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Measurement and Evaluation of the Operational Efficiency of Medical and Health Institutions in Anhui Province

-- Based on the Three Stage DEA Model

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Abstract

The COVID-19 at the beginning of 2020 has posed a serious challenge to the emergency response capacity of China's existing medical system. In order to quickly and effectively assume the emergency medical task and establish a treatment system of simultaneous coordinated operation of prevention and control, this paper takes 16 provinces in Anhui Province as examples, and uses the three-stage DEA method to calculate the operational efficiency of medical and health institutions in 2020. The results show that the comprehensive technical efficiency The pure technical efficiency and scale efficiency are 0.927, 0.972 and 0.953 respectively. Then SFA regression was used to remove the impact of environmental factors. Finally, the comprehensive technical efficiency, pure technical efficiency and scale efficiency of each decision-making unit were recalculated as 0.911, 0.969 and 0.947 respectively. Finally, according to the relevant results, the relevant establishment is proposed from the perspective of the government and hospitals.

Keywords

Public Health; Three Stage DEA; Operational Efficiency.

1. Introduction

The COVID-19 at the beginning of 2020 has posed a serious challenge to the emergency response capacity of China's existing medical system. In the face of such public health emergencies, whether we can quickly and effectively assume the emergency medical tasks and establish a treatment system of simultaneous and coordinated operation of prevention and control depends on the operational efficiency of medical and health institutions. However, after a long period of unbalanced development, China's medical construction system has many problems, such as shortage of health resources, uneven level, unreasonable organizational structure, and unreasonable expansion of scale. In order to explore and quantify the above issues, this paper measures the overall operational efficiency of medical and health institutions in Anhui Province by using the three-stage DEA model, objectively analyzes the measurement results, and finds out the scale returns of various input indicators, aiming to provide reference for the rational allocation and planning of medical resources in China.

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2. Literature Review

Consulting the existing relevant literature, Ma Chao et al. used the three-stage DEA model to evaluate the comprehensive efficiency, pure technical efficiency and scale efficiency of 613 public hospitals in 21 cities in Guangdong Province. They found that the overall operating efficiency of public hospitals in Guangdong Province was high, but the regional differences were significant. Liang Jianfeng drew on the balanced scorecard performance management theory to establish a hospital performance appraisal indicator system from four aspects: medical service efficiency management indicators, financial indicators, hospital development indicators and satisfaction indicators. Tan Huawei and others used Malmquist Tobit tool to empirically analyze the impact of private hospital development on public hospital operating efficiency, and found that the overall operating efficiency of public hospitals in China is in an improved stage, with irregular negative growth coexisting with regional and provincial differentiation.

3. Three Stage DEA Model

This paper uses the three-stage DEA model proposed by Fried to analyze the operational efficiency of medical and health institutions in Anhui Province. The three-stage DEA model is based on the traditional DEA model to eliminate the impact of environmental variables, random interference and management inefficiency, so as to make the results more accurate and reliable.

In the first stage, the input oriented BCC model is used to calculate the comprehensive technical efficiency, pure technical efficiency and scale efficiency of medical and health institutions in various regions. In the second stage, the stochastic frontier method is used to filter out the impact of environmental factors and management inefficiency, so that all decision-making units are in the same external environment; In the third stage, BCC model is also used to measure the comprehensive technical efficiency, pure technical efficiency and scale efficiency of each decision-making unit again.

The research data of this paper is from the 2021 Statistical Yearbook of Anhui Province. The research object is the medical and health institutions in 16 prefecture level cities in Anhui Province, including hospitals, grass-roots medical and health institutions, professional public health institutions and other medical and health institutions.

Table 1. Indicator Selection

Index	Variable	Minimum	Maximum	Average	Std
Input	Number of staff (person)	11285	90133	31452	20301
	Number of health institutions	647	3498	1837	826
	Health expenditure (10000 yuan)	192826	914630	456196	225891
	Number of beds	8980	67871	25480	15763
Output	Number of discharged persons	7397	59161	19827	13176
	Bed utilization rate (%)	65.5	79.3	71.1	4.5
Environment Variable	GDP (yuan)	34399	108427	64141	23996
	Population (10000)	131	937	381	233

By reviewing relevant literature[], input indicators are generally divided into human, material and financial aspects. Therefore, the number of medical and health institutions, the number of medical and health institutions, public health expenditure and the number of beds in medical and health institutions are selected as input indicators, while output indicators can be generally divided into income and treatment effect. Therefore, the number of discharged patients and the utilization rate of beds are selected as output indicators, The regional per capita GDP and population are used as exchange variables. Descriptive statistics of relevant indicators are

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shown in Table 1. It can be found that the standard deviation between the number of personnel in medical and health institutions and public health expenditure is large, reflecting the large difference in medical level between different prefecture level cities in Anhui Province.

The premise of using DEA is to test the correlation between input indicators and output indicators, that is, to judge whether they can influence each other. By calculating the Pearson correlation coefficient between two indicators, it can be found that the correlation between input indicators and output indicators is high, which meets the data orientation requirements of DEA model. The correlation coefficient matrix is shown in Table 2:

Table 2. Correlation Coefficient Matrix

	Staff	Institutions	Health Expenditure	Beds	Discharged Patients	Bed Utilization Ratio
Staff	1	0.906	0.905	0.995	0.991	0.454
Institutions	0.906	1	0.976	0.920	0.858	0.515
Health Expenditure	0.905	0.976	1	0.928	0.863	0.476
Beds	0.995	0.920	0.928	1	0.985	0.438
Discharged Patients	0.991	0.858	0.863	0.985	1	0.407
Bed Utilization Ratio	0.454	0.515	0.476	0.438	0.407	1

