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Do Hospitals Affiliated With the Kurdistan University of Medical Sciences Perform Efficiently? Non-parametric Data Envelopment Analysis

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Abstract

Background: One way to improve the performance of hospitals, the largest resource-consuming units in the healthcare sector, is to continuously evaluate their performance.

Objective: The current study assessed the performance of hospitals affiliated with the Kurdistan University of Medical Sciences using data envelopment analysis (DEA).

Methods: This retrospective descriptive-analytic study used DEA to assess efficiency types (technical, managerial, and scale) in hospitals of the Kurdistan University of Medical Sciences (n=12) in the years 2007 to 2011. The number of active beds, nurses, physicians (general and specialist), and other staff were inputs; inpatient admission and occupied bed days were outputs. Stata version 12 was used for data analysis.

Results: The mean technical, scale, and managerial efficiency values were 0.85, 0.89, and 0.95, respectively. The highest and lowest slack inputs were nurses and active beds, respectively.

Conclusion: The findings indicate that Kurdistan hospitals were less than appropriately efficient during the studied period. They also suggest that there is a capacity of about 15% for enhancing output in hospitals (compared with the most efficient studied hospitals) without increasing costs or inputs.

Keywords: Data envelopment analysis, Efficiency, Hospitals performance

1. Background

Hospitals are considered the most costly parts of a healthcare system. Assessing hospital performance using economic tools can improve performance and optimize the use of physical, technological, and human resources and facilities in hospitals. One economic tool planners and policy-makers in the healthcare sector can use is efficiency measurement.[1-4] According to Tandon et al, efficiency measurement in the healthcare sector is important for three aspects. First, the system is likely to reach a higher performance level without a large increase in input. Second, environmental factors causing the system inefficiency can be identified. Third, regular measurement of efficiency is effective over time in monitoring and assessing how to conduct reforms that promote technical and allocative efficiency in a hospital.[5] Efficiency can be defined as achieving the maximum output possible using the available inputs or producing the desired output with minimum input.[6]

Three methods are used to measure efficiency: the parametric method (stochastic frontier analysis [SFA]), the non-parametric method (data envelopment analysis [DEA]), and ratio analysis. Each of these methods has its own advantages and disadvantages and can be used under certain circumstances. For example, the ratio analysis method measures efficiency by a fraction of which the numerator is output and the denominator is input. Since this method is used to measure the efficiency of an input and an output, it is limited in cases where multiple inputs and outputs are involved. Given that hospitals manage multiple inputs and outputs at the same time, efficiency measurement is not possible using this method. In previous studies, DEA or SFA was used to overcome this limitation.[7-12]

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Studies conducted by Ismail on 15 health service providers in Sudan in 2007,[13] Zere on 86 hospitals in South Africa in 2000,[10] Kirigia et al on 28 public hospitals in Angola in 2002,[14] Akazili et al on 89 health care centers in Ghana in 2008,[15] Marschall and Flessa on 20 health service providers in rural areas in Burkina Faso in 2011,[16] Moga et al on 50 private hospitals in India in 2014,[17] and Barouni et al[18] on 8 hospitals affiliated with the Qom University of Medical Sciences in 2015 used DEA to evaluate the efficiency of hospitals and health service providers. DEA is a non-parametric method based on linear programming that estimates the frontier production function, which is the maximum possible production obtained from specific production factors. It is convex and has no point places under the curve. The DEA method, called so because it encompasses all data, measures efficiency relatively. The advantages of this approach are: (1) it can be used for multi-input and multi-output analysis; (2) inputs and outputs can have different units of measure; and (3) the type of production function does not have to be specified.[19]

2. Objective

Given the importance of studying the performance and efficiency of hospitals and the fact that the efficiency of Kurdistan hospitals had not been previously studied, the current study measured and evaluated the efficiency of Kurdistan hospitals using the non-parametric DEA method in the 2007-2011 period.

