Efficiency evaluation of hospitals affiliated with Yazd University of Medical Sciences using quantitative approach of Data Envelopment Analysis in the year 2001 to 2011

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Abstract

Hospitals are known as the largest and the most costly functioning units of health care system. Thus careful consideration of their performance and cost efficiency is of particular significance. This study intends to evaluate the efficiency of hospitals affiliated with Yazd University of Medical Sciences using Data Envelopment Analysis (DEA) method. This descriptive-analytical study has used panel data to evaluate and analyze the efficiency of all hospitals of Yazd University of Medical Sciences (13 hospitals) during 2001 to 2011. Study variables includes “hospitalization admission”, “bed occupancy percentage” and “number of surgeries” as the output variables and “number of active beds”, “number of nurses”, “number of physicians” and “number of non-clinical staff” as the input variables. Data was analyzed using Deap 2.1 software. Mean technical, managerial and scale efficiency of the studied hospitals was found to be 0.956, 0.981 and 0.952, respectively which implies an average of 4.4% improvement capacity in technical efficiency scores of the studied hospitals. Moreover, excess input rates were recognized particularly for the number of the nurses. Although the efficiency of the studied hospitals showed a favorable level and there is slight efficiency improvement required, the managers are still expected to provide the necessary planning toward increasing the efficiency. Finally studying the impact of other factors such as the quality of services and patients’ satisfaction on hospitals’ efficiency is recommended.

Key words: Efficiency evaluation, Quantitative approach, Data Envelopment Analysis, Hospital

1. Introduction

Improving public health across the society is a major goal of governmental plans in Islamic republic of Iran. Providing required facilities and resources and optimized utilization of them is critical in order to achieve this goal. Given the fact that maintenance of individuals’ health is among the developmental priorities of any country, health care professionals are continuously trying to provide health care services with the highest quality (Farzianpour at al,2012., Shahhoseini et al,2011., Afzaliet al,2009., Barnum et al,2009., Saricam et al,2012). Health care is a core issue in sustainable social, economic, political and cultural development in all human societies and has significant importance in infrastructures of different sectors of the society. Therefore, health improvement, besides being a moral obligation, is a social and economic matter and any health care program must be part of a comprehensive health politic attitude and eventually constitute an integrated sustainable development plan (Jahanshahloo et al,2011., Karimi et al,2009., Cook,2008., Emrouznejad et al,2008).

Efficiency and performance as the main bases of development, are among the most important and common methods to evaluate and measure the functioning of an economic foundation such as hospital. During the past decades studying the performance of different economic sectors or economic foundations and units through measuring and estimating the efficiency has been always of great attention among researchers of various social sciences particularly management and economics (Farzianpour et al,2011., Farzianpour et al,2011., Farzianpour et al,2011, Farzianpour et al,2011).

Several methods have been introduced to assess the efficiency of economic institutes which can generally be divided into two groups of parametric and non-parametric ones (Emami Meybodi, 2005). The parametric method is based on econometric models and micro economic theories. In these theories, the production function (costs) is estimated by panel data according to the considered assumptions and efficiency of the units is determined due to the mentioned function(Emami Meybodi, 2005., Marandi,1998., Moradi Shahr Babak,2009., Peacock et al,2001). However, non-parametric method is based on a series of optimizations using linear programming. In this method, the efficient frontier curve is made from groups of points determined by linear programming (Emami Meybodi, 2005., Marandi,1998., Moradi Shahr Babak, 2009., Peacock et al,2001) . Researchers have carried out extensive studies on efficiency assessment of hospitals in different countries of the world. Some examples include Valdmanis on 41

This research is aimed to determine the performance and efficiency score of the studied hospitals and compare their efficiency according to the study variables. Moreover, we try to identify the main contributing factors to hospitals’ efficiency and discuss how these effective factors influence on performance and efficacy of these hospitals.

2. Materials and Methods

This descriptive-analytical study, also might be said a descriptive-comparative study, based on gathered data and description of the current conditions as well as comparisons of performance and efficacy of the hospitals has been carried out from 2001 to 2011. Study sample included 13 hospitals affiliated with Yazd Shahid Sadughi University of Medical Sciences in Yazd province, Iran. Of the total 13 studied hospitals, 5 were teaching hospitals and the rest were non-teaching, also 10 out of the 13 hospitals were general and 3 were specialty. Considering the limited study population, no sampling method was used. Data was collected using several methods including direct observation, interviews and referring to the existing documents and statistics of hospitals’ activities. This information was obtained from Statistics Department of Treatment Deputy and Human Resources Department of the Support Office of the University and was recorded in a form which included a checklist of the required variables, i.e. inputs and outputs of the present study.