4. Model Solving

4.1. BCC Model

Using DEAP 2.1 software, assuming that the scale returns are variable, we measure the comprehensive technical efficiency, scale technical efficiency and pure technical efficiency of medical and health institutions in 16 prefecture level cities in Anhui Province in 2020 through the investment oriented BCC model. It can be found that the comprehensive technical efficiency of Hefei, Huaibei, Bengbu, Wuhu, Tongling and Chizhou is 1, the scale returns of 7 cities remain unchanged, and the scale returns of 8 cities decrease, The scale returns of one city are increasing, and the specific results are shown in Table 3:

Table 3. Results of Traditional DEA Model

City	Comprehensive Technical Efficiency	Pure Technical Efficiency	Scale Efficiency	Return to Scale
Hefei	1	1	1	-
Huaibei	1	1	1	-
Bozhou	0.763	0.908	0.841	drs
Suzhou	0.836	0.951	0.879	drs
Bengbu	1	1	1	-
Fuyang	0.865	0.943	0.917	drs
Huainan	0.918	0.922	0.997	drs
Chuzhou	0.878	0.914	0.961	drs
Lu'an	0.743	1	0.743	drs
Ma'anshan	0.955	0.956	0.999	-
Wuhu	1	1	1	-
Yicheng	0.946	0.952	0.994	drs
Tongling	1	1	1	-
Chizhou	1	1	1	-
Anqing	0.945	1	0.945	drs
Huangshan	0.979	1	0.979	irs

"Irs" means increasing returns to scale; "drs" means diminishing returns to scale; "-" means the return to scale remains unchanged.

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4.2. SFA Regression

Using Frontier4.1 software, the two selected environmental variables are taken as explanatory variables, and the relaxation variables of the four input variables are taken as explanatory variables for SAF regression respectively. The results are as follows:

Table 4. SFA Model Regression Results

	Staff	Institutions	Health Expenditure	Beds
Constant	-1233.852***	534.077**	117233***	-6654.065***
Coefficient of GDP	0.112***	-0.003	-1.135	0.071***
Coefficient of Population	8.434***	3.358**	924.849***	67.323***
σ^2	0.178E+8	0.990E+5	0.587E+10	0.435E+7
γ	1	0.786	0.886	0.785

The above results show the significant situation of SFA regression, indicating that it is reasonable and necessary to peel off the environmental variables when measuring the technical efficiency of medical and health institutions in various regions. From the regression results, GDP and population have significant effects on the number of staff and beds, while GDP has no significant effect on the number of institutions and health expenditure.

4.3. Adjust BCC Model

The DEA efficiency was analyzed again by combining the adjusted four inputs of actual personnel, number of institutions, health expenditure and number of beds with the original output indicators. It was found that the comprehensive technical efficiency, pure technical efficiency and scale efficiency of medical and health institutions in each city had changed, as shown in the following table:

Table 5. Efficiency Difference

City	Comprehensive Technical Efficiency		Pure Technical Efficiency		Scale Efficiency	
	Before	After	Before	After	Before	After
Hefei	1	1	1	1	1	1
Huaibei	1	1	1	1	1	1
Bozhou	0.763	0.728	0.908	0.826	0.841	0.841
Suzhou	0.836	0.745	0.951	0.972	0.879	0.824
Bengbu	1	1	1	1	1	1
Fuyang	0.865	0.915	0.943	0.936	0.917	0.865
Huainan	0.918	0.894	0.922	0.918	0.997	1.051
Chuzhou	0.878	0.865	0.914	0.872	0.961	0.954
Lu'an	0.743	0.734	1	1	0.743	0.798
Ma'anshan	0.955	0.897	0.956	0.986	0.999	0.948
Wuhu	1	1	1	1	1	1
Yicheng	0.946	0.973	0.952	0.995	0.994	0.986
Tongling	1	1	1	1	1	1
Chizhou	1	1	1	1	1	1
Anqing	0.945	0.887	1	1	0.945	0.942
Huangshan	0.979	0.943	1	1	0.979	0.949
Average	0.927	0.911	0.972	0.969	0.953	0.947

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The results show that the adjusted comprehensive technical efficiency, pure technical efficiency and scale efficiency have declined to a certain extent, mainly due to the rapid development of Anhui Province in recent years, the high GDP growth rate, which has greatly improved the consumption capacity of residents, to a certain extent, enhanced the capacity of medical expenditure, and also provided support for the increase of the number of medical institutions and health personnel, Therefore, the efficiency of environment variable stripping is reduced.

5. Conclusion

5.1. Problems

In this paper, we use a three-stage DEA model to separate the impact of environmental variables, and measure the operating efficiency of medical institutions in 16 prefecture level cities in Anhui Province. The results show that the returns to scale in 7 cities remain unchanged, 8 cities are decreasing, and 1 city is increasing, indicating that the waste of resources and insufficient returns to scale in medical and health institutions in Anhui Province still exist. At the same time, it is found in SFA regression that the number of personnel in the organization is 1, which indicates that redundancy is caused by management inefficiency.

5.2. Suggestions

In order to improve the operational efficiency of medical institutions in individual cities of Anhui Province, we propose the following suggestions for improvement:

From the government level, the government of Anhui Province should pay attention to the regional differences of medical and health institutions among different cities in Anhui Province, and reasonably plan medical and health resources. At the same time, we should make reasonable plans for the construction and expansion of medical institutions at all levels to prevent wild growth.

From the hospital level, we should strengthen the introduction of talents, establish a sound talent incentive mechanism, and improve the training of medical science and technology talents from the perspective of education. In addition, it is also necessary to pay attention to the improvement of medical management efficiency, incorporate the utilization rate of hospital beds and the number of discharged people into the evaluation indicators, form a strategic system driven by operational efficiency, and realize the full utilization of health resources.

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