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Yun Ye

Yangtze University

Richard Evans

Dalhousie University

Li Jing

Huazhong University of Science and Technology

Xiaojun Huang

Hainan Medical University

Xudong Shang

Ministry of Agriculture: Ministerio de Agricultura

Yanying Chen

Hainan Medical University

Wei Lu (✉ hy0205044@hainmc.edu.cn)

Hainan Medical University

Wei Xu (✉ xuwei515@126.com)

Southern Medical University

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Evaluation and convergence analysis of the medical service efficiency in rural medical health centers China

Yun Ye¹, Richard Evans², Li Jing³, Xiaojun Huang⁴, Xudong Shang⁵, Yanying Chen⁴, Wei Lu^{4*}, Wei Xu^{6*}

1.School of Economics and Management,Yangtze University, Jingzhou, Hubei Province, China

2.Dalhousie Univ, Digital Innovation, Halifax, NS, Canada

3.Department of Health Management, School of Medicine and Health Management, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei Province, China

4.School of Management, Hainan Medical University, 3 Xueyuan Road, Longhua District, Haikou, Hainan Province, China, 571199

5.Center of Modern Agriculture, AMI of MARA, Beijing,China

6.Southern Medical University, No.1023,South Shatai Road, Baiyun District, Guangzhou, Guangdong, China, 510515

*Co-Corresponding author: (1) Wei Xu, Email: xuwei515@126.com (2) Wei Lu, Email: hy0205044@hainmc.edu.cn

Abstract

Background: Rural Medical Health Centers (RMHCs) are the foundation of the three-level primary medical and healthcare service in China. The efficiency of RMHCs is related to the rationale behind healthcare resource allocation for China's 560 million rural population.

Methods: This study analyzed the dynamic changes in efficiency of RMHCs and its convergence using the non-oriented SBM–DEA window model and convergence model in Shanxi Province, China. Data was obtained from the Shanxi Rural Health Institute's 2014–2018 Health Statistics Report, involving 12360 RMHCs.

Results: Findings show that the medical service efficiency delivered in RMHCs is low. The average scores for the comprehensive technical efficiency and pure technical efficiency of the RMHCs in China from 2014 to 2018 were only 0.0568 and 0.0615 respectively, with nearly 68% of the values being lower than their average scores. The comprehensive technical efficiency and pure technical efficiency of RMHCs from 2014–2018 exhibited a downward trend year on year. The convergence analysis results also showed that current rural health clinic medical service efficiency had α convergence, absolute convergence and conditional convergence. If appropriate policies are followed, the medical service efficiency of the RMHCs can be improved to reach a steady-state level.

Conclusions: The medical service efficiency of RMHCs remains low and may gradually decline. The government should promote the efficiency of the medical service in RMHCs by formulating corresponding medical and health resource allocation policies to reach an optimal level.

Keywords: Rural medical health centers, Efficiency, Convergence, Medical Services.

1. Background

Since the healthcare reform of China in 2009, the medical service capacity of primary-level medical and healthcare institutions has significantly improved. However, there remains an uneven distribution of healthcare resources between urban and rural areas^[1]. In this regard, the task of allocating healthcare resources fairly is an important issue for all levels of government in China.

Rural medical health centers act as the foundation of China's three-tiered health service system, taking on important responsibilities for rural citizens^[2]. According to the China Health Statistics Yearbook 2019, 1.67 billion patients were diagnosed and treated in RMHCs during 2018, accounting for 20.13% of all outpatient visits in medical institutions at all levels across Mainland China. Moreover, RMHCs take 40% of the responsibility for basic public health services in China. The medical service efficiency score of RMHCs is related to the distribution of medical and health resources

for the 560 million rural population of China^[3]. Therefore, it is of significant importance to evaluate the medical service efficiency of RMHCs and appropriately allocate medical and health resources to solve the problems that exist in rural China.

To date, studies have evaluated the medical service efficiency of primary medical and health institutions. However, extant research mainly focuses on county and town located hospitals, with very few studying RMHCs^[4-7]. Therefore, this study takes RMHCs in the Shanxi Province as the research object, and the Data Envelopment Analysis (DEA) method is used to measure their medical efficiency. The DEA method is a mature efficiency measurement method which has been used by several scholars studying medical service efficiency^[8-15]. Further, we use absolute and conditional convergences to analyze the convergence of RMHC efficiency. The convergence theory has been applied to the healthcare field since 2000 and has received increased attention by scholars since that time. The theory has been widely used to study health service evaluation indices, such as total health cost, life expectancy, and mortality rates^[16-19]. In this study, convergence analysis is completed to identify whether the differences in medical service efficiencies between RMHCs is gradually narrowing or expanding? Similarly, is the development of regions with lower medical service efficiency lagging behind those with a higher medical service efficiency or surpassing the latter, which leads to the so-called convergence phenomenon?

