Original Research

Efficiency of medical service systems in the rural areas of Mainland China: a comparative study from 2013 to 2017

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ABSTRACT

Objectives: Inefficient rural medical service systems are one of major obstacles to the Deepening Healthcare Reform. The objectives of this work are to analyze the efficiency of China's rural medical service systems and explore the key related factors.
Study design: Two-stage study including measuring efficiency and identifying factors.
Methods: An output-oriented slacks-based data envelopment analysis model was used to measure the efficiency, and a Spearman rank correlation analysis and a multiple linear regression model were used to explore the factors.
Results: For the village-level medical service system, 20 out of 27 provinces were inefficient in 2013–2017, 12 out of 27 provinces had the efficiency lower than the average scores in 2013–2017 (0.633, 0.659, 0.638, 0.603, and 0.589), Guangdong had the highest scores of 1 in 2014–2017, whereas Tibet had the lowest scores (0.064–0.083) in 2013–2017, and the west region performed worst. For the township-level medical service system, 11 out of 27 provinces were inefficient in 2013–2017, 10 out of 27 provinces had the efficiency lower than the average scores in 2013–2017 (0.819, 0.791, 0.757, 0.787, and 0.811), Ningxia had the highest efficiency of 1 in 2013–2017, whereas Jilin had the lowest efficiency (0.313–0.370), and the central region performed worst. Additionally, rural residents' income was positively associated with the efficiency of village-level medical services, while the proportion of the vulnerable population was positively associated with the efficiency of township-level medical services.
Conclusions: Most provinces had inefficient rural medical service systems in 2013–2017. The efficiency scores varied greatly across provinces, and most scores changed a little over time. Imbalances in the development of rural medical service systems existed across regions, and the efficiency of village-level medical services and township-level medical services was associated with different factors.

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Introduction

Despite China's recent rapid urbanization, with a rate of up to 58.52% in 2017 (National Bureau of Statistics of China, 2018), over 40% of its total population still lives in the vast, remote rural areas. The development of rural healthcare and medical systems is the core part of China's New Healthcare Reform initiated in 2009 for narrowing the urban-rural gap and the regional gap. In China's rural areas, there exist two types of medical institutions delivering the primary care to local farmers, i.e. village clinics and township hospitals. Specifically, the former delivers the basic and routine outpatient services to local villagers while the latter has beds and can admit patients with non-urgent conditions. Both of them function at the bottom tier of Hierarchical Diagnosis and Treatment System, which is designed to ease the pressure of urban hospitals at the top tier that are often overloaded for receiving too many patients and eventually improve the overall performance of the national medical system.[1]

The Chinese government has increased the investments of health and medical resources in rural areas. Taking 2013 as an example, it invested 6.322 billion RMB to build 4389 township hospitals, 20,000 village clinics, and 20,000 dormitories for health personnel who work in township hospitals; it also invested 457 million RMB to train rural health personnel and 1.94 billion RMB to support the basic drugs system in rural areas.[2] Additionally, several policies on building a more effective rural medical service system have been issued in recent years, such as 'Opinions on Further Strengthening the Corresponding Support of Urban Hospitals to Rural Hospitals (2014)' and 'Suggestions on Further Strengthening the Construction of Village Doctors (2015)'. Indeed, these measures have improved the quantity and quality of rural medical services. The number of inpatients in township hospitals increased from 39.37 million in 2013 to 40.47 million in 2017, and the mortality rate of children aged below 5 years in rural areas decreased from 145 per 10,000 in 2013 to 109 per 10,000 in 2017 (China Health and Family Planning Statistics Bulletin, 2013 and 2017). However, the rural medical service system still confronts many problems, such as the insufficient and unbalanced distribution of health resources, the lack of higher quality medical personnel, and low efficiency of medical services.[3]

Inefficiency of the rural medical system was identified in the Outlines of National Healthcare and Medical Service System Planning (2015-2020) as one of major obstacles to the Deepening Healthcare Reform initiated in 2013.[4] Thus, we tried to find out how vastly the efficiency of the rural medical service system differs across provinces in China since this reform in 2013, whether there were imbalances in the development of rural medical service systems in different regions, and what might cause these differences. The answers to these questions are the prerequisite for the current development of rural medical systems in China. This article aimed to explore the development of rural medical systems in 27 provinces of China's mainland during 2013-2017, compare the efficiency of these regional medical services, and provide some management insights on improving the efficiency.

