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Analysis of Pedestrians' Jaywalking at the Signalized Midblock in Kuala Lumpur, Malaysia

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ABSTRACT

Crossing outside of a marked crosswalk or jaywalk is risky to pedestrians yet it common in Malaysia. To minimize the risk of crashes occurring to the pedestrians near the marked crosswalk, there is a need to understand jaywalking behaviour, as well as the surrounding factors that influenced the occurrence of jaywalkers. This article presents an analysis of pedestrians' jaywalking near the marked crosswalk at the selected signalized midblock in Kuala Lumpur and the effects of traffic and road infrastructure on this act. A 150m area outside marked crosswalk was segmented into several sections to observe the number of pedestrians' crossing at each section during peak and off-peak period by the trained observers and video cameras. Data on vehicle volume and the road infrastructure characteristics such as the presence of median, building entrance, side fence, vegetation on median and the presence of bus/taxi stop at each section was also recorded during field observation. The effect of traffic and road infrastructure which influenced the number of jaywalkers at each section were examined using negative binomial regression. Based on the observation of the pedestrian crossings, the highest percentage of pedestrians' jaywalking near marked crosswalk was 62% during peak hours and 55% during off-peak hours. Three factors which significantly influenced the pedestrians' jaywalking were pedestrian volume, the presence of building entrance, and the installation of fences. The result of this study suggested an appropriate locating the marked crosswalk nearest to the building entrance, provided with side fencing for channelization to minimize the number of jaywalkers at the signalized midblock.

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1. Introduction

Crossing a straight road without using any crossing facility such as a midblock crossing will be dangerous for pedestrians. Despite the environment of straight roads which is ideal for vehicles to speed up, pedestrians will be forced to walk through shorter crossing gaps (Lobjois et al., 2013) which could be risky to them. This situation can lead to pedestrian accidents which occurrence is predicted to be higher on straight roads compared to other types of road alignment. Furthermore, accident data from the police also indicates the high occurrence of pedestrian casualties (death, serious and minor injuries) which occur mostly on straight roads compared to other types of road alignment in Malaysia (Polis Diraja Malaysia [PDRM], 2017).

The installation of signalized midblock on straight roads has increased the safety of pedestrians when crossing the road. Some crossings may be equipped with pedestrian signals to enhance the safety of pedestrians by giving them the right of way to cross. Comparing to other crossing facilities, midblock is the most influential facility that encourages pedestrians to a dedicated area (Sisiopiku and Akin, 2003). However, the safety of pedestrians is still affected by their jaywalking habits which have become common in Malaysia. Jaywalking can be referred to a pedestrian who crossed a road other than marked or unmarked crosswalk (Zheng et al., 2015). In other words, jaywalker is a pedestrian who do not walk at the crosswalk at all or do not comply with the crosswalk location (Sisiopiku & Akin, 2003). Non-complying walking behaviour by pedestrians leads to more conflicts at midblock (Avinash et al. 2019).

According to Section 75(2) of the Malaysian Road Transport Act 333 1987, traffic movement is confined by the boundaries created by their roadway marks as well as traffic signs, indicating that pedestrians in Malaysia should put any crosswalk available on the road to use. This indication abides by the rules that pedestrians are prohibited from approaching the carriageway within 100m of a crosswalk (Road Transport Act, 1987). In addition, crossing outside the provided crosswalk will increase the pedestrian-vehicle interaction on the road which is associated with pedestrian crashes at signalized intersections (Wong et al., 2007). Moreover, jaywalking also leads to an unexpected situation faced by drivers by affecting their driving judgment. This occurs through the reduction of the time taken for drivers to react to the jaywalkers compared to their reactions to rule-abiding pedestrians (Zheng et al., 2015).

Providing a signalized midblock as a countermeasure to promote safe crossing for pedestrians will be effectively provided if there is no misuse committed by jaywalkers. Though jaywalking or taking illegal path was preferred probably to reduce crossing distance (Cherry et al., 2012), this behaviour is more exposed to the risk of collision with vehicle (Shaaban et al., 2018). The factors which lead the pedestrians to jaywalk near signalized midblock need to be identified in order to reduce the occurrence of jaywalking. However, there is a limited number of studies that examine the jaywalking pedestrians near signalized midblock and its influencing factors. Meanwhile, in this study, the number of pedestrians who jaywalked 150m from the signalized midblock were observed and examined. Besides, the impacts of traffic and road infrastructure on the number of jaywalking pedestrians were further analyzed through the negative binomial regression technique.

