コミュニティライフサークルの概念に基づく高齢化コミュニティ内外の利便性評価：上海市曹楊新村を事例として

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コミュニティライフサークルの概念に基づく高齢化コミュニティ内外の利便性評価：上海市曹楊新村を事例として

Evaluation of Convenience within and outside Aging Communities Based on the Concept of Community Life Circle: A Case Study of Caoyang New Village, Shanghai

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Facing the aging society in China, it has become difficult for large-scale residential communities constructed decades ago to meet the needs of the shrinking size of population and aged residents. Based on the theory of the "community life circle," this study takes up Caoyang New Village, Shanghai to quantify the Convenience of residents' life using Geographic Information Systems (GIS). By building a measurement framework to compare the 15-minute actual reachable area for elderly residents with the traditional method of defining life circles based on administrative boundaries, this study concludes that facilities including categories of health, elderly care as well as retail & shopping outside boundaries also play a significant compensatory role in the Convenience of elderly residents.

Keywords: Measurement of Convenience, 15-minute walking distance, Community life circle, Aging community 利便性の測定、徒歩 15 分距離、コミュニティライフサークル、高齢化コミュニティ

1. Introduction

According to the results of China's 7th National Census in 2021, the proportion of the population aged 65 and over is over 13.5%. Among them, as of December 31, 2022, the proportion of elderly aged 65 and over in Shanghai accounted for 28.2% of the total population (Shanghai Municipal Committee on Aging Office et al., 2023). The needs of older people for the environment and facilities are more pronounced and diversified. With the change in lifetime structure, the elderly pay more attention to the quality of life in their spare time. However, the current number of community facilities cannot meet the diversified needs of the elderly at different levels (Wu & Xu, 2021).

The old community shows complex reorganization behavior in a public environment, road relationship, street space, and building form because of many historical factors such as construction age, time change, policy change, demand growth, management, and maintenance. It is still difficult at the operational level to change the spatial pattern of streets and alleys, install more community support services, and protect and continue the historical background of old communities (Wu et al., 2021; Zhang et al., 2022).

2. Literature review

2.1 The conceptual origin and theoretical changes of Community Life Circle (CLC)

The concept of "Life Circle" can be explained as the spatial range or sphere of activities formed by residents with their homes as the center, including various activities such as shopping, leisure, commuting (to school or work), social interactions, and medical care. It originated from the "life circle composition" based on the central place theory proposed by Hideaki Ishikawa in 1941 (Sano, 2021). Then applied to the

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"Rural Living Environment Improvement Plan" in Japan in 1971 and applied to Japan's "Third Comprehensive National Development Plan" released in 1977 to address various issues stemming from urbanization (Kitamura, 1971; National Land Agency Planning & Coordination Bureau,1978; Sano, 2021). Subsequently, research on this gradually spread to South Korea and Taiwan and was introduced to mainland China by Chai Yanwei (Xiao et al., 2014).

"Life circle" often undergoes conceptual derivation in different dimensions due to its prominent ideas and content. Commonly involved dimensions include population, spatial, functional, and temporal dimensions (Xiao et al., 2014; Zuo et al., 2021; Wu et al., 2021). The temporal dimension of community planning, replacing the population dimension emphasized by modernist planning, e.g. Clarence Perry's concept of "neighborhood units" proposed in 1929 and the residential area construction in socialist countries after WWII, and the spatial dimension emphasized by New Urbanism, which focused on walkable spatial scale accessible to individuals, has become a new hotspot for the development and construction of smart cities (Perry, 1929; Wu et al., 2021).

Various community planning cases emphasizing time threshold have emerged throughout the world. These include the “15-minute city” in Paris, France, proposed by urban planners, the “20-minute city” concept put forward by scholars in the United States, and the application of “20-minute neighborhoods” in both the United States and Australia (Moreno et al., 2021; Capasso Da Silva, King, & Lemar, 2019; McNeil, 2011; Stanley & Davis, 2015). Furthermore, Singapore has introduced the concept of “20-Minute Towns” and a “45-Minute City” (Manifesty & Park, 2022).

While some of the cases and concepts proposed mentioned above extend beyond the scope of communities - including the concept of using alternative transportation modes to reach destinations within minutes - these initiatives underscore the increasing emphasis on the time threshold in current community planning, becoming a new focal point in community planning. This study focuses on walking, neglecting all the other forms of active mobility. Walking is chosen because it is the most inclusive way to travel, and it does not require any means of transport (Olivari et al., 2023).

2.2 Application and development of CLC in China

As China entered the mid-to-late stage of urbanization, urban planning gradually shifted from rapid growth to high-quality development (Cheng et al., 2023). With the construction of modern rapid transportation system and the development of communication technology, the sprawl of China’s urban space has increasingly complicated the internal relations of cities under the current administrative system. The negative effects continue to appear, and the extensive utilization of resources leads to problems including unsustainable and unbalanced development between regions (Hou & Liu, 2017).

