http://dergipark.gov.tr/ijhmt/
Int Journal Of Health Manag. And Tourism 2017, 2(2), 19-36

IJHMT **Editorial**

International Journal Of Health Management And Tourism

PUBLIC HOSPITALS and SPECIAL HOSPITALS EFFICIENCY EFFECT FACTORS : (ANKARA PROVINCE SAMPLE)[1]

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Abstract: The purposes of this study are to examine the efficiency levels of public and private hospitals, to analyze the changes in hospital activities over time, and to identify the factors those may influence on hospital efficiency by determining the cause of these changes in Ankara. In this study, data set of 40 hospitals in Ankara, which contains 27 public hospitals and 13 private hospitals, were utilized. Data Envelopment Analysis was employed to measure the efficiency levels. Malmquist Total Factor Productivity Index was used to evaluate the change of the efficiency over time. Furthermore, Tobit Model was applied to explore the factors affecting the efficiency. Result of the study, it has seen that 58% of the hospitals were operated in pure technical efficiency, 25% of the hospitals were operated in gross efficiency in 2015. During to time horizon, the efficiency was reduced in two different time periods but it was increased another three different time periods. In addition, average length of stay and ratio of inpatients were effected efficiency scores negatively; however, bed-occupancy, bed-physician and bed-nurse ratios were effected positively.

Key Words: Hospital, Efficiency, Data Envelopment Analysis, Malmquist Total Factor Productivity Index, Tobit Model.

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[1]It was made from the same titled doctoral thesis of Özgül KARAMAN KESKİN

Introduction

Hospitals situated within the health care system, are service businesses that provide a variety of health services and undertake important tasks in creating a healthy society (Özkan, 2003). In hospitals that play an important role in the health care system, medical care and related services including inpatient treatment are offered twenty-four hours, seven days a week with medical and, administrative staff (http://www.who.int/hospitals/en/). The competitive environment in which the hospitals exist, makes it necessary to provide health care at a low cost, high quality and effective manner (Atmaca and others, 2012).

Efficiency; is defined as the capacity to achieve maximum results with minimum effort or cost (Temür and Bakırcı, 2008). Technical efficiency; is producing a product with a minimal cost (Çakmak and others, 2009), scale efficiency is the success of producing at the most appropriate scale (Bal, 2010). Efficiency measurement methods are basically Ratio Analysis, Regression Analysis and Data Envelopment Analysis (Kavuncubaşı and Ersoy, 1995). Data Envelopment Analysis is widely used in the measurement of hospital performance (Akdağ and others, 2011). Examples of these studies made domestically are as follows:

Table 1. Some DEA Studies Domestically Made

Author	Scope of the Study	Input Variables	Output Variables	Result
Kavuncubaşı and Ersoy (1995)	To measure the technical efficiency of 350 general hospital in 1992	Number of beds, number of specialist physicians, number of general practitioners	Number of outpatients, number of inpatients, patient day, number of major surgical operations, number of intermediate surgical operations, number of minor surgical operations, number of births	17% technical efficient.
Ersoy and others (1997)	To measure the technical efficiency of 573 general hospital in 1993	Number of beds, number of specialist physicians, number of general practitioners	Number of discharges, number of outpatients, number of surgical operations	90,6 % technical inefficient
Güleş and others (2007)	To measure the efficiency of 50 SSK hospital in 2002	Number of beds, number of specialists, number of general practitioners, number of nurses-midwife	Number of examination, number of surgical operations, number of inpatients	28% efficient
Çakmak and others (2009)	To measure the efficiency of 41 maternity hospital in 2004	Number of beds, other expenses (excluding investment, purchase of pharmaceuticals and supplies), pharmaceutical expenditures, medical equipment purchasing expenses)	Number of outpatients, number of intermediate surgical operations, number of minor surgical operations, number of births, total revenue	29,3% technical efficient
Akdağ and others (2011)	To measure the total factor productivity of general hospital in 2001-2009 with Malmquist Index	Number of beds, number of specialist physicians, number of general practitioners	Number of outpatients, number of patient day, operation score, crude death rate	Annual average increase 10%
Şahin and others (2011)	To measure the efficiency of the 352general hospitals in2005-2008.	Number of beds, number of physicians, number of nurses, number of other personnel, the amount of operational expenses	Number of outpatients, number of inpatients, number of surgeries	CRS - 8,81%, VRS- 17,54% efficient. Increase of efficiency.

Table 1(continue). Some DEA Studies Domestically Made

Author	Scope of the Study	Input Variables	Output Variables	Result
Bayraktutan and Pehlivanoğlu (2012)	To measure the efficiency of 18 public, private and university hospitals in Kocaeli in 2006-2010	Number of beds, number of specialist physicians, number of general practitioners, number of other staff	Number of surgeries, number of outpatients, number of patients discharged, hospital mortality ratios	44,4% in 2006, 55,5% in 2007, 66,6% in 2008, 50% in 2009, 66,6% in 2010 efficient

Using the results of the efficiency obtained by DEA, examples of studies that examine the factors affecting the efficiency are as follows:

Table 2. Some Studies Studying the Factors Affecting the Efficiency of the DEA's Follow-up

