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The role of Data Envelopment Analysis (DEA) pattern in the efficiency of social security hospitals in Iran

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Abstract

Background: A remarkable increase has been observed in hospital expenditure in many countries during recent years, drawing especial attention to the problem. This study was conducted to present one of the operational research techniques pattern in evaluation of the hospital efficiency.

Methods: The ratio analysis method was used to evaluate the hospital efficiency. This method is not effective in cases in which the relationship between an input and several outputs or several inputs and several outputs are involved.Data Envelopment Analysis Pattern (DEA) is one of the operational research techniques, lacking the problems of ratio method while efficiency evaluation can determine the critical parts of hospital, reducing the efficiency of the whole hospital and meanwhile compensating the deficiency in a particular measurement. In order to introduce this method in hospital efficacy evaluation, 18 general hospitals affiliated to Iran Social Security Organization were included.

Results: This study revealed that Data Envelopment Analysis Pattern had more capacity than previous methods in relation to evaluation of the complicated organizations like hospitals.

Conclusion: Operational research techniques in efficiency evaluation would provide the possibility to compare different efficiencies among various hospitals and present the necessary solutions to compensate the insufficiency and to correct them for the managers.This technique was used for the first time in this study to measure hospital efficiency in Iran.

Keywords: Hospital, Efficiency; Data envelopment analysis; Ratio analysis

Introduction

Among the components of health systems, hospital services are the main expense imposing factor in many countries. This growth is faster in the governmental sector than in the other ones. Regarding the health care as one of the socio-economic development factors, the improvement in insurance coverage with economical changes in 1960s and 1970s and the oil crisis resulted in necessary actions against such fast growth to limit the expenses in these services.[1] Due to budget limitations and evidence showing lack of efficiency of expenses in health systems, particularly in hospitals, in all developed and to some extent in developing countries, some vast reforms started. These measures and finally the control of expenses in each country led to different results based on their conditions.[2] Like other governmental institutes, hospitals in Iran are also under pressure due to reduction in current and developmental budgets, while the request for treatment services has had a remarkable growth. Such a condition provides an unavoidable limitation in the use of financial resources for governmental institutions, particularly hospitals.[1] In such a condition and regarding the limitation of resources, managerial decision making strategies to maximize the efficiency and improve the activities in health sector for the reduction of expenses is necessary. This provides appropriate and proper utilization of opportunities for hospitals and institutes.

Since differences in hospitals' performance and efficiency are unassailable, an important and effective method for improvement and restoration would be the identification of the dimensions, where the functions

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would be partially efficient.[3] Applications of proper managerial strategies might improve the hospital efficiency level. Although finding strategic points to determine the efficiency and the level of promotion in complicated hospital systems is difficult, it seems to be necessary.[3] The important point in this report is the use of effective methods to evaluate the efficiency rate as well as critical and strategic points that require more organizational attention to increase the efficiency and provide the necessary information to the manager for effective decision-making. Since the ratio analysis method used in most efficiency analytic studies is not able to determine critical and important points in a hospital, so an efficiency reduction in the whole hospital would be seen.[4] In this study, an operational research technique entitled as Data Envelopment Analysis (DEA) was introduced and its use (the first time in Iran as to our knowledge) was evaluated by studying the efficiency of 18 general hospitals affiliated to social security organization countrywide.

Materials and Methods

In this study, DEA was used as one of the linear programming techniques being introduced in 1982 by Sherman to evaluate hospital technical efficiency and to compare it with ratio and regression methods used commonly for this purpose.[5] This model was used to measure the partial efficiency of operational units with similar minor and major goals. The advantages of this method, as compared with former efficiency measurement methods, include the evaluation of several inputs and outputs, simultaneous determination of the unit's relative condition among similar units and finally determination of some aspects of unit activities which require more evaluation and management attention to promote the efficiency (strategic points).[6]

DEA is based on the hypothesis that the efficiency of an operational unit, as a decision making unit, will be considered lower if another decision making unit with less resources in comparison with the unit under study produces at least an equal output. This technique compares the unit under study with similar units by determining one or several inputs and their relationship with one or several outputs. For example, in efficiency, the number of constant beds, as input, and the ratio of active beds with bed-days, as output, were analyzed. If efficiency coefficient (E) in the target cell section (entitled as final value in Table 1 as a sample for a hospital) is 1, the hospital is considered as efficient and non-efficient if it is below 1. Therefore, the hospital with a final value of 1 is compared with similar hospitals with respect to input and output which would be evaluated as hospital having relative efficiency.

