ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

A Comparison of Pedestrian crossing behavior at a signalized and unsignalized cross walks in Addis Ababa, Ethiopia

A Thesis in road and transport engineering

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A Thesis

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

The undersigned have examined the thesis entitled **'A Comparison of Pedestrian crossing behavior at a signalized and unsignalized cross walks in Addis Ababa, Ethiopia'** presented by **TIGIST LEGESSE YIFRU**, a candidate for the degree of **Master of Science** and hereby certify that it is worthy of acceptance.

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ABSTRACT

Pedestrians are vulnerable road users therefore, it is necessary to analyze their behavior in order to define quality measures. This paper reports the comparison of pedestrian crossing behavior at signalized and unsignalized intersections in Addis Ababa. The objective of the study is to find the factors that affect pedestrian crossing speed and waiting time and to provide MLR model for both intersection types With specific of two signalized intersection those are legehar and kidist maryam and two unsignalized intersections those are 4 killo round about and safari uncontrolled intersections. For each crosswalk observation was taken at 7:30A.M to 8:30A.M.

Data collection was taken by video observation. For the study total of 2374 sample of pedestrian are used. Different parameters are taken to test the significant factors those are Gender, Age group, Baggage handling, crossing stage, crossing direction, crossing patters, crossing situation, disability, mobile usage and crossing along the crosswalk. Student t-test and one way ANOVA were used to identify factors affecting pedestrian crossing speed while Mann-Whitney U test and Kruskal-Wallis one way ANOVA test were used to identify determining factors of pedestrian waiting time.

Male pedestrian, young pedestrian, pedestrian alone, pedestrian with no disability and pedestrian with no mobile usage cross faster. From the analysis of the crossing speed mean crossing speed is found as 1.41m/s and 1.27m/s and the recommended design crossing speed are 1.02m/s and 0.95m/s for signalized and unsignalized intersection respectively. For a better understanding, MLR model method was applied at 95% confidence interval, which showed gender, age group, crossing stage, crossing pattern, crossing situation, disability and CAS- crossing along the crosswalk as the significant factor for the crossing speed.

In the case of waiting time, 40%, 69% and 91% of pedestrian doesn't wait more than 10s for signalized and unsignalized intersections respectively. Females, old pedestrian, pedestrian with no baggage, two stage crossing, crossing by walk, being alone, crossing without mobile taking, pedestrian with no disability have higher waiting time. For a better understanding, an MLR model method was applied at 95% confidence interval was prepared for the waiting time of pedestrian analysis, which showed gender, age group, Crossing stage, crossing pattern, crossing situation and CAC- crossing along the crosswalk.

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CHAPTER 1 INTRODUTION

1.1 Background

Traffic research on roadways has been on vehicles. On designing of road way Concerns for the comfort, convenience and safety of pedestrian have often come second. The major reason is due to the complexity involved in modeling pedestrian behavior.

Pedestrian violations which make a great influence on road traffic transport are one of the main causes of traffic accidents at intersections. So, Traffic accidents involving pedestrians have become a major safety problem all over the world, particularly in developing countries like Ethiopia due to high population density, rapid urbanization, and lack of adherence to traffic regulations by both drivers and pedestrians. 93% of the world fatalities on the road occur in low- and middle –income countries, even though these countries have approximately 60% of the world vehicles. (WHO, 2020)

Approximately 1.35 million people die each year as a result of road traffic crashes. More than half of all road traffic deaths are among vulnerable road users: pedestrians, cyclists and motorcyclists. And road traffic crash cost most countries 3% of their gross domestic product. (WHO, 2020)

Addis Ababa is the capital city and the largest urban center in Ethiopia. The estimated population of Addis Ababa is 4.7 million in 2020 and since 2015 it shows 4.39% annual change. (UN World Urbanization prospect). Recently, road traffic crashes, and particularly pedestrian crashes, have become a challenging problem within the city. Walking is the principal mode of transportation in Addis Ababa accounting for about 60% of daily trips, whereas pedestrian injuries account for about 85% of total injury crashes (Getu, simon, 2016). Currently, in Addis Ababa, at least one person dies and 8 persons are injured every day, on average (Federal Police Commission of Ethiopia, 2013).

Pedestrian crossing behavior can be observed with the parameters like crossing speed, waiting time and compliance behavior. In the case of crossing speed, it is significantly lower at the unsignalized intersection than the signalized intersections. Females, children, and old pedestrians had a lower crossing speed than male, young, and adult

pedestrians, respectively. Pedestrians had to wait for less time at a signalized intersection than at unsignalized intersection. Again, male pedestrians waited less time than female pedestrians. Pedestrians who waited at the sidewalk waited a longer time than pedestrians who waited on the road. (Niaz, Atikul, Neelopal, 2019)

To improve pedestrian safety, transportation planners and engineers are predominantly concerned with understanding and modeling pedestrian crossing behavior so as to increase the walk ability and also to reduce the conflict between pedestrian and vehicles at intersections under mixed traffic conditions.

Pedestrian crossing behavior is going to be analyzed on the next chapters for the provision of proper pedestrian facilities at desired locations, as well as to improve their safety while crossing the road. This research consider the various factors that influence pedestrian crossing behavior both at a signalized and unsignalized intersections those are pedestrian crossing speed and waiting time those things are going to be seen by different parameters like gender, age, crossing in group, crossing pattern etc. How those Parameters actually influence the pedestrian crossing behavior. To see in detain video records and questioner survey is taken. It will be analyzed using descriptive and statistical methods.

1.2 Statement of the Problem

In Ethiopia the total number of vehicles registered by the authority, at both federal and regional levels, has reached close to 1.2 million vehicles. The report shows that Addis Ababa has registered around 630,440 vehicles. (Ministry of transport, 2020) but No matter which type of transportation mode is chosen by the people, walking is a part of that trip. Hence, each person is a pedestrian during some part of his/her trip.citizens use walking as the primary means of transportation, accounting for about 60% of the trips within the city (Tulu, Washington, King, et al., 2013).

Ethiopia has a high road crash rate in the world and Traffic accident on pedestrians is increasingly becoming the country's major problem especially for Addis Ababa city. .Despite the frequency of pedestrian crashes and the importance of walking as a mode of transport, the road authority in Ethiopia often gives priority to the construction and maintenance of roadways for vehicle traffic, but less attention to pedestrian facilities.

Pedestrians crossing behaviour observed in the city is different at signalized and unsignalized intersections like crossing speed and waiting time this is due to the presence of signals. Gender difference, different age group, baggage handling, crossing pattern, crossing situation and others makes a difference. Pedestrians use Different crossings patterns like oblique and perpendicular crossings. The oblique crossing most of the time make the pedestrian to be out of the designated cross walks which leads to conflict with the nearby vehicle. On the other hand sometimes the allocated pedestrian green phase is not enough for older people and for the one who carry luggage this is due to the design speed taken for the signal time design. Being disable have impact on pedestrian crossing speed and waiting time.

Pedestrian crossing behavior is an important and relevant objective when designing roadways and intersection to meet the aims such as safety, comfort and convenience. And these crossing behaviors are different for signalized and unsignalized intersections. Therefore This paper attempts to analyze the crossing behavior of pedestrians means crossing speed and compliance with signal phase time and crossing with the marked cross walk and waiting time under mixed traffic conditions by identifying the influencing factors based on descriptive and statistical methods. And finally compare the results for both intersections. This will help for better understanding of the behavior

of the pedestrian crossings separately at signalized and unsignalized intersections crosswalk and to provide safe and comfortable crossing environment (by understanding crossing behavior) for both the pedestrian and drivers.

1.3 Objectives

The main objective of this thesis is to show and compare the pedestrian crossing behavior at signalized and unsignalized intersections cross walks in the city Addis Ababa, Ethiopia.

1.3.1 General Objectives

The aim of this thesis is to show and compare the pedestrian crossing behavior at signalized and unsignalized intersections cross walk in Addis Ababa. This paper attempts to analyze the crossing behavior of pedestrians like crossing speed and waiting time to identify the influencing factors based on descriptive and statistical methods.

1.3.2 Specific Objectives

The specific objectives in the Investigation and compression of Pedestrian crossing behavior at signalized and unsignalized intersections cross walk in Addis Ababa are listed below

- Identify the factors that dominantly affect pedestrian crossing speed both at signalized and unsignalized intersections crosswalk and compare for both intersections crosswalk.
- Identify the factors that dominantly affect pedestrian waiting time and compare for both intersections crosswalk.
- Multiple linear regression model development for both crossing speed and waiting time.

1.4 The research Question

1. What are the factors that influence the pedestrian crossing speed and the difference at signalized and unsignalized intersections cross walk?
2. What are the factors that affect the pedestrian waiting time and the difference at signalized and unsignalized intersections cross walk?

1.5 Significance of the Study

Significance of the study will be

- The study will be useful for transportation planners, road agencies, government, and communities for planning, identifying and designing of the intersection according to the pedestrian crossing behavior on different type of intersections in the city or specific area.
- It will help to identify the main factors that affect the pedestrian crossing speed at the signalized and unsignalized intersections cross walk.
- It will help to identify the main factors that affect the pedestrian waiting time at the signalized and unsignalized intersections cross walk.
- It will show some good ideas for the future researchers to look in detail the factors that influence the pedestrian crossing behavior at a signalized and unsignalized intersection.

1.6 Scope of the study

The comparison of pedestrian crossing behaviors at signalized and unsignalized intersections cross walk is wide but due to time and budget problems the scope of this research is limited to the capital city, Addis Ababa. By looking only two parameters that are crossing speed and waiting time on Specific areas on two signalized intersections those are kidist maryam and legehar signalized intersections and two unsignalized intersections those are 4 killo roundabout and safari uncontrolled intersection. The independent variables depend on limited variables that is more related and depend on pedestrian circumstance those are Gender, age, baggage handling, crossing situation, crossing stage, crossing direction, crossing pattern, disability, mobile usage and crossing

along the crosswalk. Traffic conditions, geometric conditions, culture effect, pedestrian vehicular interaction and no/ of lanes are not considered in this research paper.

1.7 Organization of the thesis

This paper consists of five chapters. Chapter one deals with the back ground of the study, statement of the problem of the study, objectives of the study, research questions, the significance and scope of the thesis. Chapter two contains the review of the related literatures. Chapter three includes description of the study area, research approach, data collection, data analysis for the research under study. Next to this Chapter four describes the results and discussion of the analysis. Finally, chapter five covers the conclusion and recommendation parts.

CHAPTER 2 LITRATURE REVIEW

2.1 Introduction

Crossing behavior impact factors mainly focus on pedestrian attributes, traffic conditions, and road conditions. Pedestrian attributes, age and gender are two main factors considered to describe the pedestrians. It is shown that the male and middle-aged pedestrians have a high probability to cross the streets illegally. Besides, crowd size, clothing, and luggage are also employed to explain the different crossing speeds and waiting time. In addition, culture is considered as another important factor impacting differences in crossing behaviors.

Male pedestrians tend to violate traffic rules more frequently than females and are more likely to cross in risky situations. Young adults and adolescent pedestrians are generally more likely than older pedestrians to commit violations, whereas older road users express greater appreciation for the traffic signals at controlled pedestrian crossings and signalized intersections than younger pedestrians.

A considerable amount of research has examined factors that influence the road-crossing behaviors of pedestrians, including the physical environment (e.g., road width and type of street), road user variables (e.g., demographic characteristics), and social factors (e.g. the number of pedestrians in the group attempting to cross).

Psychological factors such as comfort perception, willingness to bypass, conformity, carelessness, anxiety, and personal preference are also analyzed in previous studies. A few studies take alcohol use into account to analyze risk of pedestrian-motor vehicle collisions.

Traffic conditions, the relative studies mainly focus on vehicle flow, traffic density, pedestrian flow, phase time and so on. The results show that the proportion of crossing at a red light decreases with the increase of vehicle flow and pedestrian flow at signalized intersections, and the probability of crossing at a red light increases while the waiting time of pedestrian is too long to exceed their tolerance limit. Besides, the left

turn ratio of vehicles is a key parameter usually used to analyze the probability of pedestrian-vehicle collisions.

Factors of road conditions, including crosswalk distance, Countdown displays, type of intersection, illumination and so on, are also considered to analyze pedestrian crossings. Some results suggest that it has a negative correlation between the proportion of compliance with traffic rules and crosswalk distance; countdown displays significantly reduce pedestrian crossing behavior at a red light, and factors appear to have different influence on illegal crossings at different intersections.

Except for the factors above, weather, and social economics are used to analyze the preference of crossings in a few studies. education and income level Pedestrian environment is complicated because pedestrians are subjected to various parameters significantly affecting their perceptions of safety. Identification of these parameters is essential to assess pedestrian facilities, and assessment methods are needed to understand how well a facility accommodates pedestrians.

2.2 Pedestrian Crossing Behavior

Research have made theoretical and methodological contribution to a practical understanding of pedestrian's behavior and the interaction between the driver and the pedestrian at pedestrian crossings (Sun et al., 2011). Pedestrian crossing behavior is divided here into five categories

1. One-step:- pedestrians cross the road without waiting near the median.
2. Two-step:- pedestrian cross up to the median in one go and subsequently cross the far side.
3. Perpendicular crossing (PC):- When a pedestrian crosses the road in a straight . pat
4. Oblique crossings (OC):- are those in which pedestrians cross the road in a zigzag manner.
5. Mixed crossings (MC) are the combination of both perpendicular and oblique type of crossings (pedestrians cross first half of the road in a straight path up to the median and the next half they cross in a zigzag manner and vice versa).

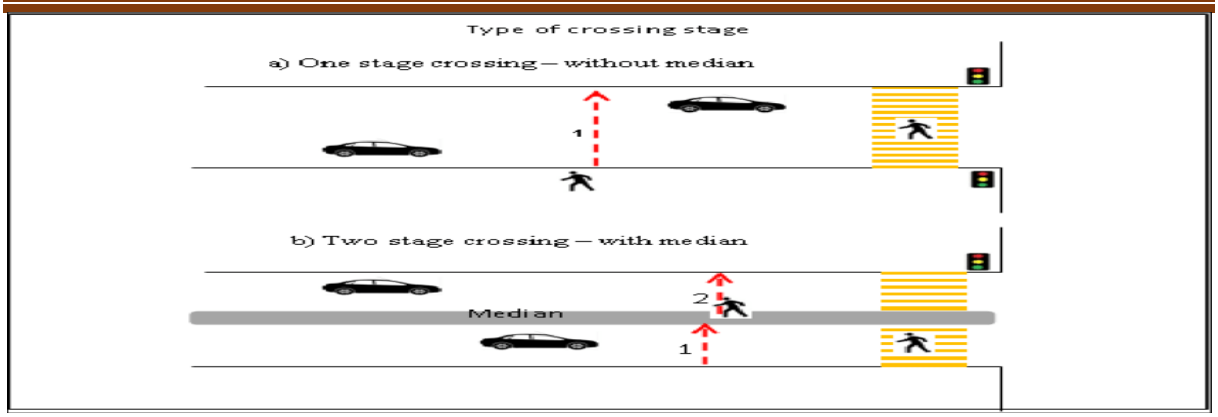


Figure 2-1 stage of pedestrian crossing

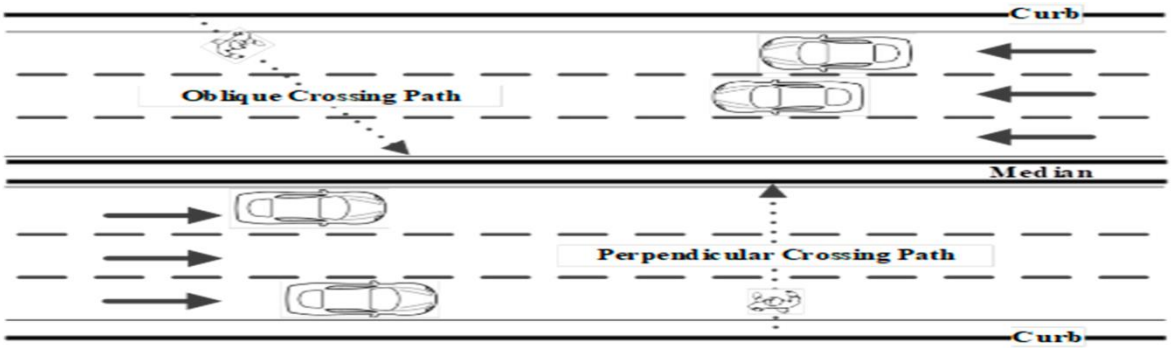


Figure 2-2 Direction of pedestrian crossing

Pedestrian crossing is also divided into three cases:

1. waiting to cross: Pedestrians will cross until the vehicle stop or there is a sufficient gap for them.

