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Research Article

EVALUATION OF BED UTILIZATION PERFORMANCE OF HOSPITAL DEPARTMENTS IN TURKEY WITH GREY RELATIONAL ANALYSIS

Arzu YİĞİT
Süleyman Demirel University, Faculty of Economics and Administrative Sciences, Department of Health Management, Isparta, Turkey
arzuyigit@sdu.edu.tr

Abstract: *This study aimed to analyze the bed utilization performance of hospital departments in Turkey with the grey relational method. Grey relational analysis was used to determine the bed utilization performance levels of surgery and internal clinics in Turkey. In this study, hospital performance indicators are used as variables; bed occupancy rate, bed turnover rate and the average length of stay. Research data were obtained from the Statistical Report of Public Hospitals Unions. Data were analyzed using MS Excel, SPSS 18 software. In this study, bed occupancy rate (BOR), the average length of stay (ALS) and bed turnover rate (BTR) performance indicators of clinics were found to be 67.3; 5.6 and 63.4, respectively. According to the grey relational analysis (GRA), the section with the most desirable characteristics represents the sections with the highest scores. The highest grey relational grade score was found to be obstetrics and gynecology (0.904) and the lowest score of skin and venereal diseases (0.474) departments. In the multidimensional analysis, it was evaluated in two categories as efficient and inefficient in evaluating the bed use performance of departments. Hospitals are the most resource-consuming element of a health care system. The hospital's bed utilization performance has a positive impact on the hospital's financial success. A significant portion of the cost of operating in hospitals is due to unnecessary patient hospitalization. To reduce hospital costs, patient beds need to be used optimally. Hence, hospital managers should regularly audit bed utilization.*

Keywords*: Hospital, Bed Utilization, Performance, Grey Related Analysis*

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1. Introduction

Bed utilization one of the most important indicators of hospital performance, accurate measurement of performance is very important in managing resources effectively and efficiently. Hospital bed utilization is influenced by various factors, which may be categorized into patient-related, physician-related, administration-related issues [1] and there is a multitude of factors that affect the demand for beds in various medical services [2]. Performance indicators for hospitals are important for management to evaluate and improve various hospital functions [3].

Bed management is the assignment and provision of beds, especially in a hospital where beds in specialist wards are scarce resources. Managing beds might seem like a simple task but bed management involves the continuous monitoring of hospital admissions, discharges and hospital utilization indices to identify vacant beds across wards [4].

Limited healthcare resources in low- and middle-income countries have led policy-makers to improve healthcare efficiency [5]. Scarce healthcare resources require carefully made policies ensuring

optimal bed allocation, quality healthcare service, and adequate financial support [6]. Optimal utilization of hospital beds is very important. Non-availability of hospital beds can shed a negative light on the image of the hospital [4]. Efficiency and performance show how well an organization uses existing resources [7]. Performance evaluation in hospitals is a process related to the evaluation, measurement, and implementation of performance in a certain period of time [8]. Performance evaluation provides useful information to hospital managers on issues related to the evaluation and monitoring of the current situation and activities.

Capacity utilization level in the evaluation of performance and cost monitoring in hospitals provides information to hospital managers. Capacity utilization rate is one of the main performance indicators in hospitals [9]. Capacity planning is central to the pursuit of balancing the quality of health care delivered with the cost of providing that care [10].

Performance measurement is highly essential for hospitals, where efficiency is a vital indicator. To measure the performance of hospitals, several hospital performance assessment methods have been proposed in the literature which among them the grey relational analysis.

2. Materials and Method

This study aimed to analyze the bed utilization performance of hospital departments with Grey relational method. The population of the study consists of 18 hospital departments affiliated to the Union of Public Hospital in Turkey. The data of the study cover the period from January 2017 to December 2017. Research data were obtained from the Statistical Report of Public Hospitals Unions [11]. The data of the study were analyzed via MS. Office Excel and SPSS 18 statistics software.

The performance criteria used in the study are as follows: BOR, BTR, and ALS. In this paper, it was assumed that all metrics had the same importance and used the same value for each sequence in the GRA. Also, a multidimensional analysis of bed utilization performance criteria was performed. It was analyzed with a scatter diagram to determine the relationship between bed usage performance indicators. In the multidimensional analysis, evaluating the bed use performance of clinics was evaluated in two categories as efficient and inefficient. Therefore, BTR's minimum, BOR's minimum and ALS maximum value that the departments are inefficient. BTR has a maximum, BOR has a maximum and ALS has a minimum means that the departments are efficient.

GRA theory, a method of decision making and analysis developed by Judong Deng in 1982. The grey system method has been extensively applied in various fields [12]. GRA is used to identify the grey relational grade among various indicators and to select the most representative one [13]. GRA is an important classification, grading and decision making method that can be used to solve multi-criteria decision-making problems. The goal of grey system theory is to bridge the gap between the natural sciences and the social sciences [14].

