



INTRA-URBAN DISTANCE VARIATIONS IN PERCEIVED 20-MINUTE NEIGHBOURHOOD FEATURES: A KRUSKAL-WALLIS ANALYSIS WITHIN AN 800m WALKABLE CATCHMENT IN BAYAN BARU, PENANG, MALAYSIA

Siti Noorhawa Azyze Ellah Azyze, Diana Mohamad Ruhizal Roosli

UNIVERSITI SAINS MALAYSIA

Abstract

The 20-Minute Neighbourhood (20MN) has emerged as a prominent urban planning framework aimed at promoting accessibility, sustainability and local living. However, its application often assumes a uniform walking threshold, potentially overlooking variations in mobility needs, environmental perceptions, and demographic characteristics. This study examines how perceived neighbourhood performance varies across age groups and distance bands within an 800 m walkable catchment in a compact urban context. Using questionnaire data and non-parametric statistical analysis, the study evaluates six 20MN domains: safe, accessible and connected mobility; local economy and daily needs; essential services and community destinations; climate resilience and environmental comfort; high-quality public realm and open spaces; and housing diversity and affordability. Kruskal–Wallis tests identify significant differences in perceived neighbourhood features across distance bands, while age-group comparisons show limited variation across the six domains. The findings indicate that spatial proximity plays a stronger role than age in shaping perceived 20MN performance within the study area, although demographic characteristics remain relevant for inclusive neighbourhood planning. This study contributes to context-sensitive 20MN planning by highlighting the importance of considering intra-neighbourhood spatial variations when evaluating accessibility and neighbourhood quality in compact tropical urban environments.

Keywords: 20-minute neighbourhood, Walkability, Age Factors, Intra-Urban Distance, Perceived Accessibility, Kruskal-Wallis Analysis

¹ Corresponding author. Email: diana_mohamad@usm.my & ruhizal@usm.my

INTRODUCTION

Urban planning in dense cities faces ongoing challenges in promoting sustainable mobility, social equity, and liveability, particularly where private vehicle use dominates and pedestrian environments are compromised. The 20-Minute Neighbourhood (20MN) concept has emerged as a key framework to address these issues, advocating that residents access essential services such as food, education, healthcare, employment, and recreation within a 20-minute walk or cycle (Thornton et al., 2022; Chau et al., 2022). Despite its growing adoption, the operationalisation of the 20MN often relies on fixed spatial thresholds, commonly represented by an 800 m walking radius, which may overlook variations in residents' perceived accessibility and neighbourhood experiences. This assumption has been increasingly questioned, particularly in relation to demographic diversity and differences in how residents experience the urban environment. Age is an important consideration within neighbourhood accessibility research, as residents across different life stages may have different mobility patterns, activity requirements, and perceptions of environmental quality (Loo et al., 2017; Kim & Ulfarsson, 2022). Furthermore, spatial separation from neighbourhood facilities may influence residents' perceptions of accessibility and engagement with local environments, even where amenities fall within a formal walking threshold (Calafiore et al., 2022; Littlejohn et al., 2024). Bayan Baru, Penang, represents a suitable tropical urban context for examining these issues due to its compact urban form, diverse neighbourhood characteristics, and varying residential relationships with local facilities. This study examines whether perceived 20MN performance varies across different distance bands and age groups within an 800 m catchment. Rather than assuming that a fixed radius represents a uniform neighbourhood experience, this research investigates how spatial and demographic characteristics relate to residents' perceptions of accessibility and neighbourhood quality. By examining intra-urban variations in perceived 20MN features, this study contributes empirical evidence towards more context-sensitive approaches to applying the 20MN framework in compact tropical urban environments.

