ISSN 2616-5872 Vol.6, Issue 1: 46-52, DOI: 10.25236/AJEE.2024.060107

Study on the Equity of Spatial Distribution of Elderly Facilities in Mianyang City

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Abstract: *Population ageing is one of the demographic features facing our country in the new era. It is expected that by the middle of the twenty-first century, people over 65 years of age will account for 30 per cent of the country's total population, and the degree of ageing will reach its peak. As the degree of ageing continues to accelerate, China will continue to face the pressure of ageing. The transformation of the elderly from daily physiological needs to multicultural needs has prompted the emergence of a new development model of specialised and diversified services for elderly resources in various fields such as economy and culture. From the point of view of the diversified development and classification of elderly resources, it is very necessary to carry out a study on the equity measurement of the spatial distribution of various elderly resources. This study combines qualitative and quantitative research, focusing on the relationship between the location, scale, service scope and accessibility of senior living facilities, identifying and analysing the distribution of senior living facilities at each level, and further exploring the reasonableness of the resource allocation of senior living facilities at each level, which is conducive to the coordinated development of senior living facilities at different levels in the future. By identifying and analysing the various types and levels of elderly facilities, we can accurately locate the areas with insufficient elderly facilities and provide an effective reference for the subsequent optimisation of the spatial distribution of elderly facilities.*

Keywords: *Elderly Facilities; Spatial Distribution; Equity*

1. Introduction

Population ageing is one of the demographic features facing our country in the new era. Over the past 30 years, the pace of ageing in China has further accelerated, with the size and proportion of the elderly population (defined as those aged 60 years or over) showing an upward trend and accelerating speed. Since 1978, the number and proportion of the elderly population aged 65 in China have continued to rise, and data from the National Bureau of Statistics show that by the end of 2021, the elderly population aged 65 and above in China reached 200 million, accounting for 14.2% of the total population. It is expected that by the middle of the 21st century, people aged 65 and above will account for 30 per cent of the country's total population, and the degree of ageing will reach its peak. As the degree of ageing continues to accelerate, China will continue to face the pressure of ageing, and it is an urgent issue for China to address how to correctly deal with the problem of ageing in the country and to alleviate the pressure brought about by ageing.

With China's economic and social development and the continuous improvement of living standards, the basic life of the elderly is no longer limited to daily living, but in the economic, cultural and other areas showing diversified needs, the demand for old-age care has gradually changed from physiological needs, such as daily care and rehabilitation care, to physical and mental needs, such as recreational activities, spiritual care, and other physical and mental needs [4]. The transformation of the elderly from daily physiological needs to multicultural needs has prompted the emergence of a new development model of specialised and diversified services for the elderly resources in economic, cultural and other fields. From the point of view of the diversified development and category division of elderly resources, it is very necessary to carry out spatial distribution fairness measurement research for a variety of elderly resources. This paper analyses the accessibility of elderly facilities from multiple levels and resources, explores the balance between the supply and demand of elderly facilities, and accurately identifies the areas where elderly facilities are lacking, revealing the spatial heterogeneity of elderly facilities, so as to

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provide a basis for the balanced spatial allocation of elderly facilities in China.

2. Study area and data source

2.1. The introduction of the research area

Mianyang, also known as Fucheng, Mianzhou, belongs to the prefecture-level city of Sichuan Province, located in the northwestern part of the Sichuan Basin, now has jurisdiction over 5 counties, 3 districts and 1 city, in charge of the Sichuan Provincial Government Office of Science and Technology City, is the only science and technology city in China approved by the Party Central Committee and the State Council for the construction of Sichuan's second-largest economy, the Chengdu-Chongqing region of the Twin Cities Economic Circle, the third city. As of October 2022, Mianyang City has three districts (Fucheng District, Youxian District, and Anzhou District), five counties (Zitong), and one county-level city (Jiangyou City), and the Sichuan Provincial Government's Science City Office. In this paper, the scope of the study selected dense population and relatively mature development of the built-up area of Mianyang City, including Fucheng District, Youxian District, and Anzhou District, three administrative districts within the 17 streets, but due to the impact of topography and other factors, as well as the development of built-up areas of Mianyang City in recent years the actual situation of the built-up area of the scope of the line and the street to adjust the total area of about 163 square kilometres, the spatial distribution of each street and the scope of the specific as shown in Figure (Fig 1).

