Measurement and Temporal Evolution Analysis of Traditional Chinese Medicine Healthcare Resource Allocation Efficiency in Chongqing

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Abstract. This paper uses panel data from 2016 to 2021 on the allocation efficiency of Traditional Chinese Medicine (TCM) healthcare resources in Chongqing, applying the DEA-Malmquist index model to comprehensively measure the allocation efficiency of TCM healthcare resources in 38 districts and counties of Chongqing. The paper aims to reveal the temporal changes and spatial differences in efficiency, and further analyze the factors influencing the efficiency of TCM healthcare resource allocation through the decomposition of total factor productivity (TFP). The study finds that from 2016 to 2021, the efficiency of TCM healthcare resources in Chongqing has shown an overall downward trend, and effective allocation has not been achieved. In terms of spatial distribution, significant differences in the efficiency of TCM healthcare resources exist across districts and counties. High-efficiency areas are mainly concentrated in certain regions of the central urban area and the southeastern part of Chongqing, while areas of medium efficiency are primarily distributed in the western part of Chongqing. Low-efficiency areas are mainly found in certain districts in the northeastern part of Chongqing. The allocation of TCM healthcare resources is uneven. The analysis of total factor productivity further indicates that technical efficiency and scale efficiency are key constraints on improving the overall efficiency of TCM healthcare resources. Regarding the spatial evolution of TFP, the central urban area maintains a relatively high and stable efficiency level, the western region shows relative stability, while the northeastern part of Chongqing experiences greater fluctuation in efficiency, and the southeastern part demonstrates a gradual improvement trend. The study suggests strengthening the development of specialty departments and talent cultivation, enhancing district and county collaboration to promote the balanced distribution of TCM healthcare resources, and innovating management models to improve the development level of Chongqing's characteristic TCM.

Keywords: Data Envelopment Analysis (DEA); TCM Healthcare Resources; Allocation Efficiency; Total Factor Productivity (TFP).

1. Introduction

Traditional Chinese Medicine (TCM) is not only an important component of China’s healthcare system, but also a unique feature and advantage of the country [1]. The development of TCM is crucial to people’s well-being. At the same time, improving public health and promoting the rational distribution of healthcare resources have always been focal points of societal attention. The fairness of the allocation of TCM healthcare resources directly affects whether people can effectively enjoy and utilize their health rights. With the continuous strengthening of national support for the TCM industry, its development has accelerated. However, in the new stage of development, the problem of uneven allocation of TCM healthcare resources still exists. The allocation and structure of TCM healthcare resources still need further adjustment and optimization [2]. Analyzing the problems in the allocation of TCM healthcare resources can help optimize the spatial distribution of these resources. This, in turn, will provide reasonable suggestions and practical measures for promoting the balanced development of TCM healthcare services, alleviating regional disparities, and creating a harmonious and stable social environment.

In recent years, the efficiency of TCM healthcare resource allocation and its spatiotemporal changes have attracted increasing attention from scholars [3, 4]. Some studies have used Data Envelopment Analysis (DEA) to analyze the efficiency of TCM healthcare resource allocation in

Guangxi, but this method primarily analyzes the effectiveness of resource allocation from a static perspective, with certain limitations when exploring the spatiotemporal dynamics of TCM healthcare resource allocation. Other researchers have used the DEA-Malmquist index model to measure the efficiency of healthcare resource allocation in China and analyze regional spatiotemporal differences. However, this approach does not delve into the factors influencing healthcare resource allocation efficiency and the degree of resource concentration. Some scholars have integrated Geographic Information System (GIS) with DEA models to analyze the fairness and efficiency differences in grassroots healthcare resource allocation, while others have used DEA-Malmquist models along with spatial autocorrelation analysis to study the spatiotemporal evolution characteristics and influencing factors of public health expenditure efficiency in China. However, there is limited research using econometric methods to explore the factors influencing the efficiency of TCM healthcare resource allocation, and few studies address the spatiotemporal evolution of TCM healthcare resource allocation. Drawing on existing research, this paper comprehensively applies the DEA-Malmquist index model to analyze the temporal characteristics and district-level evolution differences of TCM healthcare resource allocation efficiency in Chongqing from 2016 to 2021, providing theoretical support for the rational flow of TCM healthcare resources.