In section two of the Table in adjustable cells lines, the column name, number of hospitals under study and the final values show the comparative rate of these hospitals' efficiency and similar ones. Considering the input and output in the slack column, in the constraints section of the Table, the need for increasing or reducing of both input and output, considered as project limitation, is shown. In other words, the slack rate in each table reveals changes to be applied by the manger to achieve a higher efficiency in his organization input or output. In order to have a better analysis of the findings, the summary of the table of the hospitals and type of efficiency are shown in Tables 2-4.

The researchers evaluated different types of economical, technical and scale efficiency in 18 hospitals affiliated to Social Security Organization countrywide, using DEA in Dr. Shariati (Isfahan), Ayatollah Kashani (Tehran), Shariat Razavi (Tehran), Eslamshahr, Fayasbakhsh (Tehran), Hosseyniyeh Ershad (Karaj), Hevdahe Shahrivar (Mashhad), Bojnoord, Hevdahe Shahrivar (Abadan), Behbahan, Semnan, Saghez(Kurdestan), Ayatollah Kashani (Kerman), Dr. ghavazi (Sirjan), Valiasr (Ghaem Shahr), Martyr Beheshti (Kashan), Dr. Ghavazi (Malayer) and Shohadaye Kargar (Yazd) hospitals. The data collected, in field and library studies, interview and referring to available documents in social security organization, were analyzed through Excel (Solver) 95 software.

Results

As pointed out in the previous sections, the specification of this technique is that each type of efficiency for hospitals located in the covering area could be determined and compared with one another by computer softwares. Each of the hospitals studied was compared only with similar ones regarding input and output. The main outcomes of using this technique in each type of efficiency in the 18 hospitals are as follows:

The results of comparative scale efficiency are shown in Table 2. As shown in this table, 72% (13) of the hospitals lacked scale efficiency in different levels. Evaluation of this section suggested that scale efficiency correlated with active and constant bed number measurement and the hospitals with less than 75% of their constant beds as active ones did not achieve scale efficiency.

Table 1: Measure of technical efficiency in Beheshty Hospital by using DATA envelopment analysis

Target Cell (Min)

Cell	Name	Original Value	Final Value
$C$41	Efficiency	0.000	1.000

Adjustable Cells

Cell	Name	Original Value	Final Value
$B$2	W1	0	5.70519E-17
$B$3	W2	0	0
$B$4	W3	0	0
$B$5	W4	0	0
$B$6	W5	0	2.48422E-16
$B$7	W6	0	0
$B$8	W7	0	0
$B$9	W8	0	0
$B$10	W9	0	0
$B$11	W10	0	0
$B$12	W11	0	0
$B$13	W12	0	0
$B$14	W13	0	0
$B$15	W14	0	0
$B$16	W15	0	0
$B$17	W16	0	1
$B$18	W17	0	0
$B$19	W18	0	2.05212E-19
$B$20	S	0	9.73133E-14

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$C$41	1st limit	0.00	$D$41<=0	Binding	0.00
$E$41	2nd limit	74231.500	$E$41>=$E$17	Binding	0.000
$F$41	3rd limit	15.500	$F$41>=$F$17	Binding	0.000
$G$41	4th limit	75272.000	$G$41>=$G$17	Binding	0.000
$H$41	5th limit	42.500	$H$41>=$H$17	Binding	0.000
$I$41	6th limit	5.000	$I$41>=$I$17	Binding	0.000
$J$41	7th limit	1.000	$J$41=1	Binding	0.000
$B$2	W1	5.70519E-17	$B$2>=0	Binding	0
$B$3	W2	0	$B$3>=0	Binding	0
$B$4	W3	0	$B$4>=0	Binding	0
$B$5	W4	0	$B$5>=0	Binding	0
$B$6	W5	2.48422E-17	$B$6>=0	Binding	0
$B$7	W6	0	$B$7>=0	Binding	0
$B$8	W7	0	$B$8>=0	Binding	0
$B$9	W8	0	$B$9>=0	Binding	0
$B$10	W9	0	$B$10>=0	Binding	0
$B$11	W10	0	$B$11>=0	Binding	0
$B$12	W11	0	$B$12>=0	Binding	0
$B$13	W12	0	$B$13>=0	Binding	0
$B$14	W13	0	$B$14>=0	Binding	0
$B$15	W14	0	$B$15>=0	Binding	0
$B$16	W15	0	$B$16>=0	Binding	0
$B$17	W16	0	$B$17>=0	Not Binding	1
$B$18	W17	0	$B$18>=0	Binding	0
$B$19	W18	2.05212E-19	$B$19>=0	Binding	0
$B$20	S	9.73133E-14	$B$20>=0	Binding	0

