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Towards an Evaluation System of Disabled Individuals' Friendly Communities from the Perspective of Inclusive Development—A Case Study in Jinan

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Abstract: The quality of travel for residents has improved in China's urban renewal development, but there are still barriers to the activities of disadvantaged groups like people with disabilities in the city, including challenges with accessible travel and a lack of accessible design. All urban people should have access to services and be guaranteed equal rights, according to the inclusive development theory. This study examines the travel requirements and behavioural patterns of the barrier-free groups to safeguard the right of underprivileged groups to participate equally in the urban space. It also determines the impact of various types of urban land use and service facilities on the distribution of barrier-free facilities. An evaluation system based on the needs of the disabled group is established to evaluate the degree of barrier-free facilities in the surveyed areas, summarise the problems shown by the evaluation scores, and propose improvement strategies for the shortcomings of accessibility to residential areas and the controversy through web data crawling and a geographically weighted analysis. From the standpoint of inclusive development, the goal is to lessen the travel issues faced by underprivileged groups and to improve their capacity to take advantage of opportunities and have access to resources.

Keywords: inclusive development; disability friendly; accessible facilities evaluation; Jinan

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1. Introduction

1.1. Backgrounds

At the end of 2022, the urbanisation rate of China's resident population was 65.22%, which has stepped into the middle and late stages of the rapid development of urbanization. The development of urbanization has entered an important period of urban renewal, with the development path switching from "quantity" to "quality", and from large-scale incremental construction to stock-quality renovation focusing on improving urban quality [1]. In the context of urban renewal, the 2030 Agenda for Sustainable Development puts forward goals for building inclusive and sustainable cities, including the following goal: by 2030, to strengthen inclusive and sustainable cities and capacities for participatory, integrated, and sustainable human settlements planning and management in all countries and to provide universal access to safe, inclusive, accessible, and green public spaces for all, in particular, for women, children, older persons, and persons with disabilities [2]. Where the development of urban accessibility will immediately affect the travelling conditions of the elderly and persons with disabilities, etc., the construction of an accessible travelling environment is, therefore, an important part of inclusiveness. The 14th Five-Year Plan emphasises strengthening service facilities for persons with disabilities and comprehensive service capacity building, and improving the construction of barrier-free environments [3]. The State gives considerable attention to vulnerable groups, and the necessity to improve the barrier-free environment opens the way to the building of inclusive cities.

People with disabilities are a typical vulnerable group in society, and their needs must be seriously considered in the process of raising the quality of urban development. More

than 85 million Chinese citizens are disabled, and there are more than 64 million senior individuals who are disabled or semi-impaired. The design of accessible travel has emerged as a key issue in urban redevelopment since there is a sizable but unmet demand for it and significant challenges in the areas of basic life safety and social participation.

China began to build an accessible environment relatively late, with the concept of "accessibility" appearing for the first time in 1985 in a seminar on "Persons with Disabilities and the Social Environment". Some scholars have concluded that although the barrier-free design in China is being gradually improved, at the same time, there are still a lot of places that need to be improved: from the perspective of society, the designers do not have a sufficient understanding of accessible facilities, and all parties do not attach enough importance to the research and construction of the design of barrier-free access; from the perspective of management, there are often cases where barrier-free access is piled up with sundry things or damaged by road construction [4]. From a theoretical point of view, the overall research is still insufficiently emphasised, and there is a lack of better and more systematic design methods [5]. Overall, China's construction of an accessible travelling environment is insufficient because of the lack of attention to the perspectives of persons with disabilities and the psychology of persons with disabilities, as well as the lack of quantitative statistics and quantitative analyses of the degree of uniformity of the construction of accessibility facilities.

A nation's ability to advance economically and socially depends heavily on its infrastructure. However, it is crucial to evaluate the condition of the infrastructure, determine the regions that require the greatest care, and allocate the government's constrained budget to those areas [6]. More specifically, it would be effective and crucial to evaluate the present state of accessibility in a city to identify the areas that require updating and more relevance to the actual needs of people with disabilities.

The inclusive design of urban space is inextricably linked to the social component, which emphasises the city's openness, acceptance, recognition, and respect for all groups and classes of residents [7]. Current divisions should be improved to reduce the exclusion and segregation of disadvantaged groups in urban spaces, to guarantee equal power for every resident, and to promote equity and justice [8,9]. This paper analyses the travel needs and behavioural patterns of the accessible groups based on the theory of inclusive perspectives, focusing on the needs and problems of disadvantaged public groups in the context of urban regeneration and urban construction. The goals of this paper are to improve the quality of urbanisation, guarantee the right of disabled groups to use urban resources equally, and reduce the travel problems of disabled people. It proposes improvement strategies for the management of barrier-free facilities in combination with the needs of disabled groups, measuring the degree of perfection of the barrier-free environment through the establishment of an assessment system for the degree of perfection of barrier-free road facilities, to draw attention to the underprivileged groups and increase their opportunities for participation in public life.

1.2. Research Framework

Based on previous research, the urban accessibility update section is deepened, and quantitative analyses of the degree of urban accessibility improvement are conducted, an evaluation system is established, and the results of the research on the needs of persons with disabilities are made more intuitive, so as to assist in the analysis of the subsequent data and provide the basis for urban renewal. It then proposes urban renewal strategies and recommendations to make urban renewal services better and more inclusive. Figure 1 shows the flowchart of the paper's research.