In 2016, Shanghai took the lead in proposing "15-minute community life circle" (15-minute CLC) as the basic unit of community life (Shanghai Urban Planning and Land Resources Administration, 2016). Phased results have been achieved. Ma et al. (2023) conducted a longitudinal quantitative comparison of CLC facility services in Shanghai for the years 2011, 2016, and 2021, and found significant improvements in average facility coverage, diversity, and accessibility. Wu et al. (2021) selected Tianlin and Quyang subdistrict, the first batch of 15-minute CLC pilot subdistricts in Shanghai, for evaluation and analysis using measurement models. The results of their transformation are approaching the vision of planning guidelines.

In 2018, China released the "Urban Residential Area Planning and Design Standards (GB50180—2018)," which suggested that residential areas should meet residents' daily basic needs within a reasonable walking distance (Ministry of Housing and Urban-Rural Development of China, 2018). This further subdivided the CLC into 5-minute, 10-minute, and 15-minute thresholds, defining them as terms. Up to 2024, CLC planning has been widely practiced nationwide. Many cities, represented by Beijing, Wuhan, Jinan, Hangzhou, and Chengdu, have proposed their respective goals based on local conditions and successively put forward specific planning guidelines (Wu & Xu, 2021; Luo et al., 2022). These findings demonstrate that the CLC concept is suitable for the development of Chinese cities and is gradually being applied to future housing construction, renovation, and urban renewal projects in China.

2.3 Definition and quantitative measurement of Convenience in CLC

The measurement of convenience mainly focuses on how to quantify residents' subjective experience of service facilities. Convenience represents a further refinement of the concept of CLC. The essence of living convenience lies in the alignment of urban facilities and other contents with urban spaces used by residents in their daily lives (Wu & Xu, 2021). A time threshold CLC can reflect more effectively residents' actual living space than residential neighborhoods ("Xiaoqu" in Chinese) (Cao & Tang, 2022).

At the macro level, Zheng et al. (2015) collected data on population, transportation, and other factors to construct a "Jobs-housing balance index" for exploring the job-housing

distribution and commuting characteristics of key functional areas in Beijing. They investigated the matching between the supporting facilities in these areas and the job-housing relationship. Zhou et al. (2022) employed two partitioning methods: administrative boundaries and grid units divided by 1/2/3 km rules. Based on mobile phone, population, and housing price data, they respectively calculated the average commuting distance, job-housing balance, and socio-demographic attributes for each spatial unit. Burke et al. (2022) developed a framework to describe a range of urban morphological types, integrating street networks, building forms, and other metrics related to geographic scale, entropy, and density. This framework was used to evaluate the urban performance of each city typology and its ability to meet the standards established by the 15-minute city.

With the rapid development of internet technology, particularly the emergence of big data, some research has begun to focus on the meso-level, employing subjective and objective analyses to construct multi-angle, multi-dimensional evaluation systems. These studies pay attention to how people utilize public facilities within the community, enriching the comprehensiveness of research frameworks and content at this spatial scale (Qin & Zhen, 2017). For instance, research on the balance between subjective demands generated in residential areas at different spatial scales and the objective supply of urban services (Taleai et al., 2014).

At the micro-level, some studies have established effective and reliable tools to measure the perceived quality of life at the true community scale. Olivari et al. (2023) proposed the NEXI indicator, which assesses local proximity at a small scale, to measure whether local services have reached the standard of a 15-minute walk. Murgante et al. (2024) developed a set of indicators derived from configuration analysis, focusing on dimensions of density, proximity, and diversity, to evaluate the level of implementation of the 15-minute city concept standards in Terni and Matera, Italy. Zhang et al. (2019) proposed a segmentation method capable of generating multiscale units that adapt to different cognitive scales of individuals, enabling the depiction of communities at multiple scales. This method is utilized to reveal the spatial heterogeneity of living convenience and come out with three scales most suitable for individuals' perception of living convenience.

2.4 Ambiguity in Boundary Delineation for CLC

Presently, in China, urban roads are commonly used as boundaries for defining CLC. The primary purpose is to simplify the demarcation of these circles' boundaries, aligning them with the urban grassroots management units that also use urban roads as boundaries. This approach facilitates the clarification of responsibilities for CLC construction and management and naturally reflects the top-down, government-led model of CLC development (Ma et al., 2023). In Jinan, a tier-2 city, the jurisdiction of one subdistrict’s office (Jiedaoban in Chinese) corresponds to one or two 15-minute CLC. Chinese) corresponds to one or two 15-minute life circle. This correspondence is based on matching area and population indicators, with the convenience of administrative management being the primary consideration for delineating CLC boundaries (Ministry of Housing and Urban-Rural Development of China, 2018; Wu & Divigalpitiya, 2023).

However, communities as the analysis unit for measuring Convenience, but the spatial boundaries of communities are hard to define (Zhang et al., 2019). Research on public open spaces in downtown Shanghai by Du and Jin (2018) indicated the existence of many stable CLCs that span multiple streets. Imposing urban roads as boundaries for CLCs may result in a decrease in service levels and hinder an accurate assessment of their operational dynamics. Hou & Liu (2017) indicated that due to the improvement of citizens' economic capacity and their strong desire for higher quality of life, citizens' behavior is no longer constrained by administrative boundaries, resulting in widespread cross-regional behaviors. Flowerdew et al. (2008) suggested that the definition of neighborhoods is often determined by practical considerations since there is little reason to expect neighborhoods to follow ward boundaries. Yang & Zhu (2023) suggested that significant disparities between administrative boundaries and residents' actual activity areas can lead to mismatches in public service facility distribution. They selected Hongkou District in Shanghai as the study area and established a 1000-meter buffer zone outside the district boundary also for the study. By constructing a supply-demand correlation network to delineate community life circles, the results showed significant disparities between the supply-demand correlation network clusters and street units. It was found that residents commonly cross boundaries to use facilities in other life circles.

