

# Analysis of Service Efficiency of Traditional Chinese Medicine (TCM) Hospitals in China Based on Data Envelopment Analysis (DEA)

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**Abstract** In order to optimize the allocation of health resources and promote the development of traditional Chinese medicine (TCM), this research employs the China Health Statistics Yearbook 2018 to collect relevant data on TCM hospitals in 2017, and the DEA method is used to construct a BCC model for the evaluation of service efficiency of these hospitals in 30 provinces (including autonomous regions and municipalities directly under the central government) across the country. It is found that TCM hospitals in non-effective DEA provinces are not operating efficiently, with excessive investment in institutions, beds, and health staff, and insufficient output of visits, bed utilization, and the average length of stay. Given this, attention to promoting the service capacity and efficiency of TCM hospitals should be paid on the following aspects: scientific allocation of health resource, strengthened external policy control, improved internal management of hospitals, optimized characteristic services and establishment of scientific evaluation system.

## 1 Introduction

Since the 18th National Congress of the CPC, the Party Central Committee has attached great importance to the cause of TCM and has dedicated to improving the capacity of TCM services. For TCM hospitals being important vehicles for the provision of TCM services in China, its service efficiency provided is directly related to the development of TCM. Based on the statistics of TCM hospitals in 30 provinces (including autonomous regions and municipalities directly under the central government) in 2017, the Data Envelopment Analysis (DEA) is used to analyze the service efficiency of TCM hospitals in each province, and provide decision references for optimizing the allocation of health resources and improving the service efficiency.

## 2 Source and Research Methodology

### 2.1 Source

The research data, deriving from the 2018 China Statistical Yearbook of Health, has excerpted the relevant statistics of TCM hospitals in 30 provinces in 2017, including autonomous regions and municipalities directly under the central government. Tibet Autonomous Region is not included in this study for its lack of TCM hospital.

### 2.2 Research Methodology

DEA was initially created by Charnes and Cooper in 1978. It is a systematic analysis method based on the concept of relative efficiency and mathematical programming theory to evaluate the relative effectiveness of multi-input and multi-output decision-making units [1]. This study uses DEAP2.1 to build the BCC model so as to evaluate the relative effectiveness of pure technical efficiency of TCM hospitals in 30 provinces (including autonomous regions and municipalities directly under the central government) in China.

## 3 Results and Analysis

### 3.1 Establishment of Research Indicators

When using DEA to evaluate the technical efficiency of TCM hospital's health resource input and output projects, the results are directly determined by whether the representative indicator selection is reasonable or not. Through literature studies and summaries, the input indicators are identified as the number of institutions, beds and the number of health staff in TCM hospitals, and the output indicators are the number of hospital visits, discharges, bed utilization rate and the average length of stay. The specific details of each indicator are shown in Table 1.

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**Table 1.** Description statistics of input and output indicators based on DEA.

	Maximum	Minimum	Mean	Standard deviation
Number of institutions	263	13	122.97	66.36
Number of beds	63,144	2,445	27,273.87	17,096.36
Number of health staff	62,465	2,238	26,566.8	16,966.22
Medical visits (thousand)	52,772	1,405	17,616.4	13,141.6
Number of discharges	1,857,997	82,466	827,287.27	552,077.58
Bed utilization rate (%)	97.3	67.5	83.59	16.92
Average length of stay (day)	12.3	8.2	9.7	0.9

### 3.2 Results of Service Efficiency of TCM Hospitals Based on DEA

The health resource allocation efficiency of TCM hospitals in 30 provinces (including autonomous regions and

municipalities directly under the central government) in 2017 are found out through calculating the selected input indicators and output indicators within the BCC model constructed with the use of DEAP2.1. And the specific results are shown in Table 2.