Choosing the inputs and outputs is the key stage in efficiency studies. In order to do this, different performances of the studied hospitals were considered. In order to include the necessary components of the hospital resources according to the existing data, four input variables were recognized: total number of physicians, total number of full-time nurses, total number of the rest of hospital staff, and the number of beds which is usually used as a capital proxy in hospital efficiency studies (Pourmohammadi, 2009). Several DEA studies have categorized hospital activities into three groups of outpatient, emergency and hospitalization services (Ozcan et al, 1992., Hofmarcher, 2002). In addition, some unadjusted measuring units have been used for hospitalization activities such as “number of discharges”, “number of surgeries” and “patient-day” (Sahin et al 2000., Chang et al,2004). Accordingly in this investigation we used “the number of surgeries”, “the number of hospitalization admissions”, and “the percentage of bed occupancy” as the study outputs.

The gathered data was analyzed based on DEA model implying a variable returns to scale (VRS) assumption using DEAP2.1 software(Coelli et al,2012). The reported results included technical efficiency, managerial efficiency and scale efficiency of the studied hospitals based on input minimization method. In addition, demographic characteristics of the hospitals’ managers were separately recorded in a form. Finally, SPSS software and parametric statistical tests such as t-test and ANOVA were used to investigate the relation between environmental variables and demographic characteristics of the managers with hospitals’ efficiency.

3. Results

The results of the present study are reported in three parts. In the first part some important characteristics of the hospitals and their managers are discussed, in the second part technical efficiency issues of the studied hospitals under the assumptions of minimizing the inputs and variable returns to scale are reported and finally for the third
part using analytical statistics, the relation between environmental variables and demographic characteristics of the hospital managers with hospitals’ efficiency is investigated.

In the first part, regarding the type of the hospitals, of the 13 studied hospitals 5 were teaching and the rest were non-teaching; and 3 were specialty and 10 were general hospitals. A total of 1446 active beds were affiliated with Yazd University of Medical Sciences with Yazd and Abarkuh townships having the highest (n=709) and lowest (n=32) number of the beds.

Among the hospital managers, the age group with the highest frequency was younger than 40 years and the lowest frequency was for age group older than 50 years. In specialty hospitals and non-teaching hospitals, none of the managers were older than 50 years. Mean age of the hospital managers during the study period was approximately 40 years. Educational level of the majority of hospital managers was bachelor; however few managers in non-teaching and public hospitals had diploma. In addition, most of the managers had academic educations unrelated to management sciences. During the 10 year study period, none of the hospital managers were found to have a university degree in management fields of study.

In the second part, regarding the efficiency (according to the results indicated in table 1), mean technical efficiency of the hospitals affiliated with Yazd University of Medical Sciences during the study period was 0.956 which shows favorable efficiency condition. Using the DEA model under VRS assumption indicated that there is a 4% capacity for efficiency improvement in these hospitals, without any increase in the expenditures and using the same amount of the inputs. In other words, the studied hospitals can achieve the same level of the outputs (products) using 96% of their current resources.

None of the hospitals in our study had a mean technical efficiency lower than 0.8 and two hospitals were found to have maximum technical efficiency of 1.

Lowest efficiency belonged to Burns and Trauma Hospital of Yazd with efficiency score of 0.590 in 2003. Lowest level of technical efficiency among the studied hospitals was found in Khatamolanbia Hospital of Abarkuh with mean technical efficiency of 0.875. Reporting a yearly distribution, the lowest efficiency scores were reported in Burn and Trauma Hospital of Yazd during 2001, 2003 and 2004; Ghaem and Ziayi Hospitals of Ardekan in 2002; Vali-e-Asr Hospital of Bafgh in 2005, 2007 and 2008; Khatamolanbia Hospital of Abarkuh in 2006, 2009 and 2010 and finally Shahid Sadughi Hospital of Yazd in 2011.

Highest and lowest levels of mean efficiency were calculated 0.993 in 2002 and 0.932 in 2006, respectively.

According to the DEA-VRS model, technical efficiency includes managerial efficiency and scale efficiency. According to the study findings, mean managerial efficiency of the hospitals affiliated with Yazd University of Medical Sciences during the 11 year study period is 0.981. Five hospitals had the maximum managerial efficiency and the lowest level belonged to Khatamolanbia Hospital of Abarkuh.