LITERATURE REVIEW

The 20-Minute Neighbourhood and Urban Accessibility

The concept of the 20-Minute Neighbourhood (20MN) builds on foundational neighbourhood planning theories that emphasise proximity, pedestrian orientation, and local self-sufficiency (Thornton et al., 2022; Chau et al., 2022). Contemporary applications extend beyond physical proximity to incorporate social, economic, and environmental dimensions, with recent research demonstrating positive relationships between local accessibility, health

outcomes, active mobility, and social engagement (Littlejohn et al., 2024; Iqbal, 2025). However, the operationalisation of 20MN through a fixed walking threshold, commonly represented by an 800 m radius, has been increasingly questioned due to distance decay effects, whereby residents' accessibility perceptions and interaction with neighbourhood amenities may vary according to spatial distance and across different population groups (Handley et al., 2023; Calafiore et al., 2022). Empirical studies further highlight that physical proximity does not necessarily translate into perceived accessibility or effective use of neighbourhood environments, as factors such as perceived safety, pedestrian infrastructure quality, environmental comfort, and neighbourhood conditions influence walking behaviour and local engagement (Roosli et al., 2024; Ewing & Handy, 2009; Forsyth et al., 2017; Roslan et al., 2025). Therefore, understanding how residents perceive neighbourhood features across different distances is essential for evaluating the effectiveness of the 20MN framework.

Age, Walkability and Distance Sensitivity

Age represents an important demographic consideration in understanding perceptions of walking accessibility, environmental comfort, and interaction with urban environments. Previous studies indicate that older adults may experience greater sensitivity to environmental barriers, including longer walking distances, inadequate pedestrian infrastructure, and uncomfortable outdoor conditions, which may influence perceived accessibility and neighbourhood participation (Lönn et al., 2025; Sánchez-González, 2025). In particular, climatic conditions such as heat exposure and humidity may affect outdoor comfort and walking experiences, especially in tropical urban environments where thermal conditions can influence residents' engagement with outdoor spaces (Núñez-Rodríguez et al., 2025; Fastl, 2024). However, the influence of environmental conditions and distance sensitivity is not limited exclusively to older adults, as residents across different age groups may perceive neighbourhood features differently according to their mobility needs, daily activities, and environmental preferences. Consequently, age remains an important consideration when examining variations in perceived neighbourhood suitability within the 20MN framework. In tropical cities, microclimatic interventions, including shaded pedestrian routes, green infrastructure, and urban cooling strategies, may contribute to improving outdoor comfort and supporting walkability for diverse population groups (Tan, 2025; Xiong et al., 2025). Recent urban studies advocate for age-inclusive planning approaches that move beyond universal distance thresholds by recognising variations in residents' abilities and perceptions (Loukaitou-Sideris et al., 2020). Nevertheless, age-related differences remain insufficiently explored in empirical evaluations of the 20MN framework (González, 2025).

RESEARCH METHODOLOGY

Perceived 20-Minute Neighbourhood Features Across Distance Bands and Age Groups

This research focuses on urban areas of Bayan Baru, Penang, a dense tropical urban setting characterised by compact urban morphology. The study examines residents' perceptions within a nominal 800 m 20-Minute Neighbourhood (20MN) catchment, which was subdivided into three micro-scale distance bands (Table 1) and three age categories (Table 2) to investigate variations in perceived neighbourhood performance.

Table 1. Distance Band Classification within the 800 m 20-Minute Neighbourhood Catchment

Distance Band		Description
0-300m	Immediate neighbourhood	Closest proximity to local facilities and services
300-600m	Intermediate zone	Moderate walking distance within the 20MN catchment
600-800m	Outer neighbourhood edge	Outer limit of the defined 20MN catchment

Source: Author's data (2025)

The 800 m catchment was disaggregated into three distance bands to examine whether perceptions of 20MN features vary according to intra-neighbourhood spatial conditions. This approach recognises that walking experiences and perceived accessibility may differ across short-distance variations rather than assuming a uniform walking threshold throughout the entire catchment.

Table 2. Definition of Age Groups Used in the Study

Code	Age Group	Description
1	Young Adults (18-35 years)	Different activity patterns and mobility preferences
2	Middle-Aged Adults (36-55 years)	Diverse daily routines and neighbourhood requirements
3	Older Adults (56 years and above)	Potentially differences in accessibility perceptions and neighbourhood experience

Source: Author's data (2025)

Respondents were classified into three age groups to examine whether perceptions of 20MN features vary across different demographic categories. This categorisation enables comparative analysis of variations in neighbourhood perceptions across different life stages, while acknowledging that residents may experience and evaluate neighbourhood environments differently based on their

individual circumstances and needs. After data screening, 280 valid responses were retained for statistical analysis.

