Analysis of the Efficiency of China's Medical Service Resources under the Background of Hierarchical Medical Policy

Shaomin Wang, *Qunshan Tao

School of Medical Economics and Management, Anhui University of Chinese Medicine, Hefei 230012, China

*Corresponding Author: Email: taoqunshan@163.com

Abstract

Background: Hierarchical medical system (HMS) is a good policy to promote the fairness of medical services for residents. Given the importance of HMS, it is necessary to know the implementation effect of the policy. Therefore, we aimed to analyze the efficiency of medical service resources in China under the background of hierarchical medical policy.

Methods: Based on the panel data of China's medical resources in 2015-2019, we used DEA model to calculate the technical efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE) of medical resources from both lateral and longitudinal aspects. We used Malmquist index to evaluate the change trend of efficiency, and further we compared the efficiency differences of regions and medical institutions.

Results: In lateral evaluation results, TE was relatively stable, while total factor productivity (TFP) was on the rise. In longitudinal evaluation results, TE and TFP showed a downward trend.

Conclusion: The government should consider the differences in development between regions and make health plans by regions. Medical institutions should strive to break down the constraints and make use of their advantages, which is conducive to improving efficiency.

Keywords: Hierarchical medical system; Medical service resources; Efficiency

Introduction

The promulgation of the medical reform policy has made good progress in the construction of China's medical and health service system. The basic medical and health system has been initially established, and the public health has been improved significantly. However, with the deepening of reforms, some deficiencies in medical ser- vice system have gradually become prominent, manifested in the excessive concentration of medical resources and patients in large urban medical institutions. Unreasonable patient flow has caused the masses "difficulties and high ex- pense in medical care", and the medical service system is operating inefficiently (1).

In 2015, the Chinese government issued the "Guiding Opinions on Promoting the Construction of a Hierarchical Medical System", which aims to strengthen the rational use of medical resources, improve the efficiency of the medical service system, and effectively solve the issue of "difficult and expensive medical treatment" (2).

The Chinese government has taken many measures to promote the construction of HMS, such as reforming the Medicare payment system, implementing a family doctor service contract system, and building medical alliances (3-5). The government has also increased health investments. The proportion of total health expenditure in GDP increased from 6.0% in 2015 to 6.6% in 2019. Per capita health expenditure increased from 2820.9 Yuan in 2016 to 4646.7 Yuan in 2019. However, China's medical service system still faces the problems of unreasonable utilization of health resources and low efficiency of medical services.

According to the 2010 World Health report, approximately 20-40% of health resources are wasted due to inefficiency (6). To reduce the waste of resources, governments must know the causes of inefficiency and take measures.

In this work, we used DEA model to analyze the static efficiency of medical service resources. Malmquist index was used to analyze the dynamic efficiency of medical service resources in 2015-2019. Further, we compared efficiency differences, aiming to provide management ideas for improving the efficiency of medical resources.

Methods

Data envelopment analysis

Data Envelopment Analysis (DEA) is a method used to measure the relative efficiency of homogeneous decision-making units (DMU) with multiple inputs and outputs (7). The DEA model used in this study was the BCC model.

Suppose we address a set of n DMUs under evaluation. Each DMU has i inputs and r outputs (Table 1). The i-th input and the r-th output of the DMUj are denoted as x_{ij}, y_{rj} respectively. The measurement of each DMU is shown below.

$$1) \quad \begin{cases} \min \theta \\ s.t. \ \sum_{j=1}^{n} \lambda_j x_{ij} + s^+ = \theta x_0 \\ \sum_{j=1}^{n} \lambda_j y_{rj} - s^- = \theta y_0 \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j \geq 0, \ s^+ \geq 0, \ s^- \leq 0, \ j = 1, 2, ..., n \end{cases}$$

The technical efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE) of each DMU is calculated by Formula 1, and $TE = PTE \times SE$.

When $\theta < 1$, it shows the evaluated DMU is inefficient. When $\theta = 1$, and $s^+ \neq 0$ or $s^- \neq 0$, it shows the evaluated DMU is weak efficient. When $\theta = 1$, $s^+ = 0$, $s^- = 0$, it shows the evaluated DMU is efficient.

