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The Influence of Pedestrian Characteristic on Pedestrian Speed in Urban Area: A Case Study at Jalan Tuanku Abdul Rahman, Kuala Lumpur.

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ABSTRACT

Short-distance walking, alone or with additional modes, is efficient. Well-established public transport may increase the number of pedestrians since they prefer walking to work, travel, and shop because cities are connected by activities and locations. However, pedestrian-friendly paths and public transport in Malaysia have received little attention. Large-scale facilities like stadiums, movie theatres, and amusement parks are driving the need for pedestrian facilities. Thus, this study aims to examines the pedestrian characteristic at Jalan Tuanku Abdul Rahman, Kuala Lumpur. To discover significant elements, pedestrian behaviour on sidewalks at the indicated location was quantitatively investigated, taking into account general pedestrian characteristics that affect walking speed, such as age, gender, and trip companion. Using a video camera, pedestrian variables like age, gender, and trip companion were calculated for volume, speed, flow, density, and space during weekday and weekend peak hours. Extracted data were then analysed by using SPSS as a statistical software and the Highway Capacity Manual (HCM 2010) was used to classify pedestrian level of services (LOS). Age, gender, and companionship substantially determine the pedestrian flow and the study's LOS for pedestrian characteristics ranges from D to E, indicating that Jalan Tuanku Abdul Rahman's sidewalk relationship varies. This research strongly recommends a dedicated walkway to increase pedestrian space and improve services along Jalan Tuanku Abdul Rahman, Kuala Lumpur. This study will also serve as a guideline to the transport operator into improving the future of pedestrian walkway design facilities.

Keywords: Pedestrian Walkway; Level of Service(LOS); highway capacity manual; pedestrian characteristic; SPSS Software

INTRODUCTION

Walking is such a basic human behaviour that has always been ignored in the development of complex transport networks (Seiderman et al. 2001). Accessible design is the basis for any pedestrian layout to be usable by all users. The infrastructure must be developed, built, managed and maintained in order to be accessible. Adequate traffic infrastructure improves the safety and comfort of pedestrians and strengthens their visibility. Improving traffic safety in cities is primarily a matter of speed control and incorporating road design safety (Rahayuningsih et. al, 2017). A poor sidewalk facility includes a discomfort sidewalk for the pedestrian to walk and low lighting of street lights which gives the vibe of an unsafe walking environment for the pedestrian (Bargi et al. 2017). With regards to evacuation scenario, not only does pedestrian strolling increase evacuation times, but a combination of slow-moving pedestrians in a crowd frequently necessitates a slow-moving pedestrian. Other pedestrians must avoid collisions, slow down, and accumulate, which will affect the evacuation crowd traffic as a whole (Minegishi, 2020). According to Azmi et. al (2012), sidewalks and walkways are "pedestrian lanes" that provide pedestrians with segregated travel space within the public right-of-way. Sidewalks that are completely separate from the roadway are ideal for pedestrians. Increased demand for improved pedestrian control solutions is needed to minimise risks at the walkway. Enhancing pedestrian management efficiency, walkway frequency, and high walking capacity during peak hours have heightened interest over the last decade (Baneerje et. al., 2018). Well-established public transport may increase the number of pedestrians since they prefer walking to work, travel, and shop because cities are

connected by activities and locations. However, pedestrian-friendly paths and public transport in Malaysia have received little attention. Therefore, this research aims to examine pedestrian walking behaviour by observing pedestrians on video recordings as they move through the walkway. A pedestrian's walking behaviour is influenced by various factors, including age, gender, physical disability, size, group, environment, and pedestrian walking location. The interaction between pedestrians may affect their speed. Rising numbers of pedestrians have led to pedestrian conflicts between the elderly and adults. Due to the growth in the elderly population and the barrier-free movement's progress, people's diversity in architectural and metropolitan environments has grown exponentially (Gupta and Pundir 2015).