Moreover, if the alignment with administrative units is overemphasized in the process of delineating boundaries, it may contradict the core concept of CLC. The essence lies in understanding urban space from the perspective of people's actual daily behavioral activities, a concept inherently advocating for the weakening of administrative boundaries (Liao et al., 2018).

2.5 Research gap and hypothesis

Through analyzing the origin, development, and

application of CLC, this study has identified issues regarding the delineation of CLC scopes and its quality evaluation. Wu et al. (2021) pointed out that for central urban areas, breaking existing community boundaries, integrating adjacent communities, and supplementing the construction of community pedestrian networks can enhance the demanding match for 15-minute CLC. Combining previous research findings with the gap between theory and practical application, this study attempts to establish a quantitative framework to measure Convenience. It aims to measure each residential building within the study area twice: once based on administrative boundaries and once based on the actual 15-minute walking reachable range. This is to investigate whether breaking existing administrative boundaries can significantly improve residents' Convenience. In addition, Ma et al. (2023) indicated that improvements in elderly care facilities in Shanghai over the past decade have been minimal compared to other types of facilities, suggesting a need to prioritize the configuration of elderly care facilities to address the increasingly aging population. This study focuses on the demographic characteristics of people aged 60 and above, who perceive walking time thresholds most significantly and rely heavily on certain specialized facilities. It also addresses the research gap regarding the consideration of specific age characteristics in applying the 15-minute CLC concept in high-density cities (Boakye-Dankwa et al., 2019).

3. Materials and methods

3.1 Study area and data description

Caoyang New Village (hereinafter this refers to as "Caoyang") is a subdistrict situated in Putuo District of Shanghai, China (Figure 1). In the administrative hierarchy of China, "Subdistrict" corresponds to one of the smaller administrative divisions known as "Jiedao" in Chinese. As the first worker's village established in PRC, Caoyang was meticulously designed to foster vibrant neighborhoods and cohesive residential areas. This vision included allocating a minimum of 10% of community land for public open spaces or parks. It was planned with a "curved, narrow, and dense" small-scale road network system, enabling residents to access various public amenities within a 10-minute walk. This thoughtful urban design laid the groundwork for establishing a new "15-minute CLC".

Caoyang is also characterized by its aging population, with 43% of residents aged 60 and above. Recognizing the importance of addressing the needs of its elderly population, Caoyang prioritizes the preservation and enhancement of elderly care services and facilities. It emphasizes promoting "age-appropriate rehabilitation" as a critical objective for community renewal, making it an ideal subject for research in this area.

The data in this study was meticulously gathered from various reliable sources. It mainly included communities, road networks, buildings, and points of interest (POIs) in Caoyang and the surrounding urban spaces in Shanghai. These sources include Amap Open Platform, one of the largest map service providers in China, and OpenStreetMap, a collaborative mapping project.

1) POIs data: This data, collected in 2022, was sourced from Amap Open Platform, one of the largest map service providers in China. The selection of POIs was guided by the activity and needs of elderly residents, resulting in six main categories with 17 sub-item facilities. A total of 1,833 POIs were imported and screened.

   Selection Rationale: The chosen POIs reflect essential services and amenities critical to the daily lives of elderly residents, aligning with their unique needs for healthcare, physical activity, social interaction, and accessibility. Specifically:

