ISSN 2706-6827 Vol. 7, Issue 1: 77-84, DOI: 10.25236/IJFS.2025.070112

Research on Service Efficiency of Township Health Centers Based on DEA-Malmquist Index

Weikun Wang

School of Management, Hubei University of Chinese Medicine, Wuhan, Hubei, China
526501952@qq.com

Abstract: *This paper examines the changes in total factor productivity (TFP) of township health centers in China from 2018 to 2022, aiming to provide a policy basis for improving service efficiency. Statistical data on township health centers from 29 provinces (autonomous regions and municipalities directly under the central government) across China for the past five years (2012-2018) were obtained from the Data Website of the National Bureau of Statistics of China. The DEA Malmquist index method was employed to analyze the TFP of township health centers. The results indicate that between 2018 and 2022, the average technical efficiency of township health centers in China was 0.754, the average pure technical efficiency was 0.801, and the average scale efficiency was 0.939. The TFP change index of township health centers in China decreased by 4.9%, with the technical efficiency change index down by 4.3%, the technological change index down by 0.6%, the pure technical efficiency change index down by 1.2%, and the scale efficiency change index down by 3.1%. The average TFP change index for coastal, northeastern, central, and western regions was 0.984, 0.872, 0.944, and 0.954, respectively. The overall service efficiency in coastal regions was superior to that in the northeast, west, and central regions, with the northeast region exhibiting the lowest overall service efficiency.*

Keywords: *Township Health Center; Service Efficiency; Data Envelopment Analysis (DEA); Total Factor Productivity*

1. Research background

Rural townships typically have large populations with relatively limited medical resources. As a crucial component of primary health care services, enhancing the service efficiency of township health centers will significantly boost the overall development of medical services in rural areas. Improving service efficiency means being able to address patients' needs more swiftly, reduce waiting times, and ensure that every patient receives timely and effective medical care. Optimizing the consultation process and eliminating unnecessary steps will make medical services more convenient and efficient for patients, attracting more patients to seek treatment, enhancing the hospital's reputation and influence, and ultimately promoting the prosperity of medical services in rural townships. In the battle against poverty, health poverty alleviation is a vital aspect[1]. Enhancing the service efficiency of township health centers can better meet the medical needs of impoverished areas, reduce the incidence of poverty caused by illness and relapse into poverty due to illness, and provide strong support for poverty eradication efforts. In summary, researching how to improve the service efficiency of township health centers is of great significance in promoting the development of medical services in rural areas and supporting health poverty alleviation. This study employs the DEA-Malmquist index method to analyze the total factor productivity of township health centers in 29 provinces (autonomous regions, and municipalities directly under the central government) in China from 2018 to 2022, aiming to gain a comprehensive understanding of the dynamic changes in the efficiency of township health centers and provide a basis for decision-making to enhance their service efficiency.

2. Data sources and methods

2.1 Data Sources

The statistical data of township health centers in all provinces (autonomous regions, municipalities directly under the central government) across China over the past five years (2012-2018) were obtained from the "China National Bureau of Statistics Data Website" for use as research materials. Since Beijing

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and Shanghai are large cities and do not have township areas, the data for township health centers in these two cities is zero in this study. Therefore, the research materials include relevant data from township health centers in 29 provinces, autonomous regions, and municipalities directly under the central government in China (excluding Beijing, Shanghai, Hong Kong, China , Macao, China , and Taiwan, China).

According to China's geographical regional division standards, the coastal regions include Hebei Province, Beijing Municipality, Tianjin Municipality, Shandong Province, Jiangsu Province, Shanghai Municipality, Zhejiang Province, Fujian Province, Guangdong Province, Hainan Province,Hong Kong, China , Macao, China , and Taiwan, China. The western regions include Sichuan Province, Yunnan Province, Guizhou Province, Tibet Autonomous Region, Chongqing Municipality, Shaanxi Province, Gansu Province, Qinghai Province, Xinjiang Uyghur Autonomous Region, Ningxia Hui Autonomous Region, Inner Mongolia Autonomous Region, and Guangxi Zhuang Autonomous Region. The central regions include Shanxi Province, Henan Province, Anhui Province, Hubei Province, Jiangxi Province, and Hunan Province. The northeastern regions include Heilongjiang Province, Jilin Province, and Liaoning Province. The statistical data of township health centers from 8, 12, 6, and 3 provinces (autonomous regions, municipalities directly under the central government) in the coastal regions, western regions, central regions, and northeastern regions, respectively, were included in this study.