2. Literature Review

Previous studies on pedestrians have related the pedestrians' behavioural characteristics with the compliance of the provided pedestrian facilities at a specific location like signalized midblock. Basic characteristics of pedestrian such as age and gender may have an effect on their behaviour such as waiting time before crossing. For example, a study by Hamed (2001) concluded that age and gender were significantly affected pedestrians' waiting time at ten midblock crossings in Jordan. Other significant factors to waiting time were the number of crossing pedestrians, the frequency of road crossing, the occurrence of road accidents, and destination.

In other studies, Ferenchak (2016) analyzed the impacts of gender and age on the time spent on pedestrians in waiting at the midblock in India. As a result, it was found that female and older pedestrians spent a longer waiting time and faced with fewer conflicts with vehicles. A study by Wang et al. (2011) also related pedestrians' waiting time with their behaviour at the midblock and concluded that half of the pedestrians could not afford to wait longer than the 40s. Comparison among gender in their study also indicates that young men were more likely to terminate their waiting time to violate signal than women (Wang et al., 2011).

Relevant research on pedestrians at midblock crossing also focused on gap acceptance and crossing speed. Pawar and Patil (2015) modelled pedestrians gap acceptance decision using binary logit analysis to estimate gap acceptance probability and analysed factors influenced. Their study extended to estimate the critical gap using deterministic and probabilistic approaches in Pawar and Patil (2016). Study related to crossing speed at midblock was conducted by Rastogi et al. (2011). It is concluded that pedestrians crossing speed were inclined by many factors such as traffic volume, the number of traffic lane, road width, land use, personal characteristics and type of movement whether in a group or not.

Other studies on pedestrian behaviour at midblock evaluate safety margin as an indicator of the pedestrian-vehicle interaction, where greater safety margin representing safer gap. Avinash et al. (2019) in their study found that pedestrian safety margin influenced by pedestrian speed, age, platoon size, waiting time, vehicle speed, vehicle type and driver yielding behaviour.

A study by Sisiopiku and Akin (2003) estimated the spatial crossing compliance rate at different types of crosswalks. Spatial compliance in their study refers to the compliance of the crossing location, where jaywalking pedestrians (who crossed outside crossing location) were considered based on crosswalk influence area (CIA). The CIA varied based on the distance between two subsequent crosswalks. The result indicated the average spatial crossing compliance rate four crossing facilities amounted to 71.4%. Factors influenced spatial crossing compliance were investigated via survey and limited to the certain types of control including pedestrian signal, brick pavement, barriers and crosswalk. However, the factors that may affect the jaywalking act was not investigated in this study.

Study on the jaywalking pedestrians conducted by Wang et al. (2010) focused on the Pedestrian–Vehicle Interaction (PVI) behaviour and pedestrians' gap acceptance when they jaywalk outside crossing facilities. Data captured from video cameras were extracted such as gender, age group, waiting time, group size, far side and near side gap to test relationship on gap acceptance. Results showed only the near side gap time, group size and age category were significant of pedestrians to be modelled using binary logit technique.

In an analysis of pedestrian's crossing path at midblock conducted by Cherry et al. (2012), the distance taken by pedestrians who used the crosswalk (legal path) and jaywalked (illegal path) was measured from their original spot to the destination. As a result, it was shown that the distance taken by pedestrians who took the legal path was five times longer than the distance for the illegal path. Beside the crossing path, this study also investigates gap acceptance and conflict of pedestrians at midblock. Effect of the environment variables on pedestrian behaviour was examine in this study but not on the jaywalking event.

Another relevant research conducted by Zheng et al. (2015) designed a vehicle-pedestrian interaction for individuals who crossed the road without using the crosswalk or those who jaywalked. The data on the vehicle speed, driver's decision to yield, jaywalkers' decision, traffic flow, and roadway environment was collected through the instrumented vehicle. The particular locations with a high occurrence of jaywalking were observed for 45 minutes. As a result, the rate of the driver's yield to jaywalkers was lower than the yield to the crosswalk users. Additionally, there was a high correlation between the occurrence of jaywalking and the number of pedestrians, the number of bus stops, and the crossing distance. Effect of environment variables to jaywalking was evaluated but limited to the presence of median, number of bus stop and distance between crosswalk.

Shaaban and Abdel-Warith (2017) investigated the gap acceptance behaviours of jaywalking pedestrians at midblock in Qatar. Data on the pedestrian gap acceptance were extracted from the 12 hours' video recordings. Agent-based modelling technique was applied to simulate the gap acceptance of jaywalking pedestrians. However, the model considered limited variables including lane width, vehicle and pedestrian speed to simulate the critical gap.

Previous studies on pedestrians at signalised midblock highlighted the importance of pedestrian behaviours and identifying influencing factors. Pedestrian behaviours such as waiting time (Ferenchak, 2016; Hamed, 2001; Wang et al., 2011), gap acceptance behaviour (Pawar and Patil, 2016), crossing speed (Rastogi et al., 2011) and safety margin (Avinash et al., 2019) were studied specifically at midblock to understand its implication to pedestrian safety. However, a small number of pedestrian studies considered the issue of jaywalking pedestrians (Zheng et al., 2015).