2. Cross the street timely: There is a secure clearance for pedestrians to cross the street.

3. Illegal crossing: There is no secure clearance among the traffic streams, pedestrians will cross illegally.

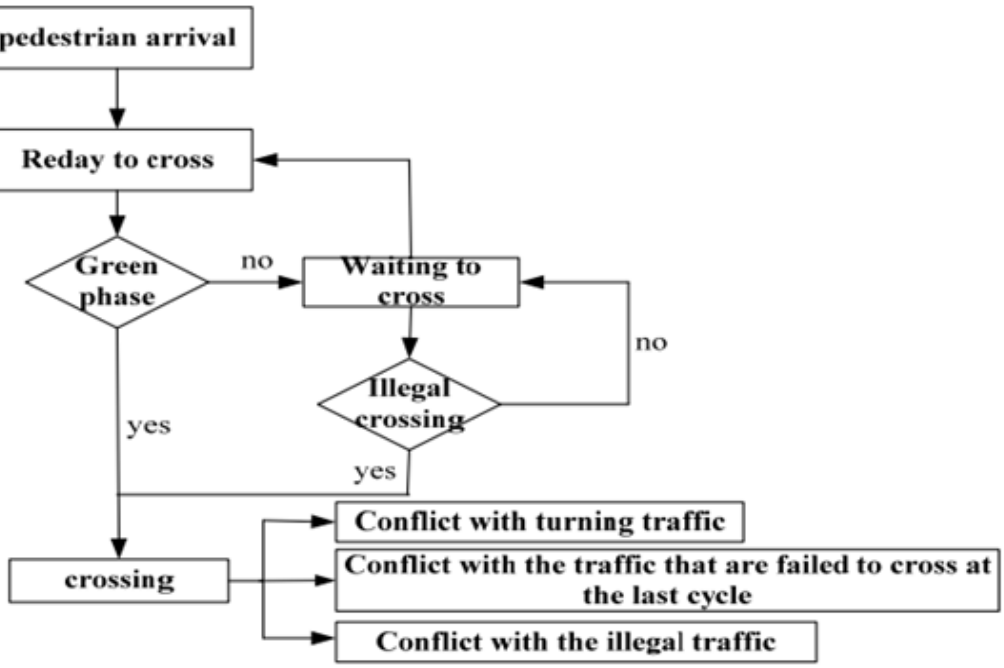


Figure 2-3 A pedestrian crossing process at signalized intersection

A clear understanding of pedestrian crossing behavior under mixed traffic conditions is needed for providing necessary infrastructure and also for enhancing pedestrian safety at intersections. To understand the pedestrian crossing behavior it is better to look in to the pedestrians crossing speed, compliance with signal, waiting time and Gap acceptance under mixed traffic conditions and to identify the influencing factors based on statistical tests.

2.2.1 Pedestrian crossing speed

Crossing speed is defined as the crossing distance divided by the crossing time. Crossing time is the time that the pedestrian uses to travel in the crosswalk without including waiting time. Crossing distance is the length of the crosswalk, which was collected by field measurement.

Pedestrian crossing speed is the crucial parameter in designing the pedestrian facilities. Pedestrian crossing speed is varying related to the pedestrian characteristics and behavior.

Highway Capacity Manual (HCM) (2010) suggested a walking speed of 1.2m/sec and indicated that walking speed depended on the proportion of elderly pedestrians (ages 65 and over) of pedestrians. If the proportion of elderly pedestrian was over

20%, it was 1.0m/sec. Coffin and Morall (1995) instructed that a design crossing speed of 1.0 m/sec was satisfactory at signalized intersections near seniors and nursing homes, where most pedestrians were elderly.

The crossing speed of pedestrians is not the same all over the world. The 15th percentile crossing speed is suggested as the design speed value. Based on this, several studies found different design speeds and various design manuals set a variety of design speed standards.

Table 2-1 Mean speed in different countries

Country	Mean Walking Speed (m/s)
Asia	
Riyadh, Saudi Arabia	1.08
Madras, India	1.20
Hong Kong	1.20
Thailand	1.22
Singapore	1.23
Colombo, Sri Lanka	1.25
Israel	1.39
Malaysia	1.31
Jordan	1.34
United States	
Columbia	1.32
New York	1.35
Pittsburgh	1.47
Others	
England	1.32
Calgary, Canada	1.40

Male pedestrians were significantly faster than female pedestrians while crossing the road. While observing the impact of age on crossing speed, previous studies suggest that with the increase of the age, pedestrian crossing speed tends to slow down.

Crossing speed is significantly lower at unsignalized intersection than signalized intersection. And also crossing speed for female, children and old pedestrian is lower than male and adult pedestrian (Niaz, atikul, 2019).

The speed of the pedestrians who cross the road alone is higher than the pedestrians who cross in a group. Furthermore, pedestrians who handle baggage cross the road slower than pedestrians who do not handle any baggage.

The use of a mobile phone while crossing also leads to a decrease in the crossing speed. Studies also show that crossing pattern, road width, and traffic volume also influence the crossing speed of the pedestrian. It is also found that the crossing speed of a pedestrian differs with the physical ability of the pedestrian.

Crossing speed is significantly lower for physically disabled pedestrians, especially wheelchair users. Song et al. calibrated a multiple linear regression model for investigating pedestrian crossing speed. Results of this model showed that crossing speed varied with gender, age, crossing by direction, one-time crossing, running across the street, and crossing while talking.

Marisamynathan and Vedagiri PERUMAL (2014) shows the field analysis that the pedestrian crossing speed is varying related to pedestrian age group Thus a new design crossing speed for pedestrians have to made.

2.2.2 Waiting time

Waiting time is the time spent by a pedestrian at the curb or median or both waiting for suitable gaps to cross the road.

Pedestrians arriving at the pedestrian crossing look for acceptable gaps between vehicles in the traffic stream. They either accept or reject such gaps. Rejection of prevailing gaps leads to longer waiting time at the curb side.

Jain et al. found in their study that waiting time of the pedestrian at unsignalized intersection varies from 1–6 s. They found that female and older pedestrian wait more time than male and younger-aged pedestrians. Mako showed in his study that the average waiting time of pedestrians was about 5.1 s at an unsignalized intersection.
waiting time is also an important traffic signal design parameter. From a study of Wang et al. it is found that 50% of pedestrians did not wait longer than 40 s.

Li showed that the average waiting time while crossing at a signalized intersection was 48.2 s. He also showed that the waiting time of males and young pedestrians was less than female and older pedestrians. Hamed found that approaching traffic volume and vehicle speeds were influential in determining the waiting time of the pedestrians.

Pedestrian doesn't want to wait more than 20 second on the curb. Control type plays significant factor pedestrian wait longer time at traffic controlled intersection than signalized and unsignalized intersection. (Niaz, atikul, 2019)

2.3 Factors for pedestrian road crossing behavior

There are a lot of studies that search for the factors that affect the pedestrian road crossing behaviors and most of the studies classified the factors in to three different categories those are the traffic environment, road user variables and the social factors.

2.3.1 Traffic Environmental Conditions

traffic environment condition is the main variable which determine the crossing behavior of the pedestrian those variables are cross walk distance, cross walk width, countdown display, type of intersections, vehicle flow, traffic density, pedestrian flow, phase time and etc. More recently, Tiwari et al. concluded that, as the signal waiting time increases, pedestrians are more likely to violate the traffic signal. And also the effect of weather, the darkness of crossing location due to poor lighting or night time , type of area ,and the population. All these factors have been proven to be significant with pedestrian crashes through the application of various statistical models.

2.3.2 Road User Variables

From almost all researches that have been done on pedestrian crossing behavior Pedestrian attributes, age and gender which are the demographic characteristics are two main factors considered to describe the pedestrians. Male pedestrians tend to violate traffic rules more frequently than females. Generally, young adults and adolescent pedestrians are more likely to commit violations than older pedestrians (e.g., MoyanoD´ıaz and Holland and Hill), and older road users are more compliance with the traffic rule for both signalized and unsignalized intersections than younger pedestrians. Other factors such as marital status, education, income and personality variables such as attitude towards risk, sensation seeking and aggression were found to be related to pedestrian behavior.

2.3.3 Social Factors

The impact of others' behaviors on the individual has been investigated and has been found to be complicated. Santor et al. found that peer conformity was one of the strongest predictors of risky behaviors in adolescents. Rosenbloom found that the presence of other pedestrians waiting at the crosswalk upon a pedestrian's arrival decreased the likelihood of crossing on red light, Moreover; Zhou et al. found that people who exhibited a greater tendency towards social conformity also had stronger crossing intentions in following other pedestrians than low conformity people.

A lot of research have been done on this title but the difference comes with this paper is the amount of parameters used for testing the factors that are around ten independent variables those are pedestrian Gender, Age group, baggage handling, crossing stage, crossing direction, crossing situation, crossing pattern, disability, mobile usage while crossing and crossing along the crosswalk. This all variables are used to find their effect on pedestrian crossing behavior on crossing speed and waiting time. In Addis Ababa there are also different papers that deal on pedestrian behavior but not specifically on the comparison at signalized and unsignalized intersections with pedestrian behavior by considering this amount of factors. Standing from different observations pedestrians crossing behavior in Addis Ababa fluctuate more depend on the personal factors than traffic conditions and road conditions and the time duration chosen for the study is one hour therefore those are the reason for this paper to concentrate more on pedestrians related factors than traffic and road geometrical factors.

CHAPTER 3 MATERIAL AND METHODOLOGY

3.1 Study Area

Addis Ababa is the capital city of Ethiopia. It is also the largest city in the country by the population. And the seat for many international organizations with more than 100 embassies has now become one of the fastest growing relatively modern cities in the sub-Saharan Africa. Following the current economic development in country, Addis Ababa has become the economic hub of the nation due its geographical as well as political significance.

It is located at about 2,440m above sea level at 9.02°00' 16.68''N 38044'49.39'' E. The 2020 Population is now estimated at 4,793,699. In 1950 the population of Addis Ababa was 392,000. Addis Ababa has grown by 201,716 since 2015, which represents a 4.39% annual change. These population estimates and projections come from the latest revision of the UN world urbanization prospects. These estimates represent the urban agglomeration of Addis Ababa, which typically includes Addis Ababa's population in addition to adjacent suburban areas. One- quarter of all people in Ethiopia that live in urban areas live in the city. The city holds 527Km2 of area in Ethiopia. The population density is estimated to be near 5,165 individuals per square kilometer available. Addis Ababa has 10 sub cities. The observations were conducted at signalized and unsignalized crosswalks.

For the case study two signalized intersections those are kidist maryam and legehar signalized intersections and two unsignalized intersections those are 4 killo roundabout and safari uncontrolled intersection are chosen based on the reason of most populous and four leg intersection. The rest reasons are listed below.

The selected study area

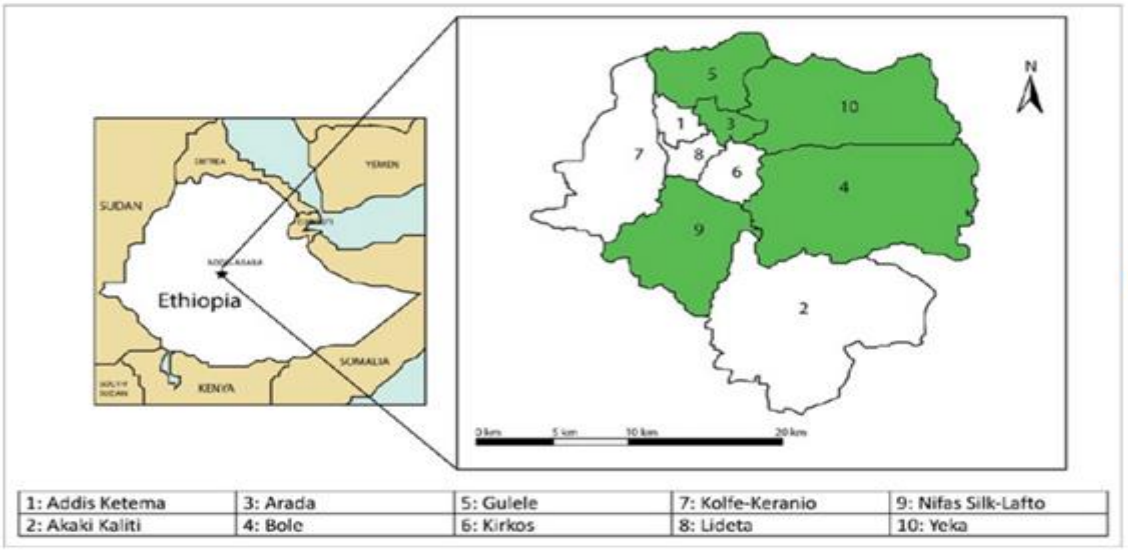


Figure 3-1 A Layout of the study area

Table 3-1 description of the selected study area

no	name of intersection	intersection control type	name of approach	sub city
1	Legehar	signalized intersection	Mexico	kirkos
			Stadium	
			Biherawi	
			Cherkos	
2	kidistMaryam	signalized intersection	4 killo	Arada
			5 killo	
			Paisa	
			Jalimeda	
4	4 killo	round about	kebena	Arada
			piasa	
			stadium	
			5 killo	
4	Safari	uncontrolled intersection	Sealite mihiret	
			semit	

Figure 3-2 Legehar signalized intersection image from google earth

Figure 3-3 Kidistmaryam signalized intersection image from Google earth

Figure 3-4 4 killo roundabout image from Google earth

The locations for carrying out the pedestrian study are decided based on the combination of traffic flow, no of population and the type of intersection.

The study locations chosen for the present study, satisfies the following criteria:

- The pedestrian traffic is enough.
- The traffic flow is continuous.
- The width of the road is uniform.
- The intersections are four leg.
- For video recording of pedestrian flow, the road width considered should be easily accessed from vantage point.

3.2 Research Design

The methodology conducted in this study are descriptive and statistical analysis; the data were used to show the pedestrian crossing behaviors at a signalized and unsignalized intersection cross walks in Addis Ababa, Ethiopia. The collection of data includes both quantitative and qualitative data. The quantitative data will be the pedestrian count, the cross walk length and width measurement etc. Whereas the qualitative data will be the pedestrians gender, sex and the like. Then the statistical analysis will be done by ONE WAY ANOVA, Kruskal Wallis, Mann whitney u test and t test.

3.3 Sampling Strategy and data collection

There are different methods for data collection. These are given below:

1. Direct observation methods
2. Video observation methods.

Data from video-based observation is used to analyze characteristics of crossings, including crossing speed and waiting time and quantify some factors of pedestrian attributes, traffic conditions and road conditions.

Data were collected at two signalized intersections and two unsignalized intersection in Addis Ababa, Ethiopia. One hour video surveys will be conduct at those sites during

peak hours of the day. Data collected by direct observation of pedestrian activities with camera set up next to crosswalks at each intersection. These cameras filmed pedestrians as they crossed the road.

The video recording offered information about pedestrian crossing volumes, crossing time, pedestrian appearance (like gender and age group), crossing behavior (such as walking or running, alone or in groups and crossing pattern), crossing locations (whether using the crosswalk or not using), waiting time and etc... On the other hand both primary and secondary data are used those are clearly presented below.

The primary data was collected from the site using

- field investigation (actual field observations)
- Pedestrian count (volume) data: Data collection will be taken on working days, except for Monday and Friday because there exists an exaggerated traffic movement on these days.
- Actual field measurements
  Geometric data length of crosswalk was collected at the selected study sites using the following specific methodology.
  - ✓ Length of crosswalk: measuring with roller meter

The secondary data obtained from

- Different research papers made on related title from internet source.

3.4 Method of Data Analysis

Independent data taken from video to be used for the study of pedestrian behavior

1) intersection controlled type :- signalized and unsignalized
2) Pedestrian gender :- Female and male
3) >> Age: - a. <18 b. 18 – 30 c.31 – 45 d. >45 Because the information on pedestrian age can be obtained from the videotape, the data collectors could not determine the exact age of any given pedestrian but, instead, estimated the age group to which the pedestrian likely belonged.
4) >> crossing stage:- one (single) stage and two stage

- One-step (pedestrians cross the road without waiting near the median).
- Two-step (they cross up to the median in one go and subsequently cross the far side).

5) >> crossing direction: - perpendicular crossing, oblique crossing and mixed crossing.
   - Perpendicular crossing (PC):- When a pedestrian crosses the road in a straight path.
   - Oblique crossings (OC):- are those in which pedestrians cross the road in a zigzag manner.
   - Mixed crossings (MC) are the combination of both perpendicular and oblique type of crossings (pedestrians cross first half of the road in a straight path up to the median and the next half they cross in a zigzag manner and vice versa).
6) >> crossing pattern :- walking or running
7) Pedestrian group size :- crossing alone or in group
8) >> baggage handling :- baggage handling and no baggage handling
9) Pedestrian disability :- disable or not
10) >> mobile usage while crossing the intersection
11) >> crossing within the marked cross walk or out side

The crossing speed was counted by three indexes: crossing speed of the 1st half (1stspeed), crossing speed of the 2nd half (2ndspeed), and the mean speed of crossing (mean speed).

The effect of pedestrian characteristics like age, gender and that of carrying baggage and luggage as well as their crossing patterns were examined on pedestrian flow characteristics like crossing speed and waiting time.