Figure 1: Study site scope (Mianyang City, Sichuan Province).

2.2. Data source and preprocessing

This study needs to obtain data: the scope of each street in the study area, POI and scale data of all kinds of senior care facilities in the study area, data of the elderly population in the study area, roads, water systems and other data in Mianyang City. The data of elderly facilities in the thesis come from Mianyang Big Data Centre, Mianyang Civil Affairs Bureau (Municipal Civil Affairs Bureau and Fucheng District Civil Affairs Bureau, Youxian District Civil Affairs Bureau), and Gaode api open data platform.

2.2.1. Acquisition of Street Scale Data for the Study Area

The boundaries of the study area as well as the boundaries of the streets in the study area in this paper are derived from the China Basic Geographic Information Database (CBGID), and the data that have been acquired are manually interpreted and modified according to the statistical data from the official government website of Mianyang City to ensure that the data are scientific and accurate.

2.2.2. Acquisition of data on residential neighbourhoods in each street

Through the real estate website and Gaode map to obtain the residential district location coordinates, scale and other information, combined with the actual situation of the data for missing data to supplement and duplicate data deletion, and combined with Mapbox API and other time line coordinate conversion, the location of each residential district for the visualisation of the conversion, and then according to the official Mianyang municipal government website statistical data has been obtained data manually interpretation and modification, to ensure that the data is scientific and accurate, and ultimately to get the distribution of residential districts in each street.

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2.2.3. Access to data on the elderly population

The WorldPOP website is based on the population grid data obtained from the seventh population census data, and then using the nighttime light remote sensing, land use, elevation slope information, and other data, and using the forest model and other methods for calculation. In this paper, Mask (mask extraction) is used to obtain the population grid data of Fucheng District and Youxian District in Mianyang City, and according to the seventh national census bulletin of Mianyang City (Fucheng District and Youxian District), WorldPOP extracts the population data for calculation and correction, and combines with the study area as well as the scope of each street to get the data of the elderly population of each street in the study area, and through further calculations, we get the study area Total and density distribution of elderly population.

2.2.4. Data acquisition for elderly facilities

Through the Mianyang Big Data Centre and Mianyang Municipal Civil Affairs Bureau (Municipal Civil Affairs Bureau and Fucheng District Civil Affairs Bureau, Youxian District Civil Affairs Bureau) to obtain information on the type, name, location and number of beds of the elderly facilities, and use python to crawl the open data platform of Gaode api to extract POI data of the elderly facilities in batch, and carry out the comprehensive collation of the collected data and data cleansing, as well as visualisation of the elderly facilities within the ArcGIS.

2.2.5. Other data access

Download and extract the road data and water system data in the study area through the National Geographic Information Resources Catalogue Service System (1:1 million), and combine them with the relevant data in the Gaode api open platform in 2023, and then process and correct the acquired data according to the actual situation.

3. Research method

3.1. Reachability analysis based on network analysis.

The network analysis method takes the elderly facilities in the form of point elements as the centre, the road vector data in the form of line elements as the connection, the road intersections in the form of point elements as the nodes, and sets the resistance value of the waiting time of the traffic lights as 30 s. The average speeds of the walking and the vehicle travelling are selected as 5 and 20km/h, respectively, and the corresponding time resistance values are calculated according to the geometric length of the road to construct the network data set. Setting 5, 10 and 15 min as the time threshold criteria for accessibility, the results of accessibility of elderly facilities were obtained by calculating based on ArcGIS 10.6 platform.