Compared with existing literature, the contributions of this paper are as follows: First, a dynamic evaluation of the medical service efficiency of China's RMHCs is completed, and the true level and change trend in the current medical service efficiency of the RMHCs are obtained. Second, convergence theory is applied to analyze the difference in medical service efficiencies to provide a basis for optimizing the dynamic management of rural medical and health resources in the future and for promoting the rationality of health resource allocation.

2. Methods

2.1 Data sources

The data presented in this study was collected from the Shanxi Rural Health Institute's 2014–2018 Health Statistics Report, which involved 12360 RMHCs; patient information was not collected.

2.2 Input and output variables

Input and output variables are used in the DEA model, and the efficiency of the medical service is calculated using the input made by the hospitals and the output obtained from the input. Unlike county and town hospitals, RMHCs mainly provide rural citizens with general diagnosis and treatment, and referral medical services for common and frequently encountered diseases. Therefore, the input–output indicators of the RMHCs are quite different from those of county and town hospitals. In this paper, based on the input and output variables of extant literature^[20–22], and combined with the characteristics of the RMHCs, we selected the number of rural doctors, technician training times for doctors, and drug expenditure, as the input variables. The output variables were the number of patients, and income from essential drugs; see Table 1. The technician training times for doctors were chosen as the input variable since the increase in technician training times for doctors can improve the medical service ability of primary doctors and promote their efficiency. The “Management Measures of RMHCs (Trial Implementation)”, issued by the National Health Commission of the People's Republic of China, clearly proposed to establish a training system for RMHCs and to encourage doctors employed in RMHCs to receive medical education^[23].

Table 1 Input–output variables of the RMHCs

Category	Variable	Definition	Unit
Inputs	Number of rural doctors	The number of rural doctors employed in each RMHC each year	person
	Technician training times for doctors	The number of rural doctors that participated in the technician training program organized by the government in each RMHC each year	person
	Drug expenditure	The expenditure of each RMHC on drugs listed in the National Essential Medicines List each year	yuan
Outputs	Number of patients	The number of patients seen in each RMHC each year	person
	Income from	The income obtained by each RMHC from the sale	yuan

	essential drugs	of drugs listed in the National Essential Medicines List each year	
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2.3 Data envelopment analysis model

The DEA is always used in operations research, management science, and mathematical economics. It is a quantitative analysis method used to evaluate the relative efficiency of comparable units of the same type by means of linear programming, based on multiple input and output indices^[24]. Conventional radial DEA models, such as the CCR and BCC models, only include the proportion of all inputs (outputs) reduced or increased. When evaluating an institution's efficiency, the influence of slack variables is not considered, which may result in the deviation of the efficiency measure. Tone^[25] proposed the SBM–DEA model (slack-based measure, as a function of the furthest distance to the frontier), which solved the problem that the radial model did not include the slack variable in the measurement of the inefficiency. The SBM–DEA model in this study is as follows:

$$\text{The objective function: } \min \rho = \frac{1 - \frac{1}{m} \sum_{i=1}^m \frac{s_i^-}{x_{ik}}}{1 + \frac{1}{q} \sum_{r=1}^q \frac{s_r^+}{y_{rk}}}$$

$$\text{Constraints: } x_k = x\lambda + s^-, y_k = y\lambda - s^+, \lambda, s^-, s^+ \geq 0$$

where m and q in the objective function represent m inputs and q outputs of each RMHC. x_{ik} and y_{rk} represent the i th input and r th output of the k th RMHC. s^- and s^+ represent the slack variable of the i th input and the slack variable of the r th output. $\frac{s_i^-}{x_{ik}}$ and $\frac{s_r^+}{y_{rk}}$ represent the inefficiencies of the i th input and r th output, respectively. In the constraints, x_k and y_k represent the input and output of the k th RMHC. λ represents the adjustment matrix, while $x\lambda$ and $y\lambda$ represent the input and output of the frontier production line. s^- and s^+ represent the slack variables of the input and output, respectively. The value of ρ is between 0 and 1. When $\rho = 1$, it indicates that the RMHC is highly effective and located in the efficiency frontier, and each slack is 0. When ρ is close to 0, it indicates that the RMHC is inefficient.

