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BEHAVIORAL OBSERVATIONS OF CROSSING PEDESTRIANS AT URBAN SIGNALIZED INTERSECTIONS

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Graphical abstract

Abstract

Analyses of pedestrian accident indicate that crossing behavior is one of the factors contributing to the high risk of accident. Understanding the pedestrian crossing behavior have been widely studied around the world, as the behavior of this vulnerable group are random and inconsistent. Thus, this study observed the crossing behavior of pedestrians at urban signalized intersections in Malaysia. The crossing behavior of 239 pedestrians was observed and videotaped at two signalized intersections in Kuala Lumpur. Data on crossing behaviors were extracted and coded for 10 behavioral categories of relevant behavior. The behavioral differences among gender were also examined. The results show that most of the pedestrian observed neglect to press the call button before crossing, which consequence of many illegal crossing. Different crossing paths were also observed for the three crossing styles at signalized intersections.

Keywords: Pedestrian, crossing behaviour, signalized intersections, gender differences, Malaysia

1.0 INTRODUCTION

Safety research on pedestrian has been widely undertook due to large number of pedestrian deaths and injury in traffic accidents [1]. The pedestrian behavioral studies are one of the scopes covered in pedestrian safety research, other than the pedestrian accident analysis, modeling, simulation, and risk estimation. This is because the behavior of pedestrians, especially during the execution of road crossing is an important elements in pedestrian safety related issue [2], [3].

Some of the pedestrian behavior studies much more focus on the violation behavior. Adopting violation behavior while crossing would increase the risk of accident [4] and the violation of pedestrian commonly observed at blackspot locations [5]. There is an evidence saying that violation behavior by pedestrian is actually driven by an automatic process called habit [6]. However, other factors might have an influence to the violation behavior of pedestrians, such as longer waiting time was found to cause higher violation [7] and the inclement weather increase the noncompliance behavior [8]. Apart from that, crossing alone and the presence of parked vehicle near crosswalk are among factors that affect red light violation [2].

Understanding the behaviors of pedestrian while crossing a road section is part of a road safety challenge. Pedestrian behavior cannot be assumed to be consistent [9]. Different characteristics, crossing facility provided, traffic environment and different culture would affect the behavior of pedestrians. Age factor might have an influence to the pedestrian behavior as declining of cognitive abilities in old pedestrian would affect their judgement in road crossing task [10] and gap selection [11]. In addition, behavior of pedestrians might varies according to the factor like gender [9], [12]. This can be notice when research found that male tend to violate signal more frequently [13], while female more likely to jaywalk [14]. Looking to the effect of gender to safety margin, male tend to adopts lower safety margin [12], [15].

At signalized intersections, pedestrians are at risk when they disregard the crossing law enforced. The issues on pedestrian behavior can be differentiated by two basic elements: temporal and spatial. The non-compliance behaviors to these two elements can be referred to as the temporal and spatial violations. The temporal violation denotes the disobedience of pedestrians with respect to time and spatial violation denotes the disobedience of pedestrians with respect to space. Being in a hurry is the key motive for pedestrians to violate the signal at signalized intersections [16]. Therefore, it is logical that pedestrian violations associated with pedestrian accidents are higher at signalized intersections compared to other crossing facilities [14]. Adopting an illegal crossing behavior at signalized intersections would increase pedestrian accident risk level [4].

Jaywalking is a common pedestrian fault that will triggered pedestrian accidents [17]. As jaywalking or crossing outside the crosswalk have become the norm in developing countries [18], cultivating a good crossing attitude among child pedestrians might be a solution in reducing this behavior.

Moreover, pedestrian behavioral research attempted to investigate how the pedestrian really react and behave in real traffic environment. For example, study on the child-adult pair behavior [19], child crossing behavior [20], crossing behavior at marked roadway [21], countdown timer effect on behavior [22], the effect of cognitive distraction through talking on phone on walking speed [23], traffic flow effect [24] and many more.

Though the behavior of pedestrians in real environment have been observed in different scope, however, results on specific behavioral patterns such as push button and crossing style at signalized intersections are still limited in previous studies. Specifically, observations on pushing the button by pedestrian before crossing. In addition, the pedestrian behavioral study at signalized intersections in Malaysia is still far behind. Thus, this study tends to document the behavior of pedestrian while crossing at signalized intersections in Malaysia, considering their crossing style and pushing button behavior. Investigation on behavioral aspects of pedestrian at signalized crossing is crucial in providing basic information for both enforcement and guideline setting. Moreover, the preference to the signalized crossing compared to other crossing facility [25] indicated a call for a research on violation behavior of pedestrian in this country as the developing country.