The research was being conducted in Kuala Lumpur, Malaysia, mainly because of its dense population, pedestrian interaction, and high walking capacity which contributes to the difficulties encountered by pedestrians and those who were traversing the road. The location is then focused towards Jalan Tuanku Abdul Rahman (TAR), which consist of high walking capacity and mixed traffic condition. Current research identifies pedestrian behaviour on walkways and sidewalk facilities located adjacent to Jalan Tuanku Abdul Rahman which support the aims of this study in examining the pedestrian movements by computing various pedestrian flow parameters, including speed, flow rate, density, and space, and develop relationships between them through quantitative analysis. The study considers the pedestrian characteristics such as age, gender, and trip companion. Statistical analysis is used to compare the various parameters for the walkway. Additionally, the probability density functions of speed distributions for individuals based on their age, gender, and trip companion are plotted. An interpretation of pedestrian behavior on a specific area, such as a walkway, was developed from the findings. The LOS standard was determined for the pedestrian at the selected location and identified the pedestrian flow from the finding. The results would identify pedestrian's operating behaviour and assess pedestrian facilities based on the Level of Services of the Highway Capacity Manual (HCM 2010). Therefore, this research was found to allows lal planners in facilitating walking as a mode of choice in urban areas based on the data obtained. Kuala Lumpur as the Malaysia's capital, should provide a pedestrian-friendly pattern to reduce congestion and increase the transportation system's efficiency for recreational purposes.

METHODOLOGY AND DATA COLLECTION

METHODOLOGY

This section describes the data collection sites, the data collection procedure, and the data analysis procedure. Most pedestrian infrastructure and the requirements required to ensure the sidewalks have inclusive walking conditions are established by evaluating advanced guidance, current literature, and expert interviews (Asadi-Shekari et al. 2019). It attempts to clarify the method used to overcome the fundamental problems that need to address. To ensure this research is successful, a summary of the research methodology carried out in this research has been established, as shown in Figure 1.

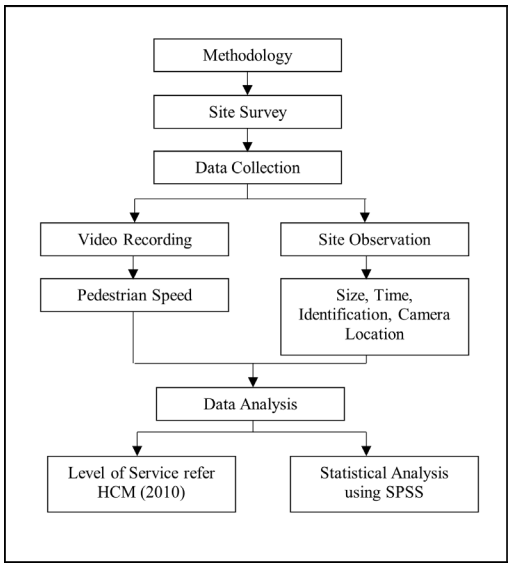

FIGURE 1. Summary of research methodology

SITES DATA

To study the pedestrian movement, Jalan Tuanku Abdul Rahman pedestrian facilities were considered at a commercial shopping area. The location is a famous shopping spot and consist of a long stretch of an open shop lined up where locals and tourists take leisure to stroll and shop. Locals made up the majority of pedestrians in the locations chosen, usually during the festive season. Video graphic data collection was used to collect data during weekday and weekend peak hours. Site observation and video recording of the passenger moving is used as measurement and data collection of pedestrian study (Hoe Goh et al. 2012). The camera was fixed to the tripod stand at the height of approximately 2 meter above the ground. The data collection process took about two hours for each weekday and weekend. Data were gathered on pedestrians travelling in both directions. The length and width of the walkway were marked for monitoring pedestrian movement within it. After removing static obstacles, the effective width was determined. Figure 2 depicts the locations of the facilities sites considered. To fulfil the study's objectives, the area consisting of a high volume of pedestrian were selected to be studied for two conditions: weekend and weekdays. It is conducted at weekends and weekdays to compare the number of pedestrians during that time. People walking in diverse situations were observed, and their overall walking pattern and interactions with other pedestrians.

FIGURE 2. Data collection location

DATA ANALYSIS PROCEDURE

After observing the data through video recording, the data will be extracted and analysed. Data extraction is the process through which various sources collect or retrieve disparate types of data, many of which may be poorly organised or completely unstructured. The data will be gathered so that the pedestrian's Level of Services (LOS) can be identified and fulfilled the objectives of this study. For each pedestrian characteristic, the LOS for flow rate, v/c ratio, and pedestrian speed were calculated using the standard LOS specified in HCM, as shown in Table 1.

