Study on the Equity of Health Resource Allocation in the Sub-central Cities of Sichuan South Provincial Economy

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Abstract: The equity of health resource allocation is crucial to the sustainable development of regional health undertakings. This study uses methods such as health resource agglomeration degree, Theil index and Moran's index to measure the equity of health resource allocation in Yibin and Luzhou. The results show that the equity of health resource allocation in the two cities is insufficient, and there is a large gap in the allocation level among various districts and counties. The health resource allocation in Yibin is more reasonable than that in Luzhou. At the same time, the allocation of health resources in the two cities is in a random distribution state, there are no obvious spatial correlation characteristics, and the impact between adjacent districts and counties is small. Therefore, this study suggested that Yibin should further improve the level of health resource allocation, Luzhou should scientifically evaluate the demand for health resources in each district and county, and further optimize the layout of health resources. In the meantime, the two cities should strengthen the coordinated allocation of health resources and the two cities should cooperate to improve the equity of health resource allocation.

1. Introduction

In December 2023, Sichuan Province issued Opinions on Supporting Yibin and Luzhou in Joining Hands to Build the Southern Sichuan Provincial Economic Sub-center, which is of great significance for promoting the high-level coordinated development of Yibin and Luzhou and this document creates conditions for the development of health undertakings in the two cities. This study mainly discusses the equity of health resource allocation in Yibin and Luzhou from 2018 to 2022, and it aims to provide a reference for optimizing the allocation of health resources in the two cities.

2. Data Sources and Research Methods

2.1. Data Sources

Referring to relevant literature [1-3], this study selects 6 evaluation indicators for the equity of health resources: medical and health institutions, beds, practicing (assistant) doctors, registered nurses, permanent population, and administrative area. The indicator data are derived from the Statistical Yearbooks of Yibin and Luzhou from 2018 to 2022.

2.2. Research Methods

With reference to the calculation formulas and methods in relevant literature, this study adopts the following methods:

- The Health Resource Agglomeration Degree (HRAD) [4-5] is used to evaluate the equity of health resource allocation from two dimensions: population and geographical area.
- The Theil Index is employed to assess the differences in health resource allocation within

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the region, and this method calculates the contribution of inter-group and intra-group differences to inequity to reflect whether inequity is caused by intra-group or inter-group differences [6-8].

- The Global Moran's I Index and Local Moran's I Index are used to reflect the spatial dependence and heterogeneity of resource allocation from the overall and local perspectives [9-10].
- The Kernel Density tool is applied to analyze the spatial distribution characteristics of health resources [11].

3. Results

3.1. Equity of Health Resource Allocation

3.1.1. Analysis of Health Resource Equity in Yibin City

In terms of allocation by geographical area, the equity of health resource allocation among districts and counties in Yibin City is insufficient, and it shows a slight downward trend. Among the 10 districts and counties, only 3 districts (Cuiping District, Jiang'an County, and Nanxi District) have HRAD values greater than 1 for all indicators. This phenomenon indicates that the equity of health resource allocation by geographical area in these three regions is relatively good, but all indicators also show a year-by-year downward trend. Taking Cuiping District, which performs the best in equity, as an example: its HRAD value for beds decreased from 3.18 in 2018 to 2.53 in 2022; the district's HRAD value for practicing (assistant) doctors decreased from 3.33 in 2018 to 2.73 in 2022; and the district's HRAD value for registered nurses decreased from 3.99 in 2018 to 2.91 in 2020. For the remaining 7 districts and counties, except that the HRAD value for the number of health institutions in Changning County and the number of beds in Xuyong District is greater than 1, the HRAD values of all indicators in other districts and counties are less than 1. This situation indicates insufficient equity in health resource allocation by geographical area in these regions. From 2018 to 2022, except for the relatively good average HRAD values of beds, practicing (assistant) doctors, and nurses in Cuiping District, all other indicators were lower than the average level of the Southern Sichuan Economic Zone (Luzhou, Zigong, Yibin, Neijiang).

In terms of allocation by population, the equity of health resource allocation among districts and counties in Yibin City is still insufficient, but the gap between districts and counties is gradually narrowing, with the average HRAD/PAD value ranging from 0.67 to 1.91 in the past five years. In comparison, the equity of health resource allocation by population is better than that by geographical area.