To analyze whether demographic factors (age and gender) or social factors (such as crossing in a group) have a significant influence on pedestrian crossing behavior, a one-way analysis of variance (ANOVA) will be first applied.

The pedestrian crossing speed will be analyzed using ANOVA test to investigate the main factors that affect the pedestrian crossing speed at signalized and unsignalized

intersections cross walk. Gender, age group, baggage handling, group size and pedestrian crossing situation, crossing pattern, crossing direction and disability are some of the parameters considered for ANOVA test based on literature review inferences. This test has been performed at 95% confidence interval. Pedestrian compliance behaviors will be analyzed using ANOVA test, and Student t test to investigate the main factors that affect the pedestrian compliance with traffic signals at intersections. Gender, age group, group, no. of pedestrians and crossing speed are the parameters to be considered for this statistical test. All testing is performed in STATA 13 software at 95% confidence interval.

As the dependent variable must be normally distributed, an ANOVA test will be carried out for the categorical predictors having more than two outcomes to identify the influential factors; an independent t-test will be carried out for the predictors having two outcomes. If the dependent variable is not normally distributed then Kruskal Wallis test will be carried out for the categorical predictors having more than two outcomes to identify the influential factors; an independent Mann Whitney u test will carried out for the predictors having two outcomes. After all tests multiple linear regression model was performed.

CHAPTER 4 RESULT AND DISCUSSION

General

The finding of the research is presented by analytical, statistical, graphical and tabular forms to make the paper more understandable. In the action to do so, the chapter is divided into five parts: general description of study area and crossing characteristic, Identifying factors related to pedestrian crossing speed, Identifying factors related to pedestrian waiting time.

4.1 General description

4.1.1 Characteristic of study area

For the study two signalized and two unsignalized intersection means roundabout and uncontrolled intersections. The numbers of lane are four, four, three and two for legehar, kidist maryam, 4 killo roundabout and safari intersections respectively. The lengths for the crosswalk are shown on the table below.

Table 4-1 Characteristics of observed intersection

Intersection	Type	Length(m)
Legehar	Signalized	25.05
Kidist Maryam	Signalized	20.40
4 killo round about	unsignalized	21.10
Safari	Unsignalized	12.40

4.1.2 Pedestrian crossing pattern and characteristics

Pedestrians have two types of crossing patterns that are perpendicular and oblique with one step crossing and two step crossing. Pedestrian cross more by perpendicular direction than oblique direction at roundabout then at uncontrolled and finally at signalized intersections. The table that show the crossing pattern for signalized intersection are shown below and for roundabout and uncontrolled intersections are shown at the appendix. Also Pedestrian classification by their characteristic and

behavior for signalized intersection is shown on the table below but for roundabout and uncontrolled intersections is shown on the appendix.

Table 4-2 crossing pattern at signalized intersection

Crossing direction	Percentage of pedestrians (%)	
	One step crossing	Two step crossing
Perpendicular	37.20	27.04
Oblique	7.49	28.28
Total	44.68	55.32

Table 4-3 table at Pedestrian classification by their characteristic and behavior at signalized intersection

Variable	Item	frequency	percentage	Total (%)
Gender	Male	884	52.53	100.00
	Female	799	47.47	
Age	0-18	266	15.81	100.00
	19-30	381	22.64	
	31-45	617	36.66	
	>45	419	24.90	
crossing speed	<1.0	61.00	3.62	100.00
	1.0-1.2	331	19.67	
	1.2-1.4	553	32.86	
	1.4-1.6	406	24.12	
	1.6-1.8	162	9.63	
	>1.8	170	10.10	
Waiting time	0-9	662	39.33	100.00
	10.-19	164	9.74	
	20-29	200	11.88	
	30-39	152	9.03	
	40-49	184	10.93	
	50-59	165	9.80	

	60-69	88	5.23	
	70-79	30	1.78	
	80-89	18	1.07	
	>90	20	1.19	
Bagagge	Yes	65	3.86	100.00
	No	1618	96.14	
crossing stage	one step	752	44.68	100.00
	Two step	931	55.32	
crossing direction	perpendicular	1081	64.23	100.00
	oblique	602	35.77	
Crossing Mode	walking	1404	83.42	100.00
	Running	279	16.58	
No. of pedestrian	Alone	1511	89.78	100.00
	Group	172	10.22	
Disability	yes	19	1.13	100.00
	NO	1664	98.87	
Mobile usage	Yes	6	0.36	100.00
	No	1677	99.64	
Crosswalk utilization	Yes	1188	70.59	100.00
	No	495	29.41	
Compliance with signal Phase	yes	1461	86.81	100.00
	No	222	13.19	

4.2 Crossing Speed

4.2.1 Descriptive analysis

From the analysis of the crossing speed mean crossing speed which is shown on the table below is found as 1.41m/s and 1.27m/s for signalized and unsignalized intersection respectively. Pedestrians have higher crossing speed at signalized intersections than unsignalized intersections. And the recommended design crossing speed are 1.02m/s and 0.95m/s for signalized and unsignalized intersection respectively. The result show mean and recommended design speed is higher for

signalized intersection than the unsignalized intersection. And the recommended design speed is lower than the design pedestrian crossing speed provided on the standards that is 1.2m/s.

Before searching for the factors that affect the crossing speed of pedestrian the descriptive statistics have to proceed and it is shown on the table below.

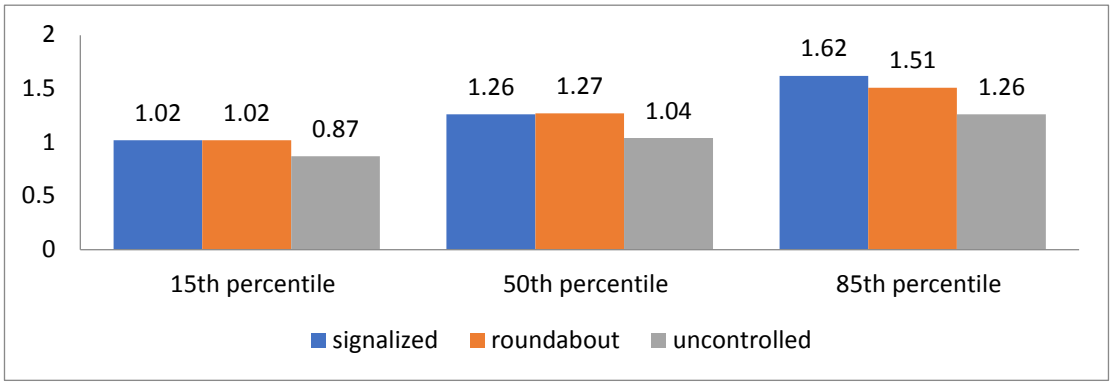


Figure 4-1a pedestrian crossing speed at different intersections

Table 4-4 Descriptive statistics for Crossing Speed at signalized intersection

No.		1683
Mean speed		1.41
95%confidence interval	Lower	1.40
	Upper	1.42
Median		1.36
Variance		0.10
standard Deviation		0.31
Minimum		0.53
Maximum		3.13
Range		2.60
15th percentile		1.02
50th percentile		1.26
85th percentile		1.62

4.2.2 Factors Affecting Pedestrian Crossing Speed

To know the effect of Gender, Age, Baggage handling, crossing stage, crossing direction, crossing situation, Disability, Mobile usage and compliance along the marked crosswalk different statistical tests were performed.

For the statistical analysis and for the regression analysis the tested parameters are coded for the simplification of the test by the software program.

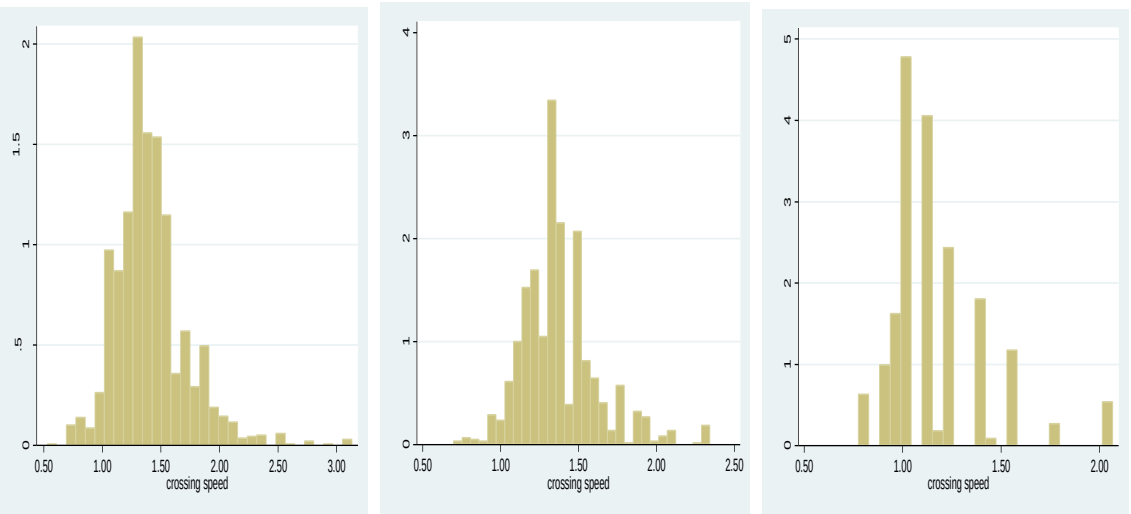
- Dependent variable
  - ✓ crossing speed
- Independent variables
  - ✓ Gender :- Female(0) and male(1)
  - ✓ Age: - a. <18 b. 18 – 30 c.31 – 45 d. >45
    - ➢ Age <18 (if Age <18 = 1, otherwise = 0)
    - ➢ Age 19-30 (if Age 19-30 = 1, otherwise = 0)
    - ➢ Age 31-45 (if Age 31-45 = 1, otherwise = 0)
  - ✓ baggage handling:- baggage handling(1) and no baggage handling(0)
  - ✓ Crossing stage: - one stage (1) and two stage (0).
  - ✓ crossing direction: - perpendicular crossing(1) and oblique crossing(0)
  - ✓ crossing pattern :- walking(1) and running(0)
  - ✓ Crossing situation:- alone(1) and group(0)
  - ✓ Disability:- disable(1) and no disable(0)
  - ✓ mobile usage:- mobile usage(1) and no mobile usage(0)
  - ✓ crossing along the cross walk:- within(1) and outside(0)

Before all stem and leaf test was performed in order to know the outlier values to make them out from the analysis.

The normality test for the crossing speed is done by the stata13 software and the results are shown by histogram, the normal probability plot and box plot. The result is shown by the histogram on the figure below. The figures are for the signalized, roundabout and uncontrolled intersections respectively. It is seen on the figure below. The shape of the curve on the histogram is almost bell shaped and it show that the data is normally distributed.

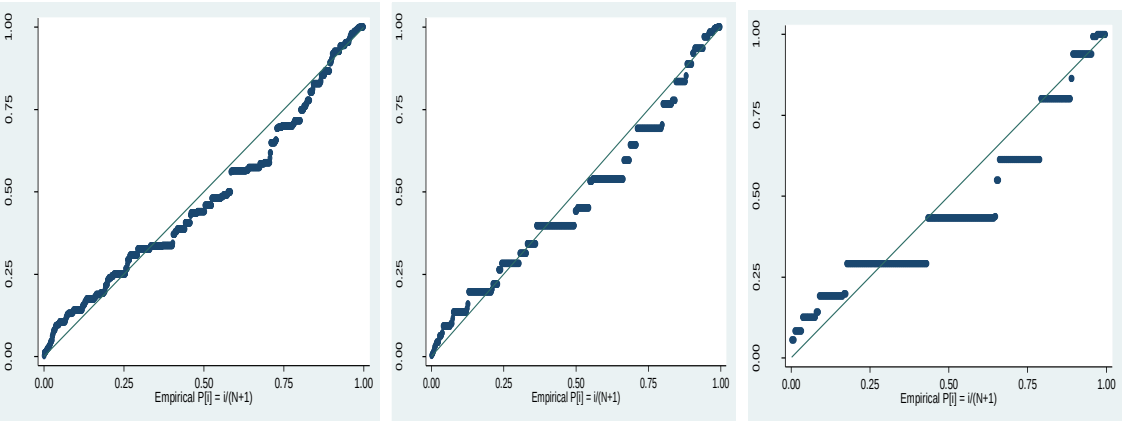
The normal probability plot graph is shown by the figure a, figure b and figure c for the signalized, roundabout and uncontrolled intersections respectively. Almost the data follow straight line this show that the data is in the normal distribution.

The box plot is shown by the figure a, figure b, figure c for the signalized, roundabout and uncontrolled intersections respectively. It shows that the data about the median has lower range and almost appears at the middle of the box it show a balanced concentration of the data. There are box plot to show the media



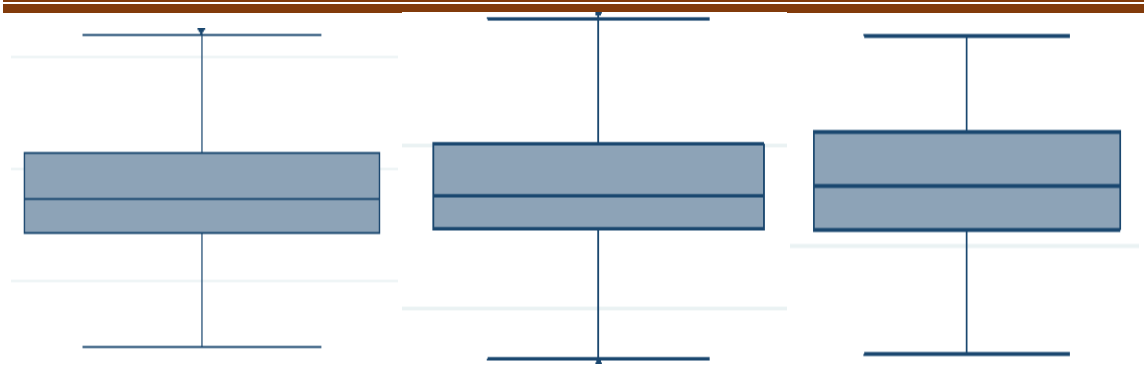
(a) (b) (c)

Figure 4-2 Histogram of crossing speed (a) at signalized intersection (b) at round about (c) at uncontrolled intersection



(a) (b) (c)

Figure 4-3Normal p-p plot of crossing speed (a) at signalized intersection (b) at round about (c) at uncontrolled intersection



(a) (b) (c)

Figure 4-4 box plot of crossing speed (a) at signalized intersection (b) at round about (c) at uncontrolled intersection

Therefore as seen on the above pictures crossing speed was normally distributed then it is possible to use a one way ANOVA test for the independent variables having more than two outcomes or t-test for the one that have only two outcomes. In addition to the normality test it is must to test for the equality of variance. Levence's test was done to test equality of variance because this criterion is must to do a one-way ANOVA or t-test because the test assumes equality of variance at the beginning to be performed. Variances were equal if the result of this test shows that p-value > 0.05. If not Welch's ANOVA test were used instead of one-way ANOVA test.

a. Gender

Gender of pedestrian is taken from the field data is taken and to test the equality of variance Levence's test of crossing speed for the three intersections type is shown on table below. the variance are equal for signalized intersection and it is not equal for roundabout and uncontrolled intersections so it is possible to use t-test for signalized intersection with equal variance and t-test for uncontrolled and roundabout with unequal variance and the result are shown on the table below.

Table 4-5 levence's test of crossing speed for gender on different intersections.

Type	p value (W0)	p value (W50)	p value (W10)
Signalized intersection	0.642	0.916	0.834
Roundabout	0.000	0.002	0.002
Uncontrolled intersection	0.000	0.010	0.000

To test if a significant difference in crossing speed exists between men and women the following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in crossing speed exists between men and women

H1: significant difference in crossing speed exists between men and women

Moving on, the P value for the t-test expressed as 0.000, 0.000 and 0.245 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level Ho can be rejected for the signalized intersection and roundabout while for uncontrolled intersection it is greater than the significant level Ho is failed to be rejected. There exists a significant difference in crossing speed between men and women for signalized intersection and roundabout and the contrary for uncontrolled intersection.

Table 4-6 t- test of crossing speed for gender on different intersections.

	Variable	N	Mean	Std. Dev	statistical test details	t-test with
Signalized	Female	799	1.36	0.28	t= -5.743	equal
	Male	884	1.44	0.32	P= 0.000	variance
Roundabout	Female	491	1.32	0.22	t=-7.283	unequal
	Male	582	1.43	0.26	P= 0.000	variance
uncontrolled	Female	231	1.16	0.20	t=-1.164	unequal
intersection	Male	387	1.18	0.27	P= 0.245	variance

Male pedestrian cross faster than female pedestrian in all type of intersections. It is similar with other previous studies that found male pedestrians were significantly faster than female pedestrians while crossing the road. This result is similar with the

result of other papers like (Onelcin,2017, Goh,2012, yemisrach,2020, Jain,2014, Marisamynathan, 2014,2017)

b. Age

There are four group of age and to find which group have great impact on the crossing speed the following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in crossing speed exists between Age groups

H1: significant difference in crossing speed exists between Age groups

Moving on, the P value for the t-test expressed as 0.000, 0.000 and 0.000 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level Ho can be rejected for all type of intersection. There exists a significant difference in crossing speed between Age groups for all type of intersection.