2.2 Research Methods

2.2.1 Data Envelopment Analysis Model

Data Envelopment Analysis (DEA) is an operational research tool designed to study economic production frontiers, with a particular focus on measuring and evaluating the production efficiency of decision-making units[2]. By constructing mathematical models, it compares the differences between inputs and outputs of decision-making units (DMUs), thereby calculating the efficiency score for each DMU. This method allows for the simultaneous consideration of multiple input (i.e., resources) and output (i.e., services) indicators, without the need to predetermine weights. Instead, it automatically calculates the efficiency scores and ranks DMUs based on existing data. Under the assumption of Variable Returns to Scale (VRS), using the BCC model, the technical efficiency (TE) of each DMU can be obtained and further decomposed into pure technical efficiency (PTE) and scale efficiency (SE), where TE = PTE×SE. The values of each indicator fall within the range of 0-1, with higher values indicating higher efficiency[3-4].

2.2.2 Malmquist Index Method

By collecting economic data from multiple time points or regions, the Malmquist Index method calculates the technological change index and efficiency change to measure the relative performance of an organization or enterprise within a given environment. The Malmquist Index can be decomposed into the Technological Change (TC) Index and the Technical Efficiency (EC) Index. The TC Index represents the movement of the production frontier due to technological changes, while the EC Index indicates how close a decision-making unit (DMU) is to the production frontier[5]. The EC Index can be further decomposed into the Pure Efficiency Change (PEC) Index and the Scale Efficiency Change (SEC) Index, thus Total Factor Productivity (TFP) = EC×TC = PEC×SEC×TC. Firstly, the production function frontier is calculated using methods such as linear programming. Then, the TC Index is computed by comparing the distance between the production function frontiers at two different time points. If the TC Index is greater than 1, it suggests a positive impact of technological progress on economic performance; if it is less than 1, it indicates a negative impact. Similarly, the EC Index is calculated by comparing the gap between the actual output and the potential maximum output of a DMU at different time points[6-7].

2.2.3 Statistical Analysis

A database was established using Excel to input panel data from 2018 to 2022, and descriptive statistical analysis was conducted. DEA analysis was performed using DEAP 2.1.

2.3 Selection of Indicators

Based on a comprehensive review of literature and considering the availability of data, this study selects the number of township health centers, the number of rural doctors and health workers, and the number of beds in township health centers as input indicators. The output indicators include the number of visits for diagnosis and treatment in township health centers, the bed utilization rate of township health centers, the number of admissions to township health centers, and the average length of stay for

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discharged patients in township health centers.

3. Results

3.1 Input and Output Indicators of Township Health Centers in China from 2018 to 2022

Table 1 shows the data for the years 2018-2022., the number of visits for diagnosis and treatment in township health centers increased by 93 million, with an average annual growth rate of 2.02%. The bed utilization rate of township health centers decreased by 13.99%, with an average annual growth rate of -7.5%. The average length of stay for discharged patients in township health centers increased by 0.31 days, with an average annual growth rate of 1.17%. The number of admissions to township health centers decreased by 7.4606 million, with an average annual growth rate of -5.05%. The number of rural doctors and health workers decreased by 241,600, with an average annual growth rate of -7.49%. The number of beds in township health centers increased by 121,800, with an average annual growth rate of 2.21%. The number of township health centers decreased by 2,544, with an average annual growth rate of -1.79%.The data results indicate that despite a decrease in the number of township health centers and the number of admissions to these centers, the number of inpatient beds allocated has increased instead of decreasing, resulting in a significant decline in the bed utilization rate of township health centers.

Table 1: Values of Input and Output Indicators for Township Health Centers in China from 2018 to 2022.

Time	Output indicators				Input indicators		
	Number of visits for diagnosis and treatment in township health centers (in hundreds of millions)	Bed utilization rate of township health centers (%)	Average length of stay for discharged patients in township health centers (in days)	Number of admissions to township health centers (in ten thousands)	Number of rural doctors and health workers (in ten thousands)	Number of beds in township health centers (in ten thousands)	Number of township health centers
2018	11.15	52.23	6.45	3985.09	90.33	133.4	36461
2019	11.76	49.09	6.59	3909.39	83.88	136.98	36112
2020	10.98	41.5	6.81	3383.33	79.2	139.03	35762
2021	11.59	39.2	6.83	3222.97	69.39	141.75	34943
2022	12.08	38.24	6.76	3239.03	66.17	145.58	33917

