Research Report

The Impact of Waiting Time towards Pedestrian Crossing Behaviour at Signalised Intersection

Nur Zarifah Harun
Azzuhana Roslan
Rizati Hamidun
Siti Zaharah Ishak
Akmalia Shabadin
Wong Shaw Voon

MI:ROS
MALAYSIAN INSTITUTE OF ROAD SAFETY RESEARCH
ASEAN ROAD SAFETY CENTRE

The Impact of Waiting Time towards Pedestrian Crossing Behaviour at Signalised Intersection

Nur Zarifah Harun

Azzuhana Roslan

Rizati Hamidun

Siti Zaharah Ishak

Akmalia Shabadin

Wong Shaw Voon

MIROS
MALAYSIAN INSTITUTE OF ROAD SAFETY RESEARCH
ASEAN ROAD SAFETY CENTRE

Contents

_____

List of Tables

List of Figures

Acknowledgements

Abstract

A large number of pedestrians are getting killed in traffic accidents each year. As we know, pedestrian accidents are more severe than other types of accidents. A review of pedestrian crash data shows that most the crashes occur while the pedestrian was crossing the road. In spite the pedestrian facilities provided, crashes involving pedestrians still occur. The pattern of pedestrian behaviour when crossing the road is depending on various factors such as traffic conditions, location of signalised intersections and the phasing of traffic signals. All these factors are pedestrian exposure to risk in relation to pedestrian crossing behaviour.

The main objective of this study is to determine the impact of waiting time towards pedestrian crossing behaviour at signalised intersection. Besides that, this study was conducted to identify the factors that influence the behaviour of pedestrians while crossing the signalised intersection. In addition, this study will look at how these factors will affect the compliance of pedestrian towards pedestrian signals.

Observation study was conducted through video recording in order to observe the pedestrian waiting time and behaviour while crossing the intersection. Ten (10) signalised intersection located in Klang Valley area was selected to conduct this study. Data collection for each selected signalised intersection was conducted by digital video camera recording on weekdays during peak hours and off-peak hours. A total of 5,286 pedestrians were observed. Among the variables recorded from the observation are pedestrian gender, a way of crossing, age group, pedestrian waiting time before crossing the intersection, the volume of pedestrian and some other variables. Using data from the observation, pedestrian behaviour database has been established.

From the observation made, study shows that the variables such being male, female, different group of age, waiting time and the way of crossing affect the proportion of violations. In addition, a pedestrian can be categorised into two (2); pedestrian who will wait at the roadside before crossing; and a pedestrian who will immediately cross the intersection after arrived at the roadside. However, through the observations made, both of these situations involve pedestrians that comply and also failed to comply with pedestrian signals. Supposedly, the pedestrian has to wait for green man phase before crossing and that green man phase is related to traffic signal cycle length. But, the results show that most of the pedestrian did not follow the pedestrian signals. Therefore, it can be concluded that the traffic condition is one of the factors that influence the pedestrian behaviour in making decision before deciding to cross the intersection, not due to long waiting time during red-man phase.

1.   Introduction

Pedestrians, motorcyclist and cyclist were known as vulnerable road users. From the first global assessment of road safety, it was found that almost half of the 1.27 million fatalities in road traffic crashes every year are pedestrians, motorcyclists and cyclists (World Health Organization, 2009). A large number of pedestrians are being killed in traffic crashes each year. Usually, pedestrian crashes are more severe than other types of crashes. A review of pedestrian crash data shows that most the crashes occur while the pedestrian is crossing the road.

The rapid pace of development in an area also affected the safety of pedestrians. According to World Health Organization (2013), in high-income countries, pedestrian collisions occur more in urban areas than rural settings; meanwhile, the opposite is true in some low- and middle-income countries. In 2010, Klang Valley had only 17% of the people using public transport for their daily trips, whereas another 83% trips were made using private transport (Chuen et al., 2014).

In spite, the pedestrian facilities provided crashes involving pedestrians still occur. The pattern of pedestrian behaviour while crossing the road is depending on various factors relating to their safety. One of the main factors contributing to injury accidents for pedestrians is careless and illegal (not using pedestrian facilities) crossings, with 70.0% of casualties (Ariffin et al., 2010). According to Marisamynathan and Perumal (2014), some of the significant factors that are affecting the pedestrian compliance behaviour are gender and group size of pedestrians.

Intersections are critical road section with a high concentration of vehicle-pedestrian crashes. Based on a study done by Lee and Abdel-Aty (2005), the number of pedestrian crash increased with a higher average of traffic volume at

intersections. Recent investigations of the pedestrian crash in Australia shows that pedestrian crashes occurring at intersections (both signalised and un-signalised), business and shopping areas. This is due to high pedestrian and vehicle volume at these locations that increase the risk factors for crashes (Palamara & Broughton, 2013).

Pedestrian whom crossing during a red-man phase is at risks. Many factors can be seen why pedestrians are violating pedestrian signals. This study focuses on the pedestrian's waiting time before violating pedestrian signals.

1.1   Aims and Objectives of the Study

The aim of this study is to identify whether the waiting time at signalised intersection gives impact to pedestrian safety. The objectives of this study are:

   i.   To evaluate the impact of waiting time towards pedestrian crossing behaviour at signalised intersection; and
   ii.   To identify the factors that influence the behaviour of a pedestrian while crossing the signalised intersection.

This study will look at how these factors will affect the compliance of pedestrian towards pedestrian signals.

1.2   Scope and Limitation of the Study

The scope of this study is focused on signalised intersection only. The study was conducted only for selected signalised intersection at Klang Valley. Data collected is based on a similar characteristic of selected sites which is the selected study area were commercial areas. A total of ten (10) sites were selected for this study. The observations were made towards pedestrians from the classified age group; elderly, adult and child. Child pedestrian counted only if they cross the intersection by themselves, not carried by an adult.

2.   Literature Review

The focus of the literature review is the identification of the impact of a pedestrian waiting time at signalised intersection towards pedestrian's safety and behaviour while crossing the signalised intersection. Various possible factors may affect the safety of pedestrians when crossing the road at signalised intersection. Based on the previous study, among of the factors are the effect of traffic volume and speed, waiting time, demographic variables, pedestrian crossing speed, the presence of pedestrian facilities, clearance phase and pedestrians' behaviour itself (Hamed, 2001; Brosseau et al., 2013; Lipovac et al., 2013).

2.1   Pedestrian Crossing Facilities

The provision of pedestrian crossings is important to ensure the safety of pedestrians, especially at an intersection that has a high volume of vehicles. There are many facilities for pedestrian crossings. Among them are the zebra crossing, pedestrian signals, pedestrian countdown displays, median refuges, etc.

Lipovac et al. (2013) studied the influence of a pedestrian countdown display on pedestrian behaviour at signalised pedestrian crossings. The study concludes that a countdown display does not have a statistically significant influence on the distribution of the total number of pedestrian offences made during the pedestrian red light, regardless of the environment (location and volume of the vehicle). Furthermore, the study shows that the duration of the red light for pedestrians (message on display) at similar crossings influences the distribution of offences (per age categories of pedestrians) during the pedestrian red light.

In the study of the effectiveness of pedestrian countdown display in reducing crashes, Pulugurtha et al. (2010) concluded that pedestrians, as well as drivers are making better decisions using the time left to cross the street displayed on pedestrian countdown signals at signalised intersections. The results of this study indicate that drivers slow to a stop (based on time left information) before the beginning of the amber phase when countdown signals are present.

2.2   Effect of Pedestrian Demographic Characteristics

Earlier studies provide significant facts about pedestrian demographic characteristics (such as age, gender) and how these characteristics influence road crossing behaviour. A study done by Brosseau et al. (2013) shows that variable such as being male, being a young adult and intersection waiting time increased the proportion of violations. Other variables decreased the probability of violations, such as the presence of a pedestrian signal or group size.