Studies carried out on the jaywalking pedestrians focus on their gap acceptance (Shaaban and Abdel-Warith, 2017; T. Wang et al., 2010) and the distance of crossing path (Cherry et al., 2012). While the study by Zheng et al. (2015) focused on jaywalking pedestrians and its influencing factors such but limited to several factors. Literature has shown that previous studies on jaywalking pedestrians do not cover certain road characteristic that affects this behaviour such as building entrance, side fence, directional flow, distance from the crosswalk, median vegetation. In this study, the occurrence of jaywalking pedestrians at a certain area near marked crosswalk and factors influenced were investigated. Jaywalking near provided crossing facility seems riskier, as drivers expecting pedestrians comply with crossing location.

3. Methodology

This study aimed to analyze the occurrence of the jaywalking pedestrians near the marked crosswalk at signalized midblock and its influencing factors. The number of pedestrians crossing in area near the marked crosswalk called the crosswalk influential area (CIA) was observed and counted for 2 hours during peak and off-peak period.

The CIA at the six selected signalized midblock were segmented into several sections to count pedestrians crossing at and outside the marked crosswalk. Traffic flow and road infrastructure characteristics were also observed in each section in the CIA. The influence of these characteristics on jaywalking pedestrians was examined using statistical analysis. The jaywalking pedestrians were obtained by counting the number of pedestrians crossing outside provided crosswalk in the CIA.

3.1. Site Selection

Six signalized midblock in the central business district in Kuala Lumpur was chosen for this study. Surrounded by various attractive places as a central business district and connected by many public transport modes, a high volume of pedestrian activity can be found in Kuala Lumpur. Each of them was represented by Site 1, 2, 3, 4, 5, and 6 and the location is shown in Figure 1.

All six selected signalized midblock are provided at locations with high pedestrian volume. The average of pedestrian volume for these signalized midblock varied from 225 ped/hr to the highest of 1574 ped/hr. High traffic volume can be observed passing through the midblock crossing, ranging from 1972 veh/hr to 4742veh/hr. The details of the six sites are summarized in Table 1.

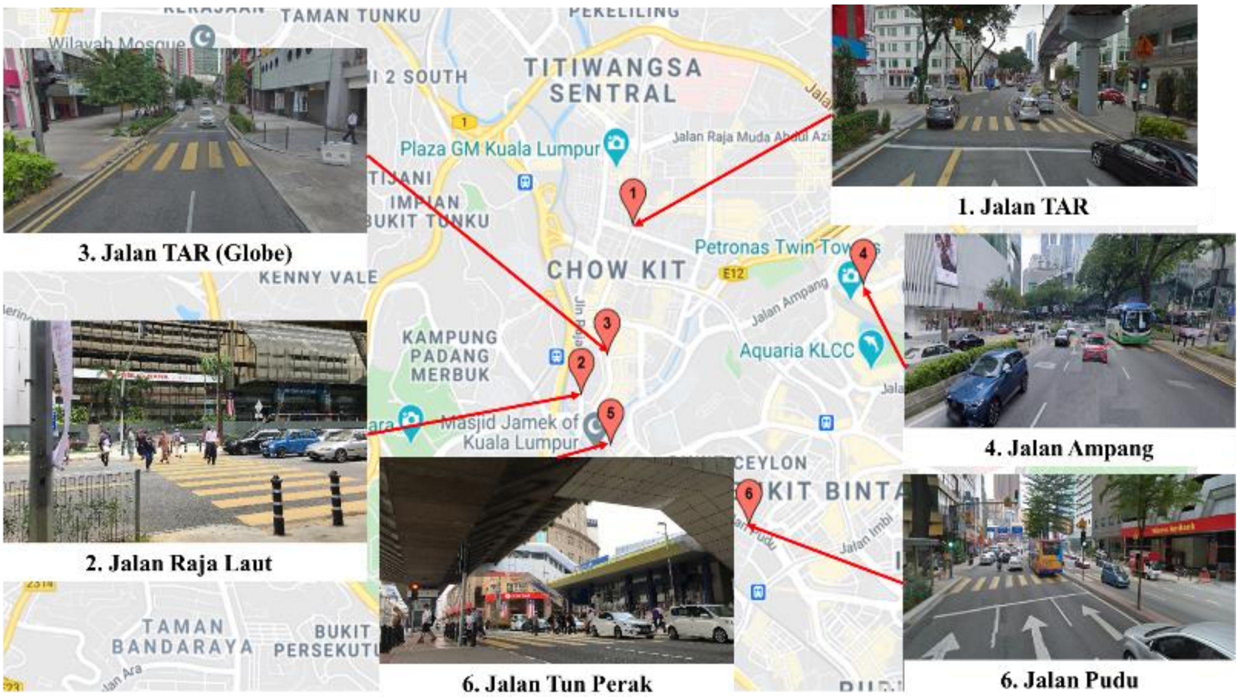


Figure 1: Six selected signalized midblock in Kuala Lumpur.