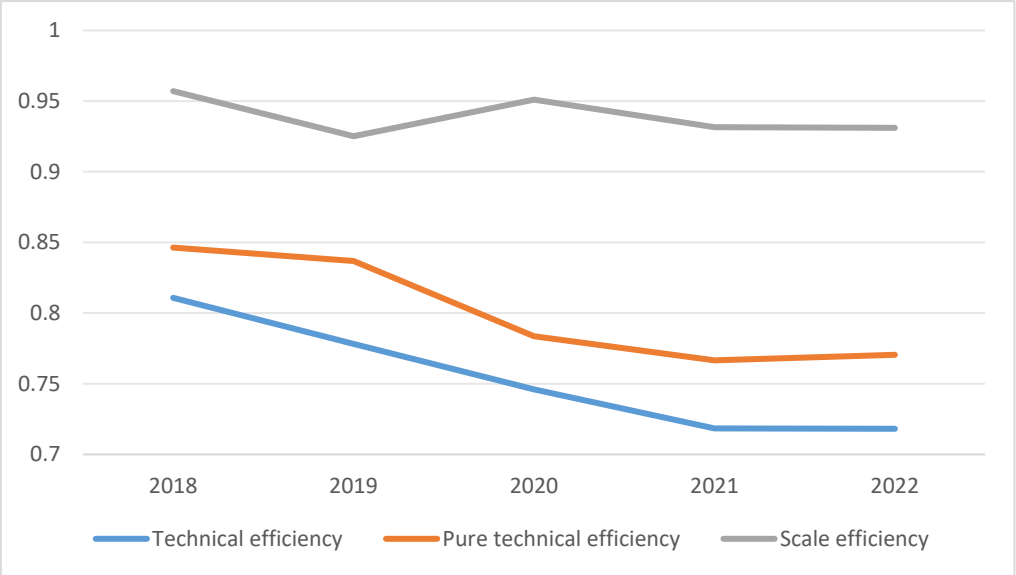

Figure 1: Average Efficiency of Township Health Centers in China from 2018 to 2022.

3.2 Analysis of Average Efficiency of Township Health Centers in China from 2018 to 2022

Using the BCC model, the efficiency of township health centers for each year from 2018 to 2022 was

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analyzed separately. The results are shown in Figure 1. The average technical efficiency for each year ranged from 0.718 to 0.811, with an average of 0.754. The average pure technical efficiency ranged from 0.767 to 0.846, with an average of 0.801. The average scale efficiency ranged from 0.925 to 0.957, with an average of 0.939. According to the data, although there were fluctuations in the average scale efficiency across the years, it showed a stable trend overall. Both the average technical efficiency and the average pure technical efficiency exhibited a significant downward trend in recent years but then stabilized after 2021.

Table 2: Decomposition of Total Factor Productivity (TFP) and Malmquist Index for Township Health Centers in China from 2018 to 2022.

Time	*The technical efficiency change index*(EC)	*The technological change index(TC)*	*The pure technical efficiency change index*(PEC)	*The scale efficiency change index*(SEC)	*The total factor productivity change index*(TFP)
2018-2019	0.946	*1.024*	1.007	0.940	0.969
2019-2020	0.943	*0.923*	0.969	0.973	0.870
2020-2021	0.941	*1.024*	0.984	0.957	0.964
2021-2022	0.996	*1.004*	0.992	1.005	1.001
Average Value by Year	0.957	*0.994*	0.988	0.969	0.951

3.3 The total factor productivity change index and Its Decomposition for Township Health Centers in China from 2012 to 2018

Table 2 presents the total factor productivity change index and the decomposition of the Malmquist index for township health centers in China from 2018 to 2022. Between 2018 and 2022, the average annual decline in the technical efficiency change index for township health centers in China is 4.3%. The decline was over 5% annually from 2018 to 2021, with the smallest decline of 0.4% occurring between 2021 and 2022.The technological change index progress declined by an average of 0.6% annually, with a notable decrease of 8.7% between 2019 and 2020, while there were slight increases in other years. The pure technical efficiency change index declined by an average of 1.2% annually, with an increase of 0.7% between 2018 and 2019 being the exception. The largest decline of 3.1% occurred between 2019 and 2020.*The scale efficiency change index* declined by an average of 3.1% annually, with an increase of 0.5% between 2021 and 2022 being the exception. The largest decline of 6% occurred between 2018 and 2019. The total factor productivity change index declined by an average of 4.9% annually, with a slight increase between 2021 and 2022 being the exception. The largest decline of 13% occurred between 2019 and 2020.

