Objective and Subjective Physical Measures of the Neighbourhood Environment among Older People

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Abstract

This paper aims to explore the relation between objective and subjective neighbourhood walkability and its impact on the physical activity level of older adults. The correlations were used to signify older people's level of physical activity in Johor Bahru neighbourhoods, Malaysia. The results show residents in a highly dense area with higher accessibility to facilities perceived higher walkability level but showed a lower actual physical activity level. People living in high intersection density areas who recognised high walkability demonstrated higher physical activity level, while residents in a highly dense area with higher accessibility show lower physical activity level. This implies that neighbourhoods with high intersection density demonstrated a highly walkable environment rather than neighbourhoods with high density and high accessibility.

Keywords: Active ageing; physical neighbourhood environment; neighbourhood liveability; quality of life

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1.0 Introduction

Malaysia, as one of the fast-developing countries in Southeast Asia, is gradually progressing towards an ageing society. Most developed nations like France experiences longer years to become an ageing society, whereas developing countries like Malaysia only took less than 20 years to become an ageing society (Hedrich et al., 2016). Data in previous years shows that the percentage of elderly in Malaysia is 6.2% in 2017 and forecasted to increase to 14.7% in 2040 (Department of Statistics, 2017). The starting point for an ageing society accounts as 7% of the ageing rate, 14% as an aged society, and 21% as a super-aged society (Okamura, 2016). The gradual increase of the elderly population in Malaysia throughout the years illustrated Malaysia as a developing country that is experiencing a fast-paced ageing trend.

The main objective of this paper is to investigate the relationship between the physical components of the objective measures for neighbourhood environment (ONE) and the perception of the neighbourhood environment by the residents (PNE) and how these relationships affect older people's level of physical activity. There is quite a large number of literature discussing on the suitable neighbourhood environment for older people in Malaysia and how the housing policy can help improve the neighbourhood environment (Tobi, Fathi, & Amaratunga, 2017). However, until recently, there is limited research conducted to investigate the relationships between ONE and PNE that can influence older people's level of physical activity. The outcome of this paper is to examine concisely how these relationships may have affected the trends of total physical activity among the respondents in the chosen study area.

The structure of this paper includes a literature review section discussion on the relevant topics of this study. The next part will discuss the methodology of this study. Next, this paper will discuss the overall results of the ONE and PNE, followed by the detailed results of the cross-tabulations between ONE and PNE. The last part of this paper includes the discussion part on how the correlation between ONE and PNE may have influence older people's walkability level, the discussions and study limitation, as well as conclusion and recommendations.

2.0 Literature Review on Active Ageing

Active ageing is integral for maintaining a healthy lifestyle, especially among older people and retirees. This concept promotes behaviours that lead to higher life expectancies and better quality of life by becoming fit and active, nurturing older people's well-being and active engagement in the community besides maintaining their healthy mental state (WHO, 2002). Older people, especially retirees, tend to have more time for themselves, where they can devote more leisure time to developing themselves physically, socially, mentally & spiritually. Recent studies have shown that older people who are more involved in leisure activity tend to engage more in social relationship, which in return can improve their mental health (Chang, Wray, & Lin, 2014).

The starting age of older people is 65 years old in most developed countries whereas 60 years old in most developing countries like Malaysia, which is generally regarded as the

starting of the retirement period (WHO, 2002; Zawawi, 2013). About 7.7 percent of the total population in Malaysia is comprised of older people aged 60 and above (Elsawahli, Ahmad, & Ali, 2016). Older people can be categorised as the young-old (65 – 74 years old), old-old (75 – 84 years old) and oldest-old (85 years old and above) (Lee et al., 2018). For this study, the young and late middle-aged adults (45 – 49 years and 50 – 59 years) are included as they will soon enter the category of older people in Malaysia and is predicted to show differences in the results of future studies.