2.0 METHOD

2.1 Site Observations

The study was conducted at two sites of signalized intersections located in Kuala Lumpur. Both sites were facilitates with signalized crosswalk which operationalize under the 'junction with pedestrian on demand' or JPOD, with no median placed on center line. Operating under JPOD, a dedicated signal phase is allocated for pedestrian to cross in all directions within specific time (all red to traffic). This type pedestrian signal operation is activated when received a signal from the push button installed. The first study site is located at intersect point of Jalan TAR and Jalan Dang Wangi surrounded with shopping block, see Figure 1. Pedestrian volume is around 2800 pedestrians per hour. The crosswalk is stretched across one way direction with five lanes. Another intersection located at Jalan Sultan Ismail and Jalan Bukit Bintang was used as the second site for this study. The crosswalk that stretch on the one way direction traffic with four lanes facilitate pedestrian with volume around 4200 pedestrians per hour.

Figure 1 Signalized crosswalk at Jalan TAR vs Jalan Dang Wangi

2.2 Procedure

Pedestrian behavioral data were observed on different days covering noon and evening peak periods. The observation of pedestrian behavior at signalized intersection was captured using a video camera. Video data offer an advantage in capturing every crossing event accurately when it manages to yield the dynamic of pedestrians' behavior. Moreover, the reaction of pedestrian toward signal indication was also captured. Two out

of four marked crosswalks were observed at each of the signalized intersections. The trained video observers were standing at a safe distance that near to the marked crosswalk. The location of video observers is free from the pedestrian path to allow better movement of the crossing.

Once the behavioral video data collection completed, the observers then transcribed it into an observation sheet designed using binary coding. These behavioral coded data which explained the activities of the crossing were then analyzed using the Statistical Software Package Software.

2.3 Material and Analysis

An observation sheet was prepared to extract the crossing activities of the observed pedestrian behavior that recorded using video camera in this study. About 239 of observed pedestrians at signalized intersections were analyzed, including 156 males (65.3%) and 83 females (34.7%). Crossing activities executed by pedestrian were divided into two phases that consider the activities before and during the crossing. The activities of pedestrian before crossing constitute of three items: the utilization of push button, looked at traffic before crossing and waiting position. Several characteristics of crossing pedestrian were recorded to explain the activities of pedestrian during crossing includes: started crossing at designated marked crosswalk, started crossing on greenman, traffic light phase at beginning of crossing, looked at traffic while crossing, finished crossing at marked crosswalks, finished crossing on the greenman phase and the type of crossing (Straight line, Diagonal, Between stops vehicle).

Demographic information on the observed pedestrian was also recorded, including the gender. Pedestrian performance on looking at traffic before execute crossing and during crossing were relying on the head movement toward the oncoming vehicle. There are ten crossing behavioral activities with 22 items were recorded for analysis.

3.0 RESULTS

The behavior of pedestrian was documented according to ten crossing activities coded. Each of the activities was coded independently for different individual. The result represents the behavior of pedestrians who arrived at the crosswalk on the redman phase, thus they executed three main behaviors: approached, waited and crossed. Those who arrived at the study site on the greenman phase and straight away proceed to cross were excluded from the result. The differences between male and female were tested using a series of X^2.

3.1 Push Button

The majority of the pedestrian (94.6%) tend to ignore the push button before execute crossing at signalized intersections. Only 5.4% of pedestrian (3.4% male, 2.0% female) realize the function of the button to get their right of way. The result shows that there was no significant difference across gender in push button behavior (χ^2 (1, N = 239) = 0.085, ns.

3.2 Looked at Traffic Before Crossing

Most of the pedestrian observed (93.3%) looked for the oncoming traffic before crossing. The remaining 6.4% of pedestrian tend to cross without looking, as they tend to follow others to cross during the greenman phase. However, there is no significant differences exist between gender (χ^2 (1, N = 239) = 3.504, ns.

3.3 Waiting Position

The majority of the observed pedestrian (94.6%) was standing on the curb. Pedestrians are more likely to wait on the curb rather than on the road. Only 5.4% of observed pedestrians started their crossing from the road edge as they used it as the waiting area before executing crossing. It is also found that there was no significant difference between gender (χ^2 (1, N = 239) = 1.532, ns.