**Table 2.** Effectiveness evaluation of TCM hospitals in 30 provinces in 2017.

Province	Technical efficiency	Pure technical efficiency	Scale efficiency	Returns to scale
Beijing	0.760	1.000	0.760	Decreasing
Tianjin	0.711	1.000	0.711	Decreasing
Hebei	0.830	0.865	0.960	Decreasing
Shanxi	0.576	0.864	0.667	Decreasing
Inner Mongolia	0.661	0.845	0.783	Decreasing
Liaoning	0.695	0.986	0.705	Decreasing
Jilin	0.634	0.815	0.778	Decreasing
Heilongjiang	0.669	0.814	0.822	Decreasing
Shanghai	1.000	1.000	1.000	Unchanged
Jiangsu	1.000	1.000	1.000	Unchanged
Zhejiang	0.784	1.000	0.784	Decreasing
Anhui	1.000	1.000	1.000	Unchanged
Fujian	0.770	0.788	0.977	Decreasing
Jiangxi	0.905	0.931	0.971	Decreasing
Shandong	0.835	0.928	0.899	Decreasing
Henan	0.796	1.000	0.796	Decreasing
Hubei	0.996	1.000	0.996	Decreasing
Hunan	1.000	1.000	1.000	Unchanged
Guangdong	0.870	1.000	0.870	Decreasing
Guangxi	0.961	1.000	0.961	Decreasing
Hainan	0.799	0.804	0.994	Increasing
Chongqing	0.935	0.979	0.955	Decreasing
Sichuan	0.952	1.000	0.952	Decreasing

Guizhou	1.000	1.000	1.000	Unchanged
Yunnan	0.944	0.978	0.966	Decreasing
Shaanxi	0.848	0.927	0.915	Decreasing
Gansu	1.000	1.000	1.000	Unchanged
Qinghai	1.000	1.000	1.000	Unchanged
Ningxia	0.853	1.000	0.853	Decreasing
Xinjiang	0.996	1.000	0.996	Decreasing

### 3.2.1 Technical efficiency Analysis

The average technical efficiency of TCM hospitals in 30 provinces (including autonomous regions and municipalities directly under the central government) in China is 0.859, and varies greatly from region to region. Among them, Shanghai, Jiangsu, Anhui, Hunan, Guizhou, Gansu, and Qinghai Provinces achieved effective DEA, accounting for 23.33% of the total. This shows that the overall technology and management level of TCM hospitals in these 7 provinces (including autonomous regions and municipalities directly under the central government) is high, and health resources are fully invested and utilized. The maximum output is basically achieved, and input indicators and output indicators achieve the highest level of medical service efficiency<sup>[2]</sup>. When based on geographical location, the effective ratio of DEA in the eastern, central, and western regions is 16.67%, 22.22%, and 33.33% respectively. The western region is slightly higher than the other two regions, with a technical efficiency of 53.33% of the decision-making units being less than 0.9. Most TCM hospitals in these areas have problems with poor operating efficiency, redundant inputs or insufficient output, and attention should be paid to adjusting the input-output structure and improving management to promote TCM hospitals' service efficiency and development<sup>[3]</sup>.

### 3.2.2 Pure technical efficiency Analysis

Pure technical efficiency refers to the maximum output that the selected decision-making unit can obtain under the current input level<sup>[4]</sup>. The average pure technical efficiency of TCM hospitals in 30 provinces (including autonomous regions and municipalities directly under the central government) is 0.951, and 17 of them have achieved effective pure technical efficiency, accounting for 56.67%. The proportions of effective pure technical efficiency in eastern, central and western regions are 58.33%, 44.44% and 66.67% respectively. In addition to the 7 provinces with effective DEA, 10 provinces including Beijing, Tianjin, Zhejiang, Henan as well as other provinces

(including autonomous regions and municipalities directly under the central government) have also reached pure technical efficiency. Though these regions have realized the full use of health resources, the invalid scale and the decreasing returns to scale show that the marginal income is decreasing with the expansion of the scale.