In addition, when using the SBM–DEA model to calculate the efficiency value, the calculated efficiency value is not comparable between different years, because the leading edge of each RMHC differs from year to year. The DEA window analysis method, proposed by Charnes ^[26], is preferred to solve this type of problem. Its analysis principle involves treating institutions in different periods as different institutions and evaluating their relative efficiency by selecting different reference sets similar to the moving average method. This method has two evident advantages: one is that the number of institutions in the reference set is multiplied several times, which is an effective way to solve the problem of insufficient number of institutions. Second, it can not only measure the efficiency of each institution on a section, but also measure the change trend in the efficiency of all institutions in the time series. This reflects the change trend in the efficiency from a dynamic perspective by considering the relationship between different periods; hence, the name dynamic DEA. In this study, the medical service efficiency refers to the comprehensive technical efficiency; comprehensive technical efficiency = pure technical efficiency $\times$ scale efficiency.

In summary, the DEA model used in this study is the SBM–DEA model combined with the Window-DEA model to evaluate the efficiency of RMHCs in Shanxi Province, China.

2.4 Convergence analysis

There are three types of convergence analysis: α convergence, absolute β convergence, and conditional β convergence^[27]. Notably, the β convergence is a necessary but insufficient condition of the α convergence, because if there is an α convergence, the efficiency of the individual absolute gap is narrow, low efficiency of this type of situation only when individuals have higher than high level of efficiency of individual growth rate can be set up; however, individuals with β convergence do not necessarily have α convergence.

(1) α convergence

In this study, the α convergence refers to the process whereby the medical service

efficiency of RMHCs changes over time. α convergence can be measured by the coefficient of variation(CV), The expression of CV is^[28]:

$$CV = \sqrt{\frac{1}{n} \sum_{i=1}^n \left[\left(\ln TE_i - \frac{1}{n} \sum_{i=1}^n \ln TE_i \right) / \frac{1}{n} \sum_{i=1}^n \ln TE_i \right]^2}$$

where TE_i represents the medical service efficiency of the i th RMHC, and n represents the total number of RMHCs.

(2) absolute β convergence

Based on the absolute β convergence, the lower the medical service efficiency of the RMHCs, the higher the growth rate of the medical service efficiency. Therefore, as time passes, inefficient RMHCs will catch up with the efficient ones and reach a stable convergence state at the same speed. The expression of the absolute β convergence is^[29]:

$$\frac{[\ln TE_{i,t} - \ln TE_{i,0}]}{T} = \alpha + \beta \ln TE_{i,0} + \varepsilon_{i,0}$$

$\frac{[\ln TE_{i,t} - \ln TE_{i,0}]}{T}$ represents the average annual growth rate of the medical service efficiency of the i th RMHC from the base period $t = 0$ to $t = T$. $\ln TE_{i,0}$ represents the logarithm of the initial medical service efficiency score of the i th RMHC, β is the convergence coefficient, and $\varepsilon_{i,0}$ is the error term. If β is significant and negative, it indicates that the average annual growth rate of the medical service efficiency is negatively correlated with the efficiency score in the base period, indicating that there is a “catch-up effect” among RMHCs. In other words, the RMHCs with a low efficiency score will eventually have a higher growth rate, and the medical service efficiency will eventually approach the same steady-state level. On the contrary, if $\ln TE_{i,0}$ is significant and positive, it indicates a widening gap in the medical service efficiency among RMHCs.

(3) conditional β convergence

The conditional β convergence allows the RMHCs to have different

characteristics, so that the gap between efficient and inefficient RMHCs persists. The expression of the conditional β convergence is^[30]:

$$\ln TE_{i,t} - \ln TE_{i,t-1} = \alpha + \beta \ln TE_{i,t-1} + \varepsilon_{i,t}$$

$\ln TE_{i,t}$ is the logarithm of the medical service efficiency score in the period t of the i th RMHC, and β is the convergence coefficient. If β is significant and negative, it indicates that the efficiency score of the i th RMHC will converge to its steady-state level over time.