Table 3: Decomposition of Total Factor Productivity (TFP) and Malmquist Index for Township Health Centers in 29 Provinces (Autonomous Regions, Municipalities Directly Under the Central Government) from 2018 to 2022.

Region	Province	*The technical efficiency change index*(EC)	*The technological change index(TC)*	*The pure technical efficiency change index*(PEC)	*The scale efficiency change index*(SEC)	*The total factor productivity change index(TFP)*
northeastern region	Liaoning Province	0.894	0.985	0.997	0.897	0.880
	Jilin Province	0.913	0.984	0.973	0.938	0.898
	Heilongjiang Province	0.856	0.979	0.936	0.915	0.838
	average value	0.888	0.983	0.969	0.917	0.872
western region	Inner Mongolia Autonomous Region	0.920	0.976	0.975	0.943	0.898
	Guangxi Zhuang Autonomous Region	1.003	1.019	1.000	1.003	1.022
	Chongqing	1.000	1.028	1.000	1.000	1.028

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	Municipality					
	Sichuan Province	0.991	0.983	1.000	0.991	0.974
	Guizhou Province	1.011	0.977	1.011	0.999	0.988
	Yunnan Province	1.018	0.985	1.029	0.989	1.003
	Tibet Autonomous Region	0.926	1.021	0.918	1.008	0.945
	Shaanxi Province	0.912	0.977	0.980	0.930	0.891
	Gansu Province	0.925	0.970	0.981	0.942	0.897
	Qinghai Province	0.984	0.928	1.000	0.984	0.914
	Ningxia Hui Autonomous Region	1.000	0.997	1.000	1.000	0.997
	Xinjiang Uyghur Autonomous Region	0.917	0.976	0.983	0.933	0.895
	average value	0.967	0.986	0.990	0.977	0.954
coastal areas	Tianjin Municipality	1.000	1.007	1.000	1.000	1.007
	Hebei Province	0.856	0.982	0.964	0.888	0.840
	Jiangsu Province	1.000	1.004	1.000	1.000	1.004
	Zhejiang Province	1.000	1.003	1.000	1.000	1.003
	Fujian Province	0.958	0.988	0.984	0.974	0.946
	Shandong Province	1.008	0.983	1.001	1.007	0.991
	Guangdong Province	0.989	1.026	0.993	0.996	1.015
	Hainan Province	1.000	1.063	1.000	1.000	1.063
	average value	0.976	1.007	0.993	0.983	0.984
central region	Shanxi Province	0.879	0.980	1.008	0.872	0.862
	Anhui Province	0.938	0.990	0.991	0.947	0.928
	Jiangxi Province	0.909	0.978	0.932	0.975	0.889
	Henan Province	0.984	0.981	1.000	0.984	0.965
	Hubei Province	0.994	0.980	1.000	0.994	0.974
	Hunan Province	0.993	1.050	1.000	0.993	1.043
	average value	0.950	0.993	0.989	0.961	0.944

The total factor productivity change index (TFP) and its decomposition for township health centers in 29 provinces (autonomous regions, municipalities directly under the central government) in China from 2018 to 2022 are shown in Table 3. The average TFP change indices for the Northeast, Western, Coastal, and Central regions were 0.872, 0.954, 0.984, and 0.944, respectively, indicating that the overall service efficiency in the Northeast region was lower than that in the Western, Coastal, and Central regions. Among the 29 provinces (autonomous regions, municipalities directly under the central government), 31.03% achieved an increase in the overall service efficiency of township health centers (TFP > 1), 13.79% achieved an improvement in technical efficiency (EC > 1), 31.03% achieved technological progress (TC > 1), 13.79% achieved an improvement in pure technical efficiency (PEC > 1), and 10.34% achieved an improvement in scale efficiency (SEC > 1).

From 2018 to 2022, a total of 20 provinces (autonomous regions, municipalities directly under the central government) in China experienced a decline in total factor productivity (TFP). Analysis of these cases revealed that the decline in TFP in Guizhou Province, Ningxia Hui Autonomous Region, and Shandong Province was solely due to technological regression. In contrast, 16 provinces (autonomous regions, municipalities directly under the central government), including Liaoning, Jilin, and Heilongjiang, experienced a decline in TFP due to a combination of technological regression and a decrease in technical efficiency. The decline in TFP in the Tibet Autonomous Region was caused by a decrease in technical efficiency, which was further decomposed and found to be influenced by a decline in pure technical efficiency.

