A Case Study of Disability-Friendly Community Infrastructure Design

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Abstract: There is a large group of disabled people in China, and as a disadvantaged group in the society, their travel is greatly affected by the physical barriers on both city and community level. In this article, the Dongan International Community in Hohhot was taken as an example to study the current accessibility level of domestic communities and to analyze the lack of assistive facilities for disabled people in them. Weighted Sums Approach is applied to conduct statistics and research, and eventually propose relevant improvement suggestions for the community in terms of disabled parking spaces, disabled toilets, and other accessible facilities.

Keywords: Disabled Population; Physical Barrier; Weighted Sums Approach; Inclusive Infrastructure.

1. Introduction

According to data revised by the World Health Organization in 2022, about 1 billion individuals, or 15% of the world's population, have certain degrees of disability. 253 million of them have varied degrees of visual impairments, 466 million have crippling deafness and hearing loss, 200 million have intellectual disability (IQ below 75), and roughly 75 million need wheelchairs on a daily basis. There are more than 85 million people with disabilities in China, accounting for 6.84% of the total population, which is equivalent to one person with a disability in every 15 people. However, people with disabilities rarely appear in the public, far below the statistics. With urbanization, cities are becoming more and more crowded, but the disabled population has to give up venturing in the city due to multiple barriers. According to the University of Ottawa, there are 4 types of barriers influencing the accessibility of the handicapped population to the urban space. First of all, the attitudinal barrier represents the behaviors and perceptions that discriminate against the disabled persons. Organizational barriers are the policies or daily practices that unfairly treat the people with disability and prevent them from fully participating into the society. Physical barriers are non-standard infrastructures and outdoor spaces that create physical impediments for the disabled persons, such as the design of sidewalks and the entrances to the building. Lastly, information barriers are impediments constraining the people with sensory disabilities. Physical barriers are one of the most influential factors towards the handicapped population. Due to physical barriers such as the infrastructures that lack the necessary standards for the need of the disabled, the disabled population, especially those with physical impairments, is unable to travel freely across the city or even the community. Thus, the disabled population will be more likely to lock themselves at home instead of venturing outside. The urban environment can be regarded as being constructed for the healthy and robust bodies and unwelcoming to the people with disabilities, both at the city and community levels. The public space claims ableism, “the systematic oppression faced by disabled persons as a minority population in a society where the ‘able-body’ occupies a position of privilege” [1]. People with disabilities are being treated unequally by this auto-disabling environment, while every citizen has the right to enjoy the varied facilities in the urban space.

Some developed countries have done a better job of building more inclusive infrastructure than China, developing urban land use plans, policies, and building codes that are beneficial to mobility for people with disabilities. But even so, their disabled populations still call for the need to build assistive infrastructures into urban spaces. In Canada, for example, 44.9 percent of those Canadians with physical disabilities need at least one assistive device, according to its 2017 census. For those aged 15 and older with physical disabilities, 38.8% of men and 49.4% of women requested accessible assistive devices in all buildings and public spaces in urban environments. In China, the most notable accessibility features for people with disabilities are tactile pavings, which assist and guide those with visual impairments and can be found on the vast majority of sidewalks in Chinese cities. But these pavings are also flawed; they are inefficient, they risk being occupied, and people may miss them, overtake them, and fail to anticipate them. But even so, communities in China are not equipped with the tactile pavings that are already common on city sidewalks. Especially in older communities, buildings are not equipped with elevators, sidewalks have no assistive designs, and there are no handicapped ramps built for wheelchair users to get around easily, creating a huge physical barrier for people with disabilities to move around in the community. People with disabilities rely heavily on others to travel, and our community services are not comprehensive towards the people with disabilities. Those with physical disabilities cannot even get out of their communities on their own, and physical barriers and accessibility in the community are a major factor affecting the mobility of the people with disability.

Thus, starting in 2016, the UN has begun to advocate for the development of a more inclusive and accessible urban environment, with the goal of removing the considerable barriers that unfairly prevent people with disabilities from participating in everyday life. Building an inclusive city starts with building a disability-friendly community with standard accessibility facilities. In this article, Weight Sums Approach will be used to explore the accessibility of the Dongan International Community in the city of Hohhot, and suggestions for building an inclusive community that is friendly to people with disabilities will be propsed.