The pedestrian flow parameters from the calculated speed, flow, density, space and volume were extracted manually to be stored in Statistical Package for Social Science (SPSS). The manual counting method was used in order to eliminate the possibility of inaccuracies brought on by automatic image recognition, particularly in the high-density range, when analyzing the fundamental flow characteristics from videos. Golakiya and Dhamaniya, 2020). Data analysis for this research was carried out using the Statistical Package for Social Science software (SPSS) to calculate descriptive statistics like standard error, t-value, and p-value. The bivariate analysis (chi-square test) was performed to ascertain the importance of influencing factors (Hoe Goh et al. 2012).

TABLE 1. Level of Service (LOS) classification for speed, flow and space (Source: Highway Capacity Manual 2010)

LOS	Speed (m/min)	Flow (ped/min/m)	Space (m^2/ped)
A	> 78	≤16	> 5.60
B	> 76 – 78	> 16 – 23	> 3.70 – 5.60
C	> 73 – 76	> 23 -33	> 2.20 – 3.70
D	> 68 – 73	> 33 – 49	> 1.40 – 2.20
E	> 45 – 68	> 49 – 75	> 0.75 – 1.40
F	≤ 45	Varies	≤ 0.75

RESULTS AND ANALYSIS

When conducting this investigation, the data were analysed using the quantitative approach. Quantitative data consisted of information about numerical variables. As a result, it can be defined as numerical data and information data obtained through a quantifiable measurement process. When it comes to the quantitative data in this research study, it was referred to the data obtained through digitalized video recording and extracted to a spreadsheet in Microsoft Excel. The procedure described in the preceding section was used to analyse the video data collected.

GEOMETRIC CONDITION OF PEDESTRIAN FACILITIES

The details of the location in Jalan Tuanku Abdul Rahman (TAR) is measured with 2 meters' width and 10 meters in length. The following sections provide the data collected.

PEDESTRIAN CHARACTERISTICS

The pedestrians were classified based on factors such as gender, age, and trip companion. The gender group was split into male and female categories, while the age group was divided into four sub-categories: below 20 years old, 21 to 40 years old, 41 to 64 years old and the elderly, which is more than 65 years. As for trip companion, it is divided into Individuals, Pairs and Groups.

AGE

There is a significant difference in age and pedestrian speed as age is also considered to affect pedestrian speed. Figure 3 shows the result of the pedestrian survey conducted in terms of age classification. From the pie chart, most pedestrians on both weekdays and weekends are 21 to 40 years old according to (Park and Bae, 2020). Nearly two percent of pedestrians at the age of 65 years old and above were present. This is because the elderly is advisable to stay at home as during data collection of this research, it was conducted after Covid-19 pandemic hit our country and therefore, the elderly are considered to be high risk to be infected. The second highest percentage is 36% for weekdays and 35% for the weekend, consisting of 41 to 64 years old. Lastly, pedestrians below 20 years old are the third highest, with a percentage of 11.7% for weekdays and 15.5% for the weekend. In comparison, during the weekend and weekdays, the highest percentage of pedestrians differs by only 4.2%, which does not show much difference.

