Research on the Evaluation of Medical Resource Allocation Efficiency in Public Hospitals from the Perspective of Resilience

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Abstract: In the medical system of Hunan Province, tertiary public hospitals are the core force, and their resource allocation efficiency is crucial to the quality of medical services. This study constructs an indicator system from the perspective of resilience and uses the super efficiency DEA model to conduct in-depth analysis of 80 tertiary public hospitals in Hunan Province in 2021. After calculation, it was found that the average comprehensive efficiency of 80 hospitals was 1.248, and only 20 hospitals achieved DEA effectiveness. The technical efficiency value is also low, with 42.5% of hospitals in a technically effective state. Insufficient scale efficiency has become an efficiency bottleneck. Besides, there is a huge difference in efficiency values between individual hospitals and cities. Therefore, hospitals need to adapt to local conditions, optimize their scale, actively promote the construction of medical consortia, promote efficient utilization of resources, and continuously improve the efficiency of their own medical resource allocation and the quality of medical services. This study not only reveals the current efficiency situation, but also provides strategic guidance for improving the quality of medical services in Hunan Province, which is of great significance for the healthy development of the medical system.

Keywords: Ultra-efficiency DEA Model; Medical Consortium; Resilience; Efficiency of Medical Resource Allocation

1. Introduction

On March 23, 2023, the Opinions on Further Improving the Medical and Health Service System were issued. The opinion stated that public hospital work target to further improve the resilient medical and health service system, gradually improve the allocation of resources and service balance, strengthen the major disease prevention and control, treatment and emergency disposal ability, coordination of traditional Chinese and western medicine development, promote orderly medical and diagnosis and treatment system construction achieved positive results. In 2020, the widespread outbreak of novel coronavirus has brought a serious impact on China's economic and social development, and also exposed the problems existing in the health system. In the face of this challenge, the construction of health system resilience has gradually received attention [1]. By strengthening the resilience of the health system, hospitals can better respond to public health events such as outbreaks and ensure the continuity and quality of medical services [2]. Hospital resource allocation is an important part of hospital resilience construction. Reasonable resource allocation can ensure that hospitals have sufficient medical resources and capabilities in the face of emergencies, and respond to treatment needs quickly and effectively.

2. Literature Review

The term "toughness" is derived from the Latin "resilio", meaning "return to the initial state". Around the 16th century, the French borrowed from this word with the meaning of "cancellation or restore". It gradually evolved into "resilience" in modern English and has been used until today. Although the specific meanings vary in different fields, the connotation of resilience is always the ability to return to a stable state after the shock. Reviewing previous literature, the study found that scholars divide resilience into two categories: one is survival [3], which believes that resilience is the ability of an organization to return to the previous state in an emergency; the other is development [4], which believes that the organization can not only restore the previous state in an emergency, but also improve its ability. Resilience includes both

vulnerability and adaptability. Scholars have proposed four main features of resilience, namely, diversity, adaptability, efficiency and cohesion [5].

The concept of hospital resilience was proposed to ensure that all new hospitals have a certain degree of resilience and can enhance their ability to keep normal functioning in a crisis. The more representative concept of "hospital resilience" is an inherent ability of a hospital to withstand shocks or stress by changing its insignificant attributes to rebuild itself [6]. Boeriu [7] pointed out that hospital resilience is the ability of hospitals to withstand, absorb and respond to disasters while maintaining key functions, and then to return to their initial state or adapt to a new state. Gemma et al [8] view hospital resilience around the support and structural hierarchy of the individual or community and their ability to gain support during a crisis. Zhong Shuang et al. [9] believe that the ability of hospitals to resist, absorb and deal with shocks while maintaining the surging medical demand.

