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Analysis of Pedestrian Crossing Behavior at Pedestrian Crossings in Shah Alam City, Malaysia

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Abstract--- *The objective of this study is the development of pedestrian crossing choice models in relation to roadway design, traffic flow and traffic control. This paper also analyzed the pedestrian crossing behavior based on pedestrian's gender and age group. The data used in the study were collected through a questionnaire survey of 663 pedestrians aged from 13 to 75 years old at eight different areas in Shah Alam City. The areas were selected according to the different types of land uses, such as city centers, commercial districts and outlying districts. This study has discovered a significant relationship between different age group and genders of pedestrians in relation to crossing behavior. In terms of age group, this study found that older pedestrian prefers to cross the pedestrian in group compare to younger pedestrian. Majority of pedestrians in the 56-75 age group prefer to walk slowly compared to the majority of the 18-35 age group pedestrians who prefer to walk a bit fast. There was a significant relationship between the gender and the size of the pedestrian crossing group which showed that females prefer to cross the pedestrian in group compare to male pedestrians. In terms of the regularity of crossing at non-designated crosswalk between male and female, male pedestrian recorded more 'often' and 'almost always' crossed at non-designated crosswalk compares to female pedestrian. The analysis of pedestrian crossing behavior in urban areas also may assist in understanding the way pedestrians interact with road and traffic environment, as well as with other pedestrians. It may also help to understand the way they balance the need for comfort and safety at the cost of delays, within the framework of existing traffic rules.*

Keywords--- *Pedestrian, Pedestrian Crossing Behavior, Gender.*

I. INTRODUCTION

Unsafe pedestrian behavior is one of the major factors that contribute to pedestrian injuries and fatalities. In year 2013, the number of road accidents in Malaysia were 135, 624 but had increased to 141, 808 in 2014, and 148, 302 in 2015. Involvement in accidents in Malaysia is also alarming 71% road death and approximately 11% are pedestrians. Pedestrian death rate per 100,000 populations in Malaysia can be considered among the highest in Southeast Asia region. Present research on pedestrians crossing behavior in urban areas is wide-ranging and has contributed a useful understanding on the role of road, traffic and pedestrian characteristics on pedestrian crossing decisions, their compliance with traffic rules and the interrelated safety.

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This study, therefore, expects to meet the government's strategy in reducing road accidents and creating more sustainable mobility environments in our cities.

II. LITERATURE REVIEW

Pedestrian is one of the most vulnerable users in a transportation system where it presents specific challenges in the transportation design field and it also has particular needs(1). Numerous studies outside of evolutionary psychology have suggested that gender differences in traffic behavior exist, based on scenario studies (e.g., (2)) as well as via direct observation (e.g., (3)). The gender difference was detected in injury risk behaviors and female pedestrians have been shown to be more vigilant than males when crossing at intersections (4). According to (5), male pedestrians are over-represented in injuries. Extensive studies have observed gender differences in term of compliance with the rules, it is also important toobservewhat males and females look at before and during crossing the crosswalk.(6)reported that situational factors had an effect on self-reported crossing behaviors of male and female pedestrians. Yagil discovered, men and women use different strategies to gain alertness of the crossing situation. Yagil revealed, women may be more focused on other pedestrian's behaviors, whereas men may be more focused on moving vehicles. Thus, it can be concluded that women are more influenced by their social atmosphere, whereas men seem to be more concerned with the physical aspects of the setting.

Besides gender, the pedestrian characteristics of age are a significant variable in relation to pedestrian behavior. Higher pedestrian age shows a relationship with decreased risk perception, larger minimum gap acceptance, and long waiting times when crossing a street(2,7). Pedestrian crossing speed is also significantly related to pedestrian age, and the speeds of pedestrians are slower as they get older. Previous studies have found that pedestrians between 21 and 30 years of age are the fastest age group (8). Several studies proved that younger pedestrian age is more willing to violate regulations, whereas older pedestrians make more unsafe decisions (2,9).(10)revealed that pedestrians at undesignated crosswalks prefer to look both ways before crossing, to wait for larger gaps, and then to run. (11) in his study has reported, pedestrian that managed to violate the traffic law by crossing the road at an unauthorized place, s/he is likely to repeat this offense at the same location. It was evidence that a person would be more likely to violate the traffic rules as an individual rather than with companions (12). (13) stated that middle-aged pedestrians in urban cities are less likely to be involved in a crash when they cross in a group. Pedestrian behaviors with characteristics such as age and gender will provide significant understandings on safety related. Therefore, this paper will identify the influence of pedestrian characteristics of behavior that will be studied at the pedestrian crossing area of the Shah Alam City.

