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Addis Ababa Institute of Technology

School of Civil and Environmental Engineering

Assessment of Pedestrian's Road Crossing Behavior on Selected Road Segments in Addis Ababa

By

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UNDERTAKING

I declare that this thesis entitled, Assessment of Pedestrian's Road Crossing Behavior on Selected Road Segments in Addis Ababa, is my original work performed under the Supervision of my research main advisor Dr. Bikila Teklu and co. advisor Engr. Emnete Tadesse and has not been presented for a degree in any other university, and that all sources of materials used for this thesis have also been acknowledged.

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ABSTRACT

The injuries and fatalities of pedestrians increases time to time in Ethiopia. This is due to either human, environmental, or engineering factors. The interaction between drivers and pedestrians has a great role to minimize accidents. However, the illegal crossing and movement of pedestrians and the driver faults cause life losses on pedestrians. To reduce the pedestrian injury and fatalities, finding out the pedestrian road crossing behavior is important. This study focused on digging out the pedestrian's behavior at three selected road segment on the selected road section in the capital city of the country and models are prepared by correlating the behaviors with human factors and speed of the pedestrians during crossing.

The study focused on human factors that influence utilization of crosswalk and crossing speed. The road crosser data is collected by video recording for the sake of its convenience. Road crosser behaviors are extracted manually then used for analysis.

Three road segments of 15 m length with zebra marked crosswalks are taken as a representative and the data recorded in three different working days. The data collected for two times per day to represent the high and low pedestrian movements. The duration for recording and observation was 15 minutes.

There are 494 pedestrians observed while crossing illegally from 1350 road crosser pedestrians. These constitute 37% of the total road crosser within 15m road segment. The extracted data from video is used for analysis by SPSS 25 to determine the influence of human factors on crosswalk utilization and crossing speed on 323 pedestrians. The human factors don't influence the crosswalk utilization preference of pedestrians. The analysis result shows human factors such as gender, number of elders, crossing group, activities and baggage has significant influence on the road crossing speed. Number of children and waiting time have no significant influence on crossing speed. A model developed for crossing speed is: CRspeed = 1.413+ 0.088Gn -0.116El – 0.11Csize – 0.039talk-0.072talkmob – 0.133redtex + 0.054Bagg.

Keywords: pedestrian's behavior, road crossing speed, road segment, crosswalk utilization

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ACRONYMS AND ABBREVIATIONS

ECA:	Economic Commission for Africa
OAU:	Organization of African Union
WHO:	World Health Organization
E.C:	Ethiopian Calendar
PMDs:	Personal Music Devices
SPSS:	Stastical Package Software for Social since
MLR:	Multiple Linear Regression
BLR:	Binary Logistic Regression
OR:	Odds Ratio
ANOVA:	Analysis of Variance
HCM:	Highway Capacity Manual
AATA:	Addis Ababa Transport Authority
P:	Pearson correlation

CHAPTER ONE

INTRODUCTION

1.1 Background

Addis Ababa is the capital and largest city of Ethiopia. It has a population of 3,384,569 according to the 2007 population census, with annual growth rate of 3.8%. This number has been increased from the originally published 2,738,248 figure and appears to be still largely underestimated. Which is located at at an elevation of 2,300 meters (7,500 ft) and is a grassland biome located at 9°1′48″N 38°44′24″ECoordinates: 9°1′48″N 38°44′24″E. The city lies at the foot of Mount Entoto and forms part of the watershed for the Awash. From its lowest point, around Bole International Airport, at 2,326 meters (7,631 ft.) above sea level in the southern periphery, the city rises to over 3,000 meters (9,800 ft.) in the Entoto Mountains to the north. As a ,Addis Ababa has the status of both a city and a state .[http://www.newgeography.com/content/003203-the-evolving-urban-form-addis-abeba]. It is where the African Union is and its predecessor the OAU were based. It also hosts the headquarters of the United Nations Economic Commission for Africa (ECA)and numerous other continental and international organizations. Addis Ababa is therefore often referred to as "the political capital of Africa" for its historical, diplomatic and political significance for the continent .

Now a day's population of Addis Ababa increases and movement of the people increases significantly. The reason is due to urbanization and better job opportunity attracts the people towards the capital city. Due to this reason the number of road users increases and it needs better facilities and transportation services. Since most of the peoples are categorized under low income workers, they use walking to do certain activities and moving from place to place. When they are walking on side of road way and crossing the road section its common seeing peoples who use the road illegally. The intervention between drivers and pedestrians is a basic phenomenon, especially in urban section, since the number of vehicles and pedestrian increases comparing to rural section. The pedestrian's safety is the main concern and the interaction between drivers and roads users' needs emphasis. There are many pedestrians observed when crossing the road illegally. This is due to either design factor, human factor, behavioral, environmental factor or a combination of them. Identifying the crossing behavior of pedestrians at selected road segment has been the main task of this research.

Walking is one means of trip and highly recommended for being healthy. Also walking has many advantages in large cities. Because it can reduce the use of vehicles and then reduces traffic congestions and air pollution due to vehicles emission. Addis Ababa city administration and transport office also highly encourage walking and using bicycle for short trips through medias.

According to WHO 2013, Walking has well established health and environmental benefits such as increasing physical activity that may lead to reduced cardiovascular and obesity-related diseases, and many countries have begun to implement policies to encourage walking as an important mode of transport. Unfortunately, in some situations increased walking can lead to increased risk of road traffic crashes and injury.

The city (Addis Ababa) has two basic road safety targets as presented by Daniel Molla,2017. The first one is by 2023, the city will halve (reduced by half) the number of deaths and injuries from road traffic crashes and the second target is by 2030, provide access to safe, affordable, accessible and sustainable transport systems for all.

1.2 Statement of the problem

Most of the time pedestrians walk along the roadway and cross the road illegally. WHO (2013b) confirmed that about 88% of the road network in developing countries, including Ethiopia, are constructed without pedestrian footpaths.

Although the mobility of people and motorization has increased in Ethiopia due to the economic advancement achieved in recent years; the adverse consequences of pedestrian crashes have become a more apparent problem. As a developing country, the problem of pedestrian crashes is severe. For instance, 1,296 pedestrians were killed and 3,003 pedestrians were injured during 2008/09 (2001 E.C.) in Ethiopia (Federal Police Commission of Ethiopia, 2010). Moreover, fatal crashes involving pedestrians comprised 50% of the total fatal crashes in the country and 35% of the injuries. According to the World Health Organization (2009), pedestrian fatal crashes accounted for 55% of deaths that occurred amongst road users in 2007. This may either due to human factor, design factors and vehicle factor.

According to Jiregna Hirpa,2017 The highest number of crashes and injuries in Addis Ababa occurred at mid-block section of the city than any other junction. About 86% of the victims were pedestrians. The main reason associated with this crash are pedestrian's improper usage of the road and drivers speed.

Although these pervious works present different injury and fatal reports on pedestrians and the pedestrians during road crossing, there is no study on the road crossing behaviors of pedestrian at road segments (Mid-blocks) in Addis Ababa till today. Hence crosswalk utilization and pedestrian crossing speed and modeling the crossing speed is the main target of the study.

1.3 Research questions

- ✓ What are the human factors that affect crosswalk utilization on mid-block segment?
- ✓ What are the human factors that affect crossing speed?
- ✓ What is the predicting model developed for crossing speed?

1.4 Objectives

1.4.1 General objective

The general objective of this research is to assess the road crossing behavior of pedestrians at selected road segment in Addis Ababa city roads.

1.4.2 Specific objectives

- To determine the effect human factors on crosswalk utilization on mid-block segment.
- To determine the effect of human factors on crossing speed.
- To develop a predicting model for pedestrian crossing speed

1.5 Scope of research

This research focused on high traffic volume roads of the capital city of Ethiopia, Addis Ababa and mainly focused on assessing road crossing behavior of pedestrian at three selected road segments. Although illegal road crossing and unsafe road crossings are common in many large cities and regions of the country this study is limited to this selected area. The study considered only human factors affecting crosswalk utilization as well as crossing speed determination. The data collection method is video recording due to its convenience and reliability.

1.6 Significance of the study

Since accidents on pedestrian during road crossing is increasing from time to time it's necessary to identify the problems on the pedestrian's side. Although other factors like drivers, design factors and the environment have their impact for the contribution for these accidents. Pedestrian are the main elements as a risk taker. So, identifying the safe and the unsafe crossing behaviors help pedestrian to minimize the severity and exposure for accident. This study helps the government and the road client for design and management of cross walk facilities.

Also, this research is used for urban planning and future research works by using as a reference and input information. The model is used for crossing speed value determination and comparative study.

1.7 Structure of the research

The research has five broad chapters. The first chapter is talking about the introduction part and consists background of the study, scope of the study, main objectives and specific objectives and significance of the study. The second chapter is review of literatures that are related with this research work and the research area. The third chapter talks about the methodology of the study. In this chapter the methods and details about variables and study locations, way of data collection. The fourth chapter consists the results and discussion of the study. The result is designed to answer the main and specific objectives. The final chapter draws conclusion and recommendation based on the results and discussions.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter comprises review of pervious works related to pedestrians and road crossing behaviors of pedestrians. From this study crossing behavior of pedestrian and cause of illegal crossings are presented. Also, the literature includes reviewing of related articles and their method of data collection and analysis.

2.2 History of accidents in Ethiopia

The crash history in Ethiopia and the capital, Addis Ababa, are studied and the possible causes, the crash locations, crash injury severities, road usage and most of the victims are presented by pervious works.

2.2.1 Crash history

Getu S. Tulu et al. (2013) studied on Characteristics of Police-reported Road Traffic Crashes in Ethiopia over a Six Year Period. The study was from July 2005 - June 2011 consisting of 12,140 fatal and 29,454 injury crashes on the country's road network. The 12,140 fatal crashes involved 1,070 drivers, 5,702 passengers, and 7,770 pedestrians, totaling 14,542 fatalities, an average of 1.2 road user fatalities per crash is reported. From this report more than half of the fatalities in Ethiopia involve pedestrians. During the six years, pedestrian collisions comprised an average of 48.55% of fatalities, while rollovers accounted for 17.34%. For injuries, the respective figures were 53.16% and 17.17%. According to the study failing to observe the priority of pedestrians and speeding were the major causes of crashes attributed by police. "The majority of crashes occurred during daylight hours. Crashes increased rapidly from 6:00am to 7:00am. Numbers were more or less steady until 8:00 pm after which they declined in most cases, though not as steeply as the morning increase. It can be seen that the change in volume by time of day is similar to the change in crashes" .

The study by Jiregna Hirpa shows most affected road users are pedestrians and accounts for 86% of the total crash injuries. From this more than 60% of the fatal data analysis shows adult age groups (18-50 years old). The majority of crashes occurred at major roads and mid-block segments (out of junction) and the cause is identified as pedestrian's conflict with vehicles. The reason for this is unsegregated vehicular and pedestrian traffic and uncontrolled vehicular speed. About half of the crashes were happened on roads that are median divided. Median divided roads are mostly major roads. Out of the locations with worst fatal crash record (more than 2.5 average fatalities in a year), 50% of them are on the ring roads. Almost all of crash spots where more than 2 average fatalities happened in a year are located on main roads; specifically, on primary arterials and ring roads. Hence, major roads have high frequency of fatal crashes

2.2.3 Road safety issue in Addis Ababa

Road safety crises shows there are 400 fatalities annually, Daniel Molla ,2017. There are massive changes in population and prosperity. The city has rapid population growth of 2.5% and rapid urbanization (15% in 2005 to 24.1% in 2025). Rapid increases in motor vehicle traffic - 25% since 2009. There is very high number of pedestrian activities and very low levels of safety protection. There is also high proportion of pedestrian casualties. 88% of all fatalities were pedestrians (2010 to 2015).