2. Data and Methods

2.1 Data Sources

Although The data used in this study is sourced from the 2016-2021 editions of the China Health and Wellness Statistics Yearbook, China Traditional Chinese Medicine Yearbook, and Chongqing Health and Wellness Statistics Yearbook.

2.2 Research Methods

2.2.1 Indicator System Design

Competitive Drawing on previous research methods [5, 6, 7, 8], this study excludes indicators related to financial input and economic benefits when constructing the indicator system. Taking into account the representativeness, broad applicability, and availability of data, the study selects the following indicators: Physical input indicators: Number of TCM healthcare institutions and the number of TCM hospital beds. Human input indicators: Number of healthcare technical personnel in TCM hospitals. Service output indicators: Number of outpatient visits, number of discharges, and average length of stay in TCM hospitals

2.2.2 Model Selection

DEA (Data Envelopment Analysis) is a method and tool used to evaluate the relative effectiveness of production decision-making units (DMUs) with multiple input and output variables of the same type. The method includes two classic models: CCR and BCC. These models assume constant returns to scale (CCR) and variable returns to scale (BCC), respectively, when measuring efficiency. This study measures the relative effectiveness of TCM healthcare resource allocation in Chongqing using the BCC model under variable returns to scale. Under variable returns to scale, the scale efficiency (SE) is calculated as the ratio of the comprehensive technical efficiency (TE) to the pure technical efficiency (PTE). The DEA efficiency calculations in this study are performed using DEAP 2.1 software.

The Malmquist index is used to calculate technical efficiency (i.e., comprehensive technical efficiency), which is then decomposed into changes in pure technical efficiency and scale efficiency. The Malmquist index uses a constructed production possibility set and distance function to measure total factor productivity (TFP), based on the benchmark technology in period t and the reference technology in period t+1. The index is decomposed into technical progress and technical efficiency. The formula for calculating the Malmquist productivity index is as follows:

$$M(x^t, y^t, x^{t+1}, y^{t+1}) =$$

$$\left[\frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \times \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}}$$

Where (x^t, y^t) represents the input and output indicators in period t, and D^t represents the distance function in period t. If the value of M>1, it indicates an improvement in production efficiency; otherwise, a decline is indicated.

2.2.3 Spatial Autocorrelation Analysis and Visualization

Spatial autocorrelation analysis is used to evaluate the degree of correlation of a variable's attribute values in neighboring spatial units and to determine whether certain factors exhibit spatial clustering within the region. Spatial autocorrelation analysis is divided into global spatial autocorrelation analysis and local spatial autocorrelation analysis. Global autocorrelation analysis detects the spatial distribution clustering of variables across the entire study area [9]. Local spatial autocorrelation analysis uses the local Moran's I index as a statistical measure to detect the spatial distribution clustering of variables within specific local areas [10]. In this study, spatial autocorrelation analysis and visualization are performed using ArcGIS 10.6 software.

3. Results

3.1 DEA Results of TCM Healthcare Resource Allocation in Chongqing

3.1.1 Effectiveness Analysis of TCM Healthcare Resource Allocation Efficiency in Chongqing

An analysis of the input-output indicators of TCM healthcare resources for the 38 districts in Chongqing in 2021 was conducted to determine the comprehensive technical efficiency, pure technical efficiency, and scale efficiency of resource allocation for each district.

