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Research Article

EFFICIENCY EVALUATION OF URMIA HOSPITALS USING DATA ENVELOPMENT ANALYSIS (DEA)

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ABSTRACT
Measuring is the basis of evaluation and what is not measured cannot be managed well. Thus, existence of scientific pattern for evaluating performance of decision-making units to implement correct and effective management is necessary and essential in order to evaluate effort and obtained results of such decision –making units continuously. Data Envelopment Analysis provides a theoretical framework for performance analysis and efficiency measurement. This method is one of the most applicable methods of calculating decision-making unit efficiency and ranking. Hospitals are known as the largest and most costly operational units of health system. Therefore, paying attention to its efficiency is highly important. Increased treatment expenses have led hospitals to be considered as economic units and economic evaluations are used for such units. Information and data of inputs including number of beds, physician and nurse activity, other personnel and outputs including outpatient reception, in-patient, and beds` occupation coefficient in 2013 were collected and constant Return to Scale model of DEA was used. The results show that 1- almost 28 percent of Urmia hospitals is efficient. 2- Using DEA method, hospital managers will be able to evaluate relative efficiency of various sections of treatment centers and provide necessary planning for efficiency improvement of such sections.

Keywords: *Data Envelopment Analysis, Decision- making Units, Efficiency, Hospital, Input, Output*

INTRODUCTION
Since performance measurement of any organization is raised as one of organization management principles, existence or lack of existence of effective and efficient performance evaluation system enjoys a direct relationship with organization survival in that lack of such issue is considered as organizational illness.
Discussion about efficiency in literature has long been in history and traces can be found in any activities. One of reasons to consider such long history for efficiency is the importance of such topic for societies. In fact, discussion concerning efficiency and effective factors is considering the fact that how an activity and work is being done in order to reach higher results with less facilities and expenses.
The role of service section is rising in a considerable number of developing countries. This is due to increased demand of the public for receiving more services concerning standards and pleasant social criteria.
Paying attention to health and hygiene in society is one of main goals of plans in Islamic Republic of Iran. Iran constitution can be pointed out as a proof which knows health and hygiene as essential needs along with complete and comprehensive health and hygiene orientation and requires the government to take advantage of all existing resources, facilities, and capacities to provide maintenance and promotion of health.
Hospitals, as one of major organizations providing health and hygiene services, enjoy especial importance and sensitivity in health economics. This feature is doubled in developing countries due to economic infrastructures and severe vulnerability while dealing with exchange rate volatility.
One of new efficiency evaluation methods of companies is Data Envelopment Analysis, DEA which is Multi-criteria method for decision making and performance evaluation of companies. In this method, companies` efficiency with accessible information can be calculated using some input and output variables and efficient and inefficient companies are separated. Also, the reasons of inefficiency of companies can be determined using sensitivity analysis.

Data Envelopment Analysis

Data Envelopment Analysis is one mathematical planning method for evaluating efficiency of decision-making units with many inputs and outputs. One of effective methods while dealing with massive data and estimation is "Data Envelopment Analysis Efficiency " enjoying standard and transparent methodology despite some limitations which lets

The managers to analyze nearly many inputs and outputs with more different scales simultaneously. In Iran, Data Envelopment Analysis has been used to evaluate service organizations, production companies, administrative organizations, and hospitals.

The Concept of Efficiency in DEA

The concept of efficiency used in DEA is division of total sum of input weights to total sum of data. When price and values (weights) are not clear for inputs and outputs or inputs and outputs enjoy different scales, DEA is used for determining efficiency. Allocated weight in DEA to each of inputs and outputs is obtained through solving linear planning model. The simplest and the most general definition of proficiency were introduced by Peter Draker which is" doing the tasks appropriately and fitly ".

Farl (1957), one of founders of efficiency-evaluation theory, in his research entitled " measuring producer efficiency "defines efficiency as sufficient output production which is more than certain amount of input and he introduces different types of efficiency as following :

1-Technical efficiency: means the ability of one unit to reach maximum output using certain amount of input.

2- Allocative efficiency: this type of efficiency refers to ability of unit for applying optimum mixture of production resources concerning input prices.

3-Economic efficiency: is obtained by multiplication of technical efficiency by allocative efficiency.

Major Models in Data Envelopment Analysis

Data Envelopment Analysis includes four main models including Constant Return to Scale, CRS, sometimes known as CCR; Variable Return to Scale, VRS, known as BCC; Increasing Return to Scale, IRS; and Decreasing Return Scale, DRS. Each of these models has two approaches of input-orientation and output-orientation. Brief explanation will be provided about CCR and BCC models which are the bases for other models.