Generally, older adults who have retired from the workforce have more considerable free time for leisure and their own self-improvement. Older people who spent more time outdoors are usually among the ones who show a higher level of physical activity according to the various activity level. The main question in leading an active ageing lifestyle is how older adults manage to maintain their physical and cognitive function in their free time after their retirement period. A report prepared by the International Council on Active Aging (2011) on the capability of sustaining physical and cognitive functions among the elderly by spending time outdoors, was mostly done through wellness activities in outdoor settings. Being exposed to daily outdoor environments in neighbourhoods such as parks, backyard spaces, and converted empty spaces can help reduce stress and mental fatigue (Kaplan, Kaplan, & Ryan, 1998). Moreover, the promotion of green exercise which is any type of physical activities performed in natural environment settings especially in water-feature settings helps to boost older people's self-esteem and mood (Barton & Pretty, 2010). Beyond improving an individual's well-being, walking or simply spending time outdoors can also facilitate social interaction, which can improve their physical and mental health (Phillipson, 2011).

The need for elderly individuals to spend time outdoors in the neighbourhood environment varies among different settings. A survey by Williams & Keen (2009) in the U.S. showed that the elderly aged 65 and above tend to do gardening, participate in community activities, and volunteer their time for charity. Furthermore, much of the leisure time of older adults after retirement is spent indoors doing house chores and home improvement, whereas, for outdoor activities, older people tend to spend time on shopping, socialising, volunteering, and exercising (Brandon, 2013).

Comparatively, a study based in Hong Kong deduced that the elderly subjects tended to spend their time in social centres and become followers of religious beliefs because they considered religious activities to be a primary pursuit in life (Chow & Chi, 1994). A similar trend was observed in Malaysia, which has multiple ethnicities and religions among its population, showing that learning is integral for a seamless ageing process involving health, spiritual and community concerns (Muhamad & Merriam, 2000). In Malaysia, the process of learning among the elderly is firmly linked with daily routines, regardless of differences in religions and ethnicities. Informal learning, especially among elderly Muslims, who constitute the majority among older people usually practiced through attending religious classes at a mosque, going to the mosque to pray during a particular time of the day, and spending one's free time reciting the Koran to improve their life's contentment (Muhamad & Merriam, 2000). Similarly, in the study as mentioned earlier, Malaysian elderlies who follow other religions also incorporate learning into their daily lives, for example by walking daily, learning new farming techniques, helping others, and giving back to their society through learning and

teaching. Most daily activities pursued by the elderly in Malaysia involve spending time outdoors, generally in the surrounding neighbourhood setting consisting of religious and recreational facilities. For this reason, good neighbourhood design and outdoor environment can help to promote active ageing by providing access to daily activities that can eventually improve older people's quality of life through regular walking and physical activity (Michael, Green & Farquhar, 2006). This may also promote social interaction among the elderlies and the community in the neighbourhood.

2.1 Relation between the Objective and Subjective Characteristics of Neighbourhood Environment and Older People's Physical Activity Level

The objective neighbourhood environment can be easily understood as the physical characteristics in the environment, whereas the subjective neighbourhood environment can be understood as the perception that is instilled among the community regarding their neighbourhood surrounding.

The objective neighbourhood environment substantially influences residents' intentions of spending time outdoors. Physical or actual features in the neighbourhood environment must be barrier-free, which can help encourage the elderly to engage in their daily activities outdoors (Anastasia, Lené, & Madeline, 2014). Moreover, both the objective and subjective attributes of the neighbourhood environment greatly affect walkability among the elderly, such as walkable destinations, safety from crime, and sidewalks (Wang & Lee, 2010). Research by Sugiyama & Thompson (2007) found out that elderly individuals in Britain walk for recreation provided available open spaces in the neighbourhood are pleasant and nuisance-free. A recent study by Lai et al. (2016) of elderly in Malaysian neighbourhoods showed that such needs as accessibility to public transportation, outdoor spaces, buildings that are elderly-friendly, and affordable healthcare services are among the highest priorities in the creation of an age-friendly environment and promotion of active ageing in Malaysia. This evidence showed that the neighbourhood environment setting is an important determinant that can influence older people's level of physical activity, in terms of both objective and subjective factors of the neighbourhood environment.