Besides that, older pedestrians have found more likely to comply with pedestrian signals than younger pedestrians (Daff et al., 1991). The differences in crossing behaviour by gender, age, and the type of pedestrian group were then identified. The results showed that women and middle-aged individuals were more likely to violate traffic rules.

The results that were highlighted in this study are the importance of engineering countermeasures as part of the solution to pedestrian violations.

2.3   Effect of Traffic Volume and Speed

King, Soole, and Ghafourian (2009) study on the illegal pedestrian crossing at signalised intersections has found that the results provide evidence that illegal crossing behaviours are associated with an increased crash level of risk. According to

Hamed (2001), the vehicle flow and speed have an impact on pedestrian waiting time and the number of attempts of their road crossing.

Traffic volume will affect the cycle length for a traffic light at the intersection. The cycle length is the total time to complete one sequence of all movements around an intersection. Cycle lengths are depending upon the intersection design, spacing between intersections and traffic characteristics. There are many things that need to be taken into considerations for developing signal coordination timing plans, such as number of cars stopped at an intersection, the spacing between intersection, traffic volumes in multiple directions and for multiple movements must be considered and not forget the pedestrian and bikers to cross the streets safely. All these factors may influence the signal coordination at every intersection. Hamed (2001) concluded that the vehicle flow and speed in the first place have an impact on pedestrian waiting time and the number of attempts of their road crossing.

2.4   Pedestrian Waiting Time

Pedestrian waiting time is interpreted as a period of pedestrians waiting for their arrival at the roadside until their crossing the street. Pedestrian waiting time is depending on the cycle length at each signalised intersection. Pedestrian is allowing crossing the streets when the traffic signal is in the red phase. Pedestrian waiting time is supposedly equal to the duration of traffic signal's green phase. Pedestrian has to wait until red phase to cross the street. There are beliefs and considerations that shorter or longer waiting time will effect on pedestrian violations. According to Lipovac et al. (2013), waiting time of pedestrians at a pedestrian crossing is an important factor that influences their safety.

Besides that, a research done by Zhou et al. (2011) shows that in the aspect of waiting time, male pedestrians expect a shorter "reasonable waiting time" (18.62 seconds) and "maximum waiting time" (49.55 seconds) than females; elder people and children are willing to accept a longer "reasonable waiting time" and "maximum waiting time" than middle-aged people.

Furthermore, a study done by Tiwari et al. (2007) shows that as signal waiting time increases, pedestrians get impatient and violate the traffic signal. This violation places them at increased risk of being struck by a motor vehicle. According to the author, the probability for a pedestrian to cross the road, when it is unsafe, i.e. motor vehicles still have green or yellow, varies with waiting time.

3.   Methodology

This study was conducted at selected signalised intersections in Klang Valley. Random signalised intersections were selected consisted of similar characteristics. Figure 1 shows the overall flow of this study.
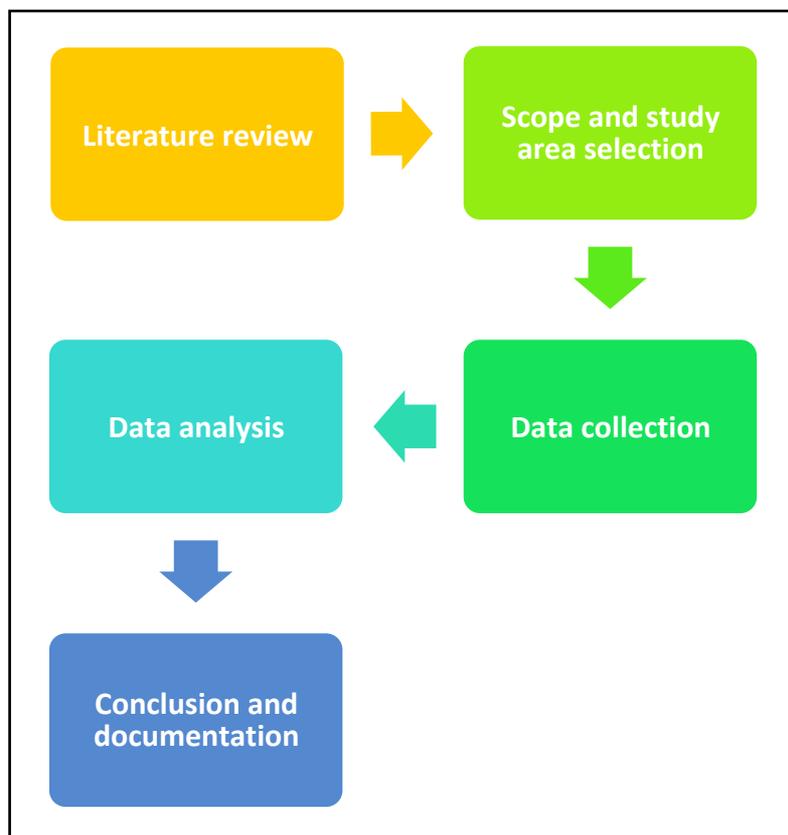
Figure 1   Study flow framework

The data collection period was from 20th May to 12th June 2015. The data collection was conducted at ten (10) signalised intersections. Figure 2 shows the characteristics of the selected signalised intersections.

Signalised Intersection Characteristics		
Similar vehicle volume	Similar geometry	Similar land use
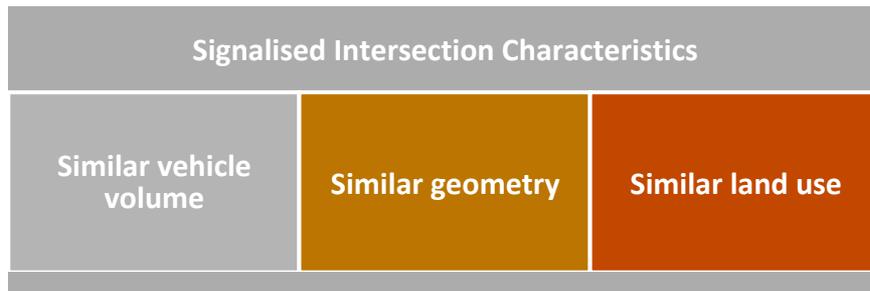
Figure 2   The characteristics of signalised intersections

After considering the characteristics of the signalised intersections, the intersection's selection was made by pedestrian crossing facilities provided such as zebra crossing, pedestrian signal and availability of pedestrian push button as shown in Figure 3.

```
Selected signalised          Pedestrian crossing          Zebra crossing
intersections based on  ───  facilities             ───┬  
characteristics stated                                  ├  Pedestrian signal
                                                        ├  With/Without push button
                                                        └  Pedestrian crossing signage
```
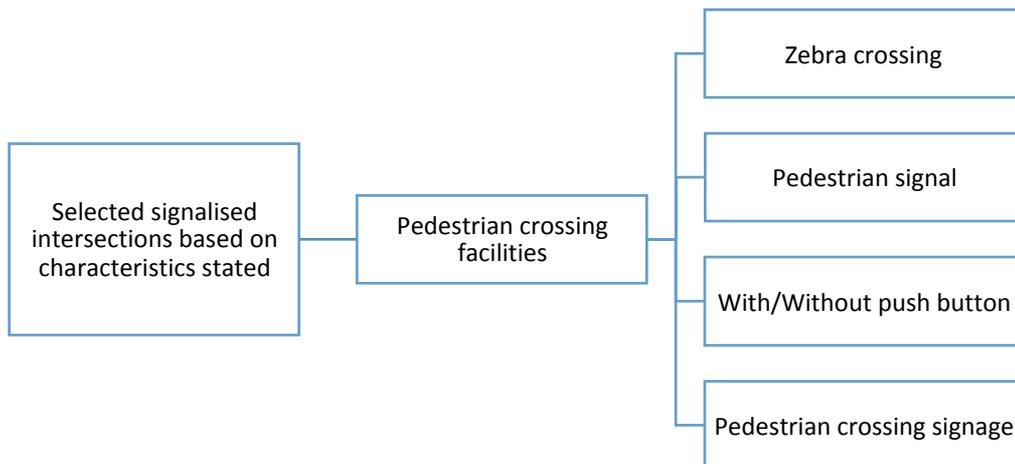
Figure 3   Selection of signalised intersections for data collection