CCR Model

As it was mentioned, each decision-making unit placed on efficiency border is efficient and units not placed on border are inefficient and the level of inefficiency is determined through the radial distance to the border. Farl method experiences the problem of input and output numbers despite the related problem to production-function selection.

Farl efficiency-border determination is only applicable for two-input and one-input and/or one-input and two-output states. In 1978, Charnes Couper and Rouds generalized Farl method to many-input and many-output state known as CCR.

CCR model was initially proposed by Charns and Rouds (1978). Since basic model of Data Envelopment Analysis is one non-linear planning model, it is not solvable through ordinary mathematical planning methods. To solve this problem, it can be changed to linear planning model by constraint of denominator to its unit.

BCC Model

Unlike CCR model, assuming constant efficiency compared to scale, BCC model assumes varying efficiency compared to scale. Using varying efficiency to scale leads to provision of highly accurate analysis by using technical efficiency according to efficiency values resulted from scale as well as management-resulted efficiency. To make input-oriented and output-oriented models in major BCC model, principles of CCR model are used. In input-oriented model, reduced inputs leads to increased efficiency but in output-oriented model, increased outputs leads to increased efficiency.

A Review on Research Literature

In a research, efficiency of hospitals supervised by Tehran Medical University during 2009-2011 was studied. Since Data envelopment analysis is one of most applicable techniques for evaluating hospitals,

relative efficiency of hospitals of Tehran Medical University was calculated using this strong mathematical technique and performance of each hospital was compared.
Alam Tabriz and Imani Pour used DEA to evaluate efficiency of hospitals under coverage of Shahid Beheshti Medical University.
Conto Dimopolous *et al.*, used DEA to evaluate technical efficiency of some hospitals and health centers in Greece. They, in their research, considered number of physicians, number of nurses, and number of beds as input indicators as well as number of In-patients, number of out-patients, and preventive hygienic service as output indicators. in 1999, a research was conducted for 15 hospitals in Bahrain by Al-Shammari which provided a multi-criteria model of DEA in order to evaluate efficiency of hospitals.

MATERIALS AND METHODS

Methodology

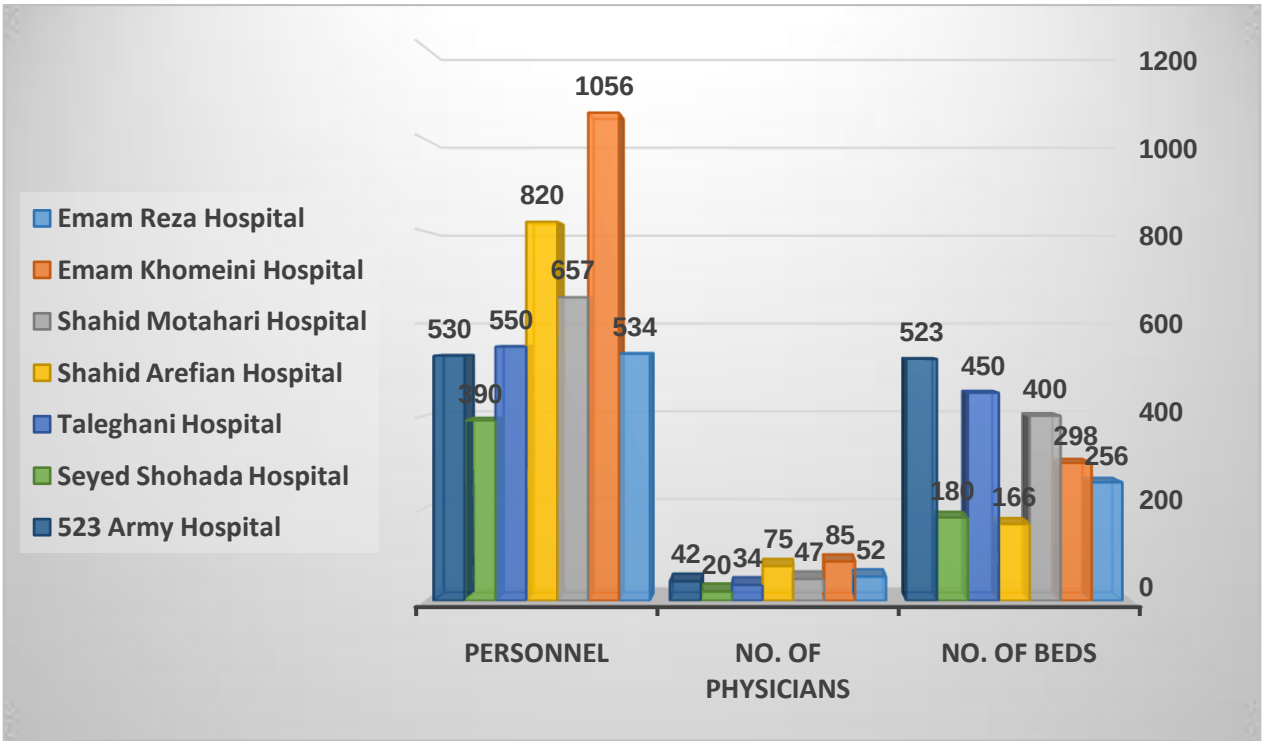
Since the main objective of this research is to study efficiency of hospitals in Urmia, it is descriptive-cross sectional study. Information is collected through two methods including field and library ones as well as taking advantage of M.A. theses, relevant articles concerning evaluation of hospitals , and direct referring to hospitals and University deputy of treatment. Input data included active bed, physician, nurse, and other personnel and output included Out-patient, In-patient, and bed/day occupation which can be used to evaluate efficiency. Then DEA method was used to evaluate the efficiency of studied hospitals.
Statistical population of this study included governmentally-run hospitals in Urmia including Seyed Shohada, Emam Reza, Emam Khomeini, Shahid Arefian, Taleghani, Motahari, and Army hospitals.

