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Comparison of Hospitals in Jakarta as Decision-Making Unit for Technical Efficiency and Cost Values: Application of DEA and SFA

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Abstract

The implementation of national health insurance in Indonesia in 2014 as an effort to provide universal health care was known as the BPJS program. It was named after the responsible agency: Badan Penyelenggara Jaminan Sosial (Health Social Security Administrator). In its early years of implementation, it was indicated that it was not financially optimal because it made a significant financial loss. Therefore, this research was conducted to examine the efficiency level of several hospitals in Jakarta from a technical and cost perspective. The 2018 data was obtained from the Ministry of Health and BPJS. The survey covered 36 hospitals from various regions in Jakarta and was analyzed using Data Envelopment Analysis and Stochastic Frontier Analysis. DEA Solver LV 8 and Frontier 4.1 were the primary tools in this study. There were two significant results of this study. First, most hospitals in Jakarta were efficient in terms of technical efficiency score of DEA (0.73) and SFA (0.52), whereas cost efficiency was mediocre with a score of DEA (0.56) and SFA (0.50). Second, three indices (regional technical efficiency score, regional cost efficiency score, and ownership cost efficiency score) showed similar patterns for DEA and SFA efficiency scores except for the ownership technical efficiency index. It is recommended that the government should immediately improve the centralized national database for hospitals and decide strategic policy to arrange for cooperation between hospitals primarily by sharing their data on hospitals' load and staff availability.

Keywords: Efficiency, Hospitals, Indonesia, DEA, SFA

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Introduction

The pursuit of efficiency is a central aim for many policymakers within various health systems. The efficiency analysis focuses on the organizational locus of production, often referred to as a decision-making unit (DMU). In health care, hospitals are the most commonly studied DMU. It is essential to underline that efficiency analysis has been primarily concerned with measuring the competence with which inputs are converted into outputs value. However, from a different perspective, these efforts have not necessarily explained the reasons behind different levels of efficiency.[1]

Data Envelopment Analysis (DEA) is a nonparametric linear programming-based technique that creates an efficiency frontier by optimizing each provider's weighted output/input ratio, with the requirement that this ratio can equal, but never exceed, unity for any other provider in the data set.[2] Since then, DEA has been widely utilized in assessing hospital technical performance in the United States and around the world at various levels of decision-making units. Sherman (1984), for example, was the first to use DEA to assess overall hospital efficiency.[3]

Stochastic Frontier Analysis (SFA) is a parametric model where one makes a priori allowance for the fact that the individual observations may be somewhat affected by random noise, and tries to identify the underlying mean structure stripped from the impact of the random elements.[4] SFA models have the advantage of allowing for statistical uncertainty while also demanding strong assumptions about the shape of the frontier. This study applies both methods to have a more thorough and optimal observation of this efficiency issue, considering the limitation we have on the data.

The reason why we did this research is that in the first few years after the launch of the national health insurance program, there were always losses. The amount of the deficit suffered by BPJS Health before taking into account the Government's interventions was 1.9 trillion (2014), 9.4 trillion (2015), 6.7 trillion (2016), 13.8 trillion (2017), 19.4 trillion (2018), and 28 trillion (2019). Considering that hospitals are the central point of decision-making in the world of health, the question arises whether hospitals experience efficiency problems?

Some general characteristics of many Indonesian hospitals are: 1) Public and private hospitals: Indonesian hospitals can be divided into public and private facilities. Public hospitals are funded and managed by the government, while private hospitals are owned and managed by private entities, including both for-profit and non-profit organizations, 2) Classification system: Hospitals in Indonesia are classified into four classes (A, B, C, and D) based on size, quality, and available facilities, with Class A being the highest level and Class D the lowest. Many top-tier hospitals are located in larger cities and offer advanced medical services, 3) Quality of care: There is a wide range in the quality of care provided in Indonesian hospitals. Top-tier private hospitals in urban areas often provide high-quality care, with state-of-the-art facilities and internationally trained staff. However, rural public hospitals may struggle with inadequate funding, outdated equipment, and a lack of qualified staff, and 4) Affordability: Public hospitals generally offer more affordable healthcare services than private hospitals. However, overcrowding and long wait times can be issues in public facilities.