The World Health Report 2010 pointed out that about 20-40% of resources spent on health were wasted because of inefficiency, and those wasted resources could be redirected toward achieving universal coverage by improving health efficiency, which indicated that inefficient medical service systems did not make full use of the resources, and the governments could do more to improve medical efficiency and reduce the waste of health resources.[5] Therefore, understanding the inefficiencies of the medical system is important for both governments and public health policy decision-makers. Existing studies measure the efficiency of medical services by Data Envelopment Analysis (DEA) at both the microlevel and macrolevel. From the micro view, decision-making units (DMUs) are individual medical institutions, such as hospitals,[6-14] nursing homes,[15] health centers,[16] and even hospital departments.[17-19] From the macro views, the medical system of a region or a country is evaluated as a DMU.[20-26]

Most of the studies on the efficiency of China's medical service systems did not distinguish between the rural and the urban. For instance, Sun and Luo[27] compared the 2015 medical data of 31 provincial regions and concluded that most provinces performed poor in 2015. The similar conclusion was drawn in Zhang et al.'s study[28] which analyzed the 2011 medical data. Wu et al.[29] investigated the changing trends in efficiency of healthcare system at the provincial level from 2003 to 2011, which found that the efficiency of China's healthcare system has declined since 2009 when the healthcare reform initiated, and the efficiency varied greatly across regions as well as across provinces. Ding et al.[30] compared the efficiency of 30 provincial medical service systems from 2009 to 2014 and found that with a slight increase over the time, efficiency differences were great across provinces but minor across regions. Zhang et al.'s study[31] on the efficiency of primary healthcare systems in China from 2012 to 2016 indicated more than 80% provinces with inefficient primary healthcare systems and a decline by 0.6% in the productivity. Although there is a slight difference in the selection of inputs and outputs in these papers, they share a very similar definition of efficiency, i.e. using fewer medical resources, including personnel and facilities, to provide better medical services to more patients. Given the large urban-rural gap existed in China, these studies cannot answer such questions as how well (or poor) rural medical systems performed.

There are some literatures on the efficiency of rural medical institutions, although most studies on China's rural healthcare are focused on the rural medical insurance and inequities in resource distribution.[32-38] Cheng et al.[39] measured efficiency of 48 township hospitals from Xiaogan Prefecture in Hubei Province in 2008-2014 and analyzed the impact of the healthcare reform on the efficiency. They found that the average efficiency increased in 2008-2012 but declined considerably in 2012-2014, and the new round of healthcare reform initiated in 2009 had a positive impact on the efficiencies before 2012. Audibert et al.[40] measured the efficiency of 24 township hospitals from Weifang Prefecture in Shandong Province in 2000-2008 and analyzed the impact of New Rural Cooperative Medical Scheme on the efficiency. They found that the efficiency declined in 2000-2008, and New Rural Cooperative Medical Scheme on average had a negative effect on efficiency. Motivated by a lack of a

nationwide study on the efficiency of China's rural medical care, this research aimed at rural medical service systems of 27 provinces in Mainland China.