3. Methods

This retrospective descriptive-analytic study used DEA to assess types of efficiency (technical, managerial, and scale) in hospitals affiliated with the Kurdistan University of Medical Sciences (n = 12) from 2007 to 2011. The study setting consisted of the following hospitals: Be'sat (A), Tohid (B), and Qods (C) in Sanandaj; Imam Khomeini in Saghez (D); Shahid Beheshti in Qorveh (E); Fajr (F) and Bu-Ali (K) in Marivan; Salahedine Ayubi in Baneh (G); Imam Khomeini in Divandarreh (H); Sina of Kamyaran (I); Imam Hussein in Bijar (J); and Shohada in Dehgolan (L). Given the benefits of DEA, the technical, managerial, and scale efficiencies of the studied hospitals were measured based on the minimum input method assuming variable returns to scale.

The input-driven DEA with the variable returns to scale assumption was used as the following linear programming:

$$Min_{\lambda,OS,IS}\ (\acute{M}_1.OS + \acute{k}_1.IS)$$
$$St: -y_i + Y\lambda - OS = 0$$
$$\theta x_i - X\lambda - OS = 0$$
$$\acute{N}_1.\lambda \le 0, \lambda \ge 0, OS \ge \lambda, IS \ge 0$$

In the above equation, the first constraint indicates that for each firm, slack product will be zero if $-y_i + Y\lambda$ is zero. The second constraint indicates that slack production factors will be zero if $\theta x_i - X\lambda$ is zero. The third constraint indicates variable returns to scale. λ is an N*1 vector which includes constant numbers that represent total reference weights.[20]

One main reason for selecting the minimum input method is that hospital outputs (number of patients), unlike its inputs, is not under the hospital's control. The main reason for selecting the variable returns to scale assumption is that it can separate scale efficiency and pure efficiency. In other words, this method allows the achievement of technical, managerial, and scale efficiencies. The relationship between these three types of efficiency is as follows:

Technical efficiency = scale efficiency × managerial efficiency

The required data was gathered by referring to hospitals to complete the self-construct checklist which contained all the research variables selected based on previous studies[1,9,18,20,21] and their availability in the studied hospitals. The data included two outputs (number of inpatient and occupied bed days) and four inputs (number of active beds, nurses (nurses and paramedics), number of physicians (general and specialist physicians), and other staff (administrative, support, and medical staff other than physicians and nurses). Stata 12 was used for data analysis.

4. Results

The average numbers of nurses, physicians, and other staff members for all hospitals in the 5-year period (2007 to 2011) were 112, 33, and 146, respectively. Moreover, the average numbers of active beds, occupied bed days, and the average number of inpatient admissions were 129, 30 976,

Table 1. Average Inputs and Outputs Used in the Study From 2007 to 2011

Hospital	Occupied Bed Days	No. of Inpatients	Other Staff	Nurses	Physicians	Active Beds
A	90 262	30 087	368	321	103	352
B	83 049	17 998	280	290	70	332
C	30 088	2540	54	45	9	100
D	32 484	16 242	200	184	42	167
E	26 944	11 290	169	100	38	133
F	11 784	4610	87	53	25	55
G	24 751	12 375	128	68	20	94
H	13 767	5740	79	54	13	64
I	13 523	6761	75	50	16	61
J	21 104	7492	121	82	24	87
K	21 864	9791	134	70	31	81
L	2095	779	54	24	7	17
Average	30 976	10 478	146	111	32	129

and 10 478, respectively. The average number of inputs and outputs for each hospital in this study are shown in Table 1.

The average technical efficiency for all hospitals during the studied period was 0.85. The current findings indicated that maximum average technical efficiency during the 5-year studied period was achieved by Quds hospital in Sanandaj and Salahedine Ayubi hospital in Baneh (technical efficiency score = 1) and the minimum average technical efficiency is for Shohada hospital in Dehgolan (technical efficiency score = 0.38). The technical efficiency scores for hospitals and the average for hospitals included in the study are shown in Table 2.

Results showed that average scale efficiency was 0.89 for hospitals affiliated with the Kurdistan University of Medical Sciences during the studied period. The maximum average scale efficiency (equal to 1) was found at Quds hospital in Sanandaj and Salahedine Ayubi hospital in Baneh during the studied period. The minimum average scale efficiency was found at Shohada hospital in Dehgolan (0.38). The highest and lowest average scores of scale efficiency in the studied period were 0.87 and 0.91, respectively, from 2009 to 2011. The scale efficiency scores for hospitals and their averages for hospitals in Kurdistan in the 2007-2011 period are shown in Table 3.