3.4 Started Crossing at Marked Crosswalks

The observation data revealed 80% of the pedestrian started crossing in a marked crosswalk or obey with spatial crossing compliance. Only 20% of them were started crossing outside the marked crosswalk or commit with spatial crossing violation, including males (16.6%) and females (3.4%). A significant gender difference was found in crossing behavior related to spatial violation (χ2 (1, N = 239) = 8.644, $p<0.05$.

3.5 Started Crossing on Greenman Phase

Males pedestrian are found more likely not to start the crossing on greenman phase than females, but failed to be significant (χ^2 (1, N = 239) = 0.217, ns. Overall, almost half of pedestrians (48.5%) started their crossing on greenman phase, while the rest violates the signal indication that allocated for them.

3.6 Traffic Light Phase at Beginning Of Crossing

The phase of the traffic light was observed (either green, amber or red) at the beginning of crossing since many pedestrians started their crossing on redman phase. There are 90.8% of the pedestrian would start crossing during the red phase of traffic light. Meanwhile, 5.0% (2.5% male, 2.5% female) of pedestrian executed crossing while the traffic light is on amber phase and 4.2% (all male) crossed during

the traffic light turned green. There was a significant gender difference in crossing behavior related to start crossing on either green, amber or red traffic light phase (χ^2 (1, N = 239) = 6.610, $p<0.05$.

3.7 Looked at Traffic While Crossing

Out of 239 pedestrians observed, 57.3% of them looked at traffic while crossing the road section. The rest (42.7%) did not look at traffic while crossing are those who crossed on greenman phase. This behavior did not differ according to gender for the whole sample (χ^2 (1, N = 239) =0.188.

3.8 Finished Crossing at Marked Crosswalks

About 78.2% of the pedestrians finished their crossing at marked crosswalk. The result did not differ according to the gender (χ^2 (1, N = 239) =0.096, ns. Men (13. 8%) are more likely to ended crossing outside marked crosswalks than women (8%). Few pedestrians observed might ended their crossing outside the marked crosswalk due to the blocked path by vehicles, although they started crossing at the marked crosswalk.

3.9 Finished Crossing on Greenman Phase

Result showed about 46.4% of the pedestrian finished their crossing on greenman phase. There is no significant difference between male and female pedestrians (χ^2 (1, N = 239) =0.022, ns. Those pedestrian started crossing on greenman phase more likely to finish crossing on greenman phase.

3.10 Type of Crossing

Three types of crossing were observed during the study; straight, diagonal crossing and crossed between stopping cars. Examples of crossing path identified for the three types of crossing are shown in Figure 2. The most frequent type of crossing observed is the straight crossing (88.7%). Figure 2(A) shows multiple crossing paths observed for the straight crossing style. Only 8.8% of pedestrians adopted the diagonal crossing and 2.5% crossed between stopped vehicles. The examples of crossing path observed for these two crossing styles were drawn in Figure 2(B) and 2 (C). There was no gender difference in crossing type (χ^2 (2, N = 239) =1.227, ns.