Methods

Data envelopment analysis

Data Envelopment Analysis (DEA), first developed by Charnes et al., in 1978,[41] is a non-parametric method to measure the efficiency of homogeneous DMUs with multiple inputs and outputs. The conventional DEA models, such as Charnes-Cooper-Rhodes (CCR) and Banker-Charnes-Cooper (BCC) models, measure the radial efficiency on the assumption that inputs or outputs undergo proportional changes. However, in medical service systems, the outputs, including the number of visits, the number of inpatients, the average length of stay, the occupancy rate of beds, and so on, do not change proportionally. Therefore, we use Slack Based Model (SBM) model, which deals with slacks directly and measures non-radial efficiency, to calculate efficiency scores of medical systems where inputs and outputs change non-proportionally.[42−44] Additionally, the DEA scores are related to the type of presumptions and orientations. We used variable return to scale model considering that each province in China's mainland has a different return to scale in practice, and we chose output orientation because local governments have more control over the outputs of rural medical services than the inputs of health resources which are allocated by the Chinese government by policies.

Assume we address a set of n DMUs under evaluation. Each DMU has m inputs, t undesirable outputs, e desirable outputs, and e slacks in desirable outputs. The ith input, hth undesirable output, rth desirable output, and rth slack in desirable outputs of the DMU_j are denoted as $x_{ij}(i = 1, \ldots m; j = 1, \ldots n)$, $z_{hj}(h = 1, \ldots t; j = 1, \ldots n)$, $y_{rj}(r = 1, \ldots e; j = 1, \ldots n)$, and $s_{rj}(r = 1, \ldots e; j = 1, \ldots n)$, respectively. Then, the efficiency of DMU_o can be measured by the following model:

$$\min \frac{1}{1 + \frac{1}{s} \times \sum_{r=1}^{e} \frac{s_{ro}^+}{y_{ro}}}$$

$$\text{s.t.} \quad x_{io} \geq \sum_{j=1}^{n} \lambda_j x_{ij} \ (i = 1, \ldots m)$$

$$z_{ho} \geq \sum_{j=1}^{n} \lambda_j z_{hj} (h = 1, \ldots t)$$

$$y_{ro} + s_{ro}^+ = \sum_{j=1}^{n} \lambda_j y_{rj} \ (r = 1, \ldots e)$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0, s_{rj}^+ \geq 0 \ (j = 1, \ldots, n)$$

Data and variables

Our data were obtained from the China Health and Family Planning Statistical Yearbook (2014−2017) and the China

Health Statistics Yearbook (2018). Note that the New National Health Statistical Survey was introduced in 2013, which revised the statistical coverage of medical institutions and health personnel. The major change is that both family planning technical service institutions and their personnel have been counted in since then (the China Health and Family Planning Statistical Yearbook, 2014). According to geographical location, 27 provinces in China's mainland are divided into the east, central, and west regions. The east eight provinces are Hebei, Liaoning, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan, the central eight provinces are Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan, and the west 11 provinces are Inner Mongolia, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

The inputs and outputs were selected according to the available data and the critical medical indicators that the Chinese government has paid close attention to.[45] For the village-level medical service system, we considered three inputs: (1) the number of village clinics; (2) the number of professional health personnel (licensed physicians, licensed physician assistants, registered nurses, and village doctors); and (3) the number of non-professional health workers. The output variable is the total number of visits. For the township-level medical service system, we chose four inputs: (1) the number of township hospitals; (2) the number of beds; (3) the number of health technical personnel; and (4) the number of other personnel (other technical personnel, administrative staffs, and logistics technical workers) and the four outputs: (1) the total number of visits; (2) the number of discharged patients; (3) the occupancy rate of beds; and (4) the average length of stay in township hospital, which can be viewed as a proxy for the quality of medical services. Because the average length of stay in township hospital is an undesirable output, we treated it as an input in the calculation, as is done in most studies.