RESULTS AND DISCUSSION

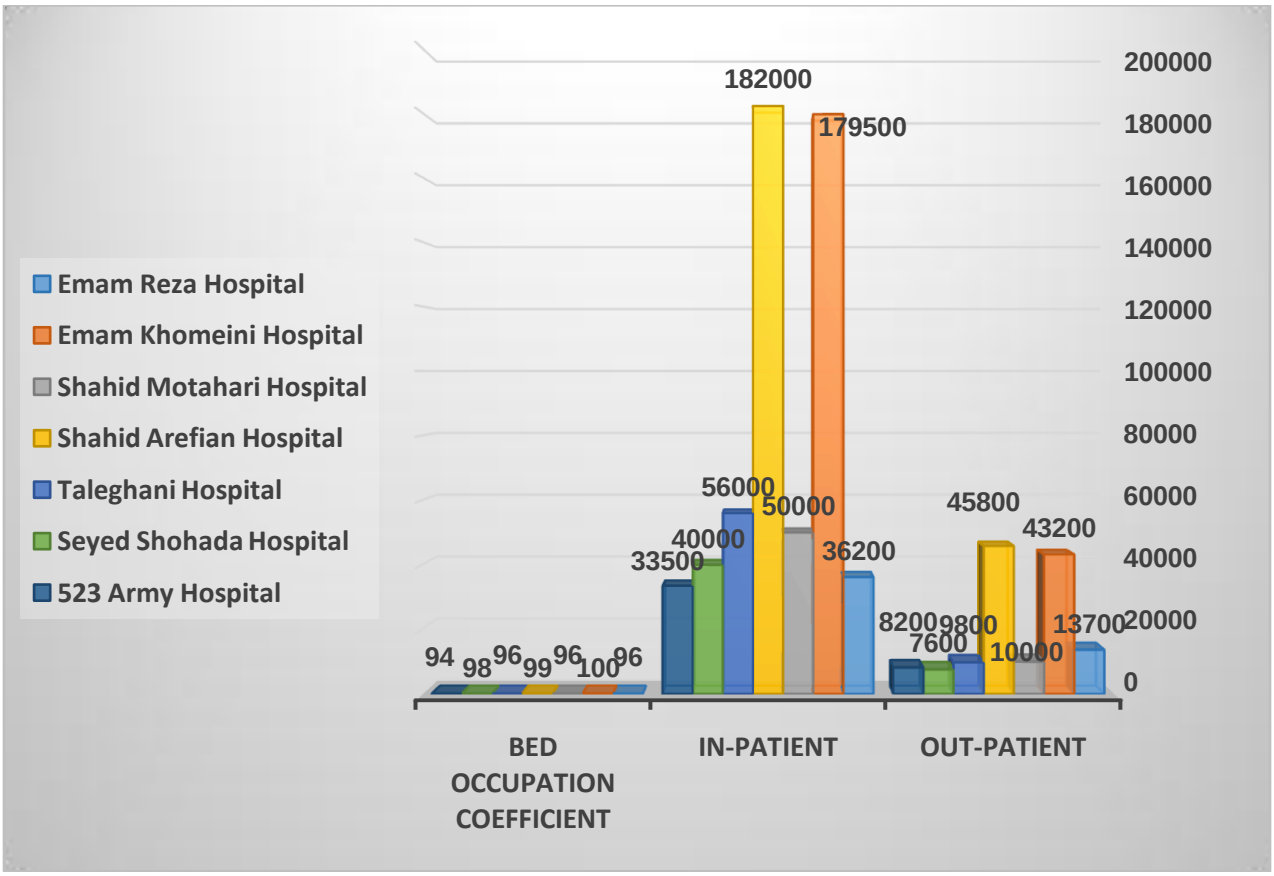
Findings

Table 4-1: Hospital Information

No	Name of Hospital	No. of beds	No. of physicians	Personnel	Out-patient	In-patient	Bed occupation coefficient
1	Emam Reza Hospital	256	52	534	13700	36200	96
2	Emam Khomeini Hospital	298	85	1056	43200	179500	100
