

The Efficiency of Public Hospitals in China: The Influence of Geographic Location and Government Ownership Level



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China continues to struggle to provide cost-efficient care to its population. Using a sample of 181 hospitals, this study assessed the efficiency of China's public hospitals by both geographic region and level of government ownership. The study found that there is an uneven distribution of medical resources and the associated uneven distribution of patients among different regions. China's middle region had a significantly lower efficiency than hospitals in China's eastern and western regions. In addition, while province-owned hospitals consumed the most resources, they also operated more efficiently compared to hospitals owned by city and county governments.

Keywords: Efficiency, Public Hospitals, China, Geographic Location, Government Ownership Level

1. Introduction

China's healthcare industry has experienced significant and persistent reform focused on improving its quality and efficiency over the past three decades(1, 2). In addition, China is confronting a rapidly aging population, necessitating the need for a robust healthcare system capable of supporting the world's largest elderly population. Yet despite ongoing efforts to improve quality and efficiency, China's healthcare system has struggled with rising costs and disparities of care. One significant problem is the lack of care available to rural Chinese citizens(3, 4). To help address these concerns, a new healthcare reform initiative was announced in 2009 to bring affordable and equitable basic healthcare to China by 2012(5). The ongoing nature of these reformations underscores the difficulty China faces in reducing healthcare costs and improving the quality and accessibility of healthcare to its large and diverse population. Despite all of these efforts, China's hospital industry is now facing significant pressure to fulfill the increasing demands from both the public and private sectors. Therefore, it is essential to investigate the performance of

China's hospitals in order to explore ways of improving their efficiency and productivity.

China's government run public hospitals are the predominate source of inpatient care. Its public hospitals employ more than 4.5 million workers and house more than 3.2 million beds as of 2011(6). Despite being government owned, these hospitals also expected to rely heavily on patient revenues for profitability(7). Under this system the pricing for most medical services is set by the government but profits of up to 15% are allowed on the sale of pharmaceuticals(8). Consequently, the prescribing of unnecessary medications is common in China, as is the adoption of high-tech treatments that can increase profitability(9, 10). China's public hospitals are also diverse in terms of government ownership level and geographical location. Public hospitals may be owned at the province, city, or county level and are spread across China's eastern, middle and western regions. As the provincial government takes charge of the regional health system, evaluating the efficiency of public hospitals becomes even more critical toward improving hospital performance.

Previous research indicated that government ownership level and the geographical region of Chinese hospitals can have a substantial impact on financial and operational performance(11). However, few studies have evaluated the efficiency of China's hospital industry in different regions and different levels of ownership. Zhang et al. (2007)(12) evaluated the efficiency of regional health production by utilizing data from 1982, 1990, and 2000. The analysis found that provinces with low efficiency scores did not improve over time, but China's eastern, middle, and western regions experienced significant overall change. Hu (2012)(13) explored regional hospital efficiency in China using province-level panel data. Their study indicates that there is an efficiency gap between coastal and non-coastal regions. However this gap has narrowed recently as a result of rapid efficiency improvement in China's western regions. Li et al. (2014)(14) examined the relative efficiency of higher level public hospitals in Beijing, China and found that although some hospitals exhibited improvements in technical efficiency, there was a slight decline overall.

While the limited studies on China's public hospital efficiency examined the impact of geographic location, very few studies explored the impact of various levels of government ownership. China's government generally classifies hospitals into three levels based on the hospital's medical equipment, building infrastructure, and quality of staff(15). Hospitals are allowed to charge different prices depending on their level. Hospitals in level 3 are allowed to charge the highest prices, and hospitals in level 1 can charge only the lowest prices. Almost all of the province hospitals and most of the large urban hospitals are level 3 hospitals. Although the fees charged by higher level hospitals are significantly greater than those at lower level hospitals, most patients choose higher level hospitals when seeking treatment due to the perception that they deliver higher quality(16). Although level 3 hospitals have the greatest advantage in terms of financing, staffing, and capital, no studies have systematically examined the efficiency of these hospitals.