Table 3. Distribution of Respondents by Distance and Age Group

Distance Band	Young Adults	Middle-Aged Adults	Older Adults	Total
0-300m	21	26	31	78
300-600m	28	34	30	92
600-800m	34	35	41	110
Total	83	95	102	280

Source: Author's data (2025)

Six key themes of the 20MN framework were investigated: i) safe, accessible and connected mobility; ii) local economy and daily needs; iii) essential services and community destinations; iv) climate resilience and environmental comfort; v) high-quality public realm and open spaces; and vi) housing diversity and affordability. While the study focuses on subjective perceptions, the findings provide insights into micro-scale neighbourhood planning considerations related to spatial accessibility and demographic variations. Figure 1 illustrates the study area and distance bands.



Figure 1: Research Area (Radius 300m, 600m and 800m)

Source: Author's fieldwork (2025)

Non-parametric methods such as the Kruskal–Wallis H test are widely recommended for analysing differences across ordinal perception data and

categorical groups, as they do not require assumptions of normality and are suitable for survey responses measured on Likert-type scales (Eiselen, 2023; Rustin & Arifin, 2026). The Kruskal–Wallis H test is particularly appropriate for comparing three or more independent groups, allowing for robust detection of statistically significant differences in perceptions across categories such as distance bands and age groups (Eiselen, 2023; Karsokiene et al., 2025). By integrating both spatial distance and demographic characteristic in the analysis of 20MN perceptions using this method, the study provides a nuanced understanding of perceived accessibility and neighbourhood experiences among different resident groups.

A quantitative survey was conducted among 280 urban residents of Bayan Baru capturing resident's perceived quality across six 20MN domains using a five-point Likert-scale. Residential locations were classified according to distance bands within the 0–800 m catchment (Table 1), while respondents were categorised into three age groups (Table 2). The Kruskal–Wallis H test was applied to identify whether statistically significant differences existed across both distance bands and age groups, with $p < 0.05$ indicating statistical significance.

ANALYSIS AND RESULTS

The analysis examined variations in perceived 20-Minute Neighbourhood (20MN) features across different age groups and distance bands to examine whether residents' perceptions of neighbourhood performance differed across distance bands and age groups. Descriptive statistics were first used to examine differences in mean perceived scores, followed by the Kruskal–Wallis H test to determine whether observed variations were statistically significant.

Perceived 20MN Features across Age Groups

The analysis of perceived 20MN features across age groups shows relatively small variations in mean scores across the six domains (Table 4). Differences between young adults, middle-aged adults, and older adults were observed, however, no consistent pattern indicates that any particular age group reported systematically higher or lower perceptions across all domains.

Older adults recorded slightly higher mean scores for local economy and daily needs (Mean = 4.4608) and housing diversity and affordability (Mean = 3.9338), while young adults reported marginally higher perceptions for safe, accessible and connected mobility (Mean = 2.4418) and high-quality public realm (Mean = 3.6657). Middle-aged adults recorded comparable perceptions across several domains. These descriptive variations indicate modest differences in mean perceptions across age groups; however, the magnitude of these differences is relatively small.

Table 4: Mean Perceived Scores of 20-Minute Neighbourhood Features
across Age Groups

Domain	Age Group	Mean	N
Theme 1: Safe, Accessible and Connected Mobility	Young Adults	2.4418	83
	Middle-Aged Adults	2.1268	95
	Older Adults	2.3524	102
	Total	2.3534	280
Theme 2: Local Economy and Daily Needs	Young Adults	4.3494	83
	Middle-Aged Adults	4.3158	95
	Older Adults	4.4608	102
	Total	4.3786	280
Theme 3: Essential Services and Community Destinations	Young Adults	3.6566	83
	Middle-Aged Adults	3.6737	95
	Older Adults	3.6373	102
	Total	3.6554	280
Theme 4: Climate Resilience and Environmental Comfort	Young Adults	3.5582	83
	Middle-Aged Adults	3.4421	95
	Older Adults	3.5000	102
	Total	3.4976	280
Theme 5: High-Quality Public Realm and Open Spaces	Young Adults	3.6657	83
	Middle-Aged Adults	3.6158	95
	Older Adults	3.6103	102
	Total	3.6286	280
Theme 6: Housing Diversity and Affordability	Young Adults	3.8404	83
	Middle-Aged Adults	3.8579	95
	Older Adults	3.9338	102
	Total	3.8804	280