3	Shahid Motahari Hospital	400	47	657	10000	50000	96
4	Shahid Arefian Hospital	166	75	820	45800	182000	99
5	Taleghani Hospital	450	34	550	9800	56000	96
6	Seyed Shohada Hospital	180	20	390	7600	40000	98
7	523 Army Hospital	523	42	530	8200	33500	94



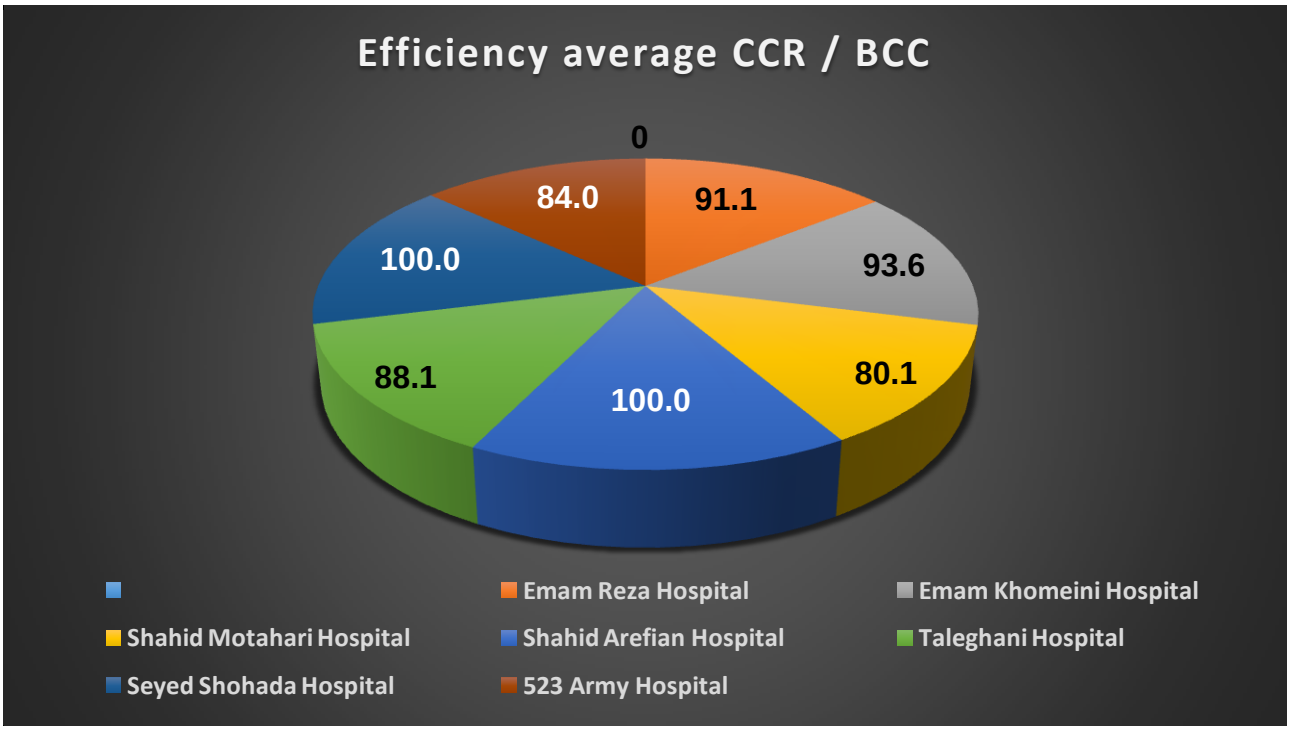
Graph 4-1: Input information of hospitals