From results, it can be seen that Jiangbei District, Tongnan District, Wulong District, Chengkou County, and Dianjiang County have a comprehensive technical efficiency of 1, and both technical efficiency and scale efficiency are optimal, indicating that these five districts and counties are DEA relatively efficient. On the other hand, 33 districts and counties, including Wanzhou District and Qianjiang District, have a comprehensive technical efficiency of less than 1, indicating that their TCM health resource allocation efficiency is not DEA efficient. Among these, six districts, including Wanzhou District, Yuzhong District, and Dadukou District, have efficient pure technical efficiency, but scale efficiency is ineffective. Fuling District and Hechuan District have achieved effective scale efficiency, but their pure technical efficiency is ineffective. In the remaining 25 districts and counties, no efficiency category is effective.

From the overall perspective of the city, the average values of comprehensive technical efficiency, pure technical efficiency, and scale efficiency across the 38 districts and counties are 0.653, 0.729, and 0.915, respectively, indicating that the TCM health resource allocation efficiency in Chongqing still needs optimization.

From the results of scale returns, 14 districts, including Wanzhou District, Qianjiang District, and Yuzhong District, have decreasing returns to scale, suggesting that the output of TCM health resources is greater than the input, and thus, the resource allocation scale should be reduced. On the other hand, 15 districts, including Shapingba District, Jiulongpo District, and Beibei District, have increasing returns to scale, meaning that these districts can continue to increase investment to expand output. The scale returns in other districts remain unchanged.

3.1.2 Temporal Variation in the Efficiency of TCM Health Resource Allocation

Using the same method, the temporal changes in the efficiency of Traditional Chinese Medicine (TCM) healthcare resource allocation across 38 districts and counties in Chongqing from 2016 to 2021 were obtained, as shown in Table 1. From a citywide perspective, the efficiency of TCM health resource allocation in Chongqing showed a downward trend from 2016 to 2021, with the overall average efficiency decreasing from 0.766 in 2013 to 0.653 in 2021, indicating that the optimal state has not yet been reached.

Table 1. Efficiency of Traditional Chinese Medicine Healthcare Resource Allocation in Districts and Counties of Chongqing

District/County	Sequential Index					
	2016	2017	2018	2019	2020	2021
Wanzhou District	1	0.345	0.28	0.178	0.3	0.782
Qianjiang District	0.687	0.95	0.591	0.596	0.666	0.635
Fuling District	0.758	0.412	0.465	0.542	0.547	0.501
Yuzhong District	0.721	0.572	0.521	0.267	0.488	0.524
Dadukou District	0.782	1	0.6	0.339	0.765	0.919
Jiangbei District	0.643	1	1	1	1	1
Shapingba District	0.719	0.385	0.252	0.24	0.349	0.347
Jiulongpo District	0.678	0.308	0.286	0.346	0.319	0.35
Nan'an District	0.743	0.538	0.296	0.238	0.391	0.561
Beibei District	0.863	0.394	0.322	0.394	0.425	0.473
Yubei District	1	0.646	0.318	0.266	0.336	0.394
Banan District	0.573	0.628	0.306	0.315	0.349	0.417
Changshou District	0.588	0.363	0.809	0.779	1	0.735
Jiangjin District	1	0.395	0.585	0.477	0.46	0.437
Hechuan District	0.632	0.998	0.364	0.327	0.403	0.395
Yongchuan District	0.688	0.616	0.558	0.603	0.71	0.635
Nanchuan District	1	0.384	0.519	0.759	0.642	0.711
Qijiang District	0.857	0.604	0.644	0.778	0.689	0.546
Dazu District	0.651	0.797	0.601	0.68	0.443	0.464
Bishan District	1	0.554	0.529	0.544	0.549	0.56
Tongliang District	0.672	0.907	0.83	0.644	0.89	0.47
Tongnan District	0.86	0.662	0.504	0.719	0.62	1
Rongchang District	0.428	0.727	0.611	0.739	0.652	0.626
Kaizhou District	0.57	0.475	0.478	0.547	0.547	0.471
Liangping District	0.939	0.653	0.52	0.635	0.76	0.683
Wulong District	1	1	0.831	0.744	1	1
Chengkou County	0.713	1	1	1	1	1
Fengdu County	1	0.866	0.778	0.89	0.94	0.74
Dianjiang County	0.778	1	1	1	1	1
Zhong County	0.395	0.786	0.612	0.663	0.768	0.777
Yunyang County	0.477	0.388	0.321	0.25	0.33	0.35
Fengjie County	1	0.628	0.468	0.345	0.605	0.598
Wushan County	0.571	0.991	0.765	0.861	0.832	0.664
Wuxi County	1	0.969	0.723	1	0.679	0.676
Shizhu County	1	0.95	1	0.947	0.9	0.803
Xiushan County	1	0.907	0.822	1	0.997	0.874
Youyang County	1	1	1	1	0.947	0.907
Pengshui County	1	0.905	0.766	0.945	0.829	0.782