The purpose of this study is to assess the efficiency of China's public hospitals by both geographical region and level of government ownership. Specifically, we will address the following research questions: (1) given the dramatic socio-economic differences across China's landscape, how does hospital efficiency vary between China's eastern, middle, and western regions? (2) How does the level of government

ownership impact China's hospital efficiency? Answering these questions will provide a greater understanding of the factors that influence hospital performance within China. This information may also provide direction for China's ongoing public hospital reform initiatives aimed at improving efficiency and decreasing medical expenses.

2. Method

Sample

In order to measure these relationships, we used a sample of 68 government-owned hospitals in China. These hospitals participated in a government survey from 2008 to 2010. After we eliminated some of these hospitals from our sample due to incomplete data, we pooled the three years of remaining survey data together. By pooling this data together, our final sample size increased to 181. While this sample size was still insufficient for a longitudinal study, it was adequate for us to evaluate the impact of geographical location and government ownership on hospital efficiency.

These hospitals are located in 10 provinces and 3 major cities, and are dispersed in a relatively even manner across the eastern, middle and western regions of China. The 10 provinces that these hospitals are located in are: Shandong, Zhejiang, Heilongjiang, Henan, Hubei, Anhui, Shanxi, Sichuan, Yunnan, and Qinghai. The 3 major cities that these hospitals are located in are: Beijing, Shanghai, and Chongqing. This sample also includes a relatively even distribution of province, city, and county run hospitals. The hospitals in this study were selected by the provincial Department of Health according to the following criteria: 1) economic variation; 2) the availability of data; 3) the willingness of hospital CEOs to perform cost analysis.

Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) was chosen to analyze the data because it is one of the principle methods applied to study hospital efficiency that has been widely used internationally due to its versatility and effectiveness (17-23). Furthermore, DEA has previously been used to compare the efficiency of China's hospitals across different geographical locations over a multi-year time period(12, 13). DEA is a linear programming methodology to measure the efficiency of multiple decision-making units (DMUs) when the production process presents a structure of multiple inputs and outputs. This measure can be either input-oriented or output-oriented. For our research, an input-based approach was applied because hospital managers generally have more control over inputs than outputs. An input-oriented measure addresses "by how much can input quantities be proportionally reduced without changing the output quantities produced?"(24). By evaluating the relationship between the specified input and output variables, DEA can answer this question and establish an efficiency score between zero and one for each DMU. A score of one represents the 'efficiency frontier' or the optimal level of efficiency for the DMU relative to its peers. All values less than one represent a percentage of the efficiency frontier. Therefore, a value of one would indicate that the DMU is efficient and a value of 0.75 would indicate that the DMU should be able to reduce its resource input by 25% to become efficient.

Two frameworks for evaluating efficiency through DEA are the constant returns to scale model (CRS) developed by Charnes, Cooper and Rhones (1978)(25) and the variable returns to scale model (VRS) introduced by Banker, Charnes and Cooper (1984)(26). An organization operates under CRS if a change in inputs leads to a proportionate change in outputs(27). Therefore, under a CRS model where doctors are inputs and surgeries are outputs, doubling the number of doctors should lead to doubling the number of surgeries performed. Under the CRS model, failure to maximize outputs from a chosen combination of inputs is considered inefficiency(27). An organization operates under VRS if a change in inputs does not lead to a proportionate change in outputs. In other words, an organization that operates under VRS may exhibit increasing or decreasing returns to scale. Under VRS, the efficiency of the organization will either increase or decrease as it changes its scale of operations, but the efficiency score generated will always be at least as high as the one given under the CRS model. Under VRS, the organizations rated as efficient will be those with the least number of inputs or the greatest number of outputs(27). We conducted our analysis using both CRS and VRS assumptions and the results for both overall efficiency and pure technical efficiency were very close. The scale efficiency was also calculated. Scale efficiency is the ratio of the CRS score and VRS score. If there is a difference in the efficiency scores obtained from a CRS and a VRS model, it indicates that the DMU has scale inefficiency.