2. Literature Review

As citizens of society, people with disabilities should have the same rights as normal people, but due to the lack of physiological structure and functions, they are in a disadvantageous position in daily life, social interaction, transportation, employment, and related daily activities. As a disadvantaged group, the income level and living condition of people with disabilities are generally different from the average level of society, and they should gain special attention and protection from the government and the society. An inclusive community, as an important part of the social support system for people with disabilities, is an important measure to protect and safeguard the rights and interests of people with disabilities and is also one of the important supports for the state and society to promote the work and development of people with disabilities.

2.1 Differences with developed countries in implementation and maintenance of disability-friendly infrastructure construction

There is a gap between China and developed countries in the construction of barrier-free facilities, which has seriously harmed the rights and interests of people with disabilities in China. Some scholars suggested that this is caused by the difference between China and developed countries in the guarantee mechanism and implementation method of those inclusive infrastructures [2]. The scholar took the United States and Japan as examples to compare with our country. The construction of social accessibility facilities in the United States is promoted and amended by the Supreme Court, in collaboration with 11 prosecution courts, 95 local courts and 4 special court judiciaries. In the construction of specific inclusive infrastructures, it is subject to comprehensive legal supervision, and lawyers can represent people with disabilities to sue the government for unreasonable and deficient in the construction of those inclusive infrastructures, and the law plays an important role in the

guarantee and implementation of these infrastructures. The construction of inclusive infrastructure in Japan is also subject to strict auditing, and its construction is divided into three stages, design plan review, mid-project inspection and acceptance after project completion. All the disability-friendly facilities have to go through these three stages, and only after the acceptance can get the permit and put into use. However, although the barrier-free facilities in China are designed, constructed, and accepted simultaneously with the major building, this mechanism does not involve the participation of disabled people, so it cannot meet the refined and humanized needs of using individuals. Many of the facilities are designed to meet the standards, not whether they are actually convenient and useful. Therefore, some scholars suggest that the future community construction in China should be tested by the comfort and satisfaction of people with disabilities, and this scholar believes that the future community should and must be an accessible community that can accommodate all kinds of groups including people with disabilities [3]. The construction of the community should be based on the principle of Regulations on barrier free environment construction, so that people with disabilities can be less dependent on others. And the experience of people with disabilities should be included in the construction of accessible communities, so that people with disabilities can experience and provide their specific opinions. It is believed that incorporating the suggestions and experiences of people with disabilities into the construction of disability-friendly infrastructure is an important measure to create an inclusive community, and improve the guarantee mechanism and implementation method of China in terms of inclusive designs. The establishment of laws and regulations about the rights and interests of people with disabilities and the construction of inclusive infrastructures need to include the participation of the Disabled Persons' Federation or other organizations representing people with disabilities

2.2 Low utilization rate of barrier-free facilities

Some scholars suggested that there is a low utilization rate of accessibility facilities in China [4]. This scholar took the disabled people in Nanjing as a sample and found that those who thought "the frequency of using accessible infrastructures is not high" accounted for more than 80% of the respondents. For example, the slope of ramps which is too high and has the risk of falling, and the tactile paving which is occupied by electric bicycle are the reasons why many disabled people choose not to use accessible infrastructures when they travel. The scholar argues that the construction of many barrier-free facilities is detached from the basic purpose of ensuring the mobility of people with physical disabilities. The current focus of building these accessible designs is on construction rather than practicality. Thus, increasing the use of barrier-free facilities should be considered an important part of building an inclusive environment and an important measure to protect the rights of people with disabilities. It is considered that this scholar's study has a large sample and covers a large number of factors, giving a complete picture of the low utilization rate of inclusive infrastructures in Nanjing. The fact that Nanjing, as a developed city in the east of China, still has such a serious situation that affects the mobility of people with disabilities shows that the disabled community in China needs more attention and protection.