3.2. Spatial fairness calculation

In order to analyse the characteristics of the spatial distribution of elderly facilities in the study area, this paper uses the spatial autocorrelation tool to study the distribution of elderly facilities [1]. Spatial autocorrelation is a spatial statistical method used to measure the relationship between a given region and neighbouring regions, which can be divided into global autocorrelation (Global Moran's I, Getis-Ord General G) and local autocorrelation (Anselin Local Moran's I, Getis-Ord Gi*), which are used to detect three spatial data distribution patterns: clustered, dispersed and random [2]. In this paper, the global Moran's index is used to explore the equity of the spatial distribution of elderly facilities in Mianyang City. The specific operations are as follows:

Global Moran's I is calculated using the formula:

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n}W_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n}W_{ij}\sum_{i=1}^{n}(x_i-\bar{x})^2}$$

The Getis-Ord General G formula is:

$$G = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n}w_{i,j}x_i x_j}{\sum_{i=1}^{n}\sum_{j=1}^{n}x_i\,x_j}$$

x_i and x_j are the attribute values of elements i and j; w_{ij} is the spatial weight between element

ISSN 2616-5872 Vol.6, Issue 1: 46-52, DOI: 10.25236/AJEE.2024.060107

i and element j; n is the total number of elements in the dataset, $i \neq j$ i.e. any i and j cannot appear as the same element.

3.3. Location entropy calculation

Locational entropy calculation is the method used to measure spatial equity. The elderly facility service population ratio (P), which is the ratio of the number of people covered by the service range of elderly facilities within the street to the number of people actually living in the street, is a further optimisation of the elderly facility service coverage based on the population demand perspective. In this paper, the calculation of locational entropy is improved by setting the elderly care facility service population ratio (P) as the ratio of the number of population within the reach of elderly care facilities in the street to the number of real population in the street, and its calculation formula is as follows:

$$P = \frac{P_a}{P_d}$$

Where P_a is the number of population within the street to which the elderly facility service is accessible; P_d is the number of real population in the street. Based on the results of the elderly facility service accessibility, the per capita elderly facility service location entropy (L) analysis was conducted to evaluate the differences in the elderly facility allocation of each study street, which was calculated by the following formula:

$$L = \frac{A_R/P_d}{A_{Rs}/P_s}$$

Where A_R is the area of accessible coverage of elderly facilities in each street and A_{Rs} is the total area of service coverage of elderly facilities based on accessibility; P_s is the total real population in the study area.

When the value of L is greater than 1, it means that the level of per capita enjoyment of elderly care in the street is higher than the average level of the whole; when $L < 1$, it means that the level of per capita enjoyment of elderly care facilities in the street is lower than the average level of the whole. Similarly, the results of the population ratio of senior living facility services (P) and per capita entropy of senior living facility services location (L) are graded using computational geometry to obtain P' and L'. The spatial fairness (F) is determined by the ratio of elderly facility service population (P) and the entropy of elderly facility service location per capita (L), and the calculation formula is as follows:

$$F = \frac{P' + L'}{2}$$

4. Results and analysis

4.1. Analysis of the basic situation of elderly facilities

4.1.1. Global Moran's I

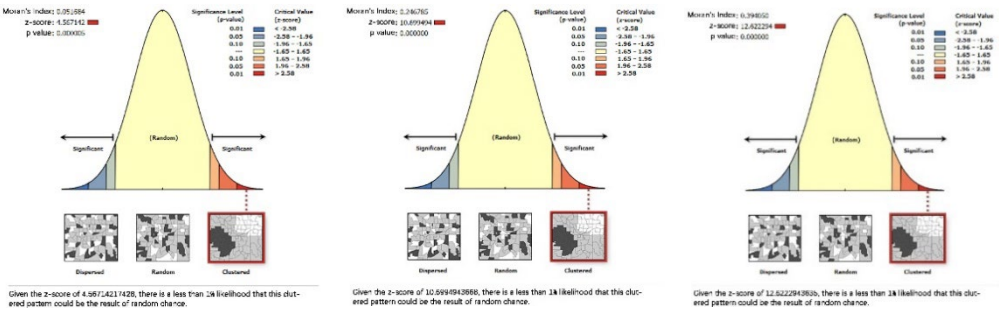

Figure 2: Global Moran's I.

When Moran's I (-1<M <1) is greater than 0, it indicates that the data show spatial positive correlation, and the larger the value, the more obvious the correlation; when Moran's I is less than 0, it indicates that the data show spatial negative correlation, and the smaller the value, the larger the spatial difference; when Moran's I is equal to 0, the spatial is random. P denotes the probability, when p is very small, the

ISSN 2616-5872 Vol.6, Issue 1: 46-52, DOI: 10.25236/AJEE.2024.060107

spatial pattern rejects the null hypothesis, and z denotes the standard deviation multiplier, which responds to the degree of dispersion of the dataset.