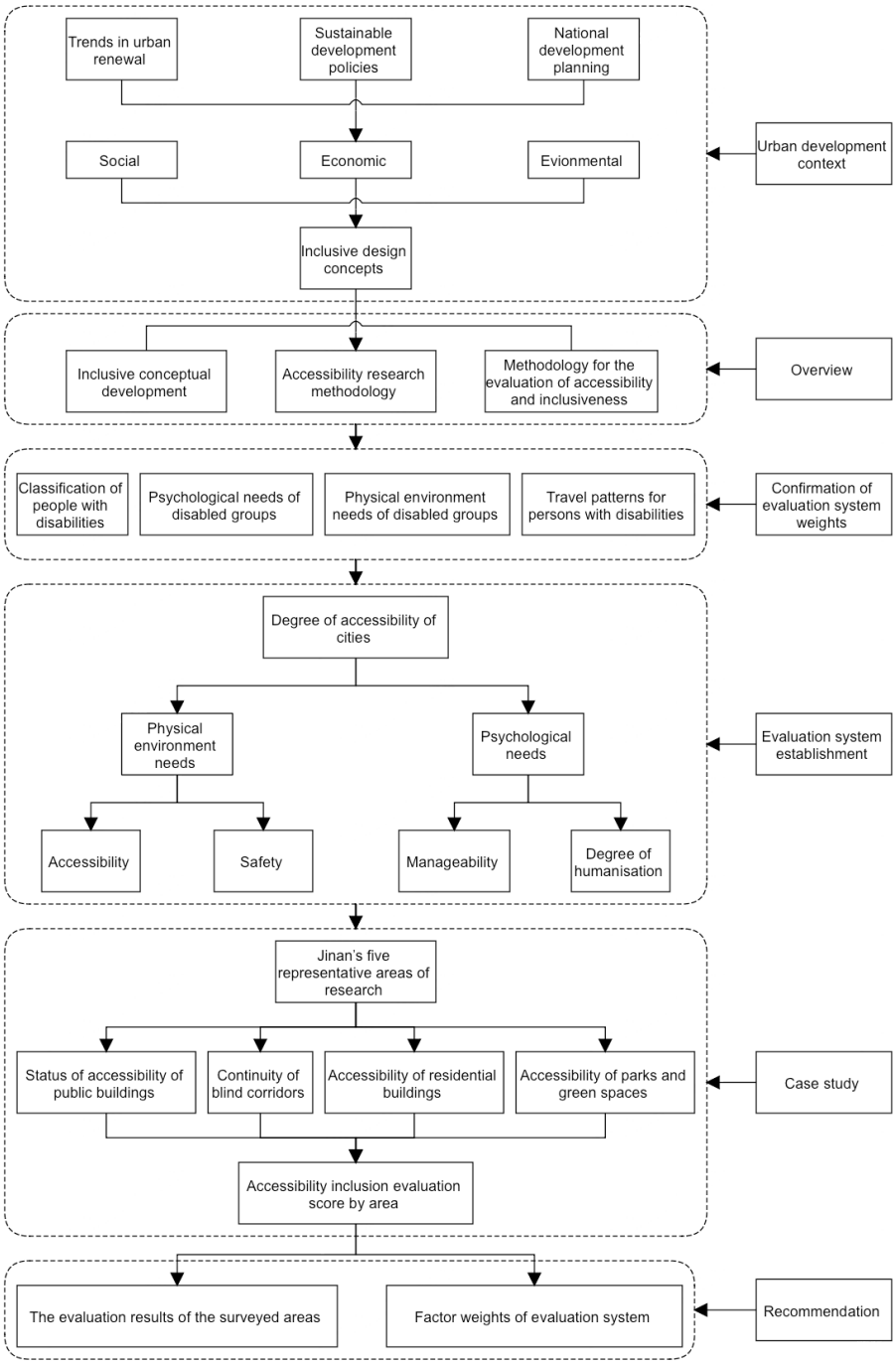


Figure 1. Research flow chart (source: the authors).

2. Overview

2.1. The Definition and Evolution of Inclusive Design Concepts

Inclusive development involves various aspects. From a social perspective, UN-Habitat first formally proposed the "inclusive city" initiative in the *World Cities Report* in 2000, emphasising the equal rights, resource sharing, and spatial balance of different urban subjects in the process of urban development, and promoting the equal participation of urban citizens in the development process under the guidance of the concept of inclusiveness; at the 2016 United Nations Conference on Housing and Sustainable Urban Development, inclusiveness was incorporated into the New Urban Agenda as a core concept, with "Cities for All, Equal Use and Enjoyment of Cities and Human Settlements by All" as a common vision to promote prosperity and improve the quality of life for all, by promoting social

cohesion, inclusiveness, and security in peaceful and pluralistic societies in which the needs of all inhabitants are met and the special needs of those in vulnerable situations are recognised [10]. The obstacles to travelling by vulnerable groups, such as the disabled and the elderly, should be eliminated and their right to participate in normal life should be guaranteed.

The notion of inclusive growth was initially introduced by the Asian Development Bank (ADB) in 2007 from an economic standpoint. Its objective was to enhance the accessibility of impoverished individuals to markets and essential productive assets, as well as to ensure their meaningful involvement in decision-making regarding resource management [11]. Within the framework of China's urban development agenda, inclusive growth entails the equitable distribution of economic development benefits throughout the urban development process, fostering coordinated and balanced development, and ultimately achieving shared prosperity [12].

In the spatial environment perspective, inclusive thinking first appeared in 1984 when Richard Hatch introduced the idea of inclusive design, defining it as "the ability of the public to participate in and control the environment". Later in 1994, Roger Coleman proposed inclusive design as an offshoot of disability design to create a friendlier future for all in terms of environmental design and assessment [13].

2.2. An Overview of Accessible Design from the Perspective of Inclusive Development

2.2.1. Introduction to Research Methods in Accessibility Studies

Previous scholarly investigations on accessibility design have employed various research methods such as questionnaires, simulations of disabled individuals' travel experiences, analysis of population characteristics, user research through zonal random sampling surveys, and others. These studies have focused on examining the current issues related to accessibility, the satisfaction levels of disabled populations, the challenges posed by obstacles, and the fairness of participation in social activities. Additionally, these studies have proposed specific strategies to address these issues. However, it is important to acknowledge that these investigations have certain limitations. For instance, they tend to overlook other types of disabilities when studying a specific group of disabled individuals. Moreover, these studies heavily rely on subjective human judgement and a qualitative analysis, lacking a quantitative analysis and the establishment of a comprehensive evaluation system. Specific literature arrangements are summarized in Table 1.

Table 1. Accessibility research methods review form.

Target	Methodology	Contents	Strategies
Utilisation rate of accessible facilities [14]	In-depth interviews and fieldwork	Socio-economic characteristics of persons with disabilities, travelling activities, living space, facility utilisation influencing factors	Universal design, optimising accessibility, frequency of use
Continuity and safe accessibility for accessible travelling [15]	Questionnaires, simulated trips for people with disabilities	Sample survey on travelling by people with disabilities, status and problems	Safeguard and regulatory system, promoting information accessibility
Status of facilities in the quarter-hour community service circle [16]	Questionnaire, factor analysis of population characteristics	Characteristics of the physically disabled population, characteristics of place needs, correlation between environmental needs and satisfaction	Addressing systemic issues, improve the education level of people with physical disabilities.

Table 1. *Cont.*

Target	Methodology	Contents	Strategies
Ordinary citizens, sanitation workers, the visually impaired [17]	Random sampling by district	Restrictions on the use of blind alleys, status of low travelling rate of visually impaired persons	Strengthening publicity, strengthening construction and maintenance, provide rehabilitation training for the visually impaired
Travelling life patterns of people with disabilities [18]	User research, environmental studies	Participation in social equity, assistive technology for travelling	Incorporate assistive technology for travelling

2.2.2. Introduction to Inclusive Evaluation

The evaluation of urban inclusiveness is a further deepening of the evaluation of accessibility. The design of accessible facilities necessitates the involvement and assessment of disability groups to ensure that their intentions and needs are comprehended and fulfilled, thereby fostering a more participatory and inclusive approach. Previous suggestions have emphasised the importance of recognising the diversity within the disabled community, promoting understanding and respect for individuals with disabilities, facilitating their active participation and cocreation in the design process, and conducting participatory observations to assess the actual usability of facilities by people with disabilities as part of the overall quality control. This research paper aims to contribute to the development of an evaluation system by investigating the specific usage requirements of individuals with disabilities. Relevant literature are summarized in Table 2 below.

Table 2. Inclusive accessibility design review form.

Concept Proposal	Participation of the Disabled	Methodology
Promote inclusive development and strengthening systematization [19].	Processes of policymaking	An analytical framework to study design and processes
Create community participation and boundary objects [20].	Participant observation Processes participation and cocreation	Two participatory agenda-setting projects
Recognize the diversity of disabilities. Expand the participation of marginalized groups in tourism decision-making [21].	Tourism producers, tourism consumers	Applying the conceptual framework for inclusive tourism development
Explore innovative barrier-free design methods [5].	Interaction with the design team	Conceptual and developmental overview Generalisation of methods and theoretical models
Inside the barrier-free community participatory planning [22]	Participation in community public hearings	Pattern language

3. Evaluation System

3.1. Establishment of the Evaluation

After consulting the pertinent policy manuals and papers in a previous article, it is necessary to research and compile the travel requirements and behavioural patterns of the

barrier-free groups to obtain the corresponding and more accurate impact indicators and weighting values. This will help with the renewal and construction of barrier-free facilities as well as the evaluation of the impact of various types of urban service facilities.

3.2. Needs of the Disabled Population

The direct aim of accessibility is to solve the mobility problems of disabled people, and through literature references, the needs of disabled people were collated from different perspectives in order to serve as a basis for the establishment of evaluation factors.

As users of barrier-free facilities and as special people in society, persons with disabilities need a change in perspective, the full consideration of their needs, the satisfaction of their needs as much as possible, and assistance in having their demands "seen and heard". Persons with disabilities have the same basic and generic needs as all human beings and the same needs to be met. Thus, in conjunction with Maslow's theory of needs, the analysis focuses on the integration of the five areas of physiology, safety, socialisation, respect, and self-actualisation [23]. The introduction and ranking of these five aspects are shown in Figure 2.

Figure 2. Maslow's hierarchy of needs.