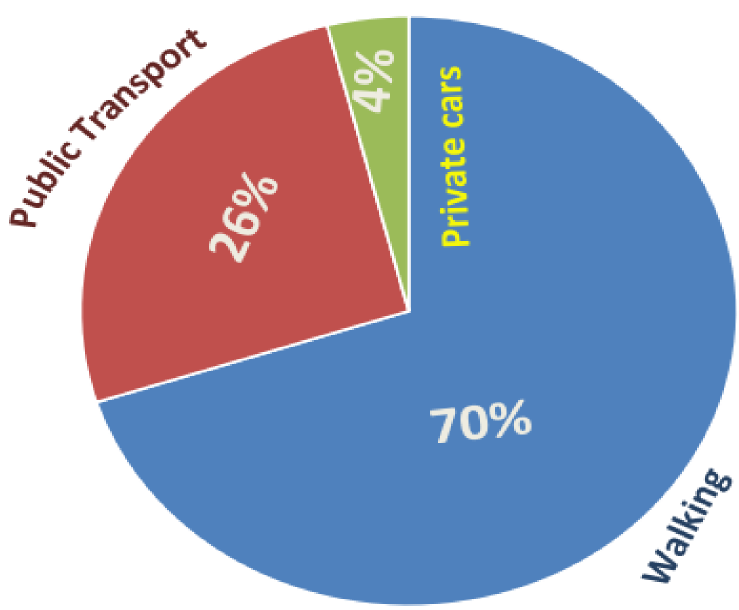


Figure 2-1: Means of transport in Addis Ababa

2.2.4 Distribution of road accidents in Addis Ababa

According Addis Ababa transport authority (AATA) accidents are increased from year to year and so different day by day. Saturday is the day of the week which most the accidents occurred. From the five working days (Monday to Friday) Friday has most accidents. The road accident data and frequency are presented from 2003 E.C TO 2007 E.C by AATA as shown in figure 2.2.

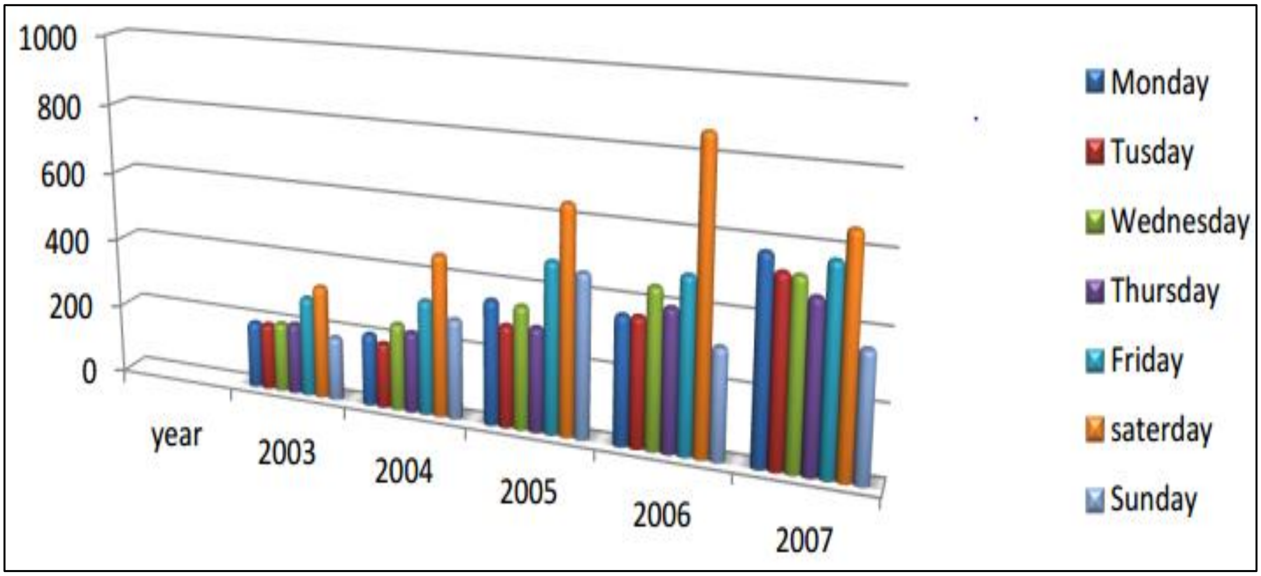


Figure 2-2: Distribution of road accident by day and year in Addis Ababa.

2.2.3 Distribution of road traffic accident by location

The location of accidents from 2003 E.C to 2007 E.C are identified based injury data and organized by AATA. The injury type and severity also identified and presented in table 2.1 for each location and year.

Table 2-1: Distribution of road traffic accident by location

Year (E.C)	Injury type	No junction	Y-junction	T-junction	Roundabout	Intersection	X-junction	Total
2003	Serious	77	4	11	17	10	15	134
	Minor	43	13	15	16	7	2	96
	property	808	139	134	160	58	38	1337
2004	Serious	158	2	6	6	0	0	172
	Minor	74	0	2	4	2	0	82
	property	897	60	40	280	400	0	1677
2005	Serious	180	18	16	16	22	4	256
	Minor	98	14	12	8	6	2	140
	property	1312	142	208	204	440	160	2466
2006	Serious	244	0	0	13	0	0	257
	Minor	141	0	0	2	0	0	143
	property	2291	0	0	280	258	0	2829
2007	Serious	266	0	0	12	10	0	288
	Minor	121	0	0	6	3	0	130
	property	2646	0	0	317	292	6	3261

As shown from table 2.1 and figure 2.3 the accident and damages are rising year to year. Most of the accidents and injuries are located on the segmental road (no junction). For the year 2003 E.C to 2007 E.C the no-junction road location accounts for highest injuries of property damages, serious injuries and minor damages.

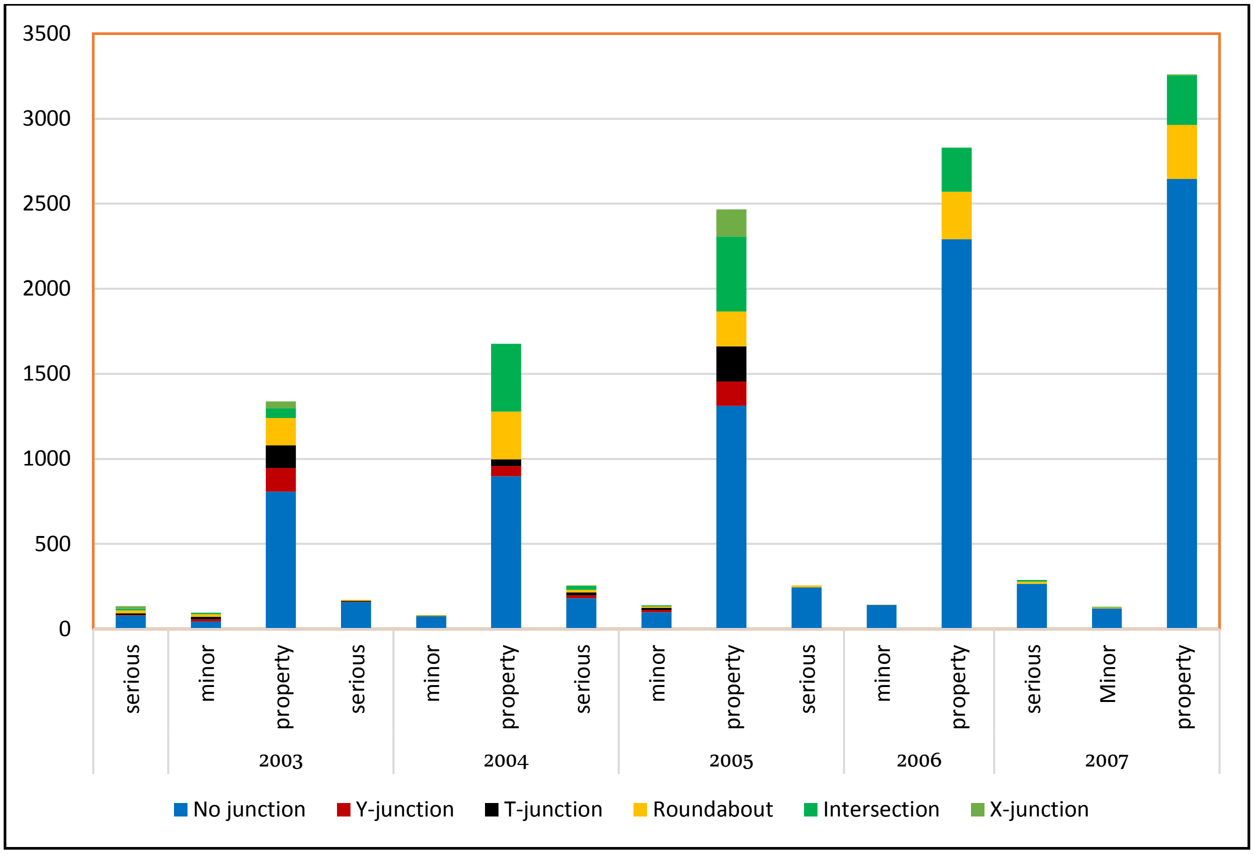


Figure 2-3: Distribution of road traffic accident by location

2.3 Pedestrian road crossing behaviors

Wickrama single and Priyankara (2011) assessed factors affecting pedestrians 'illegal road crossing behaviors. The research was conducted as two main parts; face to face interview and video survey. According to the outcome from the conjoint analysis, it gives that the most contributory for an illegal road cross is traffic condition. The range between the maximum and minimum utility values of this attribute is found to be the widest. It means when pedestrians have high potential to perform an illegal road cross when the traffic condition is at high level {i.e. more than 40veh/ min (not jammed)} and also least touching physical factor to perform an illegal road cross is side walk condition. But pedestrians will attempt to do an illegal road cross when the side walk condition is in bad condition (more than 45 people/mint/meter with Disturbance).

Deepti Muley et al. (2017) find out pedestrians' crossing behavior at marked crosswalks on channelized right-turn lanes at intersections. A total sample of 235 pedestrian observations was used for waiting behavior, crossing speed, accepted gaps, and driver yielding behavior analysis.

The results showed that the waiting behavior was independent of pedestrian characteristics and depend only on the traffic characteristics. The average road crossing speed was 1.43m/s and the gender, distraction, and group significantly affected the crossing speed. Besides, the distracted pedestrians and pedestrians crossing in groups accepted significantly larger gaps compared to undistracted and individual pedestrians. Moreover, about 15% of drivers yielded for pedestrians, yielding was irrespective of gender and mainly affected by the crossing direction. Consequently, innovative strategies in terms of engineering measures and awareness are needed to improve pedestrian safety at these locations .

Yasar I Demiroz et al. (2015) assessed the illegal road crossing behavior of pedestrians at overpass locations: Factors affecting gap acceptance, crossing times and overpass use. Data were collected at the overpasses using a video recording technique. Video cameras were fixed at the top of the overpasses to observe pedestrians crossing illegally and on the sidewalks to observe pedestrians crossing using the overpass. At four overpass locations a total of 454 (160 female and 294 male) illegal pedestrian crossings (46%) and a total of 539 (254 female and 285 male) pedestrian crossings using the overpass (54%) were observed. At overpass locations where the speed limit was 50 km/h, 254 illegal crossings were observed and at overpass locations where the speed limit was 70 km/h, 91 illegal crossings were observed totaling 345 illegal crossing. Excluding the condition where the oncoming vehicle was out of view only data from 224 pedestrians (173 illegal crossings where the speed limit was 50 km/h and 51 illegal crossings where the speed limit was 70 km/h) were analyzed. The average crossing speed of pedestrians was found to be higher in higher speed zones.

Bungum et al. (2005) assessed the relationship between distracted walking and performing routine cautionary behaviors of pedestrians crossing a busy street in a southwestern city at an intersection adjacent to a university. Trained observers recorded behaviors of 866 pedestrians as they walked across a 105-foot wide street served by a stop light and a zebra-painted crosswalk. The study found that 5.7% of the observed pedestrians crossed the street while wearing headphones or conversing on the phone, and 15.1% were eating, drinking, or smoking while in the crosswalk.

Walker et al. (2012) observed cautionary behavior (looking before crossing a road) for pedestrians with or without personal music devices (PMDs). The study found that male pedestrians listening to PMDs, displayed more looking behavior than those not listening to PMDs, while females showed no differences between the two conditions. Authors concluded that unlike cell phones, PMDs do not decrease cautionary behavior of pedestrians.

Kuzel et al. (2008b) reviewed real-world collisions involving pedestrians who were reportedly auditorily distracted. The review found that highly salient and expected roadway objects such as buses, police vehicles, and trains have been involved in collisions with reportedly distracted pedestrians at or near standardized road crossing points. The data suggested that pedestrians distracted by auditory activities, regardless of their form, may not always be sufficiently engaged in the act of crossing or walking along a street to perform the task safely.

Lichenstein et al. (2012) searched the National Electronic Injury Surveillance System, U.S. Consumer Product Safety Commission, Google News Archives and Westlaw Campus Research Databases for cases involving pedestrian distraction from 2004 to 2011. The study found 116 reports of death or injury of pedestrians wearing headphones. Of all the reports, 74% stated that the pedestrian was wearing headphones at the time of the crash and 29% mentioned that a warning was sounded before the crash. The majority of victims were male (68%) and under the age of 30 years (67%). The majority of vehicles involved in the crashes were trains (55%), and 89% of cases occurred in urban counties.