Technical efficiency refers to the ability of a firm or production unit to maximize its output given a set of inputs, or conversely, to minimize the inputs used for a given level of output. In other words, technical efficiency focuses on the optimal use of resources in the production process. In contrast, cost efficiency, also known as allocative efficiency, refers to the optimal allocation of resources in a production process to minimize costs given a certain level of output, or to maximize output given a certain budget constraint. Cost efficiency takes into account not only the technical efficiency of the production process but also the prices of the inputs. A firm or production unit is cost-efficient if it's producing the desired level of output at the lowest possible cost, given the input prices.

The clear objective of this study is to find out if hospitals in Jakarta, Indonesia had efficiency problems or not based on the fact that it was commonly known that the primary financing health services upon which the hospitals were relying on suffered huge losses in terms of money. If the problems did occur, it is also important to know whether the problems lie more on the cost aspects or on the technical aspects, hence this study will provide more information for stakeholders to take necessary steps to deal with the problem(s). This is done by comparing the result of cost efficiency and technical efficiency from both methods (in form of table) as well as by building hospital ownership index and regional efficiency map.

In the past, no research has attempted to provide an overall overview of the efficiency situation of hospitals in Jakarta, the capital of Indonesia. The research gap exists because previous research has tended to focus on using the Pabon Lasso technique which has many weaknesses and or only focuses on one hospital unit. This gap in the literature is significant because using both parametric and non-parametric methods could lead to a better overview in general. This study aims to address this research gap by investigating more hospitals and using both methods of DEA and SFA to gain a better understanding about hospital efficiency in the Jakarta area.

Methods

This is a cross-sectional, descriptive study employing econometric techniques called linear programming to explore the efficiency of hospitals such as DMU or Decision-Making Unit in Jakarta.

The target population includes both public and private hospitals in Jakarta. Public hospitals are run by the government Ministry of Health, including the army and police, and non-profit organizations. Private hospitals are managed by for-profit organizations, including enterprises and state-owned companies. Jakarta municipality is divided into six areas; five areas are in the mainland, namely North Jakarta, Central Jakarta, South Jakarta, East Jakarta, and West Jakarta.

This study began by accumulating data from 190 hospitals (before verification process) in the Jakarta Area, of which 108 were BPJS contracted, and 82 were non-BPJS contracted hospitals consisting of 16 class A hospitals, 60 class B hospitals, 62 class C hospitals, and 27 class D hospitals, and 25 hospitals with undecided class. Data on these hospitals were obtained from hospitals, the Ministry of Health, and BPJS from May to July 2019. Data retrieval from Indonesia's hospitals requires a quite expensive fee if taken directly from the hospital. In this study, some data were taken directly from the hospital, and some were taken by asking for access to the database of BPJS and the Ministry of Health. After obtaining data of all the 190 hospitals; data is firstly categorized by Class. Twenty five hospitals are of undecided class, 16 hospitals are Class A, 60 hospitals are Class B, 62 hospitals are class C and 27 hospitals are class D. Second step is selecting input time with most hospitals. Eighteen hospitals are of unknown input time, 3 hospitals are in 2011, 9 hospitals are in 2012, 8 hospitals are in 2013, 9 hospitals are in 2014, 13 hospitals are in 2015, 7 hospitals are in 2016, 30 hospitals are in 2017, 91 hospitals are in 2018, and 2 hospitals are in 2019 input time hence data from 2018 is selected to be used in this study.

For data verification, the hospitals will only be included if they have data for all six input and output variables. After data verification, there are 36 hospitals of type A (12 hospitals), type B (12 hospitals), and type C (12 hospitals) with complete data for this study's purpose. Based on ownership, there are 21 non-government hospitals, 7 government hospitals, and 8 ministries of health-owned hospitals as shown in Figure 1.