Author	Scope of the Study	Input Variables of DEA	Output Variables of DEA	Other model and variables
Lynch and Özcan (1994)	Nongovernment community hospitals in USA that closed in 1988 are compared to their nonclosed peers to test the primary hypothesis that inefficient and underutilized hospitals in competitive markets tend to close.	Capital assets, labor, supplies.	Adjusted discharges, outpatient visits, training.	Logistic regression- Hospital size, overall utilization, Medicare utilization, Medicaid patient days, Hirschman-Herfindahl Index.
Bilsel and Davutyan (2011)	The operational performance of Turkish rural general hospitals in 2006.	Beds, specialists, general practitioners, nurses, other personnel, operational expenses	Outpatients, inpatients, surgeries, number of deaths divided by total number of surgeries	The seemingly unrelated regression- Bed turnover rate, inpatients – outpatients ratio, bed occupancy, excess beds, 1990 population of the district where the hospital is located, District's % population change from 1990 to 2007, population per hospital (2006) for the whole province where the district is located, share of income and corporate taxes collected in that district within the national total for year 2000.
Kirigia and Asbu (2013)	To estimate the efficiency of public secondary level community hospitals in Eritrea in 2007.	Number of physicians, number of nurses and midwives, number of laboratory technicians, number of operational beds and cots	Number of outpatient department visits, number of inpatient department discharges	Tobit model- Outpatient visits as a proportion of inpatient days, average length of stay, population, region
Jehu-Appiah and others (2014)	To estimate the efficiency of government, mission, private and quasi-government district hospitals in Ghana in 2005	Beds, clinical staff, nonclinical staff, expenditure	Inpatient days, outpatient visits, deliveries, laboratory services	Tobit model- Ownership
Xenos and others (2016)	To examine the efficiency of Greek public hospitals in 2009.	The number of doctors, nurses, beds, non-labor expenditures (i.e. pharmaceutical supplies, etc.)	Number of patient discharged adjusted for case-mix with Roemer Index, number of diagnostic procedures	Tobit model- The catchment area population, the three dummy variables concerning hospital size based on number of beds, the proportion of outpatient visits to inpatient days, the bed occupancy rate, the average length of stay, the two dummy dichotomous variables, urban and rural, the two dummy variables, teaching or non-teaching, representing the academic status of the hospital.

Objective of the Study

The objective of the study is, to determine the efficiency levels of public hospitals and private hospitals in Ankara, changes in hospital efficiency over time and the cause of this change while examining the factors that may have an effect on the efficiency of the hospital. Once the efficiency levels of the hospitals have been determined, the amount of input needed to decrease or output needed to increase for inefficient hospitals to reach efficient status will be determined.

Scope and Limitations of the Study

The scope of the study consists of public hospitals affiliated with the Ministry of Health and private hospitals in Ankara province. The study covers the data for the years 2010-2015. The decision making units to be analyzed must have the same tasks and the similar objectives, also the inputs and outputs characterizing performance should be the same, except for differences in density or size (Ramanathan, 2003). Hospitals that do not produce the same outputs from hospitals have been excluded from analysis (for example physiotherapy hospitals with no surgical outputs). Studies were conducted with a total of 40 hospitals that are appropriate hospitals for analysis, belonging to the 2010-2015 years with full data, 27 (1-27 numbered ones) of public hospitals and 13 (28-40 numbered ones) of private hospitals.

Research Method

This research is made by scanning model. The data required for the research were obtained from the Ministry of Health. Data Envelopment Analysis was used to measure the efficiency levels of hospitals, Malmquist Total Factor Productivity Index was used for assessing the efficiency of the change in time and Tobit Model was used to examine the factors affecting the efficiency.

Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a linear programming based technique used for the calculation and comparison of the relative efficiencies of similar units (Karacabey, 2001). Relative efficiency, indicates whether the decision-making units are efficient in comparison with each other. Therefore, it should not be forgotten that the efficiency measured by DEA is relative efficiency, not absolute efficiency (Kocaman and others, 2012). The mentioned efficiency refers only to the other units to which it is compared and within the input-output cluster input into the analytic (Karaemir, 2013).

Institutions, departments, enterprises and organizations such as the efficiency of administrative units examined with similar inputs using similar output-producing are called Decision Making Unit (DMU). 100% efficiency score is assigned to the best performing DMU (Gülsevin and Türkan, 2013). Units without an efficiency score of 100 are referred to as technically inefficiency units even if the efficiency score is very close (for example 99.5) to 100 (Seyrek and Ata, 2010).

Various methods can be used in the DEA with input or output focus. The input focus is defined as examining the changes that will occur in the input quantities, keeping the output quantities constant; output focus is defined as the examination of the changes in the output quantities by keeping the input quantities constant (Yavuz, 2013).

DEA can be done under the assumption of Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS). The assumption of the CRS is that the decision-making units are suitable if they are operating at the optimal scale. The technical efficiency score obtained under the CRS is called total efficiency. Total efficiency is divided into pure technical efficiency and scale efficiency. A pure technical efficiency is the technical efficiency score obtained under the assumption of VRS (Sülkü, 2011).

Charnes-Cooper-Rhodes (CCR) and Banker-Charnes-Cooper (BCC) are the basic two models of DEA. CCR and BCC models can be handled in two different groups, one for input-oriented and one for output-oriented (Kuşkonmaz, 2014). The BCC model is also referred to as the VRS model and, CCR model is referred to as the CRS model (Cooper and others, 2011).

CCR calculates the total efficiency scores of the decision units under the assumption of a fixed return on a scale (Behdioğlu and Özcan, 2009). The objective function can be expressed as follows under the assumption of input focus (Cooper and others, 2011):

$$\text{Max. } z = \sum_{r=1}^{s} \mu_r y_{ro} \qquad (1)$$

subject to

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \qquad \sum_{i=1}^{m} v_i x_{io} = 1 \qquad \mu_r, v_i \geq 0$$

DMU_0: DMU should be calculated, x_{io}: DMU_0's observation input

y_{ro}: DMU_0's observation output, u_r and v_i: factors

The output-focused model of the CCR model is formulated as follows:

$$\text{Min } q = \sum_{i=1}^{m} v_i \, x_{io} \qquad (2)$$

subject to

$$\sum_{i=1}^{m} v_i \, x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0 \qquad \sum_{r=1}^{s} \mu_r y_{ro} = 1 \qquad \mu_r, v_i \geq \varepsilon, \square r,i$$

BCC models are obtained when the constraint of $\sum_{j=1}^{n} \lambda_j$ is added to the referred CCR model formulas (Cooper and others, 2011).

Malmquist Total Factor Productivity Index

Malmquist Total Factor Productivity Index (MTFPI), is a method used to examine the development and causes of productivity in time dimension (Dizkırıcı, 2014). MTFPI measures the total factor productivity change between two data points by calculating the ratio of the distances of each data point to the common technology (Coelli and Rao, 2005). The distance function is used for this measurement (Akhisar and Tezergil, 2014; Akyüz and others, 2013; Kula and others, 2009). MTFP change index according to the output between the main s period and the following t period is calculated by the formula;

$$m_0(y_s, x_s, y_t, x_t) = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_s, x_s)} * \frac{d_0^t(y_t, x_t)}{d_0^t(y_s, x_s)} \right]^{1/2} \qquad (3)$$

Here $d_0^s(x_t, y_t)$ refers, t period observation to the distance from s period technology. Here if the value of m_o is greater than 1, it is the growth in TFP from period s to period t, if it is lower than 1, it shows a decrease in TFP (Coelli and Rao, 2003).