   - Health: Encompasses facilities such as community

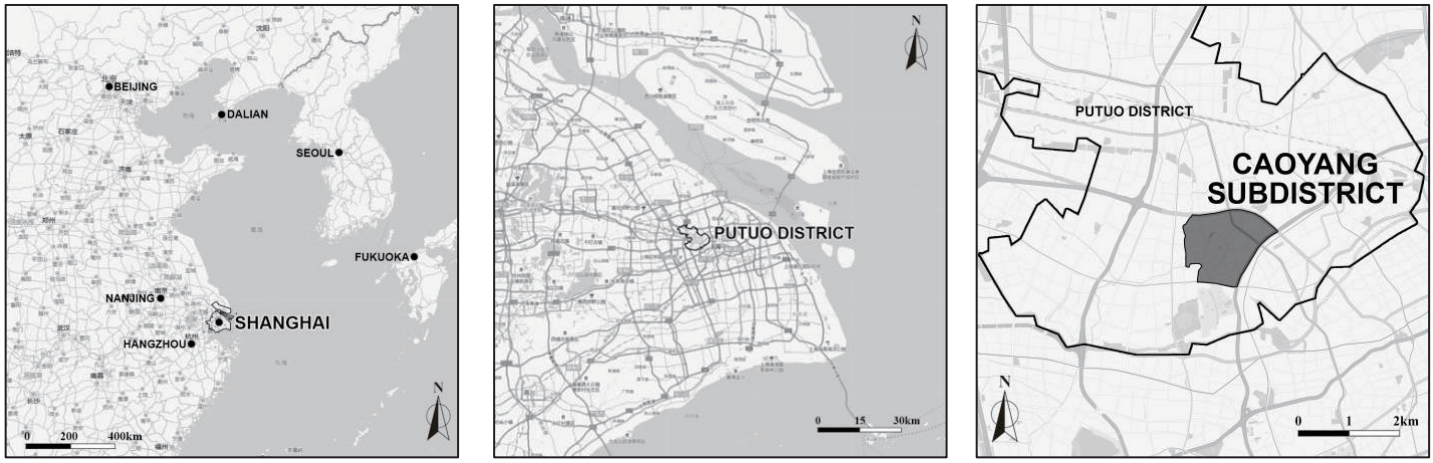

Figure 1 Location of Caoyang Subdistrict

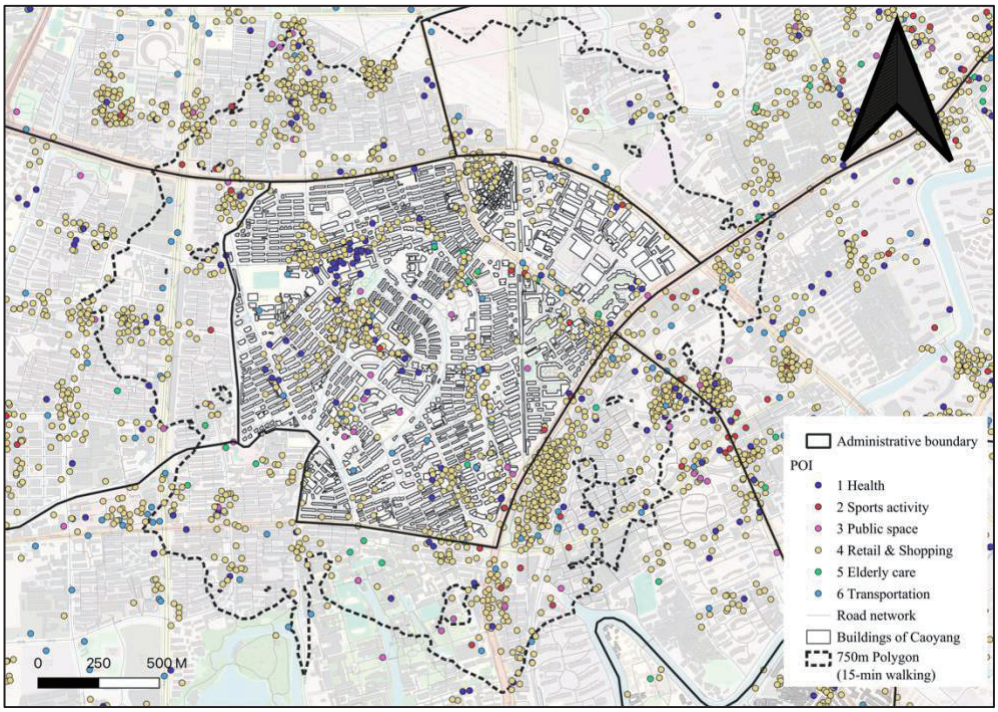

Figure 2 Distribution of POIs within and around Caoyang

medical centers, general and specialized hospitals, and pharmacies, addressing the essential healthcare needs of the elderly.

- Sports Activity: Includes gyms and fitness centers, promoting physical health and well-being.
- Public Space: Comprises attractions, leisure areas, squares, and parks, providing venues for recreation and social interaction.
- Retail & Shopping: Covers large shopping centers, fresh markets, small retail shops, and dining options, which are crucial for daily shopping and dietary needs.
- Elderly Care: Encompasses senior apartments and elderly education centers, crucial for residential care and lifelong learning.
- Transportation: Includes bus stops and subway stations, facilitating mobility and access to urban amenities.

These POI categories were selected to comprehensively capture the everyday activities and necessities that influence the quality of life for elderly residents in Caoyang. Figure 2 illustrates the distribution of POIs within and around Caoyang. The specific classification can be found in Table 1, providing a clear overview of the data used in this study.

2) Building data: This data, also sourced from Amap Open Platform, consists of vector polygon data collected in 2020. Given the transformations resulting from recent years' renovation of old community areas, some obsolete urban villages have collectively relocated. Consequently, the building data has been modified, with partial deletions and additions made in accordance with the actual conditions in 2022.

3) Road data: The road data was downloaded from

Table 1 Classification of facility

Facility Category	Facility Sub-item
1.Health	1.1. Community medical center
	1.2. General hospital
	1.3. Pharmacy
	1.4. Specialized hospital
2.Sports activity	2.1. Gymnasium
	2.2. Fitness center
3.Public space	3.1. Attraction
	3.2. Leisure
	3.3. Square & Park
4.Retail & Shopping	4.1. Large shopping center
	4.2. Fresh market
	4.3. Small retail shop
	4.4. Dining
5.Elderly care	5.1. Apartment for seniors
	5.2. Elderly education
6.Transportation	6.1. Bus stop
	6.2. Subway station

OpenStreetMap (https://www.openstreetmap.org/). In QGIS, research was conducted to eliminate expressways, elevated roads, tunnels, and other roads unsuitable for pedestrian traffic within the study area. Based on field investigations, pedestrian crossing passages were delineated (Srour et al., 2023). Additionally, certain internal roads within residential areas were supplemented to address discrepancies and deficiencies in the map data, and topology errors were corrected.