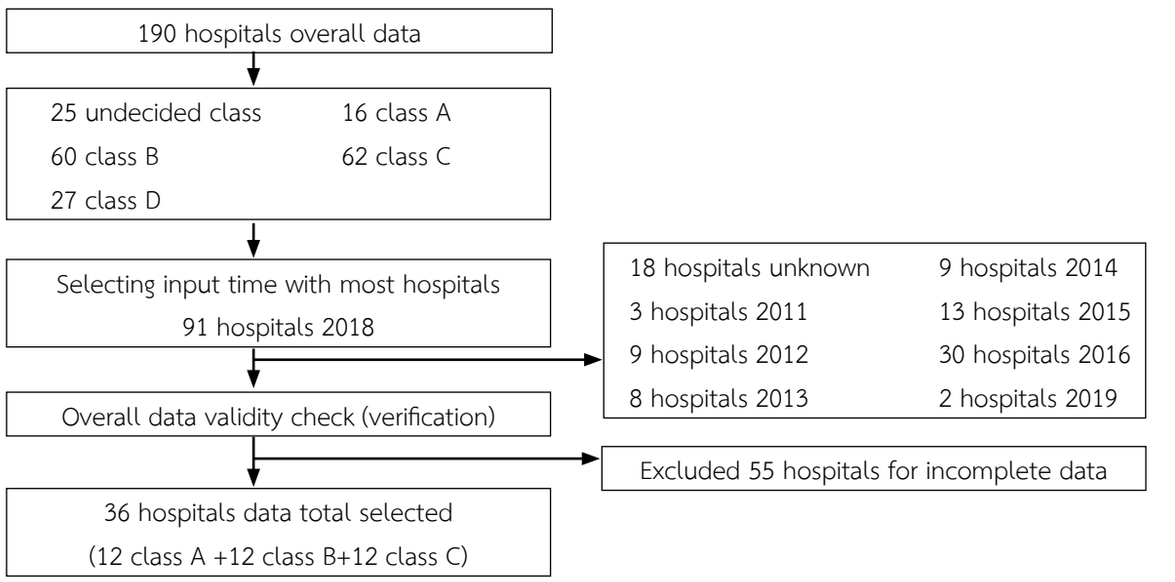

Figure 1 Sampling technique

Exclusion criteria is based on three criteria: it is impossible for a hospital to have a value of input or output is 0, the hospital that contain 0 value in its data set are eliminated from the dataset. Secondly, some hospitals have data missing in number of nurses or number of other personnel. Finally, hospital type D will not be taken into consideration as the reason that they are included the transitional hospital to accommodate the referral of first level health care facilities and operate using smaller input than other type of hospitals.

Data provided by the BPJS and the Ministry of Health was not always guaranteed to be verified. Therefore, this study also utilized a double verification system so that all data obtained were valid. The data from BPJS was obtained by filling out a form upon visiting their office. Afterward, the staff provided a link to the website where reimbursement data was available for public access. However, it was noted that the data only showed reimbursement data for the ongoing year of 2018 and did not have any data available from previous years. Hence, it is not possible for panel data analysis.

This study used the number of beds, doctors, nurses, and non-medical personnel as input variables. Hospital outputs consist of inpatient length of stay and outpatient visits. Inpatient and outpatient services constitute the majority of outputs for general hospitals. Thus, each type of service needs to be accounted for in examining hospital service production with appropriate measurements.

Data from all hospitals in this study were analysed in two stages. First, Data Envelopment Analysis (DEA) was applied to compute the efficiency scores for each hospital in 2018 using input-oriented measurement. Four input variables: a. number of beds, b. the number of doctors, c. number of nurses, d. the number of non-medical staff with two output variables: a. inpatients length of stay, b. the number of the outpatient visit were analysed with DEA Solver LV 8 software. We also used descriptive statistical analyses to assess the effect of BPJS-K contracting status on hospitals' capacity, utilization, and finance variables using Frontier 4.1 for the Stochastic Frontier Analysis application.

Results

DEA and SFA scores are considered as efficient if they reach 1. However, only several DMUS will achieve this, and others are more likely to be less than 1. Scores from 0.90 to 0.50 can be considered as efficient enough, whereas below 0.50 can be considered as in need of improvement. DEA and SFA scores might experience some differences upon similar circumstance, but most of the time the differences are not significant.

The characteristics of the hospital data in Jakarta are shown in the descriptive statistics in table 1. The table indicated data about the six variables used in this study in their median and interquartile range (IQR), maximum and minimum.

Table 1 Descriptive statistics of input and output variables

Variable	Statistics
Doctor	
Median; IQR	91.5; 84.5
Max; Min	930; 23
Nurse	
Median; IQR	187.5; 355.5
Max; Min	2,472; 28
NMS	
Median; IQR	162; 247.5
Max; Min	1,736; 24
Bed	
Median; IQR	136; 156
Max; Min	968; 18
Inpatient length of stay	
Median; IQR	6,259.5; 9,301.5
Max; Min	69,649; 539
Outpatient visits	
Median; IQR	76,735; 133,215
Max; Min	956,849; 5,966

The Spearman's rank correlation in table 2 showed a strong positive correlation with almost all variables. The relationship between doctor input and bed variables was the lowest, at 0.69. The other numbers that showed the relationship between input variables (doctor, nurse, NMS, bed) with output variables (inpatient and outpatient) showed numbers in the range of 0.76

- 0.91, p < 0.01. In this study, technical efficiency results from calculating the output variable produced by a DMU divided by the input variables needed to produce that output. In contrast, cost efficiency results from calculating the amount of money received by a DMU divided by the amount needed to produce that output.

