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Therapeutic landscape optimization strategies for age-appropriate public facilities in Shanghai

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Abstract

As urbanization accelerates and populations age, creating age-appropriate environments that support elderly health and well-being has become a critical challenge. This study focuses on optimizing the configuration of public service facilities in Shanghai from the perspective of health care and therapeutic landscapes. By combining mobile signaling data, point-of-interest data, and geospatial analysis, the research identifies key patterns in elderly travel behaviors and accessibility to public services. Results reveal disparities between urban and suburban areas, highlighting issues such as long travel distances, mismatches in facility supply and demand, and insufficient therapeutic environments. Drawing on theories of therapeutic landscape and environmental psychology, this study proposes landscape optimization strategies, including dynamic flowerbed rest areas, plant-barrier healing corners, photovoltaic art exhibition corridors, and photovoltaic health-sharing kiosks, tailored to different districts. These strategies aim to enhance travel comfort, alleviate stress, and promote social and cognitive well-being among the elderly. The findings provide theoretical insights and practical recommendations for designing inclusive and therapeutic urban spaces that cater to the unique needs of aging populations. Future research should explore pilot implementations and refine strategies based on empirical evaluations and elderly-specific preferences.

Keywords: Therapeutic landscape; Elderly health; Urban aging; Landscape healing; Public service accessibility; Big data analytics; Environmental psychology

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1. Introduction

As urbanization accelerates and populations age, cities worldwide face increasing pressure to create environments that support the health and well-being of the elderly. Public service facilities, such as health care centers, commercial areas, and recreational spaces, are vital in meeting the needs of an aging population. However, in fast-growing cities, such as Shanghai, these facilities often fall short in addressing the physical, emotional, and social needs of seniors. This raises the question: how can public spaces be redesigned to promote holistic health and healing for the elderly?

The answer lies in the therapeutic landscape, a concept rooted in environmental psychology and therapeutic landscape theory. Therapeutic landscapes are environments

intentionally designed to promote healing, reduce stress, and enhance emotional well-being through natural elements, such as plants, water features, and sensory experiences. Studies have shown that these environments can significantly benefit the elderly, who often face stress, mobility limitations, and isolation. Incorporating therapeutic landscape into public facilities can improve the quality of life for seniors by creating spaces that encourage relaxation, socialization, and physical recovery.

Shanghai, one of China's most developed and rapidly aging cities, exemplifies the challenges and opportunities associated with urban aging. The New York Post reported that, with a growing number of elderly residents expected to reach six million by 2030, the city's public service infrastructure will have to be adapted to cater to the unique needs of this population. Although Shanghai has a full set of public service facilities, these facilities prioritize functionality over therapeutic value. Therefore, it is necessary to reconsider these spaces by incorporating natural, therapeutic features to enhance the elderly's well-being.

Accessibility is a key consideration in the design of public service facilities, which should not only be physically accessible but also ensure an emotionally and physically supportive environment. Big data on elderly mobility patterns can provide new insights into where elderly populations most frequently access public services and where more therapeutic landscape interventions on commercial landscapes are needed. By integrating data-driven insights with therapeutic landscape principles, urban planners can design areas that not only fulfill the functional needs of older adults but also cater to their overall health and well-being.

This research examines how the principles of therapeutic landscape might be incorporated into the design of public service facilities in Shanghai. The research's goal is to identify high-traffic areas that can be utilized by healthy seniors. This will help understand the potential effects of therapeutic landscapes by analyzing where senior citizens tend to go, considering the existing distribution of facilities, and identifying high-traffic areas, locations where therapeutic landscapes could have the greatest effect. This research has three main objectives:

(i) To evaluate the accessibility and distribution of key public service facilities for elderly residents in Shanghai.
(ii) To analyze the potential for therapeutic landscape interventions to enhance elderly well-being within these spaces.
(iii) To propose specific design strategies for integrating therapeutic landscapes into high-demand public service areas, using big data to prioritize interventions.

In the following sections, this study reviews relevant literature on therapeutic landscapes and elderly well-being, analyzes the current distribution and accessibility of public service facilities in Shanghai, and proposes data-driven therapeutic landscape solutions that can enhance the quality of life for elderly populations in the city.

2. Literature review

2.1. The concept of therapeutic landscapes

Gesler (1993) initially introduced the concept of therapeutic landscapes to explain how physical, social, and symbolic components of certain environments contribute to healing and well-being. These designed and natural surroundings can help people recover from diseases, reduce stress, and enhance general well-being. Wilson's (1984) biophilia hypothesis holds that people have an innate affinity for their surroundings and that psychological well-being can be enhanced by exposure to natural settings. Numerous studies on the therapeutic qualities of green environments are grounded in this hypothesis. This notion was validated by Ulrich *et al.* (1991), who found that natural surroundings reduce stress and blood pressure, as well as accelerate recovery from illness. Therapeutic landscapes use these concepts to design settings that appeal to the senses and advance both emotional and physical wellness. Natural surroundings can restore cognitive ability, reduce mental fatigue, and enhance focus, according to research on Attention Restoration Theory by Kaplan & Kaplan (1989). These benefits can help reduce age-related cognitive decline and improve the general quality of life (Herzog *et al.*, 1997).

2.2. Therapeutic landscapes for the elderly

Therapeutic landscapes are increasingly understood to be fundamental to supporting the health and well-being of the elderly. Older people have specific physical, emotional, and cognitive issues, which can be alleviated through interaction with nature. Research shows that regular access to green spaces can reduce feelings of isolation and promote physical activity, which is important for maintaining mobility and cardiovascular health in older adults (Sugiyama & Thompson, 2007).

Sensory gardens, featuring fragrant and tactile plants, such as lavender, rosemary, and thyme, can benefit elderly individuals with cognitive impairments and dementia. These gardens offer a calming space that lowers the levels of agitation and anxiety, as well as improves memory and cognitive activity (Marcus & Sachs, 2013). Furthermore, exposure to natural settings leads to an improvement in sleep quality and mood, which is essential for elderly people who have insomnia or depression (Hassan & Deshun, 2024).

Milligan *et al*. (2004) highlight the social function of therapeutic landscapes in addressing loneliness among elderly people. Community gardens and green spaces facilitate social interaction, which is essential for maintaining mental well-being. Green spaces in urban areas provide restorative benefits that foster a sense of belonging and community, helping to mitigate the adverse effects of aging, including depression and cognitive impairment (Finlay *et al*., 2015).

2.3. Urban green spaces and health outcomes

Urban green spaces are important for public health, especially for elderly individuals. It has been shown through research that physical activity and health outcomes are similarly correlated to the proximity and accessibility of green spaces (Mitchell & Popham, 2008). Maas *et al*. (2006) found that individuals living within the same distances reported better general health and lower incidences of chronic illnesses, such as cardiovascular diseases and diabetes, compared with those living farther away from such areas.

The idea of green infrastructure—the interconnected network of parks, gardens, green roofs, and corridors embedded in urban settings—has gained increasing recognition as a public health intervention. Green infrastructure delivers aesthetic and ecological values; it also enhances physical activity, reduces stress, and contributes to mental health (Tzoulas *et al*., 2007). Access to green spaces is crucial for elderly populations with limited mobility and chronic health conditions (Dennis *et al*., 2020).