Neighbourhood liveability consists of tangible elements such as public infrastructure and open spaces, as well as intangible elements such as a sense of place and strong social connections among the community living in an area (Throsby, 2005). These elements consist of objective neighbourhood environment that represents the existing land uses at present and the subjective neighbourhood environment that can be regarded as the perceived assessment of the respondents towards their neighbourhood environment. A study conducted in Subang Jaya, Malaysia demonstrated the essential dimensions of neighbourhood liveability which are social networks, physical environment, availability and access to infrastructure and services, and safety from crime (Hashim & Leby, 2010), which reflects the importance of objective and subjective neighbourhood environment.

Furthermore, highly walkable neighbourhoods show a significant relationship with higher physical activity among its dwellers (Lu, Xiao, & Ye, 2017; J. F. Sallis et al., 2012). This signifies the neighbourhood environment as an essential element in promoting residents to

walk. Thus, it is pertinent to promote walking to older people since their daily routine includes walking for leisure activities that help facilitate their physical activity (Mobily, 2014) which in return will improve their quality of life. Consequently, the association between the physical environment and the subjective evaluation by the population in a settlement plays a distinctive role in determining their physical activity level and quality of life, especially among older people.

3.0 Methodology

The aim of this study was to assess the ONE and PNE measures of the neighbourhood environment to analyse their combined relationships among elderlies in Johor Bahru, Malaysia. The present study involved an analysis of three similar neighbourhoods in Johor Bahru, Malaysia, each of which consists of two-storey terraced houses and several storey apartment buildings: Taman Perling, Taman Nusantara and Taman Selesa Jaya. The land use maps for each neighbourhood can be seen based on Figure 1, 2 and 3.

Table 1. Questionnaire items on the study population and their respective housing types based on the three neighbourhoods, *N (%)*

Part A: Demographic Attributes	Taman Perling (n = 139)	Taman Selesa Jaya (n = 57)	Taman Nusantara (n = 84)	Total respondents *(n = 280)*
Gender				
Male	80 (57.55)	40 (70.18)	54 (64.29)	174 (62.14)
Female	59 (42.45)	17 (29.82)	30 (35.71)	106 (37.86)
Age (years), mean, SD	59.62 ± 4.09	62.16 ± 1.53	59.71 ± 2.96	60.16 ± 6.96
Age				
45 – 49	8 (5.76)	0	1 (1.19)	9 (3.21)
50 – 54	21 (15.11)	4 (7.02)	18 (21.43)	43 (15.36)
55 – 59	38 (27.34)	15 (26.32)	18 (21.43)	71 (25.36)
60 – 64	42 (30.22)	20 (35.09)	31 (36.9)	93 (33.21)
65 – 69	18 (12.95)	11 (19.3)	10 (11.9)	39 (13.93)
70 – 74	9 (6.47)	6 (10.53)	4 (4.76)	19 (6.79)
75+	3 (2.16)	1 (1.75)	2 (2.38)	6 (2.14)
Housing types, *N (%)*				
High-rise apartment	0	2 (3.51)	0	
4-storeys flats	49 (35.25)	0	0	
5-storeys flats	9 (6.47)	0	0	
6-storeys flats	1 (0.72)	0	0	
1-storey low cost terrace	1 (0.72)	55 (96.49)	0	
2-storeys low cost terrace	79 (56.83)	0	84 (100.00)	

Source: Author's Findings

A questionnaire survey was administered to 280 elderly respondents (aged 45 and above) in the three neighbourhoods to measure the PNE. The questionnaire combines demographic attributes, PNE and PA level. The first part includes respondent's demographic characteristics, and the second part consists of 4-Likert scales of PNE based on the Neighbourhood Environment Walkability Scale (NEWS-A) questionnaire which was developed by Saelens & Sallis (2002). Respondents with the age of 45 are included as they are regarded as young, middle-aged people who will soon enter the late-middle-aged, which is 50 years old. Besides, late middle age respondents from 50 – 59 years old are also included in this study since they will soon enter 60 years old. These age groups are considered since they are expected to show significant results later in the future, which is not

for this study. Table 1 shows the simple summary of demographic attributes which consists of gender and age items as well as the housing types of the respondents. Among the respondents aged from 45 years old to 75 and above, the average age for the three neighbourhoods are about 60 years old, where the highest portion represents residents from