Data collection for each selected signalised intersection was conducted by digital video camera recording on weekdays during peak hours (7:00 a.m. to 9:00 a.m.) and off-peak hours (10:00 a.m. to 12:00 p.m.). Data about pedestrian was gathered according to:

i. Gender;
ii. Crossing as individual, in a couple or in a group (three or more pedestrians);
iii. Age group (estimated in three group – child (0 – 12 years old), adult (13 – 60 years old) or elderly (60 years old and above));
iv. Pedestrian waiting time before crossing the intersection;
v. Pedestrian crossing time;
vi. Conflict situation occurrence (between pedestrian and vehicle);
vii. Volume of pedestrian;
viii. Crossing used;
ix. The characteristics of intersection;
x. Pedestrian behaviour while crossing (walking or running); and
xi. Non-offenders or offenders (pedestrian signal).

Besides observation towards pedestrian through video recording, the team also made classified volume count. Manual counting of classified volume data on site by vehicle type, the day of week and time of day. Figure 4 below shows the framework of classified volume count on site.
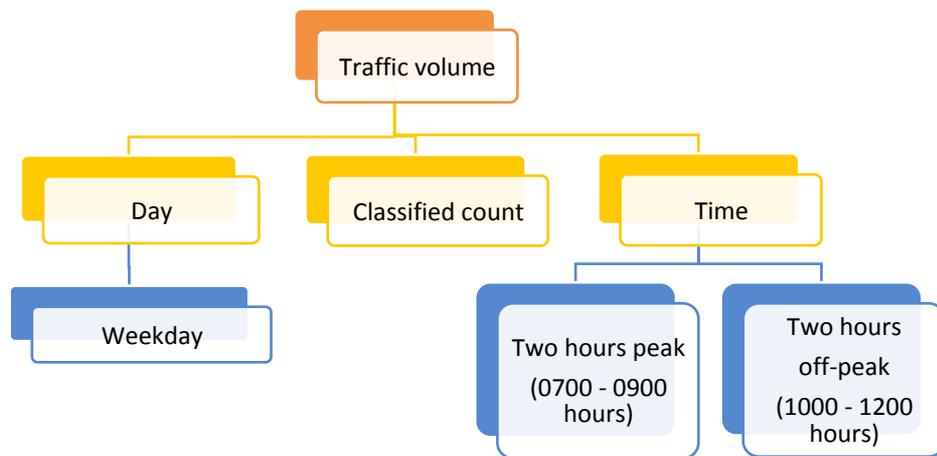
Figure 4   The framework of classified volume counts on site

As described previously, the study area is selected based on the estimated volume of pedestrians, vehicles and land use that we are assume almost the same. Therefore, the signalised intersection in the Klang Valley area was selected to conduct this study. Table 1 shows the selected signalised intersections that have been chosen:

Table 1   Location of signalised intersections

No.	Signalised intersections	Land use
1	Jalan Tun Tan Cheng Lock/Jalan Hang Kasturi, Kuala Lumpur	Commercial
2	Jalan Chow Kit/Jalan Raja Laut/Jalan Putra, Kuala Lumpur	Commercial
3	Jalan Tun Tan Cheng Lock/Jalan Tun H S Lee, Kuala Lumpur	Commercial
4	Jalan Tunku Abdul Rahman/Jalan Dang Wangi, Kuala Lumpur	Commercial
5	Jalan Raja Laut/Jalan Esfahan, Kuala Lumpur	Commercial
6	Jalan Bukit Bintang/Jalan Sultan Ismail, Kuala Lumpur	Commercial
7	Jalan Pudu/Jalan Tun Perak/Jalan Cheng Lock, Kuala Lumpur	Commercial
8	Jalan PJU 6/2, Petaling Jaya	Commercial
9	Jalan Tunku Abdul Rahman/Jalan Sultan Ismail, Kuala Lumpur	Commercial
10	Jalan Tun Tan Cheng Lock/Jalan Petaling, Kuala Lumpur	Commercial

The data collection activities were completed by 12th June 2015. After the completion of data collection at sites, observation of pedestrian was made through the recorded video. For data analysis at each signalised intersection, the pedestrian video observations and traffic volume count were made for one (1) hour during peak period (7:30 a.m. to 8:30 a.m.) and one (1) hour during the off-peak period (10:30 a.m. to 11:30 a.m.). Therefore, the volume of pedestrians and vehicle for each signalised intersection was controlled within that period.

The data were then gathered and analysed according to the objectives of the study. The descriptive analyses were done to obtain the distributions and profiles of the data. The results obtained were categorised according to the six main criteria and the new findings were highlighted in the discussion. A few conclusions were made and some recommendations were listed in order to improve the safety of pedestrian while crossing the signalised intersection. Suggestions on how to improve the further study were also included at the end of this report.

4.   Results and Discussions

This section discusses the results and findings of the study. This section is divided into six (6) subsections; 1) The characteristics of study locations; 2) Demographic characteristics; 3) Behaviour of pedestrian while crossing the intersections; 4) Temporal violations among pedestrian while crossing the signalised intersection; 5) Pedestrian waiting time before crossing the signalised intersections; and 6) The factors that influence the behaviour of pedestrian while crossing the signalised intersection.

4.1   The Characteristics of Study Locations

Data collection was carried out at ten (10) selected signalised intersections. Table 2 below shows the characteristics of each study locations.

Table 2   The characteristics of study locations

Signalised intersections	Type of intersections	No. of traffic signal phases	Pedestrian crossing facilities
Jalan Tun Tan Cheng Lock/ Jalan Hang Kasturi	3-leg Median	2 phase	• Zebra crossing • Pedestrian signal
Jalan Chow Kit/ Jalan Raja Laut/ Jalan Putra	4-leg No median	2 phase	• Zebra crossing • Pedestrian signal • Push button • Pedestrian crossing sign
Jalan Tun Tan Cheng Lock/ Jalan Tun H S Lee	4-leg No median	2 phase	• Zebra crossing • Pedestrian signal • Push button

Jalan Tunku Abdul Rahman/ Jalan Dang Wangi	4-leg No median	2 phase	• Zebra crossing • Pedestrian signal • Push button • Audible pedestrian signal
Jalan Raja Laut/ Jalan Esfahan	3-leg No median	2 phase	• Zebra crossing • Pedestrian signal • Push button • Pedestrian crossing sign
Jalan Bukit Bintang/ Jalan Sultan Ismail	4-leg Median	2 phase	• Zebra crossing • Pedestrian signal • Push button
Jalan Pudu/ Jalan Tun Perak/ Jalan Cheng Lock	3-leg Median	3 phase	• Zebra crossing • Pedestrian signal • Push button • Pedestrian crossing sign
Jalan PJU 6/2, Petaling Jaya	4-leg Median	4 phase	• Zebra crossing • Pedestrian signal • Push button • Pedestrian crossing sign
Jalan Tunku Abdul Rahman/ Jalan Sultan Ismail	4-leg Median	3 phase	• Zebra crossing • Pedestrian signal • Push button
Jalan Tun Tan Cheng Lock/ Jalan Petaling	4-leg Median	3 phase	• Zebra crossing • Pedestrian signal • Push button • Audible pedestrian signal

All selected signalised intersection in this study has at least zebra crossing and
pedestrian signal. Each signalised intersection has different characteristics such as

different type of intersection, the number of traffic signal phase and pedestrian crossing facilities.