Tobit Model

The main purpose of the model is, to describe the changes in the measured performance in the context of a specified set (inflation, interest rates, borrowing, scale etc.) of variables (Kaya, 2015). According to Tobit model or the assumption of censored normal regression model; hidden variables are linear; error terms are zero mean and equal variance. In the model, the existence of a hidden y * variable, such as a cropped regression model, is assumed. This variable is bound to the x_i explanatory variable by the parameter vector (Zorlutuna and others, 2016). A dummy variable observed in the Tobit model is:

$$y(i) = \begin{cases} 1, & y_i^* > 0 \\ 0, & y_i^* \leq 0 \end{cases} \qquad y_i^* = \beta x_i + u_i \ (i=1,\ldots,T \tag{4}$$

If $y_i^* > 0$, it is assumed that yi * is observed if $y_i^* \leq 0$ where y_i^* was not observed. Thus, the observable value of the y_i is:

$$y(i) = \begin{cases} y_i^*, & \beta x_i + u_i > 0 \\ 0, & \beta x_i + u_i \leq 0 \end{cases} \tag{5}$$

Here $u_i \approx N(0,\sigma^2)$. x_i, is a vector of explanatory variables, β indicates the unknown parameters. y_i^* is hidden variable and y_i is scores from DEA. Tobit Model when $y_i^* \leq 0$, some observations on y_i^* take a value of zero. If $y_i^* = \beta x_i + u_i$ neglects y_i observations that have a negative or zero value in the model, $u_i > \beta x_i$ cannot have zero mean with u_i model participation of observations for. For this reason, the u_i average has a discrete normal distribution that is different from zero (Zorlutuna and others, 2016; Kılıçkaplan and Karpat, 2004; Atan and Karpat Çatalbaş, 2005).

Findings

In our study, the DEAP Version 2.1 program developed by Coelli (1996) was used for analysis of efficiency by DEA and analysis of variation of efficiency within the time by MTFPI. Furthermore, Eviews 9 was used estimating the factors of affecting the efficiency in the Tobit model. IBM SPSS Statistics 22 was utilized for other analyzes. Input and output variables used in measuring efficiency levels are:

Table 3. Input and Output Variables Used in DEA

Input	Explanation	Output	Explanation
Number of Beds	The number of beds placed in patient rooms or in units provided with continuing medical care services, where patients are admitted for care and treatment at least 24 hours a day.	Number of Outpatients	The total number of patients applying to the hospitals who have been examined for any reason within a year.
Number of Physicians	The total number of specialists and general practitioners working within a year at the hospital	Number of Inpatients	The number of patients admitted to the hospitals within a year.
Number of Nurses	The total number of nurses working within a year at the hospital.	Number of Surgical	The total number of operations in group A, B, and C performed within one year at the hospital.

The descriptive Statistics for input variables are given in Table 4, the descriptive statistics for output variables are given in Table 5.

Table 4. The Descriptive Statistics for Input Variables

Year	Number of Beds				Number of Physicians				Number of Nurses			
	Min.	Max.	Mean	Std. Deviation	Min.	Max.	Mean	Std. Deviation	Min.	Max.	Mean	Std. Deviation
2010	19	1140	236	258.945	12	941	150	212.672	10	569	129	135.886
2011	19	1140	238	259.475	14	917	144	197.58	7	669	146	160.768
2012	19	1140	236	256.146	16	908	152	203.637	7	648	144	153.721
2013	19	1140	226	239.711	17	910	158	209.861	11	675	149	163.012
2014	19	997	225	221.533	17	860	152	193.953	12	665	151	158.298
2015	19	982	226	219.822	17	818	155	191.284	7	716	158	169.713

The hospitals in the study served with an average of 231 beds, 152 doctors and 146 nurses.

Table 5. The Descriptive Statistics for Output Variables

Year	Number of Outpatients				Number of Inpatients				Number of Surgical			
	Min.	Max.	Mean	Std. Deviation	Min.	Max.	Mean	Std. Deviation	Min.	Max.	Mean	Std. Deviation
2010	678	1733341	387139	415375.514	44	58591	12845	13256.053	95	72455	12273	14485.159
2011	33378	1512510	407660	404577.093	1084	50460	13174	12569.171	1262	150457	16598	26119.65
2012	37610	1924277	431769	454420.737	936	51288	13677	12769.726	750	172675	18600	29877.95
2013	36358	1863837	466105	496758.928	1015	52934	14432	13406.283	1105	166759	19693	29538.378
2014	34282	1968956	486574	529275.548	1487	49321	14926	13585.842	1399	93053	18084	21420.352
2015	37693	2456185	511728	572861.709	1265	50143	14869	13564.11	729	63548	15051	16789.344

With an average of 448,496 patients were given outpatient services, 13,987 patients were treated inpatient and 16,717 patients were operated on.