Many scholars have explained the concept of hospital resilience, but this paper believes that hospital resilience refers to the ability to effectively integrate resources and coordinate internal relations among medical institutions at all levels within the medical consortium to deal with emergencies and quickly recover from them in the face of emergencies [10]. In the event of emergencies, it is difficult for independent hospitals to take effective measures quickly, and the integration and coordination of the medical consortium can ensure that medical institutions at all levels can respond quickly, effectively respond to the treatment needs, and provide timely medical services for patients. In addition, this paper also holds that hospital resilience refers to the ability of hospital institutions to continuously improve their response and recovery speed through learning and scientific research after an emergency. Through continuous in-depth study and scientific research, the hospital can have a more comprehensive understanding of the nature and occurrence laws of emergencies, so as to formulate more accurate response strategies, constantly optimize the treatment process, and provide more efficient medical services for patients. How public hospitals in China under the background of public health emergencies toughness construction will be the focus of the future research, therefore, this paper from the hospital internal and external two dimensions, from the hospital internal learning innovation ability (scientific research and transformation ability) and external cooperation (couplet of medical cooperation) two angles select toughness under the perspective of the evaluation index, the Hunan hospital medical resource allocation efficiency, analyze the influence of the efficiency, provide Suggestions for the hospital operation in the future.

3. Ultra-efficiency DEA Model Construction

3.1 Data Sources
Public hospitals are the main body of China's medical service system. The research object of this paper is 80 public hospitals in 14 prefecture-level administrative regions in Hunan Province, and the 80 hospitals are named E1, E2 and E3... E78, E79 and E80 successively. The data of this paper comes from the performance appraisal management platform of Hunan Public Hospital in 2021, and MAXDEA software is used to calculate and analyze the data.

3.2 Research Technique
In the traditional DEA model, multiple DUMs are usually evaluated as effective. Especially when the number of input and output indicators is more, the number of effective DUM will also be more. Based on this, Anderson and Petersen proposed the ultraefficient DEA model [11]. Ultra-efficiency DEA is a new model proposed according to the traditional DEA model, which allows the calculated efficiency value over 1, which can compare and rank each DMU, making up for the deficiency of the traditional DEA model [12]. Due to the large number of samples selected in this paper, if use the traditional DEA model to calculate the hospital medical resource allocation efficiency, is easy to appear multiple decision-making unit are effective, so to avoid this problem, get more accurate efficiency evaluation, this paper selects the super efficiency DEA model of hospital medical resource allocation efficiency, as shown in equation (1):

$$\min\theta$$

$$y = \begin{cases} s.t. \sum_{j=1,j\neq k}^{n} \lambda_j x_j + s^- \leq \theta x_k \\ \sum_{j=1,j\neq k}^{n} \lambda_j y_j - s^+ \geq y_k \end{cases} \lambda_j \geq$$

$$0, s^- \geq 0, s^+ \geq 0, j = 1,2,3,\cdots,n \quad (1)$$

3.3 Index Selection

Follow the principle of index selection, at the same time effectively ensure the efficiency of medical resources allocation efficiency in Hunan province, this paper selects "hospital" and "resource allocation efficiency" keywords subject retrieval, selection within nearly 6 years published in domestic authoritative journal papers [13,14], and summarize input and output index, select health technicians (X1), beds (X2), funding income (X3), hospital in medical personnel training funds investment (X4) as the input index, the total medical number (Y1) for the output index.

Table 1. Ultra-efficiency DEA model index system

Level 1 indicators	Secondary indicators	Variable interpretation
Investment index	X 1 Number of health technicians	The number of health technicians in the four categories of medicine, medicine, care and technology
	Number of X 2 beds	Refers to the fixed number of actual beds at the end of the hospital
	X3 financial appropriation income	The government funds for medical health services, medical security subsidies and other undertakings
	X4 hospital's funding input in medical personnel training	It is reflected in the proportion of the sum of the hospital medical teaching funds, post-graduation medical education funds and continuing medical education funds to the total expenses of the hospital in the assessment year
Output indicators	Y 1 The total number of patients treated	Total number of all medical visits
	Y2 level 4 operating tables	It is pointed out that the sum of the number of patients undergoing the four-level surgery and the four-level surgery during their hospitalization
	Y3 The total number of students enrolled in hospital in the same period	The number of people enrolled in the same period who come to the hospital for half a year or more
	Y4 Total amount of scientific research project approval funds	The amount of projects approved or signed in the same year includes vertical and horizontal scientific research projects
	Y5 Total amount of transformation of scientific and technological achievements	Assess the total amount of hospital scientific research achievements in the year