3.2 Conceptual framework: build a quantitative measurement framework for Convenience

Building upon the framework proposed by Zhong et al. (2020), we have crafted a unique set of proposals for a measurement framework specifically tailored to the context and background of this study. Focusing on the micro-level context of individual residential buildings, we introduce a novel combination of three key indicators to gauge the Convenience of living. Figure 3 illustrates the overall analytical framework.

1) The number of POIs within daily reachable areas, representing the density indicator
2) The richness of POI categories within reachable areas, representing the diversity indicator.
3) The accessibility to the nearest transportation facilities, which describes the ease of reaching them. Accessibility is widely considered as an important dimension of quality of life (Silva et al., 2023).

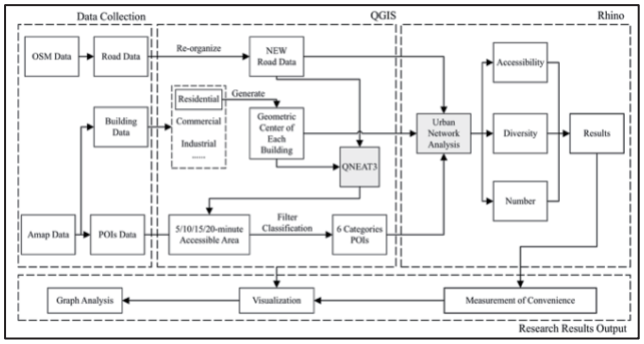

Figure 3 Overall analytical framework

The process of calculating one building involves the following steps. We extract each building classified as "Residential" from building data. Typically, a residential building has multiple entrances ("Danyuan" in Chinese). Due to the difficulty in obtaining data for each entrance, we treat each building physically, structurally, and spatially distinct from other buildings as a research unit. The geometric center of each building is then generated as the starting point for origin-destination (OD) cost matrix surveys. From each geometric center, a perpendicular line (or a line connecting to the nearest road end) is extended to the nearest road. This calculation is based on the previously sorted out road network, including the internal road of "Xiaoqu." This line represents the shortest path between the road and the research unit, symbolizing the Cost before entering the road network.

A benchmark of 750 meters in 15 minutes is set, corresponding to an average walking speed of 50 meters per minute for elderly individuals. A polygon representing a 15-minute walkable area applicable to all residents in Caoyang is generated by inputting all geometric centers as starting points into QGIS 3.32 plugin QGIS Network Analysis Toolbox 3 (QNEAT3) based on this benchmark (see Section 4). This polygon represents the actual reachable area within 15 minutes by foot while disregarding administrative boundaries. All POIs within this polygon are considered the subjects of this study.

It is evident that the scope of this polygon substantially exceeds the administrative boundary of Caoyang. Therefore, building upon the existing classification, two additional categories of POIs are introduced: "Within boundary" (Group 1) and "Outside boundary but within a 15-minute area" (Group 2). Urban Network Analysis plugin in Rhino 6.0 is utilized to calculate the number of facilities (N_i), diversity of facilities (H_i), and accessibility (A_i) for both "Group 1" and "Group 1& Group 2". Based on these calculations, two values for Convenience (C_i) are calculated.

The detailed calculation comprises three steps:

Firstly, we define N_i as the total number of facilities reachable by a single building within a daily accessible area.

Secondly, the diversity of facilities (H_i) is calculated using the Shannon-Wiener index, which has already been widely applied in built environment analysis. The formula is defined as:

$$H_i = -\sum_{i=1}^{n} P_i \ln P_i$$

where H_i indicates the diversity of building i, n is the number of facility categories of building i, and P_i indicates the proportion of the number of facilities in each facility category to the total number of facilities within the range of building i.

The third step involves assessing accessibility (A_i), which represents a crucial means for residents to connect with city space via public transportation. Transport stations also constitute vital components of any level of life circle construction. The formula is defined as:

$$A_i = N_b \times W_b \times D(d_b) + N_s \times W_s \times D(d_s)$$

where N_b, Ns indicates the number of bus/subway stations within the 15-minute walking distance range from the building, W_b, W_s indicates the weight assigned to each bus/subway station, representing its importance or influence on accessibility, d_b, d_s indicates the distance from building i to the nearest bus/subway station, D indicates a cognitive decay applied to the distance from the building to the nearest bus/subway station, reflecting the diminishing impact of distance on accessibility.

We use Gaussian distribution to describe the cognitive decay of distance. It is assumed that there is no decay when the distance is less than the expected value of this dataset; hence, the value remains constant at 1. The calculation formula is expressed as:

$$D(d)=\begin{cases} 1 & if\ d \le \mu \\ e^{-\frac{(d-\mu)^2}{2\sigma^2}} & if\ \mu < d \le 750 \end{cases}$$

where d indicates the distance from building i to the nearest bus/metro station, μ indicates the expected value (mean) of this dataset, σ indicates the standard deviation of this dataset, and e represents the base of the natural logarithm. The function's graph is depicted in Figure 4.