Table 6. Correlation Between Input-Output Variables

2010	Outpati.	Inpati.	Surg.	Beds	Phys.	Nurses	2011	Outpati.	Inpati.	Surg.	Beds	Phys.	Nurses
Outpati.	1	.723**	.791**	.795**	.845**	.766**	Outpati.	1	.699**	.719**	.783**	.833**	.822**
Inpati.	.723**	1	.900**	.920**	.873**	.834**	Inpati.	.699**	1	.776**	.898**	.858**	.816**
Surg.	.791**	.900**	1	.900**	.879**	.814**	Surg.	.719**	.776**	1	.869**	.901**	.821**
Beds	.795**	.920**	.900**	1	.943**	.935**	Beds	.783**	.898**	.869**	1	.948**	.948**
Phys.	.845**	.873**	.879**	.943**	1	.926**	Phys.	.833**	.858**	.901**	.948**	1	.947**
Nurses	.766**	.834**	.814**	.935**	.926**	1	Nurses	.822**	.816**	.821**	.948**	.947**	1
2012	Outpati.	Inpati.	Surg.	Beds	Phys.	Nurses	2013	Outpati.	Inpati.	Surg.	Beds	Phys.	Nurses
Outpati.	1	.728**	.709**	.780**	.847**	.822**	Outpati.	1	.681**	.765**	.737**	.847**	.815**
Inpati.	.728**	1	.788**	.888**	.870**	.825**	Inpati.	.681**	1	.772**	.871**	.846**	.783**
Surg.	.709**	.788**	1	.830**	.856**	,766**	Surg.	.765**	.772**	1	.845**	,899**	.816**
Beds	.780**	.888**	.830**	1	.940**	.947**	Beds	.737**	.871**	.845**	1	.920**	.926**
Phys.	.847**	.870**	.856**	.940**	1	.941**	Phys.	.847**	.846**	.899**	.920**	1	.951**
Nurses	.822**	.825**	.766**	.947**	.941**	1	Nurses	.815**	.783**	.816**	.926**	.951**	1
2014	Outpati.	Inpati.	Surg.	Beds	Phys.	Nurses	2015	Outpati.	Inpati.	Surg.	Beds	Phys.	Nurses
Outpati.	1	.662**	.813**	.732**	.859**	.817**	Outpati.	1	.592**	.783**	.713**	.847**	.821**
Inpati.	.662**	1	.827**	.871**	.831**	.781**	Inpati.	.592**	1	.782**	.844**	.801**	.763**
Surg.	.813**	.827**	1	.831**	.895**	.812**	Surg.	.783**	.782**	1	.765**	.841**	.791**
Beds	.732**	.871**	.831**	1	.914**	.928**	Beds	.713**	.844**	.765**	1	.911**	.935**
Phys.	.859**	.831**	.895**	.914**	1	.936**	Phys.	.847**	.801**	.841**	.911**	1	.949**
Nurses	.817**	.781**	.812**	.928**	.936**	1	Nurses	.821**	.763**	.791**	.935**	.949**	1

** $p<0.01$

Calculated correlation coefficients among the parameters appear to be significant for α=0.01. The results show that meaningful variables are used in the study, and there is a positive relationship between inputs and outputs.

Data Envelopment Analysis Findings

In the study, the data were first analyzed under the assumption constant returns to the scale (CRS) by the CCR model, then analyzed under the assumption variable returns to the scale (VRS) by the BCC model. The analyzes were performed using output-oriented models to determine the optimal input composition needed to produce a particular output level and output-oriented models to determine the maximum output level that could be generated using the current input level. Only input-oriented results are included here.

CRS is used for cumulative efficiency score,

VRS is used for pure technical efficiency score and

SE is used for scale efficiency score.