In addition, recent research has shown the positive effects of urban green spaces on mental health. Life in the wild led to lower scores for anxiety and depression, particularly among elderly individuals who may experience social isolation or limited mobility (Taylor *et al*., 2016). Therapeutic landscapes, including healing gardens and green corridors, facilitate contemplation, relaxation, and social interaction, leading to better emotional well-being.

2.4. Therapeutic landscapes and public service accessibility

In urban planning, ensuring that public service facilities are accessible and conducive to healing is critical for the elderly. Public spaces, such as hospitals, senior centers, and community hubs, should be designed with therapeutic landscape elements that promote relaxation and recovery. Sugiyama & Thompson (2007) found that elderly individuals tended to engage in physical activity when their environments were perceived as safe, esthetically pleasing, and integrated with natural elements.

Integrating green spaces into travel routes to and from public services ensures that accessibility is enhanced both physically and emotionally. The presence of green corridors or healing paths—equipped with shaded seating, medicinal herb plantings, and calming water features—can transform routine journeys into restorative experiences. Research by Annerstedt *et al*. (2012) suggests that exposure to green environments during transit to healthcare facilities significantly reduces patient stress and anxiety levels.

Hospitals and healthcare facilities, in particular, can benefit from incorporating healing gardens, which provide patients, caregivers, and staff with spaces to relax and recover. Ulrich (2002) emphasized that views of nature and access to outdoor green spaces contribute to faster recovery times, reduce pain perception, and lower anxiety levels. In elderly care settings, the presence of outdoor therapeutic spaces has been linked to improved mobility, cognitive function, and overall well-being (Lin *et al*., 2025).

2.5. The role of big data in optimizing therapeutic landscapes

In recent years, big data analytics has emerged as a powerful tool in urban planning, enabling the optimization of public spaces based on real-time mobility patterns. By analyzing data from mobile devices, global positioning system tracking, and public transportation systems, planners can identify areas where elderly populations are concentrated and where therapeutic landscape interventions would be most beneficial (Goodspeed *et al*., 2018). For example, Lo & Yang (2020) used big data to map the mobility patterns of elderly residents in Shanghai, identifying high-traffic areas that lacked adequate green spaces. Their findings suggest that by strategically placing healing gardens or pocket parks along common travel routes, elderly individuals can benefit from increased opportunities for rest and recovery during their journeys. Data-driven approaches to urban design ensure that therapeutic landscapes are located where they can have the greatest impact, improving both the accessibility and quality of public services.

Big data can also inform the adaptive design of landscapes to account for seasonal variations and changing usage patterns. Planners can use predictive analytics to ensure that therapeutic landscapes are functional year-round and are responsive to the evolving needs of elderly populations (Zhou & Chen, 2019). This dynamic approach to landscape design ensures that public spaces remain effective in promoting well-being, even as demographic and environmental conditions change.

3. Research area and data source

3.1. Research area

The research area is divided into 16 districts in Shanghai, China, including the central urban and suburban areas.

These regions feature distinct socio-economic attributes and diverse trends concerning the allocation of public service facilities. Public services, such as health care, cultural, and recreational facilities, are highly concentrated in the central districts, including Huangpu, Jing'an, and Xuhui, where transportation is highly convenient. In the suburban districts of Jiading, Qingpu, and Songjiang, the allocation of public services is more extensive, resulting in lower accessibility and less convenience for elderly citizens. This is because the travel behaviors of elderly populations are greatly influenced by the environmental quality of green spaces and surrounding landscape infrastructures. Locations with a high greening rate and pleasing landscape facilities provide greater therapeutic benefits, catering to the elderly who prefer these facilities and services for health, enjoyment, or culture. Thus, the understanding of therapeutic landscapes across regions is important for developing optimal landscapes for aging populations. More specifically, urban centers tend to offer greater proximity to various medical, recreational, and cultural services, but they often suffer from greenery scarcity and congested environments. On the other hand, suburban areas have more natural scenery, but they lack public services that are friendly to the elderly. This research examines facility distribution and environmental quality disparities to identify possible interventions that incorporate therapeutic landscapes into existing public services by district.

3.2. Data sources

The data used in this research include multiple sources to evaluate the accessibility and distribution of public service facilities for elderly residents, as well as the potential for incorporating therapeutic landscapes. The key data sources are listed in the following sections.

3.2.1. Mobile signaling data

Mobile signaling data is an advanced tool for analyzing travel behaviors with high spatial and temporal precision. This research used data provided by China Unicom, collected during the second half of 2021. The data include travel information at 30-min intervals, covering approximately 10 million travel records across all age groups. For this research, a specific focus was placed on residents aged 60 and above, extracting about 300,000 travel records that detail the origins and destinations (OD) of elderly trips. With a spatial resolution of 0.25 km × 0.25 km, the data are crucial for identifying frequently traveled routes and common destinations among the elderly population, allowing for precise mapping of public service usage. The specific information of the mobile signaling data used is presented in Table 1.

3.2.2. Point-of-interest (POI) data

POI data are important in researching the distribution and function of urban facilities. Overall, the POI data include 810,000 records covering 14 categories sourced from the Amap open platform (https://lbs.amap.com/) in November 2022. The research is conducted in four types of elderly services: shopping facilities, cultural and educational facilities, health service facilities, and recreational and leisure facilities. The spatial distribution of accessibility to elderly-related public services and the potential for landscape integration analysis were conducted using the POI dataset (Table 2).

3.2.3. Survey data on elderly travel patterns

Qualitative data on the population sample (100 elderly residents in five representative districts in Shanghai) include travel behaviors, challenges in accessing public service facilities, and preferences for therapeutic landscapes. The results reveal specific difficulties encountered by elderly residents in accessing healthcare services, recreational facilities, and shopping malls, as well as their need for more green spaces and rest areas during travel.

Table 1. Mobile signaling data properties

Field name	Field definition	Examples/ demonstration
Lon_min	Longitude of the lower-left corner of the grid	121.319677
Lon_max	Longitude of the upper-right corner of the grid	121.322325
Lat_min	Latitude of the lower-left corner of the grid	30.675896
Lat_max	Latitude of the upper-right corner of the grid	30.678185
id	The unique identifier of the mesh	1
Road_id	The unique identifier of the mesh	3

Table 2. Categories of point-of-interest (POI) data

Facility classification	POI included
Health service facilities	Geriatric hospitals, geriatric disease and chronic disease hospitals, geriatric outpatient services, rehabilitation hospitals, clinics, general hospitals, etc.
Cultural and educational facilities	Universities for the elderly, schools for the elderly, libraries, cultural centers, exhibition halls, museums, etc.
Recreational and leisure facilities	Activity centers for the elderly, elderly activity rooms, chess and card rooms for the elderly, community activity centers, sports and fitness centers, squares, parks, etc.
Catering facilities	Canteens for the elderly (restaurants), Chinese food, western food, fast food, cafes, dessert shops, etc.
Shopping facilities	Vegetable markets, convenience stores, supermarkets, shopping malls, etc.