Table 4-7 One Way ANOVA test of crossing speed for Age on different intersections.

	Variable	N	mean	std. Dev.	statistical test details
signalized intersection	Age 0-18	266	1.41	0.35	F=33.34 p=0.000
	Age 19-30	381	1.49	0.31	
	Age 31-45	617	1.43	0.31	
	Age >45	420	1.29	0.24	
roundabout	Age 0-18	161	1.42	0.25	F=12.66 p=0.000
	Age 19-30	217	1.44	0.24	
	Age 31-45	457	1.38	0.24	
	Age >45	238	1.31	0.24	
uncontrolled intersection	Age 0-18	159	1.16	0.18	F=7.20 p=0.000
	Age 19-30	192	1.21	0.34	
	Age 31-45	228	1.17	0.19	
	Age >45	39	1.02	0.14	

Pedestrian with age group 19-30 cross faster than the others secondly 31-45 and on the third with age group <18 and old pedestrian cross with smaller crossing time. (Onelcin, 2017,

Goh,2012, yemisrach,2020, Jain,2014, Marisamynathan, 2014, 2017) those studies provide similar results with this one it shows "While observing the impact of age on crossing speed, previous studies suggest that with the increase of the age, pedestrian crossing speed tends to slow down."

c. Baggage handling

Pedestrian cross the intersection either by handling baggage or without baggage and levence's test of crossing speed for baggage handling on the three intersection types and it is shown on the table below to test the equality of variance. the variance are equal for roundabout and it is not equal for signalized and uncontrolled intersections so it is possible to use t-test with equal variance for the roundabout and with unequal variance for the signalized and uncontrolled intersections and the result are shown on the table at the appendix.

Table 4-8 levence's test of crossing speed for baggage handling on different intersections.

Type	p value (W0)	p value (W50)	p value (W10)
Signalized intersection	0.036	0.070	0.0476
Roundabout	0.970	0.964	0.929
Uncontrolled intersection	0.002	0.010	0.003

if a significant difference in crossing speed exists between baggage handling and not handling the following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in crossing speed exists between baggage handling and no baggage handling.

H1: significant difference in crossing speed exists between baggage handling and no baggage handling.

The P value for the t-test expressed as 0.056, 0.882 and 0.000 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level Ho can be rejected for the uncontrolled intersection while for signalized intersection and roundabout while for uncontrolled intersection it is greater than the significant level Ho is failed to be rejected. There exists a significant difference in

crossing speed between baggage handling and no baggage handling for uncontrolled intersection but it is not working for signalized intersection and roundabout.

Table 4-9 t-test of crossing speed for baggage handling on different intersections.

	Variable	N	Mean	std. Dev	statistical test details	t-test
Signalized	No Baggage	1618	1.40	0.31	t= -1.942	unequal
	Yes Baggage	65	1.49	0.35	P= 0.056	variance
Roundabout	No Baggage	1060	1.38	0.25	t=0.1483	equal
	Yes Baggage	13	1.37	0.25	P= 0.882	variance
uncontrolled intersection	No Baggage	582	1.17	0.25	t=3.911	unequal
	Yes Baggage	36	1.09	0.11	P= 0.000	variance

Pedestrian with No baggage cross faster than the pedestrian which hold baggage for roundabout and uncontrolled intersection but it doesn't work for signalized intersection this reason is suggested by pedestrian fear more at signalized intersection and choose running than walking especially pedestrian who hold baggage. Pedestrians who handle baggage cross the road slower than pedestrians who do not handle any baggage (Mahmud zafri,2019, Onelcin, 2017, Jain, 2014, Rastogi, 2010). For signalized handling baggage have no impact on the crossing speed this result much with the result of (Peters, 2015)

d. Crossing stage

Pedestrian cross either in one stage or in two stage and for the study of crossing speed for the three types of intersection type and it is shown on to the table below the test for equality of variance. the variance are equal for signalized intersection and roundabout and it is not equal for uncontrolled intersections so it is possible to use t-test for the signalized and roundabout with equal variance and t-test with unequal variance for the uncontrolled intersection and the result are shown on the table below.

Table 4-10 levence's test of crossing speed for crossing stage on different intersections.

Type	p value (W0)	p value (W50)	p value (W10)
Signalized intersection	0.070	0.097	0.087
Roundabout	0.882	0.933	0.882
Uncontrolled intersection	0.001	0.010	0.003

To test if a significant difference in crossing speed exists between one stage and two stage crossing. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in crossing speed exists between one stage and two stage crossing.

H1: significant difference in crossing speed exists between one way and two way crossing.

The P value for the t-test expressed as 0.699, 0.036 and 0.000 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for the roundabout and uncontrolled intersection while for signalized intersection it is greater than the significant level, so Ho is failed to be rejected. There exists a significant difference in crossing speed between one stage and two stage crossing for roundabout and uncontrolled intersection but it is not working for signalized intersection.

Table 4-10 t-test of crossing speed for crossing stage on different intersections

.

	Variable	N	Mean	std. Dev	statistical test details	t-test
Signalized	one stage	752	1.4	0.33	t= 0.387	equal
	two stage	931	1.4	0.29	P= 0.699	variance
Roundabout	one stage	717	1.37	0.25	t=2.097	equal
	two stage	356	1.4	0.23	P= 0.036	variance
uncontrolled	one stage	606	1.17	0.25	t=-18.558	unequal
intersection	two stage	12	0.93	0.03	P= 0.000	variance

Pedestrian who cross with one stage cross faster than pedestrian who cross with two stages for roundabout and uncontrolled intersection but it is similar for signalized intersection. Mahmud Zafri, 2019 and jain, 2014 "The crossing speed of the pedestrians was also higher for a single stage than a two-stage crossing type."

e. Crossing Direction

When the pedestrian cross the road use perpendicular or oblique direction and to test the equality of variance the following Levence's test was used. And the result is variance are equal for signalized intersection and it is not equal for roundabout and uncontrolled intersections so it is possible to use t-test for the equal and unequal variance and the result are shown the table below.

Table 4-11 levence's test of crossing speed for crossing direction on different intersections.

Type	p value (W0)	p value (W50)	p value (W10)
Signalized intersection	0.071	0.053	0.051
Roundabout	0.075	0.099	0.084
Uncontrolled intersection	0.115	0.352	0.136

To test if a significant difference in crossing speed exists between perpendicular and oblique crossing. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in crossing speed exists between perpendicular and oblique crossing.

H1: significant difference in crossing speed exists between perpendicular and oblique crossing.

The P value for the t-test expressed as 0.209, 0.000 and 0.073 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for the roundabout. While for signalized and uncontrolled intersection it is greater than the significant level, so Ho is failed to be rejected. There exists a significant difference in crossing speed between perpendicular and oblique crossing for roundabout but it is not working for signalized intersection and uncontrolled intersections.

Table 4-12 t-test of crossing speed for crossing direction on different intersections.

	Variable	N	Mean	std. Dev	statistical test details	t-test
Signalized	Perpendicular	1081	1.41	0.31	t= -1.256	equal
	Oblique	602	1.39	0.31	P= 0.209	variance
Roundabout	Perpendicular	963	1.37	0.24	t=3.454	equal
	Oblique	110	1.46	0.28	P= 0.000	variance
uncontrolled intersection	Perpendicular	483	1.18	0.25	t=-1.794	equal
	Oblique	135	1.14	0.23	P= 0.073	variance

Pedestrian who cross at perpendicular direction cross faster than pedestrian who cross at oblique direction for signalized and at unsignalized intersection but for roundabout move faster who cross by oblique direction. This result is similar with the result of Mahmud Zafri, 2019 that perpendicular crossing have greater crossing speed. But for the roundabout there is similar paper that is jain, 2015.

f. Crossing pattern

Walking and running are two types of crossing patterns for pedestrian crossing at the intersections. To test for the equality of variance levence's test was used. on table below the variance are equal for signalized intersection and it is not equal for roundabout and uncontrolled intersections so it is possible to use t-test for the equal and unequal variance and the result are shown the table below.

Table 4-13 levence's test of crossing speed for crossing pattern on different intersections.

Type	p value (W0)	p value (W50)	p value (W10)
Signalized intersection	0.000	0.000	0.000
Roundabout	0.000	0.000	0.000
Uncontrolled intersection	0.000	0.000	0.000

To test if a significant difference in crossing speed exists between walking and running. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in crossing speed exists between walking and running.

H1: significant difference in crossing speed exists between walking and running.

The P value for the t-test expressed as 0.000, 0.000 and 0.000 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for the signalized, roundabout and uncontrolled intersection. There exists a significant difference in crossing speed between walking and running for all type of intersection.

Table 4-14 t-test of crossing speed for crossing pattern on different intersections.

	Variable	N	Mean	std. Dev	statistical test details	t-test for
Signalized	Walking	1404	1.34	0.24	t= 16.396	unequal
	Running	279	1.74	0.39	P= 0.000	variance
Roundabout	Walking	957	1.35	0.22	t=8.828	unequal
	Running	116	1.63	0.33	P= 0.000	variance
uncontrolled intersection	Walking	549	1.12	0.18	t=12.295	unequal
	Running	69	1.59	0.31	P= 0.000	variance

Pedestrian who cross by running cross faster than whom cross by walking this works true for the three type of intersection.

g. Crossing situation

Pedestrian are alone or in group while crossing the road. levence's test is shown on table below to test the equality of variance. the variance are equal for signalized intersection and it is not equal for roundabout and uncontrolled intersections so it is possible to use t-test for the equal and unequal variance and the result are shown below

Table 4-15 levence's test of crossing speed for crossing situation on different intersections.

Type	p value (W0)	p value (W50)	p value (W10)
Signalized intersection	0.069	0.061	0.055
Roundabout	0.002	0.003	0.003
Uncontrolled intersection	0.000	0.000	0.000

To test if a significant difference in crossing speed exists between alone and in group crossing. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in crossing speed exists between alone and group crossing.

H1: significant difference in crossing speed exists between alone and group crossing.

The P value for the t-test expressed as 0.000, 0.000 and 0.003 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for the signalized, roundabout and uncontrolled intersection. There exists a significant difference in crossing speed between crossing in group and alone for all type of intersection.

Table 4-16 t-test of crossing speed for crossing situation on different intersections.

	Variable	N	Mean	std. Dev	statistical test details	t-test for
Signalized	Alone	1511	1.42	0.31	t= -3.573	equal
	Group	172	1.33	0.33	P= 0.000	variance
Roundabout	Alone	1020	1.39	0.25	t=-5.354	unequal
	Group	53	1.26	0.16	P= 0.000	variance
uncontrolled	Alone	486	1.18	0.26	t=-2.950	unequal
intersection	Group	132	1.13	0.15	P= 0.003	variance

Pedestrian who cross alone cross faster than pedestrian who cross in group for the three types of intersections. (Onelcin, 2017, Peters, 2015, Rastogi, 2010)

h. Disability

There are two type of pedestrian those are disabled and not disable. To test the effect of physical disability can affect the crossing speed the following tests are done. levence's test is shown on table below to test the equality of variance. the variance are equal for signalized intersection and it is not equal for roundabout and uncontrolled

intersections so it is possible to use t-test for the equal and unequal variance and the result are shown the table below.

Table 4-17 levence's test of crossing speed for Disability on different intersections.

Type	p value (W0)	p value (W50)	p value (W10)
Signalized intersection	0.648	0.407	0.674
Roundabout	0.324	0.357	0.349

To test if a significant difference in crossing speed exists between being disable and not the following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in crossing speed exists between disable and not.

H1: significant difference in crossing speed exists between disable and not.

The P value for the t-test expressed as 0.000 and 0.005 for signalized intersection and roundabout respectively. As the p value is less than the significant level. Ho can be rejected for the signalized intersection and roundabout. There exists a significant difference in crossing speed between being disable and not for both type of intersection.

Table 4-18 t-test of crossing speed for Disability on different intersections.

	Variable	N	Mean	std. Dev	statistical test details	t-test for
Signalized	No disability	1664	1.41	0.26	t= 4.731	equal
	Yes disability	19	1.08	0.31	P= 0.000	variance
Roundabout	No disability	1071	1.38	0.25	t=2.836	equal
	Yes disability	2	0.89	0.10	P= 0.005	variance

Pedestrian with disability cross slower than pedestrian with no disability for all intersections. This result is similar with the previous studies there result says "Crossing speed is significantly lower for physically disabled pedestrians, especially wheelchair users" Sharifi, 2015, Pecchini, 2015.

i. Mobile usage

Some of the pedestrians talk mobile while crossing the intersection, for clarification levence's test is shown on table below to test the equality of variance. the variance are equal for signalized intersection and it is not equal for roundabout and uncontrolled intersections so it is possible to use t-test for the equal and unequal variance and the result are shown the table below.

Table 4-19 levence's test of crossing speed for Mobile usage on different intersections.

Type	p value (W0)	p value (W50)	p value (W10)
Signalized intersection	0.909	0.933	0.929
Roundabout	0.594	0.597	0.623
Uncontrolled intersection	0.629	0.399	0.669

To test if a significant difference in crossing speed exists between mobile usage and no usage of mobile. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in crossing speed exists between mobile usage and no usage.

H1: significant difference in crossing speed exists between mobile usage and no usage.

The P value for the t-test expressed as 0.408, 0.215 and 0.796 for signalized intersection, roundabout and uncontrolled intersection respectively. As the p value is greater than the significant level. Ho can't be rejected for all type of intersection type. There exists a significant difference in crossing speed between mobile usage and no mobile usage.

Table 4-20 t-test of crossing speed for Mobile usage on different intersections.

	Variable	N	Mean	std. Dev	statistical test details	t-test for
Signalized	No mobile	1677	1.41	0.31	t= 0.828	equal
	Yes mobile	6	1.3	0.3	P= 0.408	variance
Roundabout	No mobile	1070	1.38	0.25	t=1.241	equal
	Yes mobile	3	1.21	0.19	P= 0.215	variance
uncontrolled intersection	No mobile	609	1.17	0.25	t=0.259	equal
	Yes mobile	9	1.15	0.17	P= 0.796	variance

Pedestrian who talks with mobile while crossing the road have smaller crossing speed than who doesn't talk mobile while crossing for all type of intersection. This result is similar with previous studies that are Nasar, 2008, Schwebel, 2012

j. Crossing along the crosswalk

Pedestrian cross either within or outside of the crosswalk, so levence's test is shown on table below to test the equality of variance. the variance are equal for signalized intersection and it is not equal for roundabout and uncontrolled intersections so it is possible to use t-test for the equal and unequal variance and the result are shown the table below.

Table 4-21 levence's test of crossing speed for Mobile usage on different intersections.

Type	p value (W0)	p value (W50)	p value (W10)
Signalized intersection	0.000	0.000	0.000
Roundabout	0.118	0.120	0.103
Uncontrolled intersection	0.050	0.197	0.089

To test if a significant difference in crossing speed exists between crossing along the crosswalk and outside the crosswalk. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in crossing speed exists between crossing along the cross walk and outside of the crosswalk.

H1: significant difference in crossing speed exists between crossing along the cross walk and outside of the crosswalk.

The P value for the t-test expressed as 0.104, 0.000 and 0.000 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for roundabout and uncontrolled intersection. While for signalized intersection it is greater than the significant level, so Ho is failed to be rejected. There exists a significant difference in crossing speed between crossing along the crosswalk and outside of the crosswalk for roundabout and uncontrolled intersection but it is not working for signalized intersection.

Table 4-22 t-test of crossing speed for Mobile usage on different intersections.

	Variable	N	Mean	std. Dev	statistical test details	t-test for
Signalized	Within	1188	1.41	0.31	t= -1.629	unequal
	Outside	495	1.39	0.30	P= 0.104	variance
Roundabout	Within	987	1.37	0.24	t=4.322	equal
	Outside	86	1.49	0.29	P= 0.000	variance
uncontrolled	Within	330	1.21	0.25	t=-4.395	equal
intersection	Outside	288	1.12	0.24	P= 0.000	variance

Pedestrian who cross within the cross walk has higher crossing speed than who cross outside of the crosswalk for signalized and uncontrolled intersections but for roundabout it doesn't work.

4.2.3 Regression Analysis and Regression Model for crossing speed

The steps conducted to analysis and develop a regression model of crossing speed are;

Step1: Identify dependent and independent variables.