Graph 4-2: Output information of hospitals

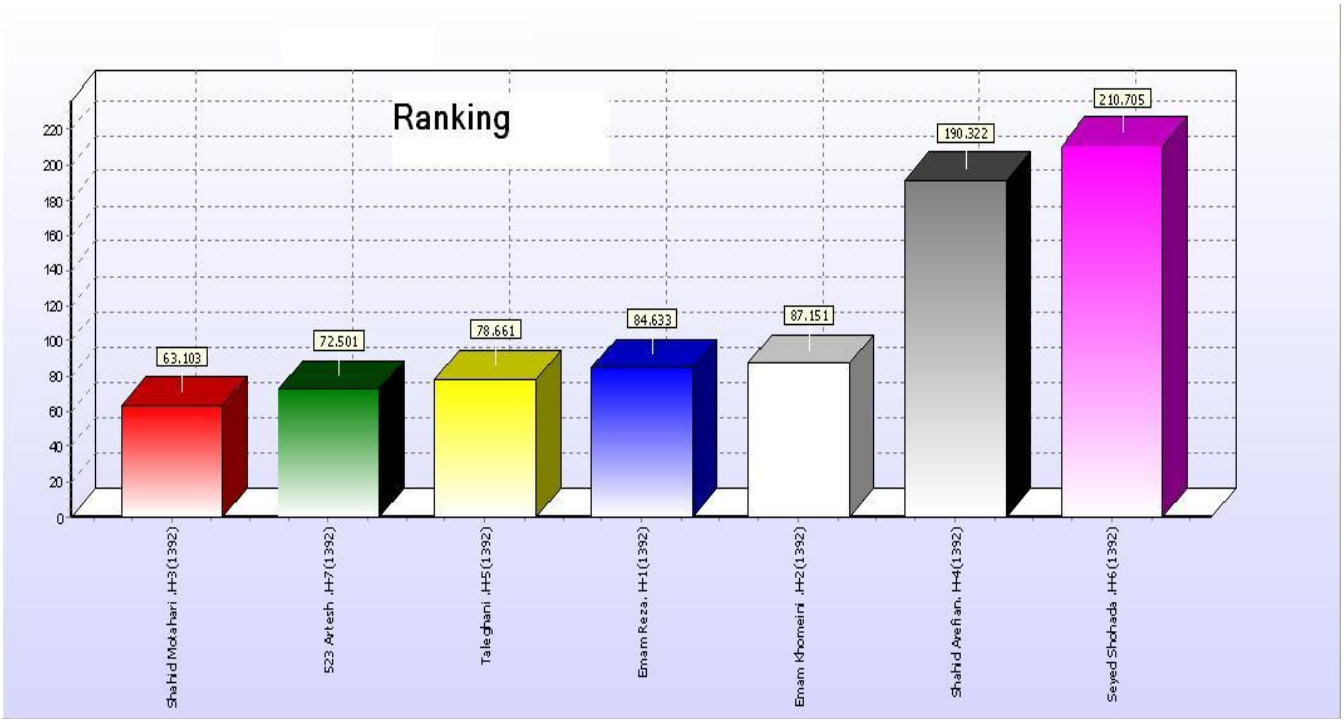
Table 4-2: Efficiency average of hospitals

No	Name of Hospital	Efficiency value CCR constant scale	Efficiency value BCC varying scale	Efficiency average	Comment
1	Emam Reza Hospital	84.633	97.529	91.1	4th rank
2	Emam Khomeini Hospital	87.151	100	93.6	3rd rank
3	Shahid Motahari Hospital	63.103	97.164	80.1	7th rank
4	Shahid Arefian Hospital	100	100	100	2nd rank
5	Taleghani Hospital	78.661	97.53	88.1	5th rank
6	Seyed Shohada Hospital	100	100	100	1st rank
7	523 Army Hospital	72.501	95.509	84	6th rank
*	Average	83.721	98.247	91	