3.2.4. Spatial data

All spatial data, such as road network (road), green space distribution (green), and building layout (building), were obtained from the Shanghai Urban Planning and Land Resource Administration Bureau. Geographic information systems (GIS) were used to analyze these data in order to examine the distance from elderly residences to public services. The aim was to identify areas with high potential for therapeutic landscape interventions by overlaying facility locational data with relevant environmental factors such as greening rates.

3.2.5. Remote sensing data

Satellite imagery (Landsat-8) was used to analyze green coverage and vegetation density across several districts in Shanghai. This integration of public service facility data and remote sensing analysis demonstrates and evaluates the overall accessibility of public green spaces around them, hence identifying potential locations to introduce therapeutic landscapes. The data were then used to quantify green space accessibility and its association with elderly travel behaviors.

3.2.6. Policy documents and government reports

This research reviewed government-issued documents, such as the Shanghai Urban Master Plan (2017-2035) (Shanghai Municipal People's Government, 2018) and the Shanghai Municipal Health Commission (Shanghai Municipal Health Commission, 2022), to understand the policy framework regarding elderly care and public service provision. They serve as a guide for the long-term planning of the aging population. This facilitates the integration of the therapeutic landscape into urban development projects.

3.3. Research framework

The research framework is based on the integration and analysis of multisource data, aiming to optimize the landscape design of public service facilities to meet the health demands of the elderly (Figure 1). The framework includes the following key steps:

(i) Data collection and integration: Collecting mobile signaling data, POI data, survey data, spatial data, and remote sensing data.
(ii) Functional zoning: Dividing the city into different functional zones based on POI data and travel frequency density analysis.
(iii) Elderly travel pattern analysis: Using mobile signaling data to analyze travel purposes, distances, and frequencies among elderly populations.
(iv) Facility layout and therapeutic environment assessment: Combining POI data with environmental quality indicators to evaluate the landscape potential around public service facilities.
(v) Travel distance and landscape demand analysis: Analyzing the relationship between travel distance and the need for therapeutic landscapes, proposing targeted landscape optimization strategies.
(vi) Results and discussion: Proposing specific landscape optimization strategies and discussing their impact on the health and travel experience of the elderly based on the analyses.

4. Research methods

This research employs a combination of spatial analysis and data-driven techniques to evaluate the distribution of elderly public service facilities in Shanghai and to assess the demand for therapeutic landscapes. The primary analytical tools include Python (version 3.11, Python Software Foundation, USA) for data processing and ArcGIS (version 10.8, Esri, USA) for geospatial mapping, along with a rich dataset comprising mobile signaling data and POI data. The research methodology is outlined in the following sections.

4.1. Functional zoning

To understand how the distribution of public service facilities aligns with elderly travel patterns, this research

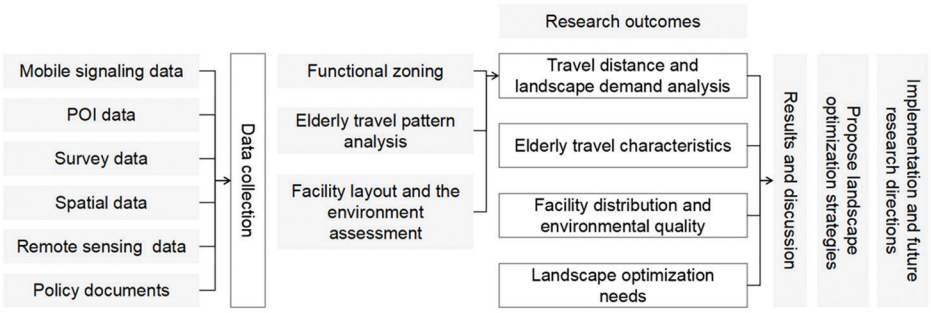

Figure 1. Research framework
Source: Diagram by the authors.
Abbreviation: POI: Point of interest.

categorized urban areas into distinct functional zones. These zones were identified based on the density and variety of public services frequented by elderly individuals, including commercial centers, healthcare institutions, cultural education facilities, and recreational spaces.

The zoning process was conducted using POI data and frequency density analysis, as defined by the following two indicators (Hu & Han, 2019):

(i) Frequency density index (Fi): This metric calculates the density of a particular type of facility (e.g., health care and recreation) within a grid unit of 250 m × 250 m, enabling the identification of areas where elderly residents primarily access public services.

$$F_i = \frac{ni}{Ni}(i = 1,2,3,4) \quad \text{(I)}$$

$$Ci = \frac{Fi}{\sum_{i=1}^{4} F_i}(i = 1,2,3,4) \quad \text{(II)}$$

(ii) Ratio index (Ci): This index determines the proportional importance of each type of facility within a grid by comparing the frequency density of each facility type against the total number of POIs. If the Ci of a facility type exceeds 0.5, the grid is classified as that type of zone; otherwise, it is categorized as a mixed-use zone.

$$C_{imax} = max\ (C_1, C_2, C_3, C_4) \quad \text{(III)}$$

$$function\,at\,a\,grid = \begin{cases} i\,type\ function, C_{imax} > 0.5 \\ mixed\ functional\,areas \\ of\ top\,two\,C_i, C_{imax} \le 0.5 \end{cases} \quad \text{(IV)}$$

These functional zones were then overlaid with environmental quality data, such as green space coverage and landscape features, to identify areas where therapeutic landscapes could be integrated into existing public service infrastructure.

4.2. Elderly travel pattern analysis

Using mobile signaling data from China Unicom, this research analyzed the travel patterns of elderly residents. The signaling data provided insights into the OD of trips made by elderly individuals aged 60 and over. By filtering OD data related to elderly travel behavior, the research extracted 300,000 relevant records, revealing the most frequented public services based on trip purpose, distance, and frequency. The analysis categorized elderly trips based on the purpose of travel:

(i) Health care: Trips to medical facilities, such as hospitals, clinics, and rehabilitation centers
(ii) Shopping and consumption: Visits to grocery stores, markets, and shopping malls
(iii) Cultural and educational activities: Trips to libraries, museums, and cultural centers
(iv) Recreational and leisure activities: Travel to parks, fitness centers, and community activity centers.

This analysis provided a detailed overview of elderly mobility patterns, highlighting the key areas where public services were concentrated, underutilized, or inaccessible due to distance or environmental factors. Additionally, it revealed which types of services elderly residents prioritized in their daily routines, allowing for a more tailored approach to therapeutic landscape interventions.

4.3. Facility layout and therapeutic environment evaluation

To evaluate the potential for therapeutic landscapes around public service facilities, the research combined POI data with environmental quality metrics, such as greening rates, access to open spaces, and the presence of calming design elements, such as water features, seating areas, and sensory gardens. The evaluation involved:

(i) Green space proximity: Using remote sensing data and satellite imagery (Landsat-8), the research measured the distance between public services and nearby green spaces. This analysis revealed gaps in green space access, particularly for facilities such as hospitals and cultural centers that serve large numbers of elderly residents.
(ii) Landscape features and accessibility: The research assessed the therapeutic potential of existing landscape features surrounding public services. Facilities were rated based on their environmental quality, with particular emphasis on the diversity of plant species, the presence of shaded walking paths, and the availability of rest areas that encourage relaxation and social interaction.
(iii) Therapeutic potential: The proximity of green spaces to elderly-friendly services was cross-referenced with travel data, highlighting which facilities would benefit most from landscape enhancements. For instance, healthcare facilities that lacked sufficient nearby green spaces were identified as key areas where healing gardens could be introduced to create a more restorative experience for patients and visitors.

