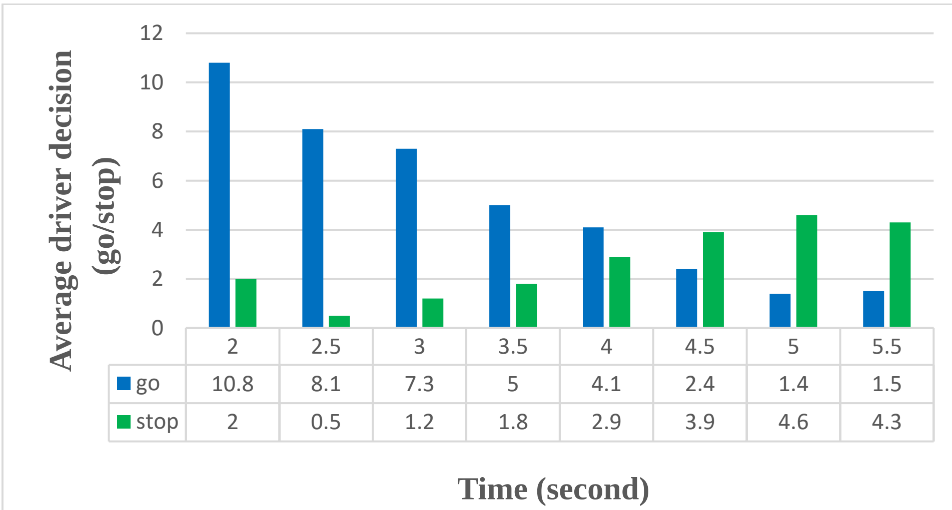


Figure (4-8): Average driver's decision in response to the yellow light inAl-Dhareeba intersection

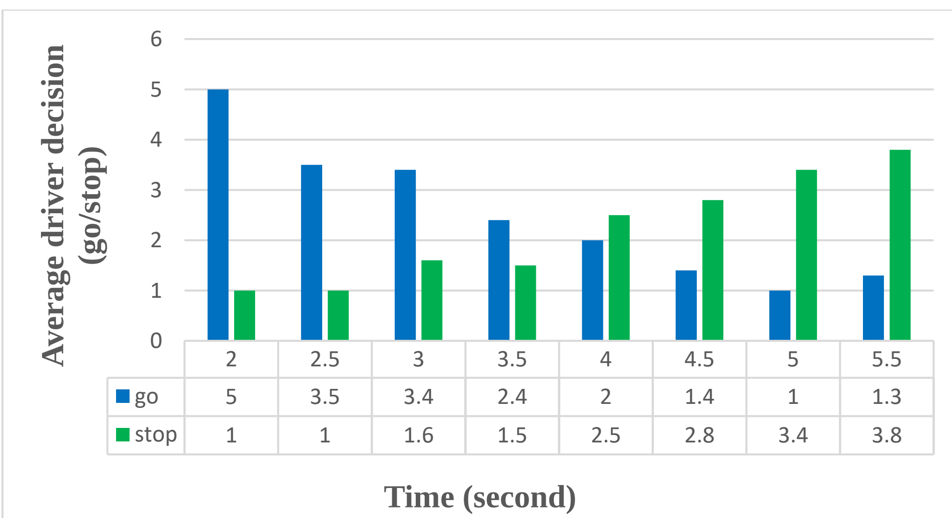


Figure (4-9): Average driver's decision in response to the yellow light in Saif Saad Intersection.

4.3.4 Vehicle type

The decision of the driver to go or stop at an intersection potentially depends on several parameters. One of these parameters we would like to investigate in this thesis is the vehicle type. While vehicles can be classified from different perspectives, vehicle size has been used in this study to classify vehicles into six types: passenger vehicles (PC), SUVs, pickups, minibusses, small trucks, and heavy trucks. Table (4-4) shows the percentage of the vehicle types in the two selected intersections for the same five days and times used for collecting speed, headway, and TTSL measurements. Table 4-4 shows similar vehicle-type percentages for the two intersections

Table (4-4): Percent of each vehicle type in two signalized intersections

Type of vehicle	Al Dhareeba intersection	Saif Saad intersection
PC	61%	62%
SUV	28%	25%
Pickup	6%	5%
Minibus	2%	4%
Small Truck	2%	3%
Heavy Truck	1%	1%

4.4 Data Collection from a Questionnaire

In this thesis, answers to electronic questionnaire questions were collected to investigate the relation between several parameters with the driver's decision during the appearance of the yellow light. These answers were analyzed and discussed in this chapter. Google Forms was used to generate the electronic questionnaire, which was available to everyone. There were approximately

600 respondents to the questionnaire over three months, and their answers were as the following.

4.4.1 Driver's personal information

The set of questions involves personal information such as gender type, age of driver, academic background, number of years of experience, and vehicle type. Males made up approximately 53.3% of the participants, while females made up 46.7%. Age and driving experience are crucial factors in determining the driver's behavior because the more years driver has, the less difficult it is to drive and navigate at intersections with traffic. To determine the types of vehicles and the most prevalent types of vehicles on the road, a question concerning personal vehicles were included in the questionnaire. The percentages of the gender type, age, and driving experience were determined from the responses of drivers to the questionnaire as shown in figure (4-10), Figure (4-11), and Figure (4-12). Regarding age, drivers between 25 to 40 had the largest percentage (52.2%), and drivers younger than age 18 had the lowest percentage. When it came to education level, drivers with a bachelor's degree made up the highest percentage (53.8%) of those who responded to the Questionnaire, while those with a primary certificate had the lowest percentage. The maximum percentage of drivers was 39.1% for drivers with less than one year of experience. Regarding personal vehicle type, the truck has the lowest percentage and the highest percentage was PC which was around 71.5%.

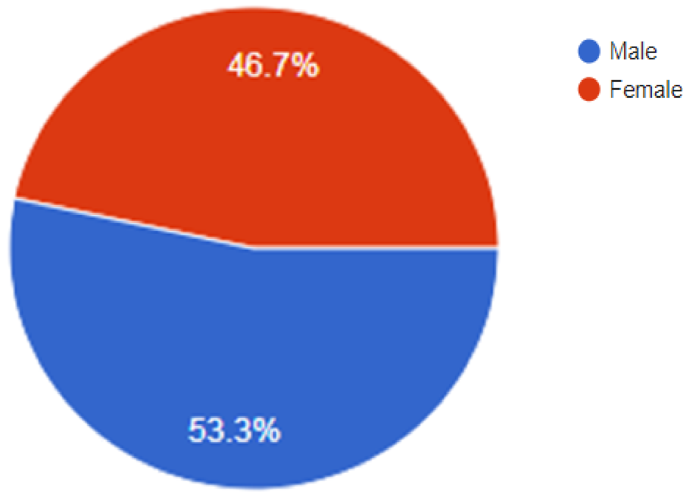


Figure (4-10): Gender type

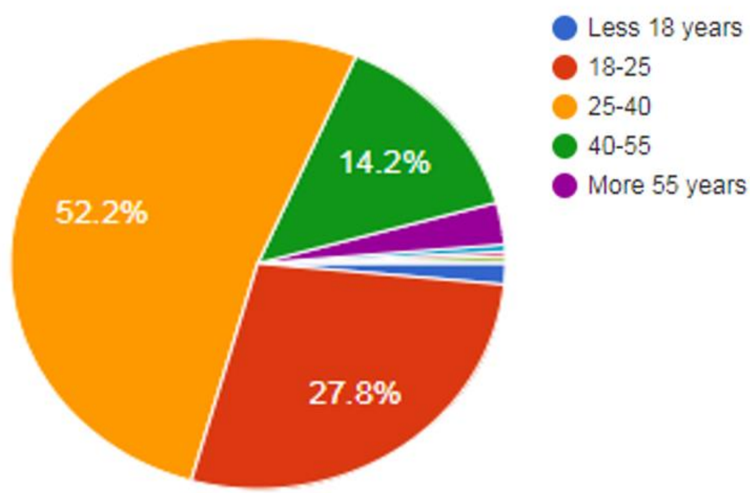


Figure (4-11): Age of the driver

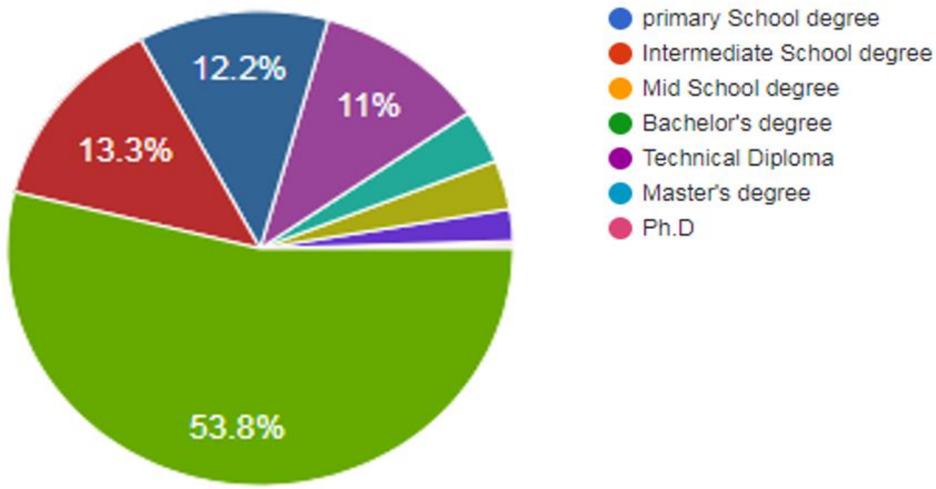


Figure (4-12): Educational level

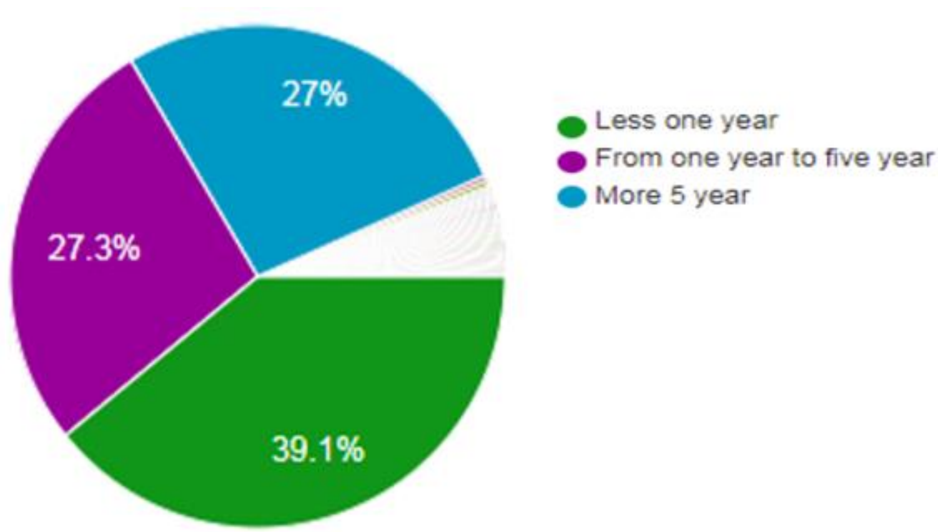


Figure (4-13): Driving experience

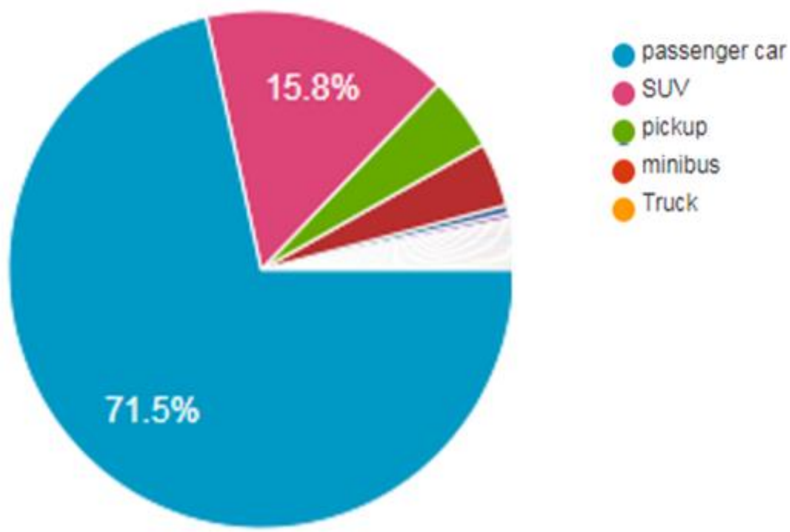


Figure (4-14): Classification of vehicles

4.4.2 The driver's decision (go/stop) from a questionnaire

This questionnaire showed the driver's choice when the traffic light changed from green to yellow and the driver was between (2-5.5) seconds from the stop line. From figure (4-15), we can see that the decision to stop during the first few seconds is more significant than the decision to go. A comparison between the questionary answers and the data collected by the cameras shows a clear discrepancy. The questionary answers show a more commitment of the drivers to follow the regulations and stop during the yellow light, while the cameras data show less commitment to stop during the yellow light where more violations are noticed.

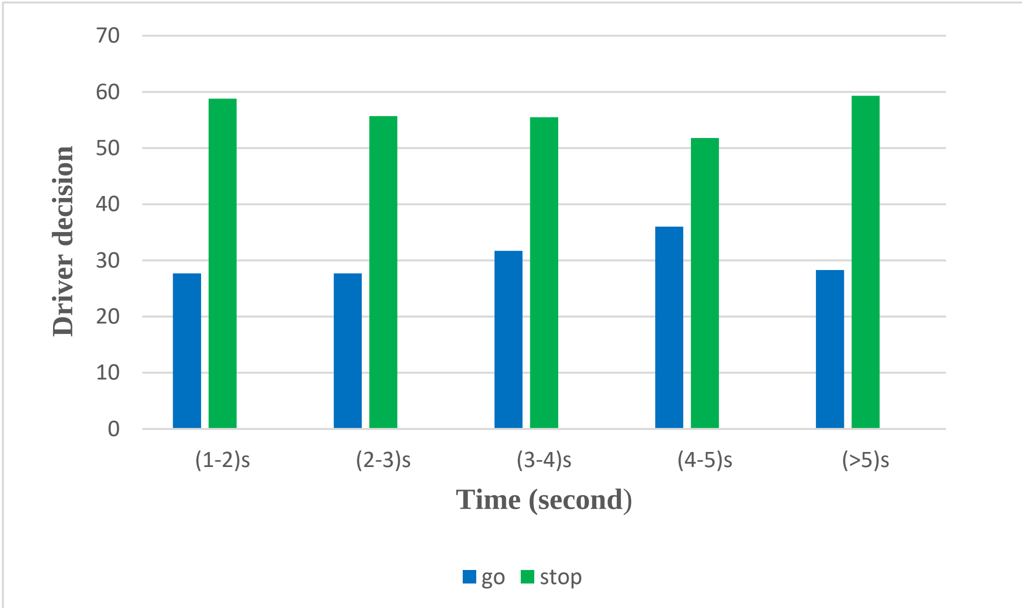
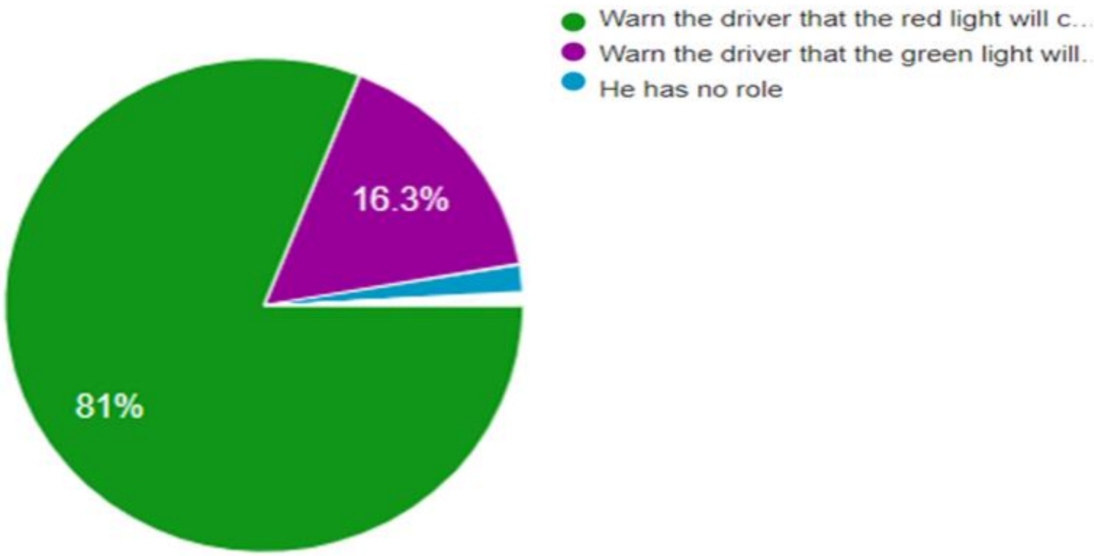