Malmquist index

Malmquist index was used to measure the dynamic efficiency of DMU in different periods. The expression of Malmquist index is shown below.

2)

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \times \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}}$$

$$= \left(\frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \right) \times \left[\left(\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)} \right) \right]^{\frac{1}{2}}$$

$$= EFFCH \times TECHCH$$

The total factor productivity change (TFPC) can be decomposed into technical efficiency change (TEC) and technical change (TC). TEC represents the effective utilization of existing medical technology, which can be decomposed into scale efficiency change (SEC) and pure technology efficiency change (PTEC). SEC reflects whether the growth of medical output is consistent with

the growth of input, PTEC reflects the change of management level of medical institutions (8). In summary, the Malmquist index decomposition is expressed as:

$$TFPC=TEC \times TC=PTEC \times SEC \times TC$$.

When $TFPC \geq 1$, it means the efficiency of medical resources is improved. When $TFPC<1$, it means the efficiency of medical resources is reduced.

Variables and data

According to the published literature (9-11) and considering the availability of data, we considered three inputs: the number of health technicians, the number of health institutions and the number of beds. It reflects the input of manpower and material resources respectively. The output variables were the number of patients and the number of discharged patients.

The data we extracted were from the 2016-2017 China Health and Family Planning Yearbook, and the 2018-2020 China Health Statistics Yearbook. The results of DEA and Malmquist were obtained on DEAP 2.1 software.

Table 1: Model variables

Categories	Variables
Inputs	Number of medical institutions
	Number of health technicians
	Number of beds
Outputs	Number of patients
	Number of discharged patients

Results

Lateral evaluation

Lateral evaluation is to evaluate the effect of HMS in 31 provinces by calculating efficiency in 2015-2019.

Static analysis of efficiency

Table 2 shows static efficiency of 31 provinces in 2015 and 2019.

TE in 31 provinces was inefficient in both periods, with an average efficiency of 0.817. In 2015 and 2019, TE in 7 regions was at the forefront of production. Shanghai, Guangdong, Guangxi and Chongqing were efficient in these two periods, accounting for 12.90%. In 2019, TE was efficient in 7 provinces including Beijing, Shanghai, Zhejiang, Hubei, Guangdong, Guangxi and Chongqing, accounting for 22.58%. Tibet, Shanxi

and Inner Mongolia were the last three regions in TE.

For PTE, the average TE in 2015 and 2019 were 0.922 and 0.920, showing a slight downward trend. In 2019, the PTE was 0.920, which was 0.080 behind the production frontier. In 2015 and 2019, there were 16 provinces with efficient PTE. Shanxi's PTE was at a low level, which was 0.573 in 2015 and 0.623 in 2009, far below the national average.

SE can reflect whether the supply of medical service resources is at the optimal scale (112). The average SE was 0.946 in 2015 and 0.949 in 2009, showing a slight upward trend. About 1/4 of the regions reached the optimal scale. The average SE was 1.000 in two years in 5 provinces: Shanghai, Guangdong, Guangxi, Chongqing and Yunnan, accounting for 16.13%.

Dynamic analysis of efficiency

Table 3 shows dynamic efficiency in 31 provinces in 2015-2019.

The average TFPC is greater than 1.000 (1.004), showing an upward trend in 2015-2019, and the development trend is good. The average increase in TFP in 31 provinces was 0.4%, mainly due to the 0.4% increase in TC. TC is an important factor affecting TFP. The specific analysis is as follows.