4.4. Elderly travel distance and therapeutic landscape demand analysis

This research further analyzed the relationship between travel distance and the need for therapeutic landscapes.

The mobile signaling data revealed the following patterns:

(i) Short-distance trips (1–5 km): Elderly residents primarily travel shorter distances to cultural and recreational facilities, such as parks, community centers, and libraries. This emphasizes the need to enhance the therapeutic potential of these spaces by adding restorative gardens, sensory plants, and quiet seating areas to promote relaxation and social interaction.

(ii) Medium-distance trips (5–50 km): These trips are often linked to essential services, including health care, where elderly residents seek medical treatment or rehabilitation services. In these areas, the research recommends integrating healing gardens and outdoor relaxation areas into healthcare campuses to alleviate the psychological and physical stress associated with medical visits.

(iii) Long-distance trips (>50 km): Rarely undertaken, these trips are typically for specialized medical services or social gatherings. The research suggests that these trips could be made more pleasant by introducing green rest stops along key travel routes, providing elderly travelers with areas to rest, recover, and enjoy nature during longer journeys.

5. Elderly travel characteristics in Shanghai

This section is intended to deliver only the key take-home message, with a more comprehensive conclusion discussed in a separate section.

5.1. Analysis of travel destinations

To analyze the travel behavior of the elderly in Shanghai, the research focuses on the distribution of three key types of public service facilities: commercial centers, hospitals, and cultural and educational facilities (Figure 2). By prioritizing travel purposes and distances, the research filtered out irrelevant grids based on facility types and combined the remaining data with facility classifications for further analysis. The public service facilities are as follows:

(i) Commercial centers: The analysis of Figure 2 shows that commercial centers are distributed across all 16 districts in Shanghai. The city-level commercial centers exhibit a concentrated spatial pattern, predominantly located in the central urban areas, reflecting the accessibility and frequency of visits by elderly residents.

(ii) Hospitals: The distribution of top-tier hospitals covers the entire city, ensuring city-wide medical service accessibility. Second-tier hospitals and community clinics are also widely available, offering substantial coverage in both urban and suburban areas. The circulation of healthcare resources across different tiers provides elderly residents with medical care options at varying distances.

(iii) Cultural and educational facilities: Cultural and educational facilities, such as libraries and museums, have a unified service radius and generally cover residential areas. However, there remains a trend of concentration towards the city center, which may limit access for elderly residents living in peripheral districts.

Overall, the spatial distribution of these facilities highlights significant variation in accessibility and service provision between central and suburban areas, with a tendency for the most essential services (e.g., medical care and cultural venues) to be clustered in the central areas.

5.2. Travel distance and therapeutic landscape demand analysis

The distance elderly residents travel to access public services plays a crucial role in determining the demand for therapeutic landscapes. Travel distances were categorized into four primary ranges to better understand the relationship between travel patterns and landscape demand:

(i) 1–5 km (short distance): Within this range, there is

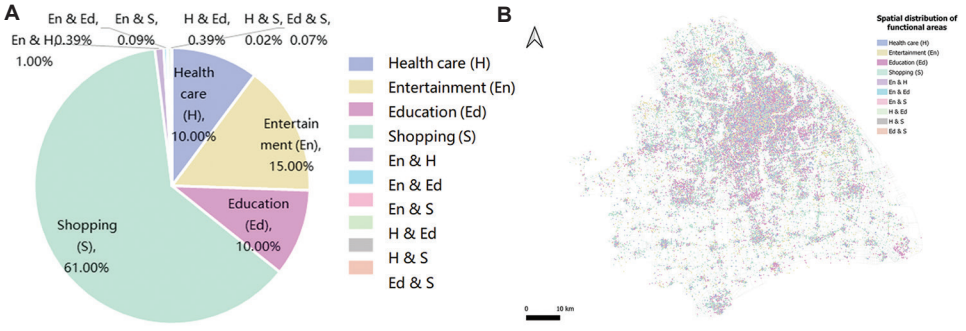

Figure 2. (A and B) Identification of elderly destinations in Shanghai
Source: Map by the authors.

minimal variation in travel frequency for different types of destinations. The majority of elderly residents tended to visit nearby services for daily shopping, healthcare services, and cultural activities. The frequency of travel for these essential services remains consistent due to their proximity to residential areas (Figures 3 and 4).

(ii) 5–50 km (medium distance): As travel distances increase, there is a significant decrease in trip frequency. In this range, elderly residents tended to limit travel for more specialized needs, such as hospital visits or participation in cultural and educational activities. These services often require longer journeys, particularly for those residing in suburban areas.

(iii) 50–75 km (long distance): The reduction in travel frequency begins to level off within this distance range. Despite the longer distances, elderly residents continued to travel for cultural, scientific, and educational activities, as well as for shopping, reflecting their willingness to travel further for these

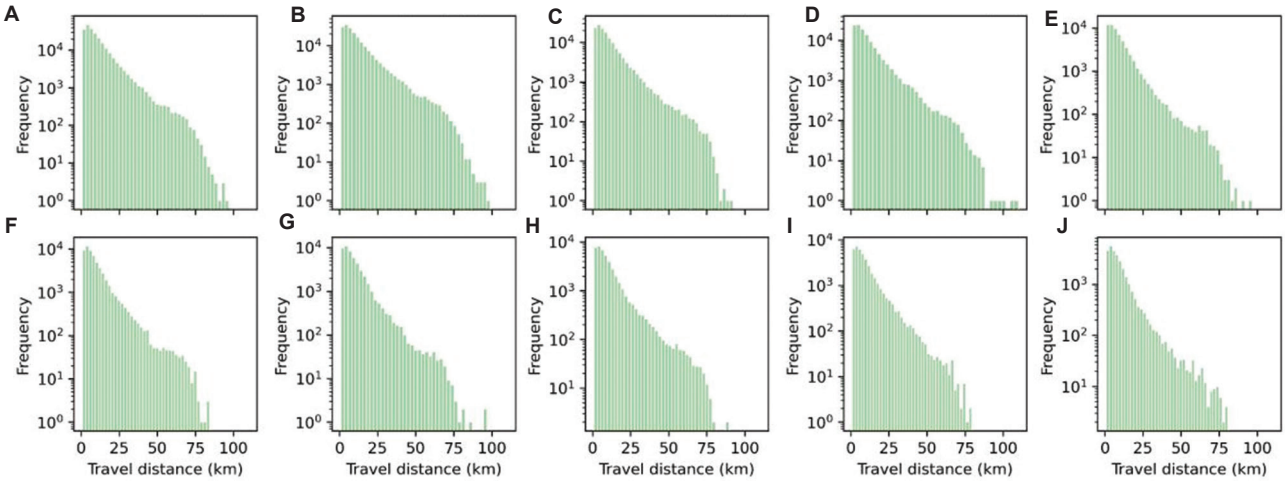

Figure 3. Distribution of elderly travel distances by destination types. (A) Education (Ed). (B) Shopping (S). (C) Health care (H). (D) Entertainment (En). (E) En and H. (F) En and Ed. (G) H and Ed. (H) H and S. (I) En and S. (J) Ed and S.
Source: Graphs by the authors.