Table 2 Spearman's rank correlation between input and output variables

Variables	Doctor	Nurse	NMS	Bed	Inpatient	Outpatient
Doctor	1					
Nurse	0.86*	1				
NMS	0.76*	0.83*	1			
Bed	0.69*	0.84*	0.86*	1		
Inpatient length of stay	0.78*	0.83*	0.79*	0.79*	1	
Outpatient visits	0.83*	0.86*	0.83*	0.83*	0.91*	1

p < .01

Comparing a DMU's technical efficiency and cost efficiency, when technical efficiency is achieved, it is not necessarily to be cost efficient and vice versa. Thus, the DMU manager must focus on technical and cost-efficiency interaction to make a suitable efficiency policy.

Table 3 shows the comparison between the technical efficiency score and cost efficiency score using DEA and SFA, indicating that most hospitals in Jakarta had a higher score in technical efficiency (0.73 and 0.52) than cost efficiency (0.56 and 0.50) and the result of DEA showed a higher score than the SFA. In terms of technical efficiency, both DEA and SFA showed that class B had a superior score (0.95 and 0.75), followed by class C (0.74 and 0.44) and class B (0.63 and 0.47). It is important to note that the gap between DEA and SFA continues to rise as the difference between both scores for class A is 0.16, for class B is 0.20, and for class C is 0.30. In terms of efficiency, out of 36 DMUs, eight DMUs had the same efficiency rating in both DEA and SFA.

On the other hand, the cost efficiency scores show that class A hospitals had the highest score using DEA and SFA (0.67 and 0.50). Class B showed the same technical efficiency score as the second higher cost efficiency score (0.55 and 0.57), and the lowest score was class C (0.52 and 0.44). In terms of efficiency ratings, out of 36 DMUs, six DMUs had the same efficiency rating in both DEA and SFA.

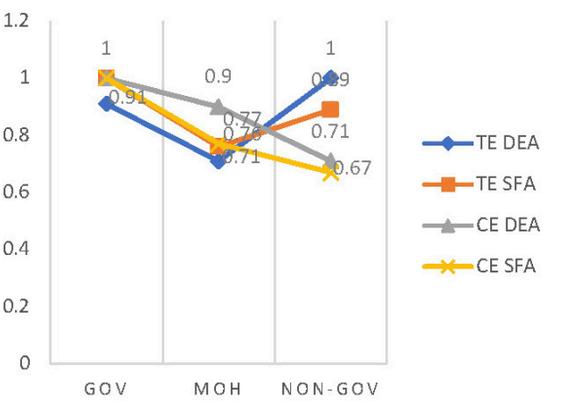

Figure 2 Hospital Ownership Efficiency Index

Using DEA and SFA, this study also compared hospitals' efficiency based on hospitals' ownership and geographical location. Figure 2 shows the pattern between the technical efficiency and cost efficiency scores in the ownership index. In terms of technical, non-government had technical score (DEA: 1, SFA: 0.89) and government (DEA: 0.91 and SFA: 1), and the lowest score was hospitals owned by the Ministry of Health (DEA: 0.71 and SFA: 0.76). Regarding cost, both DEA and SFA show the same pattern that government hospitals were the superior (1), and hospitals owned by the Ministry of Health had scores of 0.90 and 0.77, while non-government hospitals' scores were only 0.71 and 0.67. The difference between the government hospitals and that of Ministry of Health lies on the financing, whereas government hospitals use regional budget, Ministry of Health use its own financial budget.

Table 3 shows that the seven DMUs owned by the government (DMU 8, 10, 11, 17, 19, 21, and 24) had good efficiency in the use of input variables. However, eight DMUs owned by the Ministry of Health (DMU 1, 2, 3, 5, 6, 7, 9, and 12) had higher admitting inpatient and outpatient visits.