Table 2: Static efficiency of 31 provinces in 2015 and 2019

Province	2015				2019			
	TE	PTE	SE	Reward	TE	PTE	SE	Reward
Peking	0.936	0.943	0.993	irs	1.000	1.000	1.000	-
Tianjin	0.894	1.000	0.894	irs	0.928	1.000	0.928	irs
Hebei	0.871	0.879	0.990	drs	0.816	0.822	0.993	drs
Shanxi	0.569	0.573	0.994	irs	0.618	0.623	0.992	irs
Inner Mongolia	0.614	0.627	0.979	irs	0.624	0.638	0.979	irs
Liaoning	0.744	0.751	0.990	drs	0.707	0.712	0.993	irs
Jilin	0.669	0.678	0.988	irs	0.670	0.686	0.976	irs
Heilongjiang	0.758	0.764	0.992	drs	0.762	0.782	0.975	irs
Shanghai	1.000	1.000	1.000	-	1.000	1.000	1.000	-
Jiangsu	0.967	1.000	0.967	drs	0.898	1.000	0.898	drs
Zhejiang	0.983	1.000	0.983	drs	1.000	1.000	1.000	-
Anhui	0.989	1.000	0.989	drs	0.942	0.949	0.992	drs
Fujian	0.869	0.880	0.987	irs	0.873	0.874	0.999	irs
Jiangxi	1.000	1.000	1.000	-	0.986	1.000	0.986	irs
Shandong	0.835	1.000	0.835	drs	0.845	0.952	0.888	drs
Henan	0.878	0.987	0.889	drs	0.930	1.000	0.930	drs
Hubei	0.979	1.000	0.979	drs	1.000	1.000	1.000	-
Hunan	1.000	1.000	1.000	-	0.998	1.000	0.998	drs
Guangdong	1.000	1.000	1.000	-	1.000	1.000	1.000	-
Guangxi	1.000	1.000	1.000	-	1.000	1.000	1.000	-
Hainan	0.768	0.944	0.813	irs	0.746	0.852	0.876	irs
Chongqing	1.000	1.000	1.000	-	1.000	1.000	1.000	-
Sichuan	0.966	1.000	0.966	drs	0.987	1.000	0.987	drs
Guizhou	0.945	0.945	1.000	-	0.950	0.962	0.987	irs
Yunnan	1.000	1.000	1.000	-	0.961	0.961	1.000	-
Tibet	0.596	1.000	0.596	irs	0.547	1.000	0.547	irs
Shaanxi	0.780	0.781	0.999	drs	0.817	0.818	0.999	irs
Gansu	0.840	0.855	0.983	irs	0.871	0.897	0.971	irs
Qinghai	0.691	0.979	0.705	irs	0.695	1.000	0.695	irs
Ningxia	0.837	1.000	0.837	irs	0.844	1.000	0.844	irs
Xinjiang	0.984	0.995	0.989	irs	0.956	0.977	0.979	irs
East	0.912	0.965	0.946	/	0.911	0.950	0.958	/
Central	0.903	0.927	0.975	/	0.912	0.929	0.983	/
West	0.854	0.932	0.921	/	0.854	0.938	0.916	/
Northeast	0.724	0.731	0.990	/	0.713	0.727	0.981	/
Mean	0.870	0.922	0.946	/	0.870	0.920	0.949	/

Note: dis, ins, - respectively indicate that the DMU is in the stage of diminishing, increasing and constant returns.

Table 3: Dynamic efficiency of 31 provinces in 2015-2019

Province	TEC	TC	PTEC	SEC	TFPC
Peking	1.017	0.987	1.015	1.002	1.004
Tianjin	1.009	0.983	1.000	1.009	0.992
Hebei	0.984	0.998	0.983	1.001	0.982
Shanxi	1.021	0.998	1.021	0.999	1.018
Inner Mongolia	1.004	0.996	1.004	1.000	1.000
Liaoning	0.988	1.004	0.987	1.001	0.991
Jilin	1.000	1.001	1.003	0.997	1.001
Heilongjiang	1.001	1.027	1.006	0.996	1.029
Shanghai	1.000	1.010	1.000	1.000	1.010
Jiangsu	0.982	1.028	1.000	0.982	1.009
Zhejiang	1.004	1.005	1.000	1.004	1.009
Anhui	0.988	1.026	0.987	1.001	1.013
Fujian	1.001	0.997	0.998	1.003	0.998
Jiangxi	0.997	0.999	1.000	0.997	0.995
Shandong	1.003	0.998	0.988	1.016	1.001
Henan	1.014	1.000	1.003	1.011	1.015
Hubei	1.005	1.017	1.000	1.005	1.022
Hunan	1.000	1.001	1.000	1.000	1.000
Guangdong	1.000	0.997	1.000	1.000	0.997
Guangxi	1.000	1.001	1.000	1.000	1.001
Hainan	0.993	0.993	0.975	1.019	0.986
Chongqing	1.000	1.008	1.000	1.000	1.008
Sichuan	1.005	1.004	1.000	1.005	1.009
Guizhou	1.001	1.005	1.004	0.997	1.007
Yunnan	0.990	1.017	0.990	1.000	1.007
Tibet	0.979	0.996	1.000	0.979	0.974
Shaanxi	1.012	1.002	1.012	1.000	1.013
Gansu	1.009	1.001	1.012	0.997	1.010
Qinghai	1.001	1.005	1.005	0.996	1.006
Ningxia	1.002	1.007	1.000	1.002	1.009
Xinjiang	0.993	1.002	0.995	0.997	0.994
East	1.000	1.000	0.996	1.004	1.000
Central	1.005	1.007	1.002	1.002	1.011
West	1.000	1.004	1.002	0.998	1.004
Northeast	0.997	1.011	0.999	0.998	1.008
Mean	1.000	1.004	1.000	1.000	1.004