The number of four-level operating tables (Y2) reflects the comprehensive medical strength and professional level of public hospitals. It is an important index of the scale, facilities and equipment of public hospitals, and represents the advanced degree of hospitals in medical technology and equipment. It is selected as the output index. Hospital during the same period recruit training total number (Y3) reflects the members of the medical hospital in the field of talent training investment and cooperation, and the total amount (Y4) reflects the hospital to the importance of the internal learning innovation ability and support, the total amount of scientific and technological achievements (Y5) not only reflects the hospital benefits of the input and output in scientific research, also reflects the hospital of scientific research achievements into practical application ability, therefore, the three indicators for the perspective of toughness. The final indicators are shown in Table 1.

4. Results and Analysis

4.1 Specific Analysis of Medical Resource Allocation Efficiency in 80 Hospitals

In 2021, the average comprehensive efficiency of the 80 sample hospitals was 1.248, and only the comprehensive efficiency value of the top 14 sample hospitals was greater than the average, indicating that the overall level of medical resource allocation efficiency in the province is low. Some of the results are shown in Table 2 and Table 3. There are only 20 DEA effective hospitals, accounting for 25% of the sample hospitals; the average pure technical efficiency is 1.9083,34 technically

effective hospitals, accounting for 42.5% of the sample hospitals; the mean scale efficiency is 0.7745,42 hospitals with increasing scale and 38 hospitals with decreasing scale. The comprehensive efficiency and pure technical efficiency values of the top 20 sample hospitals were> 1, and the scale efficiency values were <1 (except E 02), indicating that the low comprehensive efficiency was mainly affected by the low scale efficiency.

The hospital with the largest comprehensive efficiency value is E 63 (Changde County), The value was 20.6669, The hospital with the smallest value is E 78 (Yiyang municipal tertiary hospital), Value is 0.3038; The hospital with the largest pure technical efficiency value is E 63 (a tertiary hospital in Changde District and County), A value of 32.0545, The hospital with the smallest value is E 33 (a tertiary hospital in Changsha city), Value is 0.3934; The hospital with the largest scale efficiency value is E 02 (Changsha affiliated tertiary Hospital), Value of 1.2161, The hospital with the smallest value is E 78 (Yiyang municipal tertiary hospital), Value of 0.1084, Suggesting a wide variation in efficiency values between hospital individuals.

Table 2. Table of Efficiency Values of Top 20 Hospitals

DMU	overall efficiency	pure technical efficiency	Scale efficiency	return of scale	ranking
E63	20.6669	32.0545	0.6447	descend	1
E67	6.8137	19.5392	0.3487	descend	2
E79	5.5013	9.7816	0.5624	descend	3
E17	3.9703	3.9861	0.9960	descend	4
E02	2.5441	2.0919	1.2161	descend	5
E62	2.2601	2.4516	0.9219	descend	6
E39	2.1707	2.6493	0.8194	descend	7
E69	1.7544	1.9644	0.8931	descend	8
E11	1.5625	1.6717	0.9347	descend	9
E44	1.5609	1.9631	0.7951	descend	10
E59	1.4371	1.4946	0.9615	descend	11
E56	1.3803	1.8925	0.7293	descend	12
E31	1.3703	3.1753	0.4315	descend	13
E70	1.2889	2.1638	0.5957	descend	14
E19	1.2325	2.3795	0.5179	descend	15
E01	1.2270	1.6900	0.7260	descend	16
E46	1.1486	1.1930	0.9628	rise	17
E43	1.1340	1.5646	0.7248	descend	18
E71	1.0748	1.0819	0.9935	rise	19
E52	1.0745	1.0749	0.9996	rise	20