For this study, only one (1) leg for each intersection was chosen for pedestrian and traffic volume counting. For data analysis at each signalised intersection, the pedestrian video observations and traffic volume count were made for one (1) hour during peak period (7:30 a.m. to 8:30 a.m.) and one (1) hour during the off-peak period (10:30 a.m. to 11:30 a.m.). The initial selection criteria of the study area are the area that has a volume of pedestrian and vehicles that are almost the same. However, the data showed that the number of pedestrians and vehicles at the intersection is varied. Table 3 shows the number of pedestrians (ped/hour) and vehicle (veh/hour) at each study locations for peak hour period and off-peak period. As shown in Table 3, a total of 5,308 pedestrians were observed during the study.

Table 3 The number of pedestrian and vehicles (peak hour and off-peak hour period) for each intersection

Signalised intersections	No. of pedestrian (ped/hour)		No. of vehicles (veh/hour)	
	Peak	**Off-peak**	**Peak**	**Off-peak**
Jalan Tun Tan Cheng Lock/Jalan Hang Kasturi	413	634	2,726	1,984
Jalan Chow Kit/Jalan Raja Laut/Jalan Putra	255	273	1,283	1,335
Jalan Tun Tan Cheng Lock/Jalan Tun H S Lee	262	412	246	638
Jalan Tunku Abdul Rahman/Jalan Dang Wangi	133	200	3,085	2,894
Jalan Raja Laut/Jalan Esfahan	516	255	199	368
Jalan Bukit Bintang/Jalan Sultan Ismail	394	573	5,343	2,580
Jalan Pudu/Jalan Tun Perak/Jalan Cheng Lock	101	120	2,899	3,088
Jalan PJU 6/2, Petaling Jaya	15	13	400	807
Jalan Tunku Abdul Rahman/Jalan Sultan Ismail	89	119	2,237	2,398
Jalan Tun Tan Cheng Lock/Jalan Petaling	215	316	155	59
Total	2,393	2,915	18,573	16,151
	5,308		34,724	

4.2   Demographic Characteristics

Table 4 shows the proportion of pedestrian for each signalised intersections by gender and by estimated age group for one hour during peak hour period.

Table 4   Number of pedestrian for each signalised intersection by gender and by estimated age group during peak hour period

Signalised intersections		Peak hour period				
		Elderly	Adult	Child	Total	
Jalan Tun Tan Cheng Lock/ Jalan Hang Kasturi	Male	12	265	2	279	413
	Female	6	128	0	134	
Jalan Chow Kit/ Jalan Raja Laut/Jalan Putra	Male	19	147	1	167	255
	Female	8	76	4	88	
Jalan Tun Tan Cheng Lock/ Jalan Tun H S Lee	Male	7	170	0	177	262
	Female	4	81	0	85	
Jalan Tunku Abdul Rahman/ Jalan Dang Wangi	Male	3	53	0	56	133
	Female	2	75	0	77	
Jalan Raja Laut/ Jalan Esfahan	Male	10	171	2	183	516
	Female	6	325	2	333	
Jalan Bukit Bintang/ Jalan Sultan Ismail	Male	26	253	0	279	394
	Female	15	97	3	115	
Jalan Pudu/Jalan Tun Perak/ Jalan Cheng Lock	Male	5	65	0	70	101
	Female	2	29	0	31	
Jalan PJU 6/2, Petaling Jaya	Male	0	8	0	8	15
	Female	0	7	0	7	
Jalan Tunku Abdul Rahman/ Jalan Sultan Ismail	Male	4	48	0	52	89
	Female	1	36	0	37	
Jalan Tun Tan Cheng Lock/ Jalan Petaling	Male	10	149	0	159	215
	Female	8	47	1	56	
Total		148	2,230	15	2,393	

Table 5   Total number of pedestrians by gender and estimated age group during peak hour period

	Elderly	Adult	Child	Total
Male	96 (6.7%)	1,329 (92.9%)	5 (0.3%)	1,430 (59.8%)
Female	52 (5.4%)	901 (93.6%)	10 (1.0%)	963 (40.2%)
Total	148 (6.2%)	2,230 (93.2%)	15 (0.6%)	2,393 (100%)

Figure 5   Proportion of pedestrian by gender and by estimated age group during peak hour period

Table 5 summarise the proportion of pedestrian by gender and estimated age group from all nine (9) study locations during peak hour period. During peak hour period, male pedestrians (60%) is higher than female pedestrian (40%). For the proportion of pedestrians by estimated age group, it is shown that 93% of pedestrians were an adult, followed by elderly (6%) and child (1%).
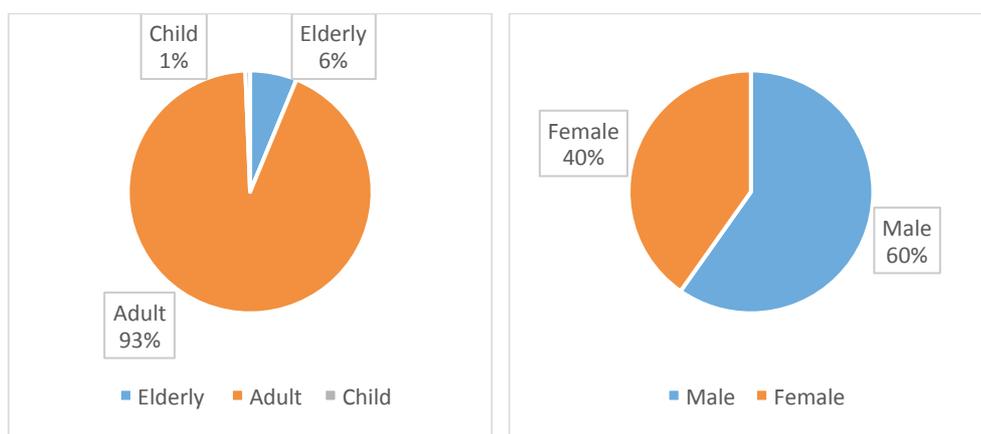
16

Table 6 Number of pedestrian for each signalised intersections by gender and by estimated age group during off-peak hour period

Signalised intersections		Off-peak hour period				
		Elderly	Adult	Child	Total	
Jalan Tun Tan Cheng Lock/ Jalan Hang Kasturi	Male	28	451	0	479	634
	Female	25	128	2	155	
Jalan Chow Kit/ Jalan Raja Laut/Jalan Putra	Male	13	185	4	202	273
	Female	4	65	2	71	
Jalan Tun Tan Cheng Lock/ Jalan Tun H S Lee	Male	4	298	1	303	412
	Female	5	104	0	109	
Jalan Tunku Abdul Rahman/ Jalan Dang Wangi	Male	14	78	3	95	200
	Female	6	97	2	105	
Jalan Raja Laut/ Jalan Esfahan	Male	11	120	8	139	255
	Female	5	108	3	116	
Jalan Bukit Bintang/ Jalan Sultan Ismail	Male	70	284	14	368	573
	Female	34	159	12	205	
Jalan Pudu/Jalan Tun Perak/ Jalan Cheng Lock	Male	17	62	2	81	120
	Female	6	32	1	39	
Jalan PJU 6/2, Petaling Jaya	Male	0	9	0	9	13
	Female	0	4	0	4	
Jalan Tunku Abdul Rahman/ Jalan Sultan Ismail	Male	3	66	3	72	119
	Female	1	44	2	47	
Jalan Tun Tan Cheng Lock/ Jalan Petaling	Male	21	203	1	225	316
	Female	8	82	1	91	
Total		275	2,579	61	2,915	