Source: Author's data (2025)

Perceived 20MN Features across Distance Bands

The descriptive analysis by distance bands demonstrates greater variation compared with age groups (Table 5). The 0–300 m zone recorded the highest perceived score for safe, accessible and connected mobility (Mean = 2.7479), suggesting that proximity contributes to perceptions of accessibility. Meanwhile, the 300–600 m zone recorded the highest mean scores for local economy and daily needs (Mean = 4.6576), essential services and community destinations (Mean = 3.9429), and high-quality public realm (Mean = 3.7527).

The 600–800 m zone generally recorded lower perceptions for selected domains, particularly essential services and community destinations, although the spatial pattern varied across the six domains particularly essential services and community destinations (Mean = 3.5227) and high-quality public realm (Mean = 3.7068). However, the results do not indicate a uniform linear decline across all domains, suggesting that different neighbourhood characteristics may influence perceptions at different spatial ranges.

Table 5: Mean Perceived Scores of 20-Minute Neighbourhood Features across Distance Band

Domain	Distance Band (m)	Mean	N
Theme 1	0–300	2.7479	78
	300–600	2.1268	92
	600–800	2.3524	110
	Total	2.3534	280
Theme 2	0–300	4.0641	78
	300–600	4.6576	92
	600–800	4.3682	110
	Total	4.3786	280
Theme 3	0–300	3.5032	78
	300–600	3.9429	92
	600–800	3.5227	110
	Total	3.6554	280
Theme 4	0–300	3.5299	78
	300–600	3.4746	92
	600–800	3.4939	110
	Total	3.4976	280
Theme 5	0–300	3.3718	78
	300–600	3.7527	92
	600–800	3.7068	110
	Total	3.6286	280
Theme 6	0–300	3.8686	78
	300–600	3.9130	92
	600–800	3.8614	110
	Total	3.8804	280

Source: Author's data (2025)

Kruskal–Wallis Test Results

The Kruskal–Wallis H test was conducted to examine whether perceived 20MN features differed significantly across distance bands and age groups (Table 6). The test was considered appropriate due to the ordinal nature of the Likert-scale responses and the non-normal distribution of perception data.

The results demonstrate that distance significantly influenced perceptions across several 20MN domains. Significant differences were identified for safe, accessible and connected mobility ($H = 9.667$, $p = 0.008$), local economy and daily needs ($H = 31.438$, $p < 0.001$), essential services and community destinations ($H = 51.784$, $p < 0.001$), and high-quality public realm ($H = 37.496$, $p < 0.001$). Among these domains, essential services and community destinations recorded the strongest effect size ($\epsilon^2 = 0.179$) indicating that perceptions of essential services and community destinations vary more strongly across distance bands than the other domains examined.

The observed pattern across distance bands indicates that perceptions of 20MN features vary within the 800 m catchment, although the direction of these differences differs by domain. For example, local economy and daily needs and essential services and community destinations recorded the highest mean perceptions within the 300–600 m zone, suggesting that the spatial distribution of amenities and neighbourhood functions may influence residents' perceptions beyond simple physical proximity.

In contrast, age-based comparisons did not demonstrate statistically significant differences across any of the six 20MN domains ($p > 0.05$). Although descriptive variations were observed among age groups, the effect sizes were negligible to small, indicating that age alone did not represent a significant determinant of perceived neighbourhood performance within the study area.