Table 3. The Efficiency Values of the Last 10 Hospitals in the Comprehensive Efficiency Ranking Table

DMU	overall efficiency	pure technical efficiency	Scale efficiency	return of scale	ranking
E66	0.3828	0.8212	0.4661	rise	71
E54	0.3729	0.5110	0.7298	rise	72
E27	0.3605	0.4968	0.7257	rise	73
E49	0.3589	0.4723	0.7599	rise	74
E74	0.3527	1.1053	0.3191	rise	75
E38	0.3475	0.6321	0.5498	rise	76
E61	0.3392	0.5844	0.5804	rise	77
E77	0.3172	0.9479	0.3347	rise	78
E33	0.3160	0.3934	0.8033	rise	79
E78	0.3038	2.8027	0.1084	rise	80

4.2 Analysis of the Efficiency of Medical Resource Allocation in Urban Hospitals

Due to the large number of tertiary hospitals selected in Hunan Province, there are many statistical results. Therefore, the average value of comprehensive efficiency, pure technical efficiency and scale efficiency of each hospital in the city replaces the efficiency value of the city, so as to directly reflect the allocation efficiency of medical resources in each city. The results are shown in Table 4.

From the perspective of the comprehensive efficiency value of each city, only the comprehensive efficiency value of Changde and Changsha is> 1, effective in DEA, indicating that the medical resource allocation

efficiency in these two hospitals is relatively optimal, and pure technical efficiency and scale efficiency are at the forefront of configuration; 85.71% of the cities in Hunan Province are in non-DEA effective state, mainly because the scale efficiency is <1, indicating that the scale is too small, increasing and benefits. The comprehensive efficiency values of Xiangxi, Yiyang, Zhuzhou and Xiangtan are <0.8, indicating that the efficiency of medical resource allocation in these four cities needs to be improved, and the regional differences are obvious. If Hunan province wants to improve the overall efficiency of resource allocation, it should focus on the construction of hospitals in the four cities.
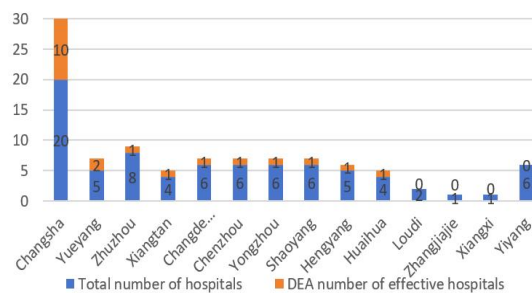
Table 4. Results of Medical Resource Allocation Efficiency in Urban Hospitals in Hunan Province

city	overall efficiency	pure technical efficiency	Scale efficiency	ranking
Changde	3.992	5.999	0.81	1
Changsha	1.656	2.788	0.756	2
Huaihua	0.976	1.163	0.852	3
Yueyang	0.957	1.179	0.797	4
Loudi	0.908	1.25	0.77	5
Chenzhou	0.887	1.593	0.714	6
Shaoyang	0.876	1.087	0.824	7
Hengyang	0.837	1.109	0.848	8
Vinh Chau	0.822	0.966	0.861	9
Zhangjiajie	0.811	0.829	0.978	10
Xiangtan	0.725	0.888	0.86	11
Zhuzhou	0.628	1.077	0.645	12
Yiyang	0.556	1.16	0.632	13
western Hunan	0.488	0.49	0.996	14

From the perspective of pure technical efficiency, the pure technical efficiency of most urban hospitals is greater than or slightly less than 1, only a city in western Hunan is <0.8, and 71.43% of the cities are in a technical effective state, indicating that the pure technical efficiency of medical resources of tertiary public hospitals in cities in Hunan province is at a good level. From the perspective of scale efficiency, the scale efficiency value of all cities is <1, combined with comprehensive efficiency = pure technical efficiency * scale efficiency, indicating that the low efficiency of medical resource allocation in these urban hospitals may be caused by scale efficiency, and improving the scale efficiency of hospitals is the key to improve the efficiency of medical resource allocation in hospitals.