Figure (4-15): The driver's decision (go/stop) from a questionnaire

4.4.3 Information about the yellow light

In answer to the question about the function of the yellow light, 81% of the drivers who responded said that it serves as a warning that the redlight is about to come and that the vehicles must stop. 16.3% of drivers said that the yellow light serves as a warning that the green light will emerge later and that they must continue as shown in Figure (4-16). 1.8% of drivers cited that the yellow light plays no part here, meaning that 1.8% of drivers don't understand why the yellow light is there and it was designed for their safety. The majority of holy Karbala governorate intersections with traffic lights have a yellow light duration of 3 seconds. We wanted to know how much attention drivers give to the yellow light at traffic crossings, so we asked drivers about the duration of the yellow light there. The duration of the yellow light is between (3-6) seconds (FHWA, 2009). As a result, the questionnaire revealed that 67.3% of drivers responded accurately, stating that the yellow light's duration ranged between (3-6) seconds; 20.2% of drivers responded that the yellow light's duration ranged between (6-10) seconds, and 6.8% of drivers expected the yellow light's duration to range between (10-15) seconds; 5.3% of drivers responded that the yellow light's duration ranges between (15-20) as shown in figure (4-17). To find out more about the driver’s behavior and whether he/she is aggressive, conservative, or hesitant, we asked the drivers when they arrived at the traffic lights and the yellow light was visible, does he/she increase the speed of his/her vehicle and continue to move or slow down his/her vehicle and stop. In this context, 46.5% answered “Yes” we increase the speed of vehicles when we see the light change from green to yellow and 51.5 % of the drivers do not try to speed up. According to this, 51.5% of drivers are seen as conservative, while the remaining 46.5% are all aggressive as shown in figure (4-18). About 53.8% of respondents to the question of whether it is difficult to decide whether to stop or cross the crossing when the light yellow appears said that it is. He does not have trouble deciding whether to stop or cross the crossing, according to 34.2% of respondents, 11.5% of drivers said they were unsure of their choice as shown in figure (4-19). The preference of 49.5% of drivers was for a longer yellow light period. According to the study, 50.5% of drivers felt that the yellow light's length was adequate and that it shouldn't be adjusted as shown in figure (4-20).



Figure(4-16): The yellow light function

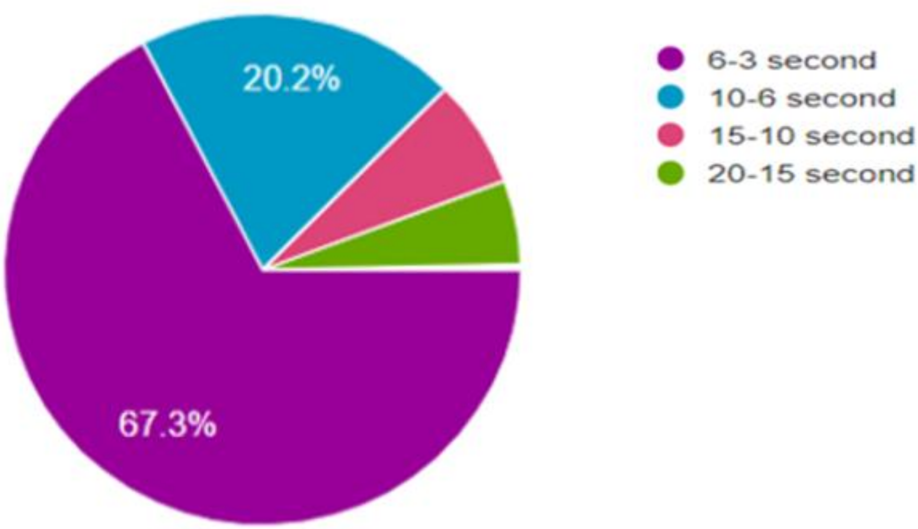
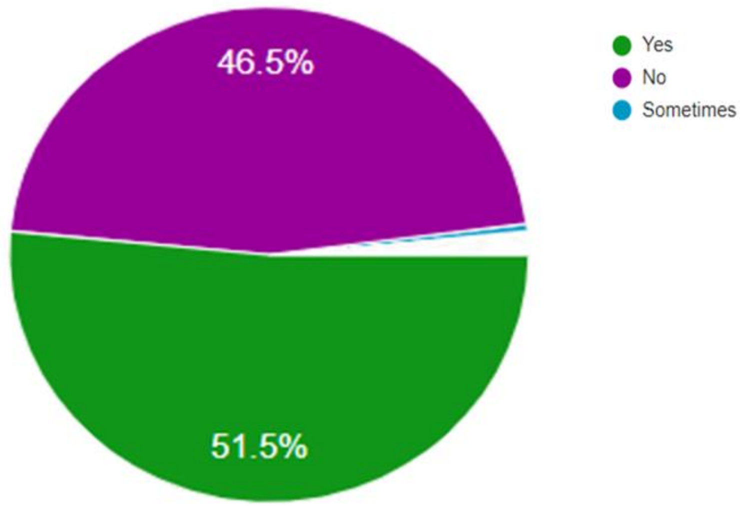
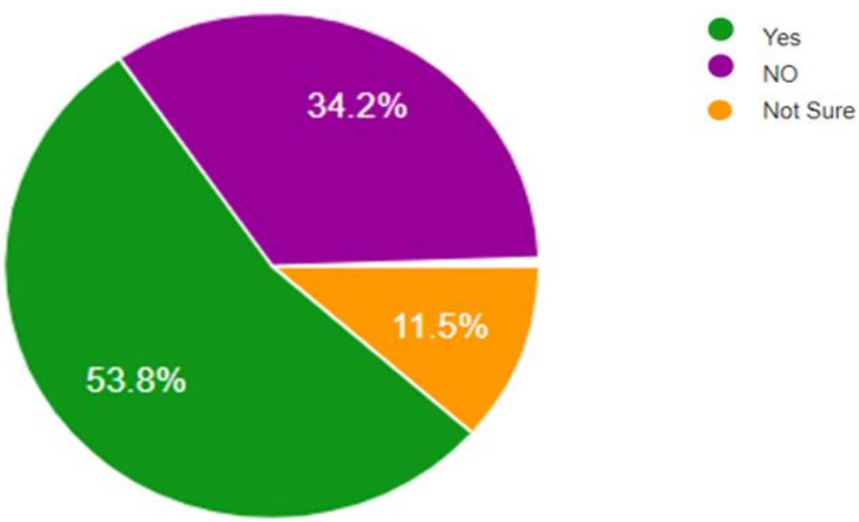


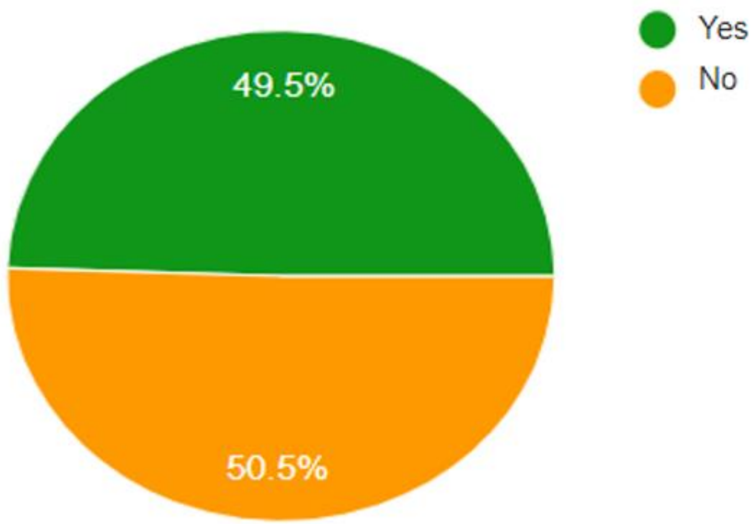
Figure (4-17): The yellow light duration



Figure(4-18): The Driver's decision when the yellow light appears



Figure(4-19): Difficulty deciding to stop



Figure(4-20): The driver's decision to increase the duration of the yellow light

4.4.4 Maintain a safe distance between vehicles

One of the most crucial components of road safety measures is the safety gap between vehicles. Maintaining it entails avoiding numerous hazardous and fatal collisions because it is the required legal separation between the vehicle and the vehicle in front. Maple time and space to stop safely if the vehicle in front suddenly stops or another emergency on the road arises. Consequently, it is vital to include a list of questions that the driver will be asked via the computerized questionnaire. How much space do you have between your vehicle and the one in front of you at intersections while the yellow light is on? About 32.8% of responses indicated that the distance is under one meter,48.5% from (1-2) meters, and 12.3 % between (1-3) meters,6.3%. More than three meters separate his/her vehicle from the vehicle in front of it as shown in figure (4-21).

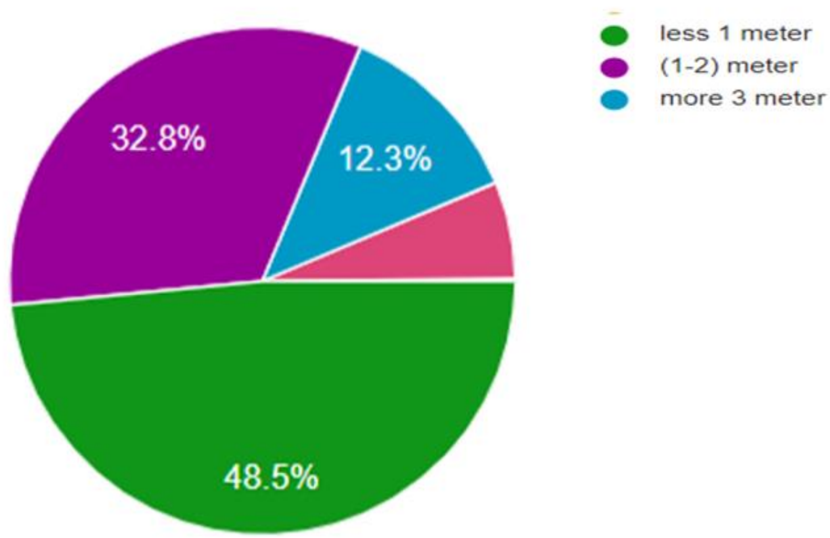


Figure (4-21): Spaces between vehicles

The videos showed that in both intersections (Saif Saad intersection and Al-Dhareeba intersection) drivers do not keep safe spaces. When drivers were asked about their opinion, do vehicles put safe distances between their vehicles and the vehicles before them when the yellow light appeared, approximately 77.8% answered “No” and 21.7% answered “Yes” as shown in figure (4-22) after that, we asked the drivers if they had stopped or crossed the intersection when the yellow light appeared and a vehicle was approaching from behind and within a close distance of their vehicles.

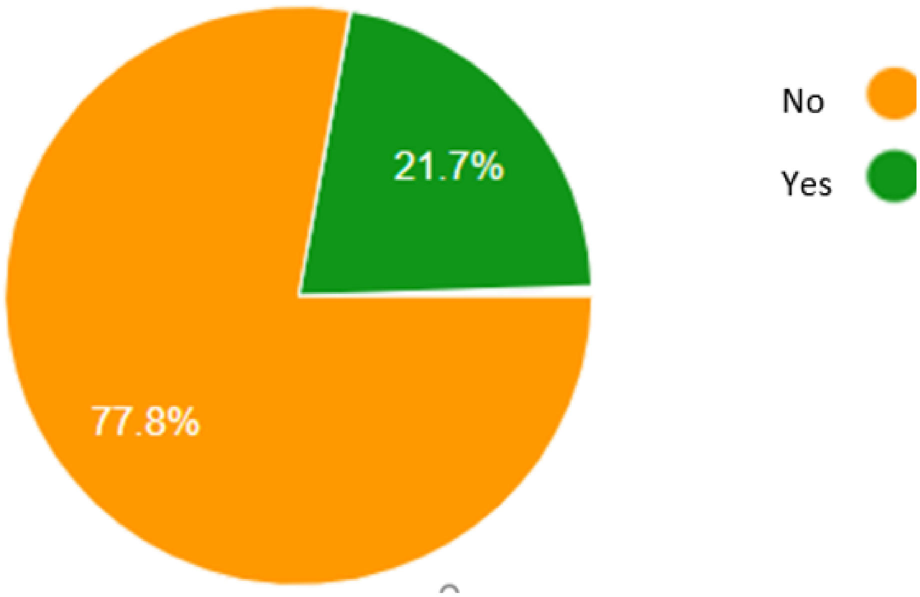


Figure (4-22): Safe distances between vehicles

Regarding the driver's decision when there is a vehicle behind him and a small distance when the yellow light appears about 58% of the drivers said "Yes", while about 30.7% said "No", and 11.2% said he/she was unsure of his/her decision as shown in figure (4-23).

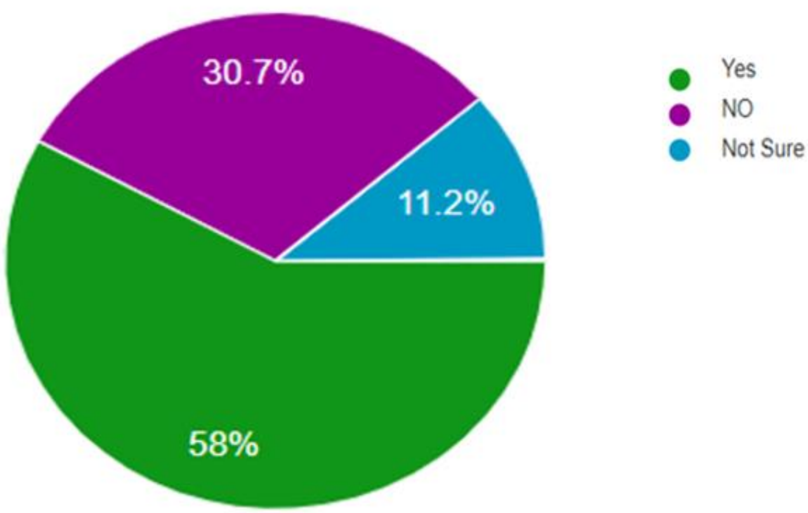


Figure (4-23): Driver decision about space between two vehicles

4.4.5 Violation of the traffic signal

The state has placed financial sanctions on drivers to dissuade them and warn them of traffic offenses to safeguard the safety of the driver as well as pedestrians, but regrettably, we have seen a lot of traffic violations that have resulted in death in recent years. Many individuals were hampered, and we were shocked by the high number of traffic offenses when we looked at the surveillance camera that we installed atAl-Dhareeba intersections and Saif Saad intersections. From the videos, we can see a lot of violated vehicles when the red light was displayed. Do you hesitate to cross when the yellow light appears, we asked them. In response to the yellow light appearing, 69.7% said "Yes" and 29.5% said "No". Because neither group hesitates to cross, the choice was made to proceed and cross even though the yellow light had already passed its expiration time. Sometimes the traffic signal turns from yellow to red as the vehicle approaches the crosswalk as shown in figure (4-24). The decision to stop in this situation is challenging for the driver, especially if there are several vehicles following the driver. The Questionnaire revealed that 73.8% of respondents had no such experience. 26.2% of the traffic signal turned from yellow to red very close to the crossing line as shown in figure (4-25). Since changing the traffic light from yellow to reconstitutes a violation, around 28.7% of respondents indicated that the driver had violated the law, while 71.2% responded "No", indicating that the driver had not violated the law as shown in figure (4-26). If the driver is moving quickly and applies the brakes, there are situations when the vehicle will not stop. When asked if they had trouble stopping their vehicle, around 34.3% said “Yes”, and 65.5% said “No”, suggesting that the driver might have trouble stopping the vehicle when the red light displays as shown in figure (4-27). Approximately 42.7% of drivers stop when the yellow light appears to avoid traffic violations, and approximately 57.3% do not stop during the yellow light because they are not afraid of breaking the law or the driver decided that could cross the intersection through the yellow light as shown in figure (4-28). This is because 3 seconds is a short time for vehicles to cross the intersection, especially if it is crowded.

