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The spatial layout of community-based elderly care facilities in Lanzhou Chengguan district based on smart city construction

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Abstract. With the accelerated process of an aging society, the number of elderly people has increased dramatically, and community-based elderly care service has become a hot topic in recent years. Lanzhou City is a typical city suffering severe aging problems in the northwest region of China. This article takes Chengguan district in Lanzhou City as an example, focuses on community-based elderly care facilities, uses the network analysis method of public facility service areas via GIS software to analyze and evaluate the accessibility of three types of facility sitting, and proposes rational suggestions for the spatial configuration. The results show that the "Integrated Service Center for the Elderly" facilities are mainly concentrated in the downtown and the densely populated residential areas with a north-sparse and south-dense distribution pattern. The "Happy Kitchen" facilities are located mainly on the west side of the downtown, filled with many unit communities and thorough public infrastructure providing corresponding hardware support. The "Health Medical and Care Station" facilities are located on Qingbaishi Street in the northeast of the city, mainly relying on the newly built community health center. The uncovered areas mainly exist in the north and south sides of Chengguan district, because these areas are mountainous regions with fewer residential areas. This article suggests constructing elderly care facilities considering different facility functions and the needs of the elderly, carrying out the hierarchical layout of elderly care facilities according to the coverage range of accessibility, and building new elderly care facilities based on old sites and facilities.

Keywords: smart city, community-based elderly care, network analysis, accessibility, GIS.

1. Introduction

Governments and social organizations have been working to build multidimensional and high-quality elderly care services to provide better elderly care services and experiences to senior citizens. Community-based elderly care, as the main form of home-based elderly care [1], undertakes most of the elderly care functions in society, providing a series of elderly care services, such as meal assistance, daytime care, and health care to senior citizens at the most basic material living unit. It has become the backbone of the home-based elderly care industry.

In China, the level of development of elderly care systems varies among cities. First-tier cities have developed elderly care facilities earlier, with accumulated experience and relatively complete policy systems [2]. However, compared to the entire northwest region, especially Lanzhou City, the

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development of the elderly care industry is slow, and the facilities and services are relatively backward. With the growing number of elderly people, the rational allocation and layout of community-based elderly care facility resources have become an important foundation for the sustainable development of the home-based elderly care service industry [3].

In order to improve the urban elderly care services in underdeveloped areas, evaluating the current status of local facilities becomes the primary task. The accessibility service area network is an effective analysis method that calculates the coverage rate of the facility service points and the ease of reaching the destination from any point in space. This method can be used to analyze the service scope of elderly care and can also be used in urban planning to study the coverage range of public facilities [4]. This study takes Chengguan District in Lanzhou City as the object, using GIS methods to conduct an accessibility analysis of facility points. The study identifies problems with the layout of urban elderly care facilities and provides scientific planning guidance.

2. Background

2.1. Location of Lanzhou city

Lanzhou is located in the northwest of China, in the transitional zone from the Qinghai-Tibet Plateau to the Loess Plateau [5], with a total area of 13,100 square kilometers. Chengguan District is the central district of Lanzhou, with advantages in politics, economy, culture, scientific research, transportation, and commerce. It is located between the north and south mountains of the city, with the Yellow River flowing through, and its geographical location is extremely advantageous. The district is approximately 20.02 kilometers long from east to west and 22.6 kilometers wide from north to south (Figure 1).