As shown in Figure 1, in terms of the number of DEA effective hospitals in each city, there are 20 DEA effective hospitals, including 10 in Changsha, 2 in Yueyang, 1 in Zhuzhou, Xiangtan, Changde, Chenzhou, Yongzhou, Shaoyang, Hengyang and Huaihua, and 0 in other cities. DEA effective hospital is Changsha, Yueyang, which is and Xiangtan, 50%, 40%, 25%, 25%, respectively that Changsha city hospital compared with other hospitals, can actively promote couplet of medical construction and the implementation of the classification system, realize the resource sharing between different levels of medical institutions, more efficient use of resources, improve the efficiency of medical resource allocation.

Figure 1. Number of DEA effective Hospitals Contained in Various Cities of Hunan Province

5. Discussion

5.1 Improve the Efficiency of Medical Resource Allocation in Hunan Hospitals and Narrow the Efficiency Gap between Cities

The study shows that in 2021, the average efficiency of medical resource allocation in Hunan province is 1.248, the average efficiency of pure technical efficiency is 1.9083, and the average efficiency of scale efficiency is 0.7745. The efficiency of resource allocation in Hunan province is low, and the efficiency gap between hospitals and hospitals and between cities and cities is large. The reason is that the outbreak of COVID-19 in 2021 has led to a sharp increase in the number of cases, which has brought a huge burden to hospitals and medical institutions in Hunan Province. Problems such as high risk of infection and shortage of medical resources have affected the efficiency of medical

resource allocation. Therefore, the government needs to tilt resources to support rural areas and economically backward areas to ensure the balanced distribution of medical resources. At the same time, strengthen the integration and sharing of medical resources, build a cross-city resource sharing platform, to promote mutually beneficial cooperation between hospitals. Through the establishment of a perfect medical resource evaluation mechanism, regular evaluation and dynamic adjustment of resource allocation, to ensure the fairness and efficiency of medical services in all cities. In addition, the management and training of the medical team should be strengthened to improve the overall quality and work efficiency of the medical staff, so as to comprehensively improve the allocation efficiency of medical resources in Hunan Province, and provide more high-quality and fair medical services for the majority of patients.

5.2 Reasonable Control of the Hospital Scale, Improve the Overall Efficiency of the Hospital

The study shows that in 2021, the scale efficiency value of the 80 tertiary public hospitals in Hunan province were less than 1, indicating that the size of the sample hospitals did not reach the optimal state. The low overall resource allocation efficiency in Hunan province is caused by the scale efficiency, so improving the scale efficiency is the way to improve the overall efficiency of hospitals. Scale efficiency is due to the production efficiency affected by the hospital scale factors. In the process of planning and development, hospitals should closely combine their own actual needs and regional health planning, and scientifically and reasonably set the number of beds, the distribution of departments and personnel allocation, so as to avoid the waste of resources caused by blind expansion. By continuously optimizing the internal organizational structure and management process, the utilization efficiency of medical resources can be significantly improved and unnecessary waste can be reduced. When supporting the development of hospitals, government departments should shift their focus to the scale remuneration of hospitals and their changes, and develop differentiated development strategies accordingly. For

hospitals in the stage of increasing scale remuneration, scale investment should be moderately increased on the basis of ensuring technical efficiency, while for hospitals with diminishing scale returns, internal management should be strengthened to prevent excessive expansion to ensure the sustainability and efficiency of hospital development.