Table 1: Summary of the study locations.

Site No.	Location	Directional Flow	Crosswalk width (m)	Average pedestrian volume (ped/hr)	Average Vehicle volume (veh/hr)
Site 1	Jalan TAR	One-way	3.0	256	2785
Site 2	Jalan Raja Laut	One-way	3.8	376	1972
Site 3	Jalan TAR (Globe)	One-way	3.0	739	2009
Site 4	Jalan Ampang	Two-way	8.1	765	4742
Site 5	Jalan Tun Perak	Two-way	12.3	1574	3577
Site 6	Jalan Pudu	Two-way	5.3	225	3227

The schematic diagram of the selected sites is presented in Figure 2. Site 1, 2, and 3 were one-way roads with no median, while Site 4, 5, and 6 were two-way roads with medians. All signalized midblock crossings considered in this study equipped with a pedestrian push-button device that is functioning well.

3.2. Data Collection

The number of pedestrians crossing at the signalized midblock and its potential variables was collected based on field observation. The marked crosswalk at signalized midblock was referred to dedicated space for pedestrians to cross during the green light of the pedestrian phase. Each marked crosswalk at the six selected sites was labelled 'CW' as shown in Figure 3. Assuming that pedestrians are attracted to cross at an area near crosswalk called the crosswalk influential area (CIA) which had been established in research by Sisiopiku and Akin (2003), this study set a fixed CIA distance of 150m (75m left + 75m right) around a marked crosswalk as there was no other crossing present nearby.

On the left side of the signalized midblock, the CIA showed in Figure 3 (a) and (b) were segmented into 3 sections which labelled as L1, L2, and L3 represented the sections located at the distance of 0-25m, 25-50m, and 50-75m from the crosswalk respectively. For the consistent marking, the left side section of the signalized midblock (L1, L2 and L3) at one-way directional road refer to the direction of the oncoming vehicle. While, on the right side of the marked crosswalk (CW), the CIA was also segmented into 3 sections R1, R2, and R3 which represented the sections located at the distance of 0-25m, 25-50m and 50-75m from the crosswalk respectively. A total of seven sections were segmented within the CIA as illustrated in Figure 3, from left L3, L2, L1, CW, R1, R2 and R3.

Pedestrians crossing at crosswalk were observed on the field using a minimum of two video cameras set up near the sidewalk. In addition, six observers were assigned at section L1, L2, L3, R1, R2 and R3 to observe and count the number of pedestrians who were crossing in that area. Video cameras and six trained observers were simultaneously record and count pedestrians at the site. The number of pedestrians crossing were recorded within each 15-minute interval for two hours during the peak (1230 - 1430) and off-peak (1000 - 1200) periods. The weather condition was sunny throughout the observation.

