

Evaluation of Health Resource Allocation Efficiency of Chinese Medicine Hospital Based on Data Envelopment Analysis

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Abstract—Objective. To study the allocation efficiency of health resources in Chinese medicine hospitals, and provide reference for further optimizing the allocation of Chinese medicine health resources in China. **Methods** The data envelopment analysis method was used to evaluate the health resource allocation efficiency of Chinese medicine hospitals in 31 provinces in 2016. **Results.** In the horizontal assessment, the average efficiency, pure technical efficiency and scale efficiency of health resources allocation were respectively 0.985, 0.990, and 0.994. Among them, the efficiency of health resource allocation makes it satisfactory for 25 provinces and cities (80.64%), and the efficiency of health resource allocation is slightly lower for 6 provinces and cities (19.36%). **Conclusion.** The overall level of health resource allocation efficiency of Chinese medicine hospitals in 2016 is relatively high, but the differences between provinces are large. Some provinces and cities need to optimize the scale and structure of investment and improve the efficiency of Chinese medicine services.

Keywords—Data envelopment analysis, Health resource allocation, Efficiency evaluation

I. INTRODUCTION

With the continuous deepening of the reform of the medical and health system, the optimal output with the most economical and less limited resources to obtain the maximum benefit is the means of rational allocation of health resources sought at this stage[1]. The Notice of the State Council on the "13th Five-Year Plan for Deepening the Reform of the Medical and Health System" issued in January 2017 requires "improving the medical and health service system. Optimizing the layout of medical and health resources, and clarifying the medical and health institutions at various provinces, levels and medical institutions. Functional positioning, enhanced collaboration, and promoted functional integration and resource sharing." This also brings new opportunities for the optimal allocation of Chinese medicine health resources. How to rationally allocate Chinese medicine health resources, improve the efficiency of existing health resource allocation, and give full play to the advantages of traditional Chinese medicine is an urgent problem to be solved. In this paper, the data envelopment analysis (DEA) method is used to evaluate the health resource allocation efficiency of Chinese medicine hospitals in 31 provinces and

cities in 2016, which provides a reference for further improving the efficiency of health resources allocation in Chinese medicine hospitals.

II. MATERIALS AND METHODS

A. Source

The data of this study are derived from the "China Health and Family Planning Statistical Yearbook" issued by the National Health and Family Planning Commission in 2017 and the "National Chinese Medicine Statistics Extract" issued by the State Administration of Chinese Medicine. The "national data" in this article refers to data of all provinces, municipalities directly under the Central Government and autonomous regions except Hong Kong, Macao and Taiwan. The research object of this paper is Chinese medicine hospital, integrated Chinese and Western medicine hospital and national hospital, collectively referred to as the national Chinese medicine hospital.

B. Research Method

1) *Data envelopment analysis:* Envelopment Analysis is a nonparametric technical efficiency analysis method based on the comparison between the evaluated objects[2], first proposed by Charnes, Cooper and Rhodes in the United States in 1978. This method analyzes the input and output indicators of the sample. The effective production frontier is determined, and the efficiency value is obtained according to the distance between the decision unit and the production front surface. It is mostly used for comprehensive evaluation of hospital operation efficiency evaluation and health decision-making. In this paper, the CCR and BCC models of DEA are mainly used. The CCR model calculates the comprehensive efficiency value under the condition of the same scale return. The BCC model calculates the pure technical efficiency and the scale efficiency value under the variable scale return[3-5]. The comprehensive efficiency is a comprehensive measurement and evaluation of the resource allocation ability and resource use efficiency of the decision-making unit. The pure technical efficiency reflects the production efficiency of the input factor at a certain (optimal) scale, and the scale efficiency reflects the actual gap between scale and optimal production scale. Using the CCR-

BCC model, it is possible to calculate the technical efficiency, pure technical efficiency and scale efficiency value of the allocation of health resources in Chinese medicine hospitals in 31 provinces and cities in 2016. The efficiency values are all between 0 and 1. If the efficiency value is equal

to 1, it means that the health resources of the provinces and cities are used in a satisfactory manner. If the efficiency value is less than 1, the utilization rate of health resources in the provinces and cities is not high.

