

Hospital Efficiency Measurement Before and After Health Sector Evolution Plan in Southwest of Iran: a DEA-Panel Data Study

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ABSTRACT

Introduction: Efficiency is one of the most important indicators of hospital performance evaluation.

Aim: The study was conducted to measure the efficiency of public hospitals. **Material and methods:**

This was a cross-sectional and panel data study. Data were retrospectively collected using hospital records and hospital information system. In this study, panel data of 17 public hospitals affiliated with Ahvaz University of Medical Sciences, in southwest of Iran were studied during 2012-2016. The output-based data envelopment analysis technique and variable return to scale assumption (VRS) were used. Regression model was used to assess factors affecting hospital efficiency. Data were analyzed using Deap2.1 and R software. **Results:** The mean of technical efficiency, managerial efficiency, and scale efficiency of the hospitals during 2012-2016 were 0.230, 0.272 and 0.732, respectively. Assessment of return to scale results over 5 years showed that 65% (11 cases) of hospitals had a decreasing return to scale, 24% (4 cases) had a constant return to scale, and 12% (2 cases) had an increasing return to scale. Also, mean of technical managerial, and scale efficiency in specialized hospitals were higher than other hospitals (0.331, 0.353, and 0.873). Beta regression analysis showed the effect of both variable length of stay and number of beds on hospital efficiency was significant (p -value <0.05).

Conclusions: The results showed that efficiency of selected public hospitals was the poor. Technical efficiency and managerial efficiency were lower than scale efficiency rate. Also, Multi- specialized hospitals were in critical status considering resource management and economies of scale.

Keywords: Hospital efficiency, Resource, Health care reform.

1. INTRODUCTION

Organizational structure of health system in Iran including Ministry of Health and Medical Education, Social Security Organization, there Government Hospitals, Private Hospitals (Non-Profit), Private Hospitals (For-Profit) and Private Teaching Hospitals. In Iran, the University of Medical Sciences, play an important role both in medical education and the provision of health services in province level. Also, social Security Organization (SSO) provides medical services to its beneficiaries by their hospitals. Private sector also provides 10-20% of the health care services (1).

In 2000, WHO reported that Iranian health system performance was ranked ninety-three among the other countries (2). One of the reasons of this can be mismanagement of resources (3). In 2014, Iranian health sector evolution plan (HSEP) started by ministry

of health. This plan included packages to: increase coverage of basic health insurance, increase quality of care, reduce out-of-pocket (OOP) payments for in-patient services, and increase quality of primary healthcare (4). Healthcare providers' concerns potentially about the sustainability and efficiency of HSEP in Iran (5).

Low hospital efficiency is one of the most important problems of Iranian health system. Several Iranian's study has been conducted in hospital efficiency evolution. In most of these studies, the efficiency indicator was reported low (2, 6-13). According to an Iranian's study, after the implementation of HSEP, the hospital efficiency was better than before (14). The results of studies in some of countries showed that the hospital efficiency was low (15-18). In some study, hospital efficiency was reported high (19-22).

Hospitals are an important economic

enterprise; therefore, measurement of its financial performance is a key action toward improvement of resource management (23, 24). Efficiency means maximum use of resources to generate returns. Two non-parametric and parametric approaches have been introduced to measure the efficiency. Data envelopment analysis (DEA) is an applied and frequent nonparametric technique to measure efficiency of units. By DEA methods can assess inefficient units and reason of the inefficiency (25). Considering the importance of hospital performance measurement, this study aimed to efficiency analyze of public hospitals using DEA technique.

2. METHODS

This is a retrospective panel data study. Seventeen public hospital affiliated with Ahvaz Jundishapur University of Medical Sciences in southwest of Iran (including 9 general hospitals, 4 specialized hospitals, and 4 Multi-specialized hospitals) were assessed using data envelopment analysis (DEA) method.

2.1. Variables and data gathering

Data of 17 hospitals were gathered from 2012 to 2016 using hospital information system and medical record documents based on input and output variables. Input variables included the number of hospital admissions, the number of nurses, and the number of available beds. The output variables included average of length of stay (LOS) and bed turnover interval.