Nasar and Troyer (2013) used data from the U.S. Consumer Product Safety Commission on injuries in hospital emergency rooms from 2004 to 2010 to evaluate pedestrians' mobile phone related injuries. The study found that pedestrian injuries that related to mobile-phone usage while walking increased compared to total pedestrian injuries in 2010. Mobile-phone use related injuries for pedestrian under 31 years old were higher for males than female. It was concluded that using a mobile phone while walking puts pedestrians at risk of accident, injury or death.

The use of mobile phones and other smartphones is growing fast worldwide. An estimated 77% of the world's population have a mobile phone. While the risk of talking and texting while driving a vehicle is now well documented much less is known about walking and distraction .Since 2005, a number of studies, conducted primarily in the United States and among young adults, have been published that suggest pedestrians who are distracted by phone conversations, or other distracting activities such as listening to music or texting, take greater risks when crossing roads. These results can probably be generalized to pedestrians in other high-income countries .The contribution of distracted walking will most likely be higher in countries where there is a greater mix of traffic, less controlled crossings or where awareness of the risks is low because these pedestrians are at higher risk in the first place .A concerted, combined approach needs to be used in all countries .Hard-hitting social marketing campaigns are needed to educate pedestrians, while policy-makers and engineers need to consider alternative ways to protect those 'talking and walking', including modifying the environment.

2.4 Crossing behaviors

From this related study the pedestrian effect on the road accidents is identified (discussed under section 2.3). Although this pervious works shows injury and fatal data on pedestrians walking and crossing the road, there is no satisfactory study on the behavior of pedestrian at zebra marked crosswalk in Addis Ababa till today. Especially countries like Ethiopia with most of the people use walking to perform daily activities, the safety of pedestrians need high emphasis. So, to identify and quantify the pedestrian's exposure during road crossing is essential study.

2.4.1 Crosswalk utilization

Pedestrian crossing is a point on a road where pedestrians traverses the road. It may be found at intersections or long section of the road. Marked crosswalks are designed by marking with white strips.

From 15m road segment there is the pedestrian's choice to use or neglect the zebra marked crosswalk. Based on their utilization there are two types of pedestrians. The first type of pedestrians is legal who used the crosswalk and the second type are illegal pedestrians who didn't use the zebra marked crosswalk.

2.4.3 Pedestrian Crossing speed

Highway Capacity Manual (HCM) (2000) Suggested design crossing speed of elderly pedestrians at mid-block crosswalks and signalized intersections were 1.0 and 1.2 m/sec, respectively and 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.

Pedestrians are vulnerable road users, and they are always at risk when making their daily trips. Hence, roadway design and traffic control devices need to consider pedestrians’ safety. the Bivariate analysis shows that crosswalk type, age and gender significantly contribute to pedestrian speed in Malaysia. Chi-square test also showed that children pedestrians are the fastest group, and elderly pedestrians are the slowest group in terms of pedestrian crossing speed. Male pedestrians have significantly faster crossing speed than female pedestrians.

The crossing speed is determined by dividing the crossing distance by crossing time. The crossing time is the time taken by the pedestrian to complete the crossing path without stopping. The crossing distance is the length of the path used by the pedestrian to cross. The crossing speed is calculated from the video recordings. The crossing distance is taken as the inner two lanes for each case. The time taken by individual and group crossers, males and females, adults, children’s and elders, and with different crossing activities is recorded. Pedestrians who changed crossing path, stop, changed direction and changed crossing condition are not included in crossing speed. During pedestrian crossing time determination, the pedestrian who cross on or parallel to zebra marked crosswalk with clear visibility to the entrance and leaving of the lanes are considered.

2..5 Gaps identified from pervious works

The research works previously done in Ethiopia doesn’t emphasize the effect of pedestrians on the traffic disturbance. While pedestrian’s activity and crossing condition can affect the traffic condition and the overall safety of the pedestrians, none of this research gives what exactly the pedestrian activity can contribute the traffic risks in Ethiopia. Internationally there are some researches to model pedestrian behaviors, like pedestrian gaps, crossing utilization and speeds but in the case of this country there are no research to model the pedestrian behavior. However pedestrian crashes and jay waking is commonly observed. So it’s a must to identify and model the pedestrians activity and crossing conditions to consider the effect of pedestrians n the traffic movement.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents and describes the approaches and techniques the researcher used to analysis data and investigate the research problem. They include the research design, study population, sample size and selection, sampling techniques and procedure, data collection methods, data quality control (validity and reliability), procedure of data collection and data analysis

3.2 Study area

The research study area is on a road segment of Addis Ababa, the capital city of Ethiopia, Which is located at an elevation of 2,300 meters (7,500 ft) and is a grassland biome, located at 9°1′48″N and 38°44′24″E Coordinates with an estimated area of 527km^2 ,(Google earth). The selected road segments represent the pedestrian volume area and random crossing. The study location (mid-block segment) is chosen because of its high crash recorded data as stated in section 2.2.1 and 2.2.4 and most of the crashes occurred in major roads of the city.

3.3 Study design

The major steps involved in this study are: (1) selection of suitable site for field survey (2) selection of observation time (3) field data collection (4) data extraction (5) analysis of pedestrian data (6) model development for pedestrian road crossing behavior (7) discussion on results.

During road crossing pedestrian may or may not use the zebra marked cross walk. Also, pedestrian may do different activities that increase exposure of accidents and may affect the traffic flow when they are crossing such as talking with mobile phones, hugging, talking, eating and others that take their concentration on the crossing time or approaching car. From this study the effect of demographic characters (age and gender), pedestrian volume, activities of pedestrian (mobile usage), and crossing pattern (alone/group crossing) on crossing speed and crosswalk utilization are studied.

The data is analyzed and interpreted using both descriptive (case reports and case series, Ecological studies, cross sectional study) and analytical methods approach. These major steps are shown below in figure.

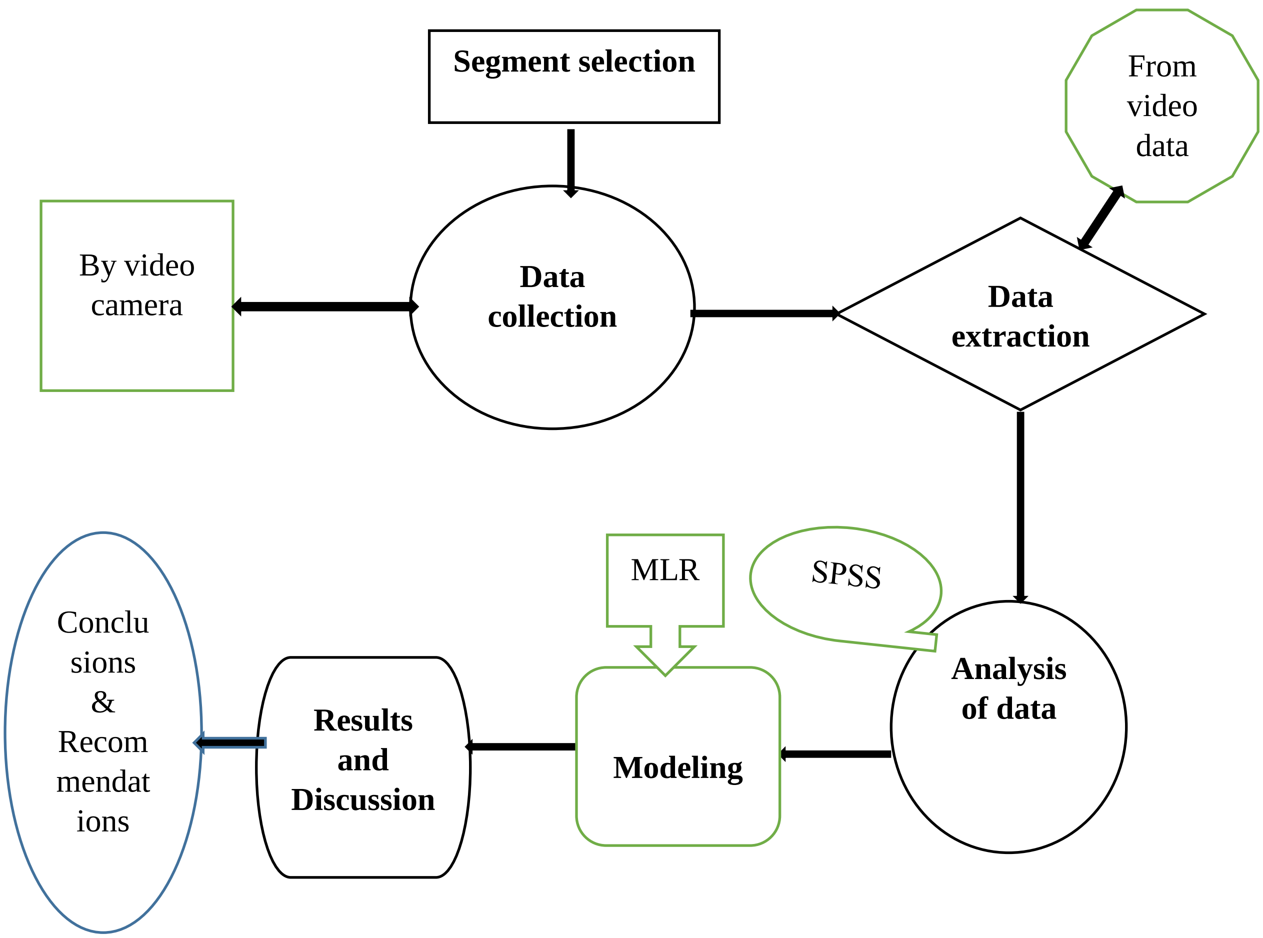


Figure 3-1: Research design

3.4 Study Population

The study populations are road users such as road crosser pedestrians on the selected segments.

3.5 Data collection

Even if most of the required data were quantitative, somehow qualitative date are also collected through this research study. The collection of the relevant information for this study have been started from deciding the title and identifying the problem. The data were collected with minimal expenditure of effort, time and money. The data collecting technique was done mainly by video recording, and observation.

3.5.1 Video recording

This data collection is the most reliable and has high significance of avoiding errors of counting pedestrian when they cross the road. The video cameras are fixed at convenient locations to record the pedestrian and vehicles data clearly. Pedestrian who use and not use zebra walk are recorded. Waiting and crossing pedestrian are recorded with video.

Video recording is the most reliable and carful method because data can be viewed by slowdown and replayed when necessary. Reducing the number of characteristics being recorded by the observer may improve count accuracy. In addition, because most data collectors are subject to fatigue and errors [17].

3.5.2 Visual Observation

This type of data collection technique is also primarily and it is directly by observing the conditions on the selected road segments. In this case different conditions observed number of lanes, crossing distance, fencing condition of pedestrian and choice of crossing section. Factors affecting pedestrian crossing behaviors and pedestrian-vehicle interaction will be identified. Crossing length of the road measured in the field of the

3.5.3 Types of data

The data type that are collected in this study is primarily data. This are pedestrian with safe and unsafe crossing, pedestrian who crosses on zebra, waiting pedestrian and vehicles and vehicle. The data that are obtained from the camera recording and observations have two main categories, General and individual.

a. General characteristics
    - pedestrian behavior (alone/group crossing)
    - Pedestrian volume

b. Individual characteristics

- Gender
- Age of pedestrian
- Pedestrian crossing path
- Pedestrian crossing speed and time
- Crossing condition (talking cellphone, stopping, stepping back, changing speed and path)
- Crossing location/cross walk utilization
- Pedestrian-vehicle interaction

3.6 Study variables

In this thesis, the variable to be studied are pedestrian crossing speed, demographic characters, waiting time of pedestrian, activities of pedestrian during crossing. From this study the effect of demographic characters (age and gender), pedestrian volume, road type and geometry, traffic volume, activities of pedestrian (mobile usage), and crossing pattern (alone/group cross) on crossing speed are studied. The pedestrian age, gender, crossing pattern, were considered as the independent variables and crossing speed and crosswalk utilization was considered as the dependent variable.

3.6.1 Dependent variable

The dependent variables in this study are pedestrian crossing speed and crosswalk utilization preference.

3.6.2 Independent variables

The independent variables in this study are pedestrian age, pedestrian gender, pedestrian volume, waiting time, pedestrian activities and pedestrian crossing pattern.