The average managerial efficiency for all hospitals during the studied period was estimated to be 0.95. The highest managerial efficiency rates were found at Quds hospital in Sanandaj and Salahedine Ayubi hospital in Baneh (managerial efficiency score = 1), and the lowest managerial efficiency was found at Shahid Beheshti hospital in Qorveh (managerial efficiency score = 0.81). The managerial efficiency values and averages for hospitals in the 2007-2011 period are shown in Table 4.

Based on the study results, the highest and lowest slack inputs were nurses (7.6% of all nurses) and active beds (1.4% of all beds), respectively. Optimal values and slack percentages for each input and output are shown in Table 5.

5. Discussion

In the past few decades, healthcare costs have risen rapidly. The growth in healthcare costs has fueled debate among health care policy makers in countries around the world regarding the limited resources available to meet such costs and how to reduce healthcare costs without reducing the quality of healthcare services. One way to reduce healthcare costs is to consider the efficiency of healthcare services, particularly hospital services. Thus, this study aimed to answer the question, "Did hospitals affiliated with the Kurdistan University of Medical Sciences perform efficiently from 2007 to 2011?" All hospitals of Kurdistan University of Medical Sciences were evaluated using DEA. Results showed that the average technical efficiency of Kurdistan hospitals in the studied period was 0.85. Such a result suggests that, based on this model, the hospitals have

Table 2. Technical Efficiency of Kurdistan Hospitals From 2007 to 2011

Hospital	2007	2008	2009	2010	2011	Average
A	0.93	0.92	0.99	0.93	0.95	0.94
B	0.95	0.91	0.75	0.93	0.93	0.89
C	1	1	1	1	1	1
D	0.89	0.81	0.91	0.87	0.68	0.83
E	0.85	0.90	0.72	0.66	0.82	0.79
F	0.73	0.92	0.91	0.61	0.67	0.77
G	1	1	1	1	1	1
H	0.68	0.89	0.70	1	0.94	0.84
I	1	1	0.97	0.93	0.82	0.94
J	0.63	0.82	0.84	1	1	0.86
K	1	1	0.86	0.85	1	0.94
L	0.27	0.15	0.18	0.62	0.69	0.38
Average	0.83	0.86	0.82	0.87	0.88	0.85

Table 3. Scale Efficiency for Kurdistan Hospitals, 2007-2011

Hospital	2007	2008	2009	2010	2011	Average
A	0.94	0.93	0.99	0.94	0.95	0.95
B	0.95	0.91	0.89	0.93	0.93	0.92
C	1	1	1	1	1	1
D	0.92	0.81	0.95	0.90	0.89	0.89
E	0.96	0.97	0.99	0.95	0.99	0.97
F	0.90	0.93	0.91	0.61	0.72	0.81
G	1	1	1	1	1	1
H	0.74	0.88	0.7	1	0.94	0.85
I	1	1	0.97	0.77	0.81	0.91
J	0.86	0.99	0.98	1	1	0.97
K	1	1	0.93	0.96	1	0.98
L	0.27	0.16	0.18	0.62	0.69	0.38
Average	0.88	0.88	0.87	0.89	0.91	0.89

Table 4. Managerial Efficiency for Kurdistan Hospitals From 2007 to 2011

Hospital	2007	2008	2009	2010	2011	Average
A	0.99	0.99	1	0.98	0.99	0.99
B	1	1	0.84	1	1	0.97
C	1	1	1	1	1	1
D	0.97	1	0.96	0.97	0.76	0.93
E	0.88	0.93	0.72	0.69	0.82	0.81
F	0.82	0.99	1	1	0.92	0.95
G	1	1	1	1	1	1
H	0.92	0.99	1	1	1	0.98
I	1	1	1	1	0.99	1
J	0.73	0.83	0.86	1	1	0.89
K	1	1	0.93	0.88	1	0.96
L	1	0.94	1	1	1	0.99
Average	0.94	0.88	0.94	0.96	0.95	0.95

Table 5. Slack and Optimum Values for Production Inputs Using DEA From 2007 to 2011