2.2. Efficiency analysis

To evaluate the hospital efficacy indicators including technical, scale, and managerial efficiency the output-based data envelopment analysis approach and the variable returns to scale assumption (VRS) was used. Based on the out-put based approach (maximizing the factors of production), to increase efficiency the organization should be increase outputs. In this method, efficiency is ranked between 0-1. If the numerical values were closer to one, the unit was more efficient. The linear relationship between the Maximize production model and efficiency is as follows.

$$\begin{aligned} \text{Max} \quad & \Phi \\ \text{S.t.} \quad & (X_o, \Phi Y_o) \in T_v \\ & \sum_{j=1}^n \lambda_j x_{ij} \leq x_{io} ; i = 1, 2, \dots, m \\ & \sum_{j=1}^n \lambda_j y_{rj} \geq \Phi y_{ro} ; r = 1, 2, \dots, s \\ & \sum_{j=1}^n \lambda_j = 1 \\ & \lambda_j \geq 0 ; j = 1, 2, \dots, n \end{aligned}$$

Decision Making Unit (T_v) is the n foundation ($j = 1, 2, 3, \dots$) With m input $x_j = \{x_{1j}, x_{2j}, x_{3j}, \dots, x_{mj}\}$ and S output $y_j = \{y_{1j}, y_{2j}, y_{3j}, \dots, y_{mj}\}$. The purpose of this model is to maximize θ (efficiency) to reach the maximum output level. Deap2.1 software was used to analyze hospital efficiency.

2.3. Regression model

To evaluate the effect of variables influencing the hospital efficiency, Beta Regression analysis was used. Beta regression can be conducted with the betareg function in the betareg package (Cribari-Neto and Zeileis, 2010). With this function, the dependent variable varies between 0 and 1, but no

observation can equal exactly zero or exactly one. The model assumes that the data follow a beta distribution (26). For this purpose, the value of 0.999 is equivalent to efficiency=1 and 0.0001 is equivalent to efficiency=0. Independent variables in this model include length of stay, number of available beds and proportion of nurse to total staff. Hospital efficacy is a dependent variable. All computations were carried out using the Beta regression model through the statistical R software.

2.4. Ethical approval

The study was approved by the ethical committee of Ahvaz Jundishapur University of Medical Sciences (AJUMS)..

3. RESULTS

Table 1 shows the average technical, managerial, and scale efficiency of the hospitals during 2012-2016. According to this table, Efficiency in most hospitals was poor (average efficiency less than 1) over the 5 years period. Also average hospital efficiency showed mean of technical efficiency and managerial efficiency were lower than scale efficiency.

Hospital	Technical efficiency	Managerial efficiency	Scale efficiency	Operational efficiency*
1	0.029	0.127	0.229	0.128
2	0.015	0.072	0.225	0.104
3	0.035	0.047	0.765	0.282
4	0.070	0.086	0.818	0.325
5	0.081	0.085	0.943	0.370
6	0.050	0.110	0.459	0.206
7	0.172	0.242	0.731	0.382
8	1	1	1	1
9	0.045	0.083	0.660	0.263
10	0.118	0.285	0.704	0.369
11	0.047	0.069	0.791	0.302
12	0.071	0.095	0.776	0.314
13	0.056	0.096	0.663	0.272
14	0.061	0.068	0.880	0.336
15	0.134	0.152	0.878	0.388
16	1	1	1	1
17	0.918	1	0.918	0.945
Mean	0.23	0.27	0.73	0.41

*the total average of technical, managerial and scale efficiency per hospital

Table 1. The average of technical, managerial and scale efficiency during 2012-2016.

Information about technical, efficiency, and scale efficiencies, and returns to the scale of 17 hospitals were assessed based on the type of activity is depicted in Table 2. The results showed that the mean of technical, managerial, and scale efficiency in the hospitals during 2012-2016 were 0.230, 0.272 and 0.732, respectively. Among the estimated indicators, the scale efficiency of hospital was better. Also, information about the efficiency of hospitals based on their type of activity showed that the mean of technical efficiency in multi-specialized, specialized and general hospitals was 0.032, 0.311, and 0.227; mean of managerial efficiency was 0.089, 0.335, and 0.316; mean of scale efficiency was 0.479, 0.873, and 0.880 respectively. Among the hospitals, specialized hospitals were in a better performance. In addition, the results of the return to scale showed 65% (11 cases), 24% (4 cases) and 12% (2 cases) of hospitals had a decreased return to scale, constant returns to scale and increased return to scale; respectively.