3.7 Observational location selection

In this study strategical sampling method is used to select different location. The observation is taken considering well-marked crosswalk(zebra) with unfenced segments, the selected areas were convenient for video recording and enhance clear observation of group and individual characteristics of the road crossers. Also, they represented different number of lanes as well as traffic volume. The possibility of illegal crossings also different. To get clear and identify the face and behavior of pedestrian 15m length of this segment is used for analysis from three road segments selected for data collection. This location has chosen by stratified techniques by. On a similar study in India by B Raghuram and P Vedgari on modelling pedestrian behavior under mixed traffic condition from the selected 135m mid-block segment only 15m is used for analysis. The selected sites have different road characteristics and pedestrian conditions. The convenient place for camera fixing and description of the sites are stated below.

3.7.1 Near to Wabi-Shebele Hotel (M-2)

This site has six lanes (3 in each direction) and pedestrian island at the middle. It has fenced segment in one direction and unfenced segment with median in the other direction.

Figure 3-2: Road segment near to Wabi-Shebele Hotel

3.7.2 In front of Mexico Square(M-1)

The location has six lanes (3 in each direction) and zebra marked cross walk with wider median (1 m). High pedestrian volume observed. The video camera was fixed at ground. Flat terrain without fenced median.

Figure 3-3: In front of Mexico square

3.7.3 Near to Bunana shay building (M-3)

This location has high number of pedestrians to cross the road. The road has two lanes in each direction and a narrow median of 0.5 m width. There is possibility of illegal movement in both direction of the crosswalk.

Figure 3-4: Near to Bunana shay building

3.8 Observation Time

There were two different stages of data collection time for each site. This was to represent the high pedestrian movement and the low pedestrian movement. This was to examine the pedestrian behaviors on different scenarios and when the speeds of vehicles were high and low. For both cases the observation duration was fifteen minutes (a total of 1h hour and 30 minutes). The data is collected under normal weather condition (sunny, no rain). pedestrian volume and behavior obtained during this time is used for analysis. Based on previous studies on the area the majority of road crash accidents occurred in the two working days of the week (Monday and Friday) as described by section 2.2.1 and 2.2.4 so this two day are preferred for data collection.

Most related research works followed similar procedure of survey time and analysis method. Pengefei LI., et al., 2013 studied Pedestrian crossing behavior at unsignalized mid-block crossing around primary school. The filming periods were from 7:00 am to 8:00 am, when a majority of children were travelling to school. The weather conditions were the same in all time periods. It was sunny and no wind with the temperature of 230 to 260.

3.9 Crosswalk utilization

From 15m road segment there is the pedestrian's choice to use or neglect the zebra marked crosswalk. Pedestrians have many reasons to use or not use the crosswalk. This may be human factor or design factors. Based on their utilization there are two types of pedestrians. The first type of pedestrians is legal who utilized the crosswalk and the second type are illegal pedestrians who didn't utilize the zebra marked crosswalk.

Figure 3-5: Crosswalk utilization

3.10 Demographic characteristics

Demographic characters basically include gender and age groups. Gender includes men and female. The crossing speed is determined for male and female pedestrian. Age is grouped in to three categories. Children aged less than 18, adults from 18 to 60 and elders who are older than 60 years. Their age is estimated from their facial expression, physical appearance and walking structure. Facial texture and physical appearance are used to estimate the age category of pedestrian. Observers were close enough to the crossings to note these surface and configuration characteristics and make an age estimation based on observation of the pedestrians.

3.11 Pedestrian crossing speed

The crossing speed is determined by dividing the crossing distance by crossing time. The crossing time is the time taken by the pedestrian to complete the crossing path without stopping. The crossing distance is the length of the path used by the pedestrian to cross. The crossing speed is calculated from the video recordings. The crossing distance is taken as the inner two lanes for each case. The time taken by individual and group crossers, males and females, adults, children's and elders, and with different crossing activities is recorded. Pedestrians who changed crossing path, stop, changed direction and changed crossing condition are not included in crossing speed. During pedestrian crossing time determination, the pedestrian who cross on or parallel to zebra marked crosswalk with clear visibility to the entrance and leaving of the lanes are considered.

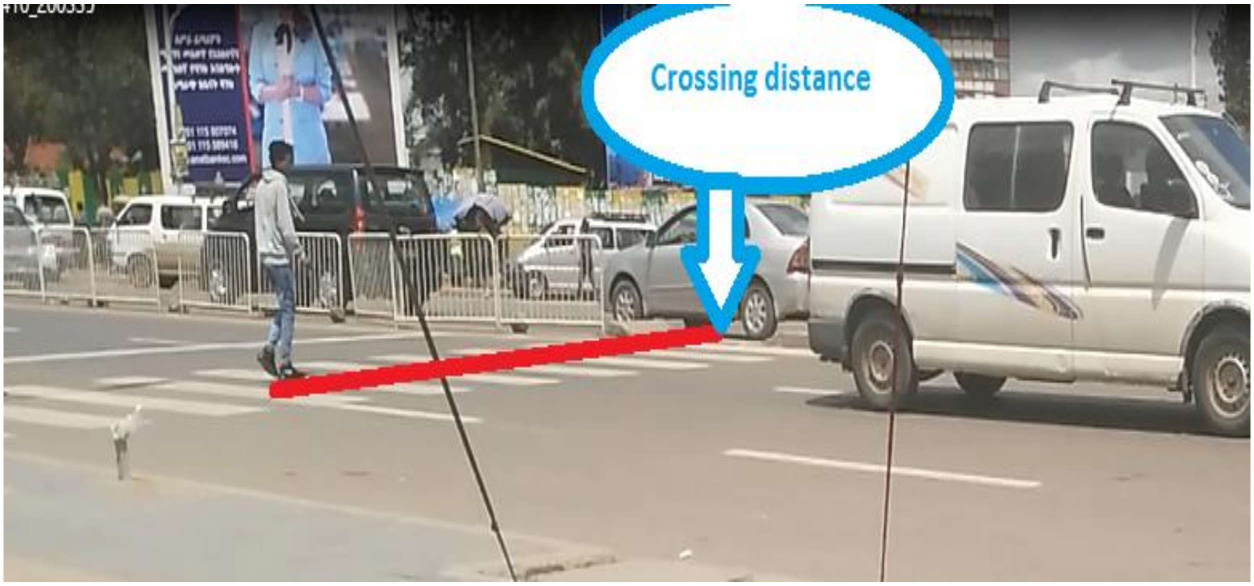


Figure 3-6: Pedestrian crossing distance

3.12 Pedestrian crossing condition

Pedestrians can cross road alone or in group. when two or more pedestrians cross the road together is considered as group crossing. A single crosser is taken as alone crosser.

Figure 3-7: Crossers group

3.13 Pedestrian crossing activities and bagging

During road crossing pedestrians may involve in different activities. Activities observed are talking mobile phone, texting or reading, bagging or caring, etc. These activities of pedestrians may affect the crossing speed, cross walk utilization preference and vehicle-pedestrian interact.

Activities are one of the main human factors that influence the crossing speed significantly. Internet browsing, texting and emailing while crossing affect pedestrians speed [18]. Also, cell phone usage, taking, reading text can influence the crossing speed and reduce attentions of pedestrians while crossing [21,22,23].

Figure 3-8: Pedestrians involved in activities and baggage

3.14 Waiting time

Before entering to the crosswalk or at the mid-block pedestrians wait the coming vehicle. This time depends on the approaching vehicle speed and the traffic volume. The waiting time is recorded using stopwatch for individual pedestrians and the average time is recoded.

Figure 3-9: Waiting at mid-block

3.15 Age estimation process

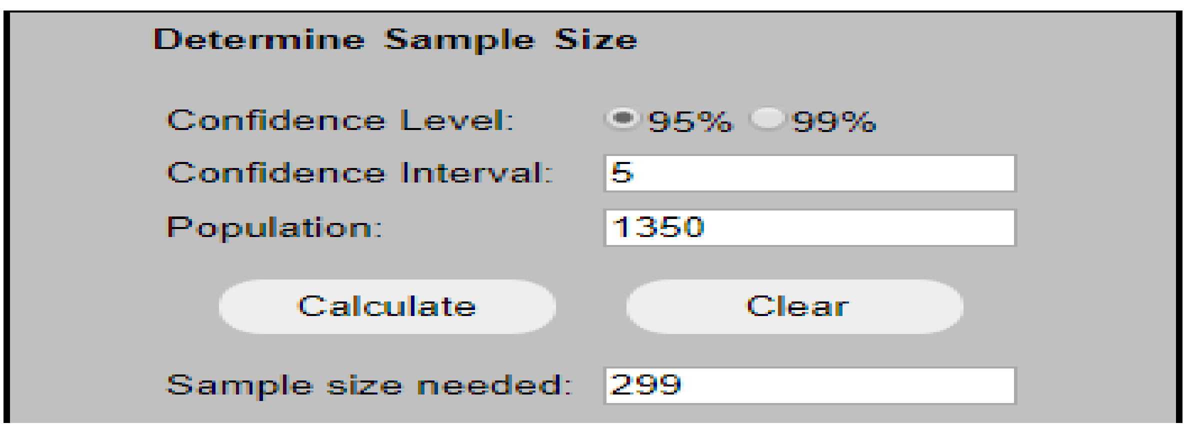
From the video age is estimated by looking facial observation and physical appearance of pedestrian. Because ages can be predicted to a particularly high degree of accuracy within the age range of 20-60, this method was justified by past research.

According to Pittenger,1975, Rhods,2009 and Sorqivist,2007, an average age estimation of an unknown person based on facial characteristics has been shown to have 2.39 years of deviation and 2.83 years of deviation the 5-year increments in which age estimations were made were therefore warranted by this past research .

For the case of this study age group is classified in to three age intervals (i.e., <18 years-children, 18-50 years-middle age (adult) and > 50 years-elders). This age grouping may have high accuracy than the literatures observed because the interval range is higher hence had less degree of errors.

3.16 Sample size determination

To represent the total population who crosses the road segment a sample size is calculated from online sample size calculator (https://www.surveysystem.com/sscalc.htm) for a confidence interval of + 5. Based on this sample size calculator from 1350 population a minimum of 299 road crossers can represent the total population. Hence for this study there are 323 road crossers behaviors have been analyzed. However, the samples analyzed are based on purposive sampling technique.



3.17 Data analysis

The qualitative and quantitative data (material) that obtained from data collection process be analyzed by statistically or descriptive analysis method. For the quantitative analysis a logistic regression conducted to model the relationships between dependent variables and several independent variables covering the characteristics of drivers, pedestrian, and the environment. IBM SPSS 25 software and Microsoft excel 2016 used with statistical and mathematical modeling.

3.17.1 Variables and coding

The dependent and independent variables are coded to use in SPSS software. Gender, age, crossers size, activities during road crossing and bagging or carrying are discrete variables. Crossing speed and waiting time are continuous variables.

Table 3-1: Description of variables and coding

Variables	Description	Coding	Symbol	Types of variable
Gender	Male or female	0=female 1=male	Gn	Discrete
Age	Child (<18 years) Adult (18 to 50 years Elder (> 50 years)	0=child 1=adult 2=elder	Age	Continues
Crosswalk utilization	Pedestrian cross on zebra or not	0=yes 1=no	Utz	Discrete
Activity	Activities of pedestrians while crossing	0=none 1=talking 2=talking mobile 3=reading or texting	Act	Discrete
Crossers pattern	No pedestrians crossing together or alone	0=alone 1=group	CRsize	Discrete
Bagging	Caring or bagging	0=yes 1=no	Bagg	Discrete
Crossing speed	Pedestrians crossing speed(m/s)	Numeric	CRspeed	Dependent variable
Waiting on side	Waiting for a clear space on side of road (sec.)	Numeric	WaitS	Continuous
Waiting on mid-block	Waiting for a clear space on mid-block of road(sec.)	Numeric	WaitM	Continuous

Categorical predictor variables cannot be entered directly into a regression model and be meaningfully interpreted, some other method of dealing with information of this type must be developed. In general, a categorical variable with n levels will be transformed into n-1 variables each with two levels. For example, age has three levels, hence it has two dichotomous variables could be constructed that would contain the same information as the single categorical variable. Similarly, activity has four levels hence it has three dichotomous variables. Dichotomous variables have the advantage that they can be directly entered into the regression model. The process of creating dichotomous variables from categorical variables is called dummy coding. These variables have the advantage of simplicity of interpretation and are preferred to correlated predictor variables.

3.17.2 Multiple Linear Regression model (MLR model)

A multiple regression model is a regression model that contains more than one regressor variable. The MLR model is useful for finding out the crossing speed of pedestrians. The study by B. Raghuram and P.Vedgari on modelling pedestrian behavior under mixed traffic condition, MLR is developed to get the accepted gap. The pedestrian may reject a greater number of available small gap size values and they may accept higher gap size values. To include a categorical variable with more than two level in a multiple regression prediction model, additional steps are needed to ensure that the results are interpretable. These steps include recoding the categorical variable into a number of separate, dichotomous variables.