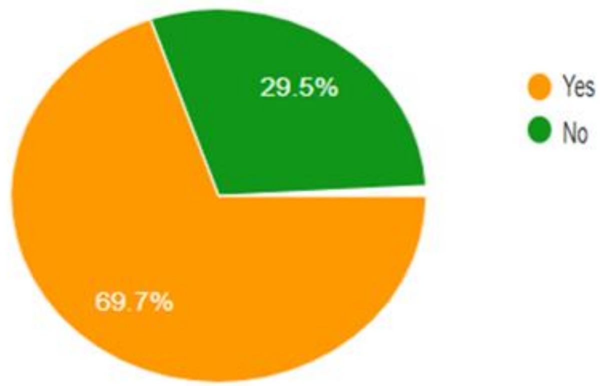


Figure (4-24): Indecisiveness in driving decisions.

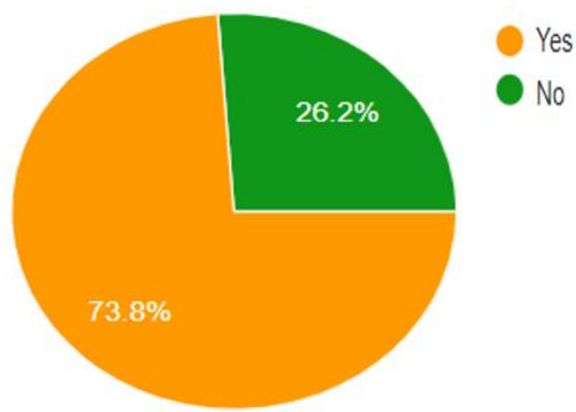


Figure (4-25): Driver's decision to stop when the traffic signal changed from yellow to red

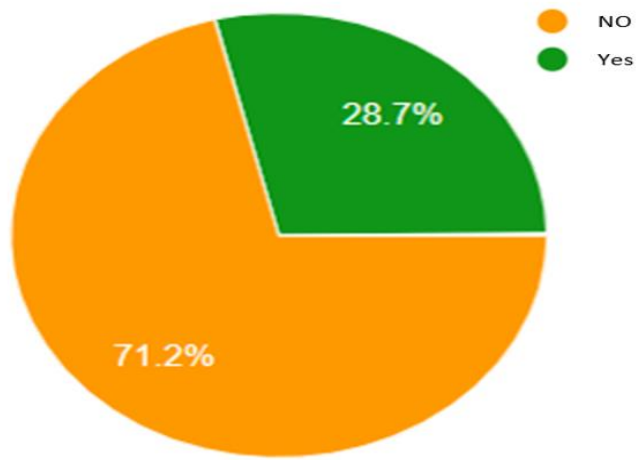


Figure (4-26): The vehicle violated the traffic signal

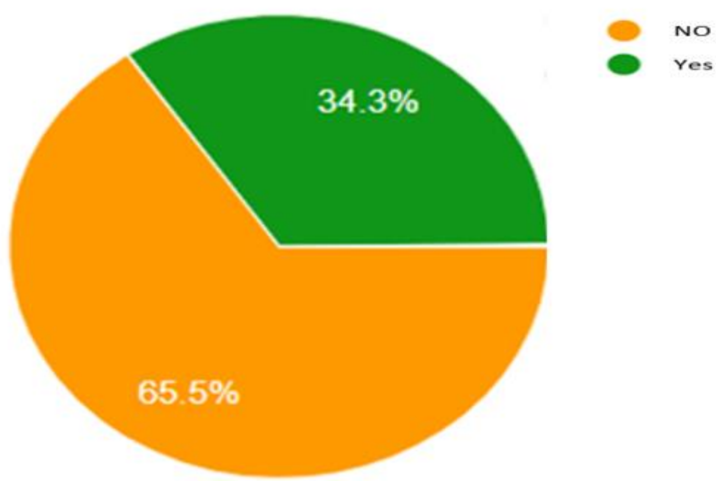


Figure (4-27): The Driver's decision when the red light displayed

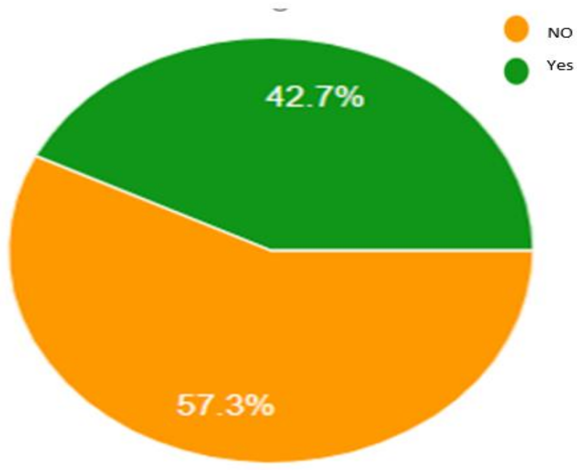


Figure (4-28): The Driver's decision to stop when the yellow light displayed

4.4.6 Obey the traffic signal

About 77.7% of female respondents are more committed than males to following traffic laws, and about 19% just said that men are more committed as shown in figure (4-29). This Figure shows how cautious women are and how afraid they are of breaking the law because some traffic offenses result in monetary fines while others result in imprisonment, which is one of the challenging issues for women in our society. With age and years of driving, the driver becomes more attentive, cautious, and experienced in traffic crossroads. When a young driver first learns to drive, some factors may influence his decision, such as anxiety or tension, particularly at traffic intersections, around 50.5% of the elderly drivers and 42.7% of the younger drivers responded, according to the person's traffic culture to the remaining questions as shown in figure (4-30).

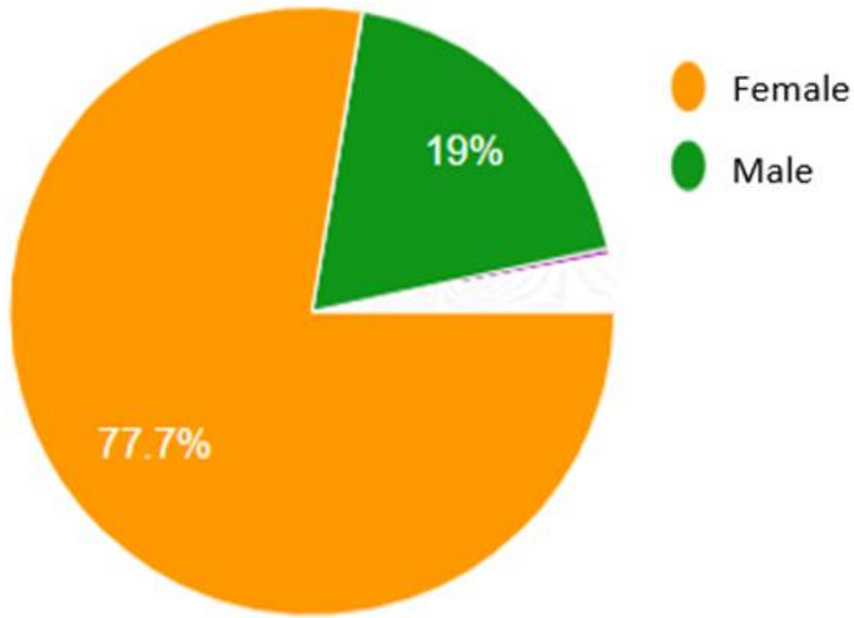


Figure (4-29): Drivers who obey traffic laws based on gender

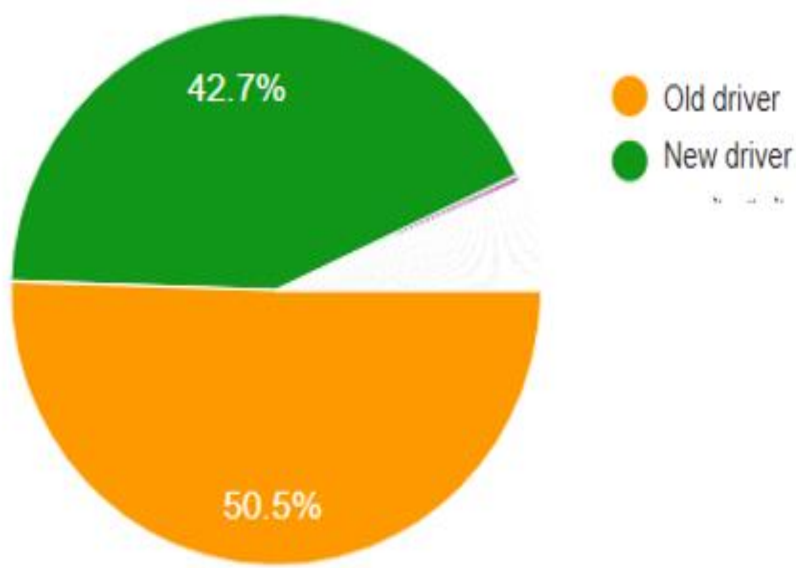


Figure (4-30): Drivers who obey traffic regulations based on age.

4.5 The Driver Behavior Analysis Using SPSS Software

We analyzed the data gathered from the videos for two intersections by using SPSS software. The data were divided into two groups, the first group, the data taken from 8 to 10 am, and the second group, the data are taken from 5 to 7 pm during the yellow light period.

4.5.1 Analysis statistics Saif Saad intersections

4.5.1.1 Descriptive statistics

The mean and standard deviation values are fixed in four models when data are entered for Saif Saad intersection in the SPSS program as shown in table(4-5).

Table (4-5): Descriptive statistics

Variables	Mean	Std. Deviation	N
Speed (km/hr)	46.81	12.38	512
Vehicle Type	1.37	1.65	513
Headway (second)	1.88	0.70	513
TTSL (second)	3.43	1.17	512

*N-Number of samples

4.5.1.2 Correlations

A statistic called correlation gauges how much two variables change in connection to each other. The correlation coefficient, which is a numerical expression of correlation, demonstrates the degree of a relationship between two variables. Values for the correlation coefficient fall between -1.0 and 1.0. When there is a complete positive correlation, the correlation coefficient is 1.

This means that the secondary security moves in lockstep, in the same direction, as the first security moves, whether up or down. A zero correlation suggests that there is no linear link at all, whereas a perfect negative correlation indicates that two assets move in opposite directions (Lindskog et al, 2000). Figure (4-31) shows steps in correlation extraction in SPSS, and table (4-6) shows the relationship between the driver's decision and the variables.

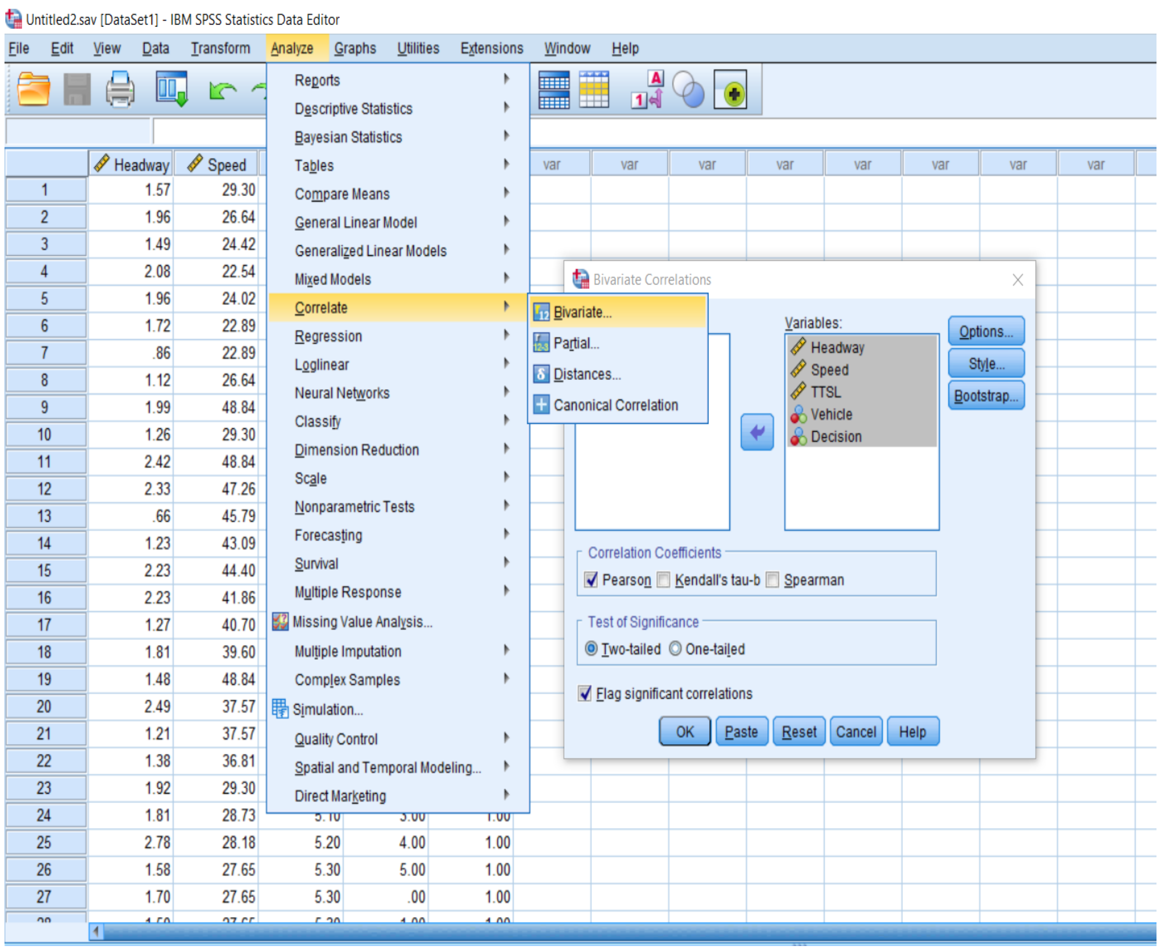


Figure (4-31): Steps in correlation extraction in SPSS

Table (4-6): Relationship between the driver's decision and the variables

Variables	**Speed**	**Headway**	**Vehicle Type**
Correlations	-0.56	-0.08	-0.003

We notice through the results that there is a relationship between the driver's decision, speed, headway, and Vehicle type reaching roughly -0.560 for the speed, -0.08 for the headway, and -0.003 for the type of vehicle.