2.3 Summary of the literature

From the articles, we can conclude that people with disabilities have a small range of daily activities and a short travel time. Therefore, the construction of accessible facilities in the community becomes an important factor for people with disabilities to travel. However, because of the inadequate guarantee mechanism and implementation method of accessible facilities in China, a large number of inclusive infrastructures cannot satisfy the needs of the disabled population, with low utilization rate and obvious deficiencies. This obviously affects the legal rights and interests of people with disabilities and their daily life. There is still more space for development in the laws and regulations, design, guarantee mechanism and audit system related to inclusive infrastructures in China.

3. Research Methodology

3.1 Research formula

Our research methodology will be based on the Weighted Sums Approach used by Abdol Aziz Shahraki in his Urban Planning for Physical Disabled People's Needs with Case Studies [5]. This method considers several criteria to assess whether a community's-built space meets the needs of people with disabilities. The formula for this research method is.

$$WS\ of\ Bi = \sum_{j=1}^{n} Wjaij, i = 1,2,2, \dots, m \quad (1)$$

This formula measures n criteria to determine whether a facility is accessible and meets the needs of people with disabilities, based on their experiences and observations of each facility, with a total community score of Bi(T), which gives

$$Bi(T) = \sum_{j=1}^{n} Wjaij, i = 1,2,3, \dots, m \quad (2)$$

This research methodology will assess how disability-friendly the community is through six sets of criteria.

[Si, i = (1,2,3,4,5,6)]

3.2 Refinement of study standards

Table 1. Accessibility standards applicable to our communities and the factors they cover

Mark	Standard Group	Indicator Investigated	Indicator Weight	Group Weight
S1	Walkway standards	Aisle width of at least 140cm	7	22
		There are blind alleys	7	
		Reasonable way of laying blind paths	4	
		No significant differences in aisle surfaces other than blind	2	
		The colour of the blind alleys contrasts with the surrounding surfaces	2	
S2	Slope Standards	Popularisation of slopes	7	20
		Slope width at least 120cm	3	
		Guardrails on both sides of the slope	3	
		Guardrail diameter up to 3.5cm	1	
		Guardrail height between 65 and 80cm	1	
		Slope gradient between 5 and 8 degrees	3	
		Minimum slope surface dimensions of 150 x 150cm	2	
S3	Lift standards	Standard lifts	10	20
		Minimum space for lift 110x140cm	4	
		Lift entrance space minimum 150 x 150cm	4	
		Lift button height between 100 and 120cm	2	
S4	Architectural door standards	Door width of at least 100cm	5	15
		No threshold or threshold below 2cm	3	
		Door handle height up to 100cm	2	
		Equipped with electric doors	5	
S5	Community Facilities Standards	Public toilets available	6	20
		Handicapped accessible toilet	6	
		Minimum 170x150cm bathroom space, wheelchair swivelable	2	
		Toilet side assist handle	2	
		No smooth or slippery surfaces	1	
		Clear signage for disabled facilities	3	
S6	Parking standards	Disabled parking spaces	2	3
		Special signs for disabled parking	1	

The six groups of criteria are walkway criteria, ramp criteria, lift measures, building door criteria, community facilities criteria, and parking criteria. Each standard covers several small factors that determine whether it is handicap friendly or not. However, as Shahraki's study was conducted on foreign buildings, some elements do not match our residents' habits and the domestic community's characteristics, such as the pull-out taps in accessible toilets. Some widely used accessibility features are not covered, such as blind corridors; as mentioned by Syaodih and Aprilesti in their paper Disability-Friendly Public Space Performance [6], "Blind corridors should be laid and logically and should not be close to maintenance holes, and They should not be close to maintenance holes and drains so as not to confuse the blind. They should be of a contrasting color to the surrounding surfaces for the benefit of people with visual impairment". In addition, Yuan Yue, in his study on the architectural design of integrated service facilities, refers to activity areas, which he describes as "places for rehabilitation, recreation and leisure for people with disabilities ..... providing a comfortable and safe healthy environment for people with disabilities" [7]. He also described the space issue of the lift entrance not mentioned by Abdol Aziz Shahraki, and Yuan Yue believes that the lift entrance should have a 150 x 150cm swing area to accommodate the wheelchair user's swivel space. With our appropriate modifications, the six sets of criteria to assess whether the community is disabled-friendly are listed in Table 1.