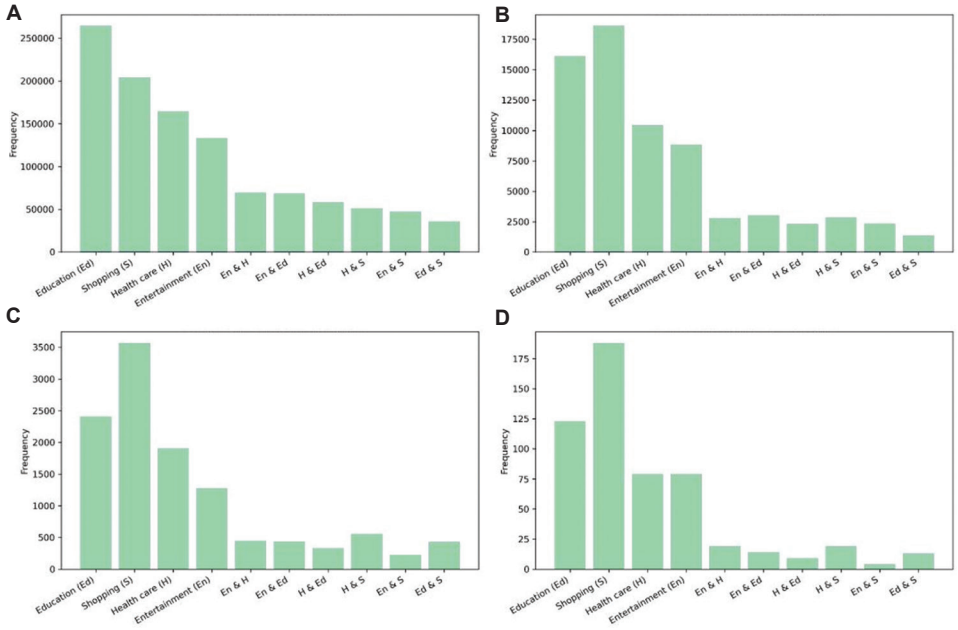

Figure 4. Distribution of elderly travel destination types by distances. (A) 1–5 km. (B) 5–50 km. (C) 50–75 km. (D) 75–100 km.
Source: Graphs by the authors.

purposes.

(iv) 75–100 km (long distance): The frequency of trips decreases sharply within this range. When travel occurred over such long distances, it was typically for more specialized services, such as advanced medical care, cultural events, or shopping at large commercial hubs. Travel for recreational activities was also common, but at lower frequencies.

This analysis suggests that elderly residents are more likely to travel longer distances for services that are perceived as essential (e.g., healthcare services) or fulfilling (e.g., cultural and recreational activities). However, travel-related stress and fatigue can be significant for longer trips, creating a strong demand for restorative landscape elements along major travel routes and near destination facilities.

5.3. Three major travel patterns of the elderly

The following analyses identify the three most common destination types among elderly residents, based on travel frequency and purpose:

(i) Cultural and educational facilities: Figure 5 shows cultural and educational facilities as the most frequented destinations for elderly residents, particularly for those who participate in lifelong learning programs, visit libraries, or attend cultural events. These trips are essential for maintaining mental stimulation and social engagement, highlighting the need for therapeutic landscapes, such as gardens or calming green spaces, within or near these facilities to enhance cognitive and emotional well-being.

(ii) Shopping and consumption: Figure 6 indicates shopping centers as the second most frequented destinations, particularly for daily necessities. Elderly residents typically visit markets, grocery stores, or shopping malls close to residential areas, though some travel longer distances to access larger shopping complexes. Adding green rest stops or seating areas near shopping centers can alleviate physical strain, providing spaces for relaxation during shopping trips.

(iii) Healthcare facilities: Figure 7 illustrates healthcare facilities as a vital travel destination for elderly residents. Despite the availability of local clinics, many choose to travel longer distances to access better-equipped hospitals. The inclusion of healing gardens or outdoor recovery spaces at hospitals could significantly enhance the therapeutic experience for elderly patients and reduce travel-related stress.

5.4. Travel origin analysis

The analysis of elderly travel origins reveals key patterns in their mobility. Figure 8 shows that most elderly residents live in areas with easy access to shopping and consumption facilities. For instance, the highest number of trips originated from shopping districts (2,762 arrivals),

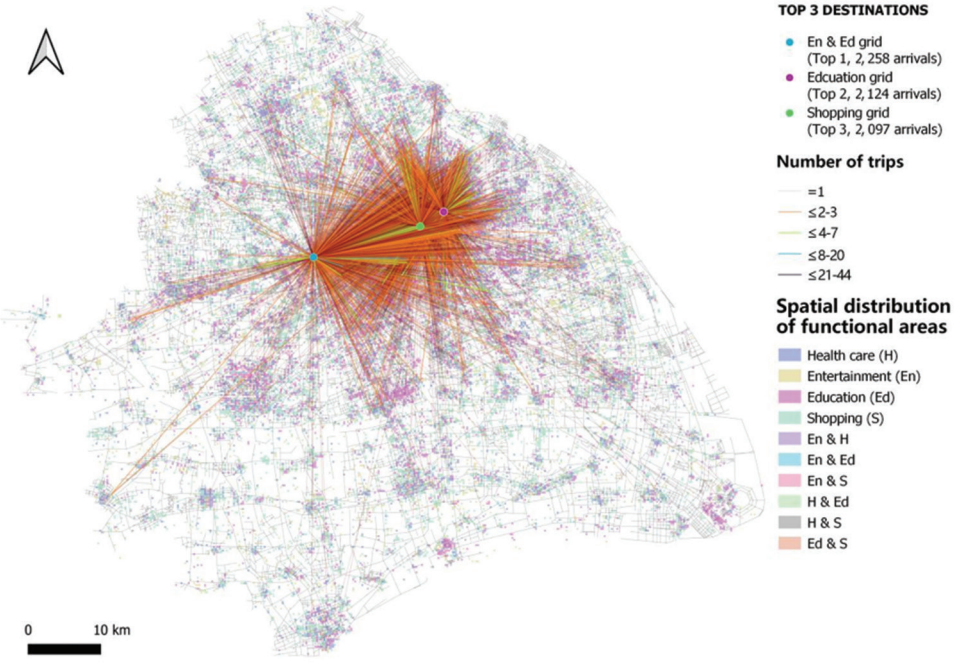

Figure 5. Top three destinations among elderly residents in Shanghai
Source: Map by the authors.