Table 3 Technical Efficiency Score and Cost Efficiency Score

DMU	Technical Efficiency		DMU	Cost Efficiency	
	DEA	SFA		DEA	SFA
1	0.63	0.52	1	0.45	0.35
2	0.56	0.29	2	0.53	0.47
3	0.43	0.35	3	0.41	0.13
4	0.64	0.53	4	0.42	0.35
5	0.74	0.49	5	0.67	0.53
6	0.36	0.31	6	1.00	0.66
7	0.60	0.42	7	0.68	0.55
8	0.54	0.45	8	0.92	0.98
9	0.73	0.53	9	1.00	0.93
10	0.77	0.54	10	1.00	0.73
11	1.00	0.45	11	0.66	0.41
12	0.99	0.63	12	1.00	0.56
13	0.61	0.35	13	0.16	0.08
14	0.99	0.80	14	0.41	0.33
15	1.00	0.86	15	0.47	0.47
16	0.57	0.53	16	0.54	0.75
17	0.95	0.64	17	0.51	0.41
18	1.00	0.92	18	0.69	0.30
19	1.00	0.99	19	0.74	0.70
20	0.96	0.71	20	0.74	0.92
21	0.58	0.59	21	0.23	0.22
22	0.41	0.18	22	0.35	0.32
23	1.00	1.00	23	0.53	0.48
24	0.78	0.80	24	0.78	0.73
25	0.28	0.27	25	0.53	0.54
26	0.15	0.10	26	0.36	0.28
27	0.87	0.97	27	0.23	0.27
28	1.00	0.52	28	0.58	0.70
29	0.85	0.78	29	1.00	0.78
30	0.33	0.39	30	0.15	0.17
31	0.32	0.13	31	0.74	0.84
32	1.00	0.80	32	1.00	1.00
33	0.42	0.35	33	0.74	0.94
34	0.64	0.22	34	0.10	0.11
35	1.00	0.78	35	0.49	0.40
36	0.86	0.49	36	0.60	0.61

Figure 3 is a map that describes the hospital's efficiency score classified by regions and using DEA and SFA. It was found that the East region was superior in terms of technical efficiency score (1), followed by the Central region (0.82, 0.97) and the same score at West region 0.78, and the South region had a lower score (0.66 and 0.71) than that of North region which was 0.73 and 0.81. In terms of cost efficiency, it shows the same pattern as the technical efficiency score. The difference only came from the highest score for the Central region (0.98 and 1), which previously showed as the second-highest score at technical efficiency. The other regions showed the same position. West region has the second-highest score in cost efficiency (1, 0.78), East region is the third (0.78 and 0.73), whereas the lowest score came from the North region (0.52 and 0.66) and South region (0.55 and 0.66).

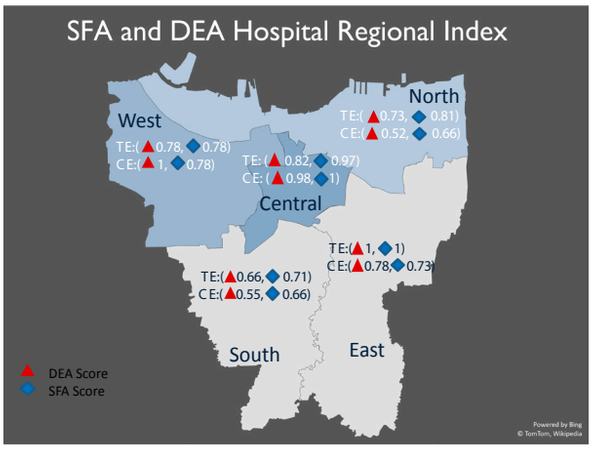

Figure 3 Map of the region's efficiency score

Overall, the DEA and SFA efficiency indices regarding the ownership and region were not much different except for technical efficiency in the ownership aspect. The Hospital Ownership Index by DEA indicated that the technical efficiency advantage was on the non-government hospitals. At the same time, the SFA estimation showed that the technical efficiency advantage was on the government hospitals.

Discussion

This cross-sectional, quantitative study employing econometric techniques called linear programming was designed to explore the efficiency of hospitals in Jakarta. Secondary data from 36 hospitals in 2018 in Jakarta were analysed using Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) to establish both technical and cost efficiency.

The result showed that the level of technical efficiency of hospitals in Jakarta based on DEA was 0.73, compared to 0.52 based on SFA, while the cost efficiency based on DEA was 0.56 and 0.50 for SFA.

DEA and SFA measures had a similar pattern of scores in three of four categories for the ownership and regional indexes. They showed a similar pattern in cost efficiency regarding ownership and technical efficiency and cost efficiency regarding the region. However, a different pattern in the technical efficiency ownership index emerged where non-government-owned hospitals were the more efficient by DEA estimation. In contrast, according to SFA estimation, government-owned hospitals were the more efficient. Perhaps, this is most likely due to the SFA consider the bottom score of each DMU and, the least for government-owned hospital is much higher than the least for non-government hospital. Whereas the total number of hospitals in calculation are more significant in DEA, and in our data, there are more DMUs from non-government than those of governments', hence the result.