	Physicians	Nurses	Other Staff	Active Beds
Total values	1249	4075	5311	4642
Optimal values	1155	3766	5088	4577
Slack percentage	7.4%	7.6%	4.1%	1.4%

a 15% capacity for improving efficiency with no increase in costs and using the same amount of inputs. A study by Bhat et al in public hospitals of Gujarat, India showed that the average technical efficiency of hospitals was 0.85, which is consistent with the results of this study.[22] Barouni et al in the public hospitals of Qom province, Iran showed that the average technical efficiency was 0.75. This implies that the hospitals of the Kurdistan University of Medical Sciences use their inputs more efficiently than the public hospitals of Qom province.[18] Another study by Jat et al showed that the average technical efficiency of public hospitals in Pradesh, India was 0.9.[23]

Results of the current study showed that the average scale and managerial efficiencies of the hospitals affiliated with the Kurdistan University of Medical Sciences were 0.89 and 0.95, respectively. The study by Pourreza et al reported the average managerial efficiency in the hospitals of Tehran University of Medical Sciences from 1196 to 2006 as 0.995.[24] Ismail evaluated the efficiency of health provider organizations in Sudan and found the average managerial efficiency of these organizations to be 0.935.[13] A study on the efficiency of public hospitals in Qom, Iran showed that the average managerial efficiency of the studied hospitals was 0.799 in 2010 and 0.812 in 2011.[18] Saber-Mahani et al reported that managerial and scale efficiencies of the public hospitals of Kerman University of Medical Sciences were 0.99 and 0.918, respectively.[25] Najarzadeh et al showed that the average scale and managerial efficiencies for Ahwaz hospitals (teaching and non-teaching) were 0.86 and 0.83, respectively.[26] A comparative study of the studied years showed that average technical, scale, and managerial efficiencies did not have a constant increasing or decreasing trend. In some years, they increased over the previous year, and in some cases, they decreased. This increasing or decreasing trend was reported in previous studies.[9,20,24] Generally, the current study showed that the average technical, scale, and managerial efficiencies increased about 0.023, 0.013, and 0.012, respectively, in 2011 from 2007.

The present study showed that about 17% of hospitals have a technical efficiency of 1; 70% of hospitals have a technical efficiency of between 0.8 and 1; and the remaining hospitals have a technical efficiency of lower than 0.8. Saber-Mahani et al showed that 16% of hospitals have an efficiency of lower than 0.8; 54% of hospitals have a technical efficiency of between 0.8 and 1, and the remaining hospitals have an efficiency of 1.[25] Qods hospital in Sanandaj and Salahedine Ayubi hospital in Baneh had a maximum technical efficiency of 1, and the difference between the optimum amount of production factors and the optimum amount of inputs was zero. Results showed that the highest and lowest differences between the optimum and actual values of production factors for all hospitals in the studied period were related to the number of nurses and active beds, respectively. Pourreza et al[24] in Tehran University of Medical Sciences and Askari et al[27] in the Yazd University of Medical Sciences showed that the highest slack inputs were related to nurses. Najarzadeh et al showed that the highest and lowest slack inputs in the educational hospitals of Ahvaz were related to nurses and active beds.[26] Barouni et al concluded that the studied hospitals of Qom province in 2010 and 2011 had slack inputs of physicians, nurses, and beds relative to the total input, and these centers must reduce their inputs (i.e., physicians, nurses, and beds) to achieve optimal technical efficiency (equal to 1).[18] Generally, the results of the current study showed that the average technical efficiency in the hospitals of the Kurdistan University of Medical Sciences is lower than most other university hospitals in Iran, indicating that the use of inputs in offering hospital services in Kurdistan hospitals is suboptimal. Therefore, the managers and policy-makers of the healthcare sector in Kurdistan province must take appropriate measures to use production resources efficiently and optimally so as to prevent the loss of healthcare resources. Since there is a surplus of labor in the studied hospitals, time and motion studies should be conducted to improve

efficiency and productivity.[9] Another appropriate measure that can be useful in this context is the continuous assessment of hospital efficiency, both quantitatively and qualitatively. The current study examined the efficiency of the studied hospitals using the DEA method which has several limitations. This method does not use any test to confirm the efficiency or non-efficiency of a hospital. Furthermore, it measures relative efficiency, not absolute efficiency. Another disadvantage of this approach is that, as the number of input and output variables increases, the number of efficient units increases as well. Accordingly, it is recommended that other methods be used, such as SFA and balanced scorecard (BSC) to assess hospital efficiency and that the results be compared with those of the present study. It is further recommended that environmental variables such as the age of hospital administrators and the type of hospital (educational or treatment) also be considered, even though some studies have shown that type of hospital is not significantly related to efficiency.[20]