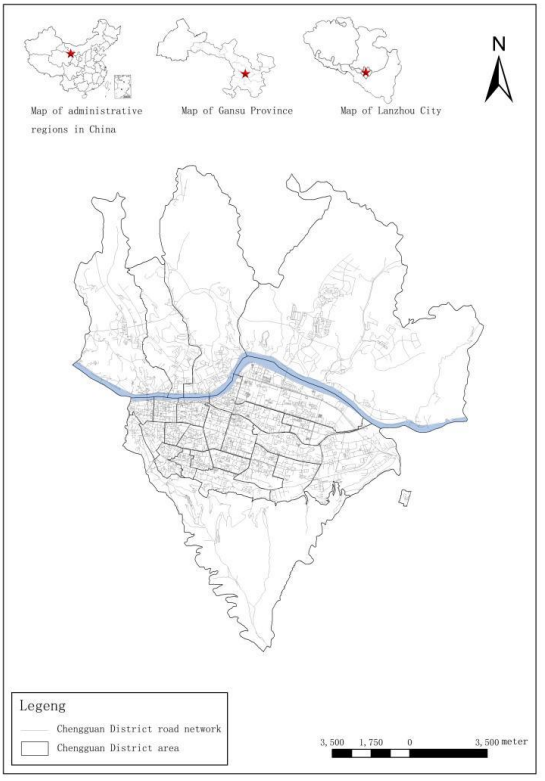

Figure 1. Location and layout of Chengguan District in Lanzhou city.

2.2. Current status of elderly care facilities in Chengguan District

Chengguan District is located in the eastern part of Lanzhou Basin, divided into two areas by the Yellow River. The buildings on the north side of the Yellow River are constructed at the relatively flat foot of the

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mountains due to the trend of the mountain ranges. Public facilities are also distributed along the Yellow River due to the terrain, which results in a relatively small population in this area. The terrain on the south side of the Yellow River is generally flat, with convenient transportation networks and a large built-up area, which accounts for a large proportion of the population. Therefore, most public facilities, commercial places, and cultural industries in the urban area are arranged here. Among them, elderly care facilities are mainly constructed as "Comprehensive Elderly Service Center", "Happy Kitchen", and "Healthy Medical Care And Nursing Station" [6, 7].

2.2.1. Comprehensive elderly service center

(1) Service Objectives and Contents

The "Comprehensive Elderly Service Center" is a "one-stop" elderly care service facility focusing on the elderly and providing daily entertainment and other activities. It is mainly located in the community.

(2) Facility Distribution

The "Comprehensive Elderly Service Centers" in Chengguan District are generally built inside community office buildings and transformed from idle houses in the community. They are mainly located in the built-up areas on the south side of the Yellow River where the road network is developed, and more are located on the west side than on the east side (Figure 2). Most streets have one facility, while a few have more than one. In addition, the elderly care facilities on the west side of the street show a clustered distribution within a small area, with several facilities close to each other, and the ones on the east side are characterized by a scattered layout within a small area.

2.2.2. Happy kitchen

(1) Service Objectives and Contents

The "Happy Kitchen" is a meal assistance service point that provides meal processing, centralized dining, or delivery for the elderly.

(2) Facility Distribution

The distribution is mainly on the west side of the built-up area (Figure 2). Each street has one "Happy Kitchen". The distribution is sparse, with more facilities on the south district's west side. There are currently no facilities on the east side.

2.2.3. Healthy medical care and nursing station

(1) Service Objectives and Contents

The "Healthy Medical Care and Nursing Station" provides residents with close, easy-to-obtain, and convenient free basic physical examinations and related physical therapy services to improve residents' physical health.

(2) Facility Distribution

There is currently only one fully functional "Healthy Medical Care and Nursing Station" located in the northeast of Qingbaishi Street in Chengguan District (Figure 2). It is directly set up in a community health care center [8], relying on existing community health care to provide elderly people with traditional Chinese and Western medical treatment, rehabilitation nursing, and health management. It can better provide elderly people with rehabilitation and physical therapy space in terms of space while also integrating social public service facility resources to alleviate social public service space pressure.