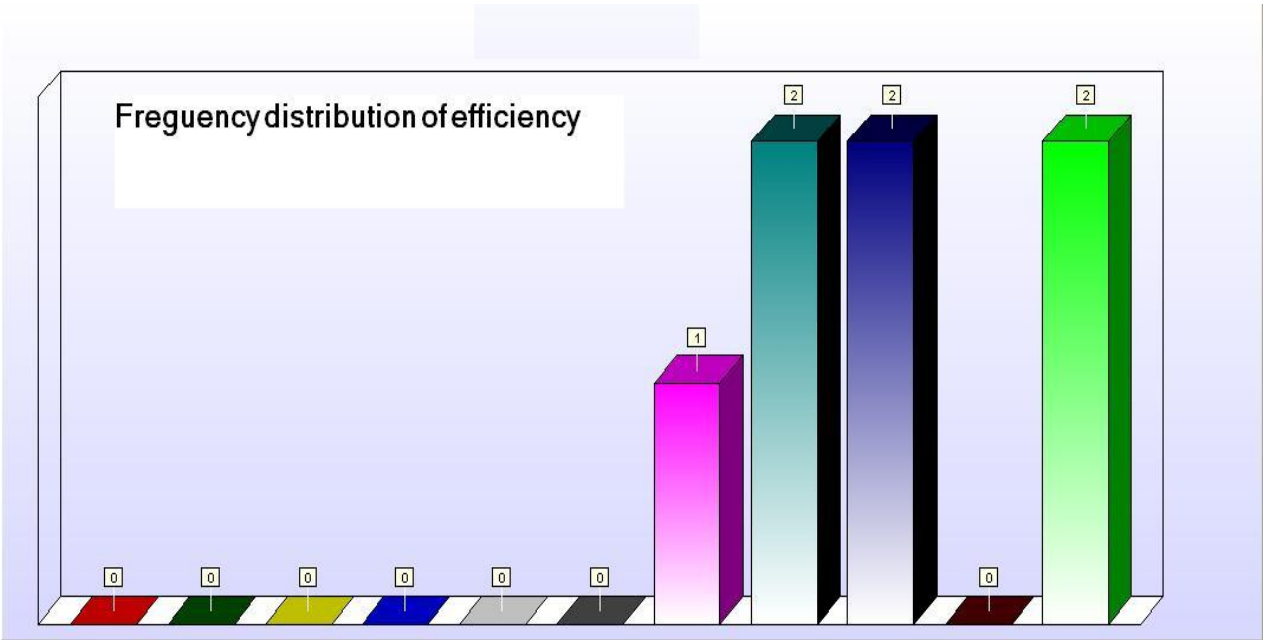
Graph 4-3: Efficiency average of hospitals

Findings of table 4-2 show that two hospitals (29%) were identified as completely efficient concerning constant scale efficiency of CCR and two hospitals (29%) had greater than 80% efficiency and total number of three hospitals, 43%, had greater than 70% efficiency and less than 80 % efficiency. Furthermore, concerning varying scale efficiency, three hospitals were completely efficient and five hospitals, 57%, had efficiency of greater than 90%.