6. Conclusion

The study results indicated that the hospitals of the Kurdistan University of Medical Sciences do not optimally use inputs and resources available to them, and that output could be increased by about 15% with the proper management of resources and the same level of inputs without increasing costs. Moreover, some inputs (physicians and nurses) had a greater surplus than others. Therefore, it is suggested that these inputs be reduced or used more efficiently with careful and comprehensive planning. The current study only used quantitative variables to assess performance with the DEA method. It is suggested that future studies also consider effectiveness indicators to estimate the efficiency of hospitals more accurately.

Authors' Contributions

Study concept and design, data gathering, analysis, and interpretation: SR; critical revision of the manuscript for important intellectual content: FGh; administrative and technical support: ND; drafting the manuscript: MB; revising the manuscript: MJ.

Conflict of Interest Disclosures

No conflicts of interest are declared.

Ethical Approval

The study was approved by the Ethics Committee of the Deputy of Research, Kurdistan University of Medical Sciences.

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Research Highlights

What Is Already Known?

The proportion of total healthcare system costs for hospitals in developed and developing countries varies between 50% and 80%. Thus, assessing hospital performance is important to decreasing inefficient usage of hospital resources and healthcare costs.

What This Study Adds?

The results of this study indicated that, although the hospitals affiliated with the Kurdistan University of Medical Sciences performed more efficiently in 2011 than in 2007, there is still an approximate 15% capacity for improving hospital efficiency based on this model using the same amount of inputs and not increasing costs.

References

1. Hajialiafzali H, Moss J, Mahmood M. Efficiency measurement for hospitals owned by the Iranian social security organisation. J Med Syst. 2007;31(3):166-172. doi:10.1007/s10916-007-9051-6.
2. Kiadaliri AA, Jafari M, Gerdtham U-G. Frontier-based techniques in measuring hospital efficiency in Iran: a systematic review and meta-regression analysis. BMC Health Serv Res. 2013;13(1):312. doi:10.1186/1472-6963-13-312.
3. Yaisawarng S. Performance measurement and resource allocation. Efficiency in the Public Sector. Springer; 2002:61-81. doi:10.1186/1472-6963-13-312.
4. Kuntz L, Scholtes S, Vera A. Incorporating efficiency in hospital-capacity planning in Germany. Eur J Health Econ. 2007;8(3):213-223. doi:10.1007/s10198-006-0021-6.
5. Tandon A, Lauer JA, Evans DB, Murray CJ. Murray CJL, Evans DB, eds. Health system efficiency: concepts. In: Health Systems Performance Assessment: Debates, Methods and Empiricism. Geneva: WHO; 2003:683-691.
6. Goudarzi R, RjabiGilan N, Ghasemi SR, Reshadat S, Askari R, Ahmadian M. Efficiency measurement using econometric stochastic frontier analysis (SFA) method, Case study: hospitals of Kermanshah University of Medical Sciences. J Kermanshah Univ Med Sci. 2014;17(10):666-672.
7. Kirigia JM, Emrouznejad A, Sambo LG. Measurement of technical efficiency of public hospitals in Kenya: using data envelopment analysis. J Med Syst. 2002;26(1):39-45. doi:10.1023/b:joms.0000023298.31972.c9.
8. Jacobs R. Alternative methods to examine hospital efficiency: data envelopment analysis and stochastic frontier analysis. Health Care Manag Sci. 2001;4(2):103-115.
9. Karimi S, Bidram R. Efficiency Estimation in General Hospitals of Isfahan University of Medical Sciences during 2005-2006 by Data Envelopment Analysis. Journal of Health Administration. 2009;12(36):39-46.
10. Zere E. Hospital efficiency in sub-Saharan Africa. Evidence from South Africa. Helsinki: UNU/WIDER; 2000.
11. Renner A, Kirigia JM, Zere EA, Barry SP, Kirigia DG, Kamara C, et al. Technical efficiency of peripheral health units in Pujehun district of Sierra Leone: a DEA application. BMC Health Serv Res. 2005;5(1):77. doi:10.1186/1472-6963-5-77.
12. Kheirollahi H, Matin BK, Mahboubi M, Alavijeh MM. Chance constrained input relaxation to congestion in stochastic DEA. An application to Iranian hospitals. Glob J Health Sci. 2015;7(4):151. doi:10.5539/gjhs.v7n4p151.
13. Ismail MA. Technical efficiency of sudan's health institutions: a state-level analysis. Population. 2010;70:19922.
14. Kirigia JM, Emrouznejad A, Cassoma B, Asbu EZ, Barry S. A