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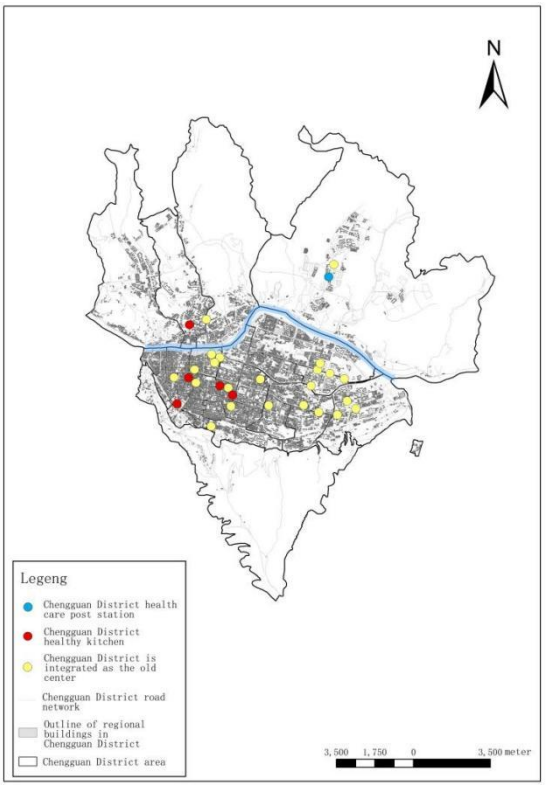

Figure 2. Current layout of relevant home care service facilities in Chengguan District.

3. Methods

3.1. Data source

This study used GIS software to extract road network data and facility location information based on Baidu Maps and POI data points for obtaining basic road network data (Figure 3) [9].

3.2. Service area network analysis

Service area analysis is an important method used in urban planning and site selection analysis to analyze the service range of public facilities [10]. The feature of a service area is "the calculation of the coverage area of the central point given a range", with the keyword being "coverage". The minimum input elements are facility points, time, and road network, while the output elements are the coverage area of the service area.

3.3. Accessibility analysis

In calculating the service range (accessibility) of community-based elderly care facilities, we consider the characteristics of the transportation mode, time, and urban road level for the elderly to community-based elderly care facilities [11].

Firstly, the road network in the Chengguan district is sorted, and roads are classified by level. The travel time of roads is calculated according to the walking time of different levels of roads: 40 meters/minute for expressways, 70 meters/minute for trunk roads, and 80 meters/minute for internal roads, branch roads, and secondary roads. Then, a transportation road network dataset is constructed [12].

Next, service area network analysis is used to create new service areas for comprehensive elderly services with elderly care facilities as facility points. The time cost is taken as the variable, and the best travel time for the elderly is referred to. The accessibilities of elderly care facilities within 0-5 min, 5-10 min, 10-15 min, 15-20 min, 20-30 min, and 30-60 min are analyzed.

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Furthermore, no obstacles are set in the accessibility analysis. The road network is defined as bidirectional without detours, ensuring that the time cost is the only factor affecting accessibility (Figure 4) [13].

Figure 3. Transportation road network dataset map.

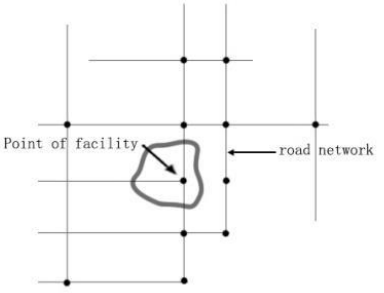

Figure 4. Sketch map of network model construction.

4. Accessibility analysis

4.1. Comprehensive elderly service center

Figure 5 shows the accessibility coverage of the "Comprehensive Elderly Service Center" in Chengguan District. The results show that more than a quarter of the residents in the study area cannot use the elderly care facilities within 30 minutes, and more than half cannot use the elderly care facilities within 60 minutes (Table 1).

Table 1. Accessibility coverage of elderly care facilities.

Regional Levels	Time (min)	Accessibility coverage rate (%, as a percentage of the total area of Chengguan District)		
		Comprehensive Elderly Service Center	Happy Kitchen	Healthy Medical Care and Nursing Station
1	0-5	2	0.4	0.04
2	5-10	5	2	0.2
	10-15	6	2	2
3	15-30	14	7	2
4	30-60	23	17	8

Note: Region level I represents the closest area that can be covered within 0-5 (min) of accessibility, while level V represents the farthest area that can be covered within 30-60 (min) of accessibility.