### 3.2.3 Scale Efficiency Analysis

The average scale efficiency of TCM hospitals in 30 provinces (including autonomous regions and municipalities directly under the central government) is 0.902. Except for the 7 provinces (including autonomous regions and municipalities directly under the central government) that have achieved effective DEA, none of them have achieved scale efficiency. Among them, Hainan Province enjoys increasing returns to scale, that is, output efficiency increases with scale expansion, and the output factors grow higher than that of production<sup>[5]</sup>. The other 22 provinces (including autonomous regions and municipalities directly under the central government) have decreasing returns to scale. In these regions attention should be paid to policy regulation, management improvement and other ways to enhance scale efficiency.

### 3.3 Analysis of Slack Variables in Non-effective DEA Provinces

Through the analysis of slack variables in non-effective DEA provinces (including autonomous regions and municipalities directly under the central government), we can fully realize the insufficiency or surplus of input and output. There are 23 non-effective DEA provinces (including autonomous regions, municipalities directly under the central government), of which 10 are technically effective, with zero slack variable. And the pure technical efficiency of the rest regions is less than 1, which means the current input level does not achieve the maximum output. The slack variables are shown in Table 3.

**Table 3.** Slack variables of input and output of TCM hospitals in non-effective DEA provinces.

	Number of institutions	Number of beds	Number of health staff	Medical visits	Number of discharges	Bed utilization rate	Average length of stay (day)
Hebei	78.65	0.00	0.00	0.00	0	14.47	0.39
Shanxi	115.61	1,961.27	0.00	693.20	0	10.81	0.00
Inner Mongolia	42.12	0.00	0.00	402.54	0	10.31	0.00
Liaoning	47.22	5,339.67	0.00	827.39	0	5.25	0.00
Jilin	9.14	0.00	0.00	405.37	0	7.58	0.00
Heilongjiang	32.49	179.65	0.00	528.23	0	8.64	0.00
Fujian	15.05	0.00	200.80	4.95	0	19.26	0.00
Jiangxi	0.00	0.00	0.00	73.58	0	8.04	0.00
Shandong	23.96	0.00	9,392.33	19.91	0	12.87	0.88
Hainan	0.42	0.00	249.68	150.68	0	15.36	0.37
Chongqing	0.00	0.00	0.00	0.00	0	1.78	0.00
Yunnan	23.49	0.00	0.00	0.00	0	5.60	0.12
Shaanxi	47.06	0.00	3,644.20	318.71	0	2.61	0.00

Through analysis, it is found that if all TCM hospitals in 30 provinces (including autonomous regions and municipalities directly under the central government) achieve effective DEA, a total of 435 institutions will be streamlined, 7,481 beds will be saved, 13,487 health staff will be reduced, 34,245,500 visits will increase, the bed utilization rate will increase by an average of 4.09%, and the average length of stay will increase by 0.059 days.

In terms of investment indicators, the most redundant are the 115.61 excessive institutions in Shanxi Province, 5,339.67 beds in Liaoning Province, and 9,392.33 health staff in Shandong Province. The redundancy rates are 54.28%, 19.74%, and 15.04% respectively. In terms of output indicators, with the full utilization of input factors, the biggest improvement in output is the increase of 8.2739 million visits in Liaoning Province, the increase of hospital bed utilization rate in Fujian Province by 19.26%, and the increase of the average length of stay in Shandong Province by 0.88 days, with the growth rates of 77.78%, 25.14% and 9.36% respectively.

## 4 Discussion and Suggestions

### 4.1 The service efficiency of TCM hospitals in various regions of China being generally low and varying greatly

In 2017, the service efficiency of TCM hospitals in all provinces (autonomous regions and municipalities directly under the central government) across the country was generally low with an average technical efficiency of 0.859. And 53.33% of the provinces had a technical efficiency of less than 0.9, while the lowest value was only 0.576. There are great differences among provinces. Social and economic development as well as constraints of the TCM development in various regions lead to a large gap in service efficiency and uneven developments of TCM

hospitals in the eastern, central and western regions. Provinces (autonomous regions and municipalities directly under the central government) with effective DEA in the eastern, central and western regions account for 16.67%, 22.22% and 33.33% respectively. The western region is slightly better than the two others. Thus, it can be concluded that improving service efficiency is a common task for most TCM hospitals.