Main Urban Area: Efficiency levels show significant differentiation. Jiangbei District performs the best, achieving relative efficiency in all years except 2016. Dadukou District shows significant

fluctuation in efficiency, but it sharply increased to 0.919 in 2021. Yuzhong District, Shapingba District, Jiulongpo District, and other regions maintain relatively low efficiency levels, with notable fluctuations.

Western Chongqing: The overall efficiency shows a fluctuating downward trend. Changshou District achieved relative efficiency in 2020, while Tongnan District reached relative efficiency in 2021. Districts like Tongliang District and Yongchuan District show relatively stable efficiency levels, with most districts fluctuating between 0.4 and 0.7.

Northeast Chongqing: There are significant efficiency differences. Chengkou County and Dianjiang County have maintained relative efficiency for six consecutive years, performing excellently. Wanzhou District shows the most notable fluctuation, with a significant increase in efficiency from 0.3 in 2020 to 0.782 in 2021. Districts such as Yunyang County and Kaizhou District continue to have low efficiency.

Southeast Chongqing: The overall efficiency level is high and relatively stable. Districts like Wulong District, Shizhu County, Xiushan County, and Youyang County maintain relatively high efficiency in most years, with small fluctuations. Notably, Wulong District achieved relative efficiency in both 2016-2017 and 2020-2021.

The data shows that the allocation of TCM health resources in Chongqing still exhibits significant regional differences, with a pronounced imbalance in development. Therefore, efforts should focus on optimizing resource allocation to improve the efficiency of TCM health resource allocation.

3.1.3 Spatial Distribution of Comprehensive Efficiency in Traditional Chinese Medicine Health Resources Allocation

The average comprehensive efficiency of 13 districts and counties, including Chengkou County, Dianjiang County, and Jiangbei District, during the period from 2016 to 2021, was above 0.90, indicating very high efficiency. These areas accounted for 35.1%. The average comprehensive efficiency of 12 districts and counties, such as Dadukou District, Yongchuan District, and Nanchuan District, during the same period, was between 0.80 and 0.90, representing high efficiency. These areas made up approximately 32.4%. The average comprehensive efficiency of 8 districts and counties, including Fuling District, Kaizhou District, and Yunyang County, was between 0.70 and 0.80 during 2016-2021, indicating an average level of efficiency, and these areas accounted for 21.6%. Four districts and counties, including Jiangbei District, Shapingba District, and Jiulongpo District, had average efficiency below 0.70, representing low or below-level efficiency, accounting for 10.8%.

The overall Moran's I index was 0.326, with a significance level of $P<0.05$, indicating a statistically significant positive spatial correlation between the provinces. In terms of districts and counties, the allocation efficiency of traditional Chinese medicine health resources in Chongqing shows significant spatial differentiation. The spatial distribution characteristics are as follows:

Main Urban Area: The efficiency level shows a distinct differentiation. Some areas, such as Jiangbei District, maintain a high efficiency level, forming a localized high-value cluster, while areas like Shapingba District and Jiulongpo District have lower efficiency levels.

Western Chongqing Area: The overall efficiency level is moderate, with districts like Bishan District and Tongliang District maintaining relatively stable and moderate efficiency, forming a contiguous moderate-efficiency region.