Firstly, the most basic physiological needs for people with disabilities are equivalent to their reliance on accessible facilities in social and urban construction, which requires designers to accurately plan the application and layout of accessible facilities in public facilities. Secondly, the same low-level safety needs for people with disabilities are the need for the safe use of accessible facilities and a safe arrival at destinations, and to ensure their safety, it is necessary to focus on the need for a regular maintenance, a reasonable design, the ease of use, and the effective use of public facilities. Social needs and respect needs

are relatively high-level needs which belong to psychological aspects. The highest level of self-fulfilment needs refers to the process by which the individual's various talents and potentials can be brought into full play in a suitable social environment and the individual's ideals and ambitions can be realised, and in the case of a person with disabilities whose physical disabilities have already become a relative limitation, the limitations on their inner pursuits should be reduced to a minimum.

Based on this theory, and taking into account the realities of the situation, evaluation factors were determined on the basis of the needs of the different categories of the disabled groups themselves, the needs of the physical environment of the disabled, the psychological needs of the disabled, and their travelling patterns.

3.2.1. Categorization of Individuals with Disabilities

Through cooperation with the Jinan Disabled Persons' Federation, theoretical training, practical research, and classification of disabled groups were completed and the types of disabilities were categorised into four types: physical (A1), visual (A2), hearing (A3), and cognitive (A4) [24].

Persons with disabilities have different levels of disability and have different requirements for environmental accessibility. Among them, persons with physical disabilities who use mobility aids and wheelchairs and persons with visual disabilities have higher accessibility requirements: Persons with physical disabilities may have some difficulty in walking, climbing steps or slopes, and standing for long periods; persons with visual disabilities who have functional impairments in their vision or field of view mostly rely on their senses of touch and hearing to perceive their surroundings, or they use crutches or service animals to assist them in getting around. People with cognitive disabilities due to slow intellectual development have higher accessibility requirements, may have difficulty in using various service facilities, and have a limited range of activities, mainly in the residential area. Therefore, the main needs of this group of people are accessible facilities with strong environmental features and simple and clear flow lines in residential areas. On the other hand, persons with hearing disabilities and persons with upper-limb disabilities, who have difficulties in verbal communication, do not have walking difficulties, and have a high degree of self-care, have less issues with the accessibility of the built environment in terms of mobility, have lower accessibility requirements for the environment, and mainly require sufficient light and a quiet acoustic environment for hearing aids.

Through the categorisation study of different disability groups, the factors affecting the mobility of people with disabilities were compiled in descending order of influence: the continuity of blind corridors, the presence of ramp connections at height differences, the simplicity and ease of use of barrier-free facilities, the flow lines within the living area, and the light and acoustic environments.

3.2.2. Physical Environmental Requirements of Inclusive Communities

The physical demand primarily pertains to the need for accessible facilities and buildings, necessitating the implementation of appropriate design and management standards to address the physiological and safety requirements of individuals with disabilities. This encompasses various aspects, such as the inclusion of accessible entrances in residential buildings, the provision of flyovers and zebra crossings on pavements, and the construction of blind alleys within residential areas. Additionally, specific considerations must be made for certain facilities, such as designing wider accessible public toilets to accommodate wheelchair access and appropriately labelling parking spaces as barrier-free in car parks [25].

Travelling safety is the common mentality of all participants in urban transport, and it is the most basic requirement for all travelling activities [26]. Compared with ordinary people, disabled people are usually less capable of self-protection in traffic accidents than ordinary people due to their physiological insufficiency, so the probability and degree of injuries are higher than those of ordinary people.

The accessibility of information and communication also satisfies the physiological and safety requirements of people with disabilities. This is primarily reflected in the media facilities in public spaces that can communicate information to people with disabilities, enabling people with various types of disabilities to obtain information, primarily necessitating the consideration of both the visual and auditory senses [25]. Therefore, the weights of transport station services, public management and service facilities, and parks and green spaces should be moderately increased. Affected by the demand for community services and the shortcomings in accessibility services and awareness, the demand for accessible facilities in public utilities, commercial service facilities, and parks should also be moderately increased.

3.2.3. Psychological Requirements of Demographically Inclusive Cohorts

The user's control over the environment and the state of things is called controllability. Among them, psychological security is an important influencing factor [26]. For example, the continuity of the distribution of accessible facilities in transport venues and the availability of simple and easy-to-use accessible facilities affect the psychological needs of people with disabilities. Satisfying these psychological needs and providing a stable and humane experience for people with disabilities during travelling is conducive to helping people with disabilities overcome or even eliminate some of their psychological barriers, which in turn increases the likelihood of travelling in the future [26]. Among the previous needs by disability group, whether the barrier-free facilities are simple and easy to use, the flow line, light, and acoustic environment in a residential area can be used as controllable travelling factors, and the degree of universality of barrier-free facilities and the degree of appropriateness for different groups of disabled people can be used to evaluate whether the facilities are humanised or not.

3.2.4. Travel Behaviours Exhibited by Individuals with Disabilities

Accessibility refers to the ease of getting from one location to another and is often used to describe how human activities can maximise access using minimal activity and is an important basis when public facilities are built and planned [27]. Many factors in the city affect the accessibility of travelling for people with disabilities, and the higher the frequency of travelling, the higher the demand for this factor by people with disabilities, and the more important it is in the evaluation system. The research used data-collation field visits to the disabled and online questionnaires to summarise the travel patterns of the disabled; a total of 200 questionnaires were distributed, and the results showed that leisure trips and shopping trips accounted for the highest proportion of travel frequency, so when assigning weights affecting the distribution of accessible facilities, the proportion of parks, green spaces, and commercial service facilities should be increased as appropriate.

Based on the data shown in the aforementioned chart about the activity requirements of individuals with disabilities, it is evident that there is a greater occurrence of leisure and shopping excursions; however, the likelihood of engaging in other forms of travel is comparatively diminished. These results are summarized in Figures 3 and 4.

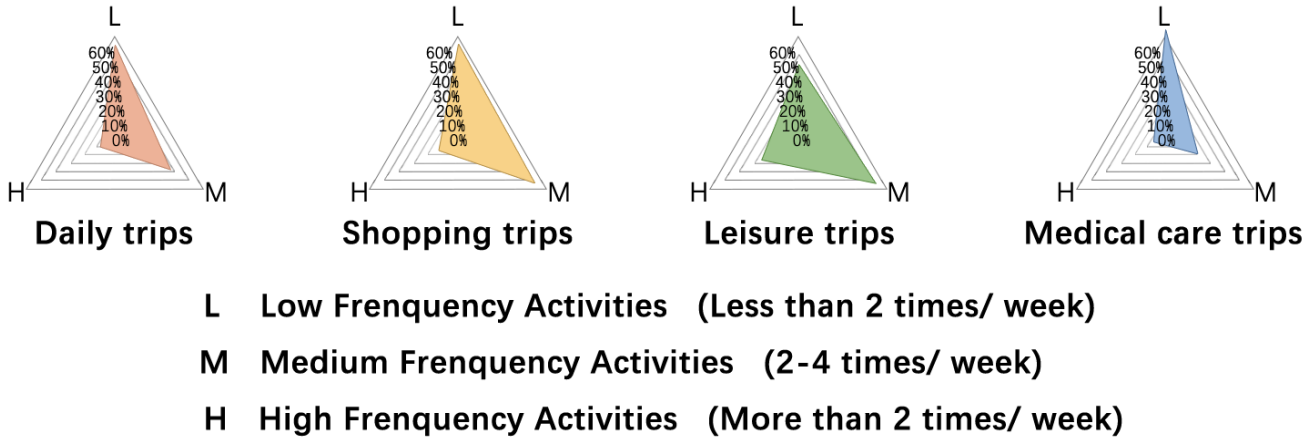


Figure 3. Radar map of frequency of travelling for different types of activities for persons with disabilities (source: the authors).

