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Evaluation of Allocative Efficiency of Township Health Center Resources in 2019 based on DEA

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Abstract

The main purpose of this paper is to find out the problems existing in the utilization of health resources in township health centers, and put forward recommendations for improvement through analyzing the allocative efficiency of health resources in national township health centers in 2019. Based on China Health Statistical Yearbook 2020, data envelopment analysis (DEA), with the number of health institutions, hospital beds and the health personnel as input indicators and the number of visits and the utilization rate of hospital beds as output indicators, was adopted to analyze and evaluate the allocative efficiency of medical and health resources in township health centers in 29 provinces (municipalities and autonomous regions). DEA data showed that in the eastern, central and western China, the average numbers of health institutions were 1,017, 1,419 and 1,301, respectively; the average numbers of hospital beds were 44,359, 61,787 and 39,699, respectively; the average number of health technicians were 47,168, 48,766 and 34,799, respectively; the average numbers of visits were 51,384,193, 43,845,654 and 30,109,460, respectively; the average utilization rates of hospital bed were 45.2%, 50.8% and 50.9%, respectively; furthermore, there were only 3 areas with a comprehensive efficiency of 1. It is concluded that there were differences in the allocation and utilization of health resources in diverse regions, and on the whole, the investment in health resources was excessive while the overall utilization efficiency was low. It is necessary to attach importance to the rational allocation of medical and health resources, strengthen scientific analysis, and implement scientific and effective planning and management so as to increase the utilization rate of health resources.

Keywords

Data Envelopment Analysis; Township Health Centers; Efficiency Evaluation.

1. Introduction

Township health centers, as primary medical and health service institutions in China, play an important role in improving the national health condition. Under the background of “Healthy China", continuously improving the resource utilization efficiency and service level of China’s township health centers is an effective means to alleviate the medical problems of residents in rural areas such as the difficulty of getting medical service. In this paper, data envelopment analysis (DEA) was adopted to analyze the utilization of medical resources in township health centers in 29 regions of China, to find out the existing problems, then put forward targeted suggestions to improve the utilization level of medical resources in China’s township health centers.

2. Data and Methods

2.1. Source

Taking China Health Statistical Yearbook 2020 as the main data source, the number of health institutions, hospital beds and health technicians in 29 provinces (municipalities directly under

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the central government and autonomous regions) in 2019 were selected as input indicators, and the number of visits and the utilization rate of hospital beds as output indicators.

2.2. Establishment of Research Indicators

The number of health institutions, at the macro level, reflects the national investment in medical and health resources, the number of hospital beds is an important indicator of the scale of township health centers, and health technicians also play a major role in the whole diagnosis and treatment process. Based on the reference of relevant research literature indicators, combined with the factual research, the author selected the number of health institutions, hospital beds and health technicians as input indicators, and the number of visits and the utilization rate of hospital beds as output indicators to analyze the allocative efficiency of health resource of township health centers.

2.2.1. Research Methods

The data of input and output of township health centers in China's 29 provincial-level regions in 2019 retrieved from China's Health Statistical Yearbook 2020 was analyzed by DEA method to obtain the allocative efficiency of resource. In addition, the concrete data of technical efficiency, scale efficiency and slack variable was used to analyze and evaluate the allocation of medical and health resources of township health centers in various regions of China in 2019.

2.2.2. Statistical Analysis Method

Excel was used to set up database and for basic data operation. DEA statistical analysis was implemented by DEAP2.1 software.

3. Results

3.1. General Analysis

The allocative efficiency of health resource of rural health centers in 29 provinces (municipalities directly under the central government and autonomous regions) was evaluated horizontally according to the data of China Health Statistical Yearbook 2020 and the specific input and output index data are shown in Table 1. Using DEAP2.1, the input and output data in Table 1 were substituted into the model for data analysis to obtain the data of allocative efficiency of township health center resources in 29 provinces (municipalities directly under the central government and autonomous regions) in 2019, to analyze the allocative efficiency of township health center resources in different regions (see Table 2).