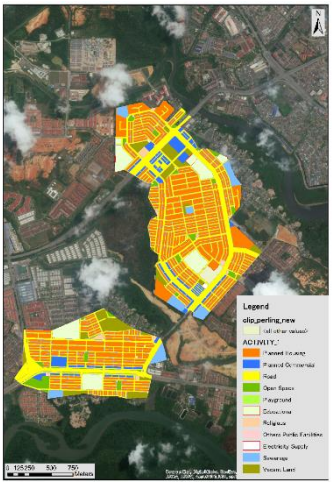

Figure 1: Land use map for Taman Perling
(Source: Author's Findings)

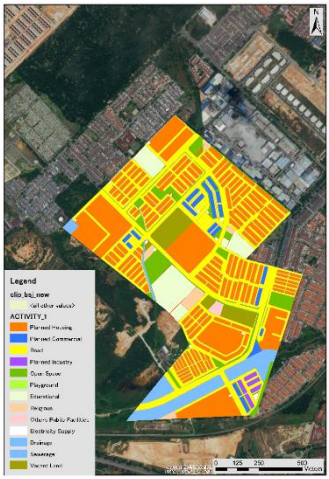

Figure 2: Land use map for Taman Selesa Jaya
Source: Author's Findings)

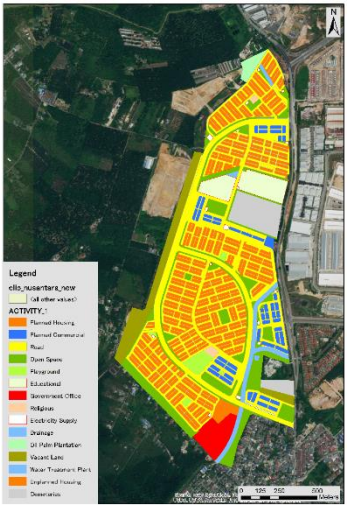

Figure 3: Land use map for Taman Nusantara
(Source: Author's Findings)

4.0 Results and Discussions

The analysis of objective measures (ONE) for population density, distance to facilities, and intersection density was performed using GIS. Concurrently, the results from the questionnaire survey are consist of the perception of neighbourhood walkability (PNE), which reflects the walkability extent among older people. The simple summary for the two analyses of ONE and PNE and the detailed analysis of the cross-tabulation between ONE and PNE are as shown in the three sub-sections below.

4.1 Objective Physical Measures of the Neighbourhood Environment (ONE)

Geographic Information System (GIS) datasets such as land use, transportation networks, and public facilities were combined and analysed to assess the objective physical measures of the neighbourhood environment. The analysis covered items such as population density, the proximity of neighbourhood attractions, and accessibility of traffic and pedestrian networks. The population density in Johor Bahru City is based on the Johor Census Data obtained from the Department of Statistics, Johor. The data can be illustrated through smaller sub-districts. According to an existing ArcGIS project on population density in Iskandar Malaysia (a broader region that includes Johor Bahru City), the highest range of population density would preferably be from 30,000 to 150,000 people per square kilometre. A moderately high population density range would be 7000 people per square kilometre and above, whereas a slightly high-density range would be from 5,200 people per square kilometre. Medium and low population density range starts from 3,330 and 1,500 people per square, respectively (Bell, 2017).

To measure accessibility, distance from each respondent's road address to three types of common facilities in the three neighbourhoods were analysed using ArcGIS. The necessary facilities include worship places such as mosques and temples, schools, and playgrounds. The distance of facilities was categorised into six categories, which are 0 – 100m, 101 – 200m, 201 – 300m, 301 – 400m, 401 – 500m, 501 - 600m and more than 600m. On the other hand, the density of intersections was analysed using ArcGIS to measure accessibility. The density of intersections is computed as the total number of crossings excluding cul-de-sacs per unit of the area from the centre of the location. A buffer of 200 meters from respondents' homes was assigned for this study. Higher intersection density denotes higher connectivity in the specified area (Dill, 2003).

Table 2 shows a simple summary of objective measures for the three neighbourhoods; namely population density, accessibility of neighbourhood attractions measuring the distance of various facilities to the respondent's homes, and permeability of road network measuring the intersection density.