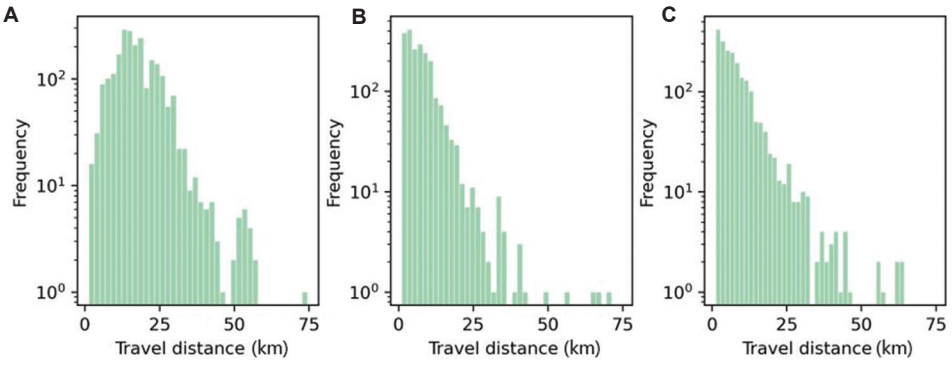

Figure 6. Distribution of distance traveled to the grid by destination types: (A) entertainment and education, (B) education, and (C) shopping
Source: Graphs by the authors.

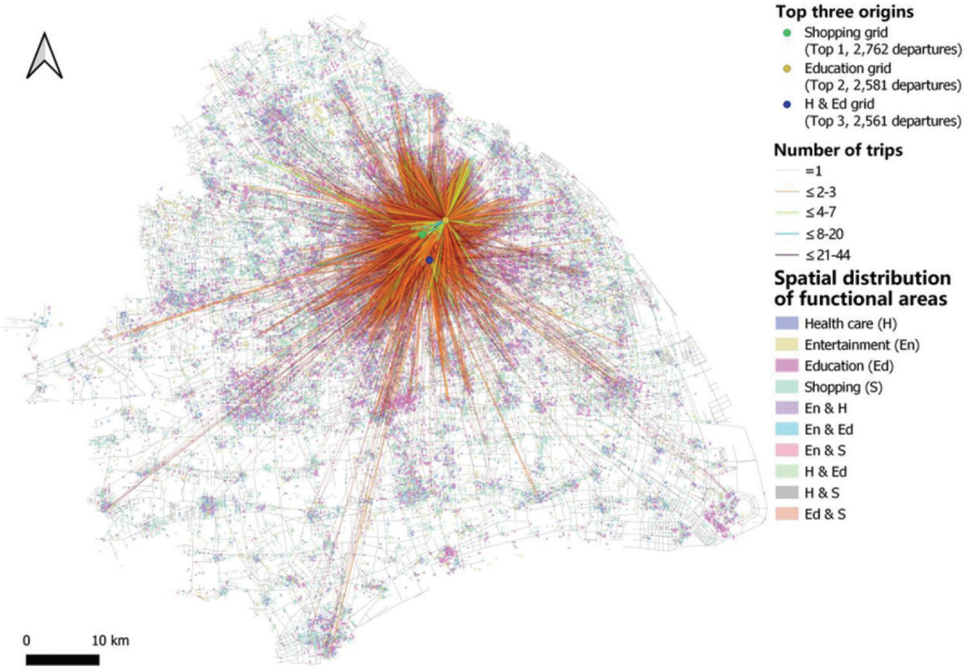

Figure 7. Distance traveled by the elderly population to the grids in Shanghai
Source: Map by the authors.

followed by educational zones (2,581 arrivals) and healthcare hubs (2,561 arrivals). These figures suggest that elderly residents prefer to live in areas that have convenient access to daily services, confirming the importance of locating therapeutic landscapes within and around these zones.

The distribution of travel origins also indicates that high-density residential areas, particularly in central districts, have a high proportion of elderly residents who rely on nearby commercial and cultural services. This reinforces the need for therapeutic landscapes in these high-frequency areas, where elderly residents spend a significant portion of their time.

5.5. Analysis of the most frequent travel routes

Figure 9 illustrates the longest and most frequently traveled routes by elderly residents. The analysis shows that the longest routes often involve travel to cultural and healthcare destinations, with some journeys exceeding 75 km. However, the majority of frequent routes are shorter, with the most common destinations being healthcare facilities (77 trips), followed by educational and shopping centers (121 trips combined).

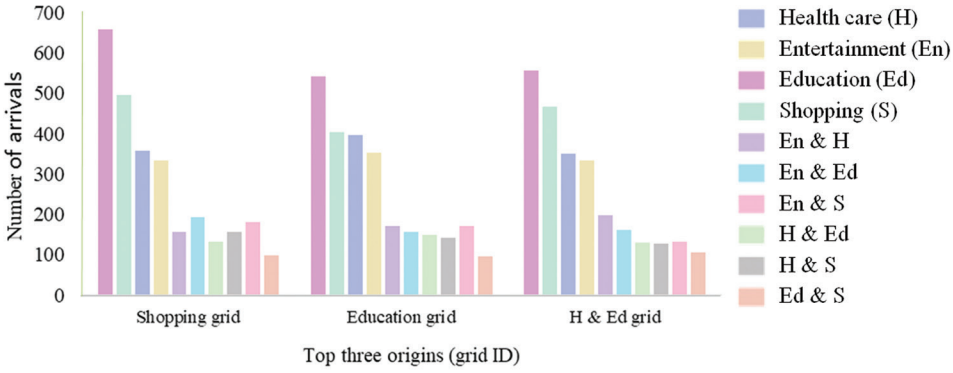

Figure 8. Number of arrivals by grid types
Source: Graph by the authors.

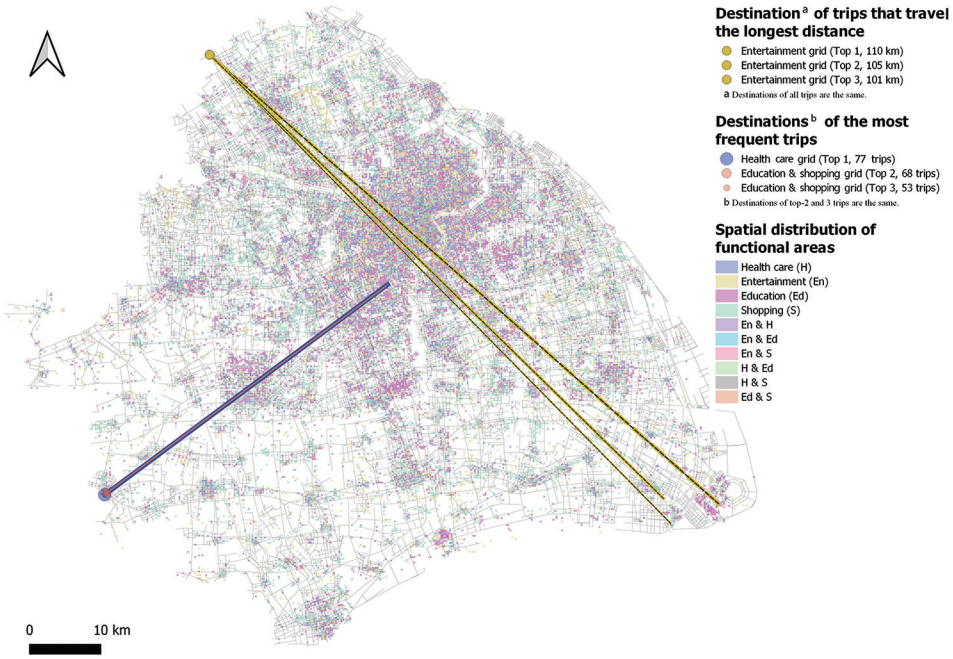

Figure 9. The top three routes with the longest travel distance and the highest frequency
Notes: [a]Destinations of all trips are the same; [b]Destinations of top second and third trips are the same.
Source: Map by authors.