As shown in the figure above (Fig 2), Moran's I of each grade of elderly facilities is greater than -1 and less than 1, and $p < 0.01$, $z > 2.58$, indicating that there is clustering of each grade of elderly facilities in the main urban area of Mianyang City and the clustering is more obvious, and the clustering becomes more obvious with the increase of the grade of the elderly facilities.

4.1.2. Getis-Ord General G

The degree of clustering of high or low values can be measured using the Getis-Ord General G statistic, which measures the density of high or low values in the study area and identifies areas of greater density.

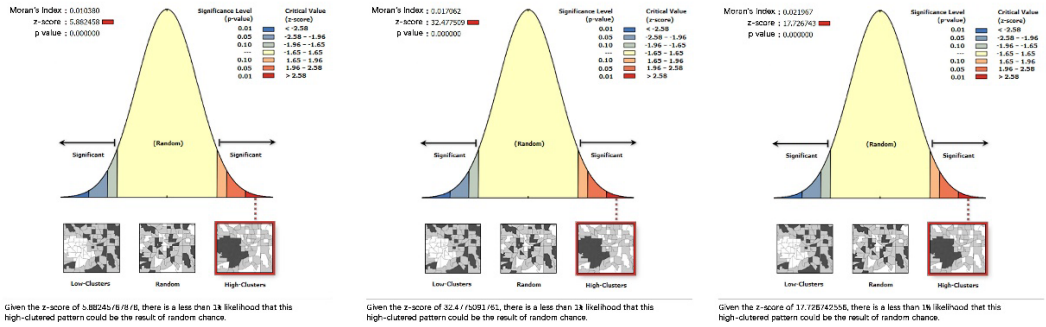

Figure 3: Getis-Ord General G.

As shown in the figure above (Fig 3), the Getis-Ord General G for each level of senior living facility shows a p-value of less than 0.00001, a z-score of, and a General G observation that is higher than the General G expectation, suggesting that high-value clustering has occurred in the accessibility of each level of senior living facility.

4.2. Location entropy results

In spatial distribution studies, nearest-neighbour hierarchical clustering [3], Ripley's K-function [4], Gini coefficient [5], Shannon's entropy [6], and spatial autocorrelation [7,8] are commonly used to explain the state of aggregation of facilities in geographic space. Spatial autocorrelation allows correlations between variables that are close to each other to be observed on a spatial scale, making it easier to identify regions with serious imbalances between supply and demand.

4.2.1. Analysis of the results of zone entropy calculation based on pedestrian accessibility

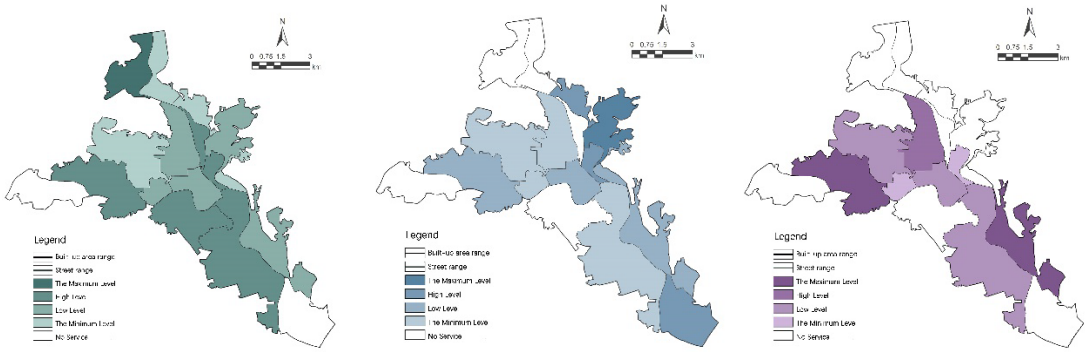

Figure 4: Spatial equity of grade elderly care facilities.