performance assessment method for hospitals: the case of municipal hospitals in Angola. J Med Syst. 2008;32(6):509-19. doi:10.1007/s10916-008-9157-5.
15. Akazili J, Adjuik M, Jehu-Appiah C, Zere E. Using data envelopment analysis to measure the extent of technical efficiency of public health centres in Ghana. BMC Int Health Hum Rights. 2008;8:11. doi:10.1186/1472-698X-8-11.
16. Marschall P, Flessa S. Efficiency of primary care in rural Burkina Faso. A two-stage DEA analysis. Health Econ Rev. 2011;1(1):1-15. doi:10.1186/2191-1991-1-5.
17. Mogha SK, Yadav SP, Singh S. Estimating technical and scale efficiencies of private hospitals using a non-parametric approach: case of India. International Journal of Operational Research. 2014;20(1):21-40.
18. Barouni M, Rahbar A, Abrazeh A, Parsa H. The estimation of technical efficiency of public hospitals in Qom using data envelopment analysis approach. Q J Sabzevar Univ Med Sci. 2015;22(2):238-244. [Persian].
19. Meybodi Emami A. Principles of Measuring Performance and Productivity: Practical Application [Persian]. 2nd ed. Tehran: Publishing Business Studies and Research Institute; 2005:10-15.
20. Ghaderi H, Goudarzi R, Gohari M. Determination technical efficiency of hospitals affiliated with Iran University of Medical Science by data envelopment analysis (2000-2004). J Health Adm. 2007;9(26):39-44. [Persian].
21. Hatam N. The role of data envelopment analysis (DEA) pattern in the efficiency of social security hospitals in Iran. Iran Red Crescent Med J. 2008;2008(3):211-217.
22. Bhat R, Verma BB, Reuben E. Hospital efficiency: an empirical analysis of district hospitals and grant-in-aid hospitals in Gujarat. J Health Manage. 2001;3(2):167-197. doi:10.1177/097206340100300202.
23. Jat TR, San Sebastian M. Technical efficiency of public district hospitals in Madhya Pradesh, India: a data envelopment analysis. Glob Health Action. 2013;6:21742. doi:10.3402/gha.v6i0.21742.
24. Pourreza A, Goudarzi G, Azadi H. Determination of technical efficiency of hospitals affiliated with Tehran University of Medical Science by the data envelopment analysis method: 1996-2006. Journal of School of Public Health and Institute of Public Health Research. 2010;7(4):79-86.
25. Saber-Mahani A, Goodarzi G, Barouni M, Khakian M. Estimation of technical efficiency of general hospitals of Kerman University of Medical sciences by data envelopment analysis (DEA) method IN 2007. J Kerman Univ Med Sci. 2010;17(1):59-67. [Persian].
26. Najarzadeh M, Torabipoor A, Ghasemzadeh R, Salehi R. Assessment of hospitals efficiency by data envelopment analysis in Ahvaz in 2006-2010. Jundishapur J Health Sci. 2012;4(3):77-87.
27. Askari R, Goudarzi R, Fallahzadeh H, Zarei B, Dehqani Tafti A. Efficiency appraisal of Yazd University of Medical Science hospitals by quantitative approach data envelopment analysis (DEA). Payavard Salamat. 2012;6(3):215-224. [Persian].