3.1.2. Analysis of Health Resource Equity in Luzhou City

In terms of allocation by geographical area, there is a large gap in the equity of health resource allocation among districts and counties in Luzhou City. Jiangyang District and Longmatan District perform relatively well. The two districts have HRAD values for the number of health institutions, beds, and practicing doctors all exceeding 1. This result indicates a relative surplus in allocation. In particular, the HRAD values of Jiangyang District for beds, practicing (assistant) doctors, and registered nurses in 2020 were 6.32, 7.05, and 7.35 respectively, which are far higher than those of the Southern Sichuan Economic Zone in 2020 (2.55, 2.34, 2.40).

In contrast, the equity of health resource allocation in four districts and counties (Naxi District, Hejiang County, Gulin County, Xuyong County) is insufficient. Except that the average HRAD value for the number of health institutions in Naxi District (1.07) is greater than 1, the HRAD values of all other indicators in these regions are less than 1. In particular, the equity of health resource allocation in Xuyong County and Gulin County is significantly insufficient, with HRAD values ranging from 0.30 to 0.55, which is only higher than that of the Northwest Sichuan Ecological Economic Zone (Ganzi, Aba) (0.03-0.11) and close to that of the Panxi Economic Zone (Panzhihua, Liangshan) (0.46-0.56).

In terms of allocation by population, the gap in the equity of health resource allocation among districts and counties in Luzhou City remains large. Firstly, the HRAD/PAD values of Jiangyang District for beds, practicing (assistant) doctors, and registered nurses range from 1.87 to 2.57, which

shows good equity, but the average HRAD/PAD value for the number of health institutions is 0.7, this value indicates insufficient equity. Secondly, the HRAD/PAD values of Naxi District, Luxian County, and Hejiang County for the number of medical and health institutions, and that of Longmatan District for practicing (assistant) doctors are greater than 1, which indicates good equity in the allocation of these indicators, but the HRAD/PAD values of other indicators are less than 1, which indicates insufficient equity. Thirdly, the equity of health resource allocation in Xuyong County and Gulin County is significantly insufficient, with HRAD/PAD values ranging from 0.48 to 0.91. However, the equity of health resource allocation by population in these two counties is better than that by geographical area.

3.2. Analysis of Spatial Differences in Health Resource Allocation

According to the calculation results of the Theil index: (1) From 2018 to 2022, the Theil Indexes of the two cities for allocation by population and geographical area were both less than 0.18, and the Theil Indexes show a downward trend, which indicates that the allocation of health resources in the two cities is gradually becoming more equitable. (2) Compared with the Theil Indexes for allocation by geographical area, the Theil Indexes of all indicators for allocation by population are lower, which indicates that health resource allocation by population is more equitable than that by geographical area. (3) Whether by population or geographical area, the Theil Indexes of health human resources such as practicing (assistant) doctors and nurses are higher than those of material health resources such as health institutions and beds. This difference indicates that the allocation of health human resources within the region is more equitable. (4) The Theil Indexes of all indicators in Luzhou City are higher than those in Yibin City. This difference indicates that the allocation of health resources in Yibin City is relatively more equitable than that in Luzhou City.

Further decomposition of the total Theil Index of various health resources into inter-group and intra-group differences shows that the contribution rate of intra-group differences to inequity exceeds 96%, indicating that inequity is mainly caused by intra-group differences rather than inter-group differences.

3.3. Spatial Correlation of Health Resource Allocation

3.3.1. Global Moran's I Index

To identify the global spatial correlation characteristics of regional medical and health resource allocation, this study uses Geoda software to calculate the Global Moran's I Index of health resource allocation in various districts and counties of the two cities from 2018 to 2022. The results show that the Z-values corresponding to the Global Moran's I Index of health resources in all districts and counties of the two cities from 2018 to 2022 did not exceed 1.96, and none of the Z-values passed the 5% significance test. This result indicates that the allocation of health resources in all districts and counties of Yibin and Luzhou shows a random distribution with no obvious spatial correlation.

3.3.2. Local Moran's I Index

This study generates LISA cluster maps and significance level maps using Geoda software to further identify the local spatial distribution pattern of medical and health resources in Yibin and Luzhou. The results show that in 2022, most areas of the two cities had no spatial heterogeneity. However, individual indicators in local areas (the number of health institutions in Pingshan County of Yibin City, and the number of beds and registered nurses in Luxian County of Luzhou City) showed a "low-high" spatial correlation. These individual indicators passed the 5% significance test. This situation means that low-value areas are adjacent to high-value areas, showing spatial heterogeneity. The "low-high" spatial correlation indicates that in these areas, high resource agglomeration areas will attract more medical institutions or nursing resources. This attraction makes the allocation of health resources in adjacent areas relatively low.