Core area I (0-5 min) is mainly distributed on both sides of the main urban area, accounting for about 0.4% of the total area of Chengguan District. It is easier for the elderly and those with limited mobility to enjoy elderly care facilities, although the coverage area is relatively small. Core area II (5-15 min) covers about 4% of the total area of the district. This time zone could be designated as a concentrated construction area for "Comprehensive Elderly Care Services" according to the suitable travel time standard, although this zone proportion is not high. Most elderly people should enjoy home-based elderly care services in this time zone. Core area III (15-30 min) covers an area of 14% of the entire district, but the longer walking time slows down the willingness of the elderly to go there.

Overall, the coverage rate of the "Comprehensive Elderly Care Service Center" in Chengguan District is better in the west and the south than in the east and the north [10]. It can be seen that there are

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significant deficiencies in the rationality of the layout of the comprehensive elderly care service in Chengguan District.

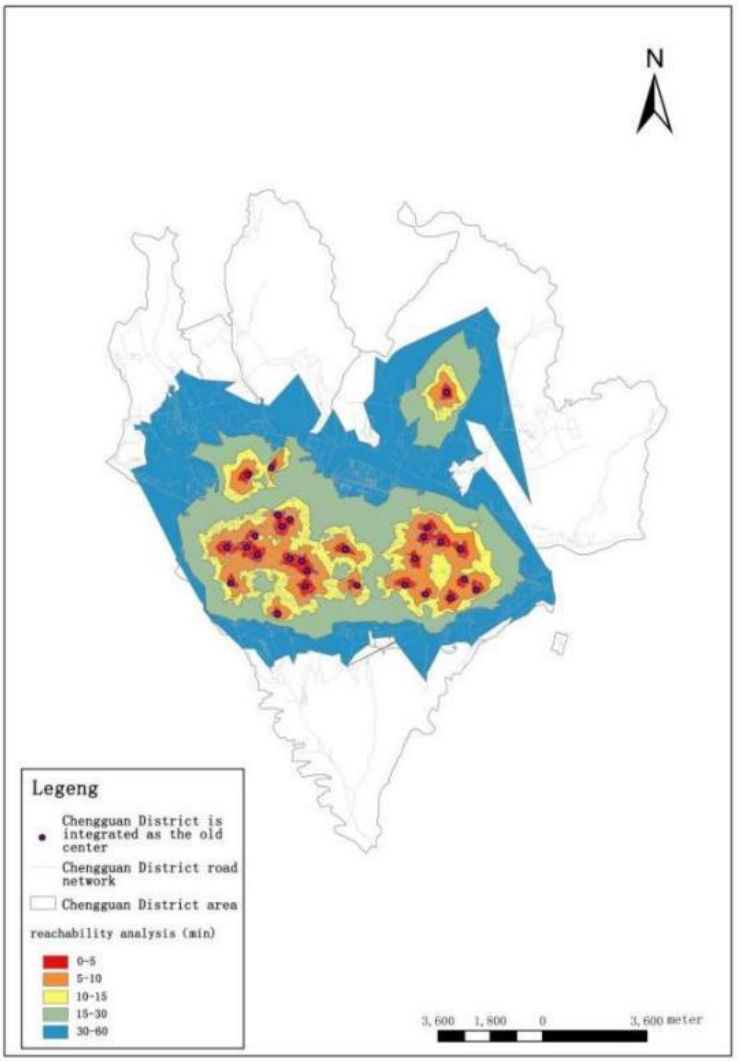

Figure 5. Accessibility analysis map of "Comprehensive Elderly Service Centers" in Chengguan District.

4.2. Happy kitchen

Results show that more than 2/3 of the area's residents cannot enjoy meal assistance services within 60 minutes, and the area that can be reached within 5 minutes only accounts for 0.4% of the study area. The distribution of this dining service is uneven and severely lacking on the north, south, and east sides of the district (Table 1, Figure 6).