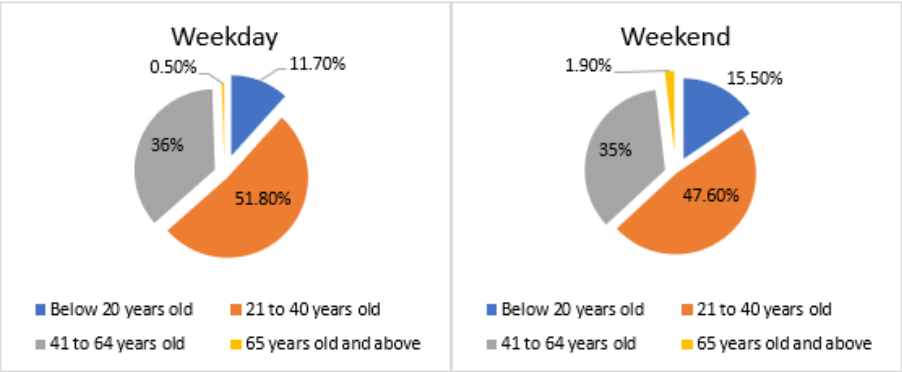

FIGURE 3. Volume (%) of pedestrian based on age factor in weekday and weekend

GENDER

Figure 4 illustrates the volume of the pedestrian corresponding to the gender of the pedestrians. According to the bar chart below, the female percentage is higher than the male percentage on weekdays and weekends, with 58.3% and 54.5%, respectively. Meanwhile, the male percentage contributes 41.7% and 45.5%, respectively, for both weekday and weekend hours.

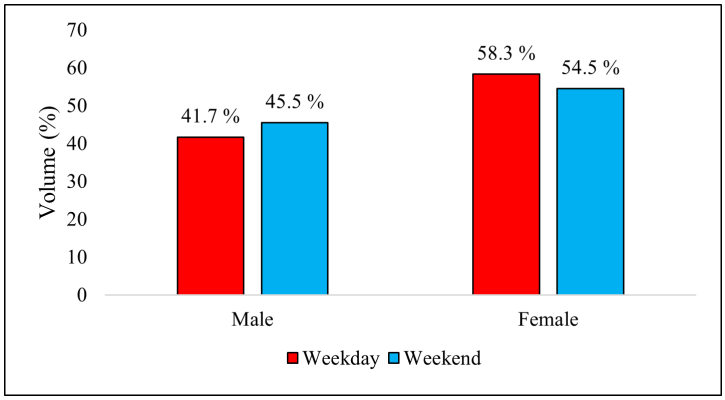

FIGURE 4. Volume (%) of pedestrian based on gender factor in weekday and weekend

TRIP COMPANION

Figure 5 provides the information about the travelling companionship for the weekday and weekend as it might affect the pedestrian speed. When walking in a group, it may lead to a slower pace since pedestrians tend to talk with the people within the group. According to the chart, it can be seen that the highest trip companion is pairs followed by group and individual. The number of pedestrians walking individually is relatively low, starting at 22.2% and 28.6 % for weekdays and weekends. Pairs continue to make up for the most number at 40.4% and 38.2% for weekdays and weekends.

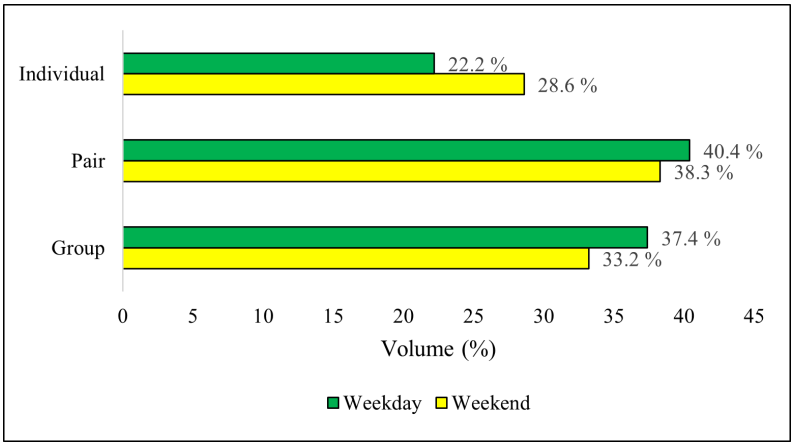

FIGURE 5. Volume (%) of pedestrian based on trip companion for weekday and weekend

The observed walking speeds for various pedestrian characteristic on walkways were tabulated in Table 2 using video recording surveys. Overall, we can see a clear trend that people walking individually have the highest mean speed at 1.194 m/s (71.64 m/min) and 1.158 m/s (69.48 m/min) for weekdays and weekends, as shown in the Table 2.