- Dependent variable
  - ✓ crossing speed
- Independent variables
  - ✓ Gender :- Female(0) and male(1)
  - ✓ Age: - a. <18 b. 18 – 30 c.31 – 45 d. >45
    - ➢ Age <18 (if Age <18 = 1, otherwise = 0)
    - ➢ Age 19-30 (if Age 19-30 = 1, otherwise = 0)

- Age 31-45 (if Age 31-45 = 1, otherwise = 0)

- ✓ baggage handling:- baggage handling(1) and no baggage handling(0)
- ✓ Crossing stage: - one stage (1) and two stage (0).
- ✓ crossing direction: - perpendicular crossing(1) and oblique crossing(0)
- ✓ crossing pattern :- walking(1) and running(0)
- ✓ Crossing situation:- alone(1) and group(0)
- ✓ Disability:- disable(1) and no disable(0)
- ✓ mobile usage:- mobile used(1) and no mobile usage(0)
- ✓ crossing along the cross walk:- within(1) and outside(0)
- ✓ compliance with the traffic light:- compliance(1) and non compliance(0)

Step 2: Statistical test, regression analysis using STATA

Step 3: Identify the significant variable at 95 % confidence interval. If the p - value is less than 0.05, then the factors are significant variable for regression model.

Step 4: Provide regression model

a. Multiple linear regression for crossing speed of uncontrolled intersection

source	Ss	df	MS
Model	47.66	14	3.97
Residual	112.88	1670	0.07
total	160.54	1684	0.1

no/ of obs = 1084
F(11, 606) =58.76
prob > F =0.000
R - squered = 0.30
Adj R-squered = 0.29
Root MSE = 0.26

Table 4-23 Estimated parameter value of MLR model for signalized intersection

Variable	Coef.	Std. error	T	p-value
Constant	1.489	0.033	44.260	0.000
Gender				
Gender (if male = 1, otherwise = 0)	0.058	0.013	4.480	0.000
Age				
Age <18 (if Age <18 = 1, otherwise = 0)	0.147	0.021	3.960	0.000
Age 19-30 (if Age 19-30 = 1, otherwise = 0)	0.164	0.019	8.800	0.000
Age 31-45 (if Age 31-45 = 1, otherwise = 0)	0.135	0.016	8.180	0.000

Baggage handling				
Baggage (if yes baggage=1, otherwise=0)	0.046	0.033	1.400	0.163
Crossing stage				
Crossing stage(if one stage=1, otherwise=0)	-0.114	0.014	-0.820	0.411
Crossing direction				
Crossing direction (if per=1, otherwise=0)	0.051	0.020	2.590	0.010
Crossing pattern				
Crossing pattern(if walking=1, otherwise=0)	-0.365	0.018	-20.52	-0.330
Crossing situation				
Crossing situation(if alone=1, otherwise=0)	0.092	0.022	4.210	0.000
Disability				
Disability(if disable=1, otherwise=0)	-0.245	0.062	-3.950	0.000
Mobile usage				
Mobile usage(if Yes=1, otherwise=0)	-0.063	0.109	-0.580	0.562
Crossing along the crosswalk				
Crossing along the crosswalk(if within=1, otherwise=0)	0.013	0.021	0.650	0.513

Since P>F is equal to 0 which is less than 0.05, the model is statistically significant. And P value for gender, for all ages, crossing direction, crossing stage and disability are less than 0.05 are significant values for the determination of the crossing speed.

Gender, Age (<18), Age (19-30), Age (31-45), crossing direction and crossing situation were positively associated with crossing speed shown on the Table above. The crossing speed increases by 0.06 when the pedestrian gender is male. The crossing speed increases by 0.15 when the pedestrian age is less than 18 means for children pedestrians by holding all other independent variables constant. The crossing speed increases by 0.16 when the pedestrian age is between 19 – 30 means young pedestrians by holding all other independent variables constant. The crossing speed increases by 0.14 when the pedestrian age is between 31 – 45 means for adult pedestrians by holding all other independent variables constant. The crossing speed increases by 0.05 when the pedestrian cross in perpendicular directions by holding all other independent variables constant. The crossing speed increases by 0.09 when the pedestrian cross alone pedestrians by holding all

other independent variables constant.

On the other hand, disability was negatively found to be associated with the crossing speed of pedestrian. Crossing speed decrease by 0.245 when pedestrian is disabling by holding all other independent variables constant. The multiple linear regression formula is provided below.

Cs=1.49 + 0.06G + 0.15Age(<18)+ 0.16Age(19-30) + 0.14Age(31-45) + 0.05CD + 0.09CS – 0.245D

- Cs- Crossing speed
- G – gender
- CD- crossing direction
- CS- crossing situation
- D- disability

b. Multiple linear regression for crossing speed of uncontrolled intersection

source	ss	df	MS
Model	14.03	12	1.17
Residual	51.34	1060	0.05
total	65.37	1072	0.06

no/ of obs = 1072
F(11, 606) =24.14
prob > F =0.000
R - squered = 0.22
Adj R-squered = 0.21
Root MSE = 0.22

Estimated parameter value of MLR model for roundabout

Variable	Coef.	Std. error	T	p-value
Constant	1.45	0.047	30.690	0.000
Gender				
Gender (if male = 1, otherwise = 0)	0.092	0.014	6.620	0.000
Age				
Age <18 (if Age <18 = 1, otherwise = 0)	0.094	0.023	4.170	0.000
Age 19-30 (if Age 19-30 = 1, otherwise = 0)	0.121	0.021	5.760	0.000
Age 31-45 (if Age 31-45 = 1, otherwise = 0)	0.075	0.018	4.290	0.000

Baggage handling				
Baggage (if yes baggage=1, otherwise=0)	-0.021	0.062	-0.350	0.724
Crossing stage				
Crossing stage(if one stage=1, otherwise=0)	-0.049	0.014	-3.380	0.001
Crossing direction				
Crossing direction (if perp=1, otherwise=0)	0.043	0.044	0.980	0.330
Crossing pattern				
Crossing pattern(if walking=1, otherwise=0)	-0.263	0.022	-11.740	0.000
Crossing situation				
Crossing situation(if alone=1, otherwise=0)	0.098	0.031	3.100	0.002
Disability				
Disability(if disable=1, otherwise=0)	-0.620	0.156	-3.970	0.000
Mobile usage				
Mobile usage(if Yes=1, otherwise=0)	-0.208	0.128	-1.630	0.103
Crossing along the crosswalk				
Crossing along the crosswalk(if within=1, otherwise=0)	-0.054	0.049	-1.100	0.271

Since P>F is equal to 0 which is less than 0.05, the model is statistically significant. And P value for gender, for all ages, crossing stage, crossing pattern, crossing situation and disability are less than 0.05 are significant values for the determination of the crossing speed.

Gender, Age (<18), Age (19-30), Age (31-45) and crossing situation were positively associated with crossing speed shown on the Table above. The crossing speed increases by 0.09 when the pedestrian gender is male. The crossing speed increases by 0.094 when the pedestrian age is less than 18 means for children pedestrians by holding all other independent variables constant. The crossing speed increases by 0.12 when the pedestrian age is between 19 – 30 means young pedestrians by holding all other independent variables constant. The crossing speed increases by 0.08 when the pedestrian age is between 31 – 45 means for adult pedestrians by holding all other independent variables constant. The crossing speed increases by 0.098 when the pedestrian cross alone pedestrians by holding all other independent variables constant.

On the other hand, crossing stage, crossing pattern and disability was negatively found to be associated with the crossing speed of pedestrian. Crossing speed decrease by 0.05 when pedestrian

cross with one stage by holding all other independent variables constant. Crossing speed decrease by 0.26 when pedestrian cross by walking by holding all other independent variables constant. Crossing speed decrease by 0.62 when pedestrian is disable by holding all other independent variables constant. And The multiple linear regression formula is provided below.

Cs= 1.45 + 0.09G + 0.094Age(<18) + 0.12Age(19-30) + 0.08Age(31-45) – 0.05CSt – 0.26CP + 0.098CS -0.62D

- Cs - Crossing speed
- G – gender
- CSt - Crossing stage
- CP- crossing pattern
- CS - crossing situation
- D – disability

c. Multiple linear regression for crossing speed of uncontrolled intersection

source	ss	df	MS
Model	16.61	11	1.51
Residual	20.99	606	0.04
total	37.6	617	0.06

no/ of obs = 618
F(11, 606) =43.61
prob > F =0.000
R - squered = 0.44
Adj R-squered = 0.43
Root MSE = 0.19

Estimated parameter value of MLR model

Variable	Coef.	Std. error	T	p-value
Constant	1.105	0.071	15.520	0.000
Gender				
Gender (if male = 1, otherwise = 0)	0.011	0.016	0.700	0.485
Age				
Age <18 (if Age <18 = 1, otherwise = 0)	0.131	0.034	3.850	0.000
Age 19-30 (if Age 19-30 = 1, otherwise = 0)	0.182	0.034	5.420	0.000
Age 31-45 (if Age 31-45 = 1, otherwise = 0)	0.162	0.331	4.890	0.000
Baggage handling				

Baggage (if yes baggage=1, otherwise=0)	-0.061	0.033	-1.890	0.059
Crossing stage				
Crossing stage(if one stage=1, otherwise=0)	0.225	0.056	4.030	0.000
Crossing direction				
Crossing direction (if perp=1, otherwise=0)	0.007	0.020	0.370	0.710
Crossing pattern				
Crossing pattern(if walking=1, otherwise=0)	-0.452	0.024	-18.750	0.000
Crossing situation				
Crossing situation(if alone=1, otherwise=0)	0.039	0.019	2.060	0.040
Mobile usage				
Mobile usage(if Yes=1, otherwise=0)	0.073	0.064	1.140	0.255
Crossing along the crosswalk				
Crossing along the crosswalk(if within=1, otherwise=0)	0.100	0.017	5.920	0.000

Since P>F is equal to 0 which is less than 0.05, the model is statistically significant. And p value for gender, for all ages, crossing direction, crossing stage , crossing pattern, crossing situation and crossing along the crosswalk are less than 0.05 are significant values for the determination of the crossing speed.

Gender, Age (<18), Age (19-30), Age (31-45), crossing stage, crossing situation and crossing along the crosswalk were positively associated with crossing speed shown on the Table above. The crossing speed increases by 0.13 when the pedestrian age is less than 18 means for children pedestrians by holding all other independent variables constant. The crossing speed increases by 0.18 when the pedestrian age is between 19 – 30 means young pedestrians by holding all other independent variables constant. The crossing speed increases by 0.16 when the pedestrian age is between 31 – 45 means for adult pedestrians by holding all other independent variables constant. The crossing speed increases by 0.23 when the pedestrian cross with one stage by holding all other independent variables constant. The crossing speed increases by 0.04 when the pedestrian cross alone by holding all other independent variables constant. The crossing speed increases by 0.01 when the pedestrian cross within the marked crosswalk by holding all other independent variables constant.

On the other hand crossing pattern was negatively found to be associated with the crossing speed of pedestrian. Crossing speed decrease by 0.45 when pedestrian cross by walking by holding all other independent variables constant. And the multiple linear regression formula is provided below.

Cs=1.105 + 0.13Age (<18) + 0.18Age (19-30) + 0.16Age (31-45) + 0.23CSt – 0.45CP + 0.04CS + 0.1CAC

- Cs - Crossing speed
- CSt - Crossing stage
- CP- crossing pattern
- CS - crossing situation
- CAS- crossing along the crosswalk

4.3 Waiting Time of Pedestrians

4.3.1 Descriptive Analysis

Waiting time of the pedestrians is another important design parameter as the exhibition of risky behavior increased for long waiting times at intersections. From the Figure below, it is found 40%, 69% and 91% of pedestrian doesn't wait more than 10s for signalized, roundabout and uncontrolled intersections respectively. The Figure below presents the waiting time of pedestrians for the three types of intersection. It can be concluded that pedestrian wait more at signalized, roundabout and uncontrolled intersection respectively.

From the previous studies it is found that Jain et al. found in their study that waiting time of the pedestrian at unsignalized intersection varies from 1–6 s. Mako showed in his study that the average waiting time of pedestrians was about 5.1 s at an unsignalized intersection. From a study of Wang et al. it is found that 50% of pedestrians did not wait longer than 40 s. Li showed that the average waiting time while crossing at a signalized intersection was 48.2 s.

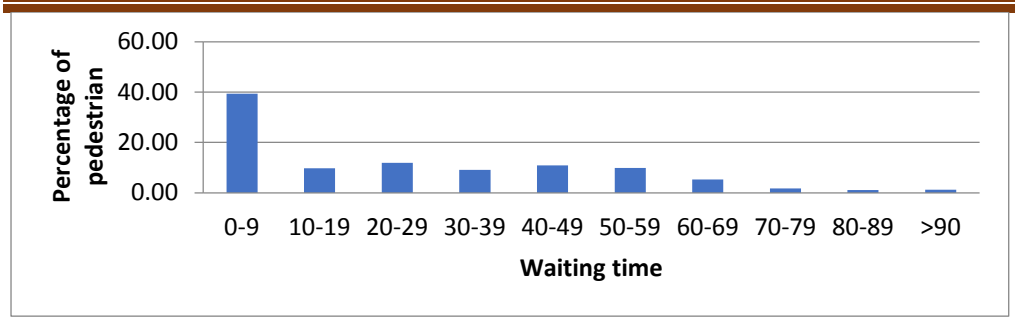


Figure 4-5 Waiting Time of Pedestrian at signalized intersection

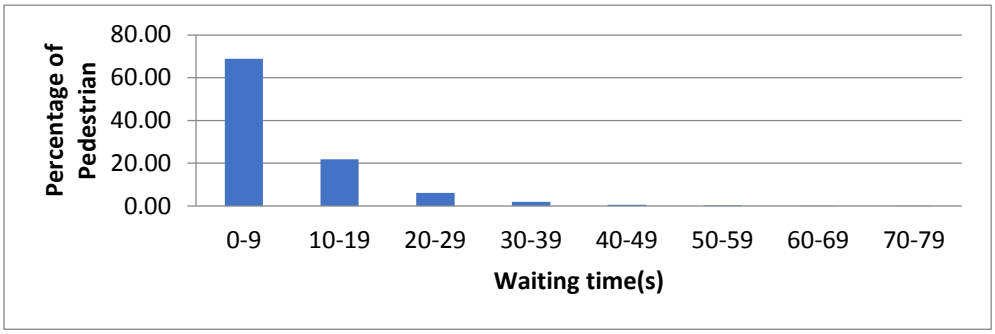


Figure 4-6 waiting time of pedestrian at roundabout

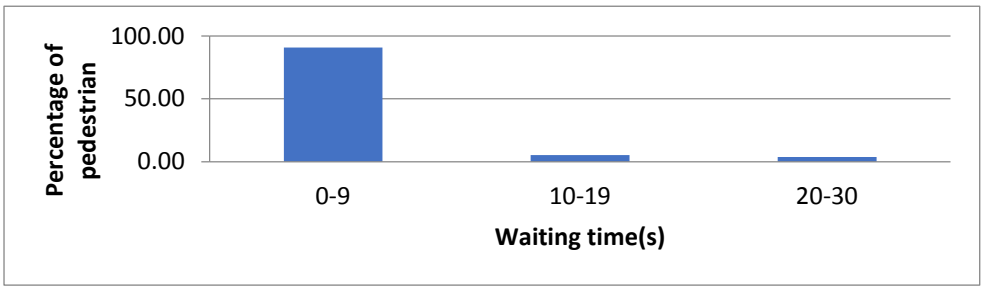


Figure 4-7 waiting time of pedestrian at roundabout

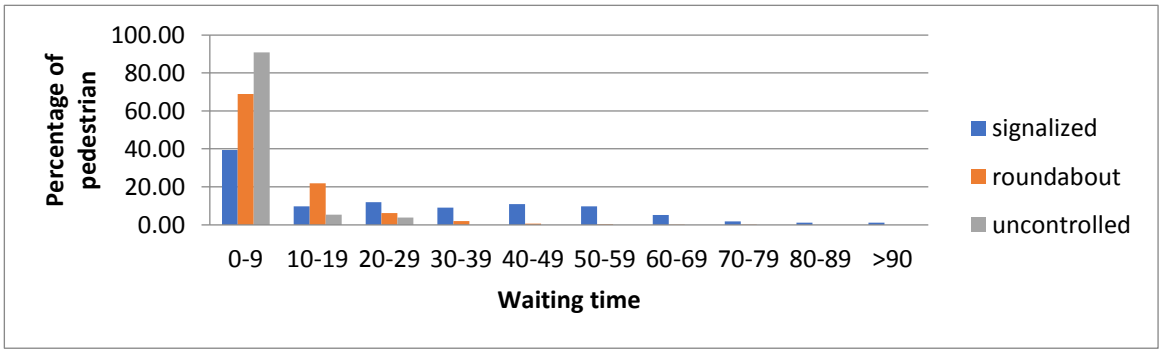
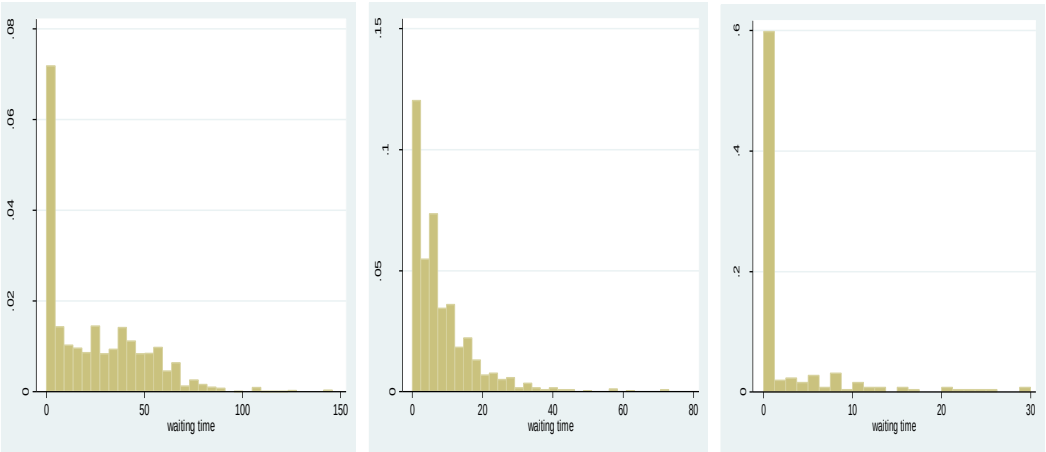


Figure 4-8 waiting time of pedestrian at all intersection types

4.3.2 Factors Affecting Pedestrian Waiting Time

In order to identify the factors that affect the waiting time of pedestrians different independent variables are considered those are Gender, age, baggage, crossing stage, crossing direction, crossing pattern, crossing situation, disability, mobile usage and crossing along the crosswalk. For the examination ANOVA and t-test can't be performed because as shown on the figure below the waiting time values are not normally distributed so Kruskal–Wallis H test was conducted for the variables having more than two categories of outcomes and Mann–Whitney U test was used for predictors with two outcomes.