During the study period the highest and lowest managerial efficiency were reported in 2009 and 2006, respectively. Mean scale efficiency of the hospitals was found to be 0.963. Three hospitals had the maximum scale efficiency and the lowest score belonged to Burn and Trauma Hospital of Yazd. Hospitals of the province showed the highest scale efficiency in 2002 and the lowest in 2001.

Applying DEA method with minimization of the inputs assumed indicated that among the hospital inputs, number of beds had the lowest excess percentage while number of nurses was found to be the input with the highest excess rate. Details on input excess are outlined in table 2.
As for the third part, results from statistical analysis investigating the relation between efficiency with environmental variables and managers’ characteristics of the selected hospitals are discussed. It must be mentioned that environmental variables have not been available for the first two years of the study period.

4. Discussion

In this study we assessed the performance and technical efficiency of the hospitals affiliated with Yazd University of Medical Sciences applying DEA approach method. Accordingly, technical efficiency of the studied hospitals using DEA method under VRS assumption was 0.956. Consistently, technical efficiency values reported by Gannon in his study on general hospitals of Ireland (Gannon, 2008); Hajiali afzali (Hajiali afzali et al, 2007) on hospitals affiliated with social security organization and Pourreza et al on hospitals affiliated with Tehran University of Medical Sciences were 0.96, 0.95 and 0.97, respectively which are comparable with mean efficiency of hospitals in Yazd province Pourreza et al, 2009).

Statistical analysis using t-test showed a significant difference between mean efficiency of teaching and non-teaching hospitals (P-value=0.037); while the efficiency of general and specialty hospitals didn’t differ significantly. In other word, although there is a difference between technical efficiency of general and specialty hospitals, this difference is not enough to consider the field of hospital’s activity (general v.s specialty) as an effective factor on the hospital’s efficiency.

Pourreza et al analyzed the efficiency of hospitals affiliated with Tehran University of Medical Sciences and showed significant difference between efficiency level of teaching and non-teaching hospitals as well as general and specialty hospitals, with teaching and general hospitals being significantly more inefficient (Pourreza et al, 2009). In contrast, Ghaderi et al assessed efficiency of hospitals affiliated with Iran University of Medical Sciences and found no significant difference between the hospitals’ efficiency regarding the type (teaching v.s non-teaching) and/or the field of activity (general v.s specialty) of the hospitals (Ghaderi et al, 2005).

There was no significant relation between educational level of the hospital managers with hospitals’ efficiency using ANOVA test; however, managers’ age had a significant relation with mean hospitals’ efficiency (P-value=0.002). Gudarzi et al showed a significant relation between managers’ educational level with hospital efficiency. They figured out that bachelor degree was significantly more associated with a higher hospital efficiency level in comparison with both Ph.D. and diploma degrees (Goudarzi et al, 2008).

Based on the results from table 2, highest excess input belonged to number of the nurses (4.71%) and the lowest excess rate was found in number of beds (1.07%).

Similarly Pourreza et al found the highest and lowest input excess percentages in numbers of nurses and number of beds, respectively Pourreza et al, 2009), while Ghaderi et al showed that highest rate of excess in inputs belonged to number of physicians and other staff and the lowest level was for number of beds( Ghaderi et al, 2005) In addition, Mahani et al in their efficiency study on hospitals affiliated with Kerman University of Medical Sciences reported the highest and lowest excess inputs for non-clinical staff and number of beds, respectively (Saber Mahani et al, 2008).

5. Conclusion

More than half of the health care workers are employed in the hospitals. In other words, personnel costs account for a major part of permanent health care expenditures. Therefore, it seems that eliminating excess human resources according to the results from DEA method can play a significant role in reducing hospitals’ as well as general national health care costs and prices.
According to the findings from the present study, main suggestions include using other efficiency assessment methods such as Balanced Score Card (BSC) and Stochastic Frontier Analysis (SFA) in order to compare the results with findings from this study to recognize the inefficient units and guide them for efficiency improvement, contributing to optimize the utilization of the current resources and excluding the excessive production factors, encouraging the authorities to prioritize individuals with related academic educations for hospital management positions and offering special facilities and privileges for the hospitals with higher efficiency scores. Although the efficiency level of the studied hospitals was found suitable, managers are expected to provide future planning to improve the efficiency level even more. Finally, studying the impact of some other factors such as the quality of services and patients’ satisfaction on hospitals’ efficiency is recommended.