### 4.2 To improve the pure technical efficiency of TCM hospitals by allocating health resources scientifically

In 2017, 56.67% of the provinces (including autonomous regions and municipalities directly under the central government) achieved effective pure technical efficiency, with an average pure technical efficiency of 0.951. However, there were still TCM hospitals in some areas that have redundant inputs and insufficient outputs, resulting in a waste of health resources. In view of this, in the process of health resource allocation, we shall reasonably plan the geographical distribution of health services, fully consider the differences of local population development trend, economic level, demand for TCM health services and other conditions<sup>[6]</sup>, and focus on increasing investment in TCM hospitals in remote, densely populated and vulnerable areas with relatively scarce medical and health resources, so as to improve the TCM service system<sup>[7]</sup>, the equity of health resource allocation and the service efficiency of TCM hospital.

### 4.3 To strengthen policy regulation and improve the scale efficiency of TCM hospitals

In 2017, the average scale efficiency of TCM hospitals in all provinces (including autonomous regions and

municipalities under the central government) in China was 0.902, and 23 provinces (including autonomous regions and municipalities under the central government) did not achieve scale efficiency. Among the 23 provinces, 95.5% was diminishing in scale efficiency, which means with the expansion of scale, the output efficiency decreases and the production factors grow higher than the output. TCM hospitals should rationally manage the hospital scale, strengthen policy regulation, change the simple development method of blindly expanding the scale, purchasing expensive medical equipment, and expanding the building area, so as to improve the rational allocation of existing health resources and realize full use of them. Besides, a sound external environment should be created for the development of TCM hospitals by formulating public policy. For example, the Shanghai municipal government has launched the practical technology promotion project of TCM and built the "national suitable technology promotion base for common and frequently-occurring diseases at grass-roots level", which has increased the outpatient income and medical visits of TCM hospitals in these areas, made full use of health resource investment, and greatly improved the service efficiency of TCM hospitals in Shanghai<sup>[8]</sup>.

#### **4.4 To improve the service efficiency of TCM hospitals by advancing management and building a scientific evaluation system**

In order to tackle the overall input redundancy, insufficient output and low operation efficiency, TCM hospitals should make a clear development strategy for the hospital, learn advanced management concepts to refine its management, and optimize workflow to reduce loss and errors. What's more, hospitals should prioritize its efficiency improvement, make full use of existing resources, and improve service efficiency to achieve Pareto optimality.

Additionally, in order to improve the service efficiency, TCM hospitals should strictly follow the relevant national regulations to carry out comprehensive performance appraisals for the timely grasp of its operation condition and scientific evaluation of the service efficiency. When analyzing and evaluating the service efficiency of TCM hospitals, it is necessary to establish a medical information management system in line with the characteristics of TCM diagnosis and treatment in combination with modern information technology and appropriately add the characteristic indicators of TCM, and input and output indicators related to the government and patients as the basis for the examination and evaluation of TCM hospitals<sup>[9]</sup>.

#### **4.5 To enhance the key competitiveness of TCM hospitals by vigorously developing special service projects of TCM**

Some studies have shown that the unsatisfactory service efficiency of TCM hospitals may be related to the following factors in recent years: "Westernization of TCM", the lack of TCM talents, distinctive TCM services

overshadowed by Western medicine, diminished advantages of TCM, and the relatively slow development of TCM technology<sup>[10]</sup>. Therefore, we shall promote the development of TCM departments in the hospital and improve clinical quality and service efficiency by clarifying the service positioning of TCM hospitals, strengthening its own internal development and construction, utilizing unique local advantages, and vigorously developing characteristic service projects of TCM. Moreover, we should focus on building disease specialty that can reflect the obvious curative effect of TCM on the basis of the original construction of key disciplines of TCM and play a leading role.

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