3. Results

Table 2 shows the change trend in the input and output of the RMHCs from 2014 to 2018. In terms of the input variables, the number of rural doctors gradually declined from 2014 to 2018, while the annual average number of rural doctors reduced from 1.2916 in 2014 to 1.2178 in 2018, and the quantity gap between different RMHCs is significant. In 2018, the number of rural doctors in some health clinics was only 1, whereas in others, the number was as high as 3. From 2014 to 2018, the annual average number of technician training times for doctors showed an overall growth trend, from 9.3375 in 2014 to 11.5742 in 2018. The drug expenditure showed a general downtrend from 28523.4912 yuan in 2014 to 19541.6241 yuan in 2018, a decrease of nearly 31%. In terms of the output variables, from 2014 to 2018, the annual number of RMHC patients declined. In 2014, the average number of patients seen was 1388.4240, which declined to 998.3769 in 2018. During the same period, the average income from essential drugs also declined year on year, from 32540.9653 yuan in 2014 to 19402.8299 yuan in 2018. In addition, the drug expenditure and essential drugs income are important factors of RMHCs' revenues and expenditures. Although drug expenditure exhibited a downtrend from 2014 to 2018, it was still much higher than the income from essential drugs, indicating that the RMHCs needed to rely on government subsidies to maintain normal operations during this period.

Table 2 Summary statistic of input–output variables (2014–2018)

Input			Output	
I1	I2	I3	O1	O2

2014					
Mean	1.2916	9.3375	28523.4912	1388.4240	32540.9653
Max	3	98	14378058	96487	19267426
Min	1	0	986	110	1000
2015					
Mean	1.2737	10.0091	21659.6877	1287.5850	22919.8553
Max	3	120	960023	91853	966573
Min	1	0	1200	100	1100
2016					
Mean	1.2429	10.5143	23492.7233	1204.7790	24426.6156
Max	3	120	1684450	92408	1168000
Min	1	0	1100	120	1100
2017					
Mean	1.2337	11.1358	23901.6523	1128.89	23950.2274
Max	3	120	890000	68512	978239
Min	1	0	1100	100	900
2018				120	
Mean	1.2178	11.5742	19541.6241	998.3769	19402.8299
Max	3	96	921025	78951	921025
Min	1	0	980	100	900

I1, number of rural doctors; I2, technician training times for doctors; I3, drug expenditure; O1, number of patients; O2, income from essential drugs.

Figure 1 shows the scores of the Technical Efficiency (TE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE) for the studied RMHCs from 2014–2018. In terms of the time series, the TE and PTE showed a decreasing trend, whereas SE increased slightly. To be specific, The average TE and PTE increased from 2014 to 2015, but declined from 2015. The TE of RMHCs in 2015 was 0.0657, which had decreased to 0.0553 in 2018, a decrease of nearly 16%. In the same time period, the PTE decreased from 0.0714 in 2015 to 0.0588 in 2018, a decrease of nearly 18%. The SE increased slightly, from 0.9401 in 2014 to 0.9604 in 2018. Therefore, the decline in the TE during 2015–2018 is mainly due to the decline in the PTE. At the present stage, the TE and PTE were both low, with nearly 68% of the TE and PTE values being lower than the average score of 2018.

Fig 1. Technical Efficiency (TE), Pure Technical Efficiency (PTE) and Scale Efficiency (SE) of rural medical health centers from 2014 to 2018

The α convergence test results showed that the α values of the RMHCs were 0.2716, 0.2871, 0.2485, 0.2520 and 0.2450 respectively, for 2014, 2015, 2016, 2017, and 2018. This shows that the RMHCs' efficiency showed a declining trend, indicating α convergence between the efficiencies of different RMHCs, which means that the efficiency decrease during the period 2014–2018. The absolute β convergence test results showed that the regression coefficient of β is negative and significant at the 1% level, indicating that the efficiency exhibited absolute β convergence, which means that RMHCs with a low initial medical service efficiency had a higher growth rate, whereas RMHCs with a high initial medical service efficiency had a lower growth rate. As a result of this growth gap, the medical service efficiency gap among RMHCs will gradually narrow. In addition, the coefficient in the conditional β convergence model is negative and significant at the 1% level, indicating that the medical service efficiency of RMHCs approaches its steady-state level over time (see Table 3).