Core Area I (0-5min) is mainly located on the west side of the main city area, accounting for approximately 0.04% of the entire Chengguan District. Core Area II (5-15 min) accounts for 4% of the entire area, and some elderly people with mobility issues hope to enjoy meal assistance services in this time zone based on field visits. Core Area III (15-30 min) accounts for 7% of the entire area, and compared with "Comprehensive Future Service Facilities," some elderly people feel that both Core Area II and Core Area III are within an acceptable walking distance. Based on the above description, it can also be seen that the different service content of the facility points can also lead to changes in the rationality of the accessibility segment range.

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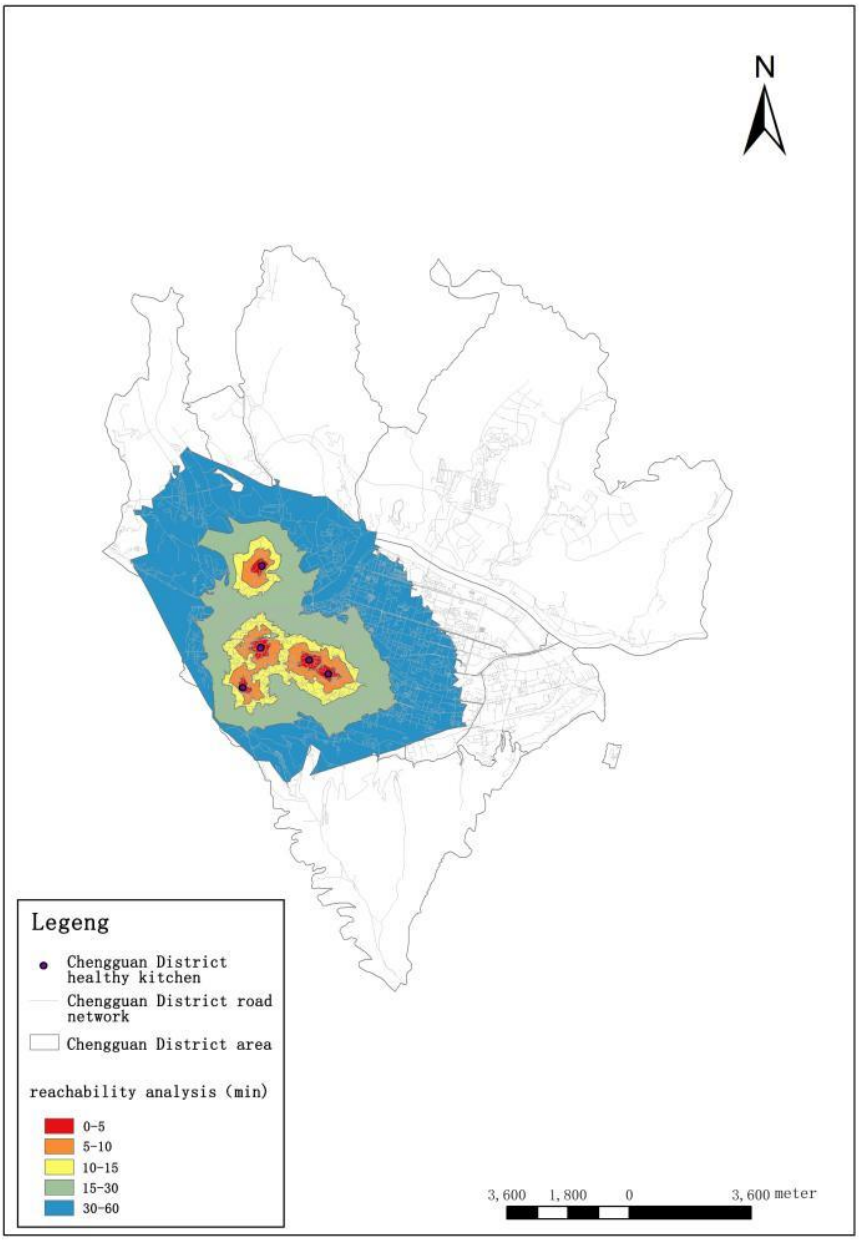

Figure 6. Accessibility analysis map of " Happy Kitchen" in Chengguan District.

