Investigating utility-based walking accessibility: equity across age groups regions in Hong Kong

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1 INTRODUCTION

Central to the concept of walkable cities is walking accessibility, which measures the ease of accessing services and amenities within a reasonable walking distance (Hansen, 1959). As a community made up of pedestrians of different socio-demographic backgrounds who may have diverse behavioral preferences, it is important to distinguish their heterogeneity in walking preferences instead of treating them as one group. For instance, Liu et al. (2020) observed different route preference among various age groups: the elderly preferred wider sidewalks and lush greenery, while young adults demonstrated a greater interest in retail outlets. On the other hand, different pedestrian groups may have different places as their desired destinations. Therefore, the distribution of points of interest (POIs) can also influence walking accessibility.

POI distributions can vary greatly in different places, particularly those new towns in development, exhibit a different POI distribution compared to old urban areas. The latter has evolved over decades, resulting in a more organic, intertwined mix of residential and commercial activities. In contrast, at the beginning stage of urban development, different urban functional areas are located separately, and POIs in new towns tend to be more concentrated within a few business clusters (Huai *et al.*, 2021). The contrasting distribution patterns of POIs may contribute to the differences in walking accessibility, prompting an investigation of the walking accessibility across different pedestrian groups in old versus new development areas.

While existing research has made extensive strides in walking accessibility, few studies have explicitly incorporated pedestrians' behavioral preferences and socio-demographic characteristics, into their analysis. Building upon previous research (Liang *et al.*, 2023), this study develops a utility-based walking accessibility measure (UBWAM) that can reflect the joint impacts of the seven walking facility attributes, POI distributions (restaurant, school, shopping mall, street market, office building, healthcare center, leisure facility, and transportation), and pedestrian heterogeneous behavioral responses to them. A comparative analysis is conducted between an established old urban area (Kwun Tong) and a new development area (Kai Tak) in Hong Kong shown in Figure 1 as a study case. The comparative results provide a practical means to pinpoint areas that necessitate walking facility improvements and increases the awareness of the walking environments for different user groups in new town planning for a more walkable and equitable city.

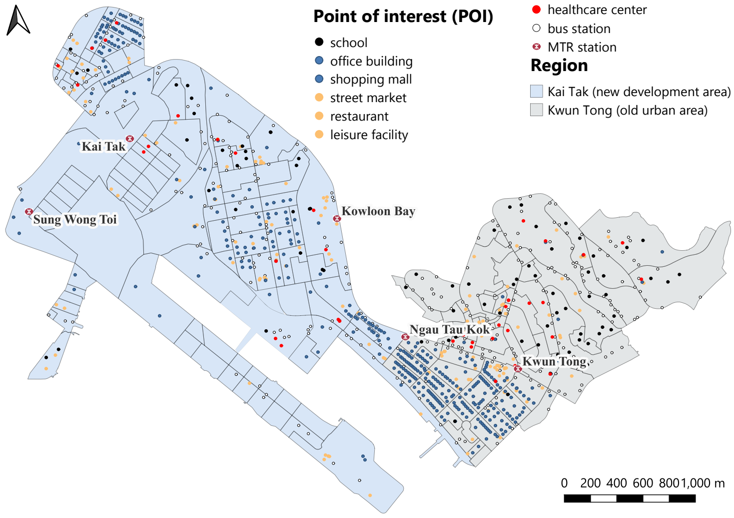

Figure 1 – *Area of study: new (Kai Tak) versus old (Kwun Tong) urban areas in Hong Kong*

2 METHODOLOGY

The workflow of the walking accessibility analysis across different pedestrian groups in new versus old urban areas is summarized in Figure 2. Stage 1 involves stated preference (SP) surveys, which obtain the sidewalk equivalent distance (SDE) of different environmental attributes and pedestrians' desired POIs as their walking destinations, and processing the raw data obtained from open-sourced geodatabase and population census of Hong Kong government. SDE can be interpreted as the equivalent normal sidewalk distance of walking on a specific attribute (e.g., staircase and slope).