ISSN 2706-6827 Vol. 7, Issue 1: 77-84, DOI: 10.25236/IJFS.2025.070112

4. Discussion and Conclusion

4.1 The overall service efficiency of township health centers in China shows a declining trend, with significant constraints on scale efficiency in some regions

Through DEA analysis, it was found that from 2018 to 2022, the average pure technical efficiency of township health centers in China declined from 0.846 to 0.771, the average scale efficiency declined from 0.957 to 0.951, and the average technical efficiency declined from 0.811 to 0.718. During these five years, although the scale efficiency of township health centers declined slightly, the technical efficiency showed a significant downward trend, indicating that the decline in pure technical efficiency was the main reason for the decline in technical efficiency. Analysis of the total factor productivity (TFP) of township health centers in China revealed that the average TFP change index was 0.951 from 2018 to 2022, representing a decline of 4.9%. In terms of decomposition indices, the technical efficiency change index declined by 4.3%, and the technological change index progress declined by 0.6%. Further decomposition of the technical efficiency change index showed that the pure technical efficiency change index declined by 1.2%, and *the scale efficiency change index* declined by 3.1%. It can be seen that the decline in TFP was mainly caused by the decline in scale efficiency. *The scale efficiency change index* was less than 1 in 69% of the provinces (autonomous regions, municipalities directly under the central government), indicating a deviation from the optimal output scale. Among the provinces (autonomous regions, municipalities directly under the central government) that did not achieve scale efficiency in 2018, although only 57.9% showed decreasing scale efficiency, the magnitude of this decrease was significant in these regions.

Based on this, it can be concluded that there is severe input redundancy in township health centers in China, and internal resources need to be optimized. The reasons for the redundancy in scale efficiency of township health centers are multifaceted. The main reason may be the inefficient utilization of resources due to uneven input. It may also be related to hospital management and operational methods. Additionally, the inability to retain highly educated talent in rural areas may lead to low operational efficiency and resource utilization rates in township health centers. For example, some township health centers may have issues such as excessive management personnel and logistical redundancy, which can affect their operational efficiency. To reduce the problem of severe input redundancy, firstly, reasonable planning and layout can be implemented to reduce unnecessary duplicate construction and resource waste, optimize resource allocation, and improve resource utilization efficiency. Secondly, a scientific management system and assessment mechanism should be established to incentivize hospital staff to improve work efficiency and service quality. Furthermore, healthcare system reform should be promoted to improve the primary healthcare service system. By strengthening the construction of the primary healthcare service network, standardizing processes, eliminating waste, reducing costs, and improving the overall efficiency and quality of primary healthcare services[8].

4.2 Enhancing technological level plays an effective role in driving total factor productivity

From 2018 to 2022, the average technological change index for township health centers in China was 1.007, with the coastal, northeastern, central, and western regions recording indices of 1.007, 0.983, 0.993, and 0.986, respectively. The coastal region was the only one among the four regions to achieve technological progress, with 62.5% of its provinces (autonomous regions, municipalities directly under the central government) experiencing technological advancement. Moreover, within the coastal region, 100% of the provinces (autonomous regions, municipalities directly under the central government) that achieved improvements in total factor productivity (TFP) also demonstrated technological progress. This shows that regardless of the region's economic development level, technological progress serves as a driving force for enhancing the efficiency of township health centers.

The technological gap has a significant impact on the TFP of both township and urban hospitals. Due to their technological advantages, urban hospitals can better utilize existing resources, improve the quality and efficiency of medical services, and thus achieve higher TFP. In contrast, township hospitals may struggle to efficiently utilize resources and optimize services due to technological backwardness and resource constraints, resulting in relatively lower TFP. Technological progress helps optimize resource allocation and enhance efficiency in hospitals. Through the application of information technology, bottlenecks can be eliminated, improving the productivity of health workers. Additionally, hospitals can gain a deeper understanding of patient needs and behaviors, enabling them to provide more precise and efficient services[9]. Simultaneously, the use of information technology facilitates automation and intellectualization within hospital management and operations, reducing operational costs and

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improving efficiency. Therefore, enhancing technological progress in township health centers is an effective way to improve the quality and standard of medical services provided by these centers.