4.5.1.3 Logistic regression binary model

The logistic model in statistics is a statistical model that depicts the probability that an event will occur by making the event's log odds a linear combination of one or more independent variables. In regression analysis, logistic regression is used to estimate a logistic model's parameters. These parameters include independent variables such as speed, headway, TTSL, and vehicle type and the dependent variable was driver decision. Four models were created using the data, and each model had a variable added to determine how the factors affected the driver's choice. The binary logistic data were characterized by the presence of infinite inputs, while the outputs were only zero and one, where the outputs represent the driver’s decision to go or stop (see figure 4-32). Table (4-7) represents the dependent variable (go/stop) that

Table (4-7): Dependent variable encoding

Dependent variable	Code
Go	0
Stop	1

Table (4-8): Vehicle type encoding

Vehicle type	Code
PC	0
SUV	1
pickup	2
Minibus	3
Small Truck	4
Heavy Truck	5

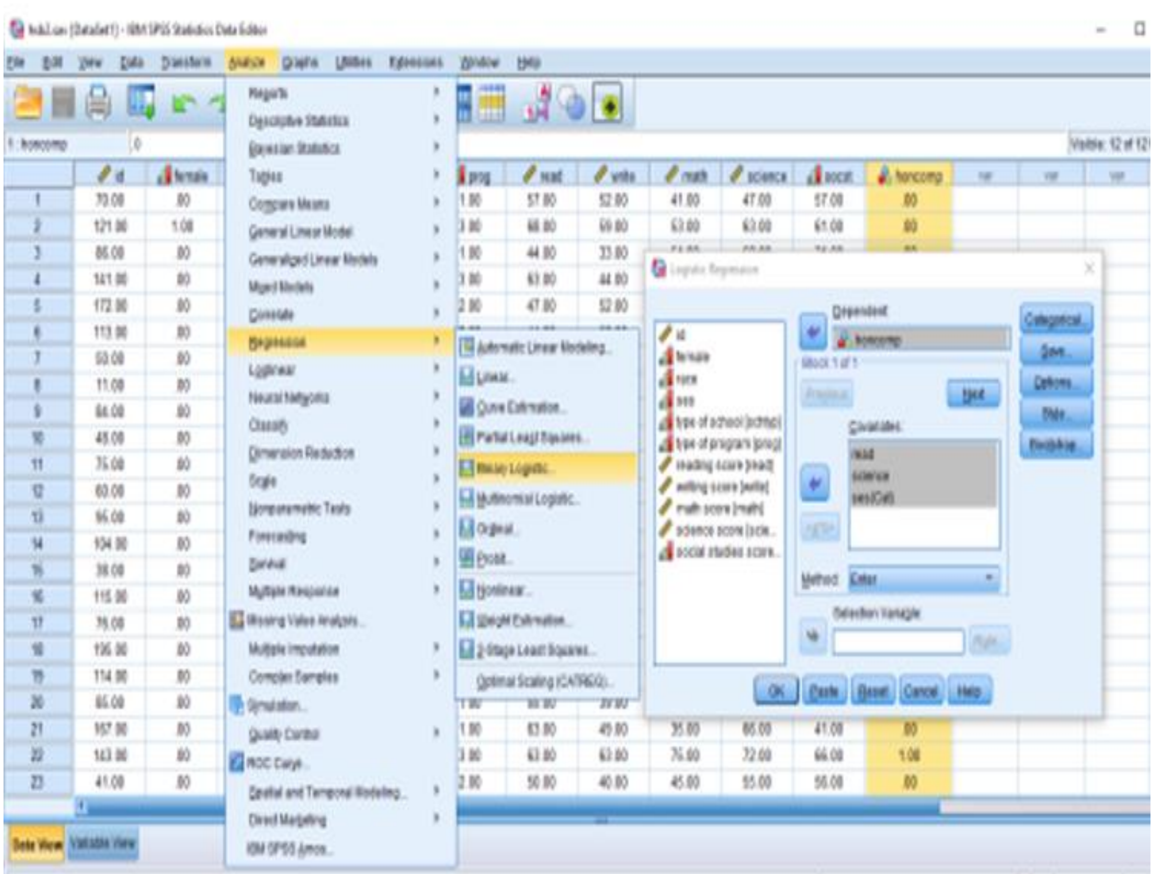


Figure (4-32): Steps in binary logistic regression extraction

In the first model**,** we added the effect of speed. The results indicated there was a significant relationship between the speed and the driver's decision to go or stop during the yellow light. The negative sign of the coefficient (β) indicated the probability of stopping increases with a decrease in the speed. Table (4-8) shows the results of the first model.

Table (4-9): Outputs of the first model

Model 1	β	S.E	Wald	df	Sig.
Speed	-0.18	0.02	89.04	1	0.00
Constant	5.09	0.02	61.29	1	0.00

$Ui=5.09+(-0.18 \times \text{Speed})$ (1-4)

β – This is the coefficient for the constant (also called the "intercept") in the null model.

S.E. – This is the standard error around the coefficient for the constant.

Wald and Sig. – This is the Wald chi-square test that tests the null hypothesis that the constant equals 0. This hypothesis is rejected because the p-value (listed in the column called "Sig.") is smaller than the critical p-value of .05 (or .01). Hence, we conclude that the constant is not 0.

df – This is the degree of freedom for the Wald chi-square test. There is only one degree of freedom because there is only one predictor in the model, namely the constant.

In the second model**,** we added the effect of headway. The results indicated there was an insignificant relationship between the headway and the driver's decision to go or stop during the yellow light. The negative sign in the coefficient (β) indicated the probability of stopping increases with a decrease in the headway, as shown in table (4-9).

Table (4-10): Outputs of the second model

Model 2	β	S.E	Wald	df	Sig.
Speed	-0.18	0.02	88.26	1	0.00
Headway	-0.51	0.29	3.17	1	0.075
Constant	6.05	0.88	48.23	1	0.00

Based on the results presented in table (4-9), the utility equation can be rewritten as:

Ui=6.05+($-0.18 \times$ Speed) +(-0.51$\times$ Headway) $(4-2)$

Column Exp (β) in Table (4-9) the odds ratio i.e. The negative sign of the variables speed and headway probability of stopping increases.

In the third model, we added the effect of TTSL. The results indicated there was a significant relationship between the TTSL and the driver's decision to go or stop during the yellow light. The negative sign in the coefficient (β) indicated the probability of stopping increases with a decrease in TTSL. Table (4-10) shows the outputs of the third model.

Table (4-11): Outputs of the third model

Model 3	β	S.E	Wald	df	Sig.
Speed	-0.18	0.06	11.19	1	0.001
Headway	0.196	0.36	3.71	1	0.054
TTSL	-0.69	0.61	32.48	1	0.00
Constant	3.47	4.77	22.58	1	0.00

Ui=3.47+($-0.18 \times$ Speed) +(0.196$\times$ Headway) + (-0.69$\times$ TTSL) $(4-3)$

In the fourth model, we added the effect of Vehicle type. The results indicated there was an insignificant relationship between the Vehicle type and the driver's decision to go or stop during the yellow light. As shown in table (4-11), the positive sign in the coefficient (β) indicated the probability of stopping decreases with an increase in the Vehicle type.

Table (4-12): Outputs of the fourth model

Model 4	β	S.E	Wald	df	Sig
Speed	0.19	0.059	11.14	1	0.001
Headway	-0.69	0.356	3.69	1	0.06
TTSL	3.47	.611	32.37	1	0.00
Vehicle Type	0.01	0.12	0.002	1	0.97
Constant	-22.69	4.80	22.34	1	0.00

Ui=-22.69+(0.19 × Speed) +(-0.69× Headway) + (3.47× TTSL)+(0.01× Vehicle Type) $(4-4)$

We observe that the Predicted (Ý) indicated the increased probability of stopping with increasing variables in the model, taking the shape of the sigmoid function as shown in figure (4-33) where the speed predicted in the first and second models was 0 and in the third and fourth models was 0.001.

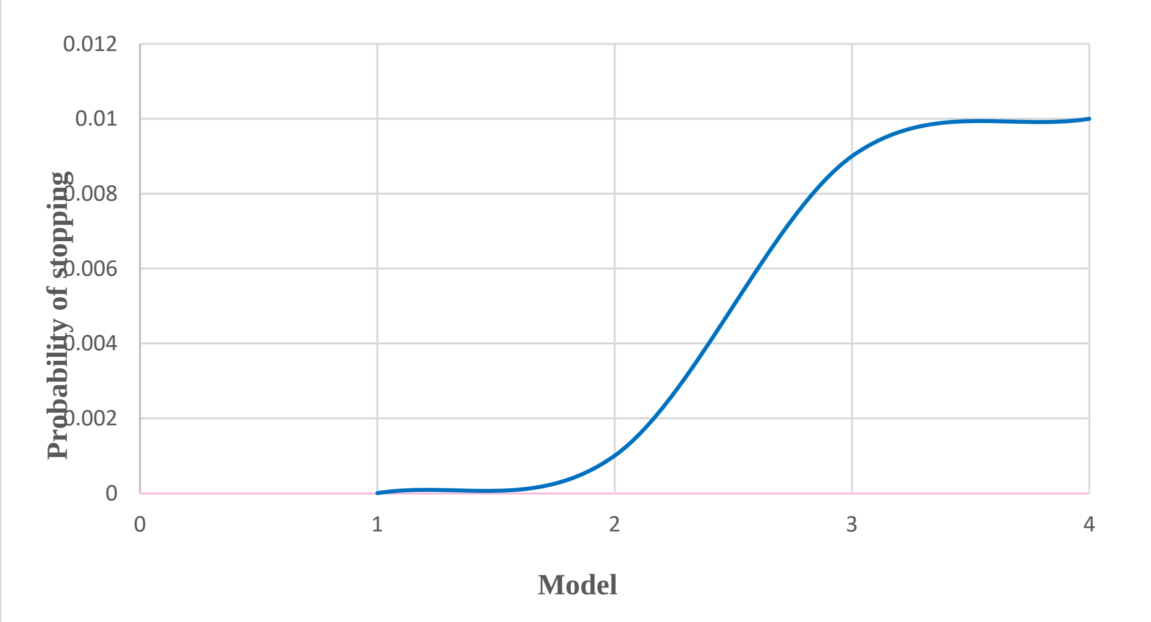


Figure (4-33): A predictive model for speed

We observe that the headway value grew in the second model, reaching 0.075 when it was entered as a speed variable, declined in the third model and was 0.054 after the introduction of TTSL, and then increased in the third model when the Vehicle type was input as shown in figure (4-34).

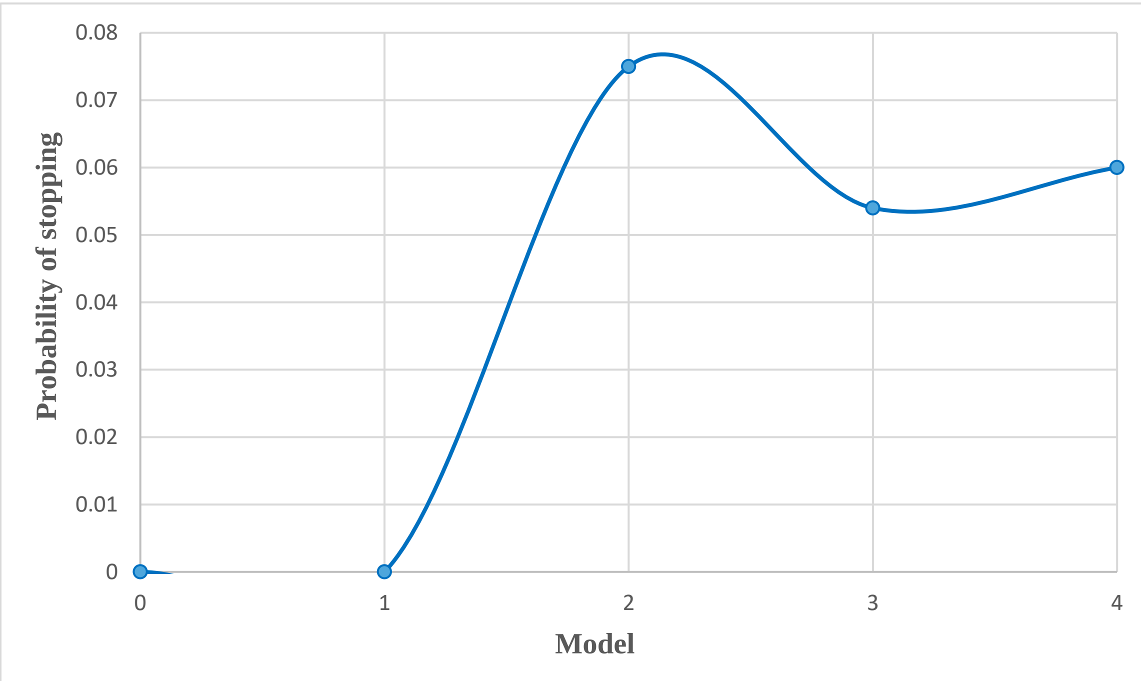


Figure (4-34): A predictive model for headway

4.5.1 Analysis statistics Al-Dhareeba intersection

Due to its proximity to the city center,Al-Dhareeba crossing is one of the crucial intersections in the holy governorate of Karbala. The crossroads is the nearest one to Imam Hussein (peace be upon him). As a result, this junction is crucial. Additionally, this intersection is constantly congested due to the importance of the nearby streets, including center Street, the Ramadan neighborhood highway, and Imam Hussein Street.

4.5.1.1 Descriptive statistics

The mean and standard deviation values are fixed in four models when data is entered for Al-Dhareeba intersection in the SPSS program as shown in table (4-12).

Table (4-13): Descriptive statistics

Variables	Mean	Std. Deviation	N
Speed(km/hr)	35.17	12.06	513
Headway(sec)	2.36	0.91	508
Vehicle Type	1.41	1.62	513
TTSL (sec)	3.94	1.70	513

*N-Number of Samples

4.5.1.2 Correlations

We notice through the results that there is a relationship between the driver's decision, headway, and Vehicle type reaching roughly -0.12 for the headway, and 0.03 for the type of vehicle.

as shown in table (4-13).

Table (4-14): Correlation between the driver's decision and the independent variables

Variables	Headway	Vehicle Type
Correlations	0.12	0.03

4.5.2.3 Logistic regression binary method

Al-Dhareeba intersection is much more crowded than Saif Saad intersection, its speed is lower. As a result, in the first model, we added the effect of speed. The results indicated there was a significant relationship between the speed and the driver's decision to go or stop during the yellow light. The negative sign in the coefficient (β) indicated the probability of stopping increases with a decrease in the speed, as shown in table (4-14).

Table (4-15): Results of the first model

Model 1	β	S.E	Wald	df	Sig.
Speed	-0.26	0.02	120.82	1	0.00
Constant	6.86	0.67	106.42	1	0.00

$U_i = 6.86 + (-0.26 \times Speed)$ (4-5)

In the second model**,** we added the effect of headway. The results indicated there was an insignificant relationship between the headway and the driver's decision to go or stop during the yellow light. The negative sign in the coefficient (β) indicated the probability of stopping increases with a decrease in the headway as shown in table (4-15).

Table (4-16): Results of the second model

Model 2	β	S.E	Wald	df	Sig.
Speed	-0.26	0.02	119.95	1	0.00
Headway	-0.002	0.16	0.99	1	0.32
Constant	7.40	0.85	75.16	1	0.00

$U_i = 7.40 + (-0.26 \times Speed) + (-0.002 \times Headway)$ (4-6)

In the third model, we added the effect of TTSL. The results indicated there was a significant relationship between the TTSL and the driver's decision to go or stop during the yellow light. The positive sign in the coefficient (β) indicated the probability of stopping decreases with an increase in the TTSL. As shown in table (4-16).

Table (4-17): Results of the third model

Model 3	β	S.E	Wald	df	Sig
Speed	-0.03	0.08	0.20	1	0.65
Headway	-0.21	0.18	1.33	1	0.25
TTSL	1.58	0.58	7.58	1	0.01
Constant	-6.04	4.65	1.69	1	0.19

U_i=-6.04+ $(-0.03 \times$ Speed) +(-0.21× Headway) +(1.58 × TTSL) (4-7)

In the fourth model, we added the effect of Vehicle type. The results indicated there was an insignificant relationship between the Vehicle type and the driver's decision to go or stop during the yellow light. As shown in table (4-17). The positive sign in the coefficient (β) indicated the probability of stopping decreases with an increase in the Vehicle type.