After completing the three steps, the formula for Convenience can be derived as follows:

$$C_i = N_i \times H_i \times A_i$$

Each building is analyzed separately, and the results are calculated twice: once including only Group 1 POIs and once including both Group 1 and Group 2 POIs. The same analysis steps are carried out for each building within Caoyang until all buildings have been analyzed.

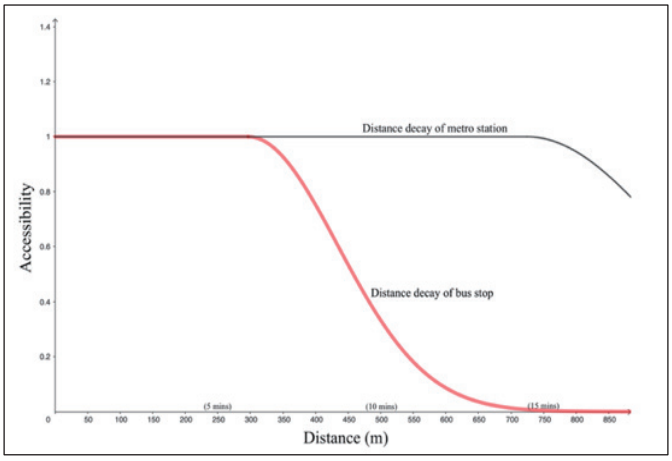

Figure 4 Distance decay of bus stop and metro station

4. Results

In general, the level of Convenience in Caoyang, as calculated based on the actual walking reachable distance (Figure 5, left), exhibits a relatively high average level, demonstrating characteristics of multi-core distribution with higher values in the east and south and lower values in the west and north. Among them, Caoyang Village 1, the earliest constructed and centrally located, as well as residential areas situated on the eastern and southern edges, show the highest values.

Areas with lower values are characterized by 1) being surrounded by or located at the end of minor roads, 2) residential cluster areas are large in size, 3) residential cluster areas have only one or a few entrances, 4) next to natural barriers such as rivers or artificial barriers like large, enclosed areas (e.g. hospitals, schools, industrial buildings etc.), and 5) proximity to main roads but lacking pedestrian crossings alongside.

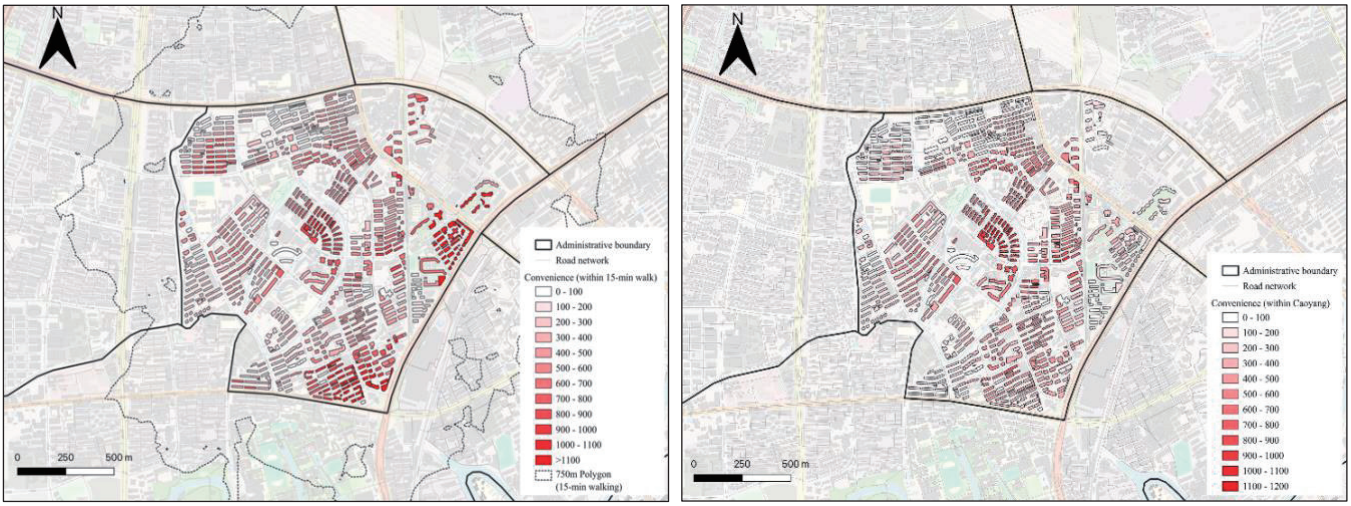

Figure 5 Convenience evaluation of Caoyang New Village as of 15-minute walking distance (left) and as of administrative boundary (right)