To develop the crossing speed model, a log normal regression was selected by considering that pedestrian human factors which followed a normal distribution.

The general model framework is given below:

$$\text{Crossing speed} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots\ldots\ldots\ldots + \beta_n X_n \quad \ldots\ldots\ldots \; 3.1$$

Where;

X_{i-n}= explanatory variables;

B_{i-n}= are estimated parameters from the model;

β_0= constant

n = number of independent variables

3.17.3 Binary logit model (BLM)

To identify the significance influence factors on pedestrian crossing behavior, a one-way analysis of variance (ANOVA), Pearson's correlation coefficients and pedestrian t test will be first performed. Further analysis will be performed by developing a logistic regression model used to describe the effect between two groups. Logistic regression measures the relationship between dependent variable and independent variables. The probability of selecting alternatives can be expressed by a utility function given by equation 3.2. in this study the probability of pedestrians to utilize zebra marked crosswalk or not utilize can be checked by a binary logit model.

$$\mathbf{U_i = a_i + B_{i1}X_1 + B_{i2}X_2 + B_{i3}X_3 + \ldots + B_{in}X_n} \quad \ldots\ldots 3.2$$

Where:

U_i = utilization of alternative i

i = the alternative (utilize / not utilize)

X= the independent variable

a = constant

B = coefficients

n = number of independent variables

The probability of utilizing the crosswalk then can be determined by the equation given in 3.3

$$\mathbf{P(i) = 1/[1+\exp(-U_i)]} \quad \ldots\ldots 3.3$$

Where P(i) is the probability of selecting alternative i

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Crosswalk utilization

Pedestrians have two alternatives to cross the road. These alternatives are either using zebra marked crosswalk or without using the crosswalk (Illegally). The human factors that affect the choosing of the alternatives are studied in this research. The probability of utilization of the crosswalk also determined. The effect of demographic factors, group size, activities and bagging or carrying has been studied in this research.

Table 4-1: Crossing preference of pedestrian high pedestrian movement

Site	Type of crossing	Total no
M-1	Illegal	87
	On zebra	274
M-2	Illegal	55
	On zebra	114
M-3	Illegal	179
	On zebra	208

Table 4-2: Crossing preference of pedestrian low pedestrian movement

Site	Type of crossing	Total no
M-1	Illegal	62
	On zebra	102
M-2	Illegal	33
	On zebra	60
M-3	Illegal	78
	On zebra	98

From table 4.1 and 4.2 its observed that many pedestrians are engaged in illegal crossing (not utilize zebra). There are 494 pedestrians observed while crossing illegally from 1350 road crosser pedestrians. These constitute 37% of the total road crosser within 15m road segment. The human factors that contribute to the illegal movement are analyzed by binary regression analysis.

Table 4-3: Binary logistic regression analysis result for crosswalk utilization

Variables in the Equation							
		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1[a]	Gn	-.088	.278	.100	1	.751	.916
	CRspeed	.333	1.318	.064	1	.801	1.395
	CRsize	-.264	.320	.683	1	.408	.768
	NBagg	-.002	.272	.000	1	.993	.998
	Child	.150	.464	.105	1	.746	1.162
	Adult	-.252	.350	.518	1	.472	.777
	None	.622	.584	1.137	1	.286	1.864
	Talking	.236	.623	.144	1	.705	1.266
	talking mobile	.717	.615	1.359	1	.244	2.049
	WaitS	-.017	.073	.058	1	.810	.983
	WaitM	-.151	.068	4.912	1	.027	.860
	Constant	-.573	1.656	.120	1	.729	.564
a. Variable(s) entered on step 1: Gn, CRspeed, CRsize, Bagg, child, adult, none, talking, talking mobile, WaitS, WaitM.							

From SPSS analysis of binary logistic regression for alternatives to utilize or not utilize the crosswalk is obtained as presented on table 4.3. Then from the analysis the independent variables with Pearson significant (p value) less than 0.05 are taken as significantly influence the utilization and greater than 0.05 are not significant values.

All human factors such as gender, age, number of crossers, activities and baggage of pedestrians can't influence the preference of crosswalk utilization. So, the studied behaviors or human factors doesn't affect the crosswalk utilization. This means whether the pedestrian is male or female, child, adult or elder, alone or group crosser, involved in activities or not or has baggage or without baggage the utilization and preference of the crosswalk is not influenced.

4.2 Factors affecting crossing speed

Crossing speed is one of the main factors that affect the design and management of the crosswalk. The crossing speed is extracted and categorized by age group, gender, crossing group, activities during crossing and bagging or carrying.

4.2.1 Crossing speed at each segment

The video recording is done for three road segments representing different conditions as stated in section 3.11 the total number of pedestrians observed in 15-meter road segment (including the crosswalk) for 15 minutes are presented in figure 4.1 to 4.6 with the number of pedestrians used for analysis. Pedestrians chosen for analysis is not randomly but in purposive way. pedestrians must follow straight path and normal walking (not running or changing path) are selected for analysis. Pedestrians covered by vehicles and other pedestrians are also excluded from analysis. The number of pedestrians taken for analysis is greater than 20% of the total observed pedestrians for all independent variables and road segments.

The analysis result from MLR of SPSS 25 is presented with Pearson significant coefficient and p value. The effect of independent variables on the crossing speed (dependent variable) is determined for each road segment.

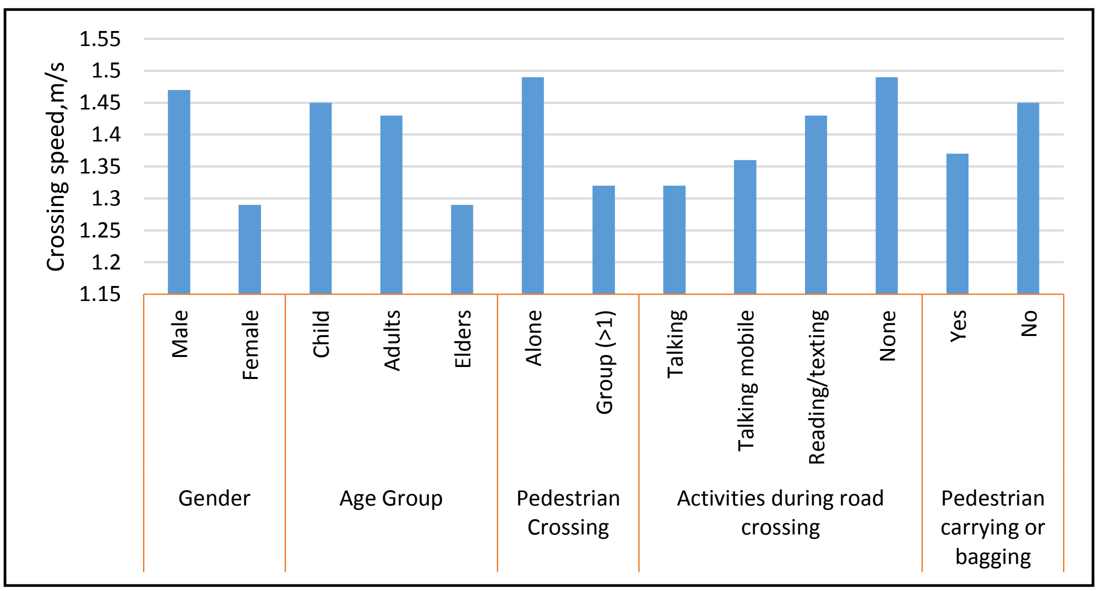


Figure 4-1: Pedestrian behavior data of high pedestrian movement at M-1

Table 4-4: Multiple linear regression analysis result with SPSS 25 at M-1 high pedestrians

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.379	.063		22.027	.000
	Gn	.107	.024	.385	4.472	.000
	Utz	.014	.025	.050	.563	.575
	Csize	-.102	.030	-.371	-3.391	.001
	NBagg	.044	.027	.146	1.623	.109
	Child	-.017	.038	-.059	-.462	.645
	Elder	-.119	.043	-.352	-2.745	.008
	None	.022	.034	.077	.654	.516
	talking mobile	-.040	.046	-.090	-.886	.379
	reading or texsting	-.114	.084	-.132	-1.360	.179
	Waitsd	-.005	.006	-.072	-.839	.405
	WaitMB	.005	.008	.058	.673	.503
a. Dependent Variable: CRsp						

Multiple linear regression gives crossing speed and model as;

CRspeed = 1.379 + 0.107Gn -0.119 El – 0.102Csize ………………………...…………... 4.1

The significant of this model is to predict the crossing speed using the demographic characters, crossing conditions and age proportion of pedestrians while crossing.

The MLR analysis of SPSS 25 for segment M-1 at high pedestrian's volume shows human factors such as gender, age(elder) and crossers size of pedestrians has significantly influenced the crossing speed having p value of less than 0.05. utilization, number of children, waiting, activities and baggage has no significant influence on crossing speed on this segment. Significant values closer to 0.05 are more sensitively affect the crossing speed.

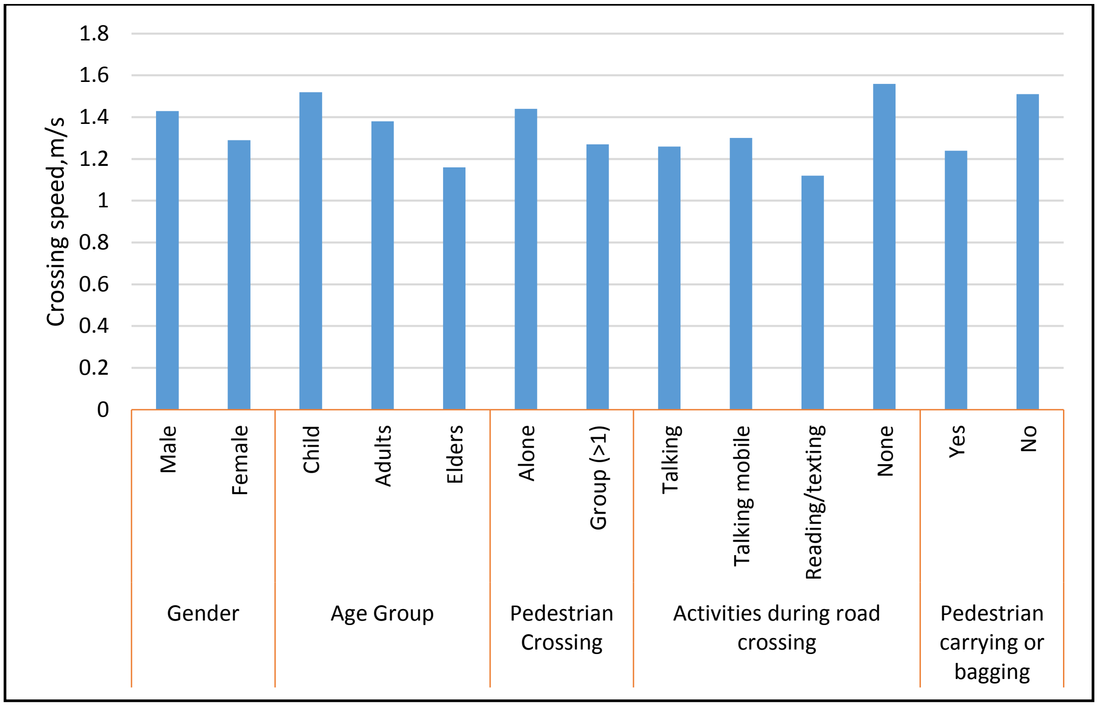


Figure 4-2: Pedestrian behavior data of low pedestrian movement at M-1

Table 4-5: Multiple linear regression analysis result with SPSS 25 at M-1 low pedestrians

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.305	.082		15.837	.000
	Gn	.101	.047	.313	2.141	.041
	Utz	.023	.037	.074	.625	.537
	Crsize	-.122	.049	-.411	-2.470	.020
	NBagg	.044	.045	.145	.979	.336
	Child	.153	.062	.371	2.475	.020
	Adult	.154	.055	.464	2.795	.009
	Talking	-.041	.057	-.128	-.725	.475
	talking mobile	-.094	.049	-.227	-1.905	.067
	reading or texsting	-.141	.060	-.286	-2.357	.026
	WaitS	.006	.010	.064	.553	.584
	WaitM	-.019	.012	-.189	-1.622	.116

a. Dependent Variable: Crspeed

Multiple linear regression gives crossing speed and model is as;

CRspeed = 1.305 + 0.101Gn + 0.153Ch +0.154Ad– 0.122Csize – 0.141Redtex ……………. 4.2

The significant of this model is to predict the crossing speed using the demographic characters, crossing conditions and age proportion of pedestrians while crossing.