In grey system theory, white refers to known information, black refers to unknown information, and the grey area in between refers to partially known information. Grey methods have the powerful advantage of being capable of dealing with complex problems concerning uncertain [15]. Grey system theory is a method used in the application of parametric statistical analysis methods where various assumptions such as homogeneity of variances, the distribution of the data to be applied are suitable for normal distribution and, for example, sufficient size are not valid [16]. GRA is a method of use in enterprise performance evaluation. GRA is an effective method for decision problems where there are

complex relations between criteria. The grey relation covers the evaluation of the relationship between two or more parameters or elements within a system. In order to compare the alternatives with the GRA method, a calculation consisting of six steps is performed. The formula used in these steps is given in Table 1 [17-19].

Table 1. Calculation steps of grey relational analysis

Step	Definition	Formula	
1	Preparation of data and formation of decision matrix. Consisting of the number of units (m) and the number of variables (n)	$x_i = (x_i(1),\ x_i(2),\ x_i(3), \dots, x_i(k))$ $k = 1,2,3, \dots, n \ ve \ i = 1,2,3, \dots, m$	1
2	Creation of reference series and comparison matrix.	$x_0 = (x_0(k))$ k=1,2,…,n	2
3	Normalization process and obtaining normalized matrix. Of these formulas; formula (3.1) is used to convert benefit, formula (3.2) is used to convert cost and formula (3.3) is used to convert average type criterion values to standard values.	$x_i(k) = \frac{x_i^{(0)}(k) - \min x_i^{(0)}(k)}{\max x_i^{(0)}(k) - \min x_i^{(0)}(k)}$	3.1
		$x_i(k) = \frac{max\ x_i^{(0)}(k) - x_i^{(0)}(k)}{\max x_i^{(0)}(k) - \min x_i^{(0)}(k)}$	3.2
		$x_i(k) = 1 - \frac{x_i^{(0)}(k) - x^0}{\max x_i^{(0)}(k) - x^0}$	3.3
4	Creating the absolute value table	$\Delta x_i(k) = \lvert x_0(k) - x_i(k) \rvert$	4
5	Calculating the grey relational coefficient	$\gamma x_0(k), x_i^* = \frac{\Delta\min + \zeta\Delta\max}{\Delta_{0i}(k) + \zeta\Delta\max}$ Where $\gamma\ x_0(k)$ – Ideal sequence ($x_0(k) = 1,\ k = 1,2\dots$) Δ min – Smallest value of $\Delta_{0i}(k)$, Δ max – Largest value of $\Delta_{0i}(k)$, $\Delta_{0i}(k)$– difference of absolute value between $x_0(k)$ and $x_i^*(k)$, $\Delta\ 0_i(k) = x_0(k) - x_i^*(k)$, ζ – Distinguishing coefficient (between 0 and 1), If all the process parameters have equal weightage then ζ is set to be 0.5.	5
6	Calculating the grey relational degree r_{0i} indicates the grey relational degree (6.2). If weight is to be applied to evaluation criteria, the formula will be as (6.2)	$r_{0i} = \frac{1}{n}\sum_{k=1}^{n} \gamma(x_0(k), x_i(k))$	6.1
		$r_{0i} = \sum_{k=1}^{n} [w_i(k) * (x_0(k), x_i(k))]$ Weight values for criteria (w_k) totals must be 1. The decision alternative with the highest grey relational degree value is determined as the best alternative.	6.2

3. Results

Hospital bed performance indicators of departments in which BOR, ALS, BRT findings are given in Table 2. The data on the bed performance indicators of the surgical and internal departments of hospitals affiliated to the Ministry of Health in Turkey is given in Table 2. BOR, ALS and BRT performance indicators of clinics were found to be 67.3; 5.6 and 63.4 respectively. As can be seen in Table 1, the clinical physical medicine and rehabilitation with the highest value in terms of BOR (80%) and the clinical skin and venereal diseases with the lowest value (33%) were found. ALS was found to be the highest value in terms of performance indicator mental health and diseases (18 days) and the lowest value in terms of Clinical Pediatric Surgery (2.0). In terms of the BRT performance indicator, the highest value was clinical obstetrics and gynecology (123.9) and the lowest value was mental health and diseases (14.4). A reference series needs to be created in order to be able to perform grey relational analysis. The reference values to be determined in the first step in accordance with the research methodology were determined in Table 2.

Table 2. Dataset and reference values of hospitals performance criteria

Departments Name	BOR	ALS	BTR
Brain and Neurosurgery	72.5	5.2	50.5
Pediatric Surgery	68.7	2.0	123.1
Child Health and Diseases	62.1	3.2	71.1
Skin and Venereal Diseases	32.9	4.7	25.6
Physical Medicine and Rehabilitation	79.6	16.5	17.6
General Surgery	69.1	3.3	76.4
Chest Surgery	62.0	5.8	39.2
Chest Diseases	79.4	7.3	39.7
Eye Diseases	55.7	1.6	123.8
Internal Medicine	66.3	5.1	47.2
Obstetrics and Gynecology	72.5	2.1	123.9
Cardiovascular Surgery	69.5	5.3	47.9
Cardiology	68.9	3.6	69.0
Neurology	65.9	6.1	39.3
Orthopedics and Traumatology	77.5	4.9	58.3
Plastic and Reconstructive Surgery	67.0	2.9	83.3
Mental Health and Diseases	73.2	18.5	14.4
Urology	69.0	2.8	90.0
Reference	79.6	1.6	123.9
Minimum	32.9	1.6	14.4
Maximum	79.6	18.5	123.9
Mean	67.3	5.6	63.4
Standard deviation	10.522	4.612	34.799