Another advantage of using DEA is that it can handle a multi-output and multi-input production frontier and is free of the behavioral assumption of profit maximization and/or cost minimization(28, 29). It is applicable to evaluate China's public hospital efficiency because these hospitals are state-run and they are required to achieve particular social welfare goals rather than profit maximization. The inputs selected for this study are the number of hospital beds, number of drug agency workers, number of doctors, number of nurses and the number of administration department workers. Inputs were selected based on the availability of data and a thorough review of the literature. In a cross-national taxonomy of hospital-based DEA efficiency studies, O'Neill et al. (2007) (18) found the number of hospital beds to be the most frequently used proxy for hospital size and capital investment and the number of clinical and non-clinical staff workers to be frequently used proxies for labor. The outputs selected for this study are the number of hospital inpatient days, the number of outpatient visits and the number emergency department visits. These outputs were chosen due to the availability of data and because they serve as widely accepted measures for determining inpatient and outpatient workload(7).

3. Results

An Overview of the Sample Public Hospitals in China

The sample statistics shown in Table 1 and those of Table 2 are the average of the three years because we pooled all the data together. Hospitals in eastern China, on average, consumed more health inputs than those in the other two regions during the period studied. Similarly, hospitals in the province consumed more health inputs than the city and county level hospitals. Table 1 clearly shows that less input was consumed by the hospitals in the west region and the county level hospitals.

Table 2 illustrates hospital outputs by geographic location and government ownership level. In general, hospitals treated more patients in China's eastern area between 2008 and 2010. However, this is unsurprising as Eastern China is the most populous region of the country. Similarly, hospitals in the province level treated significantly more patients than the other two areas.

Table 1 *The Mean and Standard Deviation of Hospital Inputs by Geographic Location and Government Ownership Level, 2008-2010*

	Location				Ownership Level	
	East	Middle	West	Province	City	County
Number of doctors	541	403	358	642	447	249
	(276)	(270)	(230)	(307)	(181)	(121)
Number of nurses	688	516	475	840	582	306
	(355)	(376)	(306)	(387)	(254)	(151)
Number of pharmacists	74	53	48	80	59	40
	(33)	(23)	(29)	(36)	(24)	(19)
Number of Administrators	266	218	212	320	263	134
	(55)	(163)	(141)	(159)	(157)	(67)
Number of beds	1116	945	847	1405	990	572
	(597)	(676)	(546)	(703)	(463)	(256)
Sample size	69	47	65	60	55	66

(The Numbers in Parentheses are the Standard Deviations)

Table 2 *The Mean and Standard Deviation of Hospital Outputs by Geographic Location and Government Ownership Level, 2008-2010*

	Location				Ownership Level	
	East	Middle	West	Province	City	County
Number of inpatient days	400919	350690	333100	531688	379302	197491
	(221840)	(275449)	(214319)	(274319)	(170041)	(79389)
Number of outpatient visits	946413	339260	449676	885193	588724	378565
	(547096)	(278601)	(448809)	(709630)	(327694)	(307011)
Number of emergency department visits	1103490	487579	593770	1180122	692672	435573
	(589385)	(384858)	(515193)	(707235)	(337495)	(337395)
Sample size	69	47	65	60	55	66

(The Numbers in Parentheses are the Standard Deviations)

The three-year aggregated efficiencies are reported in Table 3. Summary statistics (geometric means and standard deviations) for the overall efficiency (an efficiency measure with CRS), pure technical efficiency, and scale efficiency are presented by geographic location and government ownership level. Generally speaking, all of the hospitals in our study are considered to be relatively efficient because their average overall efficiency scores are higher than 0.75. There is significant difference between different locations in terms of efficiency, both the overall efficiency and pure technical efficiency were higher in the east and west areas compared to those in the middle area of the country. Regarding the effect of hospital government ownership level, hospitals owned by the province were relatively more efficient than those owned by the city or county government, though these hospitals also consumed more inputs than the other two levels. For example, the pure technical efficiency of

provincial hospitals was 0.91, while they were only 0.83 and 0.81 for city and country hospitals. In this study, because the overall efficiency was very close to the pure technical efficiency, the scale efficiency, which equals the overall efficiency divided by pure technical efficiency, was close to 1. No significant difference in scale efficiency was observed across different regions. However, the average scale efficiency of county owned hospitals was significantly higher than that of province and city owned hospitals. Table 3 asserts that during 2008-2010, the sample public hospitals in China could have handled the same level of inpatient, outpatient, and emergency department visit cases with 77% to 86% of the inputs they actually used had they been efficient.