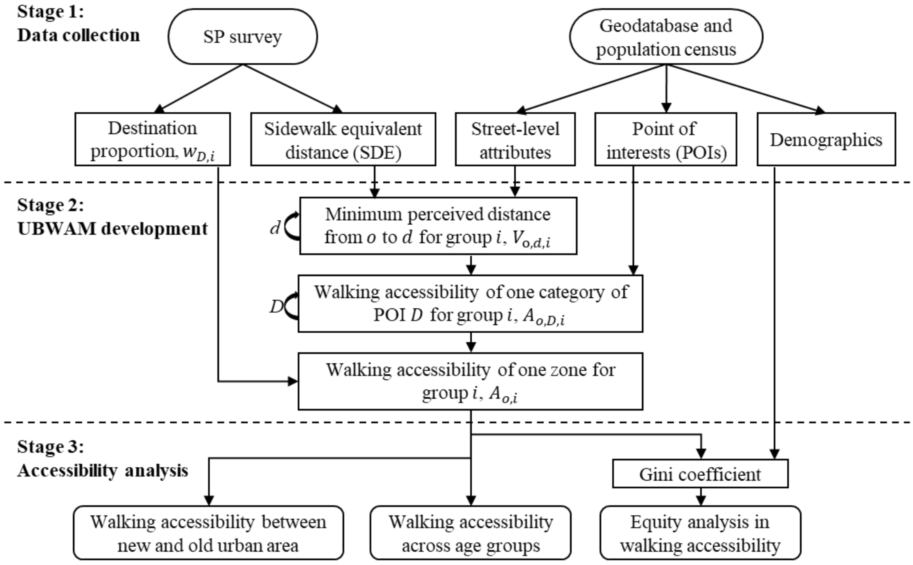

Figure 2 – *Workflow of utility-based walking accessibility analysis*

Stage 2 develops UBWAM that takes into account SDE of street-level walking facilities and pedestrians' different desired POIs based on the random utility theory. Given the perceived distance $\bar{V}_{o,d,i}$ from an origin o to one POI d as destination, the composite walking distance $A_{o,D,i}$ from that origin to one category of POIs D $(d \in D)$ for pedestrian group i takes the log-sum form as:

$$A_{o,D,i} = -\ln\left(\sum_{d\in D}\exp(-\bar{V}_{o,d,i})\right) \quad (1)$$

The utility-based walking accessibility $A_{o,i}$ for pedestrian group i in location o is the weighted sum of composite costs to all categories of POIs :

$$A_{o,i} = \sum_{D} w_{D,i} * A_{o,D,i} \tag{2}$$

where $w_{D,i}$ is the weight of desired POI category D for the group i.

Stage 3 applies the UBWAM to analyze the walking accessibility of three age groups in the new development area (Kai Tak) and old urban area (Kwun Tong) in Hong Kong. Equity analyses are also conducted to evaluate inequities in walking accessibility.

3 RESULTS AND DISCUSSIONS

3.1 Walking accessibility performance

The descriptive statistics of the walking accessibilities grouped by age and are shown in Table 1. Measured in meters, a smaller value of UBWAM represents a higher level of walking accessibility. With a smaller mean and standard deviation of UBWAM, the old urban area is found to be more walkable and equitable for pedestrians than the new development area. This can be attributed to the different distribution of POIs and the provision of pedestrian facilities. In the old urban area, the land use is mixed with diverse categories of POIs located in a compact network. Pedestrian infrastructure is well-established, providing safe and convenient pedestrian pathways. Therefore, pedestrians can reach various categories of POIs as their frequent destinations within a reasonable distance. However, the POIs in the new development area are concentrated in a few business clusters, which are far away from residential zones, especially those in the southwestern part of Kai Tak, as shown in Figure 1. Besides, insufficient pedestrian facilities, i.e., relatively low sidewalk density, poses inconvenience to pedestrians. These increase the expected walking distance for residents there to reach their destinations, resulting in a worse walking accessibility performance.