Beijing, Hebei, Shanxi, Inner Mongolia, Liaoning, Jiangxi, Shandong, Henan, Sichuan, Shaanxi, Gansu and Xinjiang were the 12 provinces where TFP changes were mainly affected by TEC, while other 19 provinces were affected by TC. Differences in TC are wide between provinces. Beijing

had the largest decline (1.3%), and Tibet had the largest increase (2.8%). TE in 31 provinces remained unchanged. SE in Tianjin, Hainan, Inner Mongolia, Tibet, Fujian, Guangdong, Hebei, Shanxi, Shandong and Jiangxi declined, while other provinces remained unchanged or increased. Among them, Tianjin decreased the most (2.1%) while Jiangsu increased the most (1.9%). PTE in Tianjin, Hainan, Inner Mongolia, Tibet, Fujian, Guangdong, Hebei and Shanxi declined, while that of other provinces remained unchanged or increased. Among them, Tianjin dropped the most (2.5%) and Jiangsu rose the most (2.1%).

Comparative analysis of differences

Table 4 shows the efficiency differences between 31 provinces, dividing the four types by spatial distribution into east, central, west and northeast parts.

In 2015-2019, the national TE was stable, with PTE decreasing and SE increasing. TE and PTE in the east regions showed a downward trend, while SE showed an upward trend. TE, PTE and SE showed an upward trend in the central regions. In the west, TE remained unchanged, while PTE decreased and SE increased. TE, PTE and SE showed a downward trend in northeast regions. In 2015 and 2019, the TE of the east and central regions was higher than the national average, the TE of the west region was slightly lower than the national average, and the TE in the northeast region was far lower than the national average.

In 2015-2019, national TFP increased by 0.4%, of which TC increased by 0.4%, and TEC remained unchanged. Regionally, TFP in the east, central, west and northeast regions showed an upward trend from 2015 to 2019. Among them, the central regions had the highest TFP growth rate of 1.1%, which was higher than that of the east, west and northeast regions. In terms of TEC, TE in northeast decreased by 0.3% while

that in other regions remained unchanged or showed an upward trend, with the highest increase in central regions. As for TC, the east, central, west and northeast regions had the same trend as the national trend, and TC was on the rise. Among them, the highest growth rate of TC is in the Northeast, at 1.1%.

Longitudinal evaluation

Longitudinal evaluation is to evaluate the effect of HMS in medical institutions by measuring efficiency in 2015-2019.

Static analysis of efficiency

Table 4 shows static efficiency of medical institutions in 2015 and 2019.

From the TE, the scores were 0.921 and 0.899 in 2015 and 2019, showing a downward trend. Medical institutions that efficient in 2015 will still be efficient in 2019, and medical institutions that inefficient in 2015 will have a lower TE in 2019. General hospitals, traditional Chinese medicine hospitals, community health service centers, community health service stations and township hospitals were efficient in both periods.

PTE showed a slight downward trend. In 2019, the average PTE of medical institutions was 0.960, which was 0.040 behind the production frontier. In these two periods, except for specialized hospitals, other medical institutions are all PTE efficient. The main reason for inefficient TE was the low score of SE while the inefficient TE in specialized hospitals was due to the low score of PTE. Specialized hospitals had low TE scores, 0.662 in 2015 and 0.640 in 2019, which were far below the national average.