4.3. Healthcare and elderly care station

The accessibility coverage analysis of the "Healthcare and Elderly Care Station" in Chengguan District shows that only residents in Qingbaishi Street have access to this service, but it still cannot achieve full coverage within 60 minutes. The core areas of "Healthcare and Elderly Care Station" in the entire study area, which can be reached on foot within the maximum acceptable time range (for the elderly), account for only 12.24% of the total area. The coverage range in the core area IV (30-60 minutes) of the entire study area is only 8%. The Kangyang Station in the southern built-up area of the Yellow River is completely missing. The overall lack of facilities in the region and the layout has major flaws (Table 1, Figure 7).

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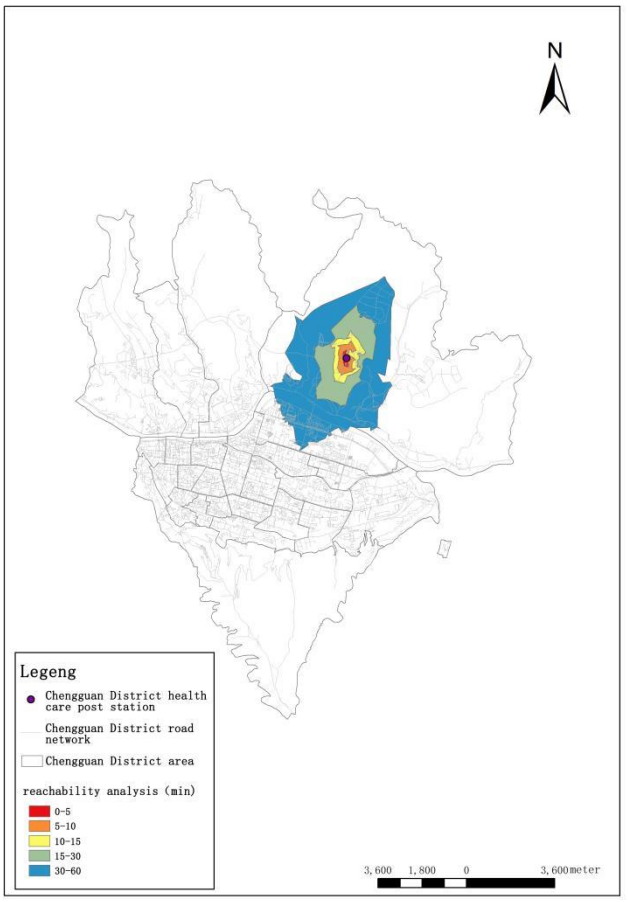

Figure 7. Accessibility analysis map of "Healthcare and Elderly Care Station" in Chengguan District.

5. Evaluation of the accessibility of elderly care service areas

5.1. Assessment of current accessibility

(1) "Comprehensive Elderly Service Centers" are mainly located in the city's core areas and the urban living areas on both the east and west sides. Through visits, it was found that the functions of the "Comprehensive Elderly Service Center" are more common and can simply meet the daily elderly care needs. As a hub-type elderly service facility complex, it has a centralized role in coordinating elderly resources, facilities, and intelligent platforms. Therefore, its distribution is relatively concentrated and relatively dense.

(2) "Happiness Kitchens" are relatively located in the western area where public service facilities are more complete. Most of the "Happiness Kitchens" are constructed based on public facilities, such as ground-floor commercial, catering, and community office space to jointly set up elderly care facilities, effectively alleviating the problem of tight distribution of "Happiness Kitchens".

(3) "Health Medical Care Stations" are located in the northeast of the urban area - Qingbaishi Street, which is also a pilot project for a "Health Medical Care Station" in the city. Because the "Health Medical Care Station" facilities generally need to rely on community health and medical points with certain equipment requirements, the distribution has a certain degree of specificity.