Table (4-18): Results of the fourth model

Model 4	β	S.E	Wald	df	Sig.
Speed	-0.03	0.08	0.20	1	0.65
Headway	-0.22	0.18	1.47	1	0.23
TTSL	1.59	0.58	7.58	1	0.01
Vehicle Type	0.11	0.099	1.24	1	0.27
Constant	-6.19	4.67	1.76	1	0.18

U_i=-6.19+ $(-0.03 \times$ Speed) +(-0.22× Headway) +(1.59× TTSL) + (0.11 × Vehicle Type) (4-8)

Due to the heavy traffic at the intersection, the speed atAl-Dhareeba intersection is very low, so there is an insignificance relationship between the speed and the driver's decision. In comparison, at SaifSaad intersection, the speed is higher, so there is a significant relationship between the speed and the driver's decision**,** while the TTSL has a significant relationship with the driver's decision to go or stop at two intersections. Observed that the probability of stopping increased with the decrease in speed and headway atAl-Dhareeba intersection. Observed that the probability of stopping increased with the decrease in headway at SaifSaad intersection. A binary logit model has been developed to describe the decision behaviors of the driver at the onset of yellow, which shows in tables (4-18) and (4-19) the prediction accuracy of the model to be 91.3% for Saif Saad Intersections and 93.6% for Al-Dhareeba intersections.

Table (4-19): Prediction accuracy of the model for Saif Saad intersection

		Predicted		
Observed		Go	Stop	% Correct
	Go	165	10	94.3
	Stop	12	67	84.8
		Predictive Power		91.3

Table (4-20): Prediction accuracy of the model for Al-Dhareeba intersection

		Predicted		
Observed		Go	Stop	% Correct
	Go	434	9	98.0
	Stop	24	45	65.2
		Predictive Power		93.6

We observe that the predicted (Ý) indicated the increased probability of stopping with increasing variables in a model, taking the shape of the sigmoid function as shown in figure (4-35) where the speed predicted in the first and second models was 0 and in the third and fourth models was 0.65.

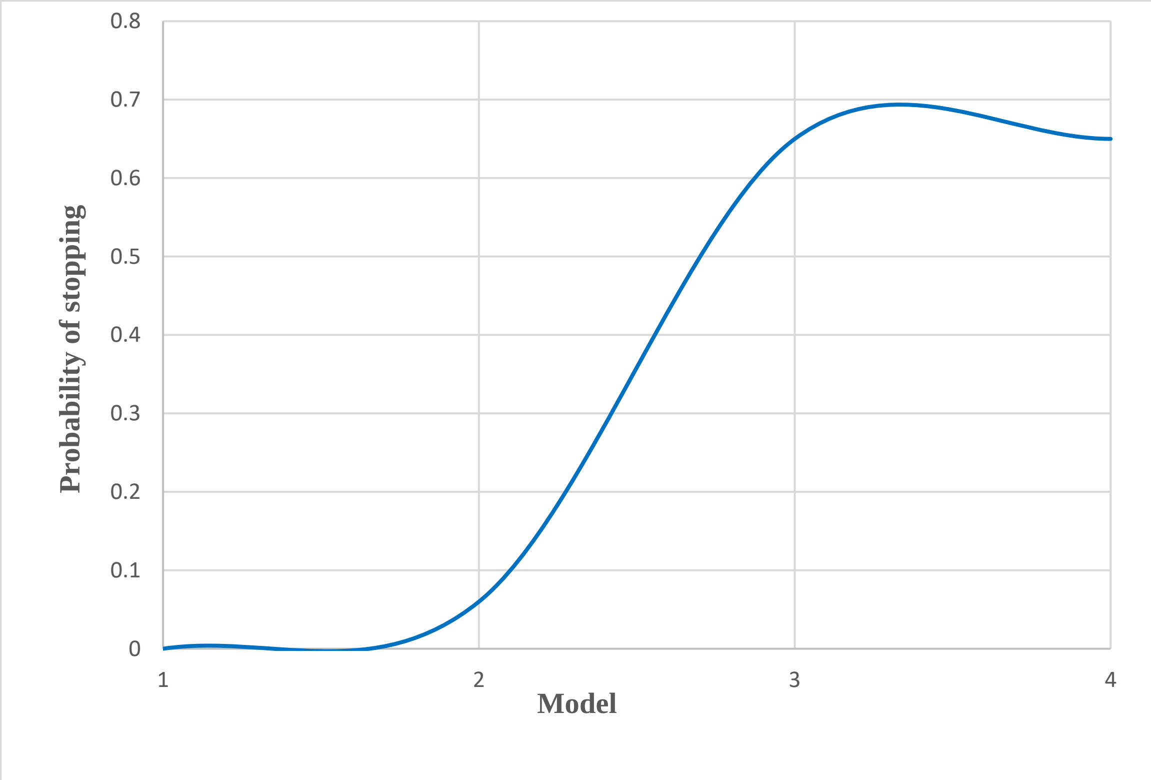


Figure (4-35): A predictive model for speed

We observe that the headway value grew in the second model, reaching around 0.32 when it was entered as a speed variable, declined in the third model and was 0.25 after the introduction of TTSL, and then increased in the third model when the Vehicle type was input as shown in figure (4-36).

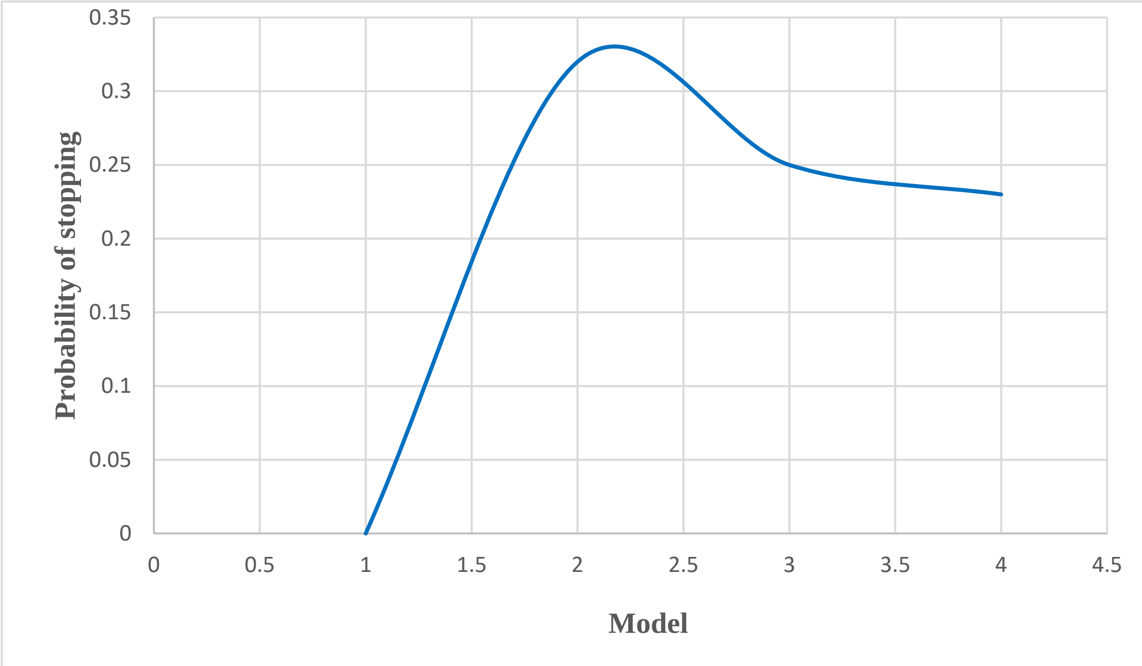


Figure (4-36): A predictive model for headway

Regarding the classification of vehicles, we observe that the fourth model's predictions are extremely high, reaching 0.27.

4.6 Summary

In the first section, an analysis is implemented regarding the driver's decision with the traffic at the yellow light. The analysis was done by observing the vehicle type, headway, TTSL, and speed of a vehicle as independent variables following the driver's decision as a dependent variable. A logistic regression model is created using the SPSS application through the aforementioned variable. In the second section questionnaire of several questions related to the driver's decision during the yellow light period is used.

Chapter Five:Conclusions and Recommendations

5 .1Conclusions

The main conclusions from this study based on the results gathered from the questionnaire data and modeling for the driver behavior during yellow indication can be summarized as the following:-

(A): Questionnaire

- In the questionnaire, 81% of the people answered that the function of the yellow light is to warn the driver that the red light will start and they should speed up.
- The questionnaire showed that 51.5% of drivers answered that they do not try to increase the speed of their vehicle when the traffic light changes from green to yellow.
- It noted that 50.5% of the drivers prefer that the duration of the yellow light be longer, and 49.5% do not prefer it.
- Regarding the driver’s decision to stop between (1-2) seconds, about 58.8% of the drivers answered that the driver chooses to stop before the pedestrian crossing line.
- Its concluded that 69.7% of the drivers hesitate to cross the intersection when the yellow light appears.
- Its obtained that 77.7% of the drivers said that women are more committed to traffic laws
- Its settled that 65.5% of the drivers were close to the pedestrian crossing line and the red light appeared and he could not stop his vehicle.

(B): RLR violations

- RLR during the hours of 8-9 am., the highest percentage of RLR violations (67.60%) happened in Al-Dhareeba intersection, while 45.46% occurred in Saif Saad intersection.

- In addition, the results showed that the frequency of RLR rates remained high in the late hours (evening) in Al-Dhareeba intersection, while it was lower in SaifSaad intersection. Both signalized intersections have a significant safety issue based on these findings

(C): Modelling of driver behavior during yellow indication

- The results of the model indicated there was an insignificant relationship between the speed, headway, and classification of the vehicle with the driver's decision to go or stop at the yellow light for Al-Dhareeba intersection.
- The results of the model indicated there was an insignificant relationship between the headway and classification of the vehicle with the driver's decision to go or stop at the yellow light for Saif Saad intersection.
- Observed that the probability of stopping increased with the decrease in speed and headway at Al-Dhareeba intersection.
- Observed that the probability of stopping increased with the decrease in headway at SaifSaad intersection.
- The developed model has been validated using 6.4% of the extracted data, which shows the prediction accuracy of the model to be 93.6% for Al-Dhareeba intersection, while Saif Saad intersection has been validated using 8.7%, and the prediction accuracy of the model to be 91.3%.

5.2 Recommendations

- Enforcing traffic laws: By applying some strategies the percentage of traffic violations can be reduced by enforcing traffic laws.

- Installing special traffic cameras: Installing special traffic cameras that record traffic violations and fine violators' drivers. Traffic monitoring cameras use deep learning algorithms to recognize number plates, recognize vehicle attributes and detect traffic violations.
- Adjusting the duration of the yellow light:- Adjusting the duration of the yellow light based on the location of the intersection and the traffic volume.
- Reduce speed limits at Al-Dhareeba intersection.
- Decreasing the duration of the green light leads to a decrease in the headway between the vehicle and an increase in the probability of stopping at the Seif Saad intersection.
- Increasing awareness of drivers: The media and training programs for drivers can both play a vital role in raising drivers' awareness of the serious risks associated with disobeying traffic signals at signalized intersections.

5.3 Future Work

- The study can be more comprehensive by studying other intersections using many cameras.
- Investigating how intersection geometry affects how drivers behave when there is a yellow light.
- Data can be collected on holidays, religious events, and weekends**.**
- A detailed study of traffic intersections, choosing the most common intersection with traffic accidents and analyzing the intersection.

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AppendixA

(The vehicle Pass and violations during the Yellow light)

(Vehicle Pass)

A.1 Saif Saad intersection data

(7:00-7:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	8	4	5	1	3
SUV	2	2			
Pickup		1			
Minibus					
Small Truck	1				
Heavy Truck					

(7:30-8:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	5	13	8	6	10
SUV	1	10	2	3	4
Pickup	1	1			
Minibus		2		1	
Small Truck		1			
Heavy Truck		1			

(8:00-8:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	10	20	8	7
SUV		10	14	6	1
Pickup		1			
Minibus		1			
Small Truck		2			
Heavy Truck					

(8:30-9:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	7	9	3	1
SUV	1	7			
Pickup	1	2			
Minibus					
Small Truck			1		
Heavy Truck					

(9:00-9:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	3	1	2	1
SUV		1			
Pickup		1	1		
Minibus					
Small Truck					
Heavy Truck					

(9:30-10:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	7	1	5	7
SUV		4		2	2
Pickup			1		
Minibus					
Small Truck					
Heavy Truck					

(10:00-10:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		8	1	6	1
SUV		5	1	2	
Pickup			1	1	
Minibus					
Small Truck					
Heavy Truck					

(10:30-11:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		3	2	3	4
SUV		2	3	1	
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(11:00-11:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	2	5	1	3
SUV		3	1		
Pickup					
Minibus					
Small Truck					
Heavy Truck		1			

(11:30-12:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	2	7		3
SUV		2	1		
Pickup	1		1		1
Minibus					
Small Truck		1			
Heavy Truck					

(12:00-12:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	2	9	3	1	5
SUV			1		2
Pickup					
Minibus					
Small Truck		4	1		1
Heavy Truck			1		

(12:30 -1:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	3	3	4	8
SUV	2	3	2	2	4
Pickup				1	
Minibus		1			
Small Truck		1			
Heavy Truck		1			

(1:00-1:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		4	1	3	3
SUV	1	1		1	1
Pickup					
Minibus	1				
Small Truck					
Heavy Truck					

(1:30-2:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	9	4	5	7
SUV		4			3
Pickup	1	1			
Minibus					
Small Truck					
Heavy Truck					

(2:00-2:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	9	4	5	7
SUV		4			3
Pickup		1			
Minibus					
Small Truck					
Heavy Truck	1				

(2:30-3:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		3			3
SUV		1			2
Pickup		1			
Minibus					
Small Truck					
Heavy Truck					

(3:00-3:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	7	4	3	4
SUV		3			
Pickup					
Minibus					
Small Truck		1			
Heavy Truck					

(3:30-4:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	2	24		2	4
SUV		10			1
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(4:00-4:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	4	5	4	1
SUV		3	2		
Pickup		1			
Minibus					
Small Truck		2			
Heavy Truck					

(4:30-5:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	4	3	4
SUV		7			1
Pickup		3			
Minibus		1			
Small Truck		1			
Heavy Truck		1			

(5:00-5:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		5	1	4	2
SUV		1			
Pickup		5	1		
Minibus					
Small Truck		2			
Heavy Truck					

(5:30-6:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		3	1	6	4
SUV		1			3
Pickup		3			
Minibus					
Small Truck					
Heavy Truck					

(6:00-6:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	3	4	4
SUV		1		6	3
Pickup				1	
Minibus					
Small Truck					
Heavy Truck					

(7:00 -7:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	3	1	1
SUV					1
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(7:30-8:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		1		3	2
SUV					
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(8:00 -8:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	3		2
SUV					
Pickup					
Minibus					
Small Truck			1		
Heavy Truck					

(8:30 -9:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		3		3	1
SUV					
Pickup					
Minibus					
Small Truck					
Heavy Truck				1	

(9:00-9:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2			
SUV					
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(9:30-10:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		1		1	
SUV					
Pickup					
Minibus					
Small Truck					
Heavy Truck					

The vehicle violations during the red light

A.2 Saif Saad intersection data

(7:00-7:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	2	1	2	1	3
SUV		1	1	1	
Pickup	2				
Minibus					
Small Truck					
Heavy Truck	1				

(7:30-8:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	4	8	21	1	10
SUV	4	2	20	2	5
Pickup	1			1	1
Minibus			1		1
Small Truck			2		
Heavy Truck					1

(8:00-8:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	12	14	8	3
SUV		10	4	6	4
Pickup		12			1
Minibus					
Small Truck					
Heavy Truck					

(8:30-9:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	7	9	3	1
SUV	1	7			
Pickup	1	2			
Minibus					
Small Truck			1		
Heavy Truck					

(9:00-9:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	6	3	2	2
SUV	1	6		2	
Pickup	1	1			
Minibus			1		
Small Truck		1	1		
Heavy Truck					