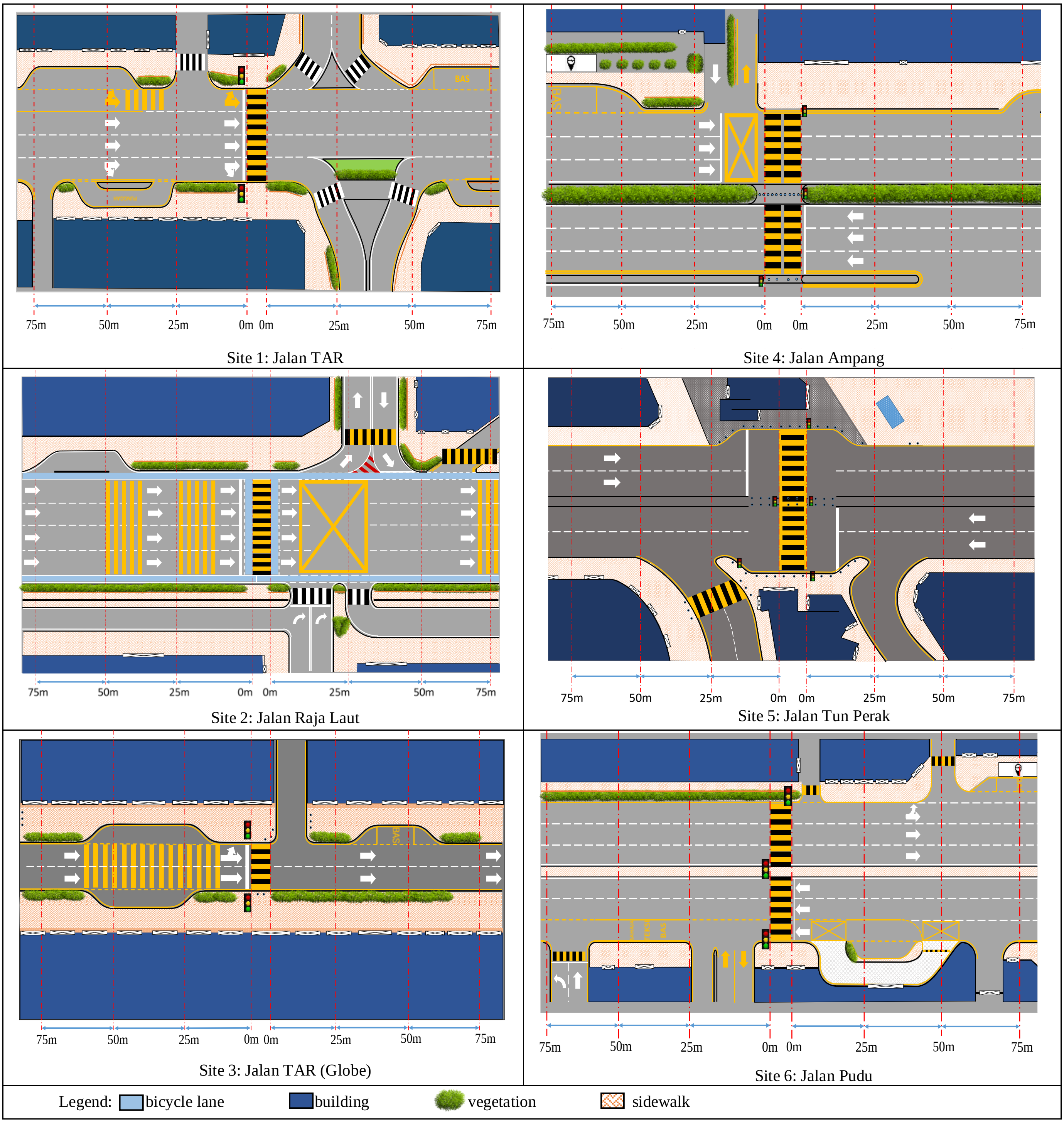
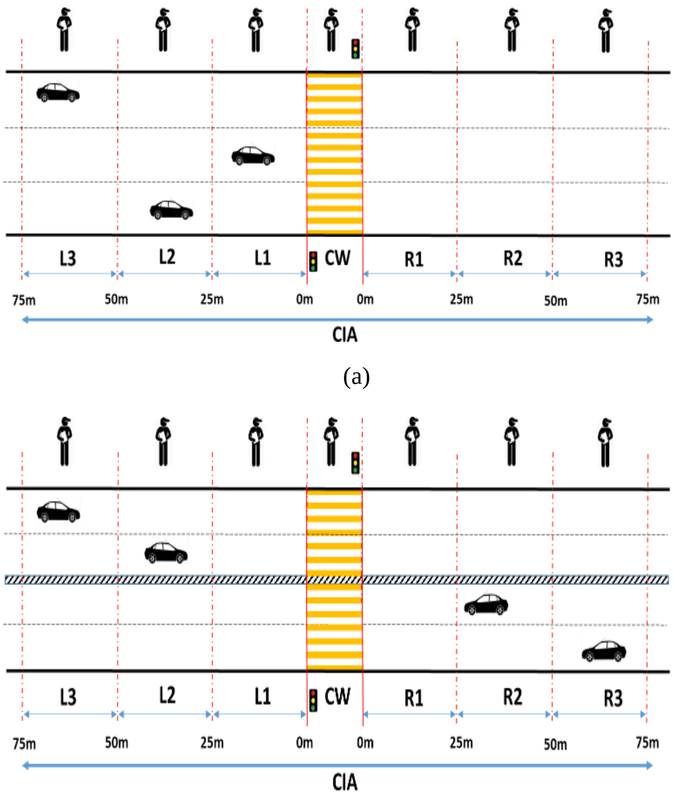


Figure 2: Schematic diagram of the selected signalized midblocks.

Video cameras were used to record data on the pedestrian crossing at marked crosswalk due to the limited number of trained observers. These cameras were placed sequentially (minimum of two cameras for each site) to capture a view that slightly overlapping of pedestrians crossing at the marked crosswalk and within 3m from both sides of the crosswalk. This configuration allowed the partial jaywalking pedestrians to be identified during video data extraction. Partial jaywalking pedestrians refer to those who crossed partially at the marked crosswalk and tend to jaywalk due to a high volume of pedestrians and narrow crosswalk. In this study, partial jaywalking pedestrians are considered to comply with the marked crosswalk location.