Table 1 – *UBWAM by age group of the study area (in meters)*

	Old urban area			**New development area**		
	Young	**Middle-aged**	**Elderly**	**Young**	**Middle-aged**	**Elderly**
Min.	69.1	111.1	170.5	33.3	53.6	120.5
Max.	1766.2	1918.0	2145.2	1744.6	1874.8	2197.6
Mean	317.6	338.3	399.6	593.8	652.7	830.2
Std.	284.9	296.6	287.9	429.2	456.9	521.6
Sample Mean		346.4			676.4	
Sample Std.		198.4			309.8	

3.2 Equity analysis: age groups and regions

Figure 3 shows the histograms of walking accessibility weighted by the population in the old urban area and new development area grouped by age. Each interval is 375m, representing a 5-minute walking distance (Papadopoulos *et al.*, 2023). The histograms indicate that only a small proportion of the population lives in zones with the highest level of accessibility. Approximately 28% of the population in the old urban area can reach their desired destinations within a 5-minute walk, while such number in the new development area is even lower, around 22%. It also shows that around 90% of the population can finish their walking trips within 15 minutes in the old urban area, while 15% of people in the new development area cannot reach their destinations within 15 minutes. Consistent with the results in Table 3, the finding suggests that the old urban area is more walkable and equitable compared to the new development area.

Gini coefficients are calculated to quantify the inequality of walking accessibility. The new development area exhibits higher Gini coefficients (0.34, 0.32, 0.29 for young, middle-ages, elderly) than the old urban area (0.30, 0.29, 0.27 for young, middle-ages, elderly), meaning that it has a relatively higher level of inequity in walking accessibility. This can be explained from the urban development perspective.

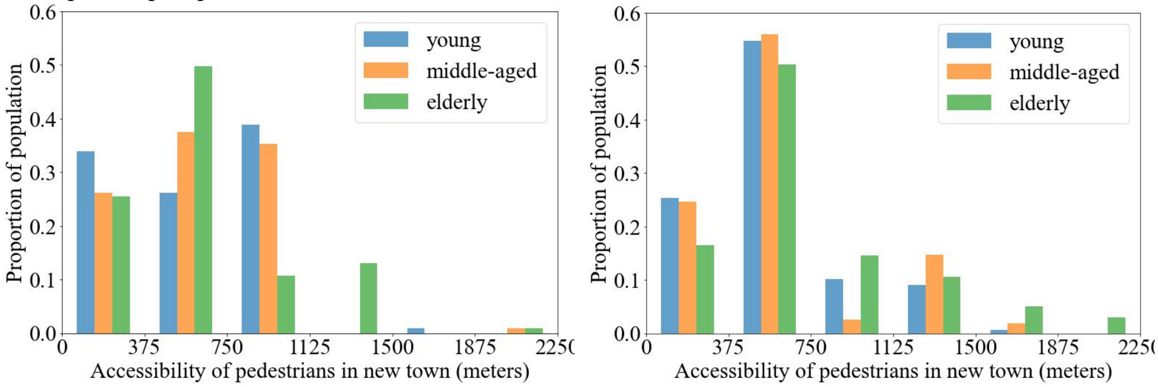

Figure 3 – *Histogram of UBWA with population old (left) and new urban areas*

The old urban area has been evolving over time, with diverse POIs and pedestrian infrastructures gradually expanding to accommodate the needs of the growing population in different age groups. Consequently, the accessibility differences among zones in the old urban area tend to be smaller. In contrast, the new development area is at the beginning stage of urban development, and POIs (e.g., shopping malls and offices) tend to be more concentrated in a few business clusters to accommodate various residents' needs with one-stop services. As a result, only a few people living near these clusters have good accessibility, while most people living far away have poor accessibility. Additionally, insufficient pedestrian facilities in the new development area have resulted in an inconvenient walking experience.

4 CONCLUSION

This study quantified and compared the characteristics and equity of walking accessibility in the old urban area versus the new development area across different age groups based on the proposed utility-based walking accessibility measure, which considered the utilities of street-level facility attributes and the distribution of points of interest. The results highlighted the importance of assessing the distribution of different types of POIs and implementing strategies to promote a mixed POI distribution that caters the diverse needs of different age groups in new development areas. Findings also suggested that it is imperative to undertake proactive measures to enhance pedestrian infrastructure in the new development area, so as to develop a walkable and equitable community for different citizens.

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