4.3 There are differences in the total factor productivity (TFP) of township health centers among the coastal, northeastern, central, and western regions

From 2018 to 2022, the total factor productivity (TFP) change index for township health centers in China's 29 provinces (autonomous regions, municipalities directly under the central government) fluctuated within the range of 0.838 to 1.063. The average TFP change index for township health centers in the coastal region was 0.984, 0.944 in the central region, 0.954 in the western region, and 0.872 in the northeastern region, indicating differences among different regions[10]. Similarly, township health centers located in economically developed areas tend to have higher overall efficiency and quality compared to those in other regions[11], which aligns with the reality of significant variations in economic development levels across different regions in China. The central region has been striving to narrow the development gap with the coastal region by undertaking industrial transfers from the east, strengthening infrastructure construction, and developing modern agriculture. The western region has been continuously advancing the strategy of developing the western region, enhancing ecological and environmental protection, developing special industries, and optimizing the business environment. The northeastern region has been implementing the strategy for revitalizing the northeast, promoting the transformation and upgrading of traditional industries, and strengthening infrastructure construction, among other measures. These efforts have contributed to reducing the development gap with the coastal region, thereby also reducing the disparities in TFP among township health centers in different regions[12-13]. Strengthening regional healthcare cooperation and exchanges can promote the flow of high-quality medical resources to less developed areas. By establishing medical consortia and providing counterpart support, we can achieve complementary advantages and common development of urban and rural medical resources. Additionally, we should encourage social forces to participate in the construction and development of township health centers, forming a diversified investment mechanism and service model.

References

[1] Luo Rong. Research on Performance Evaluation of the "Ten Thousand Doctors Supporting Rural Health Project" in Baiyin City [D]. Gansu: Lanzhou University, 2019.
[2] Li Chunfang, Chen Ningshan, Yin Aitian, et al. Application of Data Envelopment Analysis in the Efficiency Evaluation of Township Health Centers [J]. Chinese Journal of Hospital Administration, 2005, 21(3): 190-193.
[3] Guo Shuyan, Li Meng, Dong Siping. Measurement of Total Factor Productivity in 511 Secondary Public General Hospitals in Five Provinces of China [J]. West China Medical Journal, 2019, 34(12): 1356-1361.
[4] Huo Haiying, Wu Weimin. Relative Efficiency Evaluation of 26 County-level Hospitals in Guangxi Based on DEA [J]. Chinese Health Service Management, 2012, 29(11): 834-836.
[5] Lu Lu, Wang Lie, Cheng Lili. Evaluation of Operating Efficiency of Township Health Centers Based on Data Envelopment Analysis [J]. Chinese Journal of Health Statistics, 2008, 25(2): 165-166.
[6] Yang Xi, Chen Manli. Study on the Changing Trend of Total Factor Productivity of Township Health Services in China from 2003 to 2014 [J]. Chinese General Practice, 2018, 21(2): 88-92.
[7] Yang Xi, Zhu Chen. Research on Regional Differences and Collaborative Development of Service Efficiency in Traditional Chinese Medicine Hospitals in China [J]. Health Economics Research, 2019, 36(12): 25-28.
[8] Dávila S P, González J T. Improvement in the efficiency of a rehabilitation service using Lean Healthcare methodology[J]. Revista de calidad asistencial: organo de la Sociedad Espanola de Calidad Asistencial, 2015, 30(4): 162-165.
[9] Jafry M A, Jenny A M, Lubinga S J, et al. Examination of Patient Flow in a Rural Health Center in Malawi [J]. BMC Research Notes, 2016, 9(1): 363.
[10] Pan Zijing, Lu Shan, Zhang Liang. Research on Appropriate Medical Service Capacity of Township Health Centers in China [J]. Medicine and Society, 2024, 37(1): 36-42.
[11] Varabyova Y, Schreyögg J. International Comparisons of the Technical Efficiency of the Hospital Sector: Panel Data Analysis of OECD Countries Using Parametric and Non-parametric Approaches [J]. Health Policy, 2013, 112(1-2): 70-79.
[12] Gao Dian, Shi Lushaobo, Lin Jinhui, et al. Research on the Efficiency and Equity of Rural Medical and Health Resource Allocation in China Based on DEA-GIS Method [J]. Chinese General Practice,

ISSN 2706-6827 Vol. 7, Issue 1: 77-84, DOI: 10.25236/IJFS.2025.070112

2024, 27(7): 849-856.
[13] Ai Xiaoqian, Qiao Xuebin, Xu Aijun. Evaluation of Health Resource Allocation Efficiency in Traditional Chinese Medicine Medical Institutions Based on DEA [J]. Chinese Rural Health Service Administration, 2022, 42(1): 27-32, 36.