Northeastern Chongqing Area: The efficiency level shows significant variation. Although Chengkou County and Dianjiang County maintain high efficiency, districts such as Wanzhou District and Yunyang County have lower efficiency, forming low-value clusters.

Southeastern Chongqing Area: This region demonstrates relatively stable high efficiency. Districts such as Wulong District, Shizhu County, Xiushan County, and Youyang County generally maintain a high efficiency level, forming a relatively concentrated cluster of high-efficiency areas. Notably, Wulong District and Youyang County have maintained high efficiency over multiple years during the study period.

Overall, the allocation efficiency of traditional Chinese medicine health resources in Chongqing shows significant spatial differentiation, with high-efficiency areas concentrated in parts of the main urban area and southeastern Chongqing, moderate-efficiency areas mostly distributed in western Chongqing, and low-efficiency areas concentrated in parts of northeastern Chongqing. This spatial distribution pattern reflects the significant differences in the allocation efficiency of traditional Chinese medicine health resources across different regions in Chongqing, which requires further optimization of resource allocation and the promotion of balanced regional development.

3.2 Time-Spatial Evolution Analysis of Total Factor Productivity in the Allocation of Traditional Chinese Medicine Health Resources in Chongqing

3.2.1 Temporal Dynamics of Total Factor Productivity and Its Decomposition in the Allocation of Traditional Chinese Medicine Health Resources in Chongqing

This study further decomposes the total factor productivity of medical and health resources into technological progress, pure technical efficiency, and scale efficiency. Using the DEAP 2.1 software, the input-output indicators of traditional Chinese medicine health resources were analyzed to obtain the temporal dynamic changes of the efficiency of the allocation of traditional Chinese medicine health resources in Chongqing from 2016 to 2021, as shown in Table 2

Table 2. Temporal Variation Characteristics of Traditional Chinese Medicine (TCM) Healthcare Resource Allocation Efficiency in Chongqing

Year	effch	techch	pech	sech	tfpch
2016-2017	0.876	1.074	0.842	1.04	0.94
2017-2018	0.847	1.062	0.904	0.937	0.9
2018-2019	0.971	1.619	0.929	1.045	1.572
2019-2020	0.897	0.777	0.959	0.935	0.697
2020-2021	1.158	0.825	1.079	1.074	0.956

Overall, the average total factor productivity of traditional Chinese medicine health resources in Chongqing from 2016 to 2021 was 1.013, indicating an increase in the efficiency of the overall allocation of traditional Chinese medicine health resources by 12.21%. Among the components, pure technical efficiency, technical efficiency, technological progress, and scale efficiency all showed an upward trend, with annual average increases of 6.72%, 8.69%, 1.37%, and 1.01%, respectively. This suggests that from 2016 to 2021, the optimization of traditional Chinese medicine health resource allocation and improvements in the management system played a key role in enhancing the total factor productivity of these resources.

Looking at specific years, the total factor productivity showed an upward trend only in 2018-2019, while in other years, it demonstrated a stable decline. The largest decline occurred from 2019 to 2020, with a decrease of 29.3%, indicating an overall downward trend in the total factor productivity of traditional Chinese medicine health resources in Chongqing. Further decomposition of the total factor productivity shows that, except for 2020-2021, both technical efficiency and pure technical efficiency experienced negative changes, with annual decreases of 0.5 percentage points. Notably, except for the impact of the sudden public health event in 2019-2020, the change in technological progress showed a contrasting trend compared to technical efficiency. Scale efficiency fluctuated significantly across the years, with changes of 4%, -6.3%, 4.5%, -6.5%, and 7.4% between 2016-2017, 2017-2018, 2018-2019, 2019-2020, and 2020-2021, respectively. Scale efficiency showed relatively high instability. Overall, improving the total factor productivity of traditional Chinese medicine health resources requires enhancing both technical efficiency and pure technical efficiency.