Table 7: CRS, VRS, SE Results of Hospitals by Years

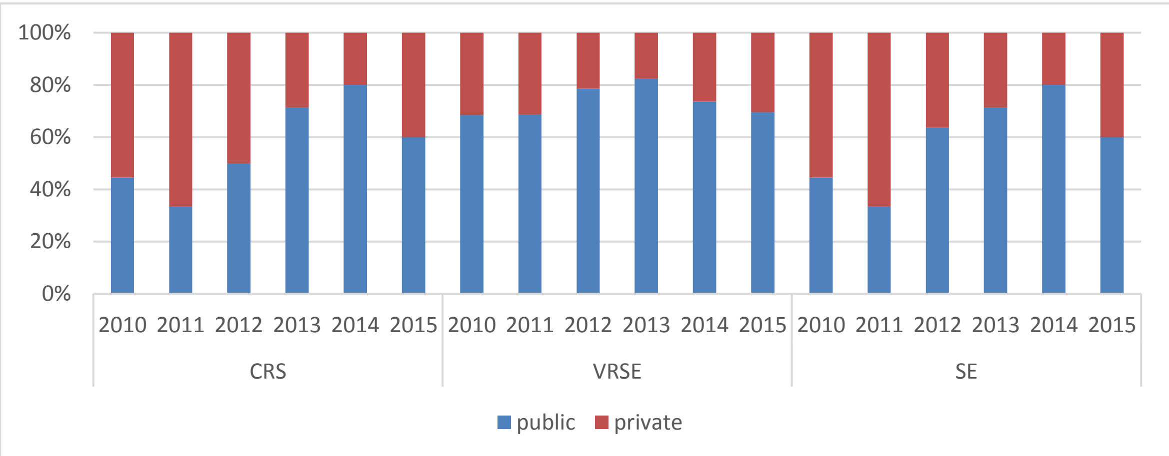
Num Ber	CRS						VRS						SE					
	2010	2011	2012	2013	2014	2015	2010	2011	2012	2013	2014	2015	2010	2011	2012	2013	2014	2015
1	0.370	0.342	0.375	0.539	0.529	0.557	0.584	0.876	0.823	1.000	0.907	1.000	0.633	0.391	0.456	0.539	0.583	0.557
2	0.388	0.385	0.304	0.348	0.392	0.404	0.999	0.514	0.368	0.406	0.396	0.405	0.388	0.749	0.826	0.858	0.989	0.998
3	0.874	0.908	0.983	1.000	1.000	1.000	0.922	0.925	1.000	1.000	1.000	1.000	0.947	0.982	0.983	1.000	1.000	1.000
4	0.453	0.372	0.417	0.477	0.533	0.580	1.000	1.000	1.000	1.000	1.000	1.000	0.453	0.372	0.417	0.477	0.533	0.580
5	0.283	0.288	0.292	0.336	0.388	0.371	0.353	0.518	0.364	0.386	0.428	0.480	0.803	0.556	0.804	0.870	0.906	0.771
6	0.444	0.490	0.238	0.342	0.540	0.581	0.575	0.689	0.541	0.586	0.653	0.674	0.772	0.711	0.440	0.583	0.827	0.862
7	0.569	0.400	0.392	0.619	0.734	0.677	1.000	1.000	0.985	1.000	1.000	1.000	0.569	0.400	0.398	0.619	0.734	0.677
8	0.912	0.808	0.794	1.000	0.878	0.717	0.919	0.842	0.822	1.000	0.985	0.986	0.992	0.960	0.965	1.000	0.891	0.727
9	1.000	0.659	0.669	0.623	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.659	0.669	0.623	1.000	1.000
10	0.673	0.666	0.629	0.693	0.787	0.833	0.744	0.702	0.671	0.694	0.793	0.835	0.904	0.948	0.938	0.998	0.992	0.998
11	0.898	0.820	0.763	0.824	0.754	0.994	0.954	0.841	0.828	0.825	0.761	1.000	0.941	0.975	0.921	0.999	0.991	0.994
12	1.000	0.803	0.910	0.998	1.000	0.981	1.000	0.813	0.927	1.000	1.000	0.982	1.000	0.988	0.981	0.998	1.000	0.999
13	0.649	0.514	0.445	0.466	0.584	0.565	1.000	0.988	1.000	1.000	1.000	1.000	0.649	0.520	0.445	0.466	0.584	0.565
14	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	0.572	0.572	0.542	0.644	0.697	0.697	0.759	0.678	0.878	0.899	0.784	0.853	0.754	0.844	0.617	0.716	0.889	0.817
16	0.729	0.917	0.548	0.614	0.959	0.644	0.884	1.000	0.683	0.833	1.000	1.000	0.825	0.917	0.803	0.738	0.959	0.644
17	0.770	0.708	0.831	1.000	1.000	0.699	0.781	0.716	0.871	1.000	1.000	0.766	0.986	0.989	0.955	1.000	1.000	0.913
18	0.587	0.573	0.583	0.366	0.488	0.710	0.788	0.668	0.895	0.777	0.982	1.000	0.745	0.858	0.652	0.471	0.497	0.710
19	0.385	0.345	0.439	0.453	0.383	0.384	1.000	1.000	1.000	1.000	1.000	1.000	0.385	0.345	0.439	0.453	0.383	0.384
20	0.967	0.864	0.884	0.994	0.768	0.931	1.000	0.933	1.000	1.000	0.840	1.000	0.967	0.925	0.884	0.994	0.915	0.931
21	1.000	1.000	1.000	0.989	1.000	1.000	1.000	1.000	1.000	0.991	1.000	1.000	1.000	1.000	1.000	0.997	1.000	1.000
22	0.874	0.803	0.842	0.722	0.642	0.827	0.938	0.831	0.893	0.902	0.966	1.000	0.933	0.966	0.943	0.800	0.664	0.827
23	0.916	0.885	0.949	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.916	0.885	0.949	1.000	1.000	1.000
24	0.232	0.204	0.174	0.180	0.288	0.346	0.356	0.293	0.220	0.252	0.320	0.350	0.651	0.697	0.791	0.717	0.899	0.987
25	0.853	0.944	0.778	0.942	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.853	0.944	0.778	0.942	1.000	1.000
26	0.883	0.996	0.784	0.809	0.837	0.677	1.000	1.000	0.943	0.819	0.838	0.749	0.883	0.996	0.831	0.988	0.999	0.904
27	0.536	0.518	0.364	0.363	0.770	0.624	1.000	1.000	1.000	0.862	1.000	0.638	0.536	0.518	0.364	0.422	0.770	0.978
28	0.674	0.892	0.435	0.423	0.778	0.915	0.811	1.000	0.579	0.456	0.799	0.958	0.830	0.892	0.751	0.929	0.973	0.955
29	0.637	0.392	0.247	0.246	0.360	0.413	0.651	0.491	0.332	0.292	0.369	0.427	0.979	0.797	0.743	0.842	0.976	0.968
30	0.394	0.373	0.225	0.260	0.288	0.410	0.403	0.409	0.225	0.263	0.357	0.465	0.978	0.913	1.000	0.988	0.808	0.881
31	0.582	0.491	0.395	0.432	0.475	0.426	1.000	0.874	0.869	0.874	1.000	1.000	0.582	0.562	0.455	0.494	0.475	0.426
32	1.000	1.000	0.581	0.599	0.623	0.674	1.000	1.000	0.591	0.606	0.672	0.677	1.000	1.000	0.982	0.988	0.927	0.995
33	1.000	0.709	0.495	0.593	0.679	0.679	1.000	0.813	0.545	0.688	1.000	1.000	1.000	0.872	0.909	0.863	0.679	0.679
34	0.447	0.609	0.503	0.519	0.647	0.921	0.484	0.656	0.561	0.590	0.999	1.000	0.925	0.929	0.897	0.879	0.647	0.921
35	0.010	0.512	0.510	0.575	0.621	0.860	0.768	0.587	0.531	0.612	0.729	0.876	0.013	0.872	0.961	0.939	0.852	0.982
36	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
37	1.000	1.000	0.693	0.890	0.967	1.000	1.000	1.000	1.000	1.000	0.981	1.000	1.000	1.000	0.693	0.890	0.985	1.000
38	0.611	0.793	0.566	0.491	0.931	1.000	0.612	0.971	0.947	0.689	1.000	1.000	0.998	0.816	0.597	0.713	0.931	1.000
39	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
40	0.835	0.732	0.471	0.498	0.710	0.857	0.850	0.863	0.857	0.794	0.727	0.922	0.982	0.848	0.550	0.627	0.977	0.930
Mean	0.700	0.682	0.601	0.647	0.726	0.749	0.853	0.837	0.794	0.802	0.857	0.876	0.819	0.815	0.770	0.810	0.856	0.864

According to the CRS result, hospitals numbered with 9, 12, 14, 21, 32, 33, 36, 37, 39 were efficient and mean efficiency score was 0.700 in 2010, hospitals numbered with 14, 21, 32, 36, 37, 39 were efficient and mean efficiency score was 0.682 in 2011, hospitals numbered with 14, 21, 36, 39 were efficient and mean efficiency score was 0.601 in 2012, hospitals numbered with 3, 8, 14, 17, 23, 36, 39 were efficient and mean efficiency score was 0.647 in 2013, hospitals numbered with 3, 9, 12, 14, 17, 21, 23, 25, 36, 39 were efficient and mean efficiency score was 0.726 in 2014, hospitals numbered with 3, 9, 14, 21, 23, 25, 36, 37, 38, 39 were efficient and mean efficiency score was 0.749 in 2015.