The last step of the GIS analysis is locating and establishing a spatial reference for each respondent based on their home's road address obtained from the questionnaire interview. The questionnaire datasets containing the PNE score were layered with the analysis of ONE which includes population density, accessibility of road networks measuring the distance of various facilities, and permeability measuring intersection density in the three neighbourhoods. Furthermore, the scores for ONE are categorised differently based on each

type of ONE measures. For population density, the scores are divided into lowest, slightly low, medium, slightly high, very high and highest population density based on the previously mentioned range developed by Bell (2017). For distance to facilities and intersection density of ONE, the scores are categorised into low, medium and high scores based on the 25th, 50th and 75th percentiles.

Table 2: Objective measures in the three neighbourhoods (ONE)

Objective measures (PNEo)	Taman Perling *(mean, s.d., max, min)*	Taman Selesa Jaya *(mean, s.d., max, min)*	Taman Nusantara *(mean, s.d., max, min)*
A) Population density (population/sq km)	8917.31, 6393.45, 30133.3, 773.3	11453.64, 4004.63, 18669.69, 2413.27	5157.2, 1349.4, 6688.4, 2861.7
B) Distance to facilities (meter)			
Mosque	338.0, 187.12, 1219.7, 82.51	438.06, 247.91, 1023.2, 134.44	803.28, 328.48, 1368.82, 140.14
School	550.22, 283.93, 1615.92, 66.15	500.38, 234.0, 1259.7, 25.48	1279.56, 540.84, 2128.43, 211.72
Play ground	337.38, 177.65, 665.97, 29.27	317.68, 208.11, 920.22, 27.09	329.89, 211.2, 790.9, 36.74
C) Intersection Density (No. of real nodes/area)	461.69, 207.61, 1277.78, 150.79	164.98, 70.42, 297.48, 42.0	151.77, 96.65, 427.21, 33.0

(Source: Author's Findings)

4.2 Subjective Physical Measures of the Neighbourhood Environment (PNE)

The NEWS-A questionnaire was used to explore the resident's perception of neighbourhood design features that can influence their level of PA (Saelens & Sallis, 2002). Consequently, the level of walkability was associated with an increase of PA level (Mena et al., 2017). An explanation of the PNEs items and the sub-items in the combined questionnaire as reflected in Table 3. The objective of item A is to measure resident's perception of residential density, based on the scoring weight of NEWS-A (J. Sallis, Black, & Chen, 2002). Higher numbers of residential density constitute higher walkability. For the other items, the scale range consists of 'Strongly Disagree, Disagree, Not Sure, Agree, and Strongly Agree'. Several additions are included in the questionnaire item B to adapt to the Malaysian neighbourhood environment such as places of worship, night markets, wet markets and clinics (M & Lee, 2018).

Furthermore, food stalls in the neighbourhood area are also included since it is logical to regard this as a component supporting social liveability in a Malaysian neighbourhood based on the pilot survey performed previously (Nordin & Nakamura, 2018). The scores for PNE are categorised into low, medium and high scores based on the 25th, 50th and 75th percentiles similarly as the ONE scores previously. Each score of PNE was divided based on the 1st, 2nd and 3rd quartiles since there is no protocol to measure precisely the categorisation of low to high walkability based on the PNE scores.

Table 3. Items in the NEWS-A questionnaire

Part 2: Perceived Measures based on NEWS-A questionnaire	Sub-items
A. Residential density	Types of residence: Bungalow, Terrace, Semi-detached, Apartment 1 – 3 stories, Apartment 4 – 6 stories, Apartment 7 – 12 stories, Apartment more than 13 stories
B. Diversity of land use mix	Distance to each destinations (minutes): Grocery store, supermarket, worship places, bus stop, coffee and restaurant, clinic, food stall, park and playground, community hall, night market, wet market
C. Accessibility	'Stores are within walking distance from home', 'Many places to go within walking distance from home', 'Walking to bus stop from home is easy'
D. Street connectivity	'Distance between traffic intersections are 100 or less' 'There are many alternative routes to get from place to place'
E. Infrastructure for walking and cycling	'Presence of sidewalks on most of the streets', 'Presence of grass strips that separates the streets from the side', 'Neighborhood streets are well lit at night', 'Residents can easily observe pedestrians and bikers on the streets', 'Presence of crosswalks and pedestrian signals'
F. Aesthetics	'Presence of trees along the streets', 'Many interesting things to look at while walking', Many attractive natural sights and good landscaping', Many attractive building and homes'
G. Safety from traffic hazards	'Heavy traffic makes it difficult to walk in the streets', 'Traffic speed on the street near home is slow 25km/h', 'Most drivers exceed the posted speed limits while driving in the neighbourhood'
H. Safety from crime	'High crime rate in the neighborhood', 'Crime in the neighborhood makes it unsafe to walk in the day', 'Crime in the neighborhood makes it unsafe to walk in the night'