(a) (b) (c)

Figure 4-9 Histogram of waiting time (a) at signalized intersection (b) at round about (c) at uncontrolled intersection

a. Gender

Gender of pedestrian is taken from the field data is taken and to test if a significant difference in waiting time exists between male and women. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in waiting time exists between male and women.

H1: significant difference in waiting time exists between male and women.

The P value for the t-test expressed as 0.615, 0.000 and 0.000 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for roundabout and uncontrolled intersection. While for signalized intersection it is greater than the significant level, so Ho is failed to be

rejected. There exists a significant difference in waiting time between male and women for roundabout and uncontrolled intersection but it is not working for signalized intersection.

Table 4-24 Results of statistical analysis between waiting time and Gender

	Variable	N	Mean	std. Dev	statistical test details
signalized	Female	799	24.78	24.11	P= 0.615
	Male	884	25.08	25.7	
roundabout	Female	491	9.18	10.11	P= 0.000
	Male	582	7.25	8.30	
uncontrolled intersection	Female	231	3.87	6.803	P= 0.000
	Male	387	1.63	4.606	

Females have higher waiting time than male for the three types of intersections. A similar finding was found in the studies of Li, 2013, Jain, 2014, Mohamod jafri,2019 which shows that females wait more than male pedestrians.

b. Age group

There are four groups of age and to find which group has great impact on the waiting time the following tests are done. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in waiting time exists between Age group.

H1: significant difference in waiting time exists between Age group.

The P value for the t-test expressed as 0.018, 0.000 and 0.71 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for signalized intersection. While for uncontrolled intersection it is greater than the significant level, so Ho is failed to be rejected. There exists a significant difference in waiting time between Age group for signalized intersection and roundabout but it is not working for uncontrolled intersection.

Table 4-25 Results of statistical analysis between waiting time and Age

	variable	N	mean	std. Dev.	statistical test details
signalized intersection	Age 0-18	266	22.73	22.9	p=0.018
	Age 19-30	381	22.54	25.16	
	Age 31-45	617	25.68	24.77	
	Age >45	420	27.43	26.05	
roundabout	Age 0-18	161	6.63	6.71	p=0.000
	Age 19-30	217	7.22	9.64	
	Age 31-45	457	7.82	8	
	Age >45	238	10.62	11.72	
uncontrolled intersection	Age 0-18	159	1.23	2.37	p=0.71
	Age 19-30	192	2.98	6.63	
	Age 31-45	228	2.45	5.41	
	Age >45	39	5.15	8.97	

Old pedestrian wait longer time than the other age groups next age group 31-45 on the third age group 19-30 finally age group <18 wait less time than the others. The result old pedestrian have longer waiting time is similar with the previous studies like (Li, 2013, Jain, 2014, Mohamod jafri,2019)

c. Baggage

Pedestrian cross the intersection either by handling baggage or without baggage. To test if a significant difference in waiting time exists between Baggage handling and no baggage handling. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in waiting time exists between Baggage handling and no baggage handling.

H1: significant difference in waiting time exists between Baggage handling and no baggage handling.

The P value for the t-test expressed as 0.135, 0.491 and 0.679 for signalized, roundabout and uncontrolled intersection respectively. As the p value is greater than significant

level, so Ho is failed to be rejected. There exists no significant difference in waiting time between Baggage handling and not for the three types of intersection types.

Table 4-26. Results of statistical analysis between waiting time and baggage

	Variable	N	Mean	std. Dev	statistical test details
Signalized	No Baggage	1618	25.05	24.83	P= 0.135
	Baggage	65	22.31	27.97	
roundabout	No Baggage	1060	8.13	9.24	P= 0.491
	Baggage	13	8.46	7.76	
uncontrolled intersection	No Baggage	582	2.53	5.77	P= 0.679
	Baggage	36	1.33	2.35	

Waiting time of pedestrian with no baggage have higher waiting time than pedestrian who hold baggage for signalized and uncontrolled intersections but it doesn't work for roundabout.

d. Crossing stage

Pedestrian cross either in one stage or in two stage and for the study of waiting time for the three types of intersection type The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in waiting time exists between one stage and two stage crossing..

H1: significant difference in waiting time exists between one stage and two stage crossing..

The P value for the t-test expressed as 0.000, 0.000 and 0.000 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for the three types of intersections. There exists a significant difference in waiting time between one stage and two stages crossing for the three types of intersections.

Table 4-27 Results of statistical analysis between waiting time and crossing stage

	Variable	N	Mean	std. Dev	statistical test details
Signalized	one stage	752	12.03	20.24	P= 0.000
	two stage	931	35.37	23.49	
roundabout	one stage	717	7.13	9.05	P= 0.000
	two stage	356	10.17	9.23	
uncontrolled intersection	one stage	606	2.45	5.69	P= 0.000
	two stage	12	3	0	

Pedestrian who cross with two stage have higher waiting time than pedestrian who cross with one stage for all type of intersections.

e. Crossing direction

When the pedestrian cross the road use perpendicular or oblique direction and to test a significant difference in waiting time exists between perpendicular and oblique direction of crossing the following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in waiting time exists between perpendicular and oblique direction of crossing

H1: significant difference in waiting time exists between perpendicular and oblique direction of crossing.

The P value for the t-test expressed as 0.000, 0.129 and 0.000 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for signalized and uncontrolled intersection. While for roundabout it is greater than the significant level, so Ho is failed to be rejected. There exists a significant difference in waiting time between perpendicular and oblique direction of crossing for signalized and uncontrolled intersection but it is not working for roundabout.

Table 4-28 Results of statistical analysis between waiting time and baggage

	Variable	N	Mean	std. Dev	statistical test details
Signalized	Perpendicular	1081	21.86	25.49	P= 0.000
	Oblique	602	30.48	22.97	
roundabout	Perpendicular	963	8.3	9.44	P= 0.129
	Oblique	110	6.7	6.87	
uncontrolled intersection	Perpendicular	483	2.89	6.12	P= 0.000
	Oblique	135	0.96	2.92	

Pedestrian who cross in perpendicular directions have higher waiting time than pedestrian who cross at oblique directions for roundabout and uncontrolled intersections but it doesn't work for signalized intersection.

f. Crossing pattern

Walking and running are two types of crossing patterns for pedestrian crossing at the intersections. To test if a significant difference in waiting time exists between walking and running. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in waiting time exists between walking and running.

H1: significant difference in waiting time exists between walking and running.

The P value for the t-test expressed as 0.000, 0.044 and 0.997 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for signalized intersection and roundabout. While for uncontrolled intersection it is greater than the significant level, so Ho is failed to be rejected. There exists a significant difference in waiting time between walking and running for signalized intersection and roundabout but it is not working for uncontrolled intersection.

Table 4-29 Results of statistical analysis between waiting time and crossing pattern.

	Variable	N	Mean	std. Dev	statistical test details
Signalized	walking	1404	25.93	25.11	P= 0.000
	running	279	19.96	23.59	
roundabout	walking	957	8.25	9.10	P= 0.044
	running	116	7.20	10.16	
uncontrolled intersection	walking	549	2.47	5.67	P= 0.997
	running	69	2.43	5.34	

Pedestrian who cross the road by walking wait more time than pedestrian who cross by running for the three types of intersections.

g. Crossing situation

Pedestrian are alone or in group while crossing the road. To test if a significant difference in waiting time exists between crossing alone or in group. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in waiting time exists between crossing alone or in group.

H1: significant difference in waiting time exists between crossing alone or in group.

The P value for the t-test expressed as 0.000, 0.006 and 0.312 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for signalized intersection and roundabout. While for uncontrolled intersection it is greater than the significant level, so Ho is failed to be rejected. There exists a significant difference in waiting time between crossing alone or in group for signalized intersection and roundabout but it is not working for uncontrolled intersection.

Table 4-30 Results of statistical analysis between waiting time and crossing situation

	Variable	N	Mean	std. Dev	statistical test details
Signalized	Alone	1511	25.72	24.95	P= 0.000
	Group	172	18.09	24.02	
roundabout	Alone	1020	8.28	9.27	P= 0.006
	Group	53	5.49	7.79	
uncontrolled intersection	Alone	486	2.66	6.06	P= 0.312
	Group	132	1.75	3.56	

Pedestrian who cross alone wait more time than pedestrian who cross in group at all type in all type of intersection. This is contrary to the finding of the previous studies that is Pedestrians tended to wait more time when they crossed in groups than being alone Mohamed jafri, 2019.

h. Disability

There are two type of pedestrian those are disabled and not disable. To test the effect of physical disability can affect the waiting time the following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in waiting time exists between being disable and no disable.

H1: significant difference in waiting time exists between being disable and no disable.

The P value for the t-test expressed as 0.071 and 0.647 for signalized intersection and roundabout respectively. As the p value is greater than the significant level, so Ho is failed to be rejected. There exists no significant difference in waiting time between being disabled and no disable for signalized intersection and roundabout.

Table 4-31 Results of statistical analysis between waiting time and disability

	Variable	N	Mean	std. Dev	statistical test details
Signalized	No disability	1664	25.00	24.87	P= 0.071
	Yes disability	19	19.47	31.84	
Roundabout	No disability	1071	8.14	9.22	P= 0.647
	Yes disability	2	5.00	7.07	

Pedestrian with disability have smaller waiting time than pedestrian with no disability for all type of intersection.

i. Mobile usage

Some of the pedestrians talk mobile while crossing the intersection. To test if a significant difference in waiting time exists between mobile usage and no mobile usage. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in waiting time exists between mobile usage and no mobile usage.

H1: significant difference in waiting time exists between mobile usage and no mobile usage.

The P value for the t-test expressed as 0.222, 0.891 and 0.076 for signalized, roundabout and uncontrolled intersection respectively. As the p value is greater than the significant level, so Ho is failed to be rejected. There exists no significant difference in waiting time between mobile usage and no mobile usage for the three type of intersection.

Table 4-32 Results of statistical analysis between waiting time and mobile usage

	Variable	N	Mean	std. Dev	statistical test details
signalized	No mobile	1677	24.95	24.89	P= 0.222
	Yes mobile	6	22.50	43.63	
roundabout	No mobile	1070	8.14	9.23	P= 0.891
	Yes mobile	3	6.33	3.78	
uncontrolled intersection	No mobile	609	2.50	5.66	P= 0.076
	Yes mobile	9	0.00	0.00	

Pedestrian who talks mobile while crossing intersection have lower waiting time than pedestrian who doesn't talk mobile for all type of intersection.

j. Crossing along the crosswalk

Pedestrian cross either within or outside of the crosswalk, To test if a significant difference in waiting time exists between crossing within and outside of the crosswalk. The following hypothesis was drawn and an independent sample mean test was performed. The result is presented in table below.

Ho: no significant difference in waiting time exists between crossing within and outside of the crosswalk.

H1: significant difference in waiting time exists between crossing within and outside of the crosswalk.

The P value for the t-test expressed as 0.000, 0.094 and 0.000 for signalized, roundabout and uncontrolled intersection respectively. As the p value is less than the significant level. Ho can be rejected for signalized and uncontrolled intersection. While for roundabout it is greater than the significant level, so Ho is failed to be rejected. There exists a significant difference in waiting time between crossing within and outside of the crosswalk for signalized and uncontrolled intersection but it is not working for roundabout.

Table 4-33 Results of statistical analysis between waiting time and disability

	Variable	N	Mean	std. Dev	statistical test details
signalized	within	1188	22.6	25.18	P= 0.000
	Outside	495	30.55	23.50	
roundabout	within	987	8.29	9.40	P= 0.094
	Outside	86	6.37	6.65	
uncontrolled intersection	within	330	3.81	6.76	P= 0.000
	Outside	288	0.93	3.37	

Pedestrian who cross the intersection within the crosswalk have higher waiting time than the one who cross outside the crosswalk at roundabout and uncontrolled intersection but there is a difference in the case of signalized intersection.

4.3.3 Regression model for waiting time of pedestrian

The steps conducted to analysis and develop a multiple linear regression model of waiting time of pedestrian at both intersection types are;

Step1: Identify dependent and independent variables.

- Dependent variable
  - ✓ crossing speed
- Independent variables
  - ✓ Gender :- Female(0) and male(1)
  - ✓ Age: - a. <18 b. 18 – 30 c.31 – 45 d. >45
    - ➢ Age <18 (if Age <18 = 1, otherwise = 0)
    - ➢ Age 19-30 (if Age 19-30 = 1, otherwise = 0)
    - ➢ Age 31-45 (if Age 31-45 = 1, otherwise = 0)
  - ✓ baggage handling:- baggage handling(1) and no baggage handling(0)
  - ✓ Crossing stage: - one stage (1) and two stage (0).
  - ✓ crossing direction: - perpendicular crossing(1) and oblique crossing(0)
  - ✓ crossing pattern :- walking(1) and running(0)
  - ✓ Crossing situation:- alone(1) and group(0)

- ✓ Disability:- disable(1) and no disable(0)
- ✓ mobile usage:- mobile used(1) and no mobile usage(0)
- ✓ crossing along the cross walk:- within(1) and outside(0)

Step 2: Statistical test, regression analysis using STATA

Step 3: Identify the significant variable at 95 % confidence interval. If the p – value is less than 0.05, then the factors are significant variable for regression model.

Step 4: Provide regression model.

a. Multiple linear regression for waiting time of signalized intersection

source	ss	df	MS
Model	246609.69	14	20550.8
Residual	800942.37	1670	479.61
total	1047552.1	1684	622.8

no/ of obs = 1084
F(11, 606) =42.85
prob > F =0.000
R - squered = 0.24
Adj R-squered = 0.23
Root MSE = 21.9

4.3.3 a Estimated parameter value of MLR model for waiting time for signalized intersection

Variable	Coef.	Std. error	T	p-value
Constant	25.699	2.838	9.060	0.000
Gender				
Gender (if male = 1, otherwise = 0)	0.597	1.095	0.550	0.586
Age				
Age <18 (if Age <18 = 1, otherwise = 0)	-1.937	1.778	-1.090	0.276
Age 19-30 (if Age 19-30 = 1, otherwise = 0)	-3.717	1.573	-2.360	0.018
Age 31-45 (if Age 31-45 = 1, otherwise = 0)	-2.195	1.391	-1.580	0.115
Baggage handling				
Baggage (if yes baggage=1, otherwise=0)	-1.143	2.806	-0.410	0.684
Crossing stage				
Crossing stage(if one stage=1, otherwise=0)	-23.323	1.176	-19.840	0.000
Crossing direction				

Crossing direction (if perp=1, otherwise=0)	-1.742	1.676	-1.040	0.299
Crossing pattern				
Crossing pattern(if walking=1, otherwise=0)	6.119	1.501	4.080	0.000
Crossing situation				
Crossing situation (if alone=1, otherwise=0)	6.331	1.848	3.430	0.001
Disability				
Disability(if disable=1, otherwise=0)	3.919	5.232	0.750	0.454
Mobile usage				
Mobile usage(if Yes=1, otherwise=0)	3.619	9.178	0.390	0.693
Crossing along the crosswalk				
Crossing along the crosswalk(if within=1, otherwise=0)	1.527	1.734	0.880	0.379

Since P>F is equal to 0 which is less than 0.05, the model is statistically significant. And p value for ages (19-30), crossing stage, crossing pattern and crossing situation are less than 0.05 are significant values for the determination of the Waiting time.