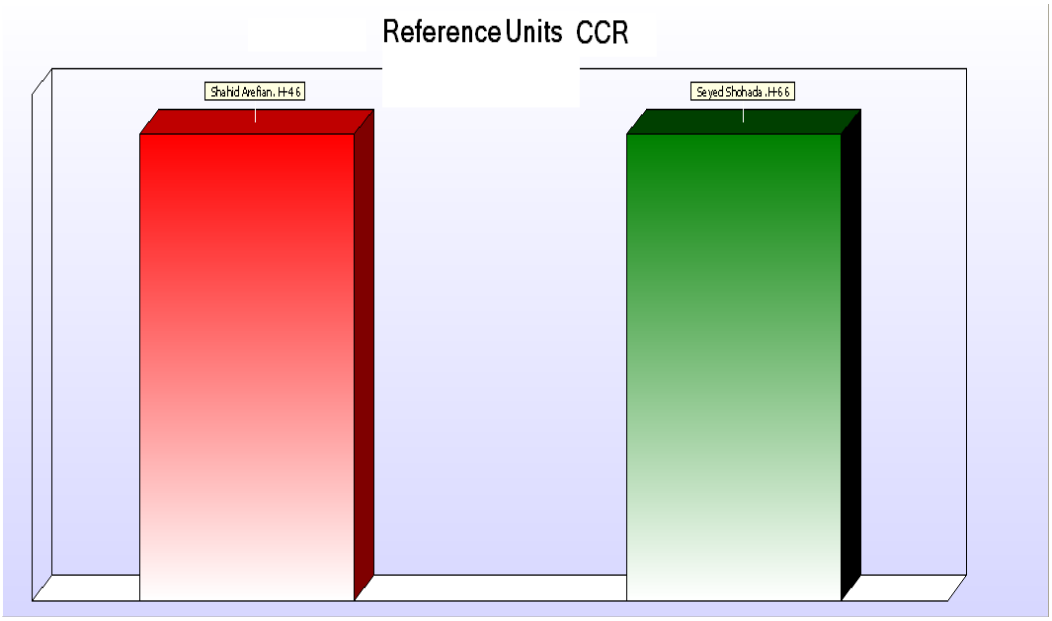
Graph 4-4: Hospital ranking

As it can be seen from graph 4-4, it is obvious that Seyed Shohada and Arefian hospitals were known as efficient hospitals ranking first and second. Emam Khomeini, Emam Reza, Taleghani, Army, and Motahari hospitals were inefficient and ranked next.



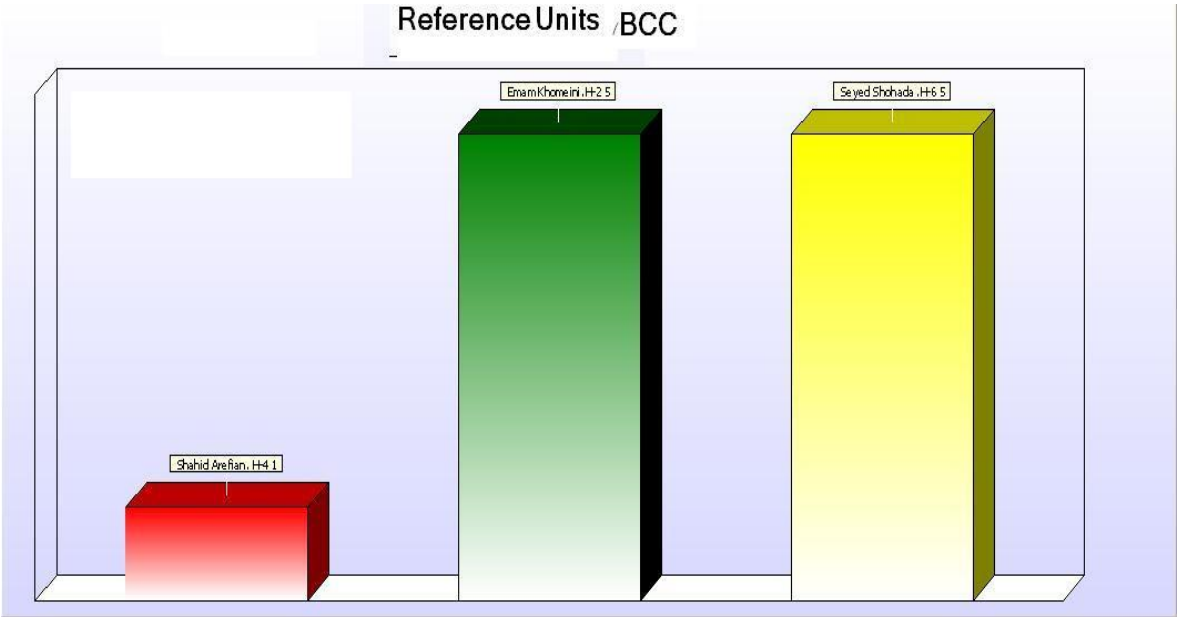
Graph 4-5: Frequency distribution of efficiency

According to graph 4-5, efficiency frequency distribution is as following: efficient units: two units; efficiency between 91-99: zero units; efficiency between 81-90: two units; efficiency between 71-80: two units; efficiency between 61-70: one unit.



Graph 4-6: Introduction of reference units CCR

According to graph 4-6, reference units in CCR model were Arefian and Seyed Shohada hospitals for other ones. Mangers of inefficient hospitals can reach efficiency borders by following reference hospitals.



Graph 4-7: Introducing reference units BCC

According to graph 4-7, reference units in BCC models were Seyed Shohada, Emam Khomeini, and Arefian hospitals for others. Mangers of inefficient hospitals can reach efficiency borders by following reference hospitals.