Table 3 Convergence of rural medical health centers

	Absolute β convergence			Conditional β convergence	
	coefficient	Std.Err		coefficient	Std.Err
β	-0.1214***	(0.0013)	β	-0.9471***	(0.0044)
R^2	0.4145		R^2	0.5540	
F	8751.18***		F	3.07***	
			Hausman	34454.96***	

***表示在 10%水平下显著

4. Discussion

This study analyzed the efficiency and convergence of RMHCs in Shanxi Province, China. It found that RMHCs were facing a low level of medical service efficiency because of insufficient healthcare resource investment. The convergence results indicated that the medical service efficiency of the RMHCs would improve and approach its homeostatic level if policies can be appropriately implemented.

From the perspective of the government's investment into RMHCs, the number of rural doctors and drug expenditure showed a decreasing trend. Rural doctors represent an important human resource in RMHCs; unfortunately, the number of rural doctors has been declining in recent years. According to the China Health Statistics Yearbook 2019, the number of rural doctors in China has dropped from 1,031,828 in 2010 to 845,436 in 2018, a drop of approximately 18%, and there have even been mass resignations of rural doctors^[31]. The reason is that their income source mainly includes three aspects: basic drugs system subsidy, basic public health services subsidy, and diagnosis and treatment income. The subsidies were the main source of income. However, as RMHCs are at the bottom of the rural medical system, the subsidies were deducted, with little left for rural doctors^[32]. In addition, rural doctors not only undertake basic medical services for rural residents, but also provide considerable basic public health services. This results in them being dissatisfied with the current situation^[33]. On the other hand, the decrease in drug expenditure is significantly related to the limited variety of essential medicines. In this situation, patients prefer to go to higher-level hospitals^[34].

From the efficiency evaluation results of the RMHCs, the average TE and PTE scores of RMHCs in the past five years were only 0.0568 and 0.0615, respectively. In particular, in 2018, nearly 68% of the TE and PTE scores were below their average level. At the same time, the TE and PTE scores were still decreasing year on year. Based on the previous analysis, it can be concluded that the decrease in the TE and PTE scores year on year is strongly related to the decline in the number of rural doctors and the insufficient input of drug resources. RMHCs should be paid more attention in this

regard. Therefore, an effective way to improve the medical service efficiency of RMHCs is to enhance the dynamic management of rural doctors and drug procurement. First, the government should improve the income subsidy mechanism for rural doctors, increase the proportion of national financial support, and reduce the proportion of county-level subsidies to ensure the availability of subsidy funds^[35]. Second, county, township, and village health service networks should be established to set up a service platform for sharing human resources for healthcare. Third, the medical insurance agency should adjust the list of essential drugs dynamically to ensure their adequate supply.

From the efficiency of RMHCs' development trend, α convergence, absolute β convergence and conditional β convergence indicate that health equalization in rural area can be achieved; however, notably, the connotation for promoting the equalization of rural medical and health resources among regions is that rural residents have equal access to medical and health resources when they need to visit hospitals. Therefore, the equalization of regional medical and health resources pursued by the government is not an absolute β convergence among regions, but a conditional β convergence based on certain factors. In other words, when allocating medical and health resources, the government should dynamically manage medical and health resources depending on the level of economic development, and population size and age structure of the rural residents in rural areas^[36], to ensure that the RMHCs reach their own optimal level of medical service efficiency.

5. Conclusion

Overall, the medical service efficiency of RMHCs remains low and may gradually decline. The government should promote the efficiency of the medical service in RMHCs to reach their own optimal level by formulating corresponding medical and health resource allocation policies.

6. Limitation

This paper has several limitations. First, the sample RMHCs were selected from a

northern province in China; other provinces were not selected in our study. Second, because of data access permissions, none of the output indicators in the DEA model were medical quality indicators and the five-year study period for convergence analysis is not enough. In the future, scholars can include more provinces in China , choose some medical quality indicators in the DEA model and increase the year period in the convergence analysis.

Abbreviation

RMHCs: Rural medical health centers

Availability of data and material

All data used is publicly available with citation to data repositories.

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Not applicable

Authors' contributions

All authors made significant contributions to this study. YY conceptualized the study. LJ and WL collected and analyzed the data. YY wrote the first draft of the manuscript. LJ, RE,WX and XS interpreted the results and revised the manuscript. XJH, YYC, WL and XS critically commented on the paper. The final version submitted for publication was read and approved by all authors.