The spatial fairness index of the main urban area of Mianyang City was derived by combining the ratio of population served by elderly facilities (P) and the entropy of per capita facility service location (L) (Fig 4). The results show that due to the variability of the spatial location of different grades of elderly facilities, the spatial fairness of each grade of elderly facilities shows a big difference, and the fairness of the elderly facility configuration in the main urban area of Mianyang City shows obvious heterogeneous characteristics, and the streets with higher spatial fairness of each grade of elderly facilities are all the streets with lower density of resident population, while the spatial fairness of the

ISSN 2616-5872 Vol.6, Issue 1: 46-52, DOI: 10.25236/AJEE.2024.060107

centre of the old urban area is lower due to the high density of the population..

The overall spatial fairness of 5-minute-rated senior living facilities is lower, and the spatial fairness of space alienation is obvious, gradually decreasing from the south to the north. Among them, Qingyi Street has a better foundation of elderly facilities with lower resident population density and the highest spatial fairness; the spatial fairness of 10-minute-rated elderly facilities is higher than the spatial fairness of 5-minute-rated elderly facilities, but the overall spatial fairness is lower, and there are 5 streets in the main urban area with missing elderly facility services, of which Youxian Street has a better foundation of 10-minute-rated elderly facilities with low resident population density and the highest spatial fairness; 15-minute-rated elderly facilities have more streets with a higher spatial fairness value of 0. The spatial fairness value of streets with more 15-minute-rated elderly facilities is 0. The areas with higher spatial fairness are mainly distributed in the peripheral areas, among which Xiaoshen Street has a better infrastructure and low resident population density, with the highest spatial fairness.

4.2.2. Analysis of the results of zone entropy calculation based on vehicular accessibility

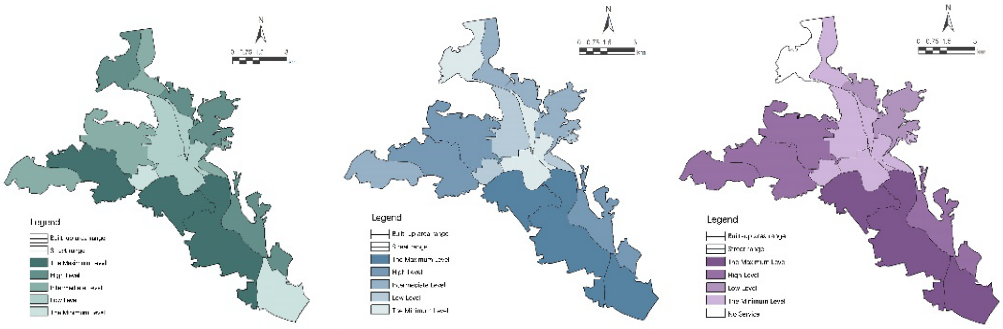

Figure 5: Spatial equity of grade elderly care facilities.

The evaluation results show that the spatial allocation fairness of elderly facilities in the main urban area of Mianyang City presents obvious heterogeneous characteristics (Fig 5). Comprehensive elderly care facility service population ratio (P) and per capita facility service location entropy (L) derived from Mianyang City, the main urban area spatial fairness index, a few streets such as Qingyi Street, Songya Street in different levels of elderly care facility spatial fairness difference is large, the streets of elderly care facility spatial fairness in the calculation of the level of the results on a similar. The overall presentation of "high in the south, low in the middle" characteristics: Tangshun Street and Shitang Street scored higher, Chenggang Street and Fuljiang Street lower.

5. Conclusion and prospect

Taking Mianyang City as an example, this paper establishes the service radius for each grade of senior living facilities in Mianyang City according to the grades, extracts the distribution of the elderly as the demand for senior living facilities by WorldPOP, and evaluates the fairness of the senior living facilities by adopting the Moran index as well as the locational entropy. It can be learnt that Mianyang city has obvious clustering situation of each grade of senior living facilities, and the distribution of each grade of senior living facilities in each street has a big difference, and the fairness of Mianyang city's senior living facilities from the whole and inter-region is low.

This paper has some innovations in the methodology and mode of assessment of the fairness of elderly facilities, but there are still some shortcomings. It does not take into account the specific differences in the demand for elderly facility resources among different groups of people, and the results obtained are not further subdivided, but are expressed as numerical values. Future research can obtain the real usage situation through data such as the satisfaction of the elderly and compare it with the results of the model in order to verify the actual value and provide a more valuable decision-making basis for the optimisation of the layout of elderly facilities.

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