3.2.2 Spatial Differences in Total Factor Productivity of Traditional Chinese Medicine Health Resources in Districts and Counties of Chongqing

Among the 38 districts and counties, the total factor productivity of traditional Chinese medicine health resources generally declined. The most significant decrease occurred in Banan District, followed by Tongliang District, Hechuan District, Pengshui County, Fuling District, and Dazu District. However, most of the regions showed a total factor productivity above 0.95, with only a modest overall decline.

From a regional perspective, the annual average changes in total factor productivity for the Main Urban Area, Western Chongqing Area, Northeastern Chongqing Area, and Southeastern Chongqing Area were 1.9%, -3.0%, 2.2%, and 10.4%, respectively. Specifically, regarding the decomposition of total factor productivity, the technological progress in Fuling District, Dadukou District, and 14 other districts and counties was less than 1, indicating that the lag in technology level hindered the improvement of the efficiency of traditional Chinese medicine health resource allocation.

In terms of technical efficiency, 12 districts and counties had values greater than or equal to 1, accounting for 31.6%, suggesting that these regions had either improved or maintained their technical efficiency. Notably, Changshou District and Wuxi County showed significant improvements in technical efficiency. In contrast, in Hechuan District, Tongliang District, Banan District, and Youyang County, technical efficiency, technological progress, and scale efficiency all showed declines.

3.2.3 Temporal and Spatial Evolution Characteristics of Total Factor Productivity in the Allocation of Traditional Chinese Medicine Health Resources in Chongqing

To further investigate the temporal and spatial evolution of the total factor productivity of traditional Chinese medicine health resources in the districts and counties of Chongqing from 2016 to 2021, the total factor productivity data for the years 2016-2017, 2018-2019, and 2020-2021 were selected for analysis.

During the period from 2016 to 2017, the total factor productivity in 15 districts and counties, including Dadukou District, Jiangbei District, and Shapingba District, was greater than 1, while the total factor productivity in the remaining 23 districts and counties was less than 1, showing an overall declining trend. Among them, Chengkou County experienced the largest decrease in efficiency, followed by Youyang County, Yuzhong District, and Fuling District. However, overall, most districts and counties had a total factor productivity above 0.9, with a relatively small overall decline. During this period, there was a clear spatial differentiation in total factor productivity. In the Main Urban Area, efficiency levels were differentiated, with areas like Jiangbei District, Dadukou District, and Yubei District maintaining high levels, while Banan District had lower efficiency levels. The Western Chongqing Area showed overall stability, with Tongliang District maintaining a moderate efficiency level. The Northeastern Chongqing Area had generally lower efficiency levels, with Chengkou County showing a noticeable decrease. The Southeastern Chongqing Area exhibited uneven performance, with Youyang County maintaining a lower efficiency level.

In the 2018-2019 period, the spatial pattern of total factor productivity changed significantly. In the Main Urban Area, Jiulongpo District showed a notable improvement in efficiency, while Hechuan District in the Western Chongqing Area, Yunyang County in the Northeastern Chongqing Area, and Xiushan County in the Southeastern Chongqing Area formed new high-value regions, reflecting a trend of multi-region development. During this period, the distribution of high-efficiency areas became more balanced across the four major regions, breaking the previously dominant pattern of a single region leading.

In the 2020-2021 period, the spatial differentiation further evolved. In the Northeastern Chongqing Area, Dianjiang County, in the Western Chongqing Area, Changshou District, and in the Main Urban Area, Dadukou District, became new high-efficiency areas. Shapingba District and Jiulongpo District in the Main Urban Area continued to maintain good efficiency levels. Wanzhou District and Yunyang County in the Northeastern Chongqing Area had relatively lower efficiency levels.