Given the frequency and length of these travel routes, it is crucial to introduce therapeutic landscape elements along high-traffic corridors. Green corridors or pocket parks along these travel routes could provide elderly travelers with a place to rest and rejuvenate during their journeys, particularly for those traveling long distances to reach healthcare or cultural facilities.

5.6. Summary and correlation analysis of elderly travel patterns

Through the analysis of millions of travel data points, this research identifies key destinations and origins that drive elderly mobility in Shanghai. The top three travel destinations—shopping, healthcare facilities, and cultural/educational services—show consistent patterns in both central and suburban districts (Figure 10). While elderly residents in the city center are more likely to visit commercial hubs and cultural venues, those in the suburbs are more willing to travel longer distances for essential services, such as healthcare services or educational facilities.

The correlation between travel frequency and the availability of public services suggests that elderly residents prioritize proximity, but they are also willing to travel farther for high-quality services, particularly in health care and cultural

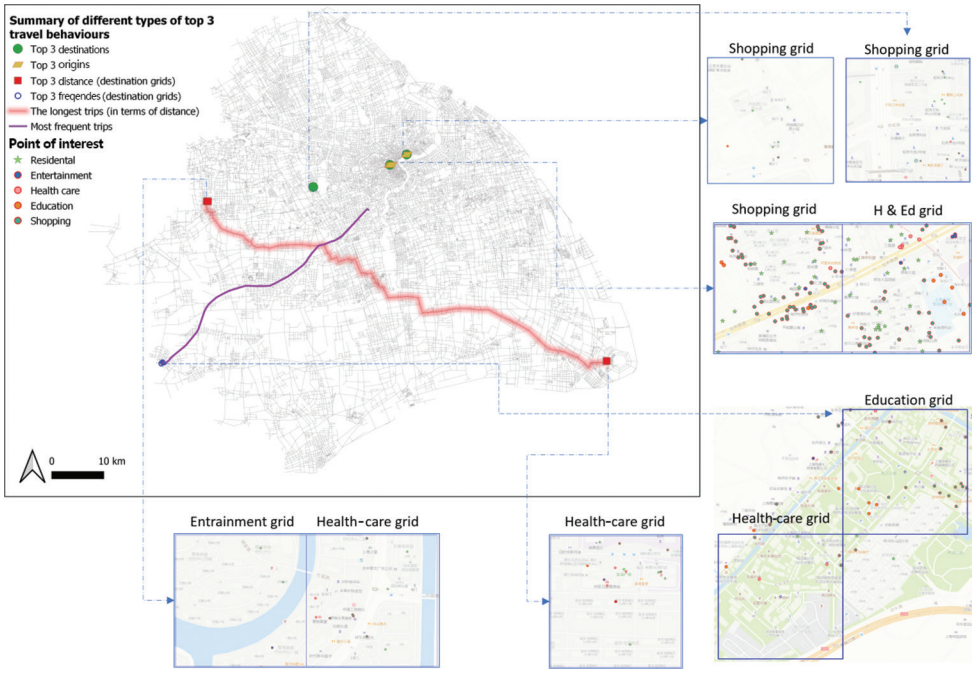

Figure 10. Summary table of the travel characteristics of elderly residents in Shanghai
Source: Map by authors.

enrichment. This travel pattern highlights the urgent need to integrate therapeutic landscapes into existing infrastructure, especially around frequently visited destinations, to improve the physical and mental well-being of elderly travelers.

6. Results

6.1. Main findings

Based on the comprehensive analysis of mobile signaling data and POI data, together with the research on the travel behavior of the elderly in Shanghai and the layout of public service facilities, the general conclusions are presented in the following sections.

6.1.1. Center-periphery difference in spatial travel characteristics of elderly residents in Shanghai

The survey found that core urban areas have an adequate supply of public service facilities and a higher diversity of services, allowing elderly residents to meet most of their daily needs through short-distance travel. In contrast, in the outer or suburban areas, insufficient basic public service facilities or limited service functionality often force elderly residents to travel longer distances for medical care, shopping, cultural activities, or entertainment needs, resulting in increased travel time and physical exertion.

6.1.2. Mismatch between the supply and demand of public service facilities leads to the phenomenon of "available nearby, yet seeking remote options"

Although a number of basic service facilities are available in urban and suburban areas, from the actual choice of elderly residents, there are cases of "seeking remote options" to access higher-level hospitals, commercial centers, or cultural institutions. The research shows that facility quality (such as top-tier hospitals and municipal commercial centers), brand recognition, and supporting environmental factors significantly influence the travel decisions of the elderly.

6.1.3. Effective allocation of elderly care facilities within the 15-min living circle needs to be enhanced

For the elderly, access to short-distance and neighborhood-level services is important. The analysis indicates that providing more balanced public services (such as daily shopping, community medical care, recreational activities, and sports) within a 15-min walking radius can significantly reduce the need for long-distance travel. This, in turn, lowers the physical and time burden on elderly residents and enhances their willingness to travel and participate in social activities.

6.1.4. The equity of public service facility distribution between urban and suburban areas needs to be enhanced across multiple dimensions

On the one hand, it is necessary to upgrade the supply of public services in suburban areas, such as adding higher-tier medical, cultural, and leisure facilities on the metropolitan

periphery. On the other hand, basic supporting facilities should be supplemented, such as improving community health service centers, convenience stores, and community activity stations. Achieving balanced development requires improvements not only in physical infrastructure but also in supporting institutional frameworks.

6.2. Landscape optimization strategy for elderly-oriented public service facilities based on health care

6.2.1. Hongqiao Central Business District: Dynamic flowerbed rest area

The pedestrian design in Hongqiao Central Business District emphasizes traffic efficiency but lacks interactive features and adequate rest spaces, making it difficult for elderly visitors to enjoy a comfortable shopping experience. The absence of rest areas contributes to fatigue and reduces their contact with nature. To address this, the introduction of dynamic flowerbed rest areas is proposed. These rest zones could incorporate modular flowerpots planted with seasonal flowers, such as calendula and hydrangea. Small photovoltaic panels can power an automated irrigation system, enhancing sustainability while creating a pleasant environment for rest and observation. This design aims to improve the walking experience by increasing the interaction between the elderly and nature, thereby enhancing relaxation and overall well-being during shopping trips.