III. METHODOLOGY

The aim of this study is the development of pedestrian crossing choice models on the basis of road and traffic. More specifically, to develop choice models for estimating the probability to cross at each location along a pedestrian trip in relation to roadway design, traffic flow and traffic control.This paper also analyzedthe pedestrian crossing behavior based on pedestrian's gender and age group. The data used in the study were collected through a questionnaire survey of 663 pedestrians aged from 13 to 75 years old at eight different areas in Shah Alam City. Selected sample was calculated based on the total population, which is about 336590 peoples, with a 99% degree of

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confidence, and 5% of the margin of error. For the development of the questionnaire, several questionnaires from the existing literature were studied. The question was designed to be rated based on Likert Scales such as always/never or agree/disagree scale. The behavioral questionnaire of Papadimitriou et al, 2016 was used as a basis. The Questionnaire was designed based on related crossing behavior elements, for example, perceptions, attitudes, beliefs, motivation etc. The questionnaire includes 4 sections:

- Section A: Demographics
- Section B: Risk Perception and Value of Time (Human Factors)
- Section C: Pedestrian Crossing Behavior
- Section D: Pedestrian Perceptions on Drivers

3.1 Field Survey Design

The field survey design consists of three walking conditions and several places have been identified as survey area according to these three crossing conditions.

- Crossing a main urban road with signal-controlled and uncontrolled crosswalks.

For this particular crossing condition, Section 7, Shah Alam has been identified as a survey area which involved UiTM's students crossing the road as access to commercial facilities near the campus. Besides that, crossing facilities near the Shah Alam's Hospital also have been surveyed to measure the effectiveness of crossing pedestrian provided and its relation to crossing behavior.

- Crossing a minor (residential) road with or without marked crosswalks.

Several schools that are located near the residential areas have been chosen as a survey area. For example, section 6, section 7, section 9, section 15 and section 19. Besides that, the area that facilitates with public transport also have been chosen as a survey area such as section 15 (Padang Jawa) and Section 19.

- Crossing a major urban arterial with signal-controlled crosswalks.

For this particular crossing condition, the high capacity urban road has been chosen as a study area such as crossing pedestrian to access the bus station in section 13, near to the Federal Highway. This crossing pedestrian also been used to access AEON Mall.

IV. RESULTS AND FINDINGS

4.1 Confirmatory Factor Analysis (CFA) in Crossing BehaviorMeasurement Model

Table 1 shows the summary of confirmatory factor analysis (CFA) for every construct in the crossing behavior measurement model. Based on Table 1, the value of factor loading for each item is greater than 0.60. Item C5 & C6 were deleted due to low factor loading less than 0.60. The requirement for unidimensionality was achieved through the item deletion procedure for low factor loading items.The value of AVE obtains from every construct are greater than 0.50. Thus, the Convergent Validity of the crossing behavior measurement model is achieved since all the value for AVE are greater than 0.50 as suggested by (14).A value of Composite Reliability (CR) greater than 0.6 is required in order to achieve construct reliability. Based on the Table 1, all the value of CR for every construct are greater than 0.60. Therefore, the Composite Reliability was achieved the required level.