5.3 Promoting the Construction of Medical Association and Accelerating the Efficient Use of Resources

In April 2017, the Guiding Opinions on Promoting the Construction and Development of Medical Federations pointed out that: medical consortium (hereinafter referred to as medical) construction, is an important step of deepening the reform and system innovation, to adjust the optimization of medical resources structure layout, promote medical and health work focus down and resources, improve basic service ability, is advantageous to the medical resources, improve the overall efficiency of the medical service system, better implementation of hierarchical diagnosis and treatment and meet the needs of the health. In the treatment of COVID-19, China takes the grid layout of medical consortium as the carrier to improve the referral mechanism between sub-designated hospitals, designated hospitals, medical consortium and tertiary general hospitals with external cooperation of medical consortium, so as to improve the efficiency and continuity of medical services and protect people's life safety and health to the greatest extent. Therefore, all hospitals in Hunan province should actively respond to and participate in the government-led medical consortium construction policy, and establish close cooperative relations with other medical institutions in the region. Through the construction of medical consortium, resource sharing and complementary advantages are realized, and the overall medical service level is improved. At the same time, strengthen the communication and cooperation with the government, social organizations and patients, and jointly promote the in-depth development of the construction of medical association. Through government support, social participation and patient feedback, the construction mode and mechanism of medical association are constantly improved to realize

the efficient utilization of medical resources and the continuous improvement of medical services.

References

[1] Moreno. Productivity growth, technical progress and efficiency change in Spanish retail trade(1995-2004):a disaggregated sect oral analysis. International Review of Retail, Distribution & Consumer Research,2008, 18(1):87-103.

[2] Liu Yajuan, Huang Lingping. Exploration of the reform of "group" clinical specialty operation assistant in XH Hospital. Hospital of China, 2021, 25 (7): 65-67.

[3] Meyer AD. Adapting to environmental jolts. Administrative Science Quarterly, 1982, 27(4):515-537.

[4] Hamel G, Valikangas L.The quest for Resilience. Harvard Business Review, 2003,81(9):52-63.

[5] Russell CM, Lance RN.Resilience as an entrepreneurial capability: integrating insights from a cross-disciplinary comparison. International Journal of Entrepreneurial Behavior & Research, 2018,24(7):1155-1180.

[6] Zhong S, Clark M, Hou XY, et al. Development of hospital disaster resilie nce: conceptual framework and potential measurement. Emergency Medicine Journal: EMJ, 2014, 31(11): 930938.

[7] BOERIU C.Hospital resilience: a recent concept in disaster preparedness .Journal of Critical Care Medicine, 2018,4(3):81-82.

[8] ABURN G, GOTT M, HOARE K. What is resilience? An integrative review of the empirical literature. Journal of Advanced Nursing,2016,72(5):980-1000.

[9] ZHONG S, CLARK M, HOU X, et al. Validation of a framework for measuring hospital disaster resilience using factor analysis. International Journal of Environmental Research and Public Health,2014,11(6):6335-6353.

[10] Bai Enthalbin, He Yuanyuan, Xu Xinglong, etc. Construction and path realization of epidemic prevention and control mechanism for major infectious diseases based on resilient medical consortium. Hospital Management in China, 2023,43 (09): 60-64.

[11] Moreno. Productivity growth, technical progress and efficiency change in Spanish retail trade(1995-2004):a disaggregated sect oral analysis. International Review of Retail, Distribution & Consumer Research,2008, 18(1):87-103.

[12] Liu Yajuan, Huang Lingping. Exploration of the reform practice of "group-type" clinical specialty operation assistant in XH Hospital. Hospital of China, 2021, 25 (7): 65-67.

[13] Huang Shuting, Pang Zhenmiao, Zou Xiaoqi, Liang Huiyi, Zhu Haishan. Analysis of medical resource allocation efficiency of Guangdong TCM Hospital based on data envelope analysis. Health Statistics of China, 2017,34 (01): 118-120

[14] Li Yingfei, Li Yue, Guo Lifang, Ma Lan, Lu Ping, Yan Yunwei, Wang Xiaojuan, Tian Qingfeng. Analysis and evaluation of the efficiency of medical service resource allocation in Henan TCM Hospital based on DEA and Malmquist index. Health Statistics of China, 2019,36 (05): 710-712.