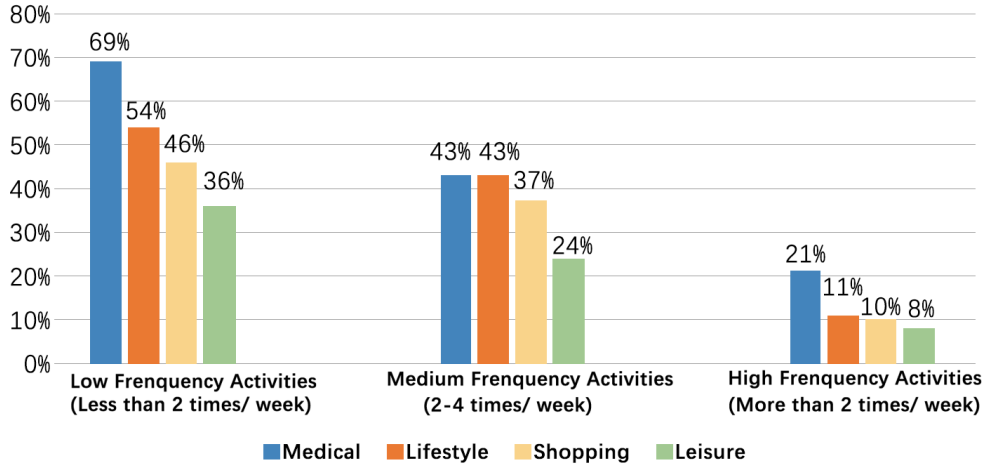


Figure 4. Histogram of travelling to different types of activities by persons with disabilities (source: the authors).

The chart illustrates the distribution of activity trips for disabled individuals across various categories. It reveals that medical and life service facilities exhibit the highest proportion in the likelihood of low-frequency trips. In terms of medium-frequency trips (2–4 days per week), both medical and life service facilities, as well as shopping facilities, demonstrate the highest proportion. As for high-frequency trips (more than 4 days per week), the proportion of medical, life, shopping, and leisure categories collectively decreases, although medical facilities remain predominant.

In conjunction with the previous section, public services and buildings for high-frequency travel were included in the accessibility factor for public buildings. Considering the constraints associated with travel distances for individuals with disabilities and the recommendations regarding the organisation of three-tier living areas, the public service facilities should consist of a blend of medical service facilities and living service facilities that are conveniently accessible to individuals with disabilities who travel by foot or wheelchair. These facilities should be accorded the highest priority compared with other service facilities.

3.2.5. Assessment of the Accessibility Scenario

In brief, the assessment of the level of adequacy of accessible facilities was conducted based on two dimensions: physical environment requirements and psychological needs. The former encompassed accessibility within buildings, road traffic safety, and the effectiveness of information exchange. The latter pertained to controllability and humanization. The specific factors for the evaluation are depicted in Figure 5.

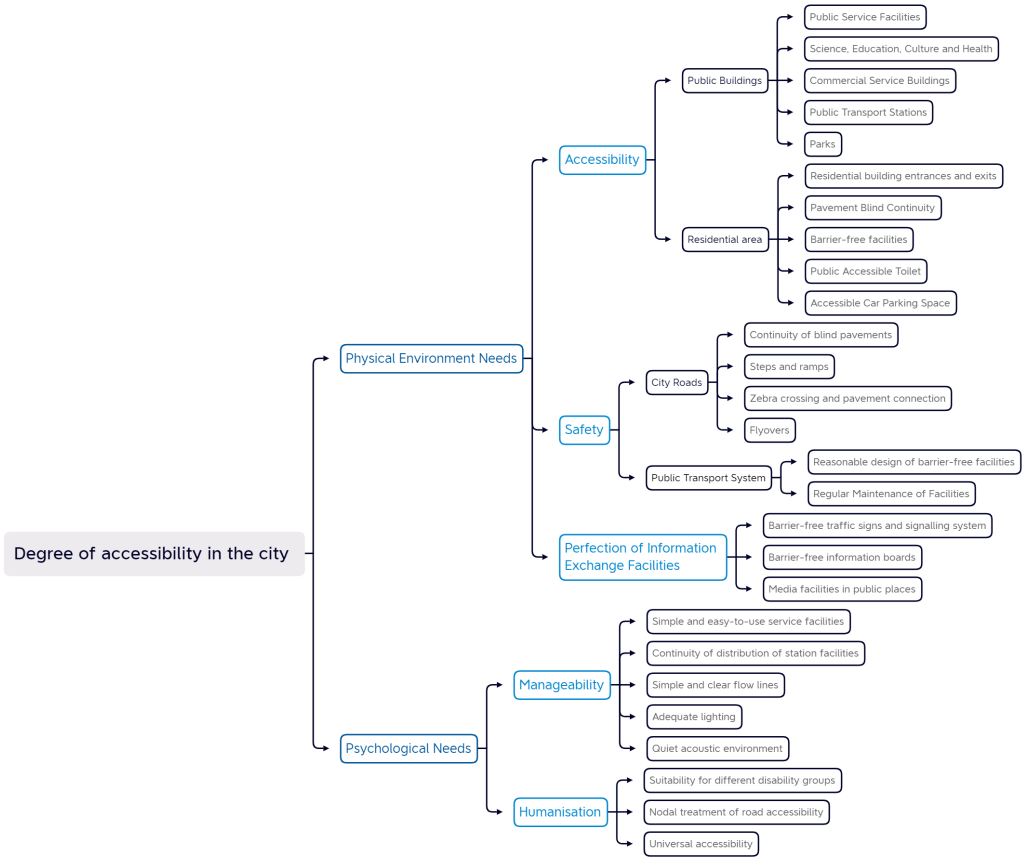


Figure 5. Factors of the evaluation (source: the authors).

In the preceding section, the hierarchical analysis approach was employed to develop an evaluation system for assessing the level of adequacy of urban accessible facilities, taking into consideration the travel and psychological requirements of individuals with disabilities. The evaluation formula was as follows:

$$Final\ Score = \sum(\sum(Initial * level3\ factor\ weight) * level2\ factor\ weight) * level1\ factor\ weight \quad (1)$$

The specific weight values are shown in the Tables 3–5.

Table 3. Primary evaluation factors.

Classification	Primary Evaluation Factor	Weight
Physical environment needs	Accessibility	0.443
	Security	0.316
Psychological needs	Controllability	0.168
	Humanisation	0.072

Table 4. Secondary evaluation factors.

Primary Evaluation Factor	Secondary Evaluation Factor	Weight
Accessibility	Public Buildings	0.413
	Residential areas	0.259
Security	City roads	0.178
	Public transport system	0.094
	Information-exchange facilities	0.056
Controllability		
Humanisation		

Table 5. Tertiary evaluation factors.

Secondary Evaluation Factor	Tertiary Evaluation Factor	Weight
Public buildings	Public service facilities	0.587
	Science, education, culture and health buildings	0.226
	Commercial service buildings	0.100
	Public transport stations	0.051
	Parks and green spaces	0.035
Residential areas	Residential building entrances and exits	0.605
	Continuity of blind pavements	0.214
	Accessibility facilities	0.097
	Public accessible toilets	0.005
	Barrier-free car parking spaces	0.034
City roads	Continuity of blind pavements	0.698
	Steps and ramps	0.186
	Zebra crossing and footpath junction	0.069
	Footbridge	0.046
Public transport system	Reasonable design of accessible facilities	0.800
	Regular maintenance of facilities	0.200
Information-exchange facilities	Barrier-free traffic signs and signalling systems	0.742
	Barrier-free information boards	0.183
	Media facilities in public places	0.075
	Simple and easy-to-use service facilities	0.499
	Continuity of distribution of station facilities	0.285
	Simple and clear flow lines	0.128
	Adequate lighting	0.057
	Quiet acoustic environment	0.032
	Suitability for different disability groups	0.528
	Nodal treatment of road accessibility	0.333
	Universal accessibility	0.140

4. Case Study

Jinan possesses a rich historical background, and the city is continuously undergoing modernization and advancement. The spatial configuration and economic progress of its districts exhibit significant disparities, particularly between the ancient cultural urban areas and the newly developed districts, which feature distinct environments and varying levels of construction quality. Furthermore, the policies governing these districts are subject to frequent updates. Consequently, the research on Jinan's districts encompassed a diverse range of sample types.