Results were varied from this study, particularly for efficiency based on DEA and SFA; however, they did not show significant differences except for a few DMUs. This finding is similar to the results of other studies, given the differences between parametric (SFA) and non-parametric (DEA) techniques used.[5, 6]

Therefore, three points can be made as a recommendation based on this study:

1) Improving the centralized national database

Research in the field of hospital efficiency requires accurate and valid data sources. This study found that the centralized national hospital database has weaknesses that influence the lack of availability of accurate hospitals and national health insurance data. Despite the new system of information database initiated by BPJS, there are several unsynchronized and incomplete information because of the lack of

monitoring. Considering that there were lots of missing or invalid data in this study and many hospitals had to be excluded, the government thus needs to strive for a better quality centralized hospital database.

This study recommends that hospitals start working together to share their service databases. The government should monitor and facilitate the shared database for efficiency study, resource allocation, and patient referral purposes. Hence, the public would gain more access to the hospitals, making hospitals more efficient.

2) The strategies for managing efficiency

The study's background is that hospitals' involvement in the BPJS scheme puts pressure on hospitals in terms of cost and maintaining quality.[7] Another study on Indonesian hospitals' efficiency found that most hospitals had similarly relatively low scores in terms of inpatient efficiency score (0.41) and outpatient efficiency score (0.40).[8] These scores indicate that most hospitals in Indonesia still need to improve overall inpatient and outpatient efficiency. Also, the challenge of improving service should not rely on performance measurement alone, as indicated by a study that found that the Indonesian government hospitals often measure things without following them up with precise adaptation, organization, and regulation that are needed.[9]

This research is expected to be a good start for further research on hospital efficiency in Jakarta. Efficiency, in reality, is not merely about making a reduction. However, it is about making adjustments between technical (number of labour and capital investments such as the number of doctors, nurses, and beds.) and budget management to control financial cash flow. Hospitals are generally independent and separated from each other. However, from this efficiency study, the government should initiate an integrated task force that utilizes a centralized database to monitor the workload faced by each hospital in real time. The government can then provide assistance to ease the workload that the hospitals are dealing with by reallocating essential resources and workload. As of today, the primary care centre only refers to the nearest hospital in its area without considering the capacity of the referred hospital. This problem can be solved by having a centralized referral system. If the patients are evenly distributed among the hospitals in Jakarta, the efficiency gap shall be reduced. Without such intervention, the problem will continue, and if it is not resolved, it may eventually affect the decision of hospitals whether to stay in the BPJS scheme.

3) The implementation in other countries.

This study complements other studies on hospital efficiency in Southeast Asia, such as that of Puenpatom and Rosenman, which examined 92 general hospitals in Thailand and found that hospitals in more affluent areas were indicated to be more efficient.[10] Klangrahad examined the efficiency of Thailand's regional hospitals using 2015 data and found that 12 out of 24 hospitals were indicated to be efficient and suggested that hospital efficiencies in tourism-intensive areas be given more attention.[11] Di Tian (2011) examined 308 hospitals in Thailand using 2010 data, showing that regional hospitals' efficiency rates are superior to the efficiency of general hospitals and community hospitals.[12] If other Southeast Asian countries are willing to provide health resources and cost data, a comparative study can be carried out that will provide a picture of hospital performance in the region, which will be a good follow-up for this study. Also, a study with multiple efficiency measurement methods is still not typical, primarily considering the costs of a comprehensive hospital survey to obtain accurate data. Therefore, it is recommended that researchers who will further develop this research focus on the quality of variables that can contribute more to the value of efficiency in hospitals and health systems.

Conclusion

Hospitals in Jakarta were quite efficient in terms of technical efficiency, as indicated by both DEA and SFA measurement results. However, the cost efficiency score could improve as the score is still in the 0.50 – 0.56 range. Regarding technical efficiency, government and non-government hospitals were superior, while

hospitals owned by the health ministry tend to be weaker. In contrast, in terms of cost efficiency, government and Ministry of Health-owned hospitals were superior, while non-government hospitals were on the weaker side. It is therefore recommended that more study should be done in the future using panel data instead of cross-section, and that the government do yearly monitoring on the subject of hospitals' efficiency.

Conflict of interest

The authors have no conflict of interest to declare.

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