A comprehensive analysis of the evolution over these three periods reveals that the total factor productivity of traditional Chinese medicine health resources in Chongqing shows significant regional differences, with a dynamic shift in the differentiation pattern. The trend has shifted from an initial advantage in the Main Urban Area to a more balanced development across multiple regions, reflecting the improvement in the spatial balance of health resource allocation efficiency. The Main Urban Area generally maintained a high-efficiency level, showing strong stability; the Western Chongqing Area was relatively stable; the efficiency levels in the Northeastern Chongqing Area fluctuated significantly; and the Southeastern Chongqing Area showed a trend of gradual improvement. At the same time, some districts and counties farther from the Main Urban Area have achieved significant improvements in efficiency through the optimization of resource allocation, promoting balanced development between regions. This spatial differentiation indicates that the allocation of traditional Chinese medicine health resources in Chongqing still needs further optimization, particularly with greater support for the Northeastern Chongqing Area, to promote coordinated development across the four major regions and reduce regional disparities.

4. Conclusion and Recommendations

4.1 Conclusion

4.1.1 Evaluation of the Efficiency of Traditional Chinese Medicine Health Resource Allocation in Chongqing

From a development sequence perspective, the efficiency of traditional Chinese medicine health resource allocation in Chongqing between 2016 and 2021 fluctuated significantly, with the overall comprehensive efficiency showing a declining trend. An analysis of the 38 districts and counties reveals that the number of districts with inefficient scale efficiency exceeded those with inefficient pure technical efficiency, and most districts maintained an increasing or stable scale efficiency. The optimization of resource allocation and improvements in technology remain the primary factors limiting the increase in efficiency.

From a spatial development perspective, there are clear differences in the comprehensive efficiency of traditional Chinese medicine health resources across districts and counties. High-efficiency areas are mainly concentrated in the Main Urban Area and Southeastern Chongqing, including Jiangbei District, Chengkou County, and Youyang County, where high efficiency is supported by improvements in the management system and policy support. In contrast, the Northeastern Chongqing Area shows significant gaps in efficiency, especially in districts like Wanzhou and Yunyang, which have low efficiency levels, highlighting the spatial disparity in resource allocation. The overall spatial pattern reveals a clear clustering characteristic, with high-efficiency areas concentrated in the Main Urban Area and parts of Southeastern Chongqing, while the Western Chongqing Area maintains a moderate efficiency level, and some districts in the Northeastern Chongqing Area form low-value clusters. Particularly, in the Northeastern Chongqing Area, such as Wanzhou and Yunyang, low efficiency levels are prevalent, showing significant spatial differences. This spatial pattern reflects the imbalance in the allocation of traditional Chinese medicine health resources in Chongqing. There is considerable potential for further optimization, especially in remote areas, to promote balanced regional development.

4.1.2 Evaluation of Total Factor Productivity in Traditional Chinese Medicine Health Resource Allocation in Chongqing

Between 2016 and 2021, the total factor productivity, technological progress, and scale efficiency of traditional Chinese medicine health resources in Chongqing showed fluctuating trends, with the overall total factor productivity experiencing several fluctuations, and the average annual increase was 12.21%. Various efficiency indicators showed different patterns of change: technical efficiency, pure technical efficiency, technological progress, and scale efficiency increased annually by 6.72%,

8.69%, 1.37%, and 1.01%, respectively. This indicates that while Chongqing made certain improvements in the allocation of traditional Chinese medicine health resources, the overall efficiency has not yet reached its optimal state.

From a spatial evolution perspective, Chongqing's total factor productivity exhibits significant spatial clustering characteristics, and the centers of these clusters have shown dynamic changes. The pattern has shifted from a single-center dominance in the Main Urban Area to a multi-center structure, reflecting the gradual improvement of spatial balance in resource allocation efficiency. The Main Urban Area and its surrounding districts have generally maintained high-efficiency levels, showing strong stability. The efficiency levels in the Northeastern Chongqing Area, however, have fluctuated greatly, showing noticeable disparities. At the same time, some districts and counties have significantly improved efficiency through optimized resource allocation, breaking the traditional concentration in the Main Urban Area and promoting balanced development between regions.