Data on the number of vehicles were extracted from video recording at sites. All types of vehicles (car, van, heavy vehicle and motorcycle) passing the crosswalk from either one or two directions were counted during the peak (1230 - 1430) and off-peak (1000 - 1200) periods. The total number of vehicles observed were calculated to generate an average vehicle volume (veh/hr) for each site. The road characteristics in the vicinity of the sites (median, bus stop, fencing, etc.) were also observed during field data collection. Information on road characteristics for each section k was recorded using an observation sheet. Photos of the road characteristics observed were also captured for the record.



(b)

Figure 3: Area segmentation for the CIA: (a) at midblock at one-way directional road and (b) at midblock at two-way directional road.

3.3. Calculation of the Percentage of Jaywalkers

The data on the pedestrian crossings at the CIA of a midblock was used to calculate the percentage of jaywalkers present at the signalized midblock. A jaywalking pedestrian refers to the pedestrian who crossed outside the provided crosswalk either in compliance with pedestrian green signal or not. In general, the percentage of jaywalkers is expressed as the number of pedestrians crossing outside provided crosswalk divided by the number of pedestrians in the CIA in a period of time (2 hours observation in this study). It can be simplified using the following formula, where an area outside provided crosswalk is referring to the section L1, L2, L3, R1, R2 and R3 or section k of midblock;

$$PJ_i = \frac{\Sigma J_k^i}{P_{CIA}^i} \times 100 \qquad (1)$$

where,

PJ_i : the percentage of jaywalkers at midblock i

ΣJ^i_k : the total number of jaywalkers at section k of midblock i ($k = L1, L2, L3, R, R2, R3$)

P^i_{CIA} : the number of crossing pedestrians in the CIA of midblock i

3.4 Negative Binomial Modelling Approach

The effect of traffic and road environment characteristics to the pedestrian jaywalking at signalized midblock crossing was evaluated in this study. Identified variables that characterized traffic and road environment were observed in each section k within 150m CIA of midblock. Using negative binomial regression, statistical analysis was conducted using SPSS.

The negative binomial models are commonly used to handle the crash data that are over-dispersed. The assumption needs to be checked whether the variance value is larger than the mean as an indication of the overdispersion parameters (Hall and Tarko, 2019). The mean number of pedestrian jaywalking is, $E(\mu)$= 86 while the variance is equal to 19594. Since the variance is larger than the mean, the negative binomial model is suitable to use to predict the pedestrian jaywalking at signalized midblock in this study. The overall model fit is assessed by testing the null hypothesis of coefficients not equal to zero. The negative binomial model applied using a stepwise process in choosing the important variables at 5% of the significant level.

Negative binomial regression is based on the Poisson-gamma mixture distribution. The mathematical expression to represent the negative binomial regression model for an observation i is written as;

$$Prob(Y = y_i|\mu_i, \alpha) = \frac{\Gamma(y_i+\alpha^{-1})}{\Gamma(\alpha^{-1})\Gamma(y_i+1)} \left(\frac{1}{1+\alpha\mu_i}\right)^{\alpha^{-1}} \left(\frac{\alpha\mu_i}{1+\alpha\mu_i}\right)^{y_i} \qquad (2)$$

where Γ is a gamma function. The parameter μ is the mean incidence rate of y per unit of exposure time t and x_i is the factors selected as independent variables;

$$\mu_i = exp(ln(t_i) + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki} \qquad (3)$$

Often, $x_1=1$, in which case β_1=intercept. The regression coefficients $\beta_1, \beta_2, \ldots, \beta_k$ are unknown parameters that are estimated from a set of data. Their estimates are symbolized as $b_1, b_2, \ldots, b_k$.

The dependent variable in the model refers to the number of pedestrians crossing at section k (jaywalking) during peak and off-peak hour. Data related to the traffic flow and road infrastructure observed in section k were also collected and were used as the independent variables in the model (refer to Table 2).

Table 2: Variables used in Negative binomial model.

Type	Variables	Categories	Unit/Code
Traffic Characteristics	Pedestrian volume	Number of pedestrians crossing in the CIA of midblock i for an hour duration	Pedestrians per hour
	Vehicle volume	Number of vehicles passed midblock for an hour duration	Vehicles per hour
Road Infrastructure Characteristics	Building Entrance	The presence of building entrance in section k	0 = no 1 = yes
	Side Fence	The presence of fence on the road edge in section k	0 = no 1 = yes
	Median	The presence of median at crosswalk location	0 = no 1 = yes
	Median Vegetation	The presence of vegetation on median in section k	0 = no 1 = yes
	Observation period	The 2 hours of observation period (peak or off peak)	1 = off peak 2 = peak
	Bus/taxi stop	The presence of bus/taxi in section k	0 = no 1 = yes
	Section category	Category of section k from certain distance of a marked crosswalk	1 = 0-25m 2 = 25-50m 3 = 50-75m

Two variables represent traffic characteristics, and seven variables represent road infrastructure characteristics. The variables in the dataset were used for statistical analysis to examine the contributing factors of the high number of pedestrians who were jaywalking at section k.