4.1. The Progression of Accessible Facilities Construction in Jinan City

Starting from 2006, after more than five years of unremitting efforts, the provincial capital Jinan's barrier-free construction policies, laws, regulations, and standards system was initially established, the number of accessible facilities further increased, the quality

was further improved, the layout was further rationalised, the whole society cared more and more about and supported a barrier-free development of the city, and the construction of urban-area accessible facilities saw some results. In September 2009, the Jinan Municipal People's Government issued The Measures for the Administration of Barrier-Free Facilities Construction in Jinan [28]. The measures established uniform provisions on the responsible departments, construction requirements, and construction projects of accessible facilities in Jinan, thus placing the construction of barrier-free facilities at the institutional level based on evidence and rules. The introduction of the regulations guaranteed and directed the significance of the promotion and improvement of accessible facilities construction in downtown Jinan as well as other areas under its jurisdiction. Taking this as a guide, Jinan began to strive to become a national barrier-free city, responding to the call of the Ministry of Housing and Construction, the China Disabled Persons' Federation, and the Committee on the Elderly, and began to create a "National Barrier-Free City" in a systematic manner. During this period, downtown pavements, major attractions, large shopping malls, and other places underwent an unprecedented large-scale barrier-free transformation.

The Municipal Construction Commission has issued a comprehensive repair plan that includes the renovation of 139 public buildings and facilities, such as Walmart, to make them barrier-free. Additionally, 10 parks and scenic spots, including Daming Lake and Baotu, will have barrier-free entrances, ramps, passages, aisles, staircases, and steps installed. Quancheng Square will also have a barrier-free lift platform established. Furthermore, 15 public transport facilities, such as the Remote Wall International Airport and East Railway Station, will undergo renovations based on their specific requirements. Major public places will see the installation of 530 Braille bus stops, while 934 major bus stops in urban areas will have passenger boarding and alighting guardrails implemented. Moreover, major bus stops in urban areas will have 2349 bus shelter seats installed. Lastly, the city's 196 residential neighbourhoods and corresponding residential buildings will be retrofitted with barrier-free pavements, green spaces, and public service facilities. Figure 6 is several real scenes of barrier-free facilities taken during the research.

4.2. Methods of Research

This paper summarises the behavioural characteristics, psychological features and group needs of disabled groups by investigating the awareness of various groups through a literature search and field observations to understand the needs and travelling characteristics of the barrier-free groups, and through field research, combined with interview and questioning methods to investigate the views of the disabled on the accessibility of the district's medium view of the trend of renewal. We explored the construction of accessible facilities in 26 subdistricts within the 5 main city districts of Jinan and analysed the current distribution of accessible facilities in the main city districts of Jinan, including the continuity, uniformity, and perfection of their distribution. Through this accessibility infrastructure research, the public's perception of the overall situation of accessibility in each area was analysed, and a visual analysis of the overall accessibility infrastructure construction in each area of Jinan City was obtained.

4.3. Research Material

This study covered 26 districts in Jinan City, including Guaiyin, Tianqiao, Shizhong, Lixia, and Lixiancheng, as well as five representatives of the central business district. There were also more than 240 research roads, 384 public buildings (including 125 bus stops, 7 large public parking lots, and 5 underground stations), 159 residential neighbourhoods, 17 parks and green spaces, and 11 historical structures. The study's overall mileage was approximately 169 km.

Figure 6. Partial accessibility facilities in the research area (**a**) Accessible ramp. (**b**) Accessible public toilet. (**c**) BRT accessible ramp and blind path. (**d**) Barrier-free elevator. (Source: Author).

4.4. Initial Examination of Research Findings

The prevailing public sentiment centred around the road infrastructure, residential structures, and commercial amenities situated alongside the park. This emphasis highlights the constrained nature of barrier-free construction efforts within the historic district, which is hindered by the need to preserve historical buildings and showcase external attractions. Consequently, the accessibility needs of disadvantaged residents and their corresponding psychological need for safety have been overlooked.

4.5. Assessment of Accessibility Infrastructure in Jinan Municipality

4.5.1. Examination of the Current State of Accessibility Features in Public Structures

The condition of accessible facilities in the three pavilions within the scope of the study was good; road sections such as Dongying Road, Xingfusi North Road, Weihai Road, Qingdao Road, Weifang Road, and other sections in Huaiyin District achieved a full coverage of blind alleys, and the setting of ramp edges was relatively perfect; recreational public buildings such as Wanshiang City, Evergrande Fortune Centre, Impression Jinan-Quanworld, Hongyang Plaza of Jinan, and Shandong Provincial Congress Theatre achieved a full coverage of barrier-free entrances and exits; and public buildings such as Hengyuan School, BeiduoYi Kindergarten, the Second Experimental Kindergarten in Huaiyin District,

Hengxin Primary School, and Majiyuan Kindergarten in Huaiyin District, and other educational public buildings also set up barrier-free entrances and exits. Other key facilities in other districts, including seven Tianqiao districts, three Shizhong districts, six Lixia districts, and four Licheng districts, also showed a generally good progress in terms of barrier-free construction. Many public places in Jinan were equipped with accessible facilities to protect the rights and interests of the disabled, such as the construction of ramps to ensure the smooth passage of prams and wheelchairs, the construction of barrier-free toilets in some parks to ensure the normal physiological needs of the disabled, the addition of barrier-free access at bus stops, and the setting up of guided tours for the blind at intersections to meet the needs of the blind.

This study analysed three distinct areas, namely the Quancheng Square area, the Quancheng Park area, and the Old Shangfu area, in order to identify the distribution of problematic points related to accessible facilities within each subarea. The analysis focused on various urban elements such as roads, bus stations, residential buildings, parks, green spaces, and buildings with historical and cultural significance. The aim was to provide a refined and systematic understanding of the identified issues, which is visualized in Figure 7.

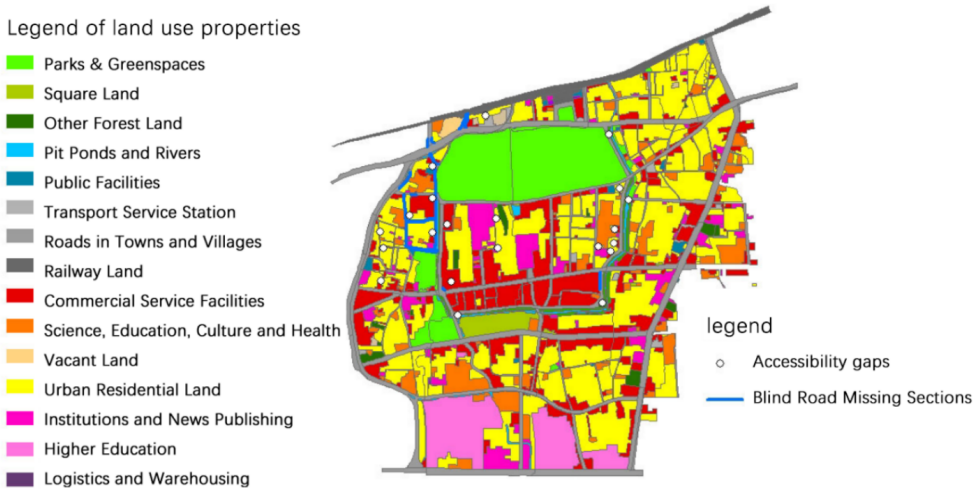


Figure 7. Distribution of problematic accessibility points and sections in the old town area (source: the authors).

Through the picture analysis, the continuity of the roads on the south and north sides of the park belt was good; however, the perfection and distribution were not good enough, which was reflected in the better degree of perfection of the barrier-free facilities on the south side of the base. A comparison with the buffer zone showed that there were localised areas of missing barrier-free facilities within 300–500 m of the buffer zone for public service facilities. In older neighbourhoods, such as the public service facilities around the settlement of the city of Zakyn, the accessibility index was poor and there were many missing locations, while the ageing phenomenon was serious, and the proportion of elderly residents with weak mobility was even higher, which required a more complete configuration of barrier-free facilities.