Table 2: Critical points of scale efficiency evaluation in understudy hospitals

No	Hospital	Efficiency Coefficient	Input	Output	
			No of Constant bed	Ratio of active and constant bed	Bed/ Day
1	H1	0.1	0	0	0
2	H2	0.245	0	0.57	0
3	H3	0.1	0	0	0
4	H4	0.772	0	0	0
5	H5	0.565	0	0.26	0
6	H6	0.1	0	0	0
7	H7	0.1	0	0	0
8	H8	0.521	0	0.380	2301
9	H9	0.528	0	0	0
10	H10	0.525	0	0.330	0
11	H11	0.322	0	0.395	0
12	H12	0.1	0	0	0
13	H13	0.316	0	0	0
14	H14	0.296	0	156.12	0
15	H15	0.261	0	0	0
16	H16	0.193	0	0	0
17	H17	0.336	0	23.085	0
18	H18	0.232	0	16.214	0

Table 3: Critical points of technical efficiency evaluation in understudy hospitals.

No	Hospital	Efficiency Coefficient	Input		Output			
			No of bed	No of full time equivalent (FTE)	Patient – Day	bed - occupancy	Bed turn over	Length of stay
1	H1	0.1	0	0	0	2345.43	0	0
2	H2	0.977	750.57	0	24989	0	0	0
3	H3	0.1	0	0	0	0	0	0
4	H4	0.1	0	0	0	0	0	0
5	H5	0.1	0	0	0	0	0	0
6	H6	0.1	0	0	0	0	0	0
7	H7	0.1	0	0	0	0	0	0
8	H8	0.1	0	0	0	0	0	0
9	H9	0.806	0	0	579.35	579.35	12.706	0.79
10	H10	0.893	0	0	480.75	480.75	11.467	0.777
11	H11	0.682	16.34	0	0	0	0	0.488
12	H12	0.1	0	0	0	0	0	0.451
13	H13	0.747	33.06	0	515.008	515.008	0	1.318
14	H14	0.535	0	0	0	0	0	0
15	H15	0.817	0	0	0	0	15.607	0
16	H16	0.1	0	0	0	0	0	0
17	H17	0.1	0	0	0	0	0	0
18	H18	0.1	0	0	0	0	0	0

With respect to technical efficiency, it should be noted that 39% (seven) of the hospitals lacked technical efficiency. A comparison between technically efficiency and scale efficiency indicated that hospitals suffered more from the former than the latter. 42% of technical inefficient hospitals (eight) had problems on input and inappropriate use of beds, while another 42% were inefficient on output or patient-day viewpoint. 71% of technically inefficient hospitals (13) hospitalized the patient for less than 3 days.This could be due to hasty discharge which had endangered the use of available hospital beds efficiently. Data from this analysis and the critical points about technical efficiency are shown in Table 3.

Table 4: Critical points of economic efficiency in the studied hospitals

No	Hospital	Efficiency Coefficient	Input			Output		
			Total expense	Full time equivalent (FTE)	No. of bed	Hoteling expense	Bed – day expense	Personnel Expense
1	H1	0.1	0	0	0	0	0	0
2	H2	0.968	1102315179	57.47	0	0	0	0
3	H3	0.964	0	410.33	0	8013.55	0	0
4	H4	0.1	0	0	0	0	0	0
5	H5	0.1	0	0	0	0	0	0
6	H6	0.1	0	0	0	0	0	0
7	H7	0.1	0	0	0	0	0	0
8	H8	0.1	0	0	0	0	0	0
9	H9	0.1	0	0	0	0	0	0
10	H10	0.1	0	0	0	0	0	0
11	H11	0.1	0	0	0	0	0	0
12	H12	0.1	0	0	0	0	0	0
13	H13	0.581	4150171253	102.78	0	6031.68	147273.24	0
14	H14	0.715	380939834	129.85	0	27038.51	75085.10	0
15	H15	0.940	1553412554	61.93	0	0		0
16	H16	0.777	2155441652	135.68	0	75950.21	65285.06	0
17	H17	0.877	0	0	0	11582.61	190869.82	0
18	H18	0.676	7092055858	2.047	0	63235.67	72034.20	0

Economic efficiency evaluation data analysis, summarized in Table 4, shows that 44% of hospitals (eight) confronted different levels of economic inefficiency. 75% of these hospitals (13) faced total expense increase. In other words, these hospitals, compared with similar ones, spent more financial resources than required (regarding the services). 87% of the hospitals (16) had different levels of economical inefficiency to use full-time employment, that is with regard to expense, these hospitals were not able to use full-time personnel optimally. Finally, 87% of economically inefficient hospitals had more bed-day and hoteling cost than similar ones.