(9:30-10:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		7	2	2	7
SUV		1	2	3	1
Pickup					
Minibus					
Small Truck		1			
Heavy Truck					

(10:00-10:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		7		4	
SUV		7			
Pickup					
Minibus					
Small Truck		1			
Heavy Truck					

(10:30-11:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		1	1	2	1
SUV		1		1	
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(11:00-11:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	3	3		1
SUV		2	2		
Pickup					
Minibus					
Small Truck					
Heavy Truck		1			

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(11:30-12:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		4	4		
SUV		2	2		
Pickup					
Minibus					
Small Truck		1			
Heavy Truck					

(12:00-12:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		8	7	1	4
SUV					2
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(12:30 -1:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		7	5	3	5
SUV		2		3	1
Pickup		1		1	
Minibus		1			
Small Truck					
Heavy Truck					

(1:00-1:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	2	3	3
SUV		2			1
Pickup		1		1	
Minibus					
Small Truck					
Heavy Truck					

(1:30-2:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		4	2	2	1
SUV				1	
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(2:00-2:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	9	4	5	7
SUV		4			3
Pickup		1			
Minibus					
Small Truck					
Heavy Truck	1				

(2:30-3:00 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C		2			2
SUV		1			2
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(3:00-3:30 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C		5	2		3
SUV		4	3		
Pickup					
Minibus					
Small Truck		1			
Heavy Truck					

(3:30-4:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		13	2	2	5
SUV		4			
Pickup					
Minibus					
Small Truck		3			
Heavy Truck					

(4:00-4:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		4	4	1	2
SUV		1	4		
Pickup		1	1		
Minibus					
Small Truck		1			
Heavy Truck					

(4:30-5:00 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C		2	1	1	2
SUV		5			1
Pickup		1			
Minibus		2			
Small Truck				1	
Heavy Truck					

(5:00-5:30 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C		4	1	4	2
SUV		2			
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(5:30-6:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	1		3
SUV		2	1		1
Pickup		1			
Minibus					
Small Truck					
Heavy Truck					

(6:00-6:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	3	4	4
SUV		1		6	3
Pickup				1	
Minibus					
Small Truck					
Heavy Truck					

(6:30 -7:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		6		4	
SUV				1	
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(7:00 -7:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		6		4	
SUV				1	
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(7:30-8:00 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C		4			
SUV					
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(8:00 -8:30 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C		2	3		2
SUV					
Pickup					
Minibus					
Small Truck			1		
Heavy Truck					

(8:30 -9:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		1	5	1	
SUV			2		
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(9:00-9:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		3			
SUV		2			
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(9:30-10:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		1			3
SUV					
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(The vehicle Pass **)**

A.3 Al-Dhareeba intersections data

(7:00-7:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	2	2	1		
SUV	1		1		
Pickup		1			
Minibus					
Small Truck					
Heavy Truck					

(7:30-8:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	5	1	2	
SUV		1	1		
Pickup				1	
Minibus					
Small Truck					
Heavy Truck		1			

(8:00-8:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	9	16	22	22	
SUV	5	2	9	7	
Pickup	2		2		
Minibus	2	1			
Small Truck					
Heavy Truck					

(8:30-9:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	9	2	3	6	
SUV	3	1			
Pickup					
Minibus	1				
Small Truck	1				
Heavy Truck					

(9:00-9:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	4	7	5	7	
SUV		2	1	1	3
Pickup		1	1	1	
Minibus					
Small Truck					1
Heavy Truck					

(9:30-10:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	7	1	5	7
SUV		4		2	2
Pickup			1		
Minibus					
Small Truck					
Heavy Truck					

(10:00-10:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		8	1	6	1
SUV		5	1	2	
Pickup			1	1	
Minibus					
Small Truck					
Heavy Truck					

(10:30-11:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		3	2	3	4
SUV		2	3	1	
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(11:00-11:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	2	5	1	3
SUV		3	1		
Pickup					
Minibus					
Small Truck					
Heavy Truck		1			

(11:30-12:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	2	7		3
SUV		2	1		
Pickup	1		1		1
Minibus					
Small Truck		1			
Heavy Truck					

(12:00-12:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	2	9	3	1	5
SUV			1		2
Pickup					
Minibus					
Small Truck		4	1		1
Heavy Truck			1		

(12:30 -1:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	3	3	4	8
SUV	2	3	2	2	4
Pickup				1	
Minibus		1			
Small Truck		1			
Heavy Truck		1			

(1:00-1:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		4	1	3	3
SUV	1	1		1	1
Pickup					
Minibus	1				
Small Truck					
Heavy Truck					

(1:30-2:00 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C	3	9	4	5	7
SUV		4			3
Pickup	1	1			
Minibus					
Small Truck					
Heavy Truck					

(2:00-2:30 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C	3	9	4	5	7
SUV		4			3
Pickup		1			
Minibus					
Small Truck					
Heavy Truck	1				

(2:30-3:00 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C		3			3
SUV		1			2
Pickup		1			
Minibus					
Small Truck					
Heavy Truck					

(3:00-3:30 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C	3	7	4	3	4
SUV		3			
Pickup					
Minibus					
Small Truck		1			
Heavy Truck					

(3:30-4:00 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C	2	24		2	4
SUV		10			1
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(4:00-4:30 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C	1	4	5	4	1
SUV		3	2		
Pickup		1			
Minibus					
Small Truck		2			
Heavy Truck					

(4:30-5:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	4	3	4
SUV		7			1
Pickup		3			
Minibus		1			
Small Truck		1			
Heavy Truck		1			

(5:00-5:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		5	1	4	2
SUV		1			
Pickup		5	1		
Minibus					
Small Truck		2			
Heavy Truck					

(5:30-6:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		3	1	6	4
SUV		1			3
Pickup		3			
Minibus					
Small Truck					
Heavy Truck					

(6:00-6:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	3	4	4
SUV		1		6	3
Pickup				1	
Minibus					
Small Truck					
Heavy Truck					

(6:30-7:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	3	4	4
SUV		1			3
Pickup				1	
Minibus					
Small Truck					
Heavy Truck					

(7:00 -7:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	3	1	1
SUV					1
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(7:30-8:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		1		3	2
SUV					
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(8:00 -8:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2	3		2
SUV					
Pickup					
Minibus					
Small Truck			1		
Heavy Truck					

(8:30 -9:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		3		3	1
SUV					
Pickup					
Minibus					
Small Truck					
Heavy Truck				1	

(9:00-9:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		2			
SUV					
Pickup					
Minibus					
Small Truck					
Heavy Truck					

(9:30-10:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		1		1	
SUV					
Pickup					
Minibus					
Small Truck					
Heavy Truck					

The vehicle violations

A.4 Al-Dhareeba Intersections data

(7:00-7:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	2	1	2	1	3
SUV		1	1	1	
Pickup	2				
Minibus					
Small Truck					
Heavy Truck	1				

(7:30-8:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	4	8	21	1	10
SUV	4	2	20	2	5
Pickup	1			1	1
Minibus			1		1
Small Truck			2		
Heavy Truck					1

(8:00-8:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	3	12	14	8	3
SUV		10	4	6	4
Pickup		12			1
Minibus					
Small Truck					
Heavy Truck					

(8:30-9:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	7	9	3	1
SUV	1	7			
Pickup	1	2			
Minibus					
Small Truck			1		
Heavy Truck					

(9:00-9:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	1	6	3	2	2
SUV	1	6		2	
Pickup	1	1			
Minibus			1		
Small Truck		1	1		
Heavy Truck					

(9:30-10:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		7	3	9	
SUV		3	2	2	
Pickup			2		
Minibus					
Small Truck					1
Heavy Truck		1			

(10:00-10:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C		7		4	
SUV		7			
Pickup					
Minibus		1			
Small Truck					
Heavy Truck					

(10:30-11:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	11	15	24	9	
SUV	14	7	14	4	
Pickup		1	2		
Minibus		1		2	
Small Truck	1	1	4		
Heavy Truck	2	1			

(11:00-11:30 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	12	15	14	14	
SUV	17	10	9	9	
Pickup	5	1	2	4	
Minibus	1			1	
Small Truck	1	1		2	
Heavy Truck	2			1	

(11:30-12:00 am)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	17	26	17	12	
SUV	23	5	10	9	
Pickup	1	1	3	4	
Minibus		1	1	1	
Small Truck		1			
Heavy Truck		1	2		

(12:00-12:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	25	29	32	19	
SUV	10	25	15	11	
Pickup	2	8	3	1	
Minibus		2		1	
Small Truck		1	2	1	
Heavy Truck		1			

(12:30 -1:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	32	25	33	18	
SUV	26	22	19	15	
Pickup	5	5	3	6	
Minibus	1	2	1	1	
Small Truck	1	2	1	2	
Heavy Truck	1		1	1	

(1:00-1:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	53	30	36	15	
SUV	24	25	27	9	
Pickup	4	2	3	3	
Minibus	1	2			
Small Truck		4	1		
Heavy Truck	1	1	1	1	

(1:30-2:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	41	20	34	22	
SUV	11	9	22	15	
Pickup	3	3	4	4	
Minibus	1	1	1		
Small Truck	1	1	2	1	
Heavy Truck	4		1	1	

(2:00-2:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	19	39	30	25	
SUV	9	14	20	15	
Pickup		1			
Minibus	2	4	2	3	
Small Truck	1	1	3	3	
Heavy Truck		1		1	

(2:30-3:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	33	39	19	19	
SUV	9	25	17	20	
Pickup	1	5	2	5	
Minibus		3	1	3	
Small Truck	2	3	2	4	
Heavy Truck		1	1	2	

(3:00-3:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	10	13	6	15	
SUV		4	3		
Pickup	2	6	1	15	
Minibus	1	1			
Small Truck		2			
Heavy Truck	1			1	

(3:30-4:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	19	8	9	15	
SUV	8	3	5	10	
Pickup	3	2		2	
Minibus	4	1	1		
Small Truck				1	
Heavy Truck	1			2	

(4:00-4:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	10	8	9	17	
SUV	4	3	4	16	
Pickup		2			
Minibus			1	1	
Small Truck		1	1	2	
Heavy Truck			1		

(4:30-5:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	10	22	9	9	
SUV	9	8	5	14	
Pickup		1		2	
Minibus		1			
Small Truck					
Heavy Truck	1	1	1	1	

(5:00-5:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	7	12	15	15	
SUV		2			
Pickup					
Minibus					
Small Truck					
Heavy Truck		2			

(5:30-6:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	8	17	21	17	
SUV	6	10	15	10	1
Pickup	5	3		3	
Minibus	1		1		
Small Truck	1		3	3	
Heavy Truck	2				

(6:00-6:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	21	11	5	15	
SUV	4	7	6	14	
Pickup	1	6	1	1	
Minibus					
Small Truck					
Heavy Truck					

(6:30 -7:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	18	12	14	18	
SUV	5	3	15	16	
Pickup	3		1		
Minibus					
Small Truck	1		1		
Heavy Truck		1			

(7:00 -7:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	14	12	15	19	
SUV	11	5	17	17	
Pickup	2	1	1		
Minibus	2		1		
Small Truck					
Heavy Truck					

(7:30-8:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	18	12	14	18	
SUV	5	3	15	16	
Pickup	3		1		
Minibus					
Small Truck	1		1		
Heavy Truck		1			

(8:00 -8:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	18	23	10	15	
SUV	18	2	8	12	
Pickup	4		1	1	
Minibus	2				
Small Truck			1		
Heavy Truck					

(8:30 -9:00 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	19	18	19	23	
SUV	10	8	12	12	
Pickup	1	2		4	
Minibus		1		1	
Small Truck	1				
Heavy Truck			1		

(9:00-9:30 P.M)

Vehicle/Day	Sunday	Monday	Tuesday	Wednesday	Thursday
P.C	21	22	15	22	
SUV	9	7	18	24	
Pickup	3		2		
Minibus					
Small Truck					
Heavy Truck					

(9:30-10:00 P.M)

Vehicle/Day	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
P.C	13	16	13	23	
SUV	8	13	10	18	
Pickup	5		1	3	
Minibus					
Small Truck					
Heavy Truck					

Appendix (B) (Speed)

B.1 Saif Saad intersection data

Sunday				Monday				Tuesday				Wednesday				Thursday			
8:0-10:00		5:00-7:00		8:00-10:00		5:00-7:00		8:00-9:00		5:00-7:00		8:00-9:00		5:00-7:00		8:00-9:00		5:00-7:00	
Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed
5	29.30	3	48.84	5	29.30	3	48.84	6	24.42	2.5	58.61	2	73.26	3	48.84	3	48.84	3	48.84
5.5	26.64	2.5	58.61	5.5	26.64	3.1	47.26	5	29.30	2.3	63.70	2.1	69.77	2	73.26	3.2	45.79	2.5	58.61
6	24.42	2.5	58.61	3.5	41.86	3.2	45.79	6	24.42	2.1	69.77	2.4	61.05	2.1	69.77	3.4	43.09	2.5	58.61
6.5	22.54	2.54	57.69	3	48.84	3.8	38.56	6.1	24.02	2.3	63.70	3.1	47.26	2.3	63.70	3.6	40.70	2.54	57.69
6.1	24.02	2.45	59.80	5	29.30	2.5	58.61	6.2	23.63	2.8	52.33	3	48.84	2.5	58.61	5	29.30	2.45	59.80
6.4	22.89	3	48.84	2.5	58.61	3	48.84	6.3	23.26	2.97	49.33	3.2	45.79	2.8	52.33	5.2	28.18	3	48.84
6.4	22.89	2.65	55.29	3	48.84	2.5	58.61	6.3	23.26	2.5	58.61	4	36.63	2.6	56.35	5.3	27.65	2.65	55.29
5.5	26.64	2.98	49.17	3.5	41.86	2	73.26	6.4	22.89	3	48.84	3.9	37.57	2.6	56.35	3	48.84	2.98	49.17
3	48.84	2.45	59.80	3	48.84	3	48.84	6.2	23.63	3.1	47.26	3.8	38.56	6	24.42	3.6	40.70	2.45	59.80
5	29.30	3.98	36.81	2	73.26	3	48.84	6.3	23.26	3.2	45.79	3.8	38.56	3	48.84	3.6	40.70	3.98	36.81
3	48.84	3	48.84	3.5	41.86	3.5	41.86	6.3	23.26	3.1	47.26	3.78	38.76	3.2	45.79	2.98	49.17	3	48.84
3.1	47.26	2.6	56.35	2.5	58.61	3.2	45.79	7	20.93	2	73.26	3	48.84	3.6	40.70	2.97	49.33	2.6	56.35
3.2	45.79	2.45	59.80	3	48.84	3.3	44.40	6.1	24.02	3	48.84	2.4	61.05	3.98	36.81	3	48.84	2.45	59.80
3.4	43.09	2.76	53.09	5	29.30	2.5	58.61	6.2	23.63	2.3	63.70	2.4	61.05	2.98	49.17	3.7	39.60	2.76	53.09
3.3	44.40	2.45	59.80	3	48.84	2.87	51.05	6.3	23.26	2.5	58.61	2.87	51.05	2.76	53.09	3.6	40.70	2.45	59.80
3.5	41.86	2.4	61.05	3.1	47.26	2.98	49.17	6.4	22.89	2.6	56.35	2.34	62.62	3	48.84	3.98	36.81	2.4	61.05
3.6	40.70	2.4	61.05	3.2	45.79	2.89	50.70	6.5	22.54	2.8	52.33	2.87	51.05	3.1	47.26	3.78	38.76	2.4	61.05
3.7	39.60	2.3	63.70	3.4	43.09	2.78	52.71	5	29.30	2.6	56.35	2.34	62.62	3.2	45.79	3.98	36.81	2.3	63.70
3	48.84	2.13	68.79	3.3	44.40	2.68	54.67	4	36.63	2.98	49.17	2.34	62.62	3.11	47.11	3.56	41.16	2.13	68.79
3.9	37.57	2.55	57.46	3.5	41.86	2.78	52.71	4.5	32.56	2.8	52.33	2.54	57.69	3.21	45.64	3.67	39.92	2.55	57.46
3.9	37.57	2.5	58.61	3.6	40.70	2.56	57.23	4.6	31.85	2.5	58.61	2.45	59.80	2.98	49.17	3.98	36.81	2.5	58.61
3.98	36.81	2.4	61.05	3.7	39.60	2.57	57.01	5.1	28.73	2.5	58.61	2.33	62.88	2.89	50.70	3.76	38.97	2.4	61.05
5	29.30	2.6	56.35	3	48.84	3.1	47.26	5.2	28.18	2.6	56.35	2.98	49.17	2.56	57.23	3.87	37.86	2.6	56.35
5.1	28.73	2.5	58.61	3.9	37.57	3.11	47.11	5.3	27.65	2.6	56.35	2.78	52.71	2.67	54.88	2.45	59.80	2.5	58.61
5.2	28.18	2.68	54.67	3.9	37.57	3.2	45.79	5.4	27.13	2.5	58.61	2.34	62.62	2.65	55.29	2.45	59.80	2.4	61.05
5.3	27.65	2.78	52.71	3.98	36.81	3.4	43.09	5.7	25.71	3	48.84	2.34	62.62	2.45	59.80	2.45	59.80	3	48.84
5.3	27.65	2.56	57.23	5	29.30	2.454	59.71	5.8	25.26	3.1	47.26	2.54	57.69	2.9	50.52	3.7	39.60	3	48.84
5.3	27.65	2.57	57.01	5.1	28.73	2.54	57.69	3	48.84	3.2	45.79	2.45	59.80	2.5	58.61	3.7	39.60	3.1	47.26
5.2	28.18	3.1	47.26	5.2	28.18	2.65	55.29	3.87	37.86	3.21	45.64	2.34	62.62	3	48.84	3.5	41.86	2.98	49.17