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Availability of data and materialsu

The data sets analyzed during this study are available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Reference

- [1] ZZhang T, Xu Y, Ren J, Sun L, Liu C (2017) Inequality in the distribution of health resources and health services in china: hospitals versus primary care institutions. *Int J Equity in Health* (16):1-8. <https://doi.org/10.1186/s12939-017-0543-9>
- [2] Li B, Zhang L (2018) Complex networks theory building for integrated healthcare research in rural China. *Int J Integrated Care* 17(5):381. <https://doi.org/10.5334/ijic.3699>
- [3] Lu W, Evans R D, Zhang T, Ni Z, Tao H, Paton C (2020) Evaluation of resource utilization efficiency in obstetrics and gynecology units in China: A three-stage data envelopment analysis of the Shanxi province. *Int J Health Planning and Management* 35(1):309-317. <https://doi.org/10.1002/hpm.2908>
- [4] Zhong K, Chen L, Cheng S, Chen H, Long F (2020) The efficiency of primary health care institutions in the counties of Hunan province, China: data from 2009 to 2017. *Int J Environmental Research and Public Health* 17(5). <https://doi.org/10.3390/ijerph17051781>
- [5] Marschall P, Flessa S (2011) Efficiency of primary care in rural Burkina Faso. A two-stage DEA analysis. *Health Economics Review* (1):1-15. <https://doi.org/10.1186/2191-1991-1-5>
- [6] Kirigia J M, Sambo L G, Renner A, Alemu W, Bah Y (2011) Technical efficiency of primary health units in Kailahun and Kenema districts of Sierra Leone. *International archives of medicine* (4):15-15. <https://doi.org/10.1186/1755-7682-4-15>
- [7] Sinay T. Productive efficiency of rural health clinics: The Midwest experience[J]. *Journal of Rural Health*, 2001, 17(3):239-250.
- [8] Sherman H D (1984) Hospital efficiency measurement and evaluation: empi

rical test of a new technique. *Medical Care* 22(10):922-938. <https://doi.org/10.1097/00005650-198410000-00005>

[9] Gözde Y (2017) Health efficiency measurement in Turkey by using data envelopment analysis: a systematic review. *Ankara Sağlık Bilimleri Dergisi* (1-2-3):49-69. https://doi.org/10.1501/Asbd_00000000062

[10] Kim J, Kim H, Leem B, Yoon J (2012) Analyzing the national medical service efficiency of OECD countries using DEA and malmquist productivity index. *Acta Biomaterialia* 37(4):197–207.

[11] Nasiripour A A, Mehrolhasani M H (2011) The efficiency of the head offices of Medical-Services Insurance Organization in Iran using AP-DEA: 2009. *Journal of Health Administration* (46):39-46.

[12] Matos R, Ferreira D-C (2021) Pedro I. Economic analysis of Portuguese public hospitals through the construction of quality, efficiency, access, and financial related composite indicators. *Social Indicators Research* (157):361-392. <https://doi.org/10.1007/s11205-021-02650-6>

[13] Ferreira DC, Marques RC (2020) Public-private partnerships in health care services: Do they outperform public hospitals regarding quality and access? Evidence from Portugal - sciencedirect. *Socio-Economic Planning Sciences* (73):1-15. <https://doi.org/10.1016/j.seps.2020.100798>

[14] Ferreira D, Nunes A, Marques R (2020) Operational efficiency vs clinical safety, care appropriateness, timeliness, and access to health care. *Journal of Productivity Analysis* (53):355-375. <https://doi.org/10.1007/s11123-020-00578-6>

[15] Ferreira D, Nunes A (2018) Technical efficiency of Portuguese public hospitals: A comparative analysis across the five regions of Portugal. *International Journal of Health Planning and Management* 34(1):411-422. <https://doi.org/10.1002/hpm.2658>

[16] Wang Z. The convergence of health care expenditure in the US States[J]. *Health Economics*, 2009, 18(1):55-70. <https://doi.org/10.1002/hpm.2658>

[17] Happich M, Von Lengerke T (2007) Convergence of life expectancy in the European Union: a Markov approach. *Applied Economics Letters* 14(3):175-1