Table 7 Total number of pedestrians by gender and estimated age group during off-peak hour period

	Elderly	Adult	Child	Total
Male	181 (9.2%)	1,756 (89.0%)	36 (1.8%)	1,973 (67.7%)
Female	94 (10.0%)	823 (87.4%)	25 (2.7%)	942 (32.3%)
Total	275 (9.4%)	2,579 (88.5%)	61 (2.1%)	2,915 (100%)

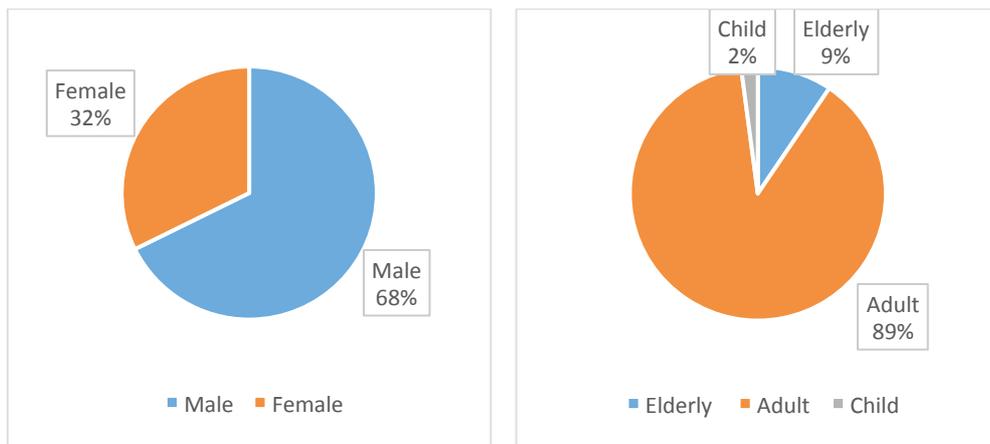**Figure 6**   Proportion of pedestrian gender and by estimated age group during off-peak hour period

Table 6 shows the number of pedestrian for each signalised intersections by gender and by estimated age group during off-peak hour period. Meanwhile, Table 7 shows the total number of pedestrians at all study locations by gender and estimated age group. For the proportion of male and female pedestrian during off-peak hour period, as shown in Figure 6, it is indicating that male pedestrian (68%) is higher than female pedestrian (32%). Based on the observations made, an adult is the majority of the pedestrian group is adults who are 89%, followed by 9% elderly and 2% child. It is concluded that the demographic of pedestrians for both peak and off-peak hour period have the similarities.

After calculating the number of pedestrians in each location, it was found that the number of pedestrians in Jalan PJU 6/2, Petaling Jaya is too low compared with other locations. Therefore, Jalan PJU 6/2, Petaling Jaya is excluded in the analysis of data for this study. Only nine (9) out of ten (10) study locations were analysed in this study.

4.3 Behaviour of Pedestrian while Crossing the Intersections

Table 8 below shows the proportion of pedestrian by way of crossing, either crossing as individual, couple or group. The data was collected to see whether this would affect the behaviour of pedestrians while crossing the intersection.

Table 8   The proportion of pedestrian by way of crossing

Signalised Intersections	Peak hour			Off-peak hour		
	Individual	Couple	Group	Individual	Couple	Group
Jalan Tun Tan Cheng Lock/ Jalan Hang Kasturi	152 (36.8%)	67 (16.2%)	194 (47.0%)	164 (25.9%)	127 (20.0%)	343 (54.1%)
Jalan Chow Kit/ Jalan Raja Laut/Jalan Putra	102 (40.0%)	42 (16.5%)	111 (43.5%)	97 (35.5%)	45 (16.5%)	131 (48%)
Jalan Tun Tan Cheng Lock/ Jalan Tun H S Lee	232 (88.2%)	28 (10.6%)	3 (1.1%)	389 (94.4%)	23 (5.6%)	0 (0%)
Jalan Tunku Abdul Rahman/ Jalan Dang Wangi	104 (78.2%)	20 (15.0%)	9 (6.8%)	59 (29.5%)	69 (34.5%)	72 (36.0%)
Jalan Raja Laut/ Jalan Esfahan	251 (48.6%)	67 (13.0%)	198 (38.4%)	142 (55.7%)	49 (19.2%)	64 (25.1%)
Jalan Bukit Bintang/ Jalan Sultan Ismail	98 (24.9%)	23 (5.8%)	273 (69.3%)	111 (19.4%)	48 (8.4%)	414 (72.3%)
Jalan Pudu/Jalan Tun Perak/ Jalan Cheng Lock	57 (56.4%)	26 (25.7%)	18 (17.8%)	52 (43.3%)	26 (21.7%)	42 (35.0%)
Jalan Tunku Abdul Rahman/ Jalan Sultan Ismail	37 (41.6%)	10 (11.2%)	42 (47.2%)	41 (34.5%)	28 (23.5%)	50 (42.0%)
Jalan Tun Tan Cheng Lock/ Jalan Petaling	99 (46.0%)	57 (26.5%)	59 (27.4%)	127 (40.2%)	57 (18.0%)	132 (41.8%)

Table 9 shows how pedestrian is crossing the intersections either walking or running while crossing. The majority of the pedestrian are walking while crossing the intersection during peak hour period. For an off-peak hour, three (3) intersections show that the numbers of the pedestrian are quite high for walk faster or running while crossing the intersection.

19

Table 9   The proportion of pedestrian by way of crossing (walking or running)

Signalised intersections	Peak		Off-peak	
	Walk	**Walk faster/Run**	**Walk**	**Walk faster/Run**
Jalan Tun Tan Cheng Lock/ Jalan Hang Kasturi	371 (89.8%)	47 (10.2%)	600 (94.6%)	34 (5.4%)
Jalan Chow Kit/Jalan Raja Laut/ Jalan Putra	196 (76.9%)	59 (23.1%)	213 (78.0%)	60 (22.0%)
Jalan Tun Tan Cheng Lock/ Jalan Tun H S Lee	251 (95.8%)	11 (4.2%)	381 (92.5%)	31 (7.5%)
Jalan Tunku Abdul Rahman/ Jalan Dang Wangi	118 (88.7%)	15 (11.3%)	181 (90.5%)	19 (9.5%)
Jalan Raja Laut/ Jalan Esfahan	497 (96.3%)	19 (3.7%)	241 (94.5%)	14 (5.5%)
Jalan Bukit Bintang/ Jalan Sultan Ismail	189 (48.0%)	205 (52.0%)	371 (64.7%)	202 (35.3%)
Jalan Pudu/Jalan Tun Perak/ Jalan Cheng Lock	95 (94.1%)	6 (5.9%)	75 (62.5%)	45 (37.5%)
Jalan Tunku Abdul Rahman/ Jalan Sultan Ismail	76 (85.4%)	13 (14.6%)	87 (73.1%)	32 (26.9%)
Jalan Tun Tan Cheng Lock/ Jalan Petaling	158 (73.5%)	57 (26.5%)	154 (48.7%)	162 (51.3%)

4.4   Temporal Violations among Pedestrian while Crossing the Signalised Intersection

Temporal violations are the situations where pedestrians do not obey pedestrian signals when crossing the road. This situation is dangerous to pedestrians because of the possibility of conflict occurrence between pedestrians and passing vehicles on the road. This situation will cause the risk of pedestrian accidents increased.