In the context of privately owned communities and real estate, as well as distant places like the southern highland areas, there persisted a prevalent deficiency in accessibility and inconsistencies in the development of accessible infrastructure.

4.5.2. Examination of Visual Impairment Continuity

Through research interviews with several handicapped individuals, it was revealed that the degree of continuity of accessible roads was a very major hurdle to disabled people's travelling. The resulting bar chart is shown below in Figure 8.

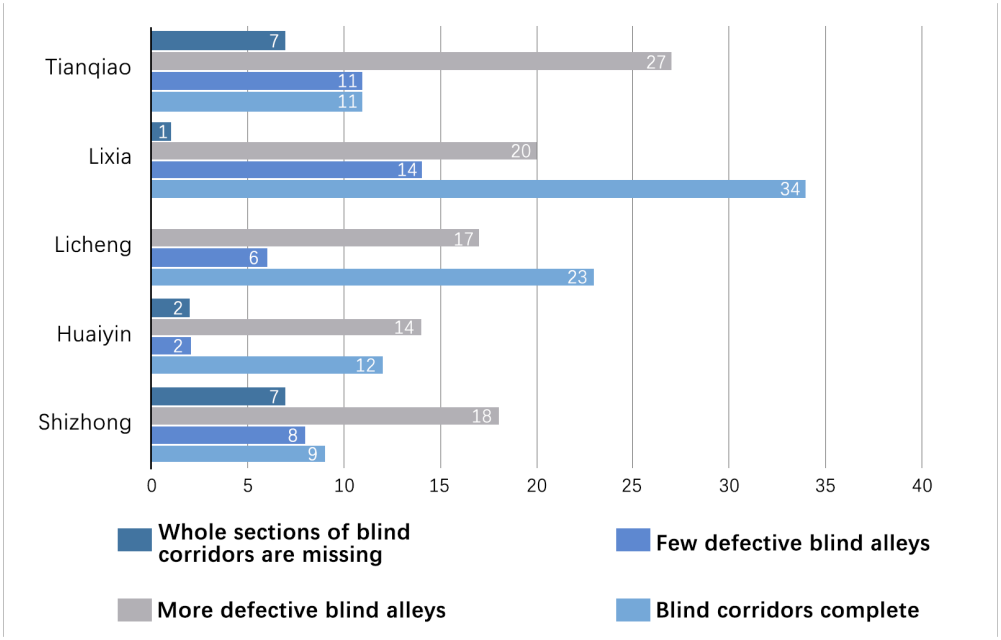


Figure 8. Road accessibility analysis (source: the authors).

Statistics on road facilities for the blind in each sub-district of the five districts in the main urban area of Jinan City found that the overall situation of the integrity of the blind on the roads accounted for a small percentage of the total roads researched, as each district was below 35%. Figure 9 shows the situation of blind access facilities in different areas on a map.

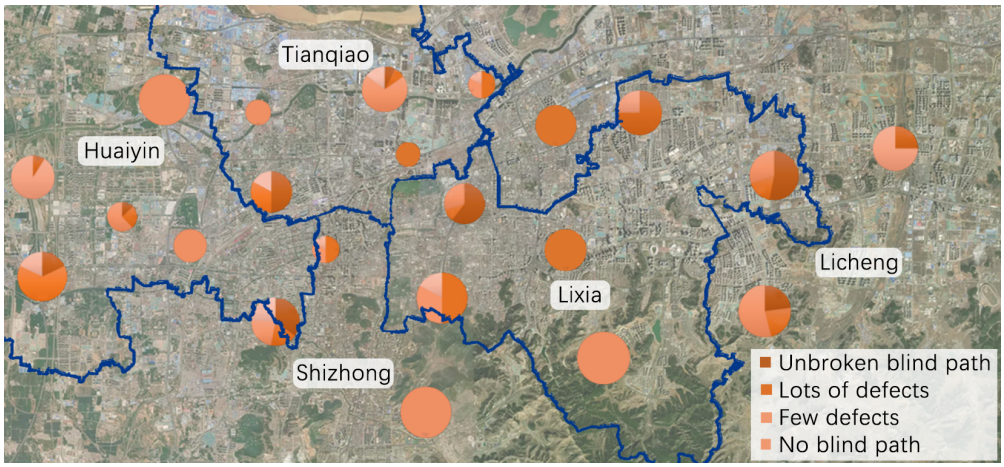


Figure 9. Summary map of Jinan Road facilities' accessibility analysis (Source: Author).

4.5.3. Examination of Accessible Facilities in Residential Structures

We conducted an in-depth investigation into the state of accessible infrastructure in residential buildings, including the examination of facilities such as lift shafts and public places within the community.

The distribution of accessible facilities in residential buildings exhibited a pattern similar to that observed in road transport facilities (Figure 10). Specifically, Lixia District demonstrated the most favourable overall situation, which was roughly commensurate with the level of economic development in each respective region. However, there were relatively fewer areas that boasted superior overall accessible facilities, indicating the need for a further improvement in the overall barrier-free environment.

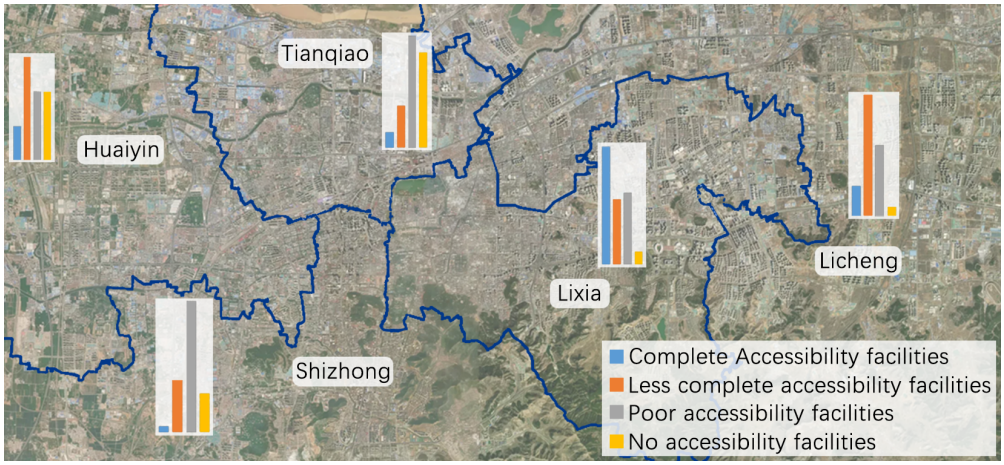


Figure 10. Summary map of analysing accessibility in residential neighbourhoods (source: the authors).

4.5.4. Examination of Accessible Facilities in Environmentally Friendly Parks

The parks were divided into seven gradients using a gradient division method, which was based on the development of barrier-free services in green areas. To visually represent this division, a map was utilised with a visualisation technique.

A visual analysis showed in Figure 11 that the accessibility of parks and green spaces in Jinan City was not good enough. According to this analysis, it could be seen that the areas with better accessible facilities were concentrated in the central area of Jinan City, and the accessible facilities in the old city areas were improved based on the existing ones, such as the Gucheng, Honglou, and Tianqiao areas, while the new city areas, such as the Hanyu and Long'ao areas, had a low degree of improvement of accessible facilities; in addition, the remote areas not part of the centre of the urban area of Jinan City, such as the Longdong area, were generally free of barriers, and the southern mountainous areas had a low degree of improvement. From this, it could be seen that the coverage of barrier-free facilities in Jinan City was not wide enough, and the areas with perfect barrier-free facilities were only limited to the central urban area, historical preservation areas, and areas with a better economic development, while the coverage and perfection of remote areas were insufficient. Figure 12 shows some areas where the accessibility facilities are incomplete.