SE showed a downward trend. It was 0.958 in 2015 and 0.939 in 2019.

Dynamic analysis of efficiency

Table 5 shows dynamic efficiency in medical institutions in 2015-2019.

In 2015-2019, TFP of medical institutions decreased by 0.4%, mainly because the decrease in TE by 0.7%. The decrease in TE of medical institutions was due to SE decreased by 0.6% and PTE decreased by 0.1%.

The decline in TFP of national hospitals, specialized hospitals and urban health centers was mainly due to the TEC, while TFPC in other medical institutions was mainly due to the TC.

Table 4: Static efficiency in medical institutions in 2015 and 2019

Institutions	2015				2019			
	TE	PTE	SE	Reward	TE	PTE	SE	Reward
GH	1.000	1.000	1.000	-	1.000	1.000	1.000	-
TCM	1.000	1.000	1.000	-	1.000	1.000	1.000	-
CWMH	0.930	1.000	0.930	irs	0.882	1.000	0.882	irs
NH	0.861	1.000	0.861	irs	0.777	1.000	0.777	irs
SH	0.659	0.662	0.996	irs	0.638	0.640	0.997	irs
CHSC	1.000	1.000	1.000	-	1.000	1.000	1.000	-
CHST	1.000	1.000	1.000	-	1.000	1.000	1.000	-
UHC	0.835	1.000	0.835	irs	0.797	1.000	0.797	irs
THC	1.000	1.000	1.000	-	1.000	1.000	1.000	-
Public hospitals	0.890	0.932	0.957	/	0.859	0.928	0.931	/
Grassroots medical institutions	0.959	1.000	0.959	/	0.949	1.000	0.949	/
mean	0.921	0.962	0.958	/	0.899	0.960	0.939	/

Note: GH: General Hospital; TCM: Traditional Chinese Medicine Hospitals; CWMH: Integrated traditional Chinese and Western Medicine Hospital; NH: National Hospital SH: Specialized Hospital; CHSC: Community Health Service Centers; CHST: Community Health Service Stations; UHC: Urban Health Center; THC: Township Health Center

Table 5: Dynamic efficiency of medical institutions in 2015-2019

Institutions	TEC	TC	PTEC	SEC	TFPC
GH	1.000	1.018	1.000	1.000	1.018
TCM	1.000	0.991	1.000	1.000	0.991
CWMH	0.987	0.992	1.000	0.987	0.979
NH	0.975	1.012	1.000	0.975	0.986
SH	0.992	1.006	0.992	1.000	0.998
CHSC	1.000	1.010	1.000	1.000	1.010
CHST	1.000	1.008	1.000	1.000	1.008
UHC	0.988	0.997	1.000	0.988	0.985
THC	1.000	0.991	1.000	1.000	0.991
Public hospitals	0.991	1.004	0.998	0.993	0.995
Grassroots medical institutions	0.999	1.003	1.000	0.999	1.001
mean	0.993	1.003	0.999	0.994	0.996

TC in general hospitals, national hospitals, specialized hospitals, community health service centers and community health service stations have improved. General hospitals had the highest TC improvement (1.8%), and traditional Chinese medicine hospitals and township hospitals had the highest TC decline (0.9%).

TEC in specialized hospitals mainly comes from PTEC, while in other medical institutions mainly comes from SEC. It can be seen that the SE of Integrated Chinese and Western medicine hospitals, national hospitals and urban health centers decreased slightly. The SE of the five types of medical institutions in general hospitals, traditional Chinese medicine hospitals, community health centers, community health stations and township health centers, remained unchanged, while TE and PTE of these medical institutions also remained unchanged.

Comparative analysis of differences

Table 4 shows the differences in efficiency of medical institutions, which were divided into two categories according to their functions: public hospitals and grassroots medical institutions.