Discussion

Lack of sufficient resources in health economy is the most important reason for taking appropriate utilization with desirable feedback of available possibilities into account in all health management sections. Consequently, hospitals as the health system section with the most expenditure require especial attention, allocating the main share of gross national product to themselves. Prevention or reduction of the waste of allocated resources to hospitals for more services and quality improvement requires studies of the ratio of outputs to inputs. This necessitates the evaluation of the hospital efficiency and productivity and the factors affecting them.[7] The findings of the present study in relation to scale efficiency showed that country-wide hospitals confronted the problem of unused input (fixed bed). Based on a report by the Ministry of Health and Medical Education conducted in 1992 on 91% of total beds in hospitals affiliated to the Ministry, 14% of them were known to be inactive, most probably due to mismanagement,lack of due attention to financial resources and also of scale efficiency.[3] As shown, 72% of the hospitals were inefficient. To compare the results with those of efficient hospitals regarding determining factors affecting efficiency, the use of up to 75% of the hospital beds nominal capacity but not the size of the hospital was the most important.42% of the hospitals had problems of input, i.e. inappropriate use of hospital beds.This should have been improved by correct management, and appropriate use of beds and an increase in bed occupancy rate. Newbrander and Kutzin (1991), in a study about hospital beds in developing countries, reported that the hospitals of these countries should be designed in a smaller size due to the stable or decreasing rate of patients referring to them.[8] Karo and Feldschtain (1967) also in a study recommended that the size of hospitals in developing countries be up to 190

beds to reach a scale efficiency.[9] Pangilinan (1992) has recommended that 120 bed be efficient and mentioned that hospitals with higher efficiency need shorter time for patient stay.[10] Sherman (1984) reported the use of extra beds in a hospital as an effective factor to reduce hospital efficiency.[5] However, the findings of the present study showed that an efficient hospital can have a range of 50 to 585 beds; therefore, the determining factor in scale efficiency is not the number of beds, but the use rate up to 75%. In other words, the results of the previous studies in relation to the positive effect of hospital smaller size to increase the efficiency do not match ours.

Toorani (1996) pointed to the efforts necessary to increase active bed-day and increase in bed occupancy rate up to 75% and also the reduction in patient length of stay in a hospital as effective factors in technical efficiency.[12] Maggnussn (1996) demonstrated the patient-day measurement to be one of the most important technical efficiency measurements and showed that this measurement would be effective in hospital efficiency as well as in patient length of stay,[4] being alsoconfirmed in the present study showing that 71% of inefficient hospitals had an average ofpatient stay of less than three days from the viewpoint of technical aspects. Such hospitals may try to elevate this rate to be suitable to approved standard levels as well as increase the occupied bed-day and to have a positive effect on hospital efficiency too. Sadaghiani (1997) noticed that the reason for the low rate of bed occupancy and increase in hospital expenses was not lack of experts and/or medical supplies (as claimed), but was more due to underuse, maintenance, manpower and improper use of the equipment, confirming the role of managers in this respect.[11] Browils (1992) showed the low rate of hospital bed occupancy to be an important factor in the increase of hospital expenses.[12]

While bed occupancy rate was reported to be 83% in developing counties,[13] the studies in Iran showed it to be 64%[9] and in the present study on 18 hospitals it was shown that only three hospitals had an occupancy rate over 75%. The problem of hospital bed shortage in Iran indicates the lack of optimal use of available facilities and requires appropriate planning to utilize the available beds before using extra ones. One of the most important functional measurements is the average stay length, which ranges from three to seven days in the studied hospitals. Hasty discharge in hospitals with short length of stay (3 days) could endanger available hospital bed use and affects the hospital services, too. Myers (1992) stated that increase and decrease in technical efficiency can depend on clinical and executive management. An economical system cannot produce economical efficiency unless technical efficiency is fulfilled. Therefore, these two efficiency aspects should be considered simultaneously.[14] In economical efficiency, 75% of inefficient hospitals offered services with higher expenses compared with similar ones and 87% of economical inefficiency in such hospitals was due to inappropriate use of full-time personnel, imposing additional financial load on the hospital while no desirable services were offered.However, most of the hospitals studied were far from the 2.64 standard of personnel per bed of the Ministry of Health and Medical Education in Iran.[15] In other words, in spite of insufficient personnel, they were not used efficiently. Regarding the findings of the present study, it could be concluded that although there were different methods to evaluate the efficiency in hospitals, using DEA technique, first used in this study in hospitals of Iran, could not determine a fixed standard in relation to hospital efficiency measurements (similar to other efficiency evaluation techniques). These points may cause hospital inefficiency if they are not paid enough attention to. This pattern could be empirically used by the hospital management and be a desirable practical measurement to evaluate the function and to present procedures to increase the efficiency.

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