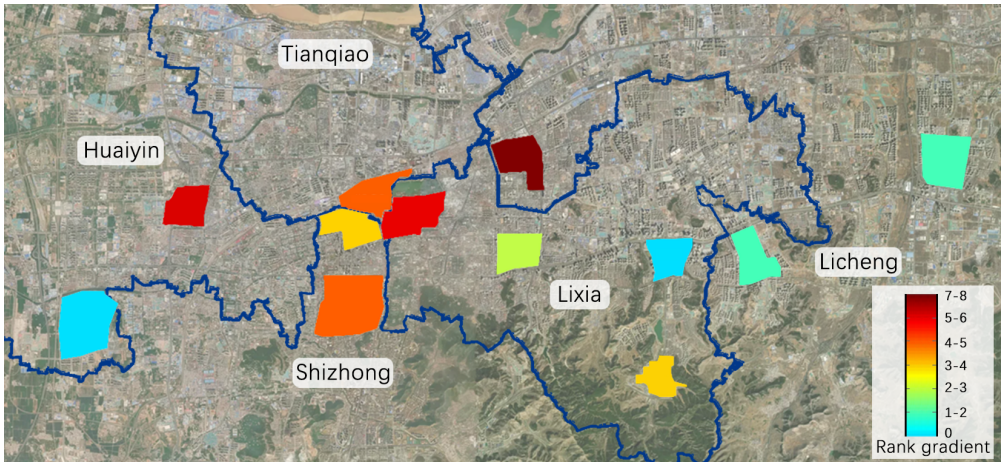
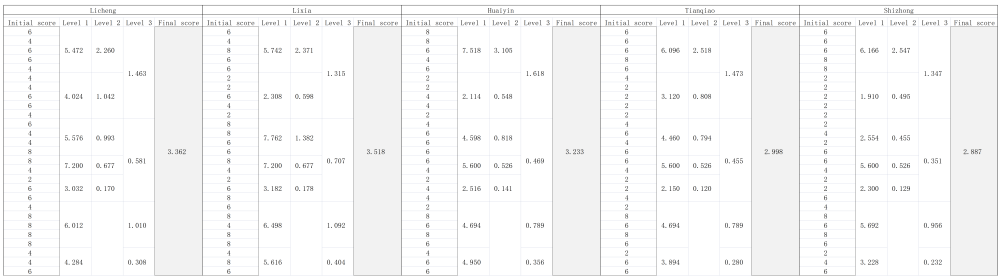


Figure 11. Summary chart of the analysis of the accessibility improvement of parks and green spaces (source: the authors).

Figure 12. Some inadequate accessibility facilities. (**a**) There are still no ramps in some small parks and there is a large height difference. (**b**) The blind path ended abruptly (source: the authors).

4.6. Assessment of Accessible Infrastructure in Researched Environments

Based on the findings of the study, the evaluation of accessible facilities in Huaiyin, Tianqiao, Shizhong, Lixia and Licheng was conducted utilising the assessment framework outlined in the preceding section whose results are arranged in Figure 13.



Licheng					Lixia					Huaiyin					Tianqiao					Shizhong				
Initial score	Level 1	Level 2	Level 3	Final score	Initial score	Level 1	Level 2	Level 3	Final score	Initial score	Level 1	Level 2	Level 3	Final score	Initial score	Level 1	Level 2	Level 3	Final score	Initial score	Level 1	Level 2	Level 3	Final score
6					6					8					6					6				
4					4					8					6	6.096	2.518			6	6.166	2.547		
6	5.472	2.260			8	5.742	2.371			6	7.518	3.105			8					8				
6					6					4					6			1.473		8			1.347	
4			1.463		6			1.315		6			1.618		4					2				
4					2					2					2					2				
4					2					2					2					2				
6	4.024	1.042			6	2.308	0.598			4	2.114	0.548			2	3.120	0.808			2	1.910	0.495		
6					4					4					2					2				
4					2					2					2					2				
6					8					4					4					2				
4	5.576	0.993			8	7.762	1.382			6	4.598	0.818			6	4.460	0.794			4	2.554	0.455		
4					6					6					4					2				
8				3.362	6				3.518	6				5.233	6				2.998	6				2.887
8	7.200	0.677	0.581		8	7.200	0.677	0.707		6	5.600	0.526	0.469		6	5.600	0.526	0.455		6	5.600	0.526	0.351	
4					4					4					4					4				
2					2					2					2					2				
6	3.032	0.170			6	3.182	0.178			4	2.516	0.141			2	2.150	0.120			2	2.300	0.129		
6					8					4					4					6				
4					6					2					2					4				
8					8					8					8					8				
8	6.012		1.010		4	6.498		1.092		6	4.694		0.789		6	4.694		0.789		6	5.692		0.956	
8					8					8					8					8				
8					8					6					6					6				
4					4					4					2					2				
4	4.284		0.308		8	5.616		0.404		6	4.950		0.356		6	3.894		0.280		4	3.228		0.232	
6					6					6					6					6				

Figure 13. Score by region (source: the authors).

The districts' scores, arranged in descending order, were as follows: Lixia: 3.518, Lixing: 3.362, Huaiyin: 3.233, Tianqiao: 2.998, Shizhong: 2.887. The accessibility was the highest in the locality of Huaiyin, and the safety, controllability, and humanisation were all the highest in Lixia. Based on the evaluation results, the corresponding factors will be updated or improved.

5. Conclusions and Recommendations

This study presents conclusions and recommendations regarding the existing issues surrounding accessible facilities. The recommendations primarily emphasise two aspects. On the one hand, it is to propose improvement strategies for the accessibility of Jinan's researched area based on the results of the research and evaluation, and on the other hand, it is to make suggestions for an inclusive urban renewal based on the factor weights in the evaluation system.

5.1. Strategies for Increasing Accessibility in Selected Jinan Districts Based on Evaluation Results

Bar charts as shown in Figure 14 were made to visually compare the district-level factor-weighted scores , and generalised improvement strategies were proposed for each of the five research areas.

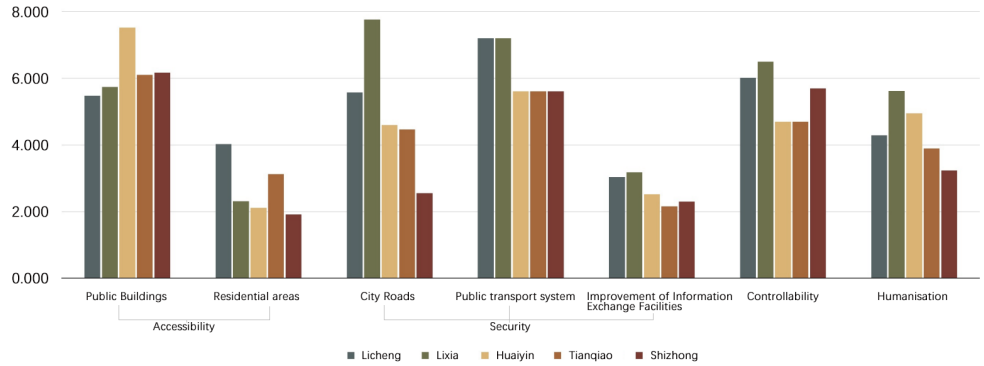


Figure 14. Comparison of level 1 scores of the five districts (source: the authors).

The five districts were all poor in terms of accessibility, information-exchange facilities, and humanisation of residential areas, and should be updated with accessible services such as bus stops, traffic signal systems, and accessible nodes, as well as maintaining blind alleys at entrances and exits of buildings and pavements in residential areas. The continuity of urban roads in the central district was also poor, and blind facilities, pavements, and zebra crossings should be managed and corrected to improve the continuity of roads.

5.2. Urban Renewal Recommendations Based on Evaluation Systems

Based on the evaluation scores, recommendations were made for the renewal of barrier-free facilities: priority was given to the renovation of barrier-free facilities in public buildings and the planning of barrier-free environments in residential areas, followed by the improvement of the accessibility of urban roads and the accessibility of the public transport system, and lastly, the management and maintenance of small-scale barrier-free service facilities, and so on.