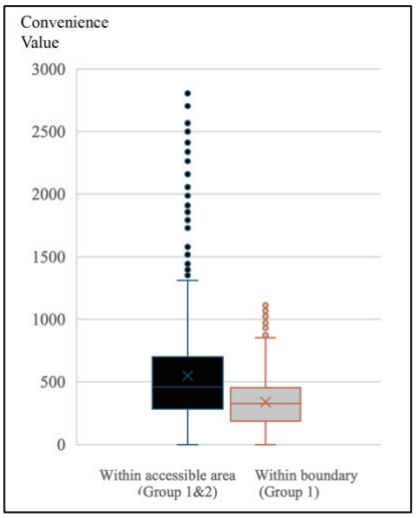

Figure 6 Convenience boxplot in Group 1&2 and Group 1

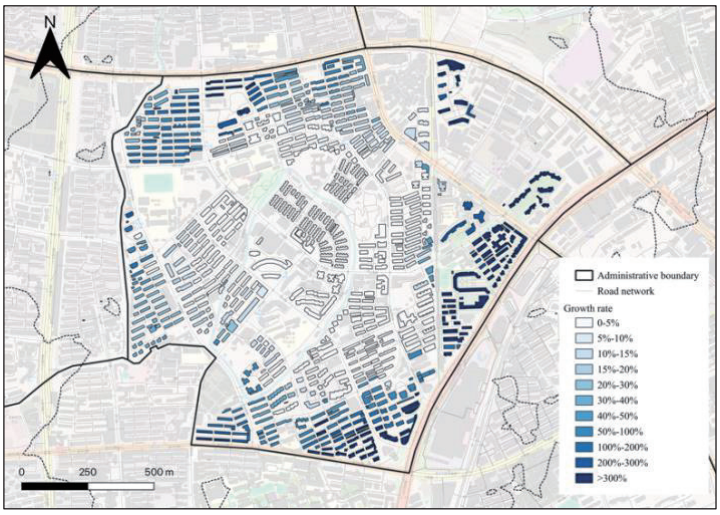

Figure 7 Growth Rate of Convenience of Caoyang New Village

On the other hand, when considering the administrative boundary for calculating living convenience (Figure 5, right), the results show that only a few buildings have higher value, approximately 70% of buildings have values close to the average, while the remaining buildings exhibit lower levels of living convenience, indicating inconvenience in accessing Caoyang community facilities. The overall distribution is higher towards the central area and lower towards the periphery, which is an evident outcome since all POIs outside the boundaries are not considered.

Comparing the results of calculations previously, it is evident that many external POIs outside the administrative boundaries, still contribute significantly to the Convenience of residential buildings within the boundaries. The size of the compensatory effect can be visually observed in the box plot of Figure 6. The median of the "Within accessible area" dataset exceeds the upper quartile of the "Within boundary" dataset, and the lower quartile of the former is also nearly equivalent to the median of the latter. The former exhibits more outliers, with the most extreme outlier reaching 2800, close to 2.5 times the maximum outlier of the latter.

The growth rate of Group 1&2 compared with Group 1 can be calculated according to the two set of data showed in Figure 5. The distribution graph of growth rates in Figure 7 provides a clearer indication of which buildings receive the most significant compensatory effects. Buildings located closer to the administrative boundaries evidently exhibit higher growth rates, while those in the central area receive minimal compensatory influence from outside the community. However, some buildings near the boundaries do not experience substantial growth, as their values in both calculations of Convenience are not notably high.

5. Discussion

5.1 Spatial distribution characteristics of Convenience

Our analysis in the results section reveals a significant finding: the convenience level in Caoyang is not uniform, but rather exhibits a multi-core distribution pattern. This means that some areas demonstrate relatively high levels of Convenience, while others have lower values in both calculations. This complex distribution pattern is a key aspect we will delve into, as it has profound implications for community planning and residents' lives.

As Figure 5 demonstrates that areas with higher convenience levels generally possess the following significant features:

1) Close to community center: One factor contributing to high convenience levels in Caoyang is the proximity to convenience facilities. This is particularly evident in residential areas positioned centrally, a design influenced by early neighborhood planning theories. These areas are surrounded by various service facilities positioned as community centers, creating a high convenience level where residents can easily access various services and amenities.
2) Close to main roads/transportation nodes: Areas with higher values, such as the northwest area and southeast corners, are attributed to the dense coverage of transportation nodes in Caoyang. While subway stations are located mainly at the edges of the community, the high values in these areas are related to their proximity to subway stations. The higher foot traffic on roads near these residential areas makes them more attractive for facility placement.
3) Close to urban complex: Residential areas along the eastern boundary, for instance, benefit from high-density facilities in mature urban regions. Adjacent to the east

boundary, a large-scale commercial complex covers an area of 480,000 square meters. It significantly enhances the index in quantity and diversity, elevating the overall Convenience level.

Figure 7 illustrates the compensatory effect of facilities outside administrative boundaries. Higher growth rates in these areas indicate significant contributions to the Convenience experienced by residents within Caoyang. The graph presents a clear "doughnut" structure, with low growth rates in the middle and high growth rates at the periphery. The growth rates at the northern, eastern, and southern edges are above 100%, indicating that elderly residents may have less than half the opportunity to use facilities within the administrative units in their daily lives. Due to the early development of Caoyang, the city's framework in recent decades has not affected its integrity, with no major roads crossing the community. Instead, main roads and a river form the administrative boundaries of Caoyang.