Results

The efficiency of village-level medical service systems

Fig. 1A−C show the efficiency scores of China's village-level medical service systems in 2013−2017. Note that 20 out of 27 provinces were inefficient in 2013−2017 with the scores less than 1, and the number of inefficient provinces in 2013−2017 was 24 (88.89%), 26 (96.30%), 24 (88.89%), 23 (85.19%), and 25 (92.59%), respectively. The average scores in 2013−2017 were 0.633, 0.659, 0.638, 0.603, and 0.589, respectively, and 12 provinces had the efficiency lower than these scores, including Fujian, Shanxi, Jilin, Heilongjiang, Hunan, Inner Mongolia, Guizhou, Tibet, Shaanxi, Gansu, Qinghai, and Xinjiang. Tibet held the lowest scores in 2013−2017, which were between 0.064 and 0.083. Conversely, Guangdong performed best in 2014−2017 with the score of 1. The three provinces with the largest average scores in 2013−2017 were Guangdong (0.992), Jiangsu (0.984), and Ningxia (0.975), whereas the three provinces with the lowest average scores in 2013−2017 were Tibet (0.076), Xinjiang (0.193), and Shanxi (0.255). In addition, the scores of most provinces changed a little over time, except
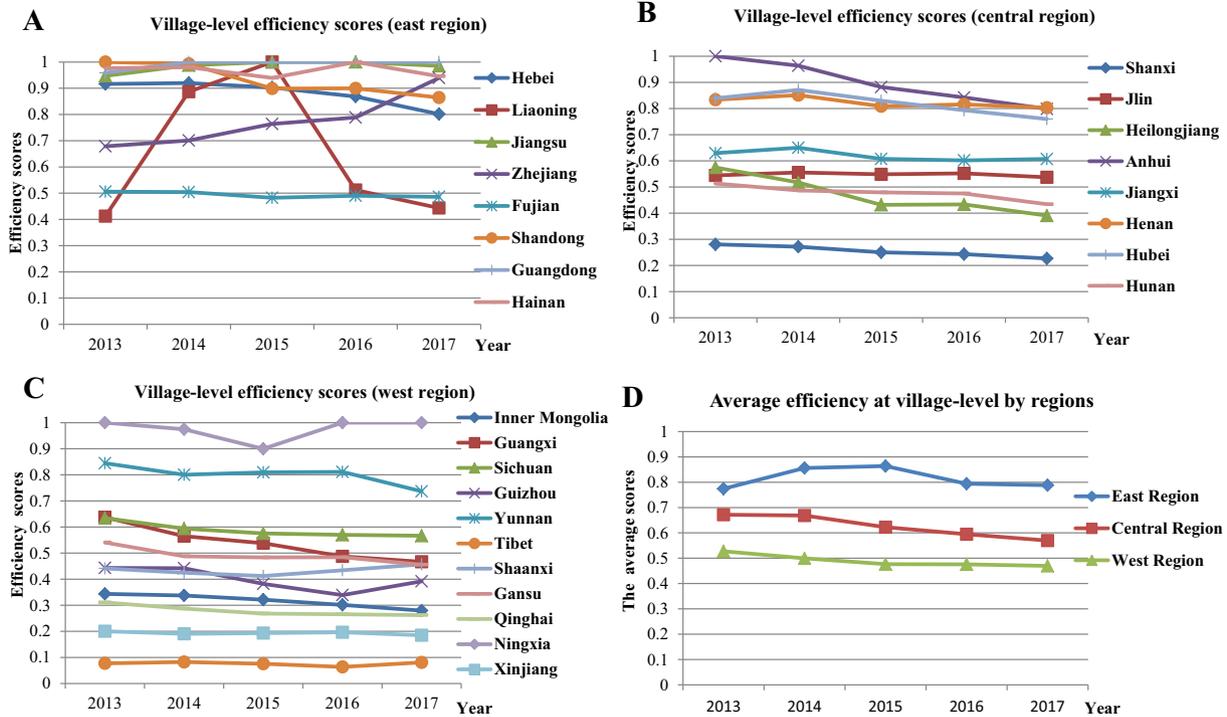
Fig. 1 — The efficiency scores of different provinces and regions of village-level medical service systems. A, B, and C present the efficiency scores of each province in 2013—2017; D shows the average efficiency scores of three regions in 2013—2017.

a few provinces such as Liaoning, whose efficiency increased greatly from 0.412 to 1 in 2013—2015 and decreased back to 0.443 in 2015—2017.