3.3 Refinement of the weighting of each criterion and factor

The weighting of each criterion used by Shahraki in his article was determined by expert opinion, the response of people with disabilities and the actual results in the field, see Table 2.

Table 2. Weights of the various criteria used by Shahraki in his text

Indicators	S1 (%)	S2 (%)	S3 (%)	S4 (%)	S5 (%)	S6 (%)	Total
Weighting	16	18	17	16	18	15	100

However, the weights of these six indicator groups do not apply to communities in China. For example, the criteria for car parking, which is a typical facility abroad to serve people with disabilities but is relatively uncommon in China, requires progress in community planning for both surface and underground car parks in our communities to be equipped with parking spaces for people with disabilities, so the weighting of the car parking criteria should be reduced when studying our communities. Furthermore, the scores of Shahraki in the references for each building for each measure are a combination of the respondents' thoughts on his survey, and the scope of the study is uncertain and highly subjective. This paper combines the opinions of experts and suggestions from people with disabilities and reassigns the weights of these six groups of criteria and the individual factors they cover to investigate whether the community facilities at East Coast International in Saihan District, Hohhot, are disabled-friendly; please refer to Table 3; and the weights of the minor factors covered by each group of criteria, please refer to Table 1.

Table 3. Weights of each criterion used in this study

Indicators	S1 (%)	S2 (%)	S3 (%)	S4 (%)	S5 (%)	S6 (%)	Total
Weighting	22	20	20	15	20	3	100

4. Case Studies

4.1 Research Subjects

The East Coast International Community in Hohhot City is selected as the research object. The East Coast International Community is one of the first new standard communities in Hohhot with good facilities, a greening rate of over 50%, a low population density, and a recreational park. According to the survey, there are nearly 100 people with various types of disabilities in the community and many elderly groups with mobility problems. To meet the travel needs and safety issues of the disabled and elderly groups in the community, the East Coast International Community

should be equipped with comprehensive and convenient barrier-free facilities. The following data was obtained from a field study of accessibility standards in six groups in the community.

Table 4. Scores obtained after survey for each criterion

Mark	Standard	Factors	Achieved or not	Score	Total score
S1	Walkway standards	Aisle width of at least 140cm	Yes (220cm)	7	7
		There are blind alleys	No	0	
		Reasonable way of laying blind paths	No	0	
		No significant differences in aisle surfaces other than blind	No	0	
		The colour of the blind alleys contrasts with the surrounding surfaces	No	0	
S2	Slope Standards	Popularisation of slopes	Yes	7	19
		Slope width at least 120cm	Yes (150cm)	3	
		Guardrails on both sides of the slope	Yes	3	
		Guardrail diameter up to 3.5cm	Yes	1	
		Guardrail height between 65 and 80cm	No (120cm)	0	
		Slope gradient between 5 and 8 degrees	Yes	3	
		Minimum slope surface dimensions of 150 x 150cm	Yes	2	
S3	Lift standards	Standard lift	Yes	10	16
		Minimum space for lift 110x140cm	Yes	4	
		Lift entrance space minimum 150 x 150cm	No	0	
		Lift button height between 100 and 120cm	Yes	2	
S4	Architectural door standards	Door width of at least 100cm	Yes	5	7
		No threshold or threshold below 2cm	No (3cm)	0	
		Door handle height up to 100cm	Yes	2	
		Equipped with electric doors	No	0	
S5	Facility standards	Public toilets available	Yes	6	9
		Handicapped accessible toilet	No	0	
		Minimum 170x150cm bathroom space, wheelchair swivelable	No	0	
		Toilet side assist handle	Yes	2	
		No smooth or slippery surfaces	Yes	1	
		Clear signage for disabled facilities	No	0	
S6	Parking standards	Disabled parking spaces	No	0	0
		Special signs for disabled parking spaces	No	0	