According to the VRS result, hospitals numbered with 4, 7, 9, 12, 13, 14, 19, 20, 21, 23, 25, 26, 27, 31, 32, 33, 36, 37, 39 were efficient and mean efficiency score was 0,853 in 2010, hospitals numbered with 4, 7, 9, 14, 16, 19, 21, 23, 25, 26, 27, 28, 32, 36, 37, 39 were efficient and mean efficiency score was 0.837 in 2011, hospitals numbered with 3, 4, 9, 13, 14, 19, 20, 21, 23, 25, 27, 36, 37, 39 were efficient and mean efficiency score was 0.794 in 2012, hospitals numbered with 1, 3, 4, 7, 8, 9, 12, 13, 14, 17, 19, 20, 23, 25, 36, 37, 39 were efficient and mean efficiency score was 0.802 in 2013, hospitals numbered with 3, 4, 7, 9, 12, 13, 14, 16, 17, 19, 21, 23, 25, 27, 31, 33, 36, 38, 39 were efficient and mean efficiency score was 0.857 in 2014, hospitals numbered with 1, 3, 4, 7, 9, 11, 13, 14, 16, 18, 19, 20, 21, 22, 23, 25, 31, 33, 34, 36, 37, 38, 39 were efficient and mean efficiency score was 0.876 in 2015.

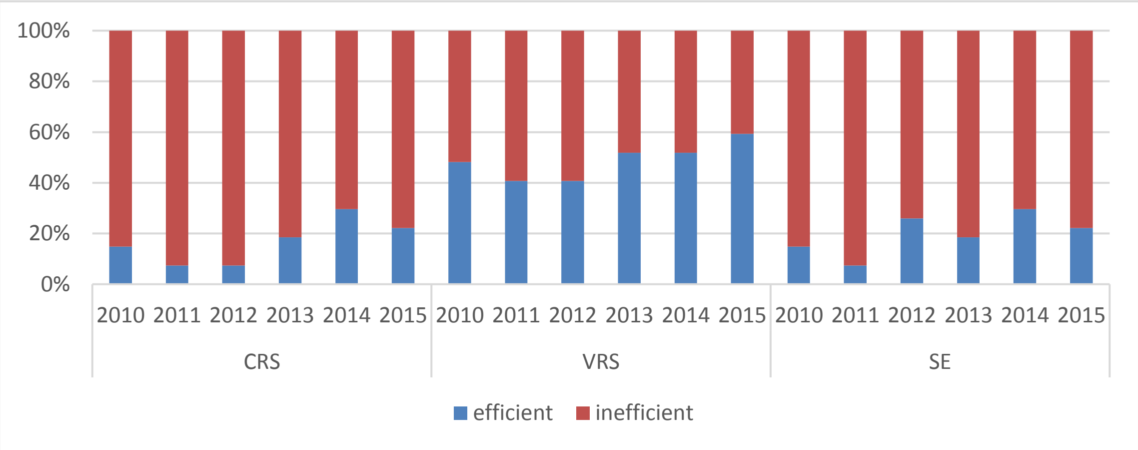
According to the SE result, hospitals numbered with 9, 12, 14, 21, 32, 33, 36, 37, 39 were efficient and mean efficiency score was 0.819 in 2010; hospitals numbered with 14, 21, 32, 36, 37, 39 were efficient and mean efficiency score was 0.815 in 2011, hospitals numbered with 14, 21, 30, 36, 39 were efficient and mean efficiency score was 0.770 in 2012, hospitals numbered with 3, 8, 14, 17, 23, 36, 39 were efficient and mean efficiency score was 0.810 in 2013, hospitals numbered with 3, 9, 12, 14, 17, 21, 23, 25, 36, 39 were efficient and mean efficiency score was 0.856 in 2014, hospitals numbered with 3, 9, 14, 21, 23, 25, 36, 37, 38, 39 were efficient and mean efficiency score was 0.864 in 2015.

Figure 1. Public-Private Distribution of Efficient Hospitals by Models (%)



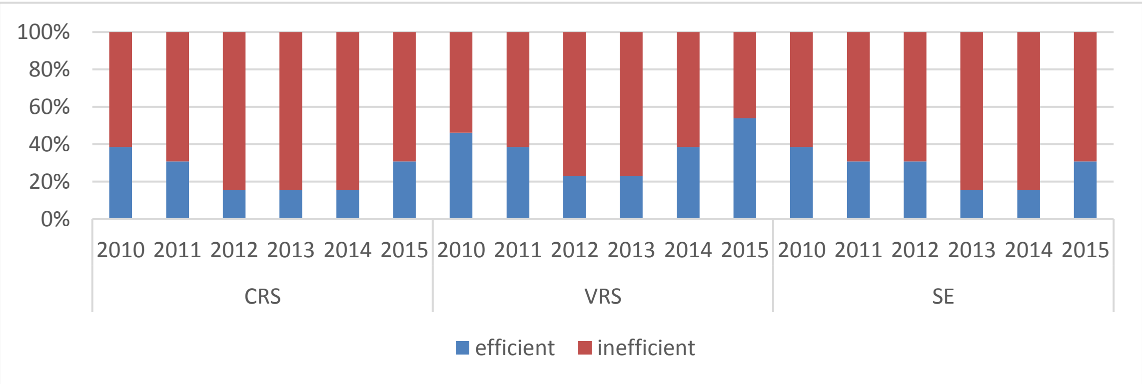
According to the CRS score 44% of the efficient hospitals were public and 56% were private in the year 2010, 33% were public and 67% were private in 2011, 50% were public and 50% were private in 2012, 71% were public and 29% were private in 2013, 80% were public and 20% were private in 2014, 60% were public and 40% were private in 2015. VRS score shows that 68% of the efficient hospitals were public and 32% were private in 2010, 69% were public and 31% were private in 2011, 79% were public and 21% were private in 2012, 82% were public and 18% private in 2013, 74% were public and 26% were private in 2014, 70% were public and 30% were private in 2015. Furthermore, SE score shows that 44% of the efficient hospitals were public and 56% were private in 2010, 33% were public and 67% were private in 2011, 64% were public and 36% were private in 2012, 71% were public and 29% were private in 2013, 80% were public and 20% were private in 2014, 60% were public and 40% were private in 2015.

Figure 2. Distribution of Efficient and Inefficient Public Hospitals by Models (%)



The numbers show that 15% of public hospitals were efficient in 2010, 7% in 2011, %7 in 2012, 19% in 2013, 30% in 2014, 22% in 2015 according to CRS records. According to VRS score 48% of the public hospitals were efficient in 2010, 41% in 2011, 41% in 2012, 52% in 2013, 52% in 2014, 59% in 2015. Continuing with SE numbers that, 15% of the public hospitals were efficient in 2010, 7% in 2011, 26% in 2012, 19% in 2013, 34% in 2014, 22% in 2015.