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Table 1: Summary of Confirmatory Factor Analysis (CFA) in Crossing BehaviorMeasurement Model

Construct	Component	Item	Factor Loading	CR	AVE
Crossing Behavior	Component 1	C1	0.61	0.84	0.65
		C2	0.94		
		C3	0.83		
	Component 2	C6	0.93	0.95	0.87
		C7	0.91		
		C8	0.96		
	Component 3	C9	0.90	0.93	0.80
		C10	0.88		
		C11	0.91		

*the detail of crossing behavior items can be referred at Table 2

4.2 Crossing behavior based on gender

This study has evaluated the behavior of pedestrians when crossing the crosswalk. The respondents were given 14 questions to test their crossing behavior. The questions were designed to be rated based on Likert Scales (1-Never, 2-Rarely, 3-Sometimes, 4-Often, 5-Almost Always). Table 2 shows the mean value of crossing behavior items that rated by male and female respondents. From the table, can be seen that most of the items were rated as "Sometimes" except for the item C_4 has been rated as "Rarely" by both genders. This shows that both genders have similar responses for those items.

Table 2: Mean Analysis for crossing behavior items based on gender

	Crossing Behavior	Mean Value	
		Male	Female
C_1	Cross at a designated crosswalk when there is no oncoming traffic	3.53	3.56
C_2	Cross at a designated crosswalk when in a hurry	3.37	3.32
C_3	Cross at a designated crosswalk when there is a shop on the other side	3.44	3.37
C_4	Cross even though the pedestrian light is red	2.36	2.13
C_5	Cross between vehicles stopped on the roadway in traffic jams	3.39	3.30
C_6	Cross without paying attention to traffic	3.22	3.07
C_7	Absent-minded while walking	3.19	3.02
C_8	Cross while talking on cell phones	3.25	3.06
C_9	Cross while listening to music on the headphones	3.28	3.17
C_10	Cross even though obstacles (parked vehicles, buildings, trees, etc.) obstruct visibility	3.37	3.24
C_11	Cross even though there are oncoming vehicles	3.27	3.18
C_12	Cross at a designated crosswalk when see other people do it	3.40	3.42
C_13	Cross at a designated crosswalk when company prompts to do it	3.33	3.42
C_14	Prompt company to cross at designated crosswalk	3.51	3.53

Maximum1, Minimum5 (1-Never, 2-Rarely, 3-Sometimes, 4-Often, 5-Almost Always)

Nevertheless, this study has proven that there is a significance difference in the pedestrian crossing size group based on gender. Table 3 showed the chi-square analysis, of which the value 13.478 is significant at the 0.05 level ($p = 0.01$). A significant relationship was observed between the gender and the pedestrian crossing size group. This showed that female prefers to cross the pedestrian in group compare to male pedestrian.

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Table 3: Difference in the pedestrian crossing size group based on gender

Pedestrian size group	**Male**	**Female**	**Total**
Usually walk alone (single pedestrian)	181 27.3%	181 27.3%	362 54.6%
Prefer to walk with a group of people because I can be more confident to cross	80 12.1%	147 22.2%	227 34.2%
Prefer to walk with a group of people so that I can follow them when crossing	28 4.2%	46 6.9%	74 11.2%
Total	289 43.6%	374 56.4%	663 100%

Chi-square = 13.478[a] *Significance =0.01*

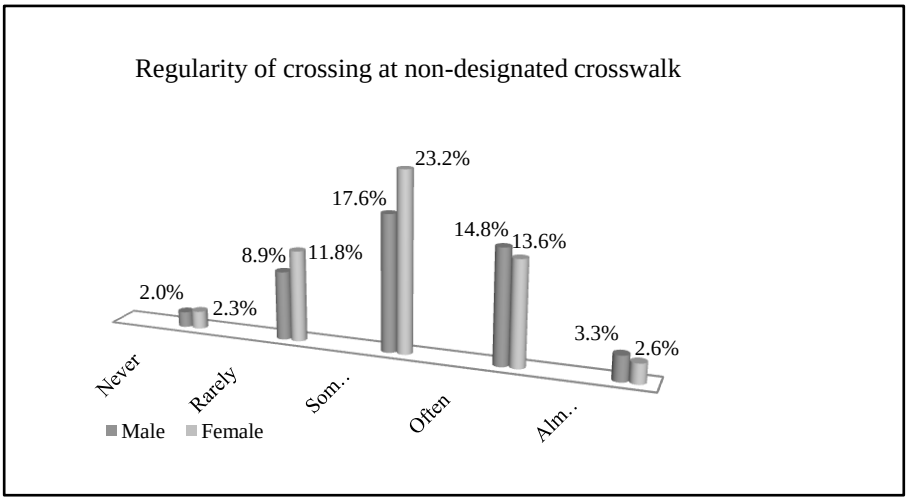

Figure 1: Regularity of crossing at non-designated crosswalk between male and female pedestrians