Table 3 Efficiency Measures by Geographic Location and Government Ownership Level, 2008-2010

	Location					Ownership Level		P-value
	East	Middle	West	P- Value	Province	City	County	
Overall efficiency	0.83	0.77	0.83	0.021	0.86	0.79	0.80	0.01
	(0.13)	(0.12)	(0.13)		(0.11)	(0.15)	(0.12)	
Pure technical efficiency	0.87	0.79	0.87	0.001	0.91	0.83	0.81	0.00
	(0.13)	(0.12)	(0.13)		(0.10)	(0.14)	(0.12)	
	0.95	0.97	0.96	0.087	0.94	0.95	0.98	
	(0.06)	(0.03)	(0.05)		(0.06)	(0.04)	(0.04)	0.00
Sample size	69	47	65		60	55	66	

(The Numbers in Parentheses are the Standard Deviations)

Table 4 shows the distribution of hospital efficiency scores based on geographic location and ownership level. Since the 25th percentile of the overall efficiency scores of the hospitals in this sample was close to 0.75, we defined any hospitals with an overall efficiency score lower than 0.75 as a low efficiency hospital. The middle area of the country had the highest percentage of hospitals with low efficiency performance (44.7%). While interestingly, the western area of the country had the lowest percentage of hospitals with low efficiency performance (26.2%) and the highest percentage of hospitals with high efficiency performance (16.9%). Regarding the effect of hospital government ownership level, province-owned hospitals had the lowest percentage of hospitals with low efficiency performance (3.3%), while the city-owned hospitals had the highest percentage with low efficiency performance (40%).

Table 4 Distribution of Overall Efficiency Scores by Geographic Location and Government Ownership Level, 2008-2010

	Location				Ownership Level	
	East	Middle	West	Province	City	County
<=0.75	22 (31.9%)	21 (44.7%)	17 (26.2%)	14 (23.3%)	22 (40%)	20 (30.3%)
>0.75 and <1	39 (56.5%)	23 (48.9%)	37 (56.9%)	39 (65%)	25 (45.5%)	39 (59.1%)
=1	8 (11.6%)	3 (6.4%)	11 (16.9%)	7 (11.7%)	8 (14.6%)	7 (10.6%)
Sample size	69	47	65	60	55	66

Table 5 Distribution of Pure Technical Efficiency Scores by Geographic Location and Government Ownership Level, 2008-2010

	Location				Ownership Level	
	East	Middle	West	Province	City	County
<=0.75	16 (23.2%)	20 (42.6%)	11 (16.9%)	7 (11.7%)	16 (29.1%)	19 (28.8%)
>0.75 and <1	39 (56.5%)	22 (46.8%)	38 (58.5%)	36 (60%)	27 (49.1%)	39 (59.1%)
=1	14 (29.3%)	5 (10.6%)	16 (24.6%)	17 (28.3%)	12 (21.8%)	8 (12.1%)
Sample size	69	47	65	60	55	66

Geographic location and ownership level had a similar effect on technical efficiency (Table 5). The middle areas of China had the highest percentage of hospitals with low technical efficiency performance (42.6%) and the lowest percentage of hospitals with high technical efficiency performance (10.6%). In addition, the province-owned hospitals had the lowest percentage of hospitals with low efficiency performance (11.7%) and highest percentage of hospitals with high efficiency performance (28.3%).