It can be seen from the data in Table 1 that among the 29 provinces (municipalities directly under the central government and autonomous regions) surveyed, Tianjin City has the lowest number of health institutions with 138, and Sichuan Province has the largest number of health institutions with 4,416, with an inter-quartile range (IQR) of 601 (The sample is a discrete randomized variable, so the data can be directly arranged from small to large. Then the position of the upper quartile can be calculated according to P25=(n+1)/4. If there is a decimal, the mean of two adjacent data can be taken. The calculation method of P75 is the same as above, and P75-P25 is the IQR.) and range of 4,287. Ningxia Hui Autonomous Region has the minimum number of hospital beds with 3,628, and Sichuan Province has the maximum number of hospital beds with 135,705. The IQR is 49158, which is large, and the range is 132,077, so there is a large difference in the investment of hospital beds in various regions. Tibet Autonomous Region has the least input of health technicians with only 4,588 people, while Sichuan Province had the most input of health technicians with 96,543 people. The IQR is 48,532.5 and the range is 91,955. The degree of dispersion and variation is large. Qinghai Province has the lowest number of visits with 2,724,771 people, while Henan Province has the largest number of visits, with 115,549,492 people, with an IQR of 54,733,919.5 and a range of 112,824,721. Tibet Autonomous Region has the lowest utilization rate of hospital beds, as low as 14.7%, while

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Chongqing has the highest utilization rate of hospital beds, as high as 78.1%, with an IQR of 24.65% and a range of 63.4%.

Table 1. Input and output indicators of township health centers in 29 provincial-level regions in China in 2019

Region	Input			Output	
	Number of health institutions	Number of beds	Health technicians	The number of visits	Utilization rate of hospital bed (%)
Eastern China					
Tianjin	138	3,860	4,950	7,603,676	16.5
Hebei	1,998	71,611	47,411	37,470,633	44
Liaoning	1,022	31,565	18,435	17,946,103	38.4
Jiangsu	1,028	74,600	85,772	96,806,451	64.2
Zhejiang	1,081	21,095	49,638	111,156,539	52.7
Fujian	882	31,521	32,823	32,733,191	45.5
Shandong	1,539	97,779	94,642	74,485,645	55.1
Guangdong	1,180	61,494	81,388	72,855,650	54
Hainan	285	5,710	9,451	11,399,849	36.5
Average	1,017	44,359	47,168	51,384,193	45.2
Central China					
Shanxi	1,313	31,223	21,099	13,271,934	29.8
Jilin	761	16,944	18,401	10,158,741	27.1
Heilongjiang	966	23,908	18,998	7,921,636	38.8
Anhui	1,380	60,258	49,071	70,732,168	47.9
Jiangxi	1,590	56,975	43,512	33,599,761	59.6
Henan	2,041	118,966	85,504	115,549,492	61.1
Hubei	1,129	80,549	67,382	55,507,918	72.9
Hunan	2,169	105,470	86,160	44,023,579	68.9
Average	1,419	61,787	48,766	43,845,654	50.8
Western China					
Inner Mongolia	1,271	22,130	19,005	10,428,519	29.7
Guangxi	1,261	69,930	67,116	46,373,030	64.8
Chongqing	846	44,207	29,903	20,773,508	78.1
Sichuan	4,416	135,705	96,543	103,399,575	73.1
Guizhou	1,329	44,041	43,604	37,617,273	48.3
Yunnan	1,361	54,351	50,299	60,564,039	49.2
Tibet	678	3,647	4,588	4,653,910	14.7
Shaanxi	1,532	36,116	45,839	25,607,059	44.3
Gansu	1,377	27,836	28,330	17,305,351	59.9
Qinghai	408	4,716	5,302	2,724,771	45.6
Ningxia	205	3,628	5,029	6,752,611	37.6
Xinjiang	926	30,079	22,029	25,113,871	65.3
Average	1,301	39,699	34,799	30,109,460	50.9

3.2. Effectiveness Analysis

It can be known from the data in Table 2 that only 3 regions that Zhejiang, Qinghai and Ningxia have relatively effective DEA allocation of health resources (comprehensive efficiency, technical efficiency and scale efficiency are 1 and the slack variable is 0), the return to scale remains unchanged, and the output is maximized. Therefore, the input of health resources is

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fully used. Furthermore, the allocation of health resources in Jiangsu, Henan, Hubei, Chongqing, Sichuan and Xinjiang is DEA weak effectiveness (technical efficiency is 1, scale efficiency < 1, the slack variable is 0 and return to scale decreases). Among 6 regions, namely 1 in eastern China, 2 in central China and 3 in western China, the utilization level of medical and health resources in township health centers till needs to be improved. The remaining 20 regions such as Tianjin, Hebei and Shanxi have relatively ineffective resource allocation (technical efficiency < 1, scale efficiency < 1, returns to scale decreases and not all slack variable is 0), including 7 regions in eastern China, 6 regions in central China and 7 regions in western China.