Previous research has indicated that the gender of a pedestrian is an important characteristic in determining the behavior of the pedestrian (7,15). According to (2,16)Holland & Hill (2007,2010), male pedestrians are more willing to violate regulations and they also tend to make unsafe decisions. Male also less likely to perceive risk while crossing the road compared to female pedestrian. This study also examines the difference of male and female pedestrian habitual in term of crossing the road. In terms of the regularity of crossing at non-designated crosswalk between male and female, the result shows majority of both genders responded that they 'sometimes' crossed at non-designated crosswalk. However, male pedestrian recorded more 'often' and 'almost always'crossed at non-designated crosswalk compares to female pedestrian.(refer Figure1)

4.3 Crossing behavior based on age group

Table 4 shows the mean value for crossing behavior items that rated by different age group respondents. From the table, can be seen that most of the items were rated as "Sometimes" by respondents aged 13 to 45 years old. However, items were rated as "*Never"* and *"Rarely"* mostly appraised by older respondents *(*age 46 – 75 years). This result indicated that different age group respond a different crossing behavior.

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Table 4: Mean difference in crossing behavior based on age group

	Crossing Behavior	**Mean Value (Age Group)**					
		13 to 17 years	**18 to 35 years**	**36 to 45 years**	**46 to 55 years**	**56 to 65 years**	**66 to 75 years**
C_1	Cross at a designated crosswalk when there is no oncoming traffic	3.55	3.54	3.47	3.57	3.74	3.55
C_2	Cross at a designated crosswalk when in a hurry	3.36	3.36	3.19	3.41	3.23	3.45
C_3	Cross at a designated crosswalk when there is a shop on the other side	3.29	3.43	3.34	3.43	3.51	3.45
C_4	Cross even though the pedestrian light is red	2.43	2.25	2.29	2.06	1.74	1.40
C_5	Cross between vehicles stopped on the roadway in traffic jams	3.38	3.35	3.18	3.39	3.31	3.36
C_6	Cross without paying attention to traffic	3.13	3.12	3.00	2.35	2.15	1.36
C_7	Absent-minded while walking	3.13	3.09	2.90	3.33	3.08	3.27
C_8	Cross while talking on cell phones	3.17	3.15	2.96	3.33	2.05	2.27
C_9	Cross while listening to music on the headphones	3.63	2.25	1.39	1.45	1.21	1.13
C_10	Cross even though obstacles (parked vehicles, buildings, trees, etc.) obstruct visibility	3.30	3.31	3.22	3.43	2.05	1.45
C_11	Cross even though there are oncoming vehicles	3.12	3.24	3.11	3.04	2.18	2.36
C_12	Cross at a designated crosswalk when see other people do it	3.43	3.44	3.29	3.39	3.38	3.36
C_13	Cross at a designated crosswalk when company prompts to do it	3.35	3.35	3.47	3.43	3.44	3.73
C_14	Prompt company to cross at designated crosswalk	3.45	3.51	3.58	3.54	2.62	2.91

Maximum1, Minimum5 (1-Never, 2-Rarely, 3-Sometimes, 4-Often, 5-Almost Always)

One-way ANOVA was conducted to compare crossing behavior between age group. Table5 shows that there is a significant difference in scores for age group 13 to 17 years, 18 to 35 years, 46 to 55 years and 56 to 75 years with value of F (2.779) = 0.017, p>0.05. This means there are significant difference between crossing behavior and the age group, categories at 0.05 level of significance.