4. Results and Discussions

4.1. The Percentage of Jaywalkers

A total of 15,477 pedestrians at the six signalized midblock chosen in this study were recorded. The number and percentage of pedestrians jaywalking at each midblock during peak and off-peak hour were calculated. Results in Table 3 summarized results from the observations conducted. Overall, the proportion of people jaywalking varies from as low as 2% to the highest of 62%, depending on the sites. On average, the proportion of jaywalking is 40.8% during peak hour and 43.3% during off-peak hour. Comparing for different site locations, the lowest percentage of jaywalker is at site number 4 (Jalan

Ampang), and the highest percentage is 62% during peak hour at Site number 2 (Jalan Raja Laut).

A non-parametric test is conducted to see if the proportion of jaywalk differs, according to the distance road directional flow (one-way or two-way). Kruskal Wallis test shows that there is no significant difference in proportion of the jaywalker either the road is a one-way, or two-way (χ^2(df=1) =1.6827, N = 36, p= 0.1946). For crossing period (peak and off-peak), the proportion of jaywalk also been tested. Result from the Kruskal Wallis test shows that there is no significant difference in proportion of jaywalk, regardless of the period they cross (χ^2(df=1) = 0.441, N = 36, p= 0.5064). The behaviour is similar whether it is peak hour or off-peak hour.

Table 3: Pedestrians crossing in the segmented sections within CIA during peak hour.

Site No.	Directional flow	Number of pedestrians jaywalked in the CIA of midblock i		Number of pedestrians crossing at marked crosswalk (CW)		Number of pedestrians crossing in the CIA of midblock i		Percentage of pedestrians jaywalking (%)	
		Peak	Off-peak	Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
1	One-way	185	186	218	175	403	361	46	52
2	One-way	541	343	333	284	874	627	62	55
3	One-way	677	444	1291	541	1968	985	34	45
4	Two-way	108	17	1935	1003	2043	1020	5	2
5	Two-way	1849	1389	1797	1258	3646	2647	51	52
6	Two-way	266	181	301	154	567	335	47	54
						Average		40.8	43.3

4.2. Factors Influencing the Jaywalking Pedestrians

Identified variables characterize the traffic and road infrastructure that influenced the number of jaywalking pedestrians at section k of the signalized midblock were evaluated using negative binomial regression in this study. A total of nine independent variables including pedestrian and vehicle volume, building entrance, side fence, median, median vegetation, observation period, presence of bus/taxi stop and the category of section k were considered in the model. The Likelihood Ratio Chi-Square of 92.502 and small p-value (0.000) indicated that the overall model matched the data. Similarly, the goodness of fit value, which was 1.145, showed that the model matched the data.

The initial analysis involved all independent variables (refer table 2) as the predictors of the jaywalkers. However, only three significant variables from the nine variables tested in this study were obtained by the final model. The result from the model indicates that pedestrian volume, presence of the side fence, and building entrance significantly influence the number of pedestrians jaywalking at section k. Table 4 summarizes the effect of each independent variable on the number of jaywalkers ($J^i{}_k$), which are represented by the value of $\beta_1, \beta_2 \dots \beta_m$ estimates. The positive sign of β indicated that the variables had positive impacts, while the negative sign indicated otherwise.

Table 4: Negative Binomial estimation results.

Variables	β	Std. Error	Wald	Sig.
(Constant)	2.805	2.0531	1.866	0.172
Pedestrian Volume	0.001	0.0002	16.459	0.000
Vehicle volume	0.000	0.004	0.080	0.777
Building Entrance (0 if no)	-1.588	0.4557	12.144	0.000
(1 if yes)	0			
Side fence (0 if no)	0.895	0.3823	5.482	0.019
(1 if yes)	0			
Median vegetation (0 if no)	1.360	0.7112	3.658	0.056
(1 if yes)	0			
Median (0 if no)	0.703	0.6316	1.238	0.266
(1 if yes)	0			
Observation period (1= off-peak)	-0.068	0.2655	0.065	0.798
(2 = peak)	0			
Bus/Taxi stop (0 if no)	-0.018	0.3627	0.002	0.961
(1 if yes)	0			
Section category at distance (1= 0-25m)	0.725	0.3799	3.645	0.056
(2 = 25-50m)	0.079	0.2983	0.069	0.792
(3 = 50-75m)	0			
Omnibus test:				
Likelihood ratio Chi-square = 92.502				
p-value = 0.00				
DF = 10				

Pedestrian volume is considered as a variable in the model to examine the impacts of traffic on the number of jaywalkers. Based on the results, the number of jaywalkers at the signalized midblock significantly increased with high pedestrian volume. This finding was in parallel to the finding by Zheng et al. (2015) who highlighted that pedestrian volume is positively related to the number of jaywalkers at the midblock.