3.3. Efficiency Analysis

Overall, the comprehensive efficiency is generally low, only Zhejiang, Qinghai and Ningxia have a comprehensive efficiency of 1, while Hunan has the lowest comprehensive efficiency of 0.287. The average comprehensive efficiency across the country is 0.58, specifically, 0.7 in eastern China, 0.46 in central China and 0.57 in western China. There are 11 regions with technical efficiency of 1, namely Jiangsu, Zhejiang, Henan, Hubei, Sichuan, Tibet, Qinghai, Ningxia, Xinjiang, Tianjin and Chongqing. Heilongjiang Province witnesses the lowest technical efficiency, as low as 0.304, while the average overall is 0.7. To be more specific, the average of eastern China is 0.73, the average of central China is 0.58, and the average of western China is 0.76. There are only three regions, namely Zhejiang, Qinghai, Ningxia, with scale efficiency of 1. The scale efficiency of 89% of the regions is less than 1 and it is greater than 0.9 in 55% of the regions. Among them, Gansu Province has the lowest scale efficiency, as low as 0.468, while the average of all regions is 0.85. In particular, the average of the eastern regions is 0.97, of the central regions is 0.82 and of the western regions is 0.78.

According to the slack variable of input and output indicators, the input of health institutions is redundant in 9 provinces of Hebei, Liaoning, Shanxi, Jilin, Heilongjiang, Anhui, Inner Mongolia, Yunnan and Gansu, including 2 regions in eastern China, 4 regions in central China and 3 regions in western China; there is redundancy in the input of hospital beds in 16 regions of Hebei, Liaoning, Fujian, Shandong, Hainan, Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Hunan, Inner Mongolia, Guangxi, Guizhou, Yunnan and Shaanxi, including 5 regions in eastern China, 6 regions in central China and 5 regions in western China; there is redundancy in the input of health technicians in Guangdong, Hainan and Qinghai, including 2 in eastern China and 1 in western China. The slack variables of output indicators in the number of visits and hospital bed utilization rate were 0, so the output was relatively sufficient.

4. Discussion and Suggestion

4.1. Adjust Measures to Local Conditions, Coordinate Regional Development and Improve the Resource Mobility

According to the DEA, there is an imbalanced distribution of medical and health resources in township health centers in China. Only Qinghai Province and Ningxia Hui Autonomous Region are DEA efficient, and the average value of technical efficiency is lower than that of scale efficiency, indicating that the level of medical technology in most areas needs to be improved. It is recommended to make full use of the existing medical infrastructure, adapt measures to local conditions, and allocate medical resources rationally to maximize efficiency. DEA efficient areas can keep the original health resources investment basically unchanged, while DEA non-efficient areas can reasonably regulate the amount of resources input, promote the circulation of medical resources in various regions and strengthen overall planning and management based on prioritizing the use of existing resources [1].

ISSN: 2688-9323

Table 2. Health resource allocation efficiency and slack variable of township health centers in 29 provincial-level regions in China in 2019