Figure 1. shows the average changes of technical, mana-

Year	Efficiency	Type of hospital**			Total*
		Multi- spe- cialized	Special- ized	General	
2012	Technical	0.038	0.354	0.264	0.232
	Managerial	0.085	0.361	0.280	0.253
	Scale	0.501	0.943	0.907	0.82
	Returns to scale	Decreased	Constant	Constant	Constant
2013	Technical	0.039	0.347	0.280	0.239
	Managerial	0.093	0.351	0.288	0.257
	Scale	0.421	0.964	0.911	0.808
	Returns to scale	Decreased	Constant	Constant	Constant
2014	Technical	0.040	0.342	0.272	0.234
	Managerial	0.114	0.376	0.324	0.287
	Scale	0.397	0.844	0.749	0.688
	Returns to scale	Decreased	Constant	Constant	Decreased
2015	Technical	0.025	0.311	0.266	0.22
	Managerial	0.097	0.355	0.315	0.273
	Scale	0.339	0.817	0.713	0.649
	Returns to scale	Decreased	Constant	Decreased	Decreased
2016	Technical	0.021	0.301	0.279	0.223
	Managerial	0.056	0.324	0.375	0.288
	Scale	0.441	0.797	0.759	0.693
	Returns to scale	Decreased	Constant	Constant	Constant
2011- 2016	Technical	0.032	0.331	0.272	0.230
	Managerial	0.089	0.353	0.316	0.272
	Scale	0.419	0.873	0.808	0.732
	Returns to scale	Decreased	Constant	Constant	Constant

* Sample size= 17 hospital

** hospital classification based on type of activity: 4 multi-specialized, 4 special-
ized and 9 general hospitals

Table 2. Hospitals efficiency and returns to scale, during 2012-2016.

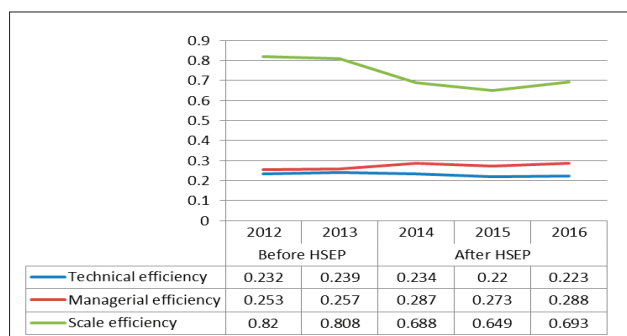


Figure 1. The changes of efficiency average before and after the implementation of the HSEP (2012-2016).

gerial, and scale efficiency in the hospitals, before and after implementation of the health sector evolution plan (HSEP) during 2012-2016.

It indicates the comparison of efficiency indicator before and after the HSEP showed that technical and scale efficiency had negative changes. While managerial efficiency had positive change after health sector evolution plan.

Table 3 shows the results of beta regression analysis. The results showed that the effect of both variable LOS and beds size on hospital efficiency indicator was significant (p -value<0.05). In other words, Increase the LOS and the number of hospital beds is positive and negative effect on hospital efficiency, respectively. The coefficient Z value (regression coefficient) shows this regression analysis is very significant for both variable LOS ($Z=2.707$) and number of available beds ($Z=3.184$). On the other hand, Beta weights indicate that the LOS variable has the most important role in the hospital efficiency. Finally, the pseudo R-squared value (model

power) shows that 50% of the hospital's efficiency changes are predictable with independent variables (length of stay and bed size) used in this model. In other words, other independent variables that not used in this model, can also affect the hospital efficiency.

Independent variable	Beta	Std. Error	Z value	Sig [*]	PR-S ^{**}
Los ^{***}	0.032	0.011	2.707	0.006	0.5053
Bed size	-0.005	0.001	-3.184	0.001	
Nurse/ Total staff	-3.883	3.453	-1.125	0.26	

*statistical significance at the 0.05 level

** Pseudo R-squared

***length of stay

Table 3. Multivariate regression analysis of factors effecting hospital efficiency.