The impact of the fence and vegetation installation on the number of jaywalkers at the area near midblock crossing were examined in this study. Side fence refers to the presence of fencing either on one side and both side of road edge in section k. Positive β from the model's result indicated that the number of jaywalkers at section k would increase with no side fence installed. In other words, the presence of side fencing had a significant negative impact on the number of jaywalkers, which might increase the use of the signalized midblock. A similar result is shown for the median vegetation, where the number of jaywalkers at section k is expected to increase when there is no vegetation on the median, but insignificant at the 5% level (p=0.056).

Furthermore, installing a fence or barrier on road median would increase the distance taken for pedestrians to cross the road and restrict them from using anything besides the crosswalk. This finding was supported by Chu et al. (2004) who hypothesized that with the increase in the distance taken for a road crossing, the lower the tendency of pedestrians to jaywalk. Besides, a study by Sisiopiku and Akin (2003) also concluded that physical barriers, such as vegetation and a concrete wall on the road median influence the pedestrian's decision on how they would cross the road.

The presence of a building entrance was another significant variable which impacted the number of jaywalking pedestrians. Refer to Table 4, Negative sign of β indicated that an absence of building entrance significantly reduce the number of pedestrians crossing or jaywalk in section k. Thus, high number of jaywalking pedestrians at section k can be expected with the presence of a building entrance in that section. Based on the significant impact seen from the presence of building an entrance, it should be considered as a trip generator for the pedestrians' activity in the urban area. Moreover, the function of building especially that serve as shopping attraction such as shop and grocery mall would influence pedestrian crossing behaviour (Granié et al., 2013). Placing the crosswalk from a far distance and insufficient pedestrian channelization from the building entrance to the crossing facility would increase the occurrence of jaywalking. Overall, jaywalking is a habit among adult pedestrians (Xu et al., 2013), yet it can be controlled by providing proper channelization.

Results indicated that the vehicle volume, presence of median, time period, presence of bus/taxi stop and section category were insignificant factors to the number of jaywalking pedestrians at signalised midblock. However, the number of jaywalkers is expected to be lower at section k without bus/taxi stop (p=0.961) during off-peak hour (p=0.798). The effect of the bus stop on the number of jaywalking pedestrians at section k is supported with the finding by Zheng et al. (2015) where the presence of bus stop results in the more jaywalking event. The positive sign of B in Table 4 indicated that the number jaywalking pedestrian increased at section k with no median (p=0.266) and located at a distance of 0-25m to crosswalk (p=0.056).

5. Conclusion

This study has presented the findings from the field observation conducted at the signalized midblock in Kuala Lumpur. Through the segmentation of the area near the marked crosswalk (refer to CIA), the number of jaywalkers at the segmented sections and the factors potentially influenced their act were examined. Comparing the number of pedestrians crossing inside and outside provided crosswalk in the CIA, the highest percentage of jaywalkers observed at six selected midblock was 62% and the lowest was 5% during the peak hours. While for the off-peak hours, the highest percentage of jaywalkers was 55% and the lowest was 2%. There is no significant difference in the percentage of jaywalkers were found between peak and off-peak duration.

Utilized the negative binomial model, results indicated that the number of jaywalking pedestrians in section near crosswalk was significantly related to pedestrian volume, presence of building entrance and side fencing. Specifically, an increase in pedestrian volume and placing marked crosswalk near the building entrance would increase the number of jaywalkers in the CIA. Subsequently, the installation of the side fencing on the road edge would significantly decrease the number of jaywalkers, therefore increase the use of the marked crosswalk.

In order to reduce the occurrence of jaywalking at the signalized midblock, results from this study recommended that the marked crosswalk be installed nearest to the building entrance and channelize them with fencing at the road edge and vegetation on the road median. The width of crosswalk could be increased especially in places with a high volume of pedestrians since the jaywalking behaviour is higher at the section with a distance of 0-25m outside the provided crosswalk. However, several factors like signal timing or raining condition that may influence the jaywalking pedestrians at this section have not considered in this study.

It is important to note that the knowledge on the issue of jaywalking among pedestrians is highly useful. It can be used to assist road engineers in developing guidelines for pedestrian facilities. Therefore, the influencing factors of pedestrians' jaywalking shall be considered for the development of urban road crossing facilities in the future. An extension of this study to analyze the influence of pedestrians' characteristics such as age and gender is recommended for future study.

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