(Source: Neighbourhood Environment Walkability Questionnaire (NEWS-A), (Saelens & Sallis, 2002))

Next, before discussing the detailed results of the questionnaire survey, Table 4 shows a general summary of the PNE items in part two of the combined questionnaire.

Table 4. General summary on the NEWS-A questionnaire items based on the three neighbourhoods

Part 2: Perceived Measures based on NEWS-A questionnaire	Taman Perling *(mean, S.D.)*	Taman Selesa Jaya *(mean, S.D.)*	Taman Nusantara *(mean, S.D.)*
A. Residential density	245.56, 77.25	422.16, 93.55	196.93, 0.65
B. Diversity of land use mix	2.29, 0.88	1.82, 0.32	3.05, 1.31
C. Accessibility	3.05, 0.37	2.74, 0.58	2.48, 0.63
D. Street connectivity	2.91, 0.53	2.79, 0.38	2.24, 0.95
E. Infrastructure for walking and cycling	2.84, 0.39	2.87, 0.18	2.42, 0.45
F. Aesthetics	2.79, 0.56	2.60, 0.37	2.27, 0.49
G. Safety from traffic hazards	2.71, 0.52	2.34, 0.37	0.84, 0.34
H. Safety from crime	1.84, 0.57	2.17, 0.66	1.96, 0.57

(Source: Author's Findings)

4.3 Significant Relationships between ONE and PNE

Since the aim of the NEWS-A integrated questionnaire is to explore the respondent's perception towards neighbourhood walkability, their daily PA needs to be understood as well. This is to distinguish how the significant relationships of ONE and PNE may influence the level of total PA performed daily in the three neighbourhoods. To find the meaningful connections between the ONE and PNE, chi-square analyses are performed based on the

cross-tabulations of each variable of ONE and PNE.

The results of the chi-square analysis show several significant relationships between ONE and PNE and similar trends of these relationships across the three neighbourhoods, which can be seen from Table 5. Based on the findings obtained, further adjusted residual analysis was done to investigate more on the nature of the significant relationships. All three measures of ONE showed substantial results with three measures of PNE, which are resident's perception towards residential density, diversity of land use mix, and street connectivity. Commonly, the residents living in a densely populated area tend to perceive their neighbourhood as having high residential density, as well as the opposite.

Several significant relationships resulted in typical trends of ONE and PNE. For example, it is widely understood that residents living in a highly-populated area tend to perceive only a moderate level of residential density and street connectivity. This scenario is typical, especially among residents living in affordable housing flats in Malaysian neighbourhoods. Malaysian developers would usually plan to locate affordable housings at the fringe of the neighbourhood boundary and do not consider the needs of the low-cost community who would often use public transportation and tend to locate the medium and high-cost properties in higher accessible areas. A study by Wahi et al. (2018) showed that most low-cost housing projects in Malaysia do not comply to the resident's needs and satisfaction, considering low-income people in Malaysia usually tend to demonstrate higher trends of commuting via public transportation (Chee & Fernandez, 2013). Interestingly, the significant relationship demonstrated in Taman Selesa Jaya shows residents living in high population density tend to perceive high street connectivity. This signifies that residents living in strata properties tend to experience higher connectivity when compared to residents living in non-strata properties, where higher connectivity in a highly-populated area can influence the resident's level of physical activity (Cerin et al., 2017) by which it is a vital characteristic in most walkable neighbourhood environment (Chiang, Sullivan, & Larsen, 2017).