4. DISCUSSION

In this study, the nonparametric method of data envelopment analysis (DEA) was used to evaluate the technical, managerial, and scale efficiency of selected public hospitals. The results showed that the mean of technical, managerial, and scale efficiencies in 17 hospitals during 2012-2016 were 0.23 (23% of efficiency), 0.27 (27% of efficiency), and 0.73 (73% of efficiency) respectively, which indicated a poor efficiency level approximately. In other words, based on an output-based approach and assuming a variable return to scale, there is capacity to improve technical efficiency and managerial efficiency in these units without an increase in costs and use of same amount of institutional resources in relation to technical efficiency and managerial efficiency of about 0.75 and scale efficiency of about 0.27. Aboulhallaj et al. performed a similar study with the aim of evaluating the some of the Iranian hospitals. The results showed that the hospitals were better in scale, managerial, and technical efficiency, respectively (27). Also, the results of Chang et al. in China showed that the average technical efficiency of hospitals studied during three years has been increased (28). Comparing the results of Aboulhallaj and Chang with the results of this study indicated that the technical efficiency values were less than the other efficiencies indicators. Since managerial performance impact on the technical efficiency (29).

Also, the result of operational efficiency evaluation showed this indicator in specialized hospitals was higher than general and multi-specialized hospitals. A similar study showed that the mean of efficiency in specialized hospitals was higher than in general hospitals (30). In a research conducted by Aboulhallaj et al. the average technical efficiency and managerial efficiency were the highest in the educational and specialized hospitals, general hospitals, general and educational hospitals, respectively. Also the average scale efficiency has been highest in the general and educational hospitals (31). In addition, in this study, the results showed that 47% (8 hospitals), 41% (7 hospitals) and 12% (2 hospitals) had decreasing, a constant, and increasing return to scale ratio, respectively. In this case, the study of Safarian et al. (7) and Dargahi et al. (30) showed deferent results. In contrast, comparing the results of this study with the results of Azar et al (32) and Mahfouzpour et al (11) showed that the changes of increasing return to scale in the studied hospital was a relatively similar trend during the period of study. In other words, the frequency of hospitals with a decreasing return to scale has been more, and

these hospitals have not been able to increase their production in proportion to the increase in their financial resources and human resources. In the present study, the changes in the technical, managerial, and scale efficiencies of hospitals before and after the health sector evaluation plan were studied. The changes caused by the implementation of this national plan showed that the average technical and scale efficiency has been reduced and managerial efficiency has been a slight increase. The results of the study by Zhou et al. (20) and Cheng et al. (33) also showed that the efficacy of the hospitals under study has decreased after reform in the their health system. The results Jia et al. (19), Cheng et al. (28) and Mahfouzpour et al. (11) were not consistent with the results of the present study.

In different studies, the effect of different factors has been analyzed on efficiency. Based on the findings of these studies, factors such as modification of managerial practices, use of modern technologies tailored to the cultural, political and social infrastructures, formulation of clinical guidelines to standardize the medical processes in order to reduce medical errors and increase the power of health care buyers (insurance organizations), length of stay, management of hospitals by specialist managers, administrative requirements, full-time hospital physicians, limiting the authority of decision makers in relation to the recruitment of staff in accordance with the needs of the hospital and optimal allocation of beds, conducting economic evaluations and employing more effective clinical interventions, and ultimately, the type of hospitals ownership had an impact on the efficiency of the hospital (7, 10, 13, 34-39). In this study, the length of stay and the number of available beds had impact on the hospital efficiency significantly. By increasing the number of beds the hospitals efficiency decreases. Optimizing the bed size can increase hospital efficiency.

5. CONCLUSION

This study offers DEA technique for evaluating the hospital efficiency. The results showed that hospitals efficiency was the poor generally. Technical efficiency and managerial efficiency rate were lower than scale efficiency. Also, Multi-specialized hospitals had a low efficiency than other hospitals and were in critical conditions considering resource management and economies of scale. Therefore, in order to eliminate mismanagement of resources, it is necessary to improve the efficiency indicators periodically.

Limitation study: In this study, there were some of the limitations. A key limitation of the study was the small sample size. A small sample size may result in many hospitals becoming efficient by default (as a result of not having a comparator from within the small sample). Another important limitation of this study was availability of hospital data. Studied hospitals had not integrated hospital information system; therefore, it could be led to increase error in data gathering and analyzing.

• Authors' contributions: Each author participated in each step of research and gave final approval for publication..

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