Crossing pattern and crossing situation were positively associated with waiting time shown on the Table above. The waiting time of pedestrian increases by 6.12 when the pedestrian cross by walking by holding all other independent variables constant. The waiting time of pedestrian increases by 6.33 when the pedestrian cross alone by holding all other independent variables constant.

On the other hand Age between 19-30 and crossing stage was negatively found to be associated with the waiting time of pedestrian. Waiting time decrease by 3.17 when pedestrian are with age group between 19 – 30 means young pedestrian by holding all other independent variables constant. Waiting time decrease by 23.32 when pedestrian are crossing with one stage by holding all other independent variables constant. And the multiple linear regression formula is provided below.

Wt=25.7 – 3.17Age (19-30) – 23.32CSt + 6.12CP + 6.33CS

- Wt – waiting time
- CSt - Crossing stage
- CP- crossing pattern
- CS - crossing situation

b. Multiple linear regression for waiting time of uncontrolled intersection

source	ss	Df	MS
Model	5140.28	12	428.36
Residual	85952.03	1060	81.09
total	91092.31	1072	84.97

no/ of obs = 1072
F(11, 606) =5.28
prob > F =0.000
R - squered = 0.06
Adj R-squered = 0.05
Root MSE = 9.00

4.3.3.b Estimated parameter value of MLR model for waiting time at round about

Variable	Coef.	Std. error	t	p-value
Constant	8.984	1.933	4.650	0.000
Gender				
Gender (if male = 1, otherwise = 0)	-1.522	0.568	-2.680	0.007
Age				
Age <18 (if Age <18 = 1, otherwise = 0)	-3.571	0.928	-3.850	0.000
Age 19-30 (if Age 19-30 = 1, otherwise = 0)	-2.779	0.856	-3.250	0.001
Age 31-45 (if Age 31-45 = 1, otherwise = 0)	-2.618	0.722	-3.630	0.000
Baggage handling				
Baggage (if yes baggage=1, otherwise=0)	1.108	2.532	0.440	0.662
Crossing stage				
Crossing stage(if one stage=1, otherwise=0)	-2.646	0.591	-4.480	0.000
Crossing direction				
Crossing direction (if perp=1, otherwise=0)	0.790	1.794	0.440	0.660
Crossing pattern				
Crossing pattern(if walking=1, otherwise=0)	0.7	0.916	0.760	0.445
Crossing situation				
Crossing situatiion(if alone=1, otherwise=0)	2.65	1.286	2.060	0.040
Disability				
Disability(if disable=1, otherwise=0)	-3.740	6.396	-0.580	0.559
Mobile usage				
Mobile usage(if Yes=1, otherwise=0)	-2.707	5.221	-0.520	0.604

Crossing along the crosswalk				
Crossing along the crosswalk(if within=1, otherwise=0)	0.120	2.021	0.060	0.953

Since P>F is equal to 0 which is less than 0.05, the model is statistically significant. And p value for gender, for all ages, crossing stage and crossing situation are less than 0.05 are significant values for the determination of the waiting time.

Crossing situation was positively associated with waiting time shown on the Table above. The waiting time of pedestrian increases by 6.33 when the pedestrian cross alone by holding all other independent variables constant.

On the other hand gender, Age less than 18, Age between 19-30, Age between 31-45 and crossing stage was negatively found to be associated with the waiting time of pedestrian. Waiting time decrease by 1.52 when the gender of the pedestrian is male by holding all other independent variables constant. Waiting time decrease by 3.57 when pedestrian age group is less than 18 means for children pedestrian. Waiting time decrease by 2.78 for pedestrian age group is between 19 and 30. Waiting time decrease by 2.62 when the pedestrian age group is between 31-45 and when pedestrian cross in one stage the waiting time decrease by 2.62 by holding the other independent variables constant. And the multiple linear regression formula is provided below. **Wt=8.98 – 1.52G – 3.57Age (<18) – 2.78Age (19-30) – 2.62Age (31-45) -2.62CSt + 2.65CS**

- Wt – waiting time
- G – gender
- CSt - Crossing stage
- CS - crossing situation

c. Multiple linear regression for waiting time of uncontrolled intersection

source	ss	df	MS
Model	2621.35	11	238.3
Residual	16942.43	606	27.96
total	19563.78	617	31.71

no/ of obs = 618
F(11, 606) =8.52
prob > F =0.000
R - squered = 0.134
Adj R-squered = 0.12
Root MSE = 5.29

4.3.3 c Estimated parameter value of MLR model for waiting time at uncontrolled intersection

Variable	Coef.	Std. error	t	p-value
Constant	1.645	2.022	0.810	0.416
Gender				
Gender (if male = 1, otherwise = 0)	-1.640	0.469	-3.500	0.001
Age				
Age <18 (if Age <18 = 1, otherwise = 0)	-3.662	0.967	-3.790	0.000
Age 19-30 (if Age 19-30 = 1, otherwise = 0)	-1.459	0.956	-1.530	0.127
Age 31-45 (if Age 31-45 = 1, otherwise = 0)	-2.338	0.942	-2.480	0.013
Baggage handling				
Baggage (if yes baggage=1, otherwise=0)	-1.427	0.926	-1.540	0.124
Crossing stage				
Crossing stage(if one stage=1, otherwise=0)	1.088	1.587	0.690	0.493
Crossing direction				
Crossing direction (if perp=1, otherwise=0)	0.720	0.569	1.270	0.206
Crossing pattern				
Crossing pattern(if walking=1, otherwise=0)	0.229	0.686	0.330	0.739
Crossing situation				
Crossing situation (if alone=1, otherwise=0)	1.330	0.545	2.440	0.015
Mobile usage				
Mobile usage(if Yes=1, otherwise=0)	-2.413	1.816	-1.330	0.185
Crossing along the crosswalk				
Crossing along the crosswalk(if within=1, otherwise=0)	2.522	0.483	5.230	0.000

Since P>F is equal to 0 which is less than 0.05, the model is statistically significant. And p value for gender, for ages, crossing situation and crossing along the crosswalk are less than 0.05 are significant values for the determination of the waiting time.

Crossing situation and crossing along the crosswalk were positively associated with waiting time shown on the Table above. The waiting time of pedestrian increases by 1.33 when the

pedestrian cross alone by holding all other independent variables constant. The waiting time of pedestrian increases by 2.52 when the pedestrian cross within the marked crosswalk by holding all other independent variables constant.

On the other hand gender, Age less than 18 and Age between 31-45 were negatively found to be associated with the waiting time of pedestrian. Waiting time decrease by 1.64 when the gender of the pedestrian is male by holding all other independent variables constant. Waiting time decrease by 3.66 when pedestrian age group is less than 18 means for children pedestrian. Waiting time decrease by 2.62 when the pedestrian age group is between 31-45 by holding the other independent variables constant. And the multiple linear regression formula is provided below.

Wt= -1.64G – 3.66Age (<18) - 2.34Age (31-45) + 1.33CS + 2.52CAC

- Wt – waiting time
- G – gender
- CS - crossing situation
- CAS- crossing along the crosswalk

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This research paper examined pedestrian crossing behavior by taking the parameters crossing speed and waiting time in the capital city of Ethiopia, Addis Ababa. At signalized and unsignalized intersections. From the analysis of the crossing speed mean crossing speed is found as 1.41m/s and 1.27m/s for signalized and unsignalized intersection respectively. And the recommended design crossing speed are 1.02m/s and 0.95m/s for signalized and unsignalized intersection respectively. The result show mean and recommended design speed is higher for signalized intersection than the unsignalized intersection. And the recommended design speed is lower than the design pedestrian crossing speed described on the standards that is 1.2m/s.

Male pedestrian, young pedestrian, pedestrian crossing alone, pedestrian with no disability and pedestrian with no mobile usage cross faster than female pedestrian, young pedestrian, pedestrian in group, pedestrian with disability, pedestrian with baggage and pedestrian with mobile respectively in all type of intersections. Pedestrian who cross in perpendicular direction, by running and crossing within crosswalk have higher crossing speed than crossing obliquely, by walking and crossing outside of crosswalk respectively for all type of intersection. Pedestrian with no baggage and one stage crossing have higher crossing speed than pedestrian with baggage and two stage crossing for unsignalized intersection.

For a better understanding, an MLR model was prepared for the crossing speed analysis, which showed gender, age group, crossing stage, crossing pattern, crossing situation, disability and CAS- crossing along the crosswalk as the significant factor for the crossing speed.

In the case of waiting time, 40%, 69% and 91% of pedestrian doesn't wait more than 10s for signalized, roundabout and uncontrolled intersections respectively.
Females, old pedestrian, pedestrian with no baggage, two stage crossing, crossing by walk, being alone, crossing without mobile taking, pedestrian with no disability have higher waiting time than male, other age groups, pedestrian with baggage, one stage

crossing, crossing by running, being in group, crossing with mobile taking, pedestrian with disability respectively for the three type of intersections. Pedestrian who cross the intersection within the crosswalk and crossing in perpendicular direction have higher waiting time than the one who cross outside the crosswalk and crossing in oblique direction respectively at unsignalized intersection but there is a difference in the case of signalized intersection.

For a better understanding, an MLR model was prepared for the waiting time of pedestrian analysis, which showed gender, age group, crossing stage, crossing pattern, crossing situation and CAS- crossing along the crosswalk.

5.2 Recommendations

- For signalized intersection in signal timing design it is better to search new design crossing speed for that specific area than to take it from standards. Findings of design crossing speed will help further in policy formulation and plan preparation.
- To increase on pedestrian safety awareness is important because most pedestrians have the group psychology. More attention has to be given on how to make pedestrians feel the importance of obeying traffic regulations themselves And Pedestrian education should start from childhood.

In addition to the above recommendations the following future research areas related with this study are also recommended.

- Pedestrian crossing behavior at three leg intersection.
- Pedestrian crossing behavior by considering waiting place and width of crosswalk.
- Design Pedestrian crossing speed and signal timing relation.
- Children crossing behavior around primary schools in Addis Ababa.
- Pedestrian crossing behavior at peak and nonpeak hour. (to consider traffic volume and pedestrian volume within the day)
- Illegal pedestrian crossing behavior at signalized intersections.
- Geometric and weather effect on pedestrian crossing behavior.

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APPENDIX

Appendix A:- some part of data extracted from video for signalized intersection

Gender	Age	BH	Cs	Wt	CSt	CD	CP	CS	D	MU	CAC
Male	>45	NO	1.14	55	Two	perp	walking	Alone	No	No	Out side
Male	19-30	NO	1.03	58	Two	perp	walking	Alone	No	No	Within
Female	31-45	NO	2.00	59	Two	perp	walking	Alone	No	No	Within
Female	31-45	NO	1.46	57	Two	perp	walking	Alone	No	No	Within
Female	>45	NO	0.95	56	Two	perp	walking	Alone	No	No	Out side
Male	31-45	NO	2.13	53	Two	perp	Running	Alone	No	No	Within
Female	31-45	NO	1.46	41	Two	perp	walking	Alone	No	No	Within
Male	19-30	NO	1.89	42	Two	perp	walking	Alone	No	No	Within
Male	0-18	NO	1.89	42	Two	perp	walking	Alone	No	No	Within
Female	31-45	NO	1.12	37	Two	perp	walking	Alone	No	No	Out side
Male	31-45	NO	1.06	27	Two	perp	walking	Alone	No	No	Out side
Female	19-30	NO	1.89	31	Two	perp	walking	Alone	No	No	Within
Female	>45	NO	1.56	22	Two	perp	walking	Alone	No	No	Within
Female	>45	NO	1.56	20	Two	perp	walking	Alone	No	No	Within
Female	31-45	yes	1.89	20	Two	perp	walking	Alone	No	No	Within
Male	19-30	NO	1.64	11	Two	perp	walking	Alone	No	No	Within
Female	19-30	NO	1.81	11	Two	perp	walking	Alone	No	No	Within
Male	>45	NO	1.14	4	Two	perp	walking	Alone	No	No	Out side
Male	>45	NO	1.70	0	one	perp	Running	Alone	No	No	Within
Female	>45	NO	0.82	0	one	perp	walking	Alone	No	No	Within
Female	19-30	NO	1.90	4	Two	perp	Running	Alone	No	No	Within
Male	19-30	NO	1.13	66	one	perp	walking	Alone	No	No	Within
Female	>45	NO	1.46	54	one	perp	walking	Alone	No	No	Within
Male	>45	NO	1.20	51	one	perp	walking	Alone	No	No	Within
Male	>45	NO	1.20	41	one	perp	walking	Alone	No	No	Within
Female	31-45	NO	1.46	5	one	perp	walking	Alone	No	No	Within
Female	31-45	NO	1.85	13	one	perp	Running	Alone	No	No	Within
Male	31-45	NO	2.04	13	one	perp	Running	Alone	No	No	Within
Female	0-18	NO	2.04	0	one	perp	Running	Alone	No	No	Within
Female	0-18	NO	2.04	0	one	perp	Running	Alone	No	No	Within
Male	31-45	NO	1.75	14	Two	perp	walking	Alone	No	No	Within
Male	31-45	NO	1.70	22	one	perp	Running	Alone	No	No	Within
Female	31-45	NO	1.70	22	one	perp	Running	Alone	No	No	Within
Female	31-45	NO	1.57	22	one	perp	walking	Alone	No	No	Within

Male	31-45	NO	1.58	60	Two	perp	walking	Alone	No	No	Out side
Male	19-30	yes	2.15	60	Two	perp	Running	Alone	No	No	Within
Male	19-30	NO	1.75	61	Two	perp	walking	Alone	No	No	Within
Female	31-45	NO	1.75	61	Two	perp	walking	Alone	No	No	Within
Female	>45	NO	1.46	41	Two	perp	Running	Alone	No	No	Within
Female	31-45	NO	1.50	81	Two	perp	walking	Alone	No	No	Within
Male	>45	NO	1.36	32	Two	perp	walking	Alone	No	No	Within
Male	31-45	NO	1.64	32	Two	perp	walking	Alone	No	No	Within
Female	>45	NO	1.28	22	Two	perp	walking	Alone	No	No	Within
Male	31-45	NO	1.64	23	Two	perp	walking	Alone	No	No	Within
Female	31-45	NO	1.38	22	Two	perp	walking	group	No	No	Within
Female	19-30	NO	1.90	23	Two	perp	walking	Alone	No	No	Within
Male	31-45	NO	1.90	15	Two	perp	walking	Alone	No	No	Out side
Female	19-30	NO	1.64	9	Two	perp	walking	Alone	No	No	Within
Male	31-45	NO	1.64	8	Two	perp	walking	Alone	No	No	Within
Male	31-45	NO	1.90	9	Two	perp	walking	Alone	No	No	Within
Male	>45	NO	1.73	4	Two	perp	Running	Alone	No	No	Within
Female	31-45	NO	1.90	2	Two	perp	Running	Alone	No	No	Within
Female	0-18	NO	1.57	0	one	perp	walking	Alone	No	No	Within
Female	31-45	NO	1.28	0	one	perp	walking	Alone	No	No	Within
Female	>45	NO	1.20	0	one	perp	walking	Alone	No	No	Within
Female	0-18	NO	1.85	0	one	perp	Running	group	No	No	Within
Female	0-18	NO	1.85	0	one	perp	Running	group	No	No	Within
Male	19-30	NO	1.57	13	one	perp	Running	Alone	No	No	Within
Male	>45	NO	1.28	9	one	perp	Running	Alone	No	No	Within
Male	31-45	NO	1.57	0	one	perp	walking	Alone	No	No	Within
Female	0-18	NO	1.57	0	one	perp	walking	Alone	No	No	Within
Female	19-30	NO	1.57	0	one	perp	Running	group	No	No	Within
Male	19-30	NO	1.46	0	one	perp	Running	Alone	No	No	Within
Male	0-18	NO	1.89	47	Two	perp	Running	Alone	No	No	Within
Male	19-30	NO	1.48	19	Two	perp	walking	Alone	No	No	Within
Male	31-45	NO	1.03	2	Two	perp	walking	Alone	No	No	Within
Female	31-45	NO	1.20	1	Two	perp	walking	group	No	No	Within