Table 6: Kruskal–Wallis Test Results and Effect Sizes for 20MN Domains

Domain	Factors	H	df	p-value	ϵ^2	Effect	Observed Pattern/ Interpretation
Theme 1	Distance	9.667	2	0.008	0.028	Small	Higher perceived accessibility was observed in the 0–300 m zone compared with the 600–800 m zone
	Age	0.768	2	0.681	0.003	Negligible	No statistically significant differences

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Domain	Factors	H	df	p-value	ξ^2	Effect	Observed Pattern/ Interpretation
Theme 2							across age groups
	Distance	31.438	2	<0.001	0.106	Medium	Highest mean perception was observed in the 300–600 m zone, with significant differences among distance groups
	Age	0.753	2	0.686	0.003	Negligible	No statistically significant differences across age groups
Theme 3	Distance	51.784	2	<0.001	0.179	Large	Highest mean perception was observed in the 300–600 m zone, while the 600–800 m zone recorded lower perceptions.
	Age	0.739	2	0.691	0.003	Negligible	No statistically significant differences across age groups
Theme 4	Distance	1.305	2	0.521	0.000	None	No meaningful differences across distance bands
	Age	0.491	2	0.782	0.001	Negligible	No statistically significant differences across age groups

Domain	Factors	H	df	p-value	ϵ^2	Effect	Observed Pattern/ Interpretation
Theme 5	Distance	37.496	2	<0.001	0.128	Medium	Higher perceptions were observed in the 300–600 m zone, with lower perceptions in the outer distance band.
	Age	0.890	2	0.641	0.003	Negligible	No statistically significant differences across age groups
Theme 6	Distance	1.518	2	0.468	0.000	None	No clear spatial pattern across distance bands
	Age	3.893	2	0.143	0.007	Negligible	No statistically significant differences across age groups

Notes:

- i. H = Kruskal-wallis test statistic
- ii. df = degrees of freedom
- iii. $p < 0.05$ = considered statistically significant
- iv. ϵ^2 = epsilon squared effect size

Source: Author's data (2025)

Overall, the findings indicate that intra-urban distance is a more influential factor than age in shaping perceived 20MN features within the 800 m catchment of Bayan Baru. While age remains an important consideration in inclusive neighbourhood planning, the statistical findings indicate that spatial accessibility and the distribution of neighbourhood functions are more strongly associated with residents' perceptions of 20MN performance than age within the study area.

DISCUSSION

The findings of this study demonstrate that the operationalisation of the 20-Minute Neighbourhood (20MN) as a uniform 800 m walking threshold requires consideration of intra-neighbourhood spatial variations. Although the 800 m radius provides a useful planning reference, the results indicate that residents do not experience neighbourhood accessibility uniformly across space. The significant differences identified across distance bands in several 20MN domains suggest that perceived neighbourhood performance is influenced by the spatial distribution of facilities, services, and environmental characteristics within the walking catchment.

The observed variations across distance bands are consistent with the concept of distance sensitivity, whereby residents' perceptions of accessibility and neighbourhood functionality may be influenced by spatial separation from local facilities and services (Handy et al., 2002; Leslie et al., 2010). Residents within the 0–300 m zone recorded higher perceptions for safe, accessible, and connected mobility, indicating that closer proximity contributes positively to perceived accessibility. However, the findings also demonstrate that the relationship between distance and perceived neighbourhood quality is not entirely linear. For example, local economy and daily needs, essential services and community destinations, and high-quality public realm recorded higher mean perceptions within the 300–600 m zone. This suggests that factors such as amenity concentration, activity intensity, and neighbourhood function may influence perceived accessibility beyond physical distance alone. The significant differences observed in local economic vitality and service-related domains further highlight the importance of spatial arrangement within the 20MN framework. While proximity remains an important consideration, the presence and distribution of neighbourhood activities influence how residents perceive the functionality and attractiveness of local environments. This aligns with Jacobs' (1961) perspective that urban vitality is shaped not only by the existence of amenities but also by their concentration, diversity, and potential to encourage everyday interaction. Therefore, planning strategies should consider balanced distribution of services and local activity nodes to support consistent neighbourhood experiences across different spatial zones. Climate-related considerations remain relevant in tropical urban environments, although the present study did not identify statistically significant differences for the climate resilience domain across distance bands or age groups. Previous research highlights that thermal conditions, shading, and environmental comfort can influence outdoor activity and walking experiences, particularly in warm climate contexts (Yin et al., 2018). Therefore, climate-responsive interventions, including shaded pedestrian routes, street trees, and green infrastructure, remain important strategies for improving outdoor comfort and supporting walkability.