Fig.1D shows that the east region had the largest average scores in 2013—2017 (0.774—0.864), while the west region had the lowest average scores (0.470—0.527). Additionally, the east region had the smallest efficiency gaps between the best provinces and the worst provinces in 2013—2017, which were 0.588, 0.496, 0.518, 0.510, and 0.557, respectively, while the west region had the largest efficiency gaps in 2013—2017, i.e. 0.922, 0.892, 0.824, 0.936, and 0.919, respectively.

The efficiency of township-level medical service systems

Fig. 2A—C present the efficiency scores of China's township-level medical service systems in 2013—2017. Note that 11 out of 27 provinces were inefficient in 2013—2017 with the scores less than 1, and the number of inefficient provinces in 2013—2017 was 17 (62.96%), 24 (88.89%), 24 (88.89%), 22 (81.48%), and 17 (62.96%), respectively. The average scores in 2013—2017 were 0.819, 0.791, 0.757, 0.787, and 0.811 respectively, and 10 provinces had the efficiency lower than these scores, including Hebei, Liaoning, Fujian, Hainan, Shanxi, Jilin, Heilongjiang, Inner Mongolia, Shaanxi, and Gansu. Jilin had the lowest scores in 2013—2017 (0.313—0.370), while Ningxia had the highest scores of 1 in 2013—2017. The three provinces with the largest average scores in 2013—2017 were Ningxia (1), Yunnan (0.979), and Sichuan (0.973), while the three provinces with the lowest average scores were Jilin (0.339), Shanxi (0.478), and Inner Mongolia (0.502). Additionally, the scores of most provinces changed a little over time, except a few

provinces such as Guizhou, whose efficiency decreased greatly from 1 to 0.624 in 2013—2016 while increased slightly in 2017.

Fig. 2D shows that the west region had the largest average scores in 2013—2014 and 2016—2017 (0.816—0.882), the east region had the largest average score in 2015 (0.822), and the central region had the lowest average scores in 2013—2017 (0.703—0.748). Additionally, the east region had the smallest efficiency gaps between the best provinces and the worst provinces in 2013—2017, and the corresponding figures were 0.354, 0.322, 0.355, 0.355, and 0.390, respectively, while the central region had the largest efficiency gaps, i.e. 0.646, 0.600, 0.659, 0.679, and 0.630, respectively.

Verify the robustness of efficiency

To verify the robustness of efficiency scores calculated by the output-oriented SBM model, we replaced 'the total number of visits' and 'the number of discharged patients' with 'the number of outpatient and emergency visits' and 'the number of inpatients', respectively, and compared the new scores with the original ones. Table 1 shows that the two sets of scores were highly and positively correlated, and there was no significant difference between them ($P > 0.05$), which indicated that our efficiency scores are robust.