3.4. Analysis of Spatial Agglomeration of Health Resource Allocation

To further explore the spatial distribution of health resources in Yibin and Luzhou, this study uses

the Kernel Density tool to analyze the spatial agglomeration characteristics of health resources in the two cities. This study crawled POI (Point of Interest) data of the two cities from Gaode Map using web crawler tools, with the deadline being September 30, 2024. This study obtained a total of 3,419 pieces of medical and health service data were obtained, including 1,703 pieces from Yibin City and 1,716 pieces from Luzhou City. The POI data of medical and health services include general hospitals, specialized hospitals, clinics, health centers, pharmacies, drugstores, medical and health supplies stores, etc. This study imported these 3,419 pieces of POI data were imported into ArcGIS 10.8 software, and used the Kernel Density tool to analyze the spatial distribution characteristics of medical and health service resources in the two cities.

The Kernel Density results show that the spatial distribution of health resource allocation in the two cities presents a state of "small agglomeration, large dispersion". Cuiping District of Yibin City, and Longmatan District and Jiangyang District of Luzhou City are high agglomeration areas of resources; Nanxi District, Changning County, Gaoxian County of Yibin City, and Naxi District, Hejiang County of Luzhou City are secondary agglomeration areas of resources; some other districts and counties also have small-scale resource agglomeration, but the overall distribution is scattered. In particular, the spatial allocation of health resources in Pingshan County, Yunlian County, Gongxian County of Yibin City, and Xuyong County, Gulin County of Luzhou City is relatively scattered, with no obvious agglomeration areas formed.

4. Conclusions and Recommendations

(1) The equity of health resource allocation among districts and counties in Yibin City is insufficient and at a low level, but the gap between districts and counties is narrowing year by year. Meanwhile, the equity of health resource allocation by population is better than that by geographical area. This study recommends that all districts and counties in Yibin City further improve the level of health resource allocation, and they should focus on the equity of health resource allocation based on the geographical dimension, especially in districts and counties with insufficient health resource allocation such as Pingshan County, Gongxian County, and Yunlian County.

(2) There is a large gap in health resource allocation among districts and counties in Luzhou City. Jiangyang District and Longmatan District have a relative surplus of health resource allocation, while Xuyong County and Gulin County are obviously insufficient. This study recommends that Luzhou City scientifically evaluate the demand for health resources in each district and county, and it should adjust the layout of health resources, and it should focus on addressing the insufficient allocation of health resources in Xuyong County and Gulin County. This study also suggests Luzhou City improve the level of primary medical services and it further promote support and assistance from areas rich in health resources to underdeveloped areas.

(3) The allocation of health resources in the two cities shows a random distribution with no obvious spatial dependence, which means that the equity of health resource allocation among districts and counties is less affected by adjacent districts and counties. However, individual indicators in local areas (Pingshan County of Yibin City, Luxian County of Luzhou City) show a "low-high" spatial correlation, which indicates that the allocation of health resources in these areas will be affected by adjacent districts and counties. Meanwhile, the gap in health resource allocation between the two cities is mainly caused by intra-group differences, and the mutual influence on the equity of health resource allocation between the two cities is small, which indicates a weak collaborative relationship in health resource allocation between them. This study recommends that the two cities seize the opportunity of joining hands to build the Southern Sichuan Provincial Economic Sub-center, strengthen the coordinated allocation of regional health resources, and they try to pilot the establishment of coordination mechanisms in districts and counties with geographical proximity and close connections, promote cooperation such as linkage of cross-regional medical treatment policies, mutual recognition of basic public health service standards, and joint research on medical and health science and technology, so that they can further improve the equity of regional medical and health resource allocation.

(4) Whether by population or geographical area, the allocation of health resources in the two cities

is becoming more equitable year by year, but the allocation of health resources in Yibin City is relatively more reasonable than that in Luzhou City. At the same time, the allocation of health resources in the two cities generally presents a state of "small agglomeration, large dispersion", each city forms an obvious high agglomeration area of health resources. This study recommends that the two cities pay attention to the spatial heterogeneity of individual indicators in local areas (Pingshan County of Yibin City, Luxian County of Luzhou City). The two cities should not only prevent the flow of health resources from low-value areas to high-value areas but also make full use of the interdependence between them, and they strengthen regional medical cooperation, and they promote efficient allocation and complementary development of regional medical and health resources.

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