Table 4-3: Necessary values to improve efficiency

No	Name of Hospital	CCR Model		BCC Model	
		Out-patient	In-patient	Out-patient	In-patient
1	Emam Reza Hospital	5672	2487	917	347
2	Emam Khomeini Hospital	26463	6368	0	0
3	Shahid Motahari Hospital	29235	5847	1459	291
4	Shahid Arefian Hospital	--	--	0	0
5	Taleghani Hospital	15191	2658	1417	248
6	Seyed Shohada Hospital	--	--	0	0
7	523 Army Hospital	12706	3110	1575	385

According to table 4-3, inefficient hospitals can be helped to reach efficiency border.

Discussion and Conclusion

According to high importance of hospitals for providing health services and their considerable effect on management system of health in the country, taking advantage of Data Envelopment Analysis along with providing the possibility to compare, rank, and follow patterns can be an important step for consistent improvement of performance is hospitals and in particular health sector of the country.

First conclusion: It is stated that more than 72 percent of Urmia hospitals did not have necessary efficiency in the studied course.

Only two units were on efficiency border in terms of CCR and BCC considering obtained results from calculations in this research and according to evaluating constant efficiency indicator and varying indicator. Generally, 5 units, 72 percent, of hospitals were inefficient.

Second conclusion: In 2013, two hospitals (29%) got one in both types of efficiency, one hospital (14%) got one in one type of efficiency, and four hospitals (57%) were not efficient in any field.

In CCR method, two out of seven hospitals, Arefian and Seyed Shohada, were efficient and five hospitals including Emam Khomeini, Emam Reza, Taleghani, Army,and Motahari were identified inefficient. Final ranking of hospitals are L 1.Arefian 2- Seyed Shohada 3- Emam Khomeini 4- Emam Reza 5- Taleghani 6- Army 7- Motahari

Third Conclusion: To reach efficiency border, inefficient units can take relevant units as reference. Reference patterns are those which provide more outputs with similar inputs of inefficient unit or provide the same output with fewer inputs. In this research in CCR model, Arefian and Seyed Shohada hospitals are considered as reference units.

Studies show that inefficient units can reach efficiency borders by exemplifying from reference units. Like for instance, the reference hospital for Emam Reza hospital is Seyed Shohada hospital, meaning that mentioned hospital can reach the same output with less input by following Seyed Shohada hospital.

Furthermore, in BCC model, Emam Khomeini, Arefian, and Seyed Shohada hospitals are introduced as reference units where more units are placed on efficiency border due to efficiency assumption to scale and obtained greater –than-efficiencies are constant considering efficiency to scale.

In this status, three hospitals including Seyed Shohada, Arefian, and Emam Khomeini enjoyed efficiency of 100. Comparing CCR model, Emam Khomeini hospital has become efficient and four hospitals including Emam Reza, Taleghani, Army,and Motahari are inefficient like CCR model and they enjoyed higher efficiency. Final ranking is as following: 1- Emam Khomeini 2- Arefian 3- Seyed Shohada 4- Emam Reza 5- Taleghani 6- Army 7- Motahari

In this condition, reference units were also determined. For example, Seyed Shohada and Arefian hospitals were reference units for Army hospital, meaning that Army hospital is able to reach the same output with less input by following mentioned hospitals.

Fourth conclusion: According to obtained results, optimum values for units have been determined to reach efficiency border. For instance, if Army hospital increases out-patient to 12706 and in-patient to 3110, it will reach efficiency border. Another example is that if Shahid Motahari raises its out-patient to 29235 and in-patient to 5847, it will reach efficiency border.

Research results indicate the fact that performance of Arefian and Seyed Shohada hospitals has been better than other hospitals during 2013.

Recommendations

✓ It is recommended that the effect of factors such as service quality and patient satisfaction on technical efficiency of mentioned hospitals be studied.

✓ Conducting comparative study of efficiency in training and non-training hospitals of Western Azerbaijan hospitals and comparing the obtained results with those of this study.

Recommendations to Future Researchers

✓ Studying the relationship between hospital management method and efficiency in hospitals of province

✓ Evaluating efficiency of Urmia hospitals for 2014 and future years in order to improve the efficiency in the hospitals.

Research Limitations

✓ Lack of sufficient and serious cooperation between hospital mangers and researcher in order to reach the certain result

✓ Lack of necessary and cohesive statistics and information

✓ Lack of similar research in the province concerning evaluating efficiency of health centers using DEA method.

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