4. Discussion

The current study found that there is a significant efficiency gap between different geographic regions, with the middle region having a significantly lower efficiency score than the eastern and western regions. This might be the result of the uneven distribution of medical resources and the associated uneven distribution of patients among different regions. For example, perhaps public hospitals located in eastern China are provided with more medical resources in an effort to treat more patients. Furthermore, these hospitals may attract and treat more patients because they are located in China’s most populous areas and because of their investment in more sophisticated medical equipment. These are consistent with previous findings of hospital efficiency using the aggregate hospital data(13). There are two common ways to classify China’s provinces based on geographic locations. One is to separate all provinces into coastal and non-coastal regions based on their proximity to the ocean. The second one is to separate all 31 provinces into three geographic locations: eastern (11 provinces), middle (8 provinces), and western (12 provinces) regions according to the Bureau of National Statistics. The current study used the second method of classifying the three regions. Historically, the eastern provinces of China have had more resources and higher income than the middle and western regions of China provinces. However, this gap has been narrowed over the last decade due to several government policies. For example, per capita GDP in the eastern region was 3.09 times that of the western region in 2000, and the ratio fell to 2.36 in 2009(30) because of the intensive efforts of developing the western provinces launched by the Chinese government since 2000. The programs of investment and infrastructure construction in the western region significantly accelerated the urbanization process in this area, which greatly boosted the overall income of the region. Moreover, these policy efforts also resulted in a faster increase in rural household income in the western region of China. However, provinces located in mid-China did not receive enough policy support from the central government compared with the western areas

over the past decade. This may be the reason why hospitals located in the middle region have not benefited in terms of improving hospital efficiency compared with their counterparts of the eastern and western regions. However, this study did not examine the direct effect of economic development and income level on hospital efficiency. The association between these factors cannot be established and needs to be further explored in the future. There is no significant difference in hospital efficiency scores between the eastern and western regions, but hospitals in both regions achieve significantly higher efficiency scores than those in the middle regions. Since economic development and income level are significantly related to hospital efficiency, it is essential that the central government of China implement policies to boost the economy for the middle regions in order to improve their hospital efficiency.

Findings from this study also indicated that although province-owned hospitals consumed the most resources, they also operated most efficiently compared to hospitals owned by city and county governments. This finding may be the result of China's policy where patients are willing to go to the higher-level province-owned hospitals for treatment, which increased the outputs of the provincial hospitals (inpatients, outpatient visits, and emergency department visits). However, this finding needs to be further examined since the present study has not controlled for quality of both inputs and outputs. In fact, although China's government has advocated "minor illness in community health centers, serious illness in the hospital," it appears that many patients still go to higher level hospitals, such as provincial and city hospitals, to seek care. Data on hospital occupancy rates provides support for this theory. The hospital occupancy rate for provincial general hospitals in 2008 was 101.2%, while this number was 95.2% for city hospitals and 82% for county hospitals(31). The major reasons why patients would like to seek care from higher-level hospitals include better quality of care, more advanced medical equipment such as CT scan and MRI, and the best-trained medical professionals working in these higher levels facilities. The concept of technical efficiency involves achieving better results (outputs) with minimum costs (inputs). Province owned hospitals in this study took care of significantly more inpatients, outpatients, and emergency department patients. For example, provincial hospitals treated 531,688 inpatient days, while county hospitals only treated 197,491 inpatients over the three-year period. Although provincial hospitals consumed more resources, the outputs of these hospitals are much bigger. However, despite the fact that the expansion of all hospital outputs, such as admissions of outpatient visits may increase the efficiency score, it may also induce the congestion problem and lower medical quality, such as higher mortality and comorbidity rates. However, this study did not include the undesired outputs in the model due to the data limitation.