In 2015-2019, the national TE, PTE and SE showed a downward trend, but the efficiency score was high. The change trend of TE, PTE and SE in public hospitals was consistent with the country. TE and PTE of grassroots medical institutions showed a downward trend, while PTE remained unchanged. In 2015 and 2019, the scores of TE, PTE and SE in grassroots medical institutions were higher than those of public hospitals.

Overall, TFP decreased by 0.4% in 2015-2019. The trend of TFP in public hospitals was consistent with the country. Unlike the national trend, TFP of grassroots medical institutions increased by 0.1%. The national TEC decreased by 0.7%, and the TEC of public hospitals and grassroots medical institutions also showed a downward trend. National TC increased by 0.3%. TC in public hospitals and grassroots medical institutions also showed an upward trend, increasing by 0.4% and 0.3% respectively.

Discussion

Lateral evaluation results
Static efficiency

Overall, the TE score was lower than 0.9 in 2019, indicating that there is still much room for improvement. PTE was the main cause of inefficient TE, as can be seen from the TE and PTE scores. The key to solving this problem is to improve the management level of medical institutions and give full play to the role of existing medical technology.

Regionally, there was a significant gap between provinces. The score of TE and PTE in the northeast was significantly lower than those in the east, central and west regions. There may be several reasons. First, compared with the east, central and west regions, the northeast has a lower level of economic development and weak capabilities of technological innovation, resulting in the disadvantage in health personnel and medical facilities in the northeast region. Secondly, the management mechanism of medical institutions is not perfect, and has a low salary, which cannot attract high-quality medical talents. This suggests the health administration should fully consider the development differences between regions, make health plans by region and promote balanced development of various regions (13).

Dynamic efficiency

Overall, TFP in 31 provinces showed an upward trend in 2015-2019, and the development trend was good. PTEC is the main cause of TEC decline, which can be seen from PTEC and SEC. The main way to improve TEC is to improve the management system and the governance mechanism.

Regionally, except Tianjin, Hebei, Liaoning, Fujian, Guangdong, Guangxi, Hainan, Tibet and Xinjiang, TFP scores of other provinces were greater than 1.000 in 2015-2019. In terms of motivations, TC in Beijing, Shandong and Inner Mongolia decreased, and the improvement of TFP comes from TEC. The increase of TFP in Jiangsu, Anhui and Yunnan benefited from TC. The increase of TFP in Tianjin, Shanghai and Zhejiang was jointly promoted by TEC and TC. In 2015-2019, TFP in all regions showed an upward trend, and central region had the largest increase. It is suggested that the central region should continue to make use of the advantages to achieve a steady improvement of benefits. TFPC in the Northeast increased, but the SEC declined. It is recommended that the government should speed up the construction of medical institutions and broaden investment and financing channels.

Longitudinal evaluation results
Static efficiency

Overall, compared with 2015, the TE of medical institutions decreased slightly in 2019. SE was the main cause of TE decline. Therefore, policy makers can adjust investment in medical institutions to improve SE. The medical institutions need to make full use of existing resources to achieve the optimal scale to improve TE.

From the perspective of medical institutions, the TE score of public hospitals was lower than that of grassroots medical institutions, mainly due to the unreasonable development scale of integrated Chinese and Western medicine hospitals and national hospitals, and the low PTE of specialized hospitals. It is recommended that integrated Chinese and Western medicine hospitals and national hospitals should determine the appropriate scale according to their functions to avoid waste of resources and specialized hospitals should constantly improve their management level to increase efficiency.

Dynamic efficiency

Overall, TFPC of medical institutions showed a downward trend. From the rise of TC, the decline of TEC and the decline of TFPC, it can be inferred that TE restricted the improvement of the operational efficiency of medical institutions. It shows that most medical institutions have weak awareness of technological innovation, and have not introduced new technology and equipment, or medical staff are not enthusiastic about learning new technology and equipment.

From the perspective of medical institutions, TFP scores in most medical institutions in 2015-2019 are lower than 1.000, indicating that there is still much room for the efficiency of medical institutions. In terms of constraints, the main reason for the TFP decline was TEC in national hospitals and specialized hospitals. TEC and TC of integrated Chinese and Western medicine hospitals and urban health centers were synchronized, that is, TEC and TC jointly restrict the growth of TFP. In 2015-2019, the average TFP in hospital was lower than that of grassroots medical institutions. It is recommended that future policies should be paid attention to.