Consequently, facilities tend to be concentrated along main roads, resulting in significant compensatory effects on Convenience for residents near the boundaries. Main roads may also bring some problems. For example, the growth rate at both ends along the east edge is higher than that near the midpoint. The reason may be that there is no suitable street passage since the east edge is an elevated road. It is necessary to detour to find the intersection when using the facilities across the road. More feasible improvement solutions include digging down pedestrian passages. The growth rate along the western boundary—formed by a natural river—is only about 50%, possibly due to the natural barrier formed by the river and the "Xiaoqu" entrances facing inward, resulting in discrepancies between the straight-line distance to external facilities and the actual walking paths and time required.

5.2 Quantifying Convenience and overcoming administrative boundaries in urban renewal of aging Chinese communities

The current redevelopment of aging communities in China faces extremely complex built environment elements and resident demands, requiring rigorous consideration and people-oriented control strategies in practical implementation.

A significant innovative aspect of this study is adopting a measurement method based on actual walking areas to assess Convenience of every single residential building in Caoyang. Using geographic information data, including POIs, road networks, and buildings, we calculated indicators, including quantity, diversity, and accessibility of public transportation nodes. This approach effectively quantifies the community livability of each residential building, providing a more direct reflection of the travel needs and lifestyle habits of elderly residents. It promotes the scientific selection and final decision-making of redevelopment strategies, aligning with the viewpoint mentioned by Zhong et al. (2020).

Contemporary planning strategies often focus on specific administrative units as the target for redevelopment, completely disregarding any content beyond the designated scope (Shanghai Urban Planning and Land Resources Administration, 2016). While the measurement based on administrative boundaries is easy to implement and manage, its limitations are apparent. It overlooks essential facilities and resources outside administrative boundaries, potentially leading to errors in residents' living experiences. However, the actual urban space is continuous and closely interconnected, with resident behavioral networks often smaller in scale and more loosely structured than spatial networks (Cao & Tang, 2022). People choose facilities based on their preferences for spatial functions, facility scale, and personal interests rather than administrative factors. Therefore, in urban planning and community redevelopment decision-making, shifting the focus to larger urban spaces and emphasizing the advantages of measurement methods based on walking reachable areas help identify practical intervention directions to improve Convenience in daily life.

Additionally, certain types of facilities such as hospitals, elderly care, and community services are indeed constrained by administrative boundaries due to factors such as household registration systems and medical insurance reimbursement policies. To address these limitations, this study proposes enhancing inter-administrative cooperation and improving cross-boundary public transportation links. By breaking down these administrative barriers, more residents can conveniently access these facilities, rather than adhering to rigid institutional constraints or engaging in redundant construction. Such approaches could offer innovative perspectives and practical solutions for integrating surrounding urban areas into the community’s functional landscape, facilitating more effective urban renewal.

5.3 Future Directions

The proposed framework for measuring Convenience in this study is still preliminary and requires refinement and further validation. Firstly, there is still room for further exploration regarding the three indicators. The quantity of facilities will decay under certain diversity conditions, which is different from the decay of distance (Zhong et al., 2020).

Accessibility can also incorporate more factors, such as the slope of bridges spanning rivers, walking speeds on different roads, and the potential influence of path choices brought about by street views and the design of public spaces. According to 2SFCA, which was used by Tao et al. (2023), factors such as business hours and service capacity can also be attached to consider facilities' supply and demand sides. Secondly, further argumentation is needed on whether 15 minutes is the most suitable threshold for CLCs or even for elderly life circles, considering that previous literature (Moreno et al., 2021; Capasso Da Silva et al., 2019; McNeil, 2011; Stanley & Davis, 2015; Manifesty & Park, 2022) has mentioned thresholds ranging from 5 to 45 minutes. In addition, consideration should be given to whether similar measurements apply to other age groups, how to balance facility selection, the weighting of facility use, and walking speed, among other issues that will be future research directions.

6. Conclusion

Our study contributes to addressing the rapid aging of the population and community transformation by providing more reliable and efficient methods to assist urban planners and decision-makers in assessing the residents' livability. We expand the application of the concept of "Convenience" by establishing a system to evaluate the convenience of each residential building at the micro-level. This enables us to identify areas with living difficulties and facility access challenges more intuitively and effectively and provides new planning strategies for setting up new facilities.

We critically reflect on China’s common community renewal patterns, where administrative divisions often define life circles. Our results highlight the surrounding urban areas that have a significant effect of making up for Convenience. These areas also need to be considered and updated with the community to measure the scope of the actual life circle of residents more accurately, especially elderly residents, to match their needs.

This study explores possibilities for further exploration. We could utilize big data from GPS wearable devices and community smart network platforms or conduct larger-scale tracking surveys organized by government agencies to enrich qualitative analysis and validate results. Additionally, the concept of Convenience can be correlated with more indicators such as population, land price, and physical health (e.g., physical activity, cognitive ability) to analyze their impacts, offering a wealth of potential for future research and application.

Furthermore, there is potential for further application. As a tier 1 city, Shanghai is at the forefront of the aging population issue, and over time, this challenge will affect tier 2, 3, and even lower-tier cities with more delayed development. As a highly accurate, widely applicable, and straightforward method, our approach can help achieve healthier and more sustainable "smart city" goals in lower-tier cities with limited budgets, promoting community renewal and development.

Declaration of competing interest

The author has no conflict of interest to report.

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Data availability

Data will be made available on request.

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