5.3	27.65	3.11	47.11	5.3	27.65	2.55	57.46	3.98	36.81			2.34	62.62	3	48.84	3.22	45.50	2.89	50.70
5.2	28.18	3.2	45.79	5.3	27.65	2.55	57.46	3.98	36.81	2.2	66.60	2.34	62.62	3.5	41.86	2.44	60.05	2.65	55.29
5.3	27.65	3.4	43.09	5.3	27.65	2.65	55.29	4.6	31.85	2.5	58.61	2.87	51.05	3.6	40.70	2.98	49.17	2.67	54.88
5.98	24.50	2.454	59.71	5.2	28.18	2.3	63.70	4.6	31.85	3	48.84	3.54	41.39	2.5	58.61	3	48.84	2.87	51.05
3.4	43.09	2.54	57.69	5.3	27.65	2.5	58.61	4.8	30.53	2.4	61.05	3	48.84	3.3	44.40	2.5	58.61	3	48.84
3.6	40.70	2.65	55.29	5.2	28.18	3	48.84	4.5	32.56	2.6	56.35	3.1	47.26	3	48.84	3	48.84	3.2	45.79
3.6	40.70	2.55	57.46	5.3	27.65	3	48.84	3.9	37.57	2.4	61.05	3.2	45.79	2.4	61.05	3.7	39.60	3.2	45.79
2.8	52.33	2.55	57.46	5.98	24.50	2.4	61.05	6	24.42	2.5	58.61	3.1	47.26	2.5	58.61	3.9	37.57	3.1	47.26
		2.65	55.29	3.4	43.09	3.2	45.79	6.8	21.55	2.4	61.05	3.23	45.36	2.4	61.05	3.6	40.70	3.5	41.86
		2.3	63.70	3.6	40.70	3	48.84	6.7	21.87	2.4	61.05	2	73.26	2.98	49.17	3.55	41.27	3.6	40.70
		2.5	58.61	3.6	40.70	3.25	45.08	6.3	23.26	2.4	61.05	2.54	57.69	2.87	51.05	3.87	37.86	3.1	47.26
		3	48.84	2.8	52.33	2.4	61.05	6.4	22.89	2.8	52.33	2.45	59.80	2.65	55.29	3.87	37.86	2.5	58.61
		3	48.84	4	36.63	2.6	56.35	6.3	23.26	2.6	56.35	2.34	62.62	2.45	59.80	3.98	36.81	2.5	58.61
		2.4	61.05	4.6	31.85	2.7	54.27	6.7	21.87	3	48.84	2.34	62.62	2.76	53.09	3.45	42.47	2.5	58.61
		3.2	45.79	4.7	31.17	2.56	57.23	6.8	21.55	2.98	49.17	2.65	55.29	3	48.84	3.65	40.14	2.7	54.27
		3	48.84	4.8	30.53	2.76	53.09	6.8	21.55	2.67	54.88	2.45	59.80	3.1	47.26	3.6	40.70	2.7	54.27
		3.25	45.08	4.87	30.09	2.998	48.87	5.8	25.26	2.45	59.80	2.34	62.62	3.21	45.64	3.89	37.67	2.8	52.33
		2.4	61.05	4.7	31.17	2.65	55.29	3.8	38.56	2.33	62.88	2.32	63.16	4	36.63	3.6	40.70	2.4	61.05
		2.6	56.35	3.33	44.00	2.56	57.23	3.7	39.60	2.55	57.46	3	48.84	2.5	58.61				
		2.7	54.27	3.66	40.03	2.45	59.80	5	29.30	2.65	55.29	3	48.84	3.98	36.81				
		2.56	57.23	3.98	36.81	2.65	55.29	5.6	26.16					2.87	51.05				
		2.76	53.09	3.65	40.14	2.56	57.23	5.6	26.16										
		2.998	48.87	3.65	40.14	2.67	54.88	6	24.42										
		2.65	55.29	3.55	41.27	2.87	51.05	6.5	22.54										
		2.56	57.23	3.53	41.51	2.3	63.70	6.4	22.89										
		2.45	59.80	5.1	28.73	3	48.84	6.3	23.26										
		2.65	55.29	3.54	41.39	3.1	47.26	6.44	22.75										
		2.56	57.23	4	36.63	3.2	45.79	6	24.42										
		2.67	54.88																
		2.87	51.05																
		2.3	63.70																
		3	48.84																
		3.1	47.26																
		3.2	45.79																

B.2 Al-Dhareeba intersection

Sunday				Monday				Tuesday				Wednesday				Thursday			
8:00-10:00		5:00-7:00		8:00-10:00		5:00-7:00		8:00-9:00		5:00-7:00		8:00-9:00		5:00-7:00		8:00-9:00		5:00-7:00	
Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed
4	29.93	3	39.90	3	39.90	3	39.9	7	17.10	3	39.90	4.5	26.60	3	39.90	3.4	35.21	3	39.90
4.5	26.60	2.59	46.22	3.3	36.27	2	59.85	6	19.95	2.5	47.88	3.5	34.20	3.98	30.08	3.6	33.25	2.5	47.88
3	39.90	3	39.90	5	23.94	2	59.85	8	14.96	3	39.90	6.5	18.42	3.1	38.61	3.8	31.50	3	39.90
3.5	34.20	3	39.90	5.5	21.76	2.5	47.88	5	23.94	2.8	42.75	6	19.95	3.2	37.41	3.2	37.41	2.8	42.75
4	29.93	2.91	41.13	4	29.93	2	59.85	7	17.10	3	39.90	7.5	15.96	3.78	31.67	5.1	23.47	3	39.90
5.6	21.38	2.61	45.86	5	23.94	2.3	52.04	7.1	16.86	3	39.90	9.5	12.60	2.5	47.88	3.4	35.21	3	39.90
5.5	21.76	2.9	41.28	4.5	26.60	2.4	49.88	7	17.10	3	39.90	8.1	14.78	2	59.85	5.6	21.38	3	39.90
3.5	34.20	3	39.90	5.5	21.76	2.5	47.88	7.1	16.86	2.5	47.88	8.2	14.60	2.66	45.00	4.4	27.20	2.5	47.88
5.1	23.47	3.1	38.61	5.1	23.47	2	59.85	6.9	17.35	2.8	42.75	8.3	14.42	2.99	40.03	4.6	26.02	2.8	42.75
4.5	26.60	3.1	38.61	5.4	22.17	3	39.90	6.8	17.60	2.9	41.28	8.4	14.25	2.56	46.76	5	23.94	2.9	41.28
4.6	26.02	2.6	46.04	5.2	23.02	2.1	57.00	6.7	17.87	2.8	42.75	8.5	14.08	2.67	44.83	3.7	32.35	2.8	42.75
5.5	21.76	2.9	41.28	4.8	24.94	2.2	54.41	5.9	20.29	2.7	44.33	7.1	16.86	2.22	53.92	3.9	30.69	2.7	44.33
3.5	34.20	2.8	42.75	4.9	24.43	2.3	52.04	8	14.96	2.5	47.88	7.9	15.15	2.31	51.82	4.1	29.20	2.5	47.88
4.5	26.60	2.6	46.04	6	19.95	3	39.90	7.8	15.35	2.4	49.88	7.2	16.63	3.5	34.20	4.2	28.50	2.4	49.88
3	39.90	2.7	44.33	6.2	19.31	2.1	57.00	7.6	15.75	2.3	52.04	7.89	15.17	3.98	30.08	2.9	41.28	2.3	52.04
3.5	34.20	3.5	34.20	6.1	19.62	2.4	49.88	7.4	16.18	2.9	41.28	7.3	16.40	4.1	29.20	5	23.94	2.9	41.28
3.8	31.50	2.8	42.75	5.7	21.00	2.5	47.88	5.5	21.76	3	39.90	7.68	15.59	4.3	27.84	4.9	24.43	3	39.90
4.4	27.20	3.2	37.41	5.5	21.76	2.5	47.88	5.9	20.29	3	39.90	7.3	16.40	5	23.94	4.9	24.43	3	39.90
4.5	26.60	3.1	38.61	6.1	19.62	2.7	44.33	5.8	20.64	3	39.90	7.5	15.96	2.5	47.88	4.4	27.20	3	39.90
4.8	24.94	2.7	44.33	6.2	19.31	2.8	42.75	6	19.95	3	39.90	7.4	16.18	2.51	47.69	3.4	35.21	3	39.90
3.7	32.35	2.9	41.28	7	17.10	2.9	41.28	5.9	20.29	2.5	47.88	7.45	16.07	2.54	47.13	3.8	31.50	2.5	47.88
5.1	23.47	2.8	42.75	6.3	19.00	2.1	57.00	6.8	17.60	2.6	46.04	6	19.95	2.54	47.13	5	23.94	2.6	46.04
3.9	30.69	2.6	46.04	6.4	18.70	2	59.85	6.7	17.87	2.7	44.33	6.5	18.42	2.65	45.17	4.1	29.20	2.7	44.33
4	29.93	2.6	46.04	6.9	17.35	2	59.85	6.9	17.35	2.8	42.75	5.5	21.76	3.5	34.20	4.5	26.60	2.8	42.75
4.5	26.60	2.59	46.22	7	17.10	2	59.85	7	17.10	2.9	41.28	5.3	22.58	3.5	34.20	4.5	26.60	2.9	41.28
3.6	33.25	2.56	46.76	6.7	17.87	2	59.85	8	14.96	2	59.85	5.2	23.02	4	29.93	4	29.93	2	59.85
4.4	27.20	3.1	38.61	5.6	21.38	2.4	49.88	7.9	15.15	2	59.85	4.5	26.60	4.55	26.31	4.5	26.60	2	59.85
3.8	31.50	3	39.90	7	17.10	2.5	47.88	7.8	15.35	2.5	47.88	4.9	24.43	2	59.85	3	39.90	2.5	47.88
5.1	23.47	2.8	42.75	5.4	22.17	2.6	46.04	8.1	14.78	3	39.90	4.8	24.94	2.4	49.88	3.5	34.20	3	39.90

5.2	23.02	2.99	40.03	5.3	22.58	2.7	44.33	8	14.96	3	39.90	4.98	24.04	2.9	41.28	4	29.93	3	39.90
5.3	22.58	2.88	41.56	4.3	27.84	2.8	42.75	7.9	15.15	3	39.90	5.31	22.54	2.65	45.17	5.6	21.38	3	39.90
3.3	36.27	3.1	38.61	4.3	27.84	2.9	41.28	7.8	15.35	2	59.85	4.98	24.04	3	39.90	5.5	21.76	3	39.90
3.4	35.21	3.1	38.61	4.9	24.43	2.5	47.88	7.9	15.15	3	39.90	5.3	22.58	3.5	34.20	3.5	34.20	3	39.90
3.6	33.25	3.2	37.41	4.4	27.20	2.7	44.33	9	13.30	3	39.90	5.3	22.58	3	39.90	5.1	23.47	2	59.85
3.8	31.50	2.95	40.58	3.9	30.69	2.5	47.88	8.9	13.45	2.9	41.28	5.2	23.02	3.5	34.20	4.5	26.60	3	39.90
3.2	37.41	2.89	41.42	3.8	31.50	2.5	47.88	8.7	13.76	3	39.90	5.1	23.47	3.8	31.50	4.6	26.02	3	39.90
5.1	23.47	3.88	30.85	4.9	24.43	2.4	49.88	8.8	13.60	2.8	42.75	5.44	22.00	3.2	37.41	5.5	21.76	2.9	41.28
3.4	35.21	2.7	44.33	4.9	24.43	2.6	46.04	8.6	13.92	2.6	46.04	5.88	20.36	3.21	37.29	3.5	34.20	3.21	37.29
5.6	21.38	2.7	44.33	5.8	20.64	2.4	49.88	8.5	14.08	2.98	40.17	5.98	20.02	3.12	38.37	4.5	26.60	3.12	38.37
4.4	27.20	2.9	41.28	5.8	20.64	2.3	52.04	8.4	14.25	3	39.90	5.77	20.75	3.5	34.20	3	39.90	3.5	34.20
4.6	26.02	3	39.90	5.8	20.64	2.1	57.00	8.3	14.42	2.9	41.28	5.6	21.38	3.6	33.25	3.5	34.20	3.6	33.25
5	23.94	2.5	47.88	5.8	20.64	2.5	47.88	8.2	14.60	2.8	42.75	5.5	21.76	2.1	57.00	3.8	31.50	2.1	57.00
3.7	32.35	2.7	44.33	5.7	21.00	3	39.90	8.1	14.78	2.89	41.42	4.5	26.60	2.3	52.04	4.4	27.20	2.3	52.04
3.9	30.69	2.9	41.28	6.8	17.60	2.6	46.04	8	14.96	2.5	47.88	4.33	27.64	2	59.85	4.5	26.60	2	59.85
4.1	29.20	3.1	38.61	5.9	20.29	2.6	46.04	7.9	15.15	2	59.85	4.76	25.15	2.4	49.88	4.8	24.94	2.4	49.88
4.2	28.50	3.2	37.41	5	23.94	3.6	33.25	6.5	18.42	2.5	47.88	4.67	25.63	2.98	40.17	3.7	32.35	2.98	40.17
2.9	41.28	2.59	46.22	3.9	30.69	2.4	49.88	7	17.10	3	39.90	4.98	24.04	2.56	46.76	5.1	23.47	2.56	46.76
5	23.94	2.99	40.03	3.8	31.50	2.3	52.04	7.1	16.86	3	39.90	4.5	26.60	2.5	47.88	5	23.94	2.5	47.88
4.9	24.43	2.78	43.06	3.8	31.50	2.6	46.04	6.5	18.42	2	59.85	3.98	30.08	3	39.90	3.9	30.69	3	39.90
4.9	24.43	2.89	41.42	5.4	22.17	2.5	47.88	6.9	17.35	2.9	41.28	3.76	31.84	3.51	34.10	3.8	31.50	3.51	34.10
4.4	27.20	2.99	40.03	4.9	24.43	2.5	47.88	6.8	17.60	2.5	47.88	3.98	30.08	3.5	34.20	3.8	31.50	3.5	34.20
3.4	35.21	2.98	40.17	4.8	24.94	2.5	47.88	6.7	17.87	2.6	46.04	3.5	34.20	3.52	34.01	5.4	22.17	3.52	34.01
3.8	31.50	2.99	40.03	5.8	20.64	2.4	49.88	3	39.90	2.5	47.88	3.5	34.20	3.88	30.85	4.9	24.43	3.88	30.85
5	23.94	2.998	39.93	5.8	20.64	2.8	42.75	4	29.93	2.9	41.28	2.78	43.06	4	29.93	4.8	24.94	4	29.93
4.1	29.20	2.98	40.17	6.9	17.35	2.7	44.33	4.5	26.60	2.8	42.75	2.65	45.17	4.1	29.20	5.8	20.64	4.1	29.20
4.5	26.60	2.5	47.88	6.7	17.87	2.6	46.04	3	39.90	3	39.90	2.4	49.88	4.2	28.50	5.8	20.64	4.2	28.50
4.5	26.60	2.59	46.22	6.8	17.60	2.6	46.04	3	39.90	2	59.85	2.1	57.00	4.98	24.04	6.9	17.35	4.98	24.04