Further analysis by gender revealed that males in Jalan Tuanku Abdul Rahman generally walked faster than females. Males and females walk at mean speeds of 1.172 m/s (70.32 m/min) and 1.095 m/s (65.7 m/min) for weekdays, while 1.117 m/s (67.02 m/min) and 1.020 m/s (61.2 m/min) for weekends, respectively. The average walking speed for age 21 to 41 is the highest among other age groups, with 1.147 m/s (68.82 m/min) for weekdays and 1.115 m/s (66.9 m/min) for the weekend. The pedestrian between 20 to 41 years old usually walked significantly faster, most likely due to their more energetic movements. In comparison, the elderly average walking speed for weekday is 0.799 m/s (47.94 m/min) and weekend is 0.949 m/s (56.94 m/min) was significantly slower than other age pedestrians' groups.

The pedestrian data were analysed by using the statistical software which is SPSS and tested for Chi-square test and T-test. The values of pedestrian speed versus age, gender and trip companion were computed at the study location and these findings were statistically significant at the 5% level. The bivariate analysis results (chi-square test) indicated that one out of the three variables was significantly associated with the pedestrian walking speed shown in

Table 2. The table also shows that age and gender show no correlation at all, which leads the data to be insignificant. For instance, when walking in a group, individuals tend to walk at the same pace as their partners or group, implying that gender and age are irrelevant.

TABLE 2. Walking speed for various types of pedestrian characteristics

Characteristics		Pedestrians								
		Gender		Age				Trip Companion		
		Men	Women	< 20	21 - 40	41 - 64	>65	Individuals	Pairs	Group
Mean walking speed (m/min)	Weekday	70.32	65.70	66.42	68.82	66.6	47.94	71.64	66.54	66.42
	Weekend	67.02	61.20	59.70	66.90	61.86	56.94	69.48	63.24	59.64
Standard Deviations	Weekday	0.180	0.137	0.148	0.154	0.166	0.221	0.187	0.131	0.163
	Weekend	0.221	0194	0.153	0.220	0.208	0.167	0.235	0.196	0.177
Sample Size	Weekday	148	214	43	188	130	1	90	156	116
	Weekend	166	201	58	175	127	7	110	158	103
Significance between 5% level influenced Speed	Weekday	Not Significant			Not Significant			Significant		
	Weekend	Not Significant			Not Significant			Significant		

The one sample t-test is a statistical test used to determine whether the mean data is statistically different from a known mean or from the hypothesis of a mean population based on pre-existing data. The walking speed was compared with the current guidelines based on the average walking speed from Singapore which is 1.23 meters per second (m/s) as determined from Hoe Goh et al. 2012 (Table 3). Table 4 shows the results of the t-test for pedestrian speed during Weekday and Weekend. The t value shown in the table is -6.457 and -6.437, which gives a p-value of 0.000. This will be a significant result for any realistic correlation coefficient due to a standard correlation coefficient being 0.05. Since 0.000 is smaller than 0.05, the null hypothesis will be rejected, which shows no difference between the sample mean and the population mean.

TABLE 3. Comparison of pedestrian walking speeds in different countries

Country	Mean Walking Speed (m/s)
Asia	
Riyadh, Saudi Arabia	1.08
Madras, India	1.20
Hong Kong	1.20
Thailand	1.22
Singapore	1.23
Columbo, Sri Lanka	1.25
England	1.31
United States	
Columbia	1.32
New York	1.35
Pittsburgh	1.47
Calgary, Canada	1.40
Jordan	1.34

Source: Nazir et al. 2012

TABLE 4. Tabulation of T-Test results (test value = 1.23m/s)

						95% Confidence Interval of the Difference	
		t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
SPEED	Weekday	-6.457	56	0.000	-0.495123	-0.12463	-0.06561
	Weekend	-6.437	49	0.000	-0.157740	-0.20698	-0.10850

To validate the above results, the pedestrian Level of Services were determine shown in Table 5. The LOS based on pedestrian speed was computed with reference to Table 1. Pedestrians in a hurry will always move faster than other pedestrians, resulting in a higher LOS value even if the walkway is congested. In contrast, pedestrians who want to enjoy walking and have time on their hands will move slowly, resulting in a low LOS value, making them one of the lowest pedestrians. The study demonstrates that the trip companion affects the LOS of pedestrian facilities (based on pedestrian speed). Due to numerous factors, the trip companion was identified as the primary parameter, and other parameters such as gender and age group were sub classified under the trip companion parameter. As a result, the evaluation table of LOS for pedestrian speed was developed referring to the characteristic, as illustrated in the table, which provides LOS values ranging from D to E.