4.2 Recommendations

4.2.1 Strengthen Specialty Development and Talent Team Training

On one hand, improve the medical and technical level of traditional Chinese medicine in Chongqing. Taking the inheritance and innovation of Chongqing's local traditional Chinese medicine as the core driving force, develop research and clinical integration for specialized traditional Chinese medicine departments focusing on local advantageous disease types, such as Bayu medicated plaster, Chongqing fire acupuncture, and Banan orthopedic traditional Chinese medicine. Focus on strengthening the innovative projects and specialty technologies of district-level hospitals in bone trauma, acupuncture, and oncology, and build traditional Chinese medicine sub-specialties with Bayu characteristics to enhance regional medical technical capabilities in various departments.

On the other hand, address the uneven distribution of Chinese medicine professionals across districts by adopting a diversified talent development strategy. Strengthen cooperation with local universities such as Chongqing University of Traditional Chinese Medicine and Chongqing Medical University through order-based training and targeted commissioned training programs to address the shortage of Chinese medicine professionals in remote areas like Northeastern and Southeastern Chongqing. At the same time, establish a regional talent incentive mechanism, create differentiated reward policies and promotion channels based on the development direction of traditional Chinese medicine specialties in each district, and support the cultivation of specialists and academic leaders at district-level hospitals. This will enhance grassroots professionals' sense of professional identity and achievement. By creating a talent-sharing mechanism, encourage the flow of high-quality traditional Chinese medicine professionals from the Main Urban Area to the grassroots level, achieving balanced development of human resources.

4.2.2 Strengthen District Collaboration and Promote Balanced Distribution of Traditional Chinese Medicine Health Resources

In line with Chongqing’s “one district, two clusters” coordinated development strategy, targeted regional collaboration plans should be formulated. As a resource-concentrated area, the Main Urban Area should fully leverage its medical resource spillover effect. By establishing regional medical alliances centered around resource-rich districts like Yuzhong and Jiangbei, it can drive the development of traditional Chinese medicine in surrounding districts. In areas with relatively weak medical resources, such as the Three Gorges Reservoir Area in Northeastern Chongqing and the Wuling Mountain Area in Southeastern Chongqing, increase fiscal investment and policy support to establish a “strong-to-weak” assistance mechanism. Implement paired support between high-quality medical institutions in the Main Urban Area and traditional Chinese medicine hospitals in the Northeastern and Southeastern regions through telemedicine, expert visits to grassroots areas, and technical guidance, helping to promote high-quality medical resources to underdeveloped areas. At the same time, develop secondary medical centers in regional central cities like Wanzhou and Qianjiang to radiate and drive the development of traditional Chinese medicine in surrounding

counties. Establish shared platforms for traditional Chinese medicine talents, technologies, and equipment within the region to improve the efficiency of resource use.

4.2.3 Innovate the Management Model of Traditional Chinese Medicine and Enhance the Development of Chongqing's Unique Traditional Chinese Medicine

Based on Chongqing's local realities and drawing on the experiences of developed regions in China, innovate the management model. Establish a system for the inheritance and innovation of Chongqing's characteristic traditional Chinese medicine, relying on institutions such as Chongqing University of Traditional Chinese Medicine and Chongqing Traditional Chinese Medicine Hospital, and form a traditional Chinese medicine science and technology innovation alliance. Strengthen research on the traditional characteristics of Bayu traditional Chinese medicine and improve the Chinese medicine quality management system. Develop service standards and evaluation systems that reflect Chongqing's local characteristics.

At the same time, innovate the management mechanisms of district-level traditional Chinese medicine institutions and promote the "Internet + Traditional Chinese Medicine" service model to improve medical service efficiency. Increase support for grassroots traditional Chinese medicine development at the district level, recommending the establishment of special funds for traditional Chinese medicine development in Chongqing to support infrastructure construction and equipment updates in district-level hospitals. Strengthen talent training and incentive mechanisms, establish a regional talent pool for traditional Chinese medicine, and reinforce quality supervision by establishing a traceability system for traditional Chinese medicine services to ensure medical safety and quality.

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