Appendix C Headway (sec)

C.1 Saif Saad intersections data (8:00-10:00) am

Sunday	Monday	Tuesday	Wednesday	Thursday
1.57	1.27	1.81	2.12	1.93
1.96	1.81	1.68	1.75	1.87
1.49	1.48	2.28	1.13	1.69
2.08	2.49	1.78	2.02	1.28
1.96	1.21	1.87	1.32	1.91
1.72	1.38	1.31	1.61	1.98
0.86	1.92	1.22	1.52	1.84
1.12	1.81	1.88	2.23	1.33
1.99	2.78	1.81	2.6	1.25
1.26	1.58	1.68	1.71	2.25
2.42	1.7	2.28	2.41	2.48
2.33	1.5	2.18	1.73	2.44
0.66	1.79	1.79	2.63	2.32
1.23	1.5	1.59	2.42	2.32
2.23	1.29	1.57	2.33	1.89
2.23	2.45	0.74		1.51
	1.47	1.67		1.06
	1.49	2.18		2.75
	1.87	1.79		2.5
	2.51	1.59		0.27
	2.27			

(5:00-7:00) p.m

Sunday	Monday	Tuesday	Wednesday	Thursday
1.52	1.19	1.95	1.94	2.74
2.51	2.08	1.58	2.44	2.86
2.13	2.27	1.64	3.14	1.96
1.64	1.87	1.83	4.14	0.94
2.61	1.49	1.25	2.22	1.28
1.53	1.47	1.8	1.38	1.53
1.74	2.45	0.67	2.66	1.89
1.67	1.29	0.84	2.82	2.2
1.59	1.5	0.9	2.86	1.32
1.31	2.3	1.74	1.7	1.28
0.68	1.61	1.86	0.8	1.93
2.66	1.38	0.81	0.74	1.87
	1.44	2.12	5	1.65
	2.05	2.04	5.71	2.23
	1.13	2.02	3.9	1.19
		2.99	2.73	
		2.38	2.44	
		2.04	1.06	
		2.15	2.22	
		1.48		

Appendix C Headway(sec)

C.2 Al - Dhareeba intersection

(8:00-10:00) a.m

Sunday	Monday	Tuesday	Wednesday	Thursday
5.86	2.76	5.16	2.61	2.25
3.73	2.96	2.02	3.71	1.32
1.54	3.49	3.85	2.23	1.95
1.89	2.85	2.83	2.8	2.6
2.2	1.91	2.58	2.78	3.96
3.06	3.18	1.2	1.19	0.87
1.32	1.26	2.44	1.54	2.06
2.86	1.46	1.56	2.11	1.49
3.06	3.73	2.65	1.91	1.88
2.49	1.49	1.76	2.66	2.45
1.86	1.07	1.78	3.06	2.27
2.03	1.88	3.01	1.32	1.49
2.81	1	2.4	1.79	1.88
2.38	4.35	2.99	1.56	2.45
3.03	2.71	2.56	2.34	2.27
2.86	2.37	2.15	1.36	1.7
3.06	3.37	1.67	1.83	1.68
2.49	1.84	1.67	3.12	1.34
1.86	3.51	3	3.76	1.3
2.03	1.88	1.93	3.27	2.55
2.81	1	2.63	3.59	2.82
2.38	3.56	0.17	1.63	1.84
3.03	4.87	1.98	2.18	2.86
1.44	2.71	1.39	2.08	2.27
4.17	2.37	3.1	0.86	1.84
2.83	3.37	1.27	2.35	2.86
1.19	1.84	1.43	3.76	2.27
		1.9	2.62	1.77
		1.14	1.86	2.59
		2.61	1.19	1.47

		3.61	1.63	1.84
		3.27		
		3.51		
		3.01		
		1.37		
		1.83		
		2.7		
		1.69		
		3.59		
		3.02		
		5.7		
		2.81		
		2.81		
		2.63		

(5:00-7:00) p.m

Sunday	Monday	Tuesday	Wednesday	Thursday
1.69	1.87		3.44	1.71
2.84	2.79	3.26	2.09	2.66
2.77	1.26	2.26	2.73	1.81
1.44	3.64	2.38	2.57	1.7
2.13	1.45	3.13	2.66	2.2
2.54	2.4	4.13	2.27	2.26
1.8	1.21	1.16	1	3.3
1.92	4.77	3.71	1.78	1.74
2.23	2.47	1.47	3.67	1.71
3.14	2.59	3.26	3.07	2.21
3.82	2.68	1.83	4.14	1.78
3.39	1.52	1.32	4.44	2.66
1.23	3.84	3.71	3.35	1.81
0.66	1.45	1.47	0.61	1.7
4.32	1.46	3.26	1.31	1.68
2.89	1.62	1.83	1.22	1.34
3.7	3.78	1.32	1.88	1.28
3.68	4.21			1.83
1.52	2.73			1.7
3.7	2.98			1.63
3.68	3.52			

Appendix D

Questionnaire

This questionnaire concerns the driver's behavior at the moment of his arrival at the intersection. If you are not sure of the information in the questionnaire, please take the opportunity to verify the information by driving at the intersections equipped with a traffic signal.

bushra.f@s.uokerbala.edu.iq (not shared) Switch account

* Required

Is the driver? *

- ◯ Male
- ◯ Female

What is the driver's age? *

- ◯ Less 18 years
- ◯ 18-25
- ◯ 25-40
- ◯ 40-55
- ◯ More 55 years
- ◯ Other: ____________

How many years of driving? *

- ◯ Less one year
- ◯ From one year to five year
- ◯ More 5 year

What is the educational attainment? *

- ◯ primary School degree
- ◯ Intermediate School degree
- ◯ Mid School degree
- ◯ Bachelor's degree
- ◯ Technical Diploma
- ◯ Master's degree
- ◯ Ph.D
- ◯ Other: ____________________

What is the personal vehicle you use? *

- ◯ passenger car
- ◯ SUV
- ◯ pickup
- ◯ minibus
- ◯ Truck
- ◯ Other: ____________________

What is the function of the yellow colour? *

- Warn the driver that the red light will come on later and you must stop
- Warn the driver that the green light will appear later and you must continue
- He has no role
- Other: ______

How long is the yellow light in your opinion? *

- 6-3 second
- 10-6 second
- 15-10 second
- 20-15 second
- Other: ______

Are you trying to increase your speed when the traffic light changes from green to red? *

- Yes
- No
- Sometimes
- Other: ______

When you are close to the pedestrian crossing line at the intersection (1-2) seconds, and the signal changes to yellow, what is your decision? *

- -Stop before the pedestrian crossing line
- -- Continue driving to cross the intersection
- -Not sure of my decision

When you are close to the pedestrian crossing line at the intersection (2-3) seconds, and the signal changes to yellow, what is your decision? *

- -Stop before the pedestrian crossing line
- -- Continue driving to cross the intersection
- -Not sure of my decision
- Other: ______

When you are close to the pedestrian crossing line at the intersection(3-4) seconds, and the signal changes to yellow, what is your decision? *

- -Stop before the pedestrian crossing line
- -- Continue driving to cross the intersection
- -Not sure of my decision
- Other: ______

When you are close to the pedestrian crossing line at the intersection (4-5) seconds, and the signal changes to yellow, what is your decision? *

- -Stop before the pedestrian crossing line
- -- Continue driving to cross the intersection
- -Not sure of my decision
- Other: ______

When you are far from the pedestrian line at the intersection (more than 5 seconds) and the signal changes to yellow, what is your decision? *

؟

- ◯ -Stop before the pedestrian crossing line
- ◯ -- Continue driving to cross the intersection
- ◯ -Not sure of my decision
- ◯ Other: ____________

Have you ever encountered the difficulty of making a decision to stop or cross the intersection when the yellow light appears? *

- ◯ Yes
- ◯ No

- ◯ Option 1

Would you prefer the yellow light to be longer? *

- ◯ Yes
- ◯ No
- ◯ Other: ____________

What is the distance between your vehicle and the vehicle ahead of you inside the traffic intersection when the yellow color appears? *

- ◯ less 1 meter
- ◯ (1-2) meter
- ◯ more 3 meter
- ◯ Other: ______

In your opinion, do vehicle drivers put safe distances between their vehicle and the vehicle and front of them when the yellow light appears? *

- ◯ Yes
- ◯ No
- ◯ Other: ______

When the yellow light appears and vehicle is driving behind you and at a close distance to your vehicle, does it affect your decision to stop or cross at intersections? *

- ◯ Yes
- ◯ NO
- ◯ Not Sure
- ◯ Other: ______

Do you hesitate to cross when the yellow light appears? *

- ◯ Yes
- ◯ No
- ◯ Other: ______

Have you ever happened to be close to the crossing line and the color changed from yellow to red? *

- ◯ Yes
- ◯ No
- ◯ Other: ____________________

Did you violate the traffic light because the color changed from yellow to red? *

- ◯ Yes
- ◯ No
- ◯ Other: ____________________

Have you ever happened to be close to a pedestrian crossing and the red light appeared and you were unable to stop your vehicle? *

- ◯ Yes
- ◯ No
- ◯ Other: ____________________

Have you ever stopped suddenly when the yellow light appeared? *

- ◯ Yes
- ◯ No
- ◯ Other: ____________________

Have you ever stopped suddenly when the yellow light appeared? *

- ◯ Yes
- ◯ No
- ◯ Other: ______

In your opinion, who is more abiding by the traffic light laws? *

- ◯ Male
- ◯ Female
- ◯ Other: ______

In your opinion, who are the most abiding by the traffic light laws? *

- ◯ Old driver
- ◯ New driver
- ◯ Other: ______

الخلاصة

تعتبر مدينة كربلاء في العراق من اهم المدن التي تشهد زيادة كبيرة في عدد سكانها. علاوة على ذلك ، نظرًا لأهمية المدينة من منظور ديني ، فقد استقبلت عددًا كبيرًا من الزوار خلال العام. لذلك ، يمكن أن توفر دراسة سلوك القيادة عند التقاطعات ذات الإشارات الضوئية في هذه المدينة خلفية تحليلية لتصميم إشارات مرورية أكثر أمانًا يمكن أن يقلل من احتمالية وقوع حوادث للسيارات عند التقاطعات. في هذا السياق ، يعد هذا العمل دراسة تجريبية تهدف إلى تحليل سلوك القيادة وتقدير قرار السائق بالتحرك أو التوقف عند التقاطعات ذات الإشارات عند ظهور الضوء الأصفر. على وجه الخصوص ، في هذه الفترة ، قد لا يتمكن السائق من التوقف بأمان قبل خط التوقف ، أو عبور التقاطع. يُعرف هذا باسم منطقة المعضلة ، والتي تعتبر مهمة للغاية لفهمها وتوصيفها ، ومع ذلك فإن تقدير قرار السائق في هذه المنطقة يعتبر عشوائيًا للغاية لأنه يمكن تغيير قرار السائق من سائق إلى آخر. هذا نهج يعتمد على البيانات وينتهي به الأمر إلى توفير نموذج يمكن استخدامه من أربع xi لتقدير قرار السائق من القياسات المرصودة. في هذه الدراسة التجريبية ، يتكون متغير الإدخال هو ثنائي yi (وقت التوقف) ، ونوع السيارة. متغير الإخراج TTSLميزات ؛ السرعة ، المسافة الأمامية ، تم جمع البيانات .(yi = 1) أو عدم تجاوز التقاطع (yi = 0) (يأخذ إما 0 أو 1) ويمثل قرار السائق لتمرير من خلال تركيب كاميرات مثبتة على تقاطع الضريبه وتقاطع سيف سعد لمدة خمسة أيام عمل في مدينة كربلاء. تم حساب المركبات المارة والمتوقفة للضوء الأصفر وكذلك المركبات المخالفة للإشارة المرورية أثناء أحد Red Light Running (RLR) التقاطعات المرورية لبداية الإشارة الحمراء. في هذا السياق ، يعد أخطر سلوكيات المرورعند التقاطعات المرورية المختلطة وواحدة من أخطر مشكلات السلامة. في المجموعة لمدة خمسة أيام من الساعة 8:00 صباحًا حتى 10:00 مساءً. RLR الأولى من التجارب ، تم قياس انتهاكات التي حدثت في كلا التقاطعين بإشارة. وشهد RLR وفقًا لهذه القياسات ، كانت هناك نسبة عالية من انتهاكات ، بينما (67.60٪) RLR تقاطع الضريبة خلال الساعات من 8:00 إلى 9:00 صباحًا أعلى نسبة من مخالفات حصل تقاطع سيف سعد على 45.46٪. في المجموعة الثانية من التجارب ، تم قياس متغيرات الإدخال لمدة خمسة أيام خلال ساعات الذروة 8:00 صباحًا - 10:00 صباحًا و 5:00 مساءً - {(xi ،yi)} والإخراج لكل تقاطع (ما مجموعه 1026 عينة (xi ،yi) 7:00 مساءً. قدمت هذه المجموعة من التجارب 513 عينة لكلا التقاطعين). تم استخدام نموذج الانحدار اللوجستي الثنائي في هذه الدراسة. لتدريب واختبار هذا المصنف

في هذه الدراسة. أشارت نتائج تقاطع الضريبة إلى وجود علاقة طفيفة بين SPSS Statistics ، تم استخدام السرعة والتقدم ونوع المركبة مع قرار السائق بالذهاب أو التوقف عند الضوء الأصفر ، في حين أن ميزة من 0.01. تشير العلامة السالبة في المعامل () إلى أن .p مهمة مع قرار السائق الذي يكون له قيمة TTSL احتمالية التوقف تزداد مع انخفاض السرعة والتقدم. في حالة تقاطع سيف سعد ، أشارت النتائج إلى وجود مع قرار السائق. تشير العلامة السالبة في المعامل () إلى أن احتمال TTSL علاقة كبيرة بين السرعة و التوقف يزداد مع انخفاض التقدم. في المجموعة الثالثة من التجارب ، تم جمع البيانات باستخدام أسئلة الاستبيان الإلكترونية المفتوحة لجميع السائقين على الإنترنت ، حيث تم إجراء تحليل إحصائي لتقديم تقييم نوعي لتأثير الجنس والعمر والمستوى التعليمي على قرار السائق .

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جمهورية العراق

وزارة التعليم العالي و البحث العلمي

جامعة كربلاء

كلية الهندسة

قسم الهندسة المدنية

استجابة السائق للتوقيت الأصفر عند التقاطعات ذات الإشارات المختارة في مدينة كربلاء ، العراق

رسالة مقدمة الى مجلس كلية الهندسة / جامعة كربلاء وهي جزء من متطلبات نيل درجة الماجستير في علوم الهندسة المدنية

من قبل:

بشرى فهد جاسم

بكالوريوس في الهندسة المدنية /جامعة كربلاء (2018-2019)

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