TABLE 5. LOS based on each factor of pedestrian speed for weekday and weekend

Level of Service (LOS) Based On Speed		Gender		Age Group				Trip Companion		
		Male	Female	< 20	21 - 40	41-64	>65	Individual	Pairs	Group
Weekday	Speed (m/ min)	70.32	65.70	66.42	68.82	66.60	47.94	71.64	66.54	66.42
	Range	>68 - 73	>45 - 68	>45 - 68	>68 - 73	>45 - 68	>45 - 68	>68 - 73	>45 - 68	>45 - 68
	LOS	D	E	E	D	E	E	D	E	E
Weekend	Speed (m/ min)	67.02	61.20	59.70	66.90	61.86	56.94	69.48	63.24	59.64
	Range	>45 - 68	>45 - 68	>45 - 68	>45 - 68	>45 - 68	>45 - 68	>68 - 73	>45 - 68	>45 - 68
	LOS	E	E	E	E	E	E	D	E	E

CONCLUSION

This study aims to examines the pedestrian characteristic at Jalan Tuanku Abdul Rahman, Kuala Lumpur. To discover significant elements, pedestrian behaviour on sidewalks at the location was quantitatively investigated, taking into account general pedestrian characteristics that affect walking speed, such as age, gender, and trip companion. The LOS varied significantly, implying that pedestrian speed is determined by gender, age group and trip companion. The interaction of these variables with pedestrian speed was deemed the primary cause of the variation in LOS. This prompted a subsequent study in which pedestrian speed was evaluated in conjunction with the factors influencing it to develop a new standard. The hypothesis that pedestrian speed varies according to each aspect was confirmed in this study, and the resulting data were used to develop a new LOS evaluation table for pedestrian speed computation. The speed tabulation will clearly illustrate the speed variation associated with pedestrian characteristics, and the chart has been validated using available survey data.

Moeinaddini et al. (2020) found that five main variables play a significant role in urban life satisfaction:

the people's perception of safety in the city, their satisfaction with healthcare services in the city, the condition of the streets and buildings in the neighborhood, their satisfaction with public transportation in the city, and the presence of retail shops in the neighborhood. One factor from the description of the condition of the neighborhood's streets that demonstrates the significance of having a pedestrian-friendly design is the presence of sidewalks. Castelli et al. (2023) discovered that another influence is the availability of amenities, in addition to a feeling of inclusivity and safety. On the other hand, it was found that socio-economic are not generally relevant, with the exception of economic insecurity in contributing to satisfaction with city life.

The study focused exclusively on the pedestrian in a free-flowing condition. The free flow condition was examined to determine the effect of the identified factors for evaluating pedestrian facilities without regard for any other constraint. Although this was a simple study, it is hoped that the findings will have broader implications, particularly as a starting point for more serious consideration of pedestrian facility design. Additionally, this study applies to accessible distance to community facilities by comparing the Malaysian experience to the western literature.

The significance of this research study is that it can be modified to meet specific objectives and applied to the real-world situations. This study was done to give a glimpse of the idea in terms of the pedestrian transportation system to obtain a better development in the future. However, there are some limitations on the scope of data collection for this research project in which it was done during the time where Covid-19 cases are still high even though the restriction on movement control was lifted by the government. Therefore, further recommendations for future data collection is that data collection will need to be conducted at different walkways that are similar in size and number of pedestrians, different days and times as the cases of Covid-19 has reduced significantly and to include the holiday season and analysing the data with variety of other factors and walkways.

The significance of this research study is that it can be modified to meet specific objectives and applied to real-world situations. This study is done to give a glimpse of the idea in terms of the pedestrian transportation system to obtain a better development in the future. There are some recommendations based on the study conducted for future development such as it is recommended that further data collection will be conducted at different walkways that are similar in size and number of pedestrians, different days and times which includes holiday season and analysing the data with variety of other factors and walkways.

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DECLARATION OF COMPETING INTEREST

None.

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