4.4.1 The Proportion of Legal, Illegal and Dangerous Crossing among Pedestrian

For this study, the way of pedestrian crossing is divided into three; 1) legal crossing; 2) illegal crossing and dangerous crossing.

i.   Legal crossing – pedestrians started crossing the intersection and finished during green-man phase
ii. Illegal crossing – pedestrians started crossing the intersection and finished during red-man phase
iii. Dangerous crossing – pedestrian start crosses the intersection during the green-man phase and get to another side when the signal has changed to red-man.

Figure 7 shows one of the examples of a pedestrian that commit to illegal crossing. The picture shows that the pedestrian is crossing the intersection during the red-man phase.

Figure 7 Pedestrian cross the intersection during red-man phase

4.4.2 The Proportion of Legal, Illegal and Dangerous Crossing at Study Locations

A total of nine (9) signalised intersections were observed. For further analysis, the sum of all pedestrians from all study locations was taken. Figure 8 below is the proportion of legal, illegal and dangerous crossing among pedestrians.
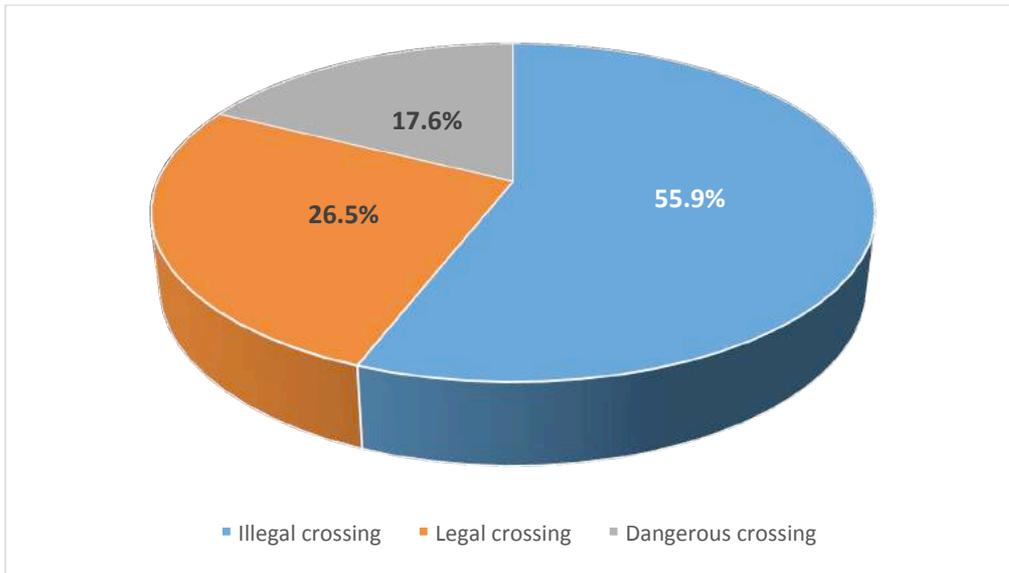
Figure 8   The proportion of legal, illegal and dangerous crossing among pedestrian

From the chart, it is shown that more than half of the pedestrian (55.9%) made an illegal crossing. 26.5% of pedestrian made a legal crossing and 17.6% of pedestrian made a dangerous crossing. As mentioned earlier, dangerous crossing happened when the pedestrian started to cross the road during green-man phase but finished crossing when the signal has changed into red-man phase. These situations can endanger the pedestrian because of the possibility of conflict occurrence between vehicles and pedestrian; hence increase the risk of an accident.

4.5   Pedestrian Waiting Time before Crossing the Signalised Intersections

Pedestrian dangerous crossing and violations to pedestrian signal are common situations. Besides to observe the behaviour of a pedestrian, this study was conducted to observe whether the pedestrian will obey the pedestrian signal before crossing or not. A total of 5,280 pedestrians were observed. Those arrived on the

green-man phase and proceeded crossing were excluded in the analysis. Only
pedestrians arrived on red-man phase were considered in this study.

Table 10   The proportion of pedestrians who arrived during red-man phase

Signalised Intersections	Arrived during red-man phase	
	Wait for green-man phase	Not wait for green-man phase
Jalan Tun Tan Cheng Lock/Jalan Hang Kasturi	332	283
Jalan Chow Kit/Jalan Raja Laut/Jalan Putra	58	93
Jalan Tun Tan Cheng Lock/Jalan Tun H S Lee	128	448
Jalan Tunku Abdul Rahman/Jalan Dang Wangi	108	44
Jalan Raja Laut/Jalan Esfahan	48	205
Jalan Bukit Bintang/Jalan Sultan Ismail	435	305
Jalan Pudu/Jalan Tun Perak/Jalan Cheng Lock	43	44
Jalan Tunku Abdul Rahman/Jalan Sultan Ismail	147	38
Jalan Tun Tan Cheng Lock/Jalan Petaling	133	67
Total	1,432	1,527

Figure 11 shows the proportion of pedestrian who arrived during the red-man
phase. There are two categories of pedestrians; i) wait for green-man phase, ii) did
not wait for green-man phase.
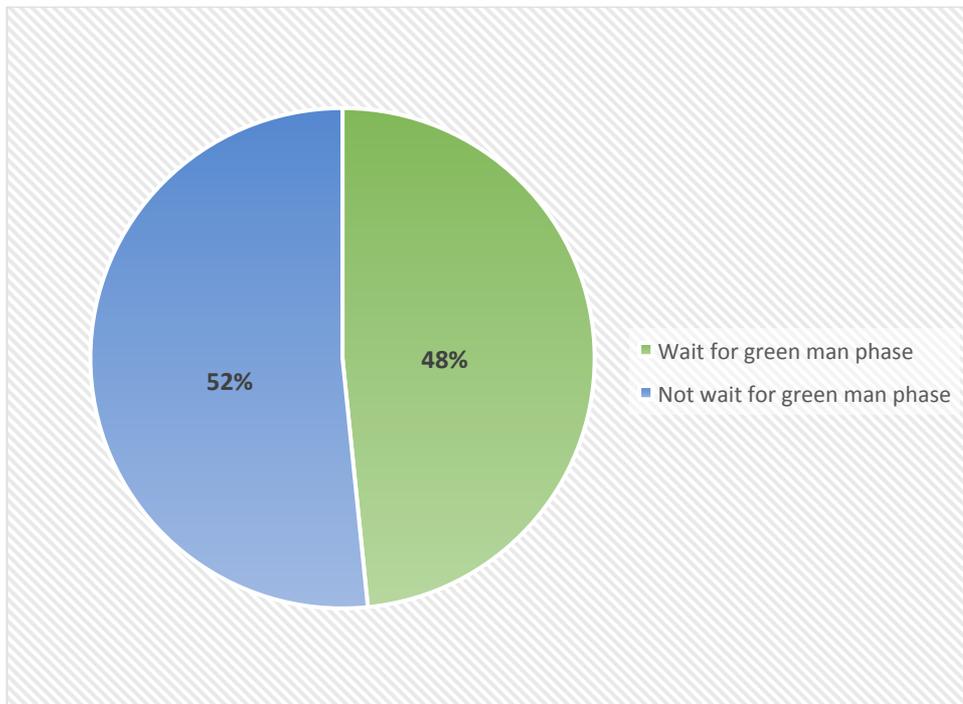
Figure 9   The proportion of pedestrians who arrived during red-man phase

As shown in Figure 9, 52% of pedestrians did not wait for green-man phase before crossing the intersections. From the observations made, pedestrians will cross the intersections once felt safe and ignore the pedestrian signals installed. Only 48% of pedestrians will wait for green-man phase to cross the intersections.