An unusual trend was observed where residents living further to the school perceived high residential density in Taman Perling. This shows that affordable housings which are high residential density area are located farther from the school, which may facilitate walking activities among the respondents, as shown by the high score of perceived residential density. Also, residents living nearby to the mosque and playground in Taman Perling and Taman Nusantara tend to recognise low diversity of land use mix and street connectivity. It may be because residents living very near to the mosque may experience barriers within the pedestrian network from their homes to the nearest mosque such as disconnected pedestrian networks which are usually caused by illegal property construction by irresponsible homeowners.

Other than that, the presence of longer length of residential terrace blocks where residents may have to walk further to get to an adjacent road can also be an essential factor that contributes to the low perception of street connectivity which confirms a previous study done by Voorhees et al. (2010) as well as contradicts findings of an earlier study done by Oakes, Forsyth, & Schmitz (2007).

Table 5: Significant results from the chi-square analyses of different cross-tabulations of the measures

ONE x PNE	Taman Perling, *N = 139, p > 0.05*	Taman Selesa Jaya, *N = 57, p > 0.05*	Taman Nusantara, *N = 84, p > 0.05*
A)Population Density (PD)			
Population density x Score A (Perception on residential density)	*X^2 (8, N = 139) = 65.8* ***very high PD, medium A*		-
Population density x Score B (Perception on diversity of land use mix)	*X^2 (8, N = 139) = 19.54* ***medium PD, high B*	-	-
Population density x Score D (Perception on street connectivity)	*X^2 (8, N = 139) = 16.17* ***medium PD, low D/high PD, medium D*	*X^2 (8, N = 57) = 14.2* ***low PD, medium D High PD, high D (preferred)*	-
Population density x Score H (Perception on safety from crime)	*X^2 (8, N = 139) = 17.32* ***medium PD, high H*	-	-
B) Distance to facilities (Dist)	Taman Perling *N = 139, p > 0.05*	Taman Selesa Jaya *N = 57, p > 0.05*	Taman Nusantara *N = 84, p > 0.05*
Distance to school x Score A (Perception on residential density)	*X^2 (12, N = 139) = 31.35* ***long Dist, high A*		*X^2 (8, N = 78) = 64.0** ***long Dist more than walking dist, low A*
Distance to school x Score F (Perception on aesthetics)		*X^2 (12, N = 57) = 11.51* ***long Dist, low F*	
Distance to school x Score G (Perception on safety from traffic)	-		*X^2 (8, N = 78) = 323.13** ***long Dist, high G*
Distance to mosque x Score A (Perception on residential density)	*X^2 (12, N = 138) = 33.13** ***short Dist, high A*	-	-
Distance to mosque x Score B (Perception on diversity of land use mix)	*X^2 (12, N = 138) = 157.29** ***short Dist., low B*	-	-
Distance to mosque x Score D (Perception on street connectivity)	*X^2 (12, N = 138) = 20.93** ***short Dist, low D*	-	-
Distance to play ground x Score A (Perception on residential density)	*X^2 (12, N = 135) = 46.88** ***short Dist, high A*	*X^2 (12, N = 57) = 10.95* ***long Dist, medium A*	-
Distance to play ground x Score B (Perception on diversity of land use mix)	-	-	*X^2 (12, N = 79) = 88.67** *** short dist, low B*
Distance to play ground x Score C (Perception on accessibility)	-	*X^2 (12, N = 57) = 15.35* ***short Dist, low C*	*X^2 (6, N = 79) = 13.0** ***short Dist, low C*
Distance to play ground x Score D (Perception on street connectivity)	*X^2 (12, N = 135) = 43.69** ***long Dist, low D*	-	-
C) Intersection Density (ID)	Taman Perling *N = 139, p > 0.05*	Taman Selesa Jaya *N = 57, p > 0.05*	Taman Nusantara *N = 84, p > 0.05*
Intersection density x Score A (Perception on residential density)	*X^2 (4, N = 139) = 10.25* ***Very high ID, low A*	-	-
Intersection density x Score B (Perception on diversity of land use mix)	-	-	*X^2 (4, N =84) = 10.07* ***Very high ID, medium B*
Intersection density x Score D (Perception on street connectivity)	*X^2 (4, N = 139) = 16.2* ***low ID, low D*	*X^2 (4, N = 57) = 12.86* ***low ID, medium D*	*X^2 (4, N = 84) = 12.33* ***high ID, high D (preferred)*
Intersection density x Score G (Perception on safety from traffic)	-	*X^2 (4, N = 57) = 10.47* ***very high ID, low G Low ID, medium G*	-