The external factors associated with the efficiency

Considering that DEA scores are relative efficiency not absolute efficiency, we conducted a Spearman rank correlation analysis first and then a multiple linear regression analysis to
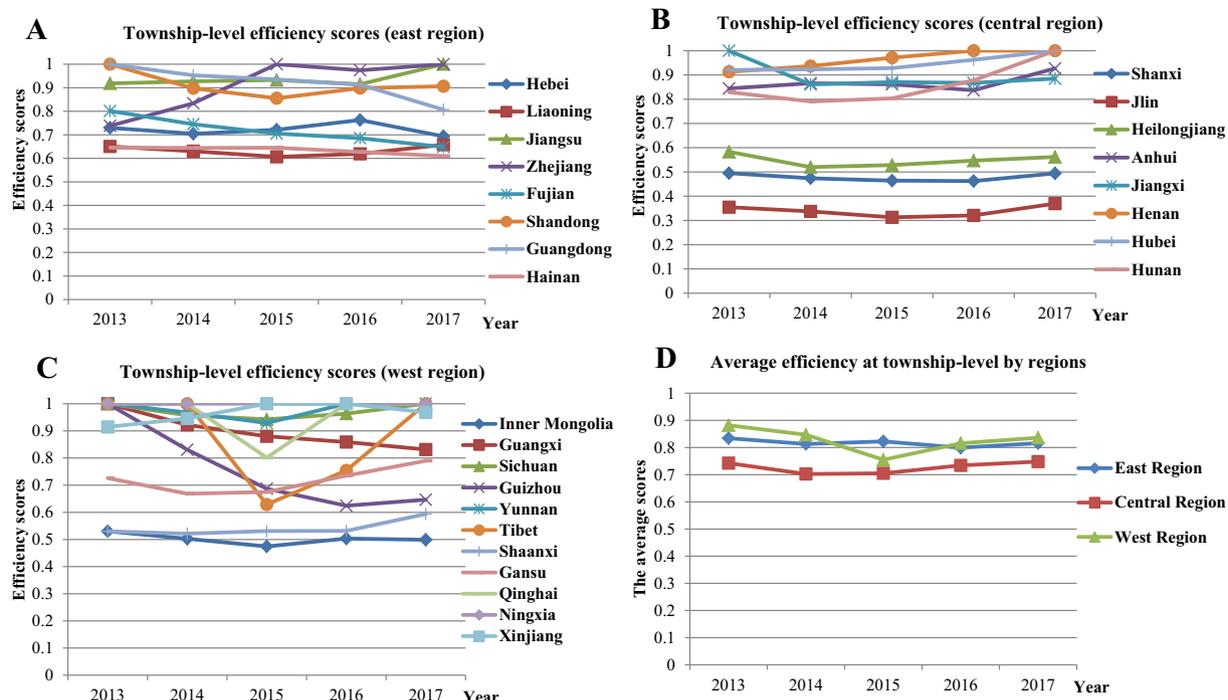
Fig. 2 − The efficiency scores of different provinces and regions of township-level medical service systems. A, B, and C present the efficiency scores of each province in 2013−2017; D shows the average efficiency scores of three regions in 2013−2017.

identify the key external factors on 2017 data. Given that many provinces got scores of one by the output-oriented SBM model, we used the output-oriented super SBM model which can further rank efficient DMUs.[46] The following is our output-oriented super SBM model:

$$\min \frac{1}{1 + \frac{1}{s} \times \sum_{r=1}^{e} \frac{s_{ro}^{+}}{y_{ro}}}$$

$$\text{s.t. } x_{io} \geq \sum_{j=1, \neq o}^{n} \lambda_j x_{ij} \quad (i = 1, \ldots m)$$

$$z_{ho} \geq \sum_{j=1, \neq o}^{n} \lambda_j z_{hj} (h = 1, \ldots t)$$

$$y_{ro} + s_{ro}^{+} = \sum_{j=1, \neq o}^{n} \lambda_j y_{rj} (r = 1, \ldots e)$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0, s_{rj}^{+} \geq 0 \; (j = 1, \ldots, n)$$

Four external factors were tentatively selected, including per capita disposable income of rural residents (X_1), the proportion of rural population aged 0−14 years and 65 years and above (X_2), the proportion of illiterate population among those aged 15 years and above in a rural area (X_3), and the proportion of the medical and health expenditure of rural residents (X_4). X_1 reflects the rural residents' ability to pay for medical

services, X_2 represents the proportion of rural vulnerable population, X_3 reflects rural education level, while X_4 represents the rural medical consumption level. Y_1 and Y_2 represent the efficiency of village-level medical services and township-level medical services, respectively. These data were sourced from the China Statistical Yearbook (2018) and the China Population & Employment Statistics Yearbook (2018).

Tables 2−4 show the results of the Spearman rank correlation analysis and the regression model, both of which indicated that the per capita disposable income of rural residents (X_1) was significantly and positively associated with the efficiency of the village-level medical services, while the proportion of rural population aged 0−14 years and 65 years and above (X_2) was significantly and positively associated with the efficiency of the township-level medical services. Note that we dropped one variable (X_3) before conducting the regression model, because Table 2 shows that X_3 was significantly correlated with X_1, and X_1 may have more effects than X_3 on the efficiency of rural medical services.