4.5.1 How Long Pedestrians Wait to Cross before Commit to Illegal Crossing

Detailed observations were made of the exact time a sample of pedestrians arrived and when they started to cross. This provided their waiting times, summarised in Figure 13. The number of pedestrians shown in Figure 10 only for pedestrian who commit illegal crossing. That is mean they are crossing during red-man phase. The

aim is to see the maximum waiting time for most pedestrian before violating the pedestrian signals.
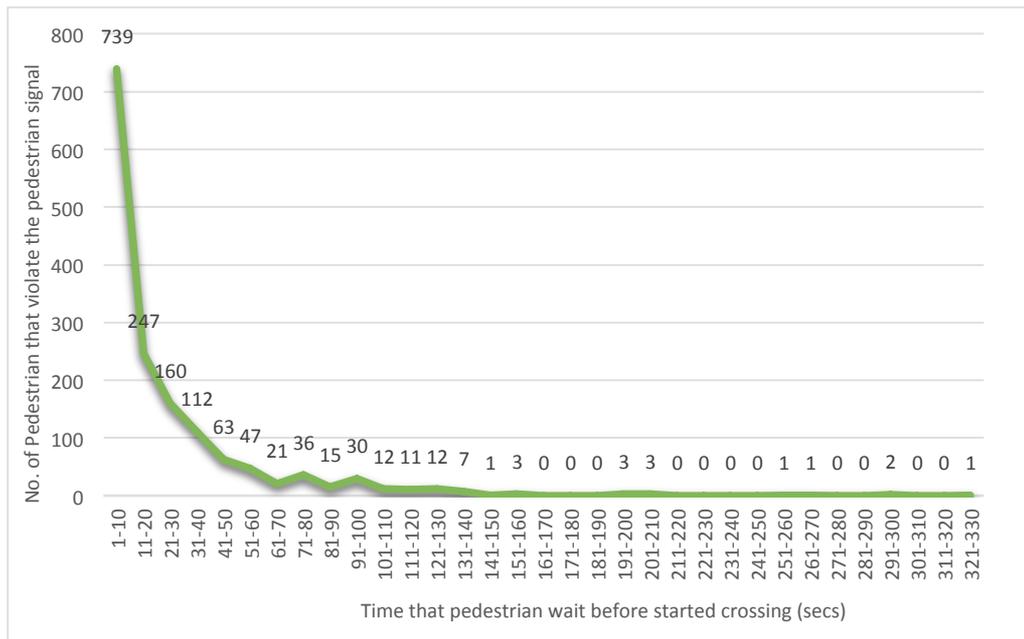
Figure 10   Time that pedestrians wait before started crossing (seconds)

A total of 1,527 pedestrians who violate the pedestrian signals were observed. The chart shows that a total of 739 or 48.4% pedestrians only wait between 1 to 10 seconds before they cross the intersections during red-man phase. It was followed by 16.2% (247) of pedestrian who wait between 11 to 20 seconds and 10.5% (160) of pedestrian who wait between 21 to 30 seconds before they cross the intersections.

The L-shaped distribution indicating that almost half of pedestrian will only wait from 1 to 10 seconds before violation of pedestrian signal occurred.

4.6 The Factors that Influence the Behaviour of Pedestrian while Crossing the Signalised Intersection

Pedestrian safety was also affected by their behaviour while crossing the street. As mentioned before, the way of pedestrian crossing is divided into three (3) categories, which are legal crossing, dangerous crossing and legal crossing. Based on observations, pedestrian tends to cross the road immediately after their arrived at the intersection or wait for a while and continue crossing if there were no vehicles at the intersection. For this analysis, all pedestrian from all signalised intersection was combined.

Figure 11 shows the proportion of pedestrian based on the way of their crossing. From the figure, for legal crossing, it was shown that the percentage of male pedestrian is higher than female pedestrian. Same goes to illegal and dangerous crossing. Obviously, the percentage for adult category was the highest because they are the majority of the pedestrian at all signalised intersections.

For pedestrian behaviour, it is shown that about 50% of a pedestrian that made legal crossing are from the pedestrian who is crossing an individual, followed by group (33%) and by a couple (17%). Meanwhile, for illegal and dangerous crossing, pedestrian who is crossing by group indicate the highest percentage, then followed by crossing individually and by the couple.
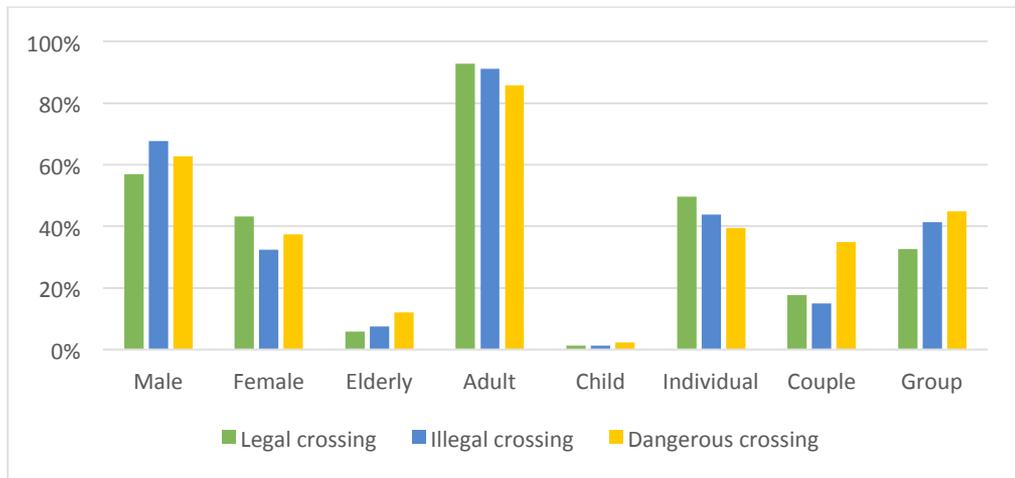
Figure 11   The proportion of pedestrian based on the way of their crossing

Figure 12 below shows the example of a group of pedestrian who commit with illegal crossing. They cross the road during red-man phase. This situation can cause conflicts between pedestrians and vehicles and increase the risk of accidents.

Figure 12   A group of pedestrian crossing the intersection during red-man phase

5.   Discussions

The study analyses the impact of waiting time towards pedestrian safety at signalised intersection. In addition, observations of pedestrian behaviour also conducted to see the effect towards their safety when crossing the intersection. Based on the outcomes from the observations, some conclusions can be made.

In conclusion, 8 out of 10 signalised intersections indicate that the number of pedestrians was higher during off-peak hour period. For number of vehicles, 7 out of 10 signalised intersections shows that the number of vehicles also higher during off-peak hour period. It is as expected because the study areas are all commercial areas.

With respect to demographic composition, for pedestrian's gender, it is a slight difference between peak and off-peak hour period. During peak hour period, 60% of male pedestrians were recorded meanwhile for off-peak hour period, 68% of male pedestrians were recorded. For those periods, male pedestrians were higher than female pedestrians. In addition, the age group of adult indicates the higher number of pedestrian at all signalised intersections. The only small percentage of child and elderly pedestrians.

When it comes to illegal crossing, more than half of the pedestrian commit with illegal crossing. For illegal and dangerous crossing, the percentage of male pedestrian is higher than female pedestrian. A recent study on pedestrian's behaviour based on gender shows that male pedestrians were found to perform more risky behaviour when crossing the road (Razzaghi & Zolala, 2015). It goes to results from study done by Li (2014). It is shown that the males seemed to be more impatient and tended to find an opportunity to cross the street, leading to a shorter waiting time.

Furthermore, this study showed that the pedestrian would continue to cross when they feel that the circumstances surrounding at the intersection are safe. Most of them ignored the pedestrian signals which is 55.9% of the pedestrian did not follow pedestrian signals. Vujanic et al. (2014) came to the different conclusions; only 17.5% of the pedestrians cross during red-man phase. This may be due to pedestrian crossing for that study was equipped with countdown display.