TABLE I. HEALTH RESOURCES INPUT-OUTPUT TABLE OF 2016 CHINESE MEDICINE HOSPITALS IN VARIOUS REGIONS OF THE COUNTRY

provinces	Input indicators				Output indicators		
	Medical institutions	Beds	Health technicians	Total expenditures (Thousand yuan)	Medical treatments (Million times)	Hospital discharges	Total income (Thousand yuan)
Beijing	191	22772	31640	584678.21	4008.6	411251	598970.52
Tianjin	56	9050	11545	347194.10	1461.6	203158	365177.25
Hebei	237	41438	39907	74251.68	2102.2	1276678	76294.95
Shanxi	236	18557	17859	38427.92	732.2	374797	40907.30
Inner Mongolia	181	21877	21871	52664.26	1017.2	466028	52148.14
Liaoning	150	26725	21798	94395.11	1075.0	604174	93992.80
Jilin	96	17465	17237	79527.02	894.1	376629	81052.32
Heilongjiang	151	24104	22185	71416.21	1037.1	566331	71682.87
Shanghai	27	9644	13241	602906.50	2314.2	350519	600435.55
Jiangsu	138	50110	54050	321294.06	4667.6	1632539	323041.78
Zhejiang	183	40567	47812	264751.49	5248.3	1160804	267095.31
Anhui	119	31271	29135	114432.78	1557.8	1039851	120273.27
Fujian	90	19991	21160	121513.94	1784.7	587648	128050.36
Jiangxi	109	26724	25335	89493.83	1321.7	879350	94334.52
Shandong	221	59516	60659	172842.04	3000.5	1808276	174909.89
Henan	286	61901	58682	94735.78	3263.6	1702542	98278.70
Hubei	136	41490	36780	139080.38	2050.0	1296885	142865.00
Hunan	172	52620	46106	121833.47	1682.6	1628797	121894.78
Guangdong	172	49466	58518	247390.93	5714.8	1532154	251944.30
Guangxi	115	29488	33439	107985.30	1900.2	938063	111758.12
Hainan	23	4156	4835	101655.19	273.3	112123	104061.00
Chongqing	101	23938	20267	181797.51	1201.4	736998	188092.64
Sichuan	266	60877	52354	103405.64	3365.1	1894787	108485.13
Guizhou	117	22997	18470	89192.74	811.2	743180	93636.49
Yunnan	164	27381	21641	70488.21	1567.3	839885	73456.76
Tibet	31	1654	1175	29579.33	148.4	31007	27944.72
Shanxi	167	29172	30187	68987.20	1266.5	843580	71695.93
Gansu	106	23063	14013	59288.70	989.1	693499	63245.30
Qinghai	49	5754	3818	36805.55	216.9	127816	40309.34
Ningxia	28	4481	3901	66912.11	334.8	133031	71762.78
Xinjiang	120	19064	15705	80279.36	662.3	574962	88312.51

2) *Indicator selection:* The key to the evaluation of health resource allocation efficiency is to select appropriate input and output indicators. Through reviewing and analysing the relevant literature on health resource efficiency evaluation [3-7], the input indicators mainly include human, financial and material aspects, such as personnel, expenses, medical and health institutions, etc.; Output indicators mainly include

medical service indicators such as medical treatment, bed use, and hospital income, etc. Based on the requirement of the number of indicators (the sum of the total number of inputs and outputs can not exceed half of the total number of decision-making units), the input indicators are the number of medical institutions, the number of beds, health technicians and total expenditures (refers to the sum of medical costs, financial

subsidies, and research project expenditures, etc.); the output indicators are the number of medical treatments, the number of hospital discharges and the total income (refers to the sum of medical income, financial subsidy income, research project income, etc.).

3) *Statistical analysis*: The data was entered, organized and databased using Excel software, and DEA evaluation was performed using DEAP2.1 software.

TABLE II. HEALTH RESOURCE ALLOCATION EFFICIENCY VALUES OF 2016 CHINESE MEDICINE HOSPITALS IN VARIOUS REGIONS OF THE COUNTRY

provinces	crste	vrste	scale	Scale reward	Relative effectiveness
Beijing	1.000	1.000	1.000	—	effective
Tianjin	1.000	1.000	1.000	—	effective
Hebei	0.987	1.000	0.987	irs	weak effective
Shanxi	0.988	1.000	0.988	irs	weak effective
Inner Mongolia	0.923	0.941	0.981	irs	invalid
Liaoning	0.916	0.917	0.999	drs	invalid
Jilin	0.945	0.946	0.999	irs	invalid
Heilongjiang	0.927	0.928	0.999	irs	invalid
Shanghai	1.000	1.000	1.000	—	effective
Jiangsu	1.000	1.000	1.000	—	effective
Zhejiang	1.000	1.000	1.000	—	effective
Anhui	1.000	1.000	1.000	—	effective
Fujian	1.000	1.000	1.000	—	effective
Jiangxi	1.000	1.000	1.000	—	effective
Shandong	0.973	1.000	0.973	drs	weak effective
Henan	1.000	1.000	1.000	—	effective
Hubei	1.000	1.000	1.000	—	effective
Hunan	1.000	1.000	1.000	—	effective
Guangdong	1.000	1.000	1.000	—	effective
Guangxi	0.992	1.000	0.992	irs	weak effective
Hainan	0.975	1.000	0.975	irs	weak effective
Chongqing	0.993	0.996	0.996	drs	invalid
Sichuan	1.000	1.000	1.000	—	effective
Guizhou	1.000	1.000	1.000	—	effective
Yunnan	0.999	1.000	0.999	irs	weak effective
Tibet	0.940	1.000	0.940	irs	weak effective
Shanxi	0.967	0.972	0.995	irs	invalid
Gansu	1.000	1.000	1.000	—	effective
Qinghai	1.000	1.000	1.000	—	effective
Ningxia	1.000	1.000	1.000	—	effective
Xinjiang	1.000	1.000	1.000	—	effective
Mean	0.985	0.990	0.994	—	—

^a Annotation: “crste” means comprehensive efficiency, “vrste” means pure technical efficiency, “scale” means scale efficiency. In the Scale reward, “—” means unchanging, “irs” means increment, “drs” means decrement.