Discussion

First, most provinces had inefficient rural medical service systems in 2013−2017, and the proportions of inefficient provinces were 74.07% at the village level and 40.74% at the township level, respectively. More than a third of provinces had scores lower than the average scores. Generally, the distribution of public medical resources in rural areas is

Table 1 — Compare the efficiency before and after variables substitution.		The village-level medical service system	The township-level medical service system
Spearman rank correlation coefficients		0.957[a]	1.000[a]
Mann—Whitney U-test	Z	−1.137	−0.028
	P-value	0.255	0.977

[a] Represent 1% level of significance.

proportionate to the scale of local residents and the radius of medical service (the Outlines of National Healthcare and Medical Service System Planning). However, services delivered by rural medical institutions were deemed poor quality for the lack of licensed doctors and advanced technologies, which resulted in the distrust of local medical services in rural residents, according to recent reports of National Health Commission of the People's Republic of China.[47—50] Owing to the reasons such as the distrust, many rural patients preferred visiting urban hospitals even for the primary treatment, which would decrease some outputs, i.e. the number of visits or (/and) the number of discharged patients, of our models and thus cause the decreased efficiency scores. It also caused overloaded urban hospitals running at the top tier of hierarchical diagnosis and treatment system.[28—30] Therefore, we suggest that local governments should increase the investment of high-quality resources including high-quality medical facilities, licensed doctors, and advanced technologies to rural medical institutions, especially in the inefficient areas, to improve the comprehensive capacity of rural medical services.

Second, the scores of rural medical services systems varied greatly across provinces and most scores changed a little over time. The efficiency gaps between the best provinces and the worst provinces in 2013—2017 were great, i.e. around 0.927 at village level and 0.658 at township-level. The explanation of the variation in scores across the provinces in rural areas is complicated. One of the possible factors that might cause the variation is the economic development. Medical institutions in the wealthy provinces are more likely to use advanced management skills and technologies, such as IT technologies and the Internet, to optimize their operations. It is also easier for them to keep experienced doctors compared with the poor provinces where rural doctors are increasingly reluctant to stay at their jobs because of low pay and poor career prospects. Therefore, the wealthy provinces would outperform the poor ones. It can be observed in a comparison of Guangdong and Tibet. They performed the best and the worst in 2013—2017, respectively. The per capita disposable income of rural residents in Guangdong in 2017 was 15,779.7 RMB, while the corresponding figure of Tibet is 10,330.2 RMB (the China Statistical Yearbook, 2018). Additionally, Guangdong issued several policies to develop its rural system such as focusing on building local rural medical insurance system and promoting rural medical technologies since 2007.[51] Furthermore, most provinces had steady scores in 2013—2017, especially for the three most inefficient provinces, i.e. Tibet, Xinjiang, and Shanxi at village-level and Jilin, Shanxi, and Inner Mongolia at township-level, which suggested that to narrow the efficiency gaps across provinces, some long-term strategies targeted to improve the efficiency and comprehensive capacity of these inefficient rural medical service systems may be needed. The Chinese government has been advocating the contracted family doctor services since 2016, which encourages residents to sign medical service contracts with family doctors. However, this policy has not yet been widely implemented in rural areas (Guidance on Promoting Family Doctor Contract Services 2016). A sound relationship between rural doctors and farmers established through family doctor contracting would

Table 2 — Spearman correlation coefficients.				
Variables	X_1	X_2	X_3	X_4
X_1	1			
X_2	0.063	1		
X_3	−0.417[b]	0.165	1	
X_4	−0.213	−0.367	−0.246	1
Y_1	0.557[a]	0.146	−0.097	−0.177
Y_2	0.147	0.459[b]	0.137	−0.360

[a] Represent 1% level of significance.
[b] Represent 5% level of significance.