(Source: Author's Findings)

The relationship between very high intersection density and low perception of residential density indicates that respondents are living in an environment where there are less diversity of housing types. It may also suggest that land use distribution in that area only consists of residential, commercial or facilities. Road networks in a smaller scale commercial land use usually have more intersections with an accessible entrance and an exit, as well as connected back lanes and side lanes that often have parking facilities. In line with a previous study (Leslie et al., 2007), a notable trend was observed where residents living in high intersection density area perceived high connectivity road network in Taman Nusantara, further demonstrating the preferred features of a walkable neighbourhood.

Furthermore, population density and perception of residential density showed the highest significant relationship for Taman Perling only. A strong correlation was found for distance to mosque and perception towards diversity of land use mix in Taman Perling, and distance to school and perception towards safety from crime in Taman Selesa Jaya. Moreover, Taman Selesa Jaya and Taman Nusantara displayed preferred characteristics of walkable neighbourhood environment where high population density and high intersection density contributes to high perception of street connectivity, further promoting walking activities among the respondents.

These notable trends further justify the relationship between ONE and PNE and how it influences the total walkability level of respondents according to the PNE results in the three neighbourhoods. Overall, Taman Nusantara, which is constituted as having a walkable environment, displayed higher walkability level of PNE scores, followed by respondents in Taman Selesa Jaya and Taman Perling (shown in Table 5).

5.0 Limitations of the Study

Upon conducting the questionnaire survey, the respondents consisting of older people and younger older people might give a biased answer since the total time taken to interview a respondent takes about 20 to 30 minutes. Older people tend to elaborate further and be more responsive to the questions from the survey, and the interviewees spent more time on them. Nevertheless, younger older people tend to participate briefly answering the questions and interviewees spent lesser time on them during the survey. Even so, the interviewees managed to interview all the items in the questionnaire with no missing response. Furthermore, the respondents were spatially located based on their given road address, and their exact location within the road address was unknown. The only solution was to aggregate and determine the respondent's location at the middle distance of their given road address. This may influence the ONE analyses in terms of varying distance to various facilities.

Besides, when performing distance analysis to facilities in ArcGIS, some respondents are not accessible to facilities such as the school and playground. This is because some parts of the neighbourhood are not thoroughly connected by the road networks and are separated by a highway where the u-turn ramps are located outside the neighbourhood boundary, making it a limitation of this study. Additionally, we can assume that the significant outcomes of this research paper concern a small sample size population in several districts in the three neighbourhoods and it would be biased to consider the meaningful relationships

obtained as a representation for one whole housing area. Furthermore, future chi-square analyses could be conducted to explore the detailed connections between ONE and PNE with the walkability level among the respondents in the three neighbourhoods.

6.0 Conclusion and Recommendations

To conclude, this research paper resulted in desired outcomes of several significant relationships between ONE and PNE. The common trends were observed between population density, accessibility and permeability (ONE), with residential density, diversity of mix land uses and street connectivity (PNE). Significant correlations were observed, especially between high population density with high street connectivity, which confirms previous researches of walkable neighbourhood characteristics. The study outcomes show residents living in neighbourhoods with higher population density and higher intersection density perceived higher neighbourhood walkability, as demonstrated by residents in Taman Selesa Jaya and Taman Nusantara. This may be mainly due to various factors such as the usage of motorised vehicles and significant correlation with perception towards the safety of crime. The outcomes of this study further demonstrate the physical characteristics of having high intersection density as a preferred walkable neighbourhood among older adults. This implies that neighbourhoods with high intersection density demonstrated a highly walkable environment rather than neighbourhoods with high density and high accessibility. By considering these physical indicators, future extensive spatial planning for the neighbourhood environment in Malaysia can eventually facilitate older people in Malaysia towards improving their well-being and quality of life.

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