Overall, the area with the best accessibility coverage for these three home-based elderly care service facilities is the western core urban area (Figures 5-7). The western core area has two home-based elderly care service facilities: "Comprehensive Elderly Service Centers" and "Happiness Kitchens". The coverage rate of elderly care facilities is higher than that of a single layout of elderly care facilities in urban areas. Elderly people in this area can have a multidimensional elderly care service experience. In

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addition, there are also two elderly care service facilities: "Comprehensive Elderly Service Centers" and "Health Medical Care Stations" in the northeast district. However, the "Health Medical Care Station" is only distributed on the northeast side of the city. The southern and northern ends of the city are almost not covered by elderly care facilities, which is the weakest link in the entire city's elderly care facilities.

5.2. Problems and suggestions

The research results show that the distribution of elderly care facilities in Chengguan district is uneven, with many gaps. Considering the functionality, hierarchy, and characteristics of elderly care facilities, combined with the analysis results of site selection and accessibility, some specific measures are proposed.

(1) Increase the level of elderly care facilities.

Each street needs to be designed with a reasonable facility layout according to different access levels and sites [14]. Considering the facility function and the demand from the elderly, we suggest that community- and home-based elderly care services should be built in stages and levels according to the proportion of "Comprehensive Elderly Service Center", "Happy Kitchen", and "Healthcare and Nursing Station". First, it is recommended to construct "Comprehensive Elderly Service Centers" and "Happy Kitchens" in the core areas with 0-15 min accessibilities because these facilities can provide urgent elderly care services and daily entertainment activities. At the same time, the site requirements for these two facilities are within the most suitable walking time for the elderly. Considering that not all elderly people need daily therapy services, the location of "Healthcare and Nursing Stations" does not need to be densely arranged, only to meet the requirements of one station per street.

(2) Rely on existing facilities and site renovation to build elderly care facilities.

Considering the limitation of urban development land indicators, it is unsuitable for large-scale construction of new facilities in the future [15]. Therefore, it is encouraged to use the existing infrastructure in idle time and transform them into medium and small-sized community- and home-based elderly care facilities under the premise of meeting the requirements of elderly care facility construction. They can be divided into small blocks, and fully utilize and revitalize the existing community facility resources to improve the efficiency of facility utilization and the rationality of space layout.

The construction of "Comprehensive Elderly Service Centers" can be based on existing community stations or the transformation of old office buildings in the community. "Happy Kitchens" can use the ground floor of buildings or staggered periods of some restaurants to provide catering services for the elderly [16]. Considering that the construction of "Healthcare and Nursing Stations" requires certain medical equipment and space, it is best to use the equipment and space of community health and medical care for deployment.

6. Conclusion

This article summarizes the distribution characteristics of elderly care facilities in the Chengguan District of Lanzhou city, analyzes the accessibility coverage of three main types of elderly care facilities, and puts forward suggestions for the layout of elderly care facilities.

The Comprehensive Elderly Service Centers have the largest number of facilities and are mainly located in the core area of the district, especially the western parts, with small and regional cluster distributions.

The Happy Kitchen Meal Service Points are developing well regarding the number of existing facilities. Based on the spatial aggregation of facilities, there is a higher concentration in the northwest of the Yellow River. The focus of future construction chould be on the east side of the Yellow River, using the current development advantages for multi-core distribution and reducing blank areas.

The existing Health and Medical Care Relay Stations have few facilities in the district. Considering their construction relies on community health and medical location selection, they can follow the requirements of "one street, one relay station" to a certain extent in the later stage.

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Regarding the overall spatial distribution of community-based elderly care facilities in Chengguan District, the number of facilities and spatial aggregation in the core urban area is significantly higher than that in the outer core of the built-up area. However, the current spatial layout cannot meet the needs of the development of elderly care facilities. We recommend that facility layout be carried out hierarchically and by level based on the proportion of different facilities. The old buildings could be transformed and upgraded into elderly care facilities to expand the distribution of elderly care facilities throughout the city and meet the elderly care needs.

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