For segment M-1 at low pedestrian movement, the analysis result of MLR for human factors such as gender, crossing size, adult and child, reading or texting has a significant influence ($P < 0.05$) on the crossing speed. Human factors such as baggage, talking, talking mobile, waiting time and crosswalk utilization have no significant influence on crossing speed ($P > 0.05$).

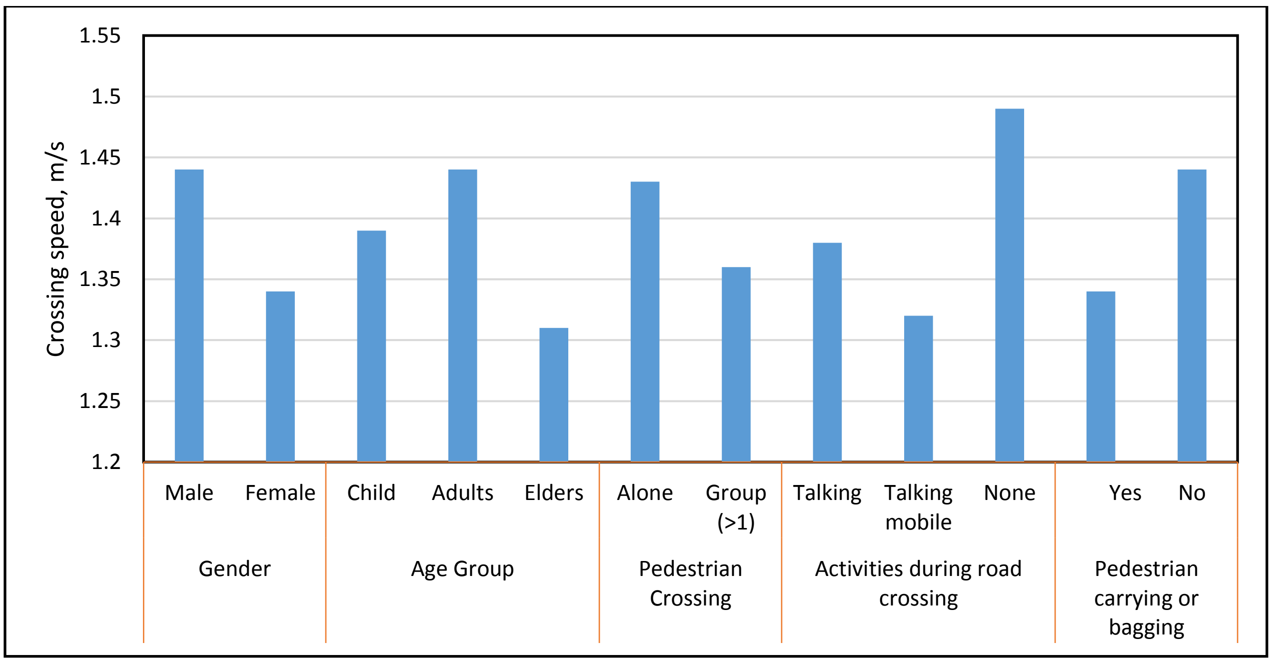


Figure 4-3: Pedestrian behavior data of high pedestrian movement at M-2

Table 4-6: Multiple linear regression analysis result with SPSS 25 at M-2 high pedestrian

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.200	.061		19.828	.000
	Gn	.101	.029	.395	3.481	.001
	Utz	-.024	.026	-.093	-.908	.371
	Crsize	-.066	.035	-.258	-1.909	.065
	NBagg	.039	.025	.154	1.555	.130
	child	.155	.045	.455	3.413	.002
	adult	.148	.034	.576	4.295	.000
	none	.088	.032	.336	2.759	.010
	talking mobile	-.011	.039	-.037	-.280	.781
	WaitS	-.002	.009	-.027	-.233	.818
	WaitM	.005	.007	.079	.753	.457
a. Dependent Variable: Crspeed						

Multiple linear regression gives crossing speed and model as;

CRspeed = 1.20 + 0.101Gn + 0.155Ch +0.148Ad + 0.088none ………………...………… 4.3

The significant of this model is to predict the crossing speed using the demographic characters, crossing conditions and age proportion of pedestrians while crossing.

From this analysis, age, gender and activities (none) has a significant influence ($p<0.05$) on the crossing speed. However, crossing size, baggage, talking mobile, waiting time and utilization of crosswalk of pedestrians have a p value greater than 0.05 hence not significantly influence the crossing speed of the pedestrians.

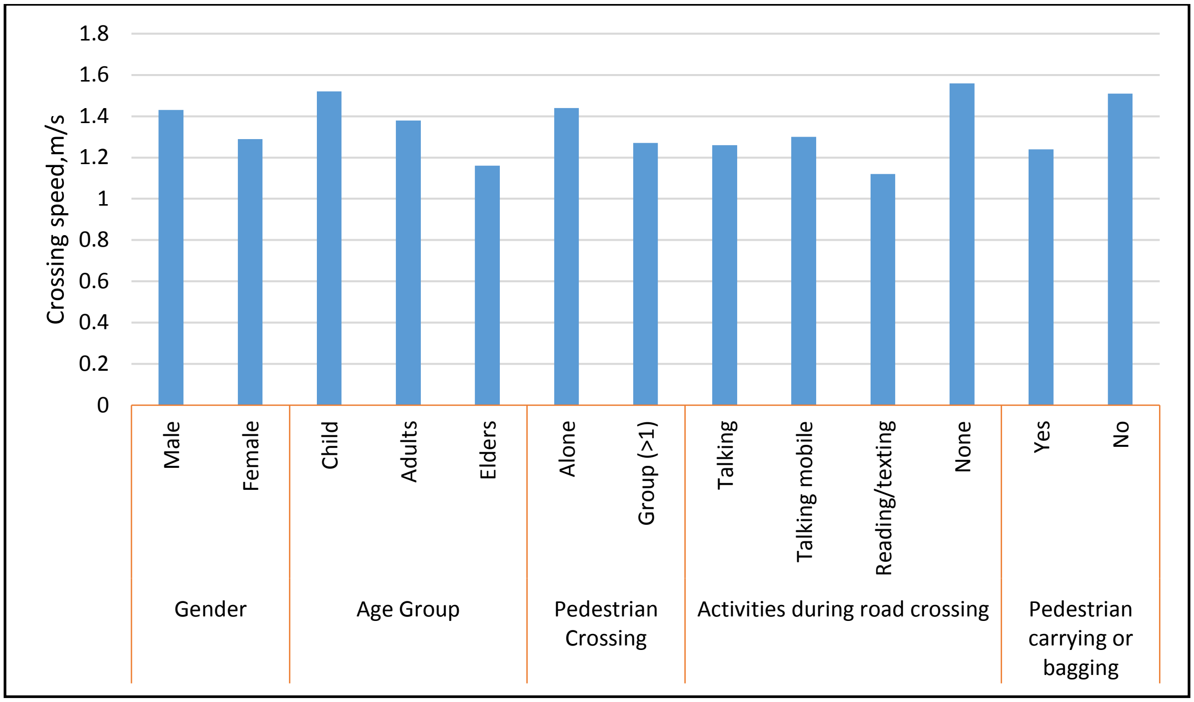


Figure 4-4: Pedestrian behavior data of low pedestrian movement at M-2

Table 4-7: Multiple linear regression analysis result with SPSS 25 at M-2 low pedestrians

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.365	.081		16.775	.000
	Gn	.100	.042	.293	2.365	.034
	Utz	.049	.041	.130	1.176	.261
	CRsize	-.130	.130	-.384	-1.003	.334
	NBagg	.055	.058	.162	.938	.365
	child	.061	.054	.118	1.127	.280
	elder	-.130	.088	-.250	-1.479	.163
	talking	-.076	.146	-.224	-.517	.614
	talking mobile	-.124	.072	-.238	-1.713	.110
	reading or texting	-.237	.139	-.276	-1.709	.111
	WaitS	.009	.014	.079	.671	.514
	WaitM	.011	.011	.110	.988	.341

a. Dependent Variable: Crspeed

Multiple linear regression gives crossing speed and model is developed as;

CRspeed = 1.365 + 0.100Gn ………………………………………………………………… 4.4

The significant of this model is to predict the crossing speed using the demographic characters, crossing conditions and age proportion of pedestrians while crossing.

Human factors like age, activity, crossers size, baggage Waiting times, and crosswalk utilization have no significant influence on crossing speed since they have a p value greater than 0.05. However, gender have significant influence on the crossing speed with a p value less than 0.05. the positive sign of the Pearson correlation coefficient indicates direct relationship and a negative sign indicates indirect relationship with the crossing speed.

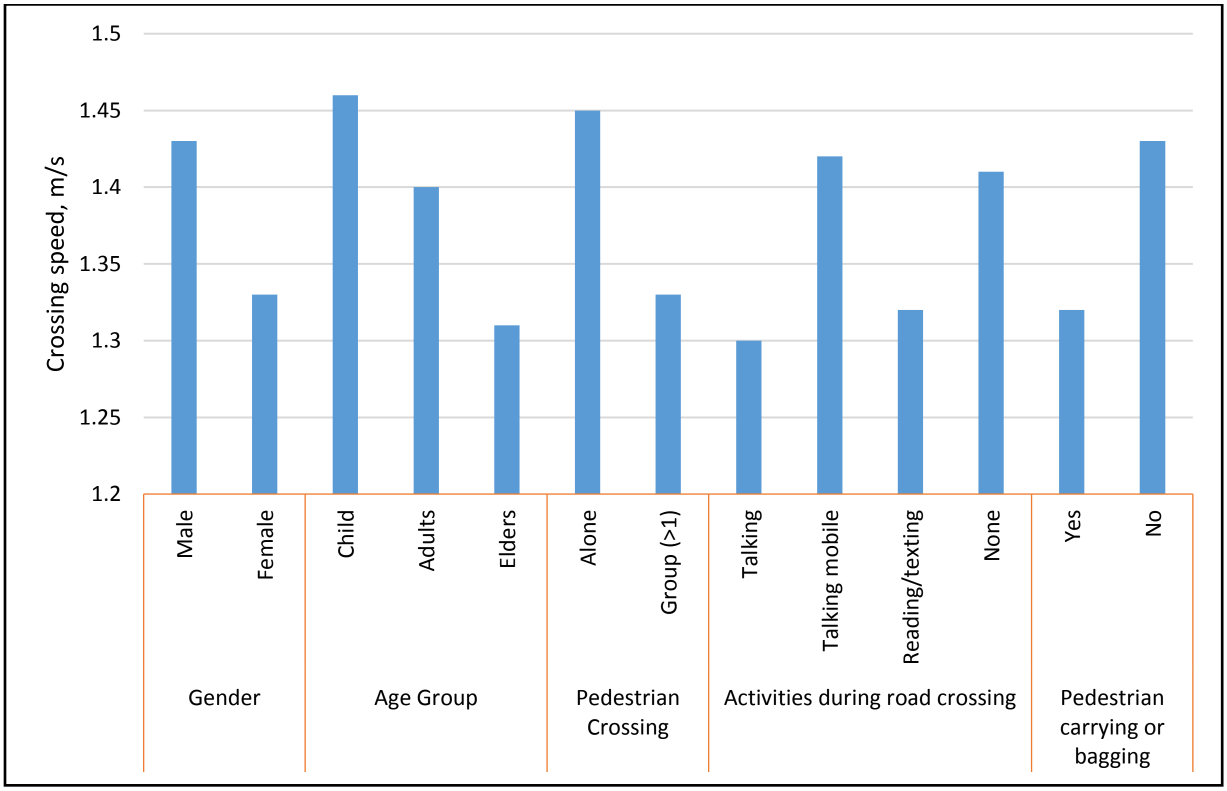


Figure 4-5: Pedestrian behavior data of high pedestrian movement at M-3

Table4-8: Multiple linear regression analysis result with SPSS 25 at M-3 high pedestrians

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.343	.033		40.236	.000
	Gn	.055	.023	.207	2.361	.021
	Utz	-.003	.022	-.012	-.141	.888
	CRsize	-.118	.026	-.445	-4.625	.000
	NBagg	.056	.024	.207	2.295	.024
	child	.143	.045	.321	3.172	.002
	adult	.076	.029	.258	2.583	.012
	talking	-.026	.030	-.082	-.859	.393
	talking mobile	-.038	.030	-.106	-1.253	.214
	reading or texting	-.110	.049	-.188	-2.233	.028
	WaitS	-.010	.013	-.067	-.810	.420
	WaitM	-.001	.011	-.009	-.103	.918
a. Dependent Variable: CRspeed						

Multiple linear regression gives crossing speed and model as;

CRspeed = 1.343 + 0.055Gn – 0.118Cs + 0.143Ch + 0.076Ad–0.11redtex + 0.056NBagg…4.5

The significant of this model is to predict the crossing speed using the demographic characters, crossing conditions and age proportion of pedestrians while crossing.