Irrespective of the pedestrian waiting time, for those who arrived during red-man phase, the results indicate that only 48% of pedestrian will wait at the roadside before crossing. 52% of pedestrian violate the pedestrian signal. They started crossing immediately after they arrived at the roadside even though they arrived during red-man phase. Another study was done by Galanis and Nikolaos (2012), in middle size cities in Greece, only 15% of the pedestrians cross the intersections during red-man phase. Environment and traffic condition may influence the differences in the number of violation.

In terms of maximum waiting time, almost half of the pedestrian (48.4%) who commit illegal crossing or cross during red-man phase only wait for about 1 to 10 seconds before they violate the pedestrian signals. The moment of arrival at the intersection seems to give little impact on pedestrian's crossing behaviour. Li (2014) drawn a conclusion where the results show a U-shaped distribution of the pedestrians' intended waiting time. The U-shaped distribution shows that there are a large proportion of pedestrians cross the street immediately after arriving the roadside, and also there are large proportion of pedestrians who will wait for green-man phase for cross the intersections. It is different from the findings of this study. This study shows a L-shaped distribution where most of the pedestrians will cross the intersections based on traffic conditions. From the observation made, pedestrians will illegally cross the intersections when the traffic flow and speed are lower.

31

Lastly, the factors such as demographic characteristics and the way of crossing will affect the pedestrian safety while crossing the intersections. Other study in Montreal, Canada has found similar results. The variables such as being male, and being a young adult increased the proportion of pedestrian's violation towards pedestrians' signals (Brosseau et al., 2013).

6. Conclusions and Recommendation

This study was conducted to determine the impact of waiting time towards pedestrian safety at signalised intersection, and to identify the factors that influence behaviour of pedestrian while crossing the signalised intersection. A total of 5,280 pedestrians from nine (9) signalised intersections were observing using video recording. An observation was made for two (2) hours (peak and off-peak period) for each signalised intersection. The following conclusions can be drawn from the study.

To begin with it, studies show that the variables such being male, female, different group of age, waiting time and the way of crossing affect the proportion of violations. To decrease the dangerous crossing proportion, it is better to suggest each pedestrian signal must be installed with pedestrian countdown timer. Pedestrian countdown timer can help pedestrians to decide whether they have sufficient time to cross or not. Therefore, it can reduce the risk of conflict and collision between vehicles and pedestrian.

Pedestrian can be categorised into two (2); pedestrian who will wait at the roadside before crossing; and pedestrian who will immediately cross the intersection after arrived at the roadside. However, through the observations made, both of these situations involve pedestrians that comply and also failed to comply with pedestrian signals. Supposedly, the pedestrian has to wait for green-man phase before crossing and that green-man phase is related to traffic signal cycle length. However, the results show that most of the pedestrian did not follow the pedestrian signals. Therefore, it can be concluded that the traffic situation is one of the factors that influence the behaviour of pedestrians before deciding to cross.

Waiting time at signalised intersection is depends on traffic signal cycle length. Pedestrian need to wait for green-man phase (during red phase traffic signal) for them to cross the intersection. Long waiting times at signalised intersections will cause pedestrians to be impatient and tend to violate pedestrian signals. Non-compliance with pedestrian signals may increase the risk of conflicts and collision between vehicles and pedestrian and will further harm their safety. From this study, more than half of the pedestrians do not comply and violate the traffic signals, and from that, almost half of them only wait about 1 to 10 seconds before violating pedestrian signals. It is shows that pedestrian behaviour while crossing the intersections was based on the traffic condition at a time, not due to long waiting time during red-man phase.

There are several limitations to these findings. Observations made involving many pedestrians at one time. Therefore, there is a possibility of the occurrence of an error made during the observations process by using the recorded video. Other than that, the results of this study only apply for selected signalised intersections based on this study location. It does not apply to other signalised intersections.

References

Lipovac, K., Vujanic, M., Maric, B., & Nesic, M. (2013). The influence of a pedestrian countdown display on pedestrian behavior at signalized pedestrian crossings. *Transportation Research Part F 20*, 121-134.

Pulugurtha, S. S., Desai, A., & Pulugurtha, N. M. (2010). Are pedestrian countdown signals effective in reducing crashes? *Traffic Injury Prevention*, 632-641.

Brosseau, M., Zangenehpour, S., Saumier, N., & Miranda-Moreno, L. (2013). The impact of waiting time and other factors on dangerous pedestrian crossings and violations at signalized intersections: A case study in Montreal. *Transportation Research Part F 21*, 159-172.

King, M. J., Soole, D., & Ghafourian, A. (2009). Illegal pedestrian crossing at signalised intersections: Incident and relative risk. *Accident Analysis and Prevention 41*, 485-490.

Hamed, M. M. (2001). Analysis of pedestrians' behavior at pedestrian crossings. *Safety Science*, 63-82.

Zhou, Z., Ren, G., Wang, W., Zhang, Y., & Wang, W. (2011). Pedestrian crossing behaviors at signalized intersections: Observational study and survey in china. *Journal of the Transportation Research Board*, 65-73.

Tiwari, G., Bangdiwala, S., Saraswat, A., & Gaurav, S. (2007). Survival analysis: Pedestrian risk exposure at signalised intersections. *Trasportation Research Part F 10*, 77-89.

Marisamynathan, & Perumal, V. (2014). Study on crossing behavior at signalized intersections. *Journal of Traffic and Transportation Engineering*, 103-110.

Chuen, O. C., Karim, M., & Yusoff, S. (2014). Mode choice between private and public transport in Klang Valley, Malaysia. *The Scientific World Journal*.

Ariffin, A. H., Mohd Jawi, Z., Md Isa, M., Abu Kassim, K., & Shaw Voon, W. (2010). pedestrian casualties in road accidents - Malaysia perspective. *MIROS Road Safety Conference*, 280-289.

World Health Organization. (2013). *Pedestrian safety: a road safety manual for decision-makers and practitioners.* Geneva: WHO Library Cataloguing-in-Publication Data.

World Health Organization. (2009). *Global status report on road safety: Time for action.* Geneva: WHO Library Cataloguing-in-Publication Data.

Lee, C., & Abdel-Aty, M. (2005). Comprehensive analysis of vehicle-pedestrian crashes at intersections in Florida. *Accident Analysis & Prevention*, 775-786.

Palamara, P., & Broughton, M. (2013). *An investigation of pedestrian crashes at traffic intersections in the Perth Central Business.* Pearth: Curtin-Monash Accident Research Centre (C-MARC).

Razzaghi, A., & Zolala, F. (2015). Exploring the pedestrian's behaviors in crossing the street based on gender. *Austin Journal of Emergency and Critical Care Medicine*.

Li, B. (2014). A bilevel model for multivariate risk analysis of pedestrians' crossing behaviour at signalized intersections. *Transportation Research Part B 65*, 18-30.

Vujanic, M., Pesic, D., Antic, B., & Smailovic, E. (2014). Pedestrian risk at the signalized pedestrian crossing equipped with countdown display. *International Journal for Traffic and Transport Engineering*, 52-61.

Galanis, A., & Nikolaos, E. (2012). Pedestrian crossing behaviour in signalized crossings in middle size cities in Greece. *REAL CORP 2012 Tangungsband*, 563-570. Schwechat.

Research Report

The Impact of Waiting Time towards Pedestrian Crossing Behaviour at Signalised Intersection

MI:ROS
MALAYSIAN INSTITUTE OF ROAD SAFETY RESEARCH
ASEAN ROAD SAFETY CENTRE