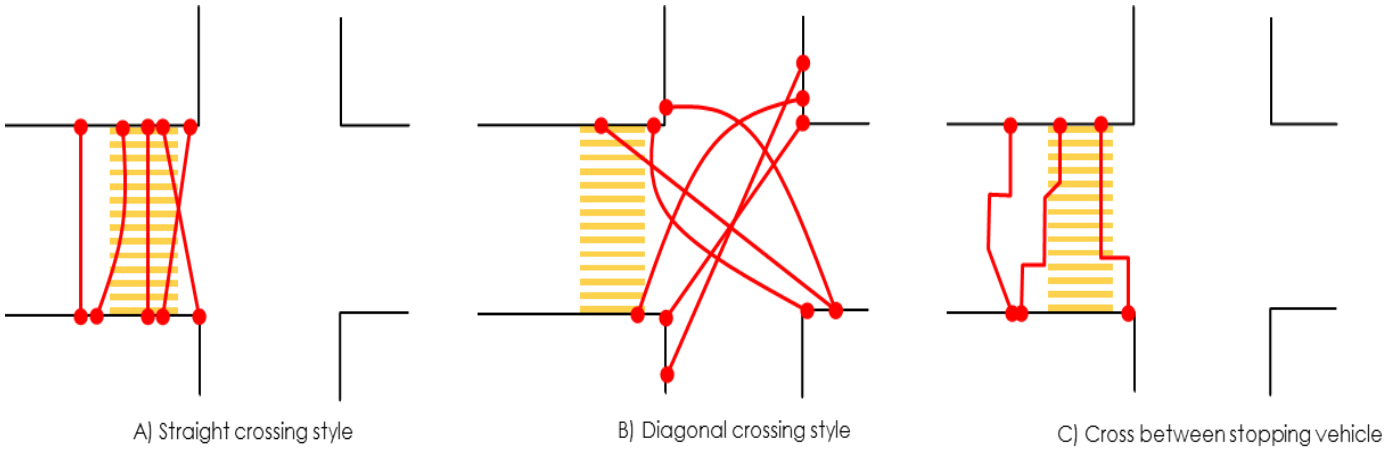

Figure 2 Different crossing paths according to the three types of crossing at signalized intersection

4.0 DISCUSSION

The behavior of crossing pedestrian at signalized intersection was explored according to two crossing phases: before and during the crossing. Results indicate that pressing buttons in order to activate the right of way for pedestrian is always neglected by most of the pedestrians. It is only 5.4% utilized this crossing facility correctly by pressing the call button. It appears to contradict pattern of crossing behavior in another country, such as Zeedyk and Kelly in [19] observed only 9% of pedestrians did not press the button when observing adult-child pair's behavior. Pressing button before start crossing is actually an important element in crossing task when using controlled crossing facility such as JPOD and pelican crossing. Low percentage in pressing button behavior can be related to the low percentage of pedestrian (48.5%) who started their crossing on greenman phase, or comply with temporal crossing compliance.

Three types of crossing style were observed in this study: straight crossing, diagonal crossing and cross between stopping vehicles. For the straight crossing, pedestrian may started and finished crossing at crosswalk or may started and finished crossing outside crosswalk. It is possible for them to start at crosswalk but finished outside crosswalk, or vice versa. Most of pedestrian with straight crossing style observed during the greenman phase. Figure 2(B) shows different paths taken by pedestrian with diagonal crossing style, and most of pedestrian adopted this style while the pedestrian signal phase is activated (all red to traffic). Due to longer crossing distance [26], this crossing style requires longer crossing time that should be considered in designing signal phasing, or they might trapped in the middle of the intersections. Pedestrian also tend to adjust their crossing path once they had crossing constraint, like avoiding vehicles that stopped on the crosswalk. Only few pedestrians seem to take an advantage of stopped vehicle to cross, although they are actually violating the signal.

Majority of pedestrians tend to look at traffic before crossing, but some of them not constantly look at traffic while crossing, as they were crossing on the greenman phase. Observation of this behavior can be noted when the observed pedestrian turned their head toward the traffic before and during the crossing. Similar technique used by [9] when observing pedestrian behavior at signalized intersections and found that there is no different among gender in looking at vehicles while pedestrian crossing at signalized intersections. Those who crossed on the greenman phase might feel safe crossing while getting their right of way and just focus on finishing their crossing rather than to make sure that they are in the safe crossing.

The differences among gender only emerge in the two coded behaviors related to spatial violation while started crossing and the dangerous crossing while the traffic light for vehicle turn green. Men significantly often started their crossing randomly and tend to execute dangerous crossing at signalized intersections. This might become the reason why men always have higher involvement in pedestrian accident [27], [28] and normally labelled as a risk taker pedestrian [13]. This result, however inconsistent with [9] who conclude that men have low temporal crossing compliance but does not differ with women in spatial crossing compliance.

5.0 CONCLUSION

This study provides thoughtful information on pedestrian crossing behavior at signalized intersection in Malaysia. Results from observation indicate that most of the pedestrians disregard the call button function at signalized intersections before crossing. This would result in high temporal crossing violation and dangerous crossing by several pedestrians. In addition, various crossing paths were observed in three crossing styles. Majority of pedestrians observed in this study adopted straight crossing style with inconsistent paths. Only few of them were observed crossing with diagonal and crossed between stopped vehicles.

The use of video and observation grid appears to be an operative tool in analyzing pedestrian crossing behavior in the actual traffic environment. Overall, the gender difference in crossing behavior is not obvious except for the two behavioral codes: starts crossing at marked crosswalks and the phase of traffic light at beginning of the crossing. These two behavioral codes indicated the dangerous crossing attitude adopted often by male pedestrians.

The findings of this study rely on the actual behavior of crossing pedestrian which might be useful in understanding the cultural effect in different countries that requires an extension works to have a better design for the pedestrian signal setting. Observation on pedestrian behavior at other signalized intersections with different signal setting are also recommended.

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