Table 5: One-way ANOVA test of difference in crossing behavior based on age group

	Sum of Squares	**df**	**Mean Square**	**F**	**p-value**
Between Groups	6.556	5	1.311	2.779	0.017
Within Groups	310.014	657	0.472		
Total	316.570	662			

4.3.1 A pedestrian crossing size group based on age group

This study has identified that there is a significance difference in the pedestrian crossing size group based on age group. Table 6 showed the chi-square analysis, of which the value 36.484 is significant at the 0.05 level (p = 0.00). A significant relationship was observed between the age group and the pedestrian crossing size group. From the table can be seen that older pedestrian prefer to cross the pedestrian in group compare to younger pedestrian.

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Table 6: Difference in the pedestrian crossing size group based on Age Group

Pedestrian Size Group			**Age Group**			
	13-17 years	**18-35 years**	**36-45 years**	**46-55 years**	**56-75 years**	**Total**
Usually walk alone (single pedestrian)	39 5.9%	214 32.3%	47 7.1%	36 5.4%	3 0.5%	362 54.6%
Prefer to walk with a group of people because I can be more confident to cross	47 7.1%	124 18.7%	23 3.5%	12 1.8%	21 3.2%	227 34.2%
Prefer to walk with a group of people so that I can follow them when crossing	24 3.6%	32 4.8%	9 1.4%	6 0.9%	26 4.0%	74 11.2%
Total	110 16.6%	370 55.8%	79 11.9%	54 8.1%	50 7.6%	663 100.0%

Chi-square = 36.484 *Significance =0.00*

4.3.2 Pedestrian walking speed based on age group

Pedestrian's walking speed when crossing the pedestrian also, has been examined in this study. Based on findings, they are difference of walking speed between the age group. A significant relationship was observed between crossing speed and the pedestrian's age group with 61.607 chi-square value and is significant at the 0.09 level (p=0.00). It can be concluded that, majority of pedestrians in the 56-75 age group prefer to walk slowly compared to the majority of the 18-35 age group pedestrians who prefer to walk a bit fast.

Table 7: Difference in the pedestrian crossing speed based on Age Group

Crossing Speed			**Age Group**			
	13-17 years	**18-35 years**	**36-45 years**	**46-55 years**	**56-75 years**	**Total**
Walk slowly	40 16.3%	107 43.5%	38 15.4%	25 10.2%	36 14.6%	246 37.1%
Walk a bit faster	59 15.6%	247 65.5%	37 9.8%	21 5.6%	13 3.4%	377 56.9%
Really fast	11 27.5%	16 40.0%	4 10.0%	8 20.0%	1 2.5%	40 6%
Total	110 16.6%	370 55.8%	79 11.9%	54 8.1%	50 7.6%	663 100.0%

Chi-square = 61.607 Significance =0.00

V. CONCLUSION

This study has discovered a significant relationship between different age group and genders of pedestrians in relation to crossing behavior. In terms of age group, this study found that older pedestrian prefers to cross the pedestrian in group compare to younger pedestrian. From the results of one-way ANOVA comparing crossing behavior between age groups, it shows that there is a significant difference in scores for age group 13 to 17 years, 18 to 35 years, 46 to 55 years and 56 to 75 years. Majority of pedestrians in the 56-75 age group prefer to walk slowly compared to the majority of the 18-35 age group pedestrians who prefer to walk a bit fast. A significant relationship was observed between the gender and the pedestrian crossing size group. This showed that female prefers to cross the pedestrian in group compare to male pedestrian. In terms of the regularity of crossing at non-designated

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crosswalk between male and female, male pedestrian recorded more 'often' and 'almost always' crossed at non-designated crosswalk compares to female pedestrian. The analysis of pedestrian crossing behavior in urban areas may assist in understanding the way pedestrians interact with road and traffic environment, as well as with other pedestrians. It may also help to understand the way they balance the need for comfort and safety at the cost of delays, within the framework of existing traffic rules. Incorporating behavioral data in describing motivations, preferences and perceptions of pedestrians emerge as an effective approach to model crossing behavior.

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