Region	Comprehensive efficiency	Technical efficiency	Scale efficiency	Returns to scale	S1-	S2-	S3-	S1+	S2+	Relative efficiency
Eastern China										
Tianjin	0.914	1.000	0.914	Increase	0.000	0.000	0.000	0.000	0.000	Inefficient
Hebei	0.385	0.392	0.982	Decrease	267.471	18,938.178	0.000	0.000	0.000	Inefficient
Liaoning	0.530	0.531	0.997	Increase	246.935	11,266.475	0.000	0.000	0.000	Inefficient
Jiangsu	0.988	1.000	0.988	Decrease	0.000	0.000	0.000	0.000	0.000	Weak efficient
Zhejiang	1.000	1.000	1.000	Remain unchanged	0.000	0.000	0.000	0.000	0.000	Efficient
Fujian	0.499	0.550	0.907	Decrease	0.000	5,576.417	0.000	0.000	0.000	Inefficient
Shandong	0.523	0.542	0.965	Decrease	0.000	14,248.531	0.000	0.000	0.000	Inefficient
Guangdong	0.667	0.676	0.988	Decrease	0.000	0.000	1,516.727	0.000	0.000	Inefficient
Hainan	0.831	0.834	0.996	Increase	0.000	351.405	908.162	0.000	0.000	Inefficient
Average	0.704	0.725	0.971	-	-	-	-	-	-	-
Central China										
Shanxi	0.346	0.362	0.957	Increase	245.796	6,538.749	0.000	0.000	0.000	Inefficient
Jilin	0.317	0.340	0.934	Increase	63.511	1,515.532	0.000	0.000	0.000	Inefficient
Heilongjiang	0.294	0.304	0.969	Decrease	50.036	3,223.526	0.000	0.000	0.000	Inefficient
Anhui	0.661	0.665	0.994	Decrease	146.349	25,496.181	0.000	0.000	0.000	Inefficient
Jiangxi	0.404	0.529	0.763	Decrease	0.000	6,327.145	0.000	0.000	0.000	Inefficient
Henan	0.608	1.000	0.608	Decrease	0.000	0.000	0.000	0.000	0.000	Weak efficient
Hubei	0.645	1.000	0.645	Decrease	0.000	0.000	0.000	0.000	0.000	Weak efficient
Hunan	0.287	0.400	0.718	Decrease	0.000	5,631.119	0.000	0.000	0.000	Inefficient
Average	0.445	0.575	0.824	-	-	-	-	-	-	-
Western China										
Inner Mongolia	0.321	0.338	0.951	Increase	223.215	3,201.435	0.000	0.000	0.000	Inefficient
Guangxi	0.495	0.632	0.784	Decrease	0.000	783.593	0.000	0.000	0.000	Inefficient
Chongqing	0.566	1.000	0.566	Decrease	0.000	0.000	0.000	0.000	0.000	Weak efficient
Sichuan	0.493	1.000	0.493	Decrease	0.000	0.000	0.000	0.000	0.000	Weak efficient
Guizhou	0.426	0.461	0.925	Decrease	0.000	8,906.802	0.000	0.000	0.000	Inefficient
Yunnan	0.562	0.575	0.977	Decrease	20.377	17,822.435	0.000	0.000	0.000	Inefficient
Tibet	0.612	1.000	0.612	Increase	0.000	0.000	0.000	0.000	0.000	Inefficient
Shaanxi	0.291	0.307	0.947	Decrease	0.000	3,318.637	0.000	0.000	0.000	Inefficient
Gansu	0.380	0.811	0.468	Decrease	479.819	0.000	4,383.352	0.000	0.000	Inefficient
Qinghai	1.000	1.000	1.000	Remain unchanged	0.000	0.000	0.000	0.000	0.000	Efficient
Ningxia	1.000	1.000	1.000	Remain unchanged	0.000	0.000	0.000	0.000	0.000	Efficient
Xinjiang	0.651	1.000	0.651	Decrease	0.000	0.000	0.000	0.000	0.000	Weak efficient
Average	0.852	0.76	0.781	-	-	-	-	-	-	-

(S1-, S2-, S3-, S1+, S2+ are the slack variables of the number of health institutions, the number of hospital beds, the number of health technicians, the number of visits, and the utilization rate of hospital beds, respectively).

4.2. Improve Management and Strengthen Regulation

Most areas witness a relatively inefficient DEA, indicating a relatively low efficiency of resource utilization. The input of resources cannot be fully utilized, so it is difficult to meet the market demand. It is recommended to strengthen resource management and appropriately invest health resources such as medical staff, the number of hospital beds and the number of institutions to reduce the burden of medical and health investment and improve the efficiency of resource utilization.

ISSN: 2688-9323

4.3. Strengthen the Input of Human Resources and Strengthen the Information Management

Medical technicians are encouraged to participate in practical training to improve professional ability and operation level, solve medical problems independently, and improve health work efficiency. Information management plays an important role in the management of medical and health institutions, therefore, it is advised to strengthen the training of health informatization talent, perfect the salary management system, fully mobilize the health personnel, cultivate information technology awareness, and transform the traditional ideas, to improve the overall service level and efficiency and fully utilize the hospital health resources [2]. Make good use of the incentive mechanism to give financial subsidies and living subsidies to medical technicians in township health centers. Medical personnel are encouraged to practice in remote areas and active medical technicians are given priority in arranging leading posts at the primary medical units.[3].

4.4. Strengthen the Construction of Medical Community and Consolidate the Technological Foundation

Township health centers should build a developed medical community to provide patients with more high-quality referral services and further promote the rationalization and moderation of resource allocation. Since the township health centers have a weak foundation and there is great resistance to development, medical service hardware equipment should be optimized and upgraded to give full play to the function and effectiveness of various medical equipment. At the same time, make the most of the policy advantages of the medical community model to establish close ties with medical and health institutions at all levels and make joint efforts, to promote the flow and sharing of medical and health resources, facilities and talents. Through long-term cooperation, superior hospitals regularly guide and help township health centers to continuously fill management gaps, improve the overall level of scientific management, and strictly standardize the input and use of medical and health resources [4].

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