4.2 Formula calculation

By substituting the scores obtained for each indicator into the formula, if the community is planned to be accessible and disabled-friendly, it can obtain：

WS of B0 = (22 x 0.22) + (20 x 0.20) + (20 x 0.20) + (15 x 0.15) + (20 x 0.20) + (3 x 0.03) = 19.18 (3)

It brings the results of our research on the East Coast International Community in the Saihan District of Hohhot into the formula, setting the community as B1, and get：

WS of B1 = (7 x 0.22) + (19 x 0.20) + (16 x 0.20) + (7 x 0.15) + (9 x 0.20) + (0 x 0.03) = 11.39 (4)

4.3 Evaluation of Summary

Figure 1. Elevators, parking spaces, ramps, and walkway facilities in the community

Based on these six groups of indicators, it can conclude that the ideal barrier-free community has a score of 19.18. The lower the score, the society under examination is doing a poor job in building facilities for people with disabilities. After calculation, the score of the East Coast International Community is 11.39. By comparing the data, it can find that the East Coast International Community in Hohhot does not fully meet the needs of the disabled regarding free movement, and there is still more room for improvement. Of the six criteria determining whether a community is disabled-friendly, East Coast International scored 7/22 on the walkway criterion, 19/20 on the slope criterion, 16/20 on the lift criterion, and 10/15 on the building door criterion, respectively 11/20 on the facilities criterion, and 0 on the parking criterion. Compared to other older communities in China, the East Coast International Community has achieved relatively good results regarding accessibility to lifts and ramps, meeting the majority of factors such as ramp gradient, size, and charge space. The community is also equipped with public toilets, and the doors of the units in the community are generally up to standard. However, the planning and design of the community leave much to be desired.

(1) Lack of accessible parking spaces

First, the East Coast International Community does not have unique parking spaces for the disabled to facilitate travel. The nearest parking space can be designated as an accessible parking space.

(2) The absence of blind alleys

Secondly, the East Coast International Community does not have blind corridors on the internal walkways, and there are no excessively bright color contrasts. This will significantly facilitate the mobility of people with disabilities who travel alone. Although blind passages have been widely used on urban pavements in China, they are still relatively rare in the community.

(3) Building doors are too high and not equipped with electric doors

The door frames are too high for wheelchair access, and the building doors still require a manual swipe to open the electric gates, which is inconvenient for people with mobility problems.

(4) Lack of accessible toilets

A barrier-free toilet for the disabled should be more significant than an ordinary toilet so that wheelchair users can turn around quickly and be equipped with auxiliary facilities and signs stating that it is a toilet for the disabled so they can use it conveniently.

5. Conclusions

Through the research, it can be seen that there is a lack of parking spaces for disabled people in the East Coast International Community. There are no blind lanes on the sidewalks in the community, and there is a lack of signs of barrier-free facilities for disabled people. The reasons for these problems are that the community has shortcomings in the consideration of facilities that are convenient for the disabled during the construction and design process, and the society does not pay enough attention to the disabled and the quality of life. People are accustomed to the fact that there must be someone to take care of disabled people around them, but they ignore the obstacles and difficulties that disabled people may encounter when traveling alone. Therefore, the care for disabled people is seriously insufficient in design. Based on the existing problems in the community, suggestions relevant departments to supervise the construction of new infrastructure in the community, such as adding handrails that are convenient for the disabled, widening the ramp in front of the corridor, and converting unused parking spaces to disabled people at a certain rate can be proposed. The lack of awareness of caring for the disabled in the construction and design process is a common phenomenon. For a long time, the image of the disabled in people's minds is that of "crippled people" who must depend on others and have no ability to live. In fact, the personality and social value of the disabled are downgraded. The welfare of a large number of disabled people in my country has not been resolved, largely because my country has not yet formed a complete legal and regulatory system to protect the legitimate rights and interests of disabled people. The problem of persons with disabilities is an inherent problem in human society. For any country with a social system, at any stage of social development, it is unavoidable and cannot be ignored, and it is a serious social problem involving a considerable number of people.

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