Table 3 — Regression results of the village-level medical service system (2017).							
Variables	Non-standardized coefficients		β	t	P-values	95% CI	
	B	Standard Deviation (S.D.)				Lower	Upper
Constant	−1.176	1.134		−1.037	0.311	−3.522	1.170
X_1	0.000	0.000	0.507	2.841	0.009	0.000	0.000
X_2	3.147	2.714	0.220	1.160	0.258	−2.467	8.761
X_4	−0.202	3.386	−0.012	−0.060	0.953	−7.206	6.804

CI, confidence interval.
$R^2 = 0.307$.

Table 4 − Regression results of the township-level medical service system (2017).

Variables	Non-standardized coefficients		β	t	P-values	95% CI	
	B	Standard Deviation (S.D.)				Lower	Upper
Constant	−0.546	0.518		−1.054	0.303	−1.619	0.526
X_1	0.000	0.000	0.188	1.175	0.252	−0.000	0.000
X_2	4.403	1.240	0.605	3.550	0.002	1.837	6.968
X_4	−0.610	1.548	−0.069	−0.394	0.697	−3.811	2.592

CI, confidence interval.
$R^2 = 0.441$.

benefit the quality of medical services, which suggests that local governments should encourage rural residents to sign the contracts.

Third, imbalances existed in the development of rural medical service systems in different regions. At village-level, the east region performed best and the west region performed worst in 2013−2017. At township-level, the west region performed best in 2013−2017 except 2015, the east region performed best in 2015, and the central region performed worst in 2013−2017. According to the China Statistical Yearbook, the east villagers had the highest income, whereas the west villagers had the lowest income. Generally, village clinics provide basic outpatient services, and higher-income villagers are more likely to visit doctors for minor diseases than lower-income villagers. Different from village clinics, township hospitals also provide inpatient services, and the west region is undeveloped, its geographical area is larger, and traffic is more inconvenient; therefore, its rural residents are more likely to visit township hospitals for inpatient services.[31] Additionally, the west region had many preferential policies to develop township hospitals. The east region is developed and has more advanced technologies and more high-quality health resources.[52] Conversely, the central region is the most vulnerable region. Overall, both the Chinese government and local governments should develop the west village-level medical service systems and the central township-level medical service systems first.

Finally, the village-level efficiency and the township-level efficiency were positively associated the per capita disposable income of rural residents (X_1) and the proportion of rural population aged 0−14 years and 65 years and above (X_2), respectively. In general, villagers had limited income, and higher-income villagers are more likely to visit doctors for minor diseases than lower-income villagers. Township hospitals provide primary inpatient services, and the vulnerable population, such as children and the elderly, are more likely to choose inpatient services than young adults; therefore, township-level medical service system with a higher ratio of vulnerable population may have higher efficiency. The similar results had been found in Ding et al.'s study,[30] which found that the proportion of population aged 0−14 years and above 65 years was positively associated with the efficiency of China's 31 provincial medical services. They regarded children and the elderly as the vulnerable population that will affect the demands for medical services.

Conclusions

We used the output-oriented SBM model to measure the efficiency of China's rural medical service systems based on data from 27 provinces in 2013−2017 and explore the key related factors. We found that most provinces had inefficient rural medical services systems in 2013−2017; the efficiency scores of rural medical service systems varied greatly across provinces and most scores changed a little over time; the imbalances existed in the development of rural medical service systems across regions; and the efficiency of village-level medical services and township-level medical services was associated with different factors, i.e. rural residents' income and the proportion of vulnerable population, respectively.

However, the empirical study presented here has a few limitations. First, we used only five main village-level indicators and eight main township-level indicators to measure the efficiency of rural medical service systems. As the elements and operation process of the rural medical service system are very complicated, our analysis can provide limited insights of the efficiency of China's rural medical service systems. Second, we identified the key factors approximately based on the data of rural areas because village-level data and township-level data cannot be obtained separately.

Author statements

Ethical approval

Not required, this study was entirely an analysis of data from published secondary sources, and there was not any specific human subject involved.

Competing interests

None declared.

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