Waiting times, talking each other, talking mobile and crosswalk utilization have no significant influence on crossing speed since they have a p value greater than 0.05. However other human factors like age, gender, activity (reding or texting), crossers size and baggage have significant influence on the crossing speed with a p value less than 0.05. Significant values closer to 0.00 are more sensitively affect the crossing speed. The positive sign of the Pearson correlation coefficient indicates direct relationship and a negative sign indicates indirect relationship with the crossing speed.

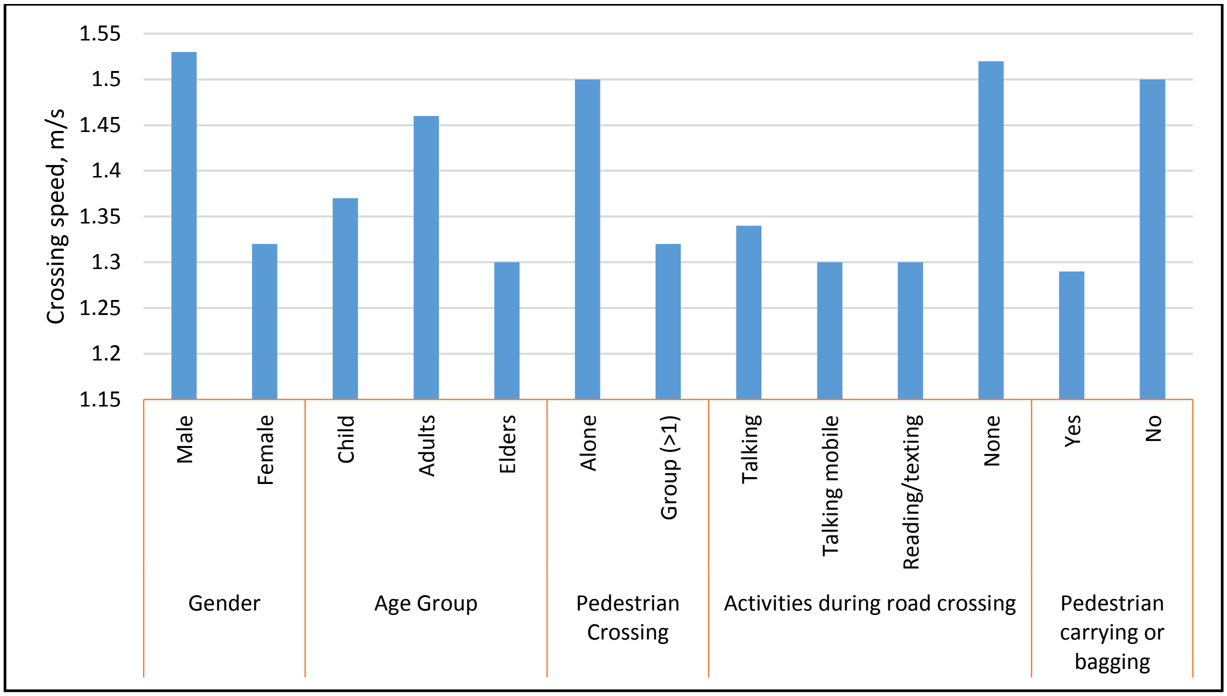


Figure 4-6: Pedestrian behavior data of low pedestrian movement at M-3

Table 4-9: Multiple linear regression analysis result with SPSS 25 at M-3 low pedestrians

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.409	.034		41.381	.000
	Gn	.074	.035	.258	2.106	.043
	Utz	.017	.024	.061	.715	.480
	CRsize	-.086	.041	-.296	-2.115	.042
	NBagg	.097	.042	.325	2.288	.029
	child	.003	.036	.008	.079	.937
	elder	-.127	.037	-.303	-3.399	.002
	talking	-.055	.049	-.176	-1.138	.263
	talking mobile	-.020	.044	-.044	-.457	.651
	reading or texting	-.108	.052	-.216	-2.101	.043
	WaitS	-.005	.009	-.049	-.580	.566
	WaitM	-.007	.009	-.072	-.788	.436
a. Dependent Variable: CRspeed						

Multiple linear regression gives the data presented on table 4.15. The dependent variable is crossing speed and model is developed as;

CRspeed = 1.409+ 0.074Gn -0.127El – 0.086Csize – 0.108redtex + 0.097NBagg…..........…. 4.6

The significant of this model is to predict the crossing speed using the demographic characters, crossing conditions and age proportion of pedestrians while crossing.

Number of children, talking, talking mobile, waiting times and crosswalk utilization have no significant influence on crossing speed since they have a p value greater than 0.05. however other human factors like number of elder pedestrians, gender, reading or texting activity, crossers size and baggage have significant influence on the crossing speed with a p value less than 0.05. the positive sign of the Pearson correlation coefficient indicates direct relationship and a negative sign indicates indirect relationship with the crossing speed.

Generally, the average speed of road crosser pedestrians is greater than the speed Suggested design crossing speed by (HCM) (2000) of elderly pedestrians at mid-block crosswalks and signalized intersections 1.0 and 1.2 m/sec, respectively and suggested a walking speed of 1.2m/sec as described in section 2.4.3.

4.3 Crossing speed for all selected segments

The overall crossing speed is the combined effect of variables of all the selected segments. This combined speed analysis gives the governing factors that can affect the speeds of pedestrian during road crossing. The significant of the variables are checked by p value (which is less than 0.05) at 95% confidence level. For the dependent variable that are significant, a model is developed using multiple linear regression.

Table 4-10: Multiple linear regression analysis result with SPSS 25 for all sites

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.413	.015		91.926	.000
	Gn	.088	.011	.310	8.156	.000
	Utz	.003	.010	.009	.251	.802
	CRsize	-.110	.012	-.392	-8.894	.000
	NBagg	.054	.011	.187	4.793	.000
	Child	.027	.015	.064	1.775	.077
	Elder	-.116	.014	-.316	-8.516	.000
	Talking	-.039	.014	-.127	-2.843	.005
	talking mobile	-.072	.015	-.181	-4.873	.000
	reading or texting	-.133	.024	-.207	-5.622	.000
	WaitS	-.001	.003	-.014	-.390	.697
	WaitM	-.001	.003	-.012	-.338	.736
a. Dependent Variable: CRspeed						

The result of Pearson significant (p value) is for gender is 0.00 which is less than 0.05. it shows that gender has significant influence on the crossing speed of pedestrians. Number of elder pedestrians also has significant effect on crossing speed having p value of 0.00. Crossing group size and baggage has influence the crossing speed of pedestrians having p value of 0.00 for both. Pedestrian activities such as, group talking, talking mobile and reading or texting also have a significant influence on the overall crossing speed with a p value less than 0.05.

Crosswalk utilization, number of children and waiting time have non-significant influence on the crossing speed.

From Multiple linear regression analysis results presented on table 4.16. The dependent variable was crossing speed and model is developed for variables that have significant effect.

CRspeed = 1.413+ 0.088Gn -0.116El – 0.11Csize – 0.039talk-0.072talkmob – 0.133redtex + 0.054NBagg…...………………………………………………………………...……. 4.7

The significant of this model is to predict the crossing speed using the demographic characters, crossing conditions and age proportion of pedestrians while crossing as ageneral model for all segments.

From the model developed, the proportion of men can increase the crossing speed by 0.088.the number of elder road crossers can reduce the crossing speed by 0.116 times the proportion of elders relative to adults. Talking with others, talking mobile and reading or texting can reduce the crossing speed by 0.039,0.072 and 0.133 respectively. Crossing the road without baggage or carrying goods can increase the crossing speed by 0.054.

Group crossing can reduce the crossing speed by 0.11 times proportion of group crossers relative to pedestrians crossing alone. The sign of Pearson correlation coefficients (Beta) shows the relationship between the crossing speed and independent variables. Variables that have positive sign has direct relationship and coefficients with negative sign indicate indirect relationship with crossing speed. Gender has positive Pearson correlation coefficient (B=0.088). this shows the flow of male pedestrian can increase the crossing speed.), hence it indicates the flow elder pedestrians can reduce the crossing speed. The road crossing group size also has a negative correlation coefficient (-0.11). this shows group crossing can reduce the crossing speed of the pedestrians than a single crosser. Pearson correlation coefficient for activities of pedestrian is negative hence it has indirect relationship. Pedestrians involved with activities i.e. talking, reading or texting and talking mobile while crossing can reduce the crossing speeds of a pedestrian. Pedestrians without baggage and carrying things has larger speed than with baggage due to a positive correlation coefficient value.

Generally, the crossing speeds of pedestrians has been affected by human factors such as gender, age crossing group size, activities during crossing and crossing with baggage and carrying things and goods.

Crosswalk utilization has a Pearson significant (p value) of 0.955 which is greater than 0.05, so it non-significant. These shows weather the pedestrian utilize zebra crosswalk or can’t affect the crossing speed. Waiting time at side or median of crosswalk have no significant influence (p value >0.05) on the crossing speed of pedestrians.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study on assessment of pedestrian road crossing behavior on selected road segments has conducted. Human factors that could and couldn't affect the Utilization of zebra marked crosswalk and the road crossing speed of pedestrians were identified. A predicting model for pedestrians crossing speed was developed by considering the variables that have significant influence.

The findings of this study indicate 494 pedestrians observed while crossing illegally from 1350 road crosser pedestrians. These constitute 37% of the total road crosser within 15m road segment. Human factor such as gender, age, activities, crossers group, baggage and waiting times have no significant influence on pedestrian's preference for utilization of the crosswalk. Hence pedestrian's utilization of crosswalk is independent of the human factors.

The crossing speed is highly influenced by gender, number of elders, activities, crossers group and baggage of the pedestrians with p value less than 0.05. Number of children and waiting times at the side or median has no significant effect on determining the pedestrians crossing speed. Hence to use them in the model for design crossing speed is vital.

Male pedestrians cross faster than female pedestrians. Adult pedestrians cross faster than elder pedestrians. Pedestrians involved in carrying goods or hanging bags, talk mobiles, group talking and writing or reading text crosses slowly than non-involved pedestrians. Crossers in group has lower speed than single crosser.

The developed Model for crossing speed determination is CRspeed = 1.413+ 0.088Gn -0.116El – 0.11Csize – 0.039talk-0.072talkmob – 0.133redtex + 0.054NBagg. Road crossing speed has a direct relationship with the proportion of male pedestrians and crossers without baggage. Also, the crossing speed has indirect relationship with the proportion of elder pedestrians, group crossers and involvement in activities while crossing the road. Hence this model can be used to predict the road crossers speed on mid-block segments and crosswalk.

5.2 Recommendations

From the limitation of this study the following recommendations are proposed for future study.

Since this study focused on human factors on crossing speed and crosswalk utilization further study by considering design factors and vehicle factors should be done.

The behavior study of pedestrians should be extended for intersections, roundabouts and sidewalks.

Further study on the pedestrian’s factor behavior such as road using familiarity, frequency of crossing and purpose of crossing should be included in future works.

Since some of the pedestrians were covered by large vehicles during recording drone camera is preferable to record and examine pedestrian vehicle interaction and their decision making.

Lightening effect (day and night) and rainfall effect are not considered in this study, further study is recommended by considering the effect of rainfall and lightening.

The finding of this research shows crosswalk utilization is independent of human factors.so design factors such as fencing, grade separated junctions and others must be considered.

Road facility designs should take in to consideration of pedestrians involved in activities, demographic characteristics and age of pedestrians.

To determine the design crossing speed of pedestrians, human factors should be studied and proportion and categories should be identified.

Those designers who wants to use this model should incorporate all the human factors depicted on the model.