III. RESULT

This paper selects the horizontal analysis of the allocation of health resources in Chinese medicine hospitals in 31 provinces and cities in 2016. The data of input and investment indicators are shown in Table I. Using DEAP2.1 software, the data in Table I is brought into the CCR-BCC model to calculate the health resource allocation efficiency value of the national Chinese medicine hospitals in 2016, as shown in Table II. It can be seen

from Table II that the average efficiency, pure technical efficiency, and scale efficiency of the allocation of health resources in Chinese medicine hospitals in 31 provinces and cities nationwide are 0.985, 0.990, 0.994, respectively, indicating that the resource allocation efficiency is relatively high. Among them, the comprehensive efficiency, technical efficiency and scale efficiency of 18 provinces and cities such as Beijing, Tianjin, Shanghai and Jiangsu are equal to 1, indicating that the utilization rate of health resources in these

provinces and cities is relatively high. The distribution is 7 in the east, 5 in the middle, and 6 in the west, indicating that the health resources of Chinese medicine hospitals in these provinces and municipalities have been fully utilized, and the optimal output of resource utilization has been basically realized. The pure technical efficiency of seven provinces and cities such as Hebei, Shanxi and Shandong is equal to 1, indicating that the allocation of health resources in these provinces and cities is slightly lower. The distribution is 3 in the east, 1 in the middle, and 2 in the west, indicating that the health resources of these provinces are excessively invested, and the growth rate of output is lower than the growth rate of input. In practice, the scale of investment should be appropriately controlled. The allocation of health resources in Chinese medicine hospitals in the remaining 6 provinces and municipalities is relatively ineffective, accounting for 19.35% of the province. The distribution is one in the east, two in the middle, and three in the west, indicating that the size and input and output of these areas are not matched, and there are problems such as excessive investment or insufficient output. In terms of scale remuneration, the economies of Liaoning, Shandong and Chongqing have diminished their scale returns, indicating that these provinces and municipalities have a large scale of investment. If increase investment in health resources, it will not bring higher benefits. The increase in scale income of 10 provinces and cities such as Hebei, Shanxi, Inner Mongolia and Heilongjiang indicates that the scale of health resources input in these provinces and cities is insufficient, and reasonable increase in investment scale will have higher overall efficiency.

IV. DISCUSSION

General Secretary Xi repeatedly emphasized in the 19th National Congress that "it is necessary to increase investment in the Chinese medicine industry, focusing on the development of traditional Chinese medicine services and the training of Chinese medicine personnel." Since the new medical reform in 2009, the efficiency of health resource allocation has gradually become more reasonable. The average efficiency of health resources allocation in 2016 has reached 0.985, indicating that the Party Central Committee and the State Council attach great importance to the work of Chinese medicine. A series of policy measures have been taken to promote the development of Chinese medicine and have made remarkable achievements. However, in recent years, the number of health institutions, the number of beds and the shortage of resources for health technicians and the scale of investment have led to low efficiency in the allocation of health resources in the six provinces, resulting in large differences in efficiency values among provinces. From the above analysis, it is found that the allocation efficiency of health resources in the eastern region is relatively high, and cities in the western region, and the comprehensive efficiency of health resources allocation in Liaoning is the lowest, followed by Inner Mongolia, indicating that the ability to use health resources in different regions is not the same, resulting in a difference in configuration efficiency.

Therefore, we should pay attention to the use of resources in the western region, coordinate the health resources of provinces and cities by introducing talents and advanced equipment, and further improve the rationality of resource allocation and resource utilization.

V. CONCLUSIONS

Data Envelopment Analysis (DEA) is widely used in evaluation efficiency, and the selection of evaluation indicators is directly related to the credibility, authenticity and scientificity of the evaluation results [8]. By consulting the relevant literature, there is no complete study on the efficiency evaluation standard system. Based on the experience and summary of the scholars, this paper selects the indicators that cover the input and output of health resources as much as possible and conducts tentative exploration. A reference basis, the validity and scientific nature of the results need further study. Due to the limitations of the evaluation model on the number of indicators, some meaningful indicators may be missed, such as bed occupancy rate. In future research, statistical methods can be used. For example, cluster analysis can select meaningful indicators and reuse levels. Analytical method (AHP) determines the weight coefficient of indicators, and can more objectively express the connotation of indicators, comprehensively analyze different periods and different influencing factors, and provide practical and effective opinions and suggestions for the efficiency of health resources allocation in Chinese medicine hospitals.

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