1. New public buildings should strictly comply with barrier-free design norms and build barrier-free facilities with high quality; old public buildings with substandard facilities should be rectified and supervised within a limited period and follow-up maintenance management should be strengthened [29];
2. In residential areas, the barrier-free facilities that should be paid attention to include ramps, passages, doors, handrails and lifts, etc.; road accessible facilities should be improved with kerb ramps, blind corridors, etc.; and ancillary public service facilities, such as public toilets, accessible parking spaces, low-level service facilities and lifting platforms, etc., should also be fully equipped [30];
3. The improvement of road continuity should focus on the management and maintenance of blind alleys, connecting height differences with ramps, etc.; the standardisation strategy of the transport system includes: regulating the taxi industry to eliminate the phenomenon of taxis refusing to carry the disabled, transforming bus stop signs set in a high position and with a small font, and in terms of traffic management, increasing the punishment of vehicles occupying blind alleys, etc. [31];
4. Other accessible service facilities should be more user-friendly, easier to use, and regularly maintained and managed, and nonstandard facilities should be remedied to reduce inaccessibility or poor accessibility [32];
5. With the development of information technology and intelligence, intelligent assistive facilities for disabled people travelling have been paid attention to and researched, and various intelligent accessible facilities such as smart blind canes, smartphones with accessibility functions, and smart wheelchairs have appeared one after the other; some scholars have also researched the monitoring of high-risk zones for vulnerable groups, such as the elderly, who are prone to fall in outdoor environments [33], which provides a scientific basis for the construction of the public service field and enhances the convenience and safety of disabled people's travels as well as the efficiency and accuracy of the improvement of the barrier-free environment.

6. Conclusions and Prospect

At present, Chinese cities are in the stage of quality improvement, and there is still room for exploring research on urban renewal. The evaluation system established in this paper is only a tool and basis for one branch of this renewal. On this basis, more in-depth and comprehensive research will be carried out at a later stage to gradually build more inclusive and livable cities.

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References

1. Wang, P. *Wang Pingping: The Total Population Decreased Slightly and the Level of Urbanization Continued to Improve*; State Statistics Bureau: Beijing, China, 2023.
2. 2030 Agenda for Sustainable Development. New York, USA, 2016; Available online: https://sdgs.un.org/2030agenda (accessed on 20 October 2023)
3. National Development and Reform Commission. *Outline of the 14th Five-Year Plan (2021–2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China*; National Development and Reform Commission: Beijing, China, **2021**.
4. Huang, B.; Lv, X.; Fang, Y. Survey and Reflection on the Status of accessibility facilities. *For. Sci. Technol. Intell.* **2023**, *55*, 165–167.
5. He, X.; Yang, Y. A Review of the Current Research Status of Accessible Design Methods. *Packag. Eng.* **2023**, *44*, 60–73. [CrossRef]
6. Boix-Cots, D.; Pardo-Bosch, F.; Pujadas, P. Analysis and Comparison of the Infrastructure Report Cards as a Decision Making Tool for Sustainable Development. *Buildings* **2023**, *13*, 2166. [CrossRef]
7. Huang, X.; White, M.; Langenheim, N. Towards an Inclusive Walking Community—A Multi-Criteria Digital Evaluation Approach to Facilitate Accessible Journeys. *Buildings* **2022**, *12*, 1191. [CrossRef]
8. Tang, Y.; Liu, Y.; Wang, Y. From Growth to Inclusion: The Multidimensional Connotation and Assessment of Inclusive Cities from the Perspective of the Right to the City. *J. Shanghai Adm. Coll.* **2023**, 48–64.
9. Harris, E.; Franz, A.; O'Hara, S. Promoting Social Equity and Building Resilience through Value-Inclusive Design. *Buildings* **2023**, *13*, 2081. [CrossRef]
10. United Nations. New Urban Agenda. In Proceedings of the Section III United Nations Conference on Housing and Sustainable Urban Development, Quito, Ecuador, 20 October 2016.
11. Asian Development Bank. *Strategy 2020: The Long-Term Strategic Framework of the Asian Development Bank 2008–2020*; Asian Development Bank: Manila, Philippines, 2008.
12. Xiang, D. Implications of the Concept of Inclusive Development for the Construction of Social Policy in China. *Soc. Sci.* **2012**, *1*, 70–74.
13. Xu, J. Multi-dimensional analysis and visualisation of inclusive design methodology. *Design* **2021**, *34*, 102–105.
14. Jing, X.; Xia, J.; Chen, H.; Wang, X. A study on the low utilisation rate of barrier-free facilities from the perspective of disabled people—A case study of Nanjing city. *Urban Plan.* **2020**, *44*, 47–56.
15. Zhao, P.; Chen, J. Study on the continuity of barrier-free design at the boundary of public space in old urban areas–Hangzhou City as an example. *Intell. Build. Smart City* **2022**, *8*, 160–164. [CrossRef]
16. Yuan, Z.; Liu, T.; Shao, L. Accessibility Needs and Satisfaction of the Physically Disabled in Beijing's Quarter-hour Community Service Circles. *Planner* **2019**, *35*, 25–31.
17. Wu, Y.; Gao, G.; Wu, M.; Wang, X.; Xue, P.; Gou, B. Investigation and analysis of the application status of urban barrier-free facilities (blind passage). *Chin. Tissue Eng. Res.* **2020**, *24*, 271–275.
18. Zhang, M.; Fu, J.; Liu, J.; Yan, M. Research on Urban Public Transport Travelling Service for Disabled People. *Packag. Eng.* **2022**, *43*, 199–207. [CrossRef]
19. Andersen, A.D.; Andersen, P.D. Foresighting for inclusive development. *Technol. Forecast. Soc. Chang.* **2017**, *119*, 227–236. [CrossRef]
20. Hinrichs, M.M.; Johnston, E.W. The creation of inclusive governance infrastructures through participatory agenda-setting. *Eur. J. Futures Res.* **2020**, *8*, 15. [CrossRef]
21. Gillovic, B.; McIntosh, A. Accessibility and Inclusive Tourism Development: Current State and Future Agenda. *Sustainability* **2020**, *12*, 15. [CrossRef]
22. Sun, J. *A Pattern Language-based Participatory Planning Approach for Barrier-free Communities*; Harbin Institute of Technology: Harbin, China, 2021.
23. Maslow, A.H. *Motivation and Personality*; Harper and Row: New York, NY, USA, 1970.

24. Hong, C.; Donghui, Z. Barrier-free design of residential areas and characteristics of disabled people. *Sichuan Archit. Sci. Res.* **2009**, *35*, 259–261.
25. Jin, C. A Study on Barrier-Free Travelling for People with Disabilities from a Systems Perspective. Master's Thesis, Guangxi Normal University, Guilin, China, 2019.
26. Cai, Y. Research Review on the Mobility Psychology of Disabled People and Suggestions on Urban Transport Planning. In Proceedings of the Annual Conference on Urban Planning in China 2016, Shenyang, China, 24–27 September 2016; p. 12.
27. Karlqvist, A. *Some Theoretical Aspects of Accessibility-Based Models//Dynamic Allocation of Urban Traffic Models*; Columbia University Press: New York, NY, USA, 1971.
28. General Office of Jinan Municipal People's Government .*Jinan City Barrier-Free Facilities Construction Management Measures*; General Office of Jinan Municipal People's Government: Jinan, China, 2009; pp. 8–9.
29. Sun, Z. A Study on Enhancing the Satisfaction of Barrier-Free Facilities Construction. Master's Thesis, Tianjin University, Tianjin, China, 2021.
30. Zhang, W. Standardised Construction Practice of Barrier-Free Facilities in Urban Residential Areas. *China Stand.* **2021**, *2*, 145–149.
31. Ye, H. Jinan: Barrier-Free Facilities for the Disabled Are Difficult to Satisfy. *China Disabl. People* **2013**, *12*, 6.
32. Zhang, S.; Xu, B. Barrier-free facilities still face the "three no-uses" barrier. *Beijing Dly.* **2023**, *8*.
33. Meng, J.; Yang, L.; Lei, H. Promoting Elderly Care Sustainability by Smart Village Facilities Integration—Construction of a Public Service Field with Introduction of Fall Posture Monitoring. *Buildings* **2023**, *13*, 2144. [CrossRef]