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APPENDICES

Appendix 1-A: Pedestrian behavior @ M-1 on high volume crossing

Observed Parameter		Total No. of pedestrian	No. of pedestrian for analysis	Average crossing speed (m/s)
Gender	Male	206	45	1.46
	Female	155	32	1.32
Age Group	Child	45	8	1.40
	Adults	249	53	1.44
	Elders	67	16	1.30
Pedestrian Crossing	Alone	220	42	1.45
	Group (>1)	141	35	1.35
Activities during road crossing	Talking	83	17	1.33
	Talking mobile	23	8	1.38
	Reading/texting	11	2	1.25
	None	244	50	1.44
Pedestrian carrying or bagging	Yes	109	23	1.32
	No	252	54	1.44

Appendix 1-B: Pedestrian

behavior @ M-1 on low volume crossing

Observed Parameter		Total No. of pedestrian	No. of pedestrian for analysis	Average crossing speed (m/s)
Gender	Male	115	28	1.47
	Female	49	12	1.29
Age Group	Child	26	6	1.45
	Adults	113	29	1.43
	Elders	25	5	1.29
Pedestrian Crossing	Alone	92	22	1.49
	Group (>1)	72	18	1.32
Activities during road crossing	Talking	56	12	1.32
	Talking mobile	14	6	1.36
	Reading/texting	9	4	1.43
	None	85	18	1.49
Pedestrian carrying or bagging	Yes	61	16	1.37
	No	103	24	1.45

Appendix1-C: Pedestrian behaviour @ M-2 on high volume crossing

Observed Parameter		Total No. of pedestrian	No. of pedestrian for analysis	Average crossing speed (m/s)
Gender	Male	88	26	1.44
	Female	81	17	1.34
Age Group	Child	20	7	1.39
	Adults	113	26	1.44
	Elders	36	10	1.31
Pedestrian Crossing	Alone	108	26	1.43
	Group (>1)	61	17	1.36
Activities during road crossing	Talking	45	18	1.38
	Talking mobile	34	10	1.32
	Reading/texting	6	0	-
	None	84	15	1.49
Pedestrian carrying or bagging	Yes	53	18	1.34
	No	116	25	1.44

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Appendix 1-D: Pedestrian behavior @ M-2 on low volume crossing

Observed Parameter		Total No. of pedestrian	No. of pedestrian for analysis	Average crossing speed (m/s)
Gender	Male	49	14	1.43
	Female	44	11	1.29
Age Group	Child	7	3	1.52
	Adults	75	19	1.38
	Elders	11	3	1.16
Pedestrian Crossing	Alone	76	14	1.44
	Group (>1)	93	11	1.27
Activities during road crossing	Talking	65	12	1.26
	Talking mobile	12	3	1.30
	Reading/texting	5	1	1.12
	None	87	9	1.56
Pedestrian carrying or bagging	Yes	63	13	1.24
	No	106	12	1.51

Appendix 1-E: Pedestrian behavior @ M-3 on high volume crossing

Observed Parameter		Total No. of pedestrian	No. of pedestrian for analysis	Average crossing speed (m/s)
Gender	Male	209	54	1.43
	Female	178	39	1.33
Age Group	Child	38	9	1.46
	Adults	251	67	1.40
	Elders	46	17	1.31
Pedestrian Crossing	Alone	188	41	1.45
	Group (>1)	199	52	1.33
Activities during road crossing	Talking	90	20	1.30
	Talking mobile	42	15	1.42
	Reading/texting	12	5	1.32
	None	243	53	1.41
Pedestrian carrying or bagging	Yes	137	37	1.32
	No	250	56	1.43

Appendix1-F: Pedestrian behavior @ M-3 on low volume crossing

Observed Parameter		Total No. of pedestrian	No. of pedestrian for analysis	Average crossing speed (m/s)
Gender	Male	96	23	1.53
	Female	80	22	1.32
Age Group	Child	21	9	1.37
	Adults	132	30	1.46
	Elders	23	6	1.30
Pedestrian Crossing	Alone	112	27	1.50
	Group (>1)	64	18	1.32
Activities during road crossing	Talking	40	13	1.34
	Talking mobile	17	5	1.30
	Reading/texting	14	4	1.30
	None	105	23	1.52
Pedestrian carrying or bagging	Yes	55	16	1.29
	No	121	29	1.50

Appendix 2-A: MLR result of M-1 at high pedestrian movement

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	1.379	.063		22.027	.000
	Gn	.107	.024	.385	4.472	.000
	Utz	.014	.025	.050	.563	.575
	Csize	-.102	.030	-.371	-3.391	.001
	NBagg	.044	.027	.146	1.623	.109
	child	-.017	.038	-.059	-.462	.645
	elder	-.119	.043	-.352	-2.745	.008
	none	.022	.034	.077	.654	.516
	talking mobile	-.040	.046	-.090	-.886	.379
	reading or texsting	-.114	.084	-.132	-1.360	.179
	Waitsd	-.005	.006	-.072	-.839	.405
	WaitMB	.005	.008	.058	.673	.503

a. Dependent Variable: CRsp

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	adult	.[b]	.	.	.	.000
	talking	.[b]	.	.	.	.000

a. Dependent Variable: CRsp

b. Predictors in the Model: (Constant), WaitMB, child, none, Gn, Utz, Waitsd, reading or texsting, Bagg, talking mobile, Csize, elder

Appendix 2-B: MLR result of M-1 at low pedestrian movement

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.305	.082		15.837	.000
	Gn	.101	.047	.313	2.141	.041
	Utz	.023	.037	.074	.625	.537
	Crsize	-.122	.049	-.411	-2.470	.020
	NBagg	.044	.045	.145	.979	.336
	child	.153	.062	.371	2.475	.020
	adult	.154	.055	.464	2.795	.009
	talking	-.041	.057	-.128	-.725	.475
	talking mobile	-.094	.049	-.227	-1.905	.067
	reading or texsting	-.141	.060	-.286	-2.357	.026
	WaitS	.006	.010	.064	.553	.584
	WaitM	-.019	.012	-.189	-1.622	.116

a. Dependent Variable: Crspeed

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	none	.[b]	.	.	.	.000

a. Dependent Variable: Crspeed

b. Predictors in the Model: (Constant), WaitM, talking mobile, WaitS, child, Utz, reading or texsting, Bagg, Crsize, Gn, adult, talking

Appendix 2-C: MLR result of M-2 at high pedestrian movement

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.200	.061		19.828	.000
	Gn	.101	.029	.395	3.481	.001
	Utz	-.024	.026	-.093	-.908	.371
	Crsize	-.066	.035	-.258	-1.909	.065
	NBagg	.039	.025	.154	1.555	.130
	child	.155	.045	.455	3.413	.002
	adult	.148	.034	.576	4.295	.000
	none	.088	.032	.336	2.759	.010
	talking mobile	-.011	.039	-.037	-.280	.781
	WaitS	-.002	.009	-.027	-.233	.818
	WaitM	.005	.007	.079	.753	.457

a. Dependent Variable: Crspeed

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	elder	.[b]	.	.	.	.000
	talking	.[b]	.	.	.	.000

a. Dependent Variable: Crspeed

b. Predictors in the Model: (Constant), WaitM, Gn, Utz, none, Bagg, adult, WaitS, talking mobile, child, Crsize

Appendix 2-D: MLR result of M-2 at low pedestrian movement

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.365	.081		16.775	.000
	Gn	.100	.042	.293	2.365	.034
	Utz	.049	.041	.130	1.176	.261
	CRsize	-.130	.130	-.384	-1.003	.334
	NBagg	.055	.058	.162	.938	.365
	child	.061	.054	.118	1.127	.280
	elder	-.130	.088	-.250	-1.479	.163
	talking	-.076	.146	-.224	-.517	.614
	talking mobile	-.124	.072	-.238	-1.713	.110
	reading or texting	-.237	.139	-.276	-1.709	.111
	WaitS	.009	.014	.079	.671	.514
	WaitM	.011	.011	.110	.988	.341

a. Dependent Variable: Crspeed

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	adult	.[b]	.	.	.	.000
	none	.[b]	.	.	.	.000

a. Dependent Variable: Crspeed

b. Predictors in the Model: (Constant), WaitM, reading or texting, Utz, Gn, talking, child, WaitS, talking mobile, elder, Bagg, CRsize

Appendix 2-E: MLR result of M-3 at high pedestrian movement

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.343	.033		40.236	.000
	Gn	.055	.023	.207	2.361	.021
	Utz	-.003	.022	-.012	-.141	.888
	CRsize	-.118	.026	-.445	-4.625	.000
	NBagg	.056	.024	.207	2.295	.024
	child	.143	.045	.321	3.172	.002
	adult	.076	.029	.258	2.583	.012
	talking	-.026	.030	-.082	-.859	.393
	talking mobile	-.038	.030	-.106	-1.253	.214
	reading or texting	-.110	.049	-.188	-2.233	.028
	WaitS	-.010	.013	-.067	-.810	.420
	WaitM	-.001	.011	-.009	-.103	.918

a. Dependent Variable: CRspeed

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	elder	.[b]	.	.	.	.000
	none	.[b]	.	.	.	.000

a. Dependent Variable: CRspeed

b. Predictors in the Model: (Constant), WaitM, Utz, talking mobile, WaitS, adult, CRsize, Gn, reading or texting, Bagg, talking, child

Appendix 2-F: MLR result of M-3 at low pedestrian movement

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.409	.034		41.381	.000
	Gn	.074	.035	.258	2.106	.043
	Utz	.017	.024	.061	.715	.480
	CRsize	-.086	.041	-.296	-2.115	.042
	NBagg	.097	.042	.325	2.288	.029
	child	.003	.036	.008	.079	.937
	elder	-.127	.037	-.303	-3.399	.002
	talking	-.055	.049	-.176	-1.138	.263
	talking mobile	-.020	.044	-.044	-.457	.651
	reading or texting	-.108	.052	-.216	-2.101	.043
	WaitS	-.005	.009	-.049	-.580	.566
	WaitM	-.007	.009	-.072	-.788	.436

a. Dependent Variable: CRspeed

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	adult	.[b]	.	.	.	.000
	none	.[b]	.	.	.	.000

a. Dependent Variable: CRspeed

b. Predictors in the Model: (Constant), WaitM, Gn, Utz, WaitS, reading or texting, talking mobile, elder, CRsize, child, Bagg, talking

Appendix 2-G: over all MLR analysis result from SPSS

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.413	.015		91.926	.000
	Gn	.088	.011	.310	8.156	.000
	Utz	.003	.010	.009	.251	.802
	CRsize	-.110	.012	-.392	-8.894	.000
	NBagg	.054	.011	.187	4.793	.000
	child	.027	.015	.064	1.775	.077
	elder	-.116	.014	-.316	-8.516	.000
	talking	-.039	.014	-.127	-2.843	.005
	talking mobile	-.072	.015	-.181	-4.873	.000
	reading or texting	-.133	.024	-.207	-5.622	.000
	WaitS	-.001	.003	-.014	-.390	.697
	WaitM	-.001	.003	-.012	-.338	.736

a. Dependent Variable: CRspeed

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	adult	.[b]	.	.	.	.000
	none	.[b]	.	.	.	.000

a. Dependent Variable: CRspeed

b. Predictors in the Model: (Constant), WaitM, Gn, child, talking mobile, Utz, WaitS, reading or texting, elder, CRsize, Bagg, talking

Appendix 3-A: Binary logistic regression result for crosswalk utilization

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Gn	-.088	.278	.100	1	.751	.916
	CRspeed	.333	1.318	.064	1	.801	1.395
	CRsize	-.264	.320	.683	1	.408	.768
	NBagg	-.002	.272	.000	1	.993	.998
	child	.150	.464	.105	1	.746	1.162
	adult	-.252	.350	.518	1	.472	.777
	none	.622	.584	1.137	1	.286	1.864
	talking	.236	.623	.144	1	.705	1.266
	talking mobile	.717	.615	1.359	1	.244	2.049
	WaitS	-.017	.073	.058	1	.810	.983
	WaitM	-.151	.068	4.912	1	.027	.860
	Constant	-.573	1.656	.120	1	.729	.564

a. Variable(s) entered on step 1: Gn, CRspeed, CRsize, Bagg, child, adult, none, talking, talking mobile, WaitS, WaitM.

Appendix 4-A Dummy variable coding in SPSS

```
RECODE Age (0=1) (ELSE=0) INTO ch.
VARIABLE LABELS  ch 'child'.
EXECUTE.
RECODE Age (1=1) (ELSE=0) INTO ad.
VARIABLE LABELS  ad 'adult'.
EXECUTE.
RECODE Age (3=1) (ELSE=0) INTO el.
VARIABLE LABELS  el 'elder'.
EXECUTE.


RECODE Act (0=1) (ELSE=0) INTO none.
VARIABLE LABELS  none 'none'.
EXECUTE.
RECODE Act (1=1) (ELSE=0) INTO talk.
VARIABLE LABELS  talk 'talking'.
EXECUTE.
RECODE Act (2=1) (ELSE=0) INTO talkmob.
VARIABLE LABELS  talkmob 'talking mobile'.
EXECUTE.
RECODE Act (3=1) (ELSE=0) INTO redtex.
VARIABLE LABELS  redtex 'reading or texsting'
```

Appendix 5-A: Sample images taken from the recorded video