Figure 3. Distribution of Efficient and Inefficient Private Hospitals by Models (%)



According to CRS result, 38% of the private hospitals were efficient in 2010, %31 in 2011, %15 in 2012, 15% in 2013, 15% in 2014, 31% in 2015. The numbers show that 46% of the private hospitals were efficient in 2010, 38% in 2011, 23% in 2012, 23% in 2013, 38% in 2014, 54% in 2015 according to VRS result. SE data shows that 38% of the private hospitals were efficient in 2010, 31% in 2011, 31% in 2012, 15% in 2013, 15% in 2014, 31% in 2015.

Malmquist Index Findings

In Table 8 Malmquist index summary of annual means can be seen.

Table 8. Malmquist Index Summary of Annual Means

Year	Effch	Techch	Pech	Sech	Tfpch
2	1.049	1.083	0.983	1.067	1.136
3	0.862	1.138	0.917	0.940	0.981
4	1.081	0.947	1.017	1.063	1.023
5	1.159	0.860	1.089	1.065	0.998
6	1.041	0.964	1.030	1.011	1.004
Mean*	1.034	0.993	1.005	1.028	1.027

*geometric means

Effch: Technical efficiency change, Techch: Technological change, Pech: Pure technical efficiency change, Sech: Scale efficiency change, Tfpch: Total factor productivity change.

The increase seen in TFP during the second, fourth and sixth years, shows a decline in other years. Technical efficiency declined in the third year and increased in other years. Technological change has decreased in the ongoing years that increased during the second and third years.

Tobit Model Findings

In the analysis, CRS efficiency scores are used which obtained from DEA were dependent variable and five independent variables.

Table 9. Variables Used in Tobit Model Analysis

Variables	Explanation
Average Length of Stay	The number obtained by dividing the total number of days in a given period by the total number of patients (discharged and dead). The low rate is desirable (Çukurova and others, 2014: 192,194).
Inpatient Ratio	Indicates how many of the patients who applied to hospital polyclinic in one year were hospitalized and treated. The total number of patients hospitalized at a given time is divided by the total number of patients referred to the emergency department and the outpatient clinic, and the result is multiplied by 100 (Çukurova and others, 2014: 192,194).
Bed Occupancy Ratio	Indicates what percentage the hospital beds are being used. In a given period, the total number of days in the hospital is divided by the number of days and the number of beds in the same period, and the result is multiplied by 100 (Çukurova and others, 2014: 192,194).
Number of beds/ratio of physicians	Indicates the number of hospitals in a given period is calculated by dividing the number of beds by the number of doctors working at the same time. It indicates the number of patients bed per doctor.
Number of beds/ratio of nurses	Indicates the number of hospitals in a given period is calculated by dividing the number of beds by the number of nurses working at the same time. It indicates the number of patients bed per nurse.

In multivariate analyzes, normal distribution of continuous variables is an important first step. (Tabachnick and Fidell, 2013: 79). The normality of the variables is assessed by descriptive statistics measured by graphs, skewness and flatness and statistical tests such as Kolmogorov-Smirnov, Shapiro-Wilk (Chan, 2003).

For the normal distribution, the values of the parameter calculated by dividing the skewness and flatness coefficients by their standard errors should be within α=.05 için±1.96 for z score (Ghasemi and Zahedias, 2012:489; Kim, 2013: 53).

The z score for CRS is within ± 1.96 for each year. It is assumed that the CRS score is normally distributed due to the z value and no transformations are made. Conversion to the independent variables deviate from a normal distribution is applied. After conversion of all argument was included in the normal distribution limits.

In the study, the regression analysis was made separately for years, the results for the year 2015 were given as an example.

Table 10. Tobit Model Estimate Results (2015)

Variable	Coefficient	Std. Error	z-stat.	Prob.
Average Length of Stay	-1.648	0.161	-1.025	0.0000*
Inpatient Ratio	-0.525	0.070	-7.514	0.0000*
Bed Occupancy Ratio	0.013	0.002	8.245	0.0000*
Beds/ Physicians	0.180	0.031	5.889	0.0000*
Beds/ Nurses	0.214	0.087	2.473	0.0134**
C	0.489	0.137	3.558	0.0004*
* p<.010	** p<.05			
Log likelihood			1.541	
Pseudo R^2 (McFadden)			2.082	
Adjusted McFadden R^2			1.661	
Left censored observation			0	
Right censored observation			10	
Uncensored observation			30	
Total observation			40	

The estimated coefficients of the independent variables appear to be statistically significant. When other variables are fixed, one unit increase in average length of stay, resulted 1.648 unit decrease in efficiency; one unit dose of the inpatient ratio, in efficiency resulted in a decrease of 0.525 unit; one unit increase in bed occupancy rate, resulted a 0.013 unit increase in efficiency, one unit increase in bed/physician ratio, resulted an increase of 0.180 unit in efficiency and an increase of one unit of bed/nurse ratio, increased by 0.214 unit in efficiency.

The impact of the variables on the total efficiency is seen in Table 11 according to the results for the years 2010-2015.

Table 11. Impacts of Variables on Total Efficiency (2010-2015)

Variables	2010	2011	2012	2013	2014	2015
Average Length of Stay	-	-	-	-	-	-
Inpatient Ratio	-	-	-	-	-	-
Bed Occupancy Ratio	+	+	+	+	+	+

Beds/ Physician	+	+	+	+	+	+
Beds/ Nurses	+	+	+	+	+	+

Due to average length of stay and inpatient ratio increase, efficiency scores are affected negatively; as bed occupancy rate, bed/physician ratio and bed/nurse ratio increase, efficiency scores are affected positively.

Conclusion and Recommendations

Objective of the study is, to determine the efficiency levels of public hospitals and private hospitals in Ankara, changes in hospital efficiency over time and the cause of this change while examining the factors that may have an effect on the efficiency of the hospital. Once the efficiency levels of the hospitals have been determined, the amount of input needed to increase or decrease the output needed for inefficient hospitals to reach efficient status will be determined.

According to the obtained DEA results, hospitals numbered to 14, 36, 39 were efficient in all year and in all models. Hospitals numbered with 2, 5, 6, 10, 15, 24, 29, 35, 40 did not reach the efficiency limit in any model for the research years.