-
78. <https://doi.org/10.1080/13504850500425261>
- [18] Gaechter M, Theurl E (2011) Health status convergence at the local level: empirical evidence from Austria. *International Journal for Equity in Health* (10):34. <https://doi.org/10.1186/1475-9276-10-34>
- [19] Zhang G, Zhang L, Wu S, Xia X, Lu L (2016) The convergence of Chinese county government health expenditures:capitation and contribution. *BMC Health Service Research* (16):408. <https://doi.org/10.1186/s12913-016-1635-8>
- [20] Ferruccio, Pelone, Dionne, Sofia, Kringos, Alessandro, Romaniello, Monica, Archibugi, Chiara (2015) Primary care efficiency measurement using data envelopment analysis: a systematic review. *Journal of Medical Systems* (39):156. <https://doi.org/10.1007/s10916-014-0156-4>
- [21] Cantor VJM, Poh KL (2018) Integrated analysis of healthcare efficiency: a systematic review. *Journal of Medical Systems* 42(1):1. <https://doi.org/10.1007/s10916-017-0848-7>
- [22] Kohl S, Schoenfelder J, Fugener A, Brunner JO (2019) The use of Data Envelopment Analysis (dea) in healthcare with a focus on hospitals. *Health Care Management Science* (22):245–286. <https://doi.org/10.1007/s10729-018-9436-8>
- [23] Management Measures of RMHCs(Trial Implementation) <http://www.nhc.gov.cn/jws/s3581/201406/55de13fd597a4918bfc42e3a5b7ff2b8.shtml>. Accessed 3 June 2014.
- [24] Ji YB, Lee C (2001) Data envelopment analysis. *Stata Journal* 10(2):267-280. <https://doi.org/10.1007/b109347>
- [25] Tone K (2001) A slacks-based measure of efficiency in data envelopment analysis. *European Journal of Operational Research* 130(1):498-509. [https://doi.org/10.1016/S0377-2217\(99\)00407-5](https://doi.org/10.1016/S0377-2217(99)00407-5)
- [26] Charnes A, Clark CT, Cooper CW, Golany, B (1984) A developmental study of data envelopment analysis in measuring the efficiency of maintenance units in the u.s. air forces. *Annals of Operations Research* 2(1):95-112. <https://doi.org/10.1007/BF01874734>
- [27] Sala-I-Martin X (1996) The classical approach to convergence analysis. *Ec*

-
- onomics Working Papers (437):1019-1036. <https://doi.org/10.2307/2235375>
- [28] Dalgaard C, Vastrup J (2001) On the measurement of σ -convergence. *Economics Letters*. 70(2):283–7. [https://doi.org/10.1016/S0165-1765\(00\)00368-2](https://doi.org/10.1016/S0165-1765(00)00368-2)
- [29] Baumol W J (1986) Productivity growth, convergence, and welfare: what the long-run data show. *American Economic Review* 76(5):1072-1085. <https://doi.org/10.2307/1816469>
- [30] Barro R J, Sala-i-Martin X (1990) Economic growth and convergence across the United States. *Nber Working Papers* 76(5):1072-1085. <https://doi.org/10.2307/1816469>
- [31] Chen ZM, Yin WQ, Jia HY (2015) Formation mechanism of the turnover intention of rural doctors under essential medicine system based on grounded theory. *Chinese General Practice* 18(25):3036.
- [32] Yang L, Wang H, (2019) Who will protect the health of rural residents in China if village doctors run out?. *Australian Journal of Primary Health* (25):99-103. <https://doi.org/10.1071/PY18048>
- [33] Wang Q, Kong Y, Sun J, Zhang Y, Wang J (2019) What are the challenges faced by village doctors in provision of basic public health services in Shandong, China? A qualitative study. *International Journal of Environmental Research & Public Health* 16(14):2519. <https://doi.org/10.3390/ijerph16142519>
- [34] Zhou Z, Su Y, Campbell B, Zhou Z, Gao J, Yu Q, Chen J, Panet Y (2015) The financial impact of the ‘zero-markup policy for essential drugs’ on patients in county hospitals in western rural China. *Plos One* 10(3):1-17. <https://doi.org/10.1371/journal.pone.0121630>
- [35] Qin XQ, Yin WQ, Huang DM, Chen ZM, Jia HY, Zhu LL, Zheng JF (2016) Research on the development of rural doctors in the background of the new healthcare reform based on the grounded theory. *Chinese Journal of Health Policy* (6):20-25.
- [36] Huang M, Luo D, Wang Z, Cao Y, Yi L (2020) Equity and efficiency of maternal and child health resources allocation in Hunan Province, China. *BMC Health Service Research* (20):300. <https://doi.org/10.1186/s12913-020-05185-7>