In addition, built environment characteristics that encourage walking and active mobility continue to represent important considerations in neighbourhood planning (Ewing & Cervero, 2010). Although age was included as an important demographic factor in this study, the statistical results indicate that age-group differences were not significant across the six 20MN domains. While descriptive variations were observed among young adults, middle-aged adults, and older adults, these differences were relatively small and did not demonstrate a consistent pattern of disadvantage among any particular age group. This suggests that, within the Bayan Baru context, spatial characteristics and neighbourhood conditions may have a stronger influence on perceived 20MN performance than age alone.

Nevertheless, age remains an important consideration in inclusive neighbourhood planning. Previous studies have highlighted that residents at different life stages may experience and evaluate neighbourhood environments differently due to variations in mobility needs, daily activities, and environmental preferences (Loukaitou-Sideris et al., 2020). Therefore, while this study does not identify significant age-based differences, incorporating demographic diversity remains essential to ensure that 20MN planning. Overall, the findings suggest that the 20MN should not be interpreted solely as a fixed spatial radius, but rather as a dynamic neighbourhood experience influenced by distance, amenity distribution, and environmental conditions. Results highlight that spatial accessibility represents a key determinant of perceived neighbourhood performance within the 800 m catchment of Bayan Baru, while demographic characteristics should continue to inform inclusive planning approaches. This perspective supports a more context-sensitive application of the 20MN framework, particularly in dense tropical urban environments where walking experiences are influenced by physical and experiential factors.

CONCLUSION

The findings of this study offer important implications for the operationalisation of the 20MN concept within Malaysia's planning framework, particularly in relation to the PLANMalaysia planning guidelines and the aspirations outlined in the Twelfth Malaysia Plan, which emphasise liveability, inclusivity, and low-carbon urban development. The present findings demonstrate that defining the 20MN as a uniform 800 m radius may overlook experiential and demographic realities. The significant differences identified across distance bands indicate that physical proximity alone does not necessarily translate into consistent perceptions of accessibility, neighbourhood services, and overall neighbourhood quality. Therefore, the application of 20MN principles should consider intra-neighbourhood spatial variations rather than relying solely on fixed distance-based benchmarks.

The study further aligns with Malaysia's sustainable mobility and healthy city aspirations by highlighting climate comfort as a decisive factor in tropical urban contexts. Existing guidelines encourage pedestrian infrastructure and green elements; however, the results underscore the necessity of embedding microclimatic design, including shaded pedestrian routes, street trees, green infrastructure, and well-designed pedestrian facilities as core neighbourhood infrastructure rather than aesthetic enhancements. Integrating these elements into local plans and development control standards would strengthen policy implementation and ensure that walkability remains functional across age diverse population groups.

From a stakeholder perspective, local authorities, developers, and community planners can utilise these findings to refine neighbourhood design strategies. Rather than concentrating amenities at a single centre within an 800 m buffer, planners could introduce decentralised micro-nodes and evenly distributed service clusters to sustain perceived economic vitality across distance bands. The findings suggest the potential value of distributed service nodes and balanced activity locations to maintain neighbourhood functionality across different distance zones. Inclusive design considerations, such as barrier-free pedestrian facilities, safe crossings, and resting areas, should continue to be incorporated to support residents with diverse mobility needs. Community stakeholders may also leverage these insights to advocate for equitable infrastructure improvements that reflect lived realities rather than theoretical standards.

This study contributes to the growing body of 20MN research by examining perceived neighbourhood performance within a dense tropical Southeast Asian context, an area that remains less represented compared with Global North case studies. By demonstrating that perceived accessibility varies across intra-neighbourhood distances, the study extends understanding beyond conventional spatial thresholds and highlights the experiential dimension of the 20MN framework. Conceptually, the findings support viewing the 20MN not only as a fixed geographical radius but also as a dynamic socio-spatial construct shaped by perceived accessibility across different intra-neighbourhood distances within the broader neighbourhood environment.

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