According to the CRS result that gives the total efficiency score; 23% of the hospitals were efficient in the year 2010, 15% in the year 2011, 10% in the year 2012, 18% in the year 2013 and 25% in the years 2014 and 2015 respectively.

According to the VRS result that gives the pure technical efficiency score; 48% of the hospitals were efficient in the year 2010, 40% in the year 2011, 35% in the year 2012, 43% in the year 2013, 48% in the year 2014 and 58% in the year 2015 respectively.

According to the SE result that gives the scale efficiency score; 23% of the hospitals were efficient in the year 2010, 15% in the year 2011, 13% in the year 2012, 18% in the year 2013 and 25% in the years 2014 and 2015 respectively.

As can be seen, the proportion of hospitals on the pure technical efficiency limit calculated by the VRS model is higher than the total efficiency limit calculated by the CRS model. It is understood from this that some of the hospitals providing technical efficiency were not able to provide a total efficiency due to the scale inefficiency. It is also seen that in all results, there was loss of efficiency between the years 2010-2012 and the efficiency was at the lowest level in the year 2012, increasing in the following years. It is thought that the Decree Law No. 663 on the Organization and Duties of the Ministry of Health and its Affiliates published on 11 October 2011 has an effect on this result. It is estimated that the Ministry of Health is experiencing a decline in the efficiency of public hospitals during the restructuring process and that the system has increased in efficiency at the end of the process.

When the factors affecting efficiency were examined, the average length of stay and the inpatient ratio were negative; bed occupancy rate, bed / physician ratio and bed / nurse ratio were found to be positively affected to the efficiency scores. In general, the most important factor affecting efficiency is the rate of inpatient, the second most important factor is the average length of stay; we can say that the important factors that have a positive impact on efficiency are bed / nurse ratio and bed / physician ratio, respectively, and the least effective factor is the bed occupancy ratio.

In our study, according to the annual average change indexes of 2010-2015 period, it is determined that the technical efficiencies of the hospitals increased but the technological changes decreased. Although the technological change is negative, the total factor productivity has been positively changed due to the high technical efficiency. A total of 21 hospitals (1, 3, 4, 5, 6, 7, 10, 11, 12, 15, 17,18, 21, 23, 24, 25, 28, 34, 35, 38, 40 numbered hospitals), 16 of which were public and 5 privates, increased total factor productivity.

In our study, potential change quantities are calculated for the year 2015 total activity scores. Efficient hospitals are not concerned about inefficient use of inputs or inadequate production of outputs as they are over the efficiency limit, so there is no need to go through any changes in the available quantities. The regulations foreseen for hospitals that do not provide efficiency in the year 2015 are as follows:

The hospital numbered 1 should reduce the number of beds and the number of physicians by 44%, the number of nurses by 63%, the hospital numbered 2 should reduce the number of beds by 73%, the number of physicians and the number of nurses by 60%, the hospital numbered 4 should reduce the number of beds, the number of physicians and, the number of nurses by 42%, the hospital numbered 5 should reduce the number of beds, the number of physicians and, the number of nurses by 63%, the hospital numbered 6 should reduce the number of beds and, the number of physicians by 42%, the number of nurses by 63%, the hospital numbered 7 should reduce the number of beds by 32%, the number of physicians by 40%, the number of nurses by 42%, the hospital numbered 8 should reduce the number of beds by 49%, number of physicians and number of nurses by 28%, the hospital numbered 10 should reduce the number of beds by 26%, number of physicians and number of nurses by 17%, the hospital numbered 11 should reduce the number of beds by 41%, number of physicians and, number of nurses by 1%, the hospital numbered 12 should reduce the number of beds by 13%, number of physicians and, number of nurses by 2%, the hospital numbered 13 should reduce the number of beds by 63%, number of physicians and number of nurses by 244%, the hospital numbered 15 should reduce the number of beds, number of physicians and, number of nurses by 30%, the hospital numbered 16 should reduce the number of beds by 58%, the number of physicians by 36%, the number of nurses by 39%, the hospital numbered 17 should reduce the number of beds by 39%, number of physicians and, the number of nurses by 30%, the hospital numbered 18 should reduce the number of beds by 52%, the number of physicians and, the number of nurses by 30%, the hospital numbered 19 should reduce the number of beds and, the number of physicians by 62%, the number of nurses by 28%, the hospital numbered 20 should reduce the number of beds by 49%, the number of physicians and, the number of nurses by 7%, the hospital numbered 22 should reduce the number of beds by 30%, the number of physicians by 17%, the number of nurses by 19%, the hospital numbered 24 should reduce the number of beds and, number of physicians by 65%, the number of nurses by 69%, the hospital numbered 26 should reduce the number of beds by 34%, the number of physicians and, the number of nurses by 32%, the hospital numbered 27 should reduce the number of beds, the number of physicians and, the number of nurses by 38%, the hospital numbered 28 should reduce the number of beds and, number of physicians by %9, the number of nurses by 32%, the hospital numbered 29 should reduce the number of beds and, number of physicians by %59, the number of nurses by 72%, the hospital numbered 30 should reduce the number of beds and, number of physicians by 59%, number of nurses by 65%, the hospital numbered 31 should reduce the number of beds by 57%, number of physicians and, the number of nurses by 74%, the hospital numbered 32 should reduce the number of beds by 33%,number of physicians by 48%, the number of nurses by 52%, the hospital numbered 33 should reduce the number of beds by 41%, number of physicians and, the number of nurses by 32%, the hospital numbered 34 should reduce the number of beds and, the number of nurses by 8%, the number of physicians by 26%, the hospital numbered 35 should reduce the number of beds by 14%, number of physicians by 19%, the number of nurses by 62%,the hospital numbered 40 should reduce the number of beds and, the number of physicians by 14% and, the number of nurses by 65%.

These and similar studies can be taken into account in order to ensure the efficiency of the hospitals and therefore the health system. It is thought that similar studies done in Turkey are expected to make a significant contribution to the Turkish health system.

Our work focuses on the technical efficiency of hospitals. Other issues (such as financial, quality or customer satisfaction) are not included. These and similar topics are the subject of other studies.

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İnternet: http://www.who.int/hospitals/en/ 02.07.2017