Conclusion

In lateral evaluation, based on DEA model, we can see the TE of 31 provinces was inefficient in 2015 and 2019. There is still room for improvement in TE and SE in most provinces. Efforts should be made to improve the management system, expand investment and achieve the best scale. It can be seen from the Malmquist index that the average TFP showed an upward trend in 2015-2019. TC plays a leading role in the improvement of TFP, followed by TEC. The efficiency gap between provinces is large. China's government should consider the development differences between regions and formulate health planning in different regions to improve the efficiency of medical resources.

In longitudinal evaluation, based on the DEA model, we can see the TE showed a downward trend in 2015-2019, and the SE was the main cause of inefficient TE. China's government should adjust its investment in medical institutions and determine the optimal scale based on the functions and development needs of medical institutions. It can be seen from the Malmquist index that the average TFP showed a downward trend in 2015-2019, mainly due to the decline in TE, and SE was the main cause of inefficient TE. From the perspective of medical institutions, public hospitals are lower than grassroots medical institutions in terms of TEC and TFPC. It is recommended that the government cannot blindly increase or reduce investment in medical institutions. Planning should be based on actual needs to avoid redundancy of health personnel and waste of health resources.

Ethical Considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Chen, R, Zhao, YL, Du, J, et al (2014). Health workforce equity in urban community health service of China. *PloS ONE*, 9(12): e115988-e115988.

2. Li N, Zhang RT, Xing YP, (2019). A Novel Multi-attribute Decision-Making Method and Its Application in Solving the Downward Referral Problem in the Hierarchical Medical Treatment System in China. *IEEE Access*, 7:185205 – 185227.

3. Li HM, Chen YC, Gao HX, et al (2018). Effectiveness evaluation of quota payment for specific diseases under global budget: A typical provider payment system reform in rural China. *BMC Health Serv Res*, 18(1): 635.

4. Xiao XP, Huang YM, Li BE, et al (2019). Residents' Awareness of Family Doctor Contract Services, Status of Contract with a Family Doctor, and Contract Service Needs in Zhejiang Province, China: A Cross-Sectional Study. *Int J Environ Res Public Health*, 16(18): 3312

5. Cai Y, Wen C, Tang L, et al (2018). Exploration and Consideration of the Medical Alliance Modes. *Iran J Public Health*, 47(08):1160-1165.

6. World Health Organization. Improving health system eciency as a means of moving towards universal coverage. 2010. https://www.who.int/healthsystems/topics/financing/healthreport/28UCefficiency.pdf. [Accessed 30 September 2018].

7. Shwartz, M, Burgess, JF, Zhu J (2016). A DEA based composite measure of quality and its associated data uncertainty interval for health care provider profiling and pay-for-performance. *European Journal of Operational Research*, 253(02):489-502.

8. Yang YC, Xu X, Xiang N, et al (2019). Study on efficiency of tertiary traditional Chinese medicine public hospitals in China based on data envelopment analysis (DEA)-Malmquist index. *Chinese Health Resources*, 22(06):435-439.

9. Zhao L, Yang LC (2020). Operational Efficiency of Community Health Service Centers in Tianjin before and after the Implementation of Hierarchical Diagnosis and Treatment. *Chinese General Practice*, 23(01):30-34.

10. Gao CS, Lei Z (2019). Effect and Trend of Hierarchical Medical Policy in High-Quality De-

velopment Stage. *Academic Journal of Zhongzhou*, (11):65-72.

11. Yao JW, Peng LX, Ding GW, et al (2016). Hierarchical Diagnosis and Treatment Pilot Model and Effects Evaluation of Huining County of Gansu Province. *Chinese General Practice*, 19(22):2632-2635.

12. Bates LJ, Mukherjee K, Santerre RE (2006). Market Structure and Technical Efficiency in the Hospital Services Industry: A DEA Approach. *Med Care Res Rev*, 63(04):499-524.

13. Liu S, Zhang H, Zhang Q, et al (2020). Study on the Level and Equity of Health Human Resources Allocation in Guangdong Province. *Medicine and Society*, 33(07):9-13.