Acknowledgement

Since this study is based on a research thesis approved in Yazd University of Medical Sciences, the authors wish to offer their sincere regards to Research Department of Yazd University of Medical Sciences. Also kind collaboration of all individuals involved in this study particularly managers and staff of the selected hospitals is greatly appreciated.

Table 1: ranking and efficiency scores of the studied hospitals using DEA model in the year 2001 to 2011.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Hospital</th>
<th>Township</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ayatollah Khatami Khater</td>
<td>--</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Psychology</td>
<td>Taft</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Imam Jafar Sadegh Meybod</td>
<td>0.894</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.981</td>
<td>1</td>
<td>0.983</td>
</tr>
<tr>
<td>4</td>
<td>Fatemeh-al-zahra Mehriz</td>
<td>0.985</td>
<td>1</td>
<td>0.904</td>
<td>1</td>
<td>1</td>
<td>0.972</td>
<td>0.924</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.980</td>
</tr>
<tr>
<td>5</td>
<td>Shahid Rahnemun Yazd</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.940</td>
<td>1</td>
<td>1</td>
<td>0.988</td>
<td>0.843</td>
<td>0.979</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Ghaem and Ardekhan</td>
<td>0.938</td>
<td>0.915</td>
<td>0.943</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.960</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.977</td>
</tr>
<tr>
<td>7</td>
<td>Mohamad Sadegh Afshar</td>
<td>0.970</td>
<td>1</td>
<td>0.944</td>
<td>1</td>
<td>0.988</td>
<td>1</td>
<td>0.928</td>
<td>0.923</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.977</td>
</tr>
<tr>
<td>8</td>
<td>Mostafa Khomeini Tabas</td>
<td>--</td>
<td>1</td>
<td>--</td>
<td>--</td>
<td>0.819</td>
<td>0.891</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.967</td>
</tr>
<tr>
<td>9</td>
<td>Shahid Yazd</td>
<td>--</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.740</td>
<td>0.740</td>
<td>0.940</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inputs</td>
<td>Number of beds</td>
<td>Number of physicians</td>
<td>Number of nurses</td>
<td>Number of non-clinical staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary value</td>
<td>105.28</td>
<td>22.32</td>
<td>56.05</td>
<td>107.56</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimum value</td>
<td>104.15</td>
<td>21.61</td>
<td>53.41</td>
<td>105.79</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excess value</td>
<td>1.13</td>
<td>0.71</td>
<td>2.64</td>
<td>1.77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excess percentage</td>
<td>1.07</td>
<td>3.18</td>
<td>4.71</td>
<td>1.64</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Excess percentages of the inputs using DEA-VRS model in the year 2001 to 2011.

<table>
<thead>
<tr>
<th>Environmental variables</th>
<th>Number of hospitals</th>
<th>Mean efficiency</th>
<th>Standard deviation</th>
<th>t</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>teaching</td>
<td>42</td>
<td>0.910</td>
<td>0.112</td>
<td>2.12</td>
</tr>
<tr>
<td></td>
<td>Non-teaching</td>
<td>74</td>
<td>0.954</td>
<td>0.939</td>
<td></td>
</tr>
<tr>
<td>Field</td>
<td>general</td>
<td>78</td>
<td>0.952</td>
<td>0.079</td>
<td>1.753</td>
</tr>
</tbody>
</table>

Table 3: Relation between environmental variables and managers’ characteristics with hospitals’ efficiency in the year 2001 to 2011.
<table>
<thead>
<tr>
<th>Specialty</th>
<th>38</th>
<th>0.910</th>
<th>0.135</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diploma</td>
<td>17</td>
<td>0.922</td>
<td>0.102</td>
</tr>
<tr>
<td>Bachelor</td>
<td>74</td>
<td>0.933</td>
<td>0.110</td>
</tr>
<tr>
<td>Master</td>
<td>15</td>
<td>0.960</td>
<td>0.092</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>10</td>
<td>0.961</td>
<td>0.069</td>
</tr>
<tr>
<td>M.D.</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Younger than</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>63</td>
<td>0.968</td>
<td>0.063</td>
</tr>
<tr>
<td>41-50</td>
<td>48</td>
<td>0.904</td>
<td>0.131</td>
</tr>
<tr>
<td>Older than 50</td>
<td>5</td>
<td>0.885</td>
<td>0.087</td>
</tr>
<tr>
<td>Related</td>
<td>14</td>
<td>0.960</td>
<td>0.092</td>
</tr>
<tr>
<td>Unrelated</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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