Appendix b:- some part of data extracted from video for roundabout

Gender	Age	BH	Cs	Wt	CSt	CD	CP	CS	D	MU	CAC
FEMALE	0-18	NO	1.32	0	one	perp	Walking	Alone	No	No	Within
MALE	0-18	NO	1.24	0	one	perp	Walking	Alone	No	No	Within
MALE	19-30	NO	1.24	0	one	perp	Walking	Alone	No	No	Within
MALE	0-18	NO	1.51	0	one	perp	Walking	Alone	No	No	Within
FEMALE	>45	NO	1.41	9	one	perp	Walking	Alone	No	No	Within
MALE	0-18	NO	2.34	7	one	perp	Running	Alone	No	No	Within
MALE	31-45	NO	1.92	5	one	perp	Running	Alone	No	No	Within
FEMALE	>45	NO	1.06	0	one	perp	Walking	group	No	No	Within
FEMALE	31-45	NO	1.41	0	one	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	1.06	0	one	perp	Walking	group	No	No	Within
MALE	31-45	NO	1.62	0	one	perp	Walking	Alone	No	No	Within
FEMALE	0-18	NO	1.17	0	one	perp	Walking	group	No	No	Within
FEMALE	0-18	NO	1.17	0	one	perp	Walking	group	No	No	Within
MALE	31-45	NO	1.89	25	Two	oblique	Running	Alone	No	No	Out side
FEMALE	>45	NO	1.07	23	Two	perp	Walking	Alone	No	No	Within
MALE	19-30	NO	1.73	23	Two	oblique	Running	Alone	No	No	Out side
FEMALE	31-45	NO	1.47	22	Two	oblique	Running	Alone	No	No	Out side
MALE	31-45	NO	1.18	10	Two	perp	Walking	Alone	No	No	Within
MALE	>45	NO	1.35	17	Two	perp	Walking	Alone	No	No	Within
FEMALE	31-45	NO	1.35	11	Two	perp	Walking	Alone	No	No	Within
FEMALE	31-45	NO	1.41	0	one	oblique	Walking	Alone	No	No	Out side
MALE	>45	NO	1.32	10	one	perp	Walking	Alone	No	No	Within
FEMALE	0-18	NO	1.24	5	one	perp	Walking	Alone	No	No	Within
MALE	0-18	NO	1.51	4	one	perp	Running	group	No	No	Within
MALE	0-18	NO	1.51	4	one	perp	Running	group	No	No	Within
FEMALE	>45	NO	1.35	73	Two	perp	Walking	Alone	No	No	Within
MALE	0-18	NO	1.76	22	one	perp	Walking	Alone	No	No	Within
MALE	0-18	NO	1.41	26	one	perp	Walking	Alone	No	No	Within
FEMALE	19-30	NO	1.26	73	Two	perp	Running	Alone	No	No	Within
FEMALE	31-45	NO	1.41	17	one	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	1.06	2	one	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	1.17	9	one	perp	Walking	Alone	No	No	Within
FEMALE	>45	NO	1.17	9	one	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	0.82	10	Two	perp	Running	Alone	Yes	No	Within
FEMALE	31-45	NO	1.32	2	one	perp	Walking	Alone	No	No	Within
FEMALE	>45	NO	1.07	5	Two	perp	Walking	Alone	No	No	Within
MALE	0-18	NO	1.68	7	Two	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	1.85	6	Two	perp	Walking	Alone	No	No	Within
MALE	19-30	NO	1.85	3	Two	perp	Running	Alone	No	No	Within

MALE	>45	NO	0.96	0	one	perp	Walking	Alone	Yes	No	Within
FEMALE	>45	NO	1.06	14	one	oblique	Walking	Alone	No	No	Out side
FEMALE	31-45	NO	1.06	14	one	oblique	Walking	Alone	No	No	Out side
MALE	31-45	NO	1.06	9	one	perp	Walking	group	No	No	Within
FEMALE	0-18	NO	1.11	9	one	perp	Walking	Alone	No	No	Within
FEMALE	31-45	NO	1.11	7	one	perp	Walking	Alone	No	No	Within
FEMALE	31-45	NO	0.96	8	one	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	1.17	8	one	perp	Running	Alone	No	No	Within
FEMALE	31-45	NO	0.96	6	one	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	1.17	8	one	oblique	Walking	Alone	No	No	Out side
MALE	31-45	NO	1.17	6	one	oblique	Walking	Alone	No	No	Out side
MALE	0-18	NO	1.51	0	one	perp	Running	Alone	No	No	Within
FEMALE	19-30	NO	1.51	13	one	perp	Walking	Alone	No	No	Within
FEMALE	31-45	NO	1.41	6	one	perp	Walking	Alone	No	No	Within
MALE	19-30	NO	1.51	0	one	perp	Walking	Alone	No	No	Within
MALE	>45	NO	1.92	0	one	perp	Running	Alone	No	No	Within
MALE	31-45	NO	1.32	8	one	oblique	Walking	Alone	No	No	Out side
MALE	19-30	NO	2.34	6	one	oblique	Running	Alone	No	No	Out side
MALE	0-18	NO	1.92	5	one	oblique	Running	Alone	No	No	Out side
MALE	0-18	NO	1.92	5	one	perp	Running	Alone	No	No	Within
MALE	0-18	NO	1.76	3	one	perp	Running	Alone	No	No	Within
MALE	19-30	NO	1.32	3	one	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	1.32	3	one	perp	Walking	Alone	No	No	Within
FEMALE	>45	NO	1.11	0	one	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	1.32	0	one	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	1.41	0	one	perp	Walking	Alone	No	No	Within
MALE	>45	NO	1.32	0	one	perp	Walking	Alone	No	No	Within
MALE	31-45	NO	1.41	0	one	perp	Walking	Alone	No	No	Within
MALE	0-18	NO	1.62	0	one	perp	Walking	Alone	No	No	Within
MALE	19-30	NO	1.62	0	one	perp	Walking	Alone	No	No	Within
FEMALE	>45	NO	1.32	5	one	perp	Running	Alone	No	No	Within
MALE	0-18	NO	1.51	0	one	oblique	Walking	Alone	No	No	Within
FEMALE	31-45	NO	1.35	15	Two	perp	Walking	Alone	No	No	Within

Appendix c:- some part of data extracted from video for uncontrolled intersection

Gender	Age	BH	Cs	Wt	CSt	CD	CP	CS	D	MU	CAC
MALE	31-45	NO	1.24	0	one	perp	walking	Alone	No	No	Out side
MALE	19-30	NO	1.13	0	one	oblique	walking	Alone	No	No	Out side
MALE	31-45	NO	0.89	0	one	oblique	walking	Alone	No	No	Out side
FEMALE	31-45	NO	0.90	3	Two	perp	walking	Alone	No	No	Within
FEMALE	19-30	NO	0.90	3	Two	perp	walking	Alone	No	No	Within
MALE	31-45	yes	1.13	0	one	oblique	walking	Alone	No	No	Out side
FEMALE	0-18	NO	1.24	0	one	perp	walking	Alone	No	No	Within
MALE	>45	NO	0.89	10	one	perp	walking	Alone	No	No	Within
FEMALE	31-45	NO	1.24	10	one	perp	walking	Alone	No	No	Within
FEMALE	19-30	NO	1.13	0	one	perp	walking	Alone	No	No	Out side
MALE	31-45	NO	1.03	0	one	perp	walking	Alone	No	No	Out side
MALE	>45	NO	0.95	0	one	oblique	walking	Alone	No	No	Out side
FEMALE	19-30	NO	1.03	0	one	oblique	walking	Alone	No	No	Within
FEMALE	>45	NO	1.03	0	one	perp	walking	group	No	No	Within
FEMALE	>45	NO	1.03	0	one	perp	walking	group	No	No	Within
FEMALE	>45	NO	1.13	0	one	perp	walking	group	No	No	Within
FEMALE	0-18	NO	1.03	0	one	perp	walking	group	No	No	Within
MALE	0-18	NO	1.03	0	one	perp	walking	group	No	No	Within
FEMALE	19-30	NO	1.55	0	one	perp	Running	group	No	No	Within
FEMALE	19-30	NO	1.55	0	one	perp	Running	group	No	No	Within
MALE	19-30	NO	1.03	4	one	perp	walking	Alone	No	No	Within
MALE	19-30	NO	1.03	4	one	perp	walking	Alone	No	No	Within
MALE	0-18	NO	1.03	0	one	perp	walking	Alone	No	No	Within
MALE	31-45	NO	1.38	0	one	perp	walking	Alone	No	No	Within
FEMALE	0-18	NO	1.38	6	one	perp	walking	Alone	No	No	Within
MALE	0-18	NO	1.55	0	one	perp	walking	Alone	No	No	Within
MALE	0-18	NO	1.03	0	one	oblique	walking	Alone	No	No	Out side
MALE	19-30	NO	1.38	0	one	perp	walking	group	No	No	Out side
MALE	19-30	NO	1.38	0	one	perp	walking	group	No	No	Out side
MALE	0-18	NO	1.38	0	one	perp	Running	group	No	No	Within
FEMALE	0-18	NO	1.38	0	one	perp	Running	group	No	No	Within
FEMALE	19-30	NO	1.13	0	one	perp	walking	Alone	No	No	Within
MALE	31-45	NO	1.38	0	one	perp	Running	Alone	No	No	Within
FEMALE	0-18	NO	1.13	0	one	perp	walking	group	No	No	Within
MALE	0-18	NO	1.13	0	one	perp	walking	group	No	No	Within
FEMALE	0-18	NO	1.55	0	one	perp	Running	Alone	No	No	Within
MALE	>45	NO	0.95	8	one	perp	walking	Alone	No	No	Within
MALE	31-45	yes	0.95	0	one	perp	walking	Alone	No	No	Within

MALE	19-30	yes	1.13	0	one	oblique	walking	Alone	No	No	Out side
MALE	19-30	NO	0.95	8	one	perp	walking	Alone	No	No	Within
MALE	31-45	NO	0.83	0	one	perp	walking	Alone	No	No	Out side
MALE	31-45	NO	1.24	0	one	perp	walking	Alone	No	No	Within
FEMALE	31-45	yes	1.13	0	one	perp	walking	group	No	No	Within
FEMALE	19-30	NO	1.13	0	one	perp	walking	group	No	No	Within
FEMALE	19-30	NO	1.13	0	one	perp	walking	group	No	No	Out side
MALE	19-30	NO	0.95	0	one	perp	walking	group	No	No	Within
MALE	19-30	NO	1.13	0	one	perp	walking	group	No	No	Within
MALE	31-45	yes	0.95	0	one	perp	walking	Alone	No	No	Within
FEMALE	0-18	NO	1.13	0	one	oblique	walking	Alone	No	No	Out side
MALE	31-45	NO	1.13	2	one	perp	walking	Alone	No	No	Within
MALE	19-30	NO	1.13	1	one	perp	walking	Alone	No	No	Out side
MALE	31-45	NO	1.24	0	one	oblique	walking	Alone	No	No	Within
FEMALE	0-18	NO	1.03	0	one	perp	walking	Alone	No	No	Within
FEMALE	0-18	NO	1.03	0	one	perp	walking	Alone	No	No	Within
MALE	19-30	NO	1.13	0	one	perp	walking	Alone	No	No	Within
MALE	0-18	NO	1.55	1	one	oblique	Running	Alone	No	No	Within
MALE	0-18	NO	1.03	0	one	perp	walking	Alone	No	No	Out side
MALE	0-18	NO	1.03	0	one	perp	walking	Alone	No	No	Out side
MALE	0-18	NO	1.03	0	one	perp	walking	Alone	No	No	Out side
MALE	0-18	NO	1.03	0	one	perp	walking	Alone	No	No	Out side
FEMALE	31-45	NO	1.24	0	one	perp	walking	Alone	No	No	Out side
FEMALE	31-45	NO	1.13	0	one	perp	walking	Alone	No	No	Within
MALE	31-45	NO	1.13	0	one	perp	walking	Alone	No	No	Within
FEMALE	0-18	NO	1.13	7	one	perp	walking	group	No	No	Within
FEMALE	0-18	NO	1.13	7	one	perp	walking	group	No	No	Within
MALE	19-30	NO	1.13	0	one	perp	walking	Alone	No	No	Out side
FEMALE	19-30	NO	1.24	16	one	oblique	walking	Alone	No	No	Within
FEMALE	19-30	NO	1.77	21	one	perp	Running	Alone	No	No	Within
MALE	19-30	NO	1.55	13	one	perp	Running	Alone	No	No	Within
FEMALE	31-45	NO	1.13	0	one	perp	walking	Alone	No	No	Within
FEMALE	31-45	NO	1.13	0	one	oblique	walking	Alone	No	No	Out side
FEMALE	31-45	NO	1.24	0	one	perp	walking	Alone	No	No	Within
MALE	31-45	NO	1.38	0	one	perp	walking	Alone	No	No	Within
MALE	31-45	NO	1.55	0	one	perp	walking	Alone	No	No	Within
FEMALE	0-18	NO	1.03	8	one	perp	walking	Alone	No	No	Within
MALE	0-18	NO	1.03	8	one	perp	walking	Alone	No	No	Within
MALE	31-45	NO	1.13	0	one	perp	walking	Alone	No	No	Within
MALE	0-18	NO	1.03	2	one	perp	walking	Alone	No	No	Within
MALE	0-18	NO	1.03	2	one	perp	walking	Alone	No	No	Within

Appendix d:- crossing pattern for roundabout and uncontrolled intersection

Table 4.1.2 b at round about

Crossing direction	Percentage of pedestrians (%)	
	One step crossing	Two step crossing
Perpendicular	59.46	30.29
Oblique	7.36	2.89
Total	66.82	33.18

Table 4.1.2 c at uncontrolled intersection

Crossing direction	Percentage of pedestrians (%)	
	One step crossing	Two step crossing
Perpendicular	76.21	1.94
Oblique	21.84	0.00
Total	98.06	1.94

Appendix e:- Pedestrian classification by their characteristic and behavior

table 4.1.2 e table at Pedestrian classification by their characteristic and behavior at roundabout

Variable	Item	frequency	percentage	Total (%)
Gender	Male	387	62.62	100.00
	Female	231	37.38	
Age	0-18	159	25.73	100.00
	19-30	192	31.07	
	31-45	228	36.89	
	>45	39	6.31	
crossing speed	<1.0	108	17.48	100.00

	1.0-1.2	294	47.57	
	1.2-1.4	147	23.79	
	1.4-1.6	42	6.80	
	1.6-1.8	9	1.46	
	>1.8	18	2.91	
Waiting time	0-9	561	90.78	100.00
	10.-19	33	5.34	
	20-29	24	3.88	
Baggage	Yes	36	5.83	100.00
	No	582	94.17	
crossing stage	one step	606	98.06	100.00
	Two step	12	1.94	
crossing direction	perpendicular	483	78.16	100.00
	oblique	135	21.84	
Crossing Mode	walking	549	88.83	100.00
	Running	69	11.17	
No. of pedestrian	Alone	486	78.64	100.00
	Group	132	21.36	
Disability	yes	0	0.00	100.00
	NO	618	100.00	
Mobile usage	Yes	9	1.46	100.00
	No	609	98.54	
Crosswalk utilization	Yes	330	53.40	100.00
	No	288	46.60	

table 4.1.2 d table at Pedestrian classification by their characteristic and behavior at uncontrolled intersection

Variable	Item	frequency	percentage	Total (%)
Gender	Male	582	54.24	100.00
	Female	491	45.76	
Age	0-18	161	15.00	100.00
	19-30	217	20.22	
	31-45	457	42.59	
	>45	238	22.18	
crossing speed	<1.0	29.00	2.70	100.00
	1.0-1.2	219	20.41	
	1.2-1.4	338	31.50	
	1.4-1.6	320	29.82	
	1.6-1.8	104	9.69	
	>1.8	63	5.87	
Waiting time	0-9	739	68.87	100.00
	10.-19	234	21.81	
	20-29	66	6.15	
	30-39	21	1.96	
	40-49	6	0.56	
	50-59	4	0.37	
	60-69	1	0.09	
	70-79	2	0.19	
Baggage	Yes	13	1.21	100.00
	No	1060	98.79	
crossing stage	one step	717	66.82	100.00
	Two step	356	33.18	
crossing direction	perpendicular	963	89.75	100.00
	oblique	110	10.25	
Crossing Mode	walking	957	89.19	100.00

	Running	116	10.81	
No. of pedestrian	Alone	1020	95.06	100.00
	Group	53	4.94	
Disability	yes	2	0.19	100.00
	NO	1071	99.81	
Mobile usage	Yes	3	0.28	100.00
	No	1070	99.72	
Crosswalk utilization	Yes	987	91.99	100.00
	No	86	8.01	

Appendix f:- Descriptive statistics for Crossing Speed

Table 4.2 b Descriptive statistics for Crossing Speed at uncontrolled intersection

No.		618
Mean speed		1.17
95%confidence interval	Lower	1.15
	Upper	1.19
Median		1.13
Variance		0.06
standard Deviation		0.24
Minimum		0.78
Maximum		2.07
Range		1.29
15th percentile		0.87
50th percentile		1.04
85th percentile		1.26

Table 4.2 c Descriptive statistics for Crossing Speed of roundabout

No.		1073
Mean speed		1.38
95%confidence interval	Lower	1.37
	Upper	1.39
Median		1.35
Variance		0.06
standard Deviation		0.24
Minimum		0.70
Maximum		2.34
Range		1.65
15th percentile		1.02
50th percentile		1.27
85th percentile		1.51