5. Study Limitations

The first limitation of this study relates to generalizability. Our study included 68 public hospitals that participated in the survey from 2008 to 2010. After eliminating the hospitals with missing data, 181 hospitals composed of the final study sample. This is a relatively small number relative to the total number of China's public hospitals. However, this sample represents an even distribution of hospitals in terms of geographic location (east, middle, and west areas) and government ownership (province, city, and county). Therefore, the generalizability concern has been

minimized. The second limitation of this study is that we did not examine the quality of care in this study. There have been reports that hospital patient relationships are increasingly tense in China in recent years. The poor service attitudes, lack of patient trust, and a skyrocketing of malpractice lawsuits have raised public concern(32, 33). However, our study did not incorporate quality indicator in the analysis due to data limitation. Future studies should take this into consideration when evaluating the overall efficiency of hospitals. The third limitation of this study is that we did not investigate the efficiency trend due to the data limitation. Future studies should analyze the improvement of efficiency in China's public hospitals over a certain period of time to examine the causation between geographical location, government ownership, and hospital efficiency. Finally, although hospitals in this study are generally very efficient, system deficiencies and lack of regulation have increased medical expenses in a lot of areas such as the distorted pharmaceutical utilization and over-investment and overuse of high tech diagnosis and treatments. Further studies need to be conducted to examine the trend of efficiency in China's public hospitals. Despite these limitations, our study is the first research that provides important insight into the relationship between geographic location, government ownership levels and hospital efficiency of China's public hospitals. The findings of this study will offer invaluable policy implications for public hospital reforms in the future. China's government should encourage private investment into more public hospitals to make them more efficient. This could help these hospitals better cope with the increasing demands of patients. Efforts to increase efficiency may be especially beneficial to the hospitals that are located in the middle region of China, and to hospitals that are owned by cities given that government owned hospitals were found to be less efficient than private hospitals in the literature(34).

6. Conclusion, Policy, and Practice Implications

This study provides important guidance for policy makers and healthcare managers by identifying factors that could potentially impact health system and hospital efficiency. However, even if this study found that hospitals located in different locations and ownership levels have different efficiency, the more efficient hospitals may not always be the most desirable. For example, the excessive and disproportionate "supply of patients" that are admitted to the higher-level provincial hospitals often experience delays in service due to the limited number of physicians and nurses. In addition, clinicians in these over-crowded hospitals may have to work long hours under great stress, which may deteriorate the quality of care and the important patient-clinician relationship. Since lower efficiency often means excessive hospital inputs (doctors, nurses, hospital beds, etc.) at the fixed output level and /or a shortage of hospital outputs (inpatient, outpatient etc.) at the given amount of inputs, it is important to improve the efficiency of hospitals by appropriately directing patients to the under- used hospitals through specific reimbursement policy. At the same time, policy makers should also consider how to adequately staff medical personnel of the over-crowded hospitals to better assure the quality of care.

Over the years, China has been trying to determine how to provide affordable healthcare services to its vast and aging population through a series of healthcare policy reforms. One of the more influential reforms affecting public hospital efficiency relates to the removal of the pharmaceutical mark-up. This policy change

was implemented as it tries to increase the financial support for equipment and infrastructure of its public hospitals. As a result, the fee schedule of medical services in public hospitals is being adjusted to increase hospital revenue from medical services rather than from pharmaceutical sales. This change in funding is expected to decrease the overutilization of pharmaceuticals. It is also expected to result in the maximization of medical services as the proportion of hospital revenue from pharmaceuticals decrease. While this maximization of services may result in greater hospital efficiency, it may also quickly deteriorate the quality of healthcare provided within China's public hospital system by discouraging personalized patient care and encouraging the inappropriate overutilization of hospital resources.

Furthermore, China's vast rural middle region and its correlation to lower efficiency in this study may indicate that geographic location and its higher preponderance of lower-tiered hospitals may be a proxy for the lower economic conditions of this region. For example, China's higher-tiered hospitals are often far better funded and better resourced than lower-tiered hospitals. Higher-tiered hospitals are typically located in China's large, urban areas. Therefore, perhaps geographic location and government ownership of hospitals are likely representative of the area's level of economic conditions. As a result, it is important for policy makers to develop policies that address the broader and more prevalent issue of an uneven distribution of economic resources in China while considering the redistribution of medical resources to more equitably address the medical needs of China's population.

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