Incorporating soft, tactile materials and ergonomic seating will further support comfort and engagement. Positioned strategically near common rest locations, such as benches and shaded areas, these flowerbeds provide not only visual and sensory relaxation but also help to minimize physical strain. Additionally, integrating interactive elements such as health suggestions or environmental education displays will make these resting places not only restorative but also engaging. The seasonal variation in plantings motivates repeated visits, providing fresh sensory experiences throughout the year.

6.2.2. Medical service grid in Jing'an district: Plant-barrier healing corner

Functionality is highlighted in the pedestrian design of Hongqiao Central Business District, lacking interaction and the setting of rest spaces, making the elderly easily feel tired in the shopping process and reducing their connection with nature. The road uses modular flower pots with seasonal flowers such as calendula and hydrangea to form dynamic flowerbed rest areas along the path, and with small photovoltaic panels to provide power for the flowerbed irrigation system, providing spaces for the elderly to rest and watch. The overall design has also increased the happiness of the trail, interaction between the elderly and nature, and allows them to relax more easily while shopping.

Apart from the plant barriers, these spaces could feature low, curved chairs designed to promote relaxation and support natural posture. Armrests would provide extra support, particularly for senior citizens with limited mobility. Beyond serving as physical and psychological buffers, the plant-barrier design also acts as a sound barrier, reducing noise from nearby busy streets or medical facilities and creating a tranquil oasis that encourages recovery. Moreover, adding soft lighting or wind chimes that respond to the breeze would enhance the ambiance in the evening, extending the space's usability beyond daylight hours and transforming it into a 24-h restorative environment.

6.2.3. Tangshan Road cultural and entertainment zone: Photovoltaic art exhibition corridor

The rigid, square-paved layout of the cultural and entertainment zone on Tangshan Road reveals areas where elderly individuals tend to linger without actively engaging, leading to low participation in cultural activities. To address this, a photovoltaic exhibition corridor is proposed along the pedestrian corridor as a display platform where seniors can showcase their handicrafts or paintings. This corridor expands the plaza's interactive function and provides seniors a creative outlet, promoting cultural participation and fostering a sense of community.

Furthermore, the exhibition corridor could incorporate adjustable lighting to highlight the displayed artworks, improving visibility and accessibility for seniors with varying levels of visual ability. Tactile panels or braille descriptions would further support inclusivity, ensuring that visually impaired individuals can also engage with the art. Interactive features, such as digital screens that provide artist profiles or allow seniors to submit their work digitally, could further enrich the experience, transforming the venue into a vibrant hub of cultural expression and social interaction.

6.2.4. Scientific, educational, cultural, and medical facilities in the southwest corner of the city: Photovoltaic health-sharing kiosk

The southwest corner of the city encompasses a large cluster of scientific, educational, cultural, and medical facilities. However, following redevelopment, it lacks designated spaces for rest and social interaction. As a result, elderly individuals engaging in long-distance activities often experience fatigue due to insufficient functional

support. To address this, a photovoltaic health-sharing kiosk is proposed. Powered by a photovoltaic system, the kiosks can support digital displays that share health data, academic content, and community information. Surrounding the kiosk, medicinal plants, such as rosemary and parsley, will be planted to create a restful environment conducive to relaxation and academic exchange. Designed with rehabilitation and learning functions, these kiosks aim to relieve physical fatigue and promote knowledge sharing, fostering spaces for elderly individuals to recover physically and mentally.

Digital interfaces within the kiosks can offer personalized health information, such as medication reminders or upcoming medical appointments, further integrating health support into the built environment. For elderly individuals with limited mobility, the kiosks can offer ergonomically designed seating with back support and armrests. Additional green elements, such as small herb gardens, will enhance sensory stimulation and contribute to a tranquil atmosphere. This design motivates active participation in health management, relaxation, and meaningful social interaction, empowering elderly individuals and promoting their overall well-being.

7. Discussion

This study focuses on optimizing the landscape design of public service facilities to enhance the health and wellness experience of the elderly in Shanghai, based on their spatial distribution and travel patterns. By analyzing mobile phone signaling and POI data, the research reveals the elderly's primary destinations and travel frequencies in areas such as shopping, health care, and culture. Based on these findings, four landscape optimization strategies are proposed for specific districts in Shanghai: Hongqiao Central Business District, the medical service grid in Jing'an district, the cultural and entertainment zone on Tangshan Road, and the scientific, educational, cultural, and medical facilities in the city's southwest corner. The proposed strategies include dynamic flower bed rest areas, plant-barrier healing corners, photovoltaic art exhibition corridors, and photovoltaic health-sharing pavilions. These strategies address both functional needs and the elderly's desires for natural interaction, privacy, and social and psychological relaxation.

The results indicate that rational landscape design can significantly enhance the elderly's daily travel comfort, alleviate psychological pressure, and satisfy their social needs. For instance, the dynamic flower bed rest area in Hongqiao Central Business District increases the interest and dynamic engagement of the shopping trail, improving the shopping experience of the elderly. Meanwhile, the proposed plant-barrier healing corner for the medical service grid in Jing'an district offers privacy and quiet spaces, relieving the elderly's anxiety regarding medical care. These instances demonstrate that therapeutic landscape optimization enhances the practicability of public service facilities and enriches the experiential dimension of the areas.

However, there are limitations to this research. First, the proposed landscape optimization strategies have not yet been implemented or evaluated in real-world settings. Future pilot projects in Shanghai could assess their effectiveness, using measures such as user satisfaction and health indicators among the elderly. Second, the focus on Shanghai's urban environment limits the scope of the study, as it does not address the travel needs of the elderly in rural or suburban areas. Future research could expand to other cities or regions to assess the broader applicability of these strategies. Finally, advancements in technology, such as photovoltaic power supply and intelligent sensing, offer further opportunities to enhance the therapeutic landscape. Incorporating these technologies may provide more personalized and intelligent landscape services for elderly users.

Future research should further integrate the nuanced demands of the elderly group with empirical investigations. While mobile signaling data reveal a macro-level understanding of travel patterns and intensity, they do not capture subjective factors, such as health status, economic capacity, psychological needs, and travel preferences. To address this gap, future studies should incorporate in-depth questionnaires, interviews, and longitudinal follow-up to better identify and quantify the real needs of the elderly in areas such as health care, social support, culture, and recreation. These insights can then inform more targeted and practical improvements in public service facility planning, environmental design, and urban renewal initiatives by governments and communities.

8. Conclusion

In short, this study addresses the specific needs of the elderly in the context of an aging society by exploring how empirical analysis and innovative landscape design can enhance their travel experience. It offers new ideas and practical suggestions for creating an inclusive, healthy, and harmonious urban environment. This optimization approach is grounded in both practical application and theoretical support, providing a valuable reference for future research on the integration of therapeutic landscapes in public spaces.

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Conflict of interest

The authors declare that they have no competing interests.

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Writing – original draft: Wen Wen, Yixiu Deng, Jiatong Li
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Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

The datasets used and analyzed during this study are available from the corresponding author, Kai Shang, upon reasonable request.

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