It is difficult to compare the different kinds of factors because they exert a different influence. Therefore, the standardized transformation of these factors must be done. After the values in the decision matrix are arranged, the decision matrix is normalized by using the equality in the materials and methods section. At this stage, a normalization process has been carried out to ensure that the alternatives are comparable so that they can be stripped of their units and their size drawn to lower levels. The normalized decision matrix is shown in Table 3. After the normalized decision matrix is obtained, the differences between the normalized values of the reference series and the normalized values in the matrix are calculated. The difference matrix consisting of calculated values is shown in Table 3.

The elements of the grey relational coefficient matrix were calculated for maximum and minimum values among all criteria. The values of Δ_{max} and Δ_{min} calculated in the difference data sequence used for the calculation of grey relational data are given below. The parameter ζ is 0.5 as in many studies in the literature [17-19]. The grey relational coefficient matrix obtained from the calculations is shown in Table 3.

Table 3. Normalized Decision and Absolute Matrix

	Normalized values			**Absolute value**		
Departments Name	BOR	ALS	BTR	BOR	ALS	BTR
Brain and Neurosurgery	0.848	0.787	0.330	0.152	0.213	0.670
Pediatric Surgery	0.767	0.976	0.993	0.233	0.024	0.007
Child Health and diseases	0.625	0.905	0.518	0.375	0.095	0.482
Skin and Venereal Diseases	0.000	0.817	0.102	1.000	0.183	0.898
Physical Med. and Rehabilitation	**1.000**	0.118	0.029	**0.000**	0.882	0.971
General Surgery	0.775	0.899	0.566	0.225	0.101	0.434
Chest Surgery	0.623	0.751	0.226	0.377	0.249	0.774
Chest Diseases	0.996	0.663	0.231	0.004	0.337	0.769
Eye Diseases	0.488	**1.000**	0.999	0.512	**0.000**	0.001
Internal Medicine	0.715	0.793	0.300	0.285	0.207	0.700
Obstetrics and Gynecology	0.848	0.970	**1.000**	0.152	0.030	**0.000**
Cardiovascular Surgery	0.784	0.781	0.306	0.216	0.219	0.694
Cardiology	0.771	0.882	0.499	0.229	0.118	0.501
Neurology	0.707	0.734	0.227	0.293	0.266	0.773
Orthopedics and Traumatology	0.955	0.805	0.401	0.045	0.195	0.599
Plastic and Reconstructive Surgery	0.730	0.923	0.629	0.270	0.077	0.371
Mental health and diseases	0.863	0.000	0.000	0.137	1.000	1.000
Urology	0.773	0.929	0.690	0.227	0.071	0.310
Reference	**1.000**	**1.000**	**1.000**			
Δ_{max}				1.000		
Δ_{min}				0.000		
ζ				0.500		

Once the absolute matrix is obtained, the grey relational coefficient matrix is formed. There are two different situations in which the criteria are of equal and different weight in the evaluation of the grey relational coefficient matrix. In this study, the criteria were assumed to be of equal importance.

In this step, the grey relational coefficient was calculated and based on this coefficient, the grey relational degree was found. The reason why the variables used in this research are equally weighted is that there is no information about which of these variables is superior in the literature. The findings are given in Table 3. According to the bed usage performance indicators, the sections with the highest grey relational grade were determined. In the last step, the scores obtained as a result of the GRA and the ranking of the internal and surgical clinics were performed. According to the grey relational analysis, the section with the most desirable characteristics represents the sections with the highest scores. The highest grey relational grade score was found to be obstetrics and gynecology (0.904) and the lowest score was skin and venereal diseases (0.474) departments.

Table 4. Grey relational coefficient matrix, grey relational degrees and sorting

	Grey Relational Data (criteria equal-weighted)			Grey Relational	
Departments Name	BOR	ALS	BTR	Degree	Ranking
Brain and Neurosurgery	0.767	0.701	0.427	0.632	11
Pediatric Surgery	0.682	0.955	0.986	0.874	2
Child Health and Diseases	0.572	0.841	0.509	0.640	10
Skin and Venereal Diseases	0.333	0.732	0.358	0.474	18
Physical Medicine and Rehabilitation	1.000	0.362	0.340	0.567	14
General Surgery	0.690	0.833	0.535	0.686	7
Chest Surgery	0.570	0.668	0.393	0.544	16
Chest Diseases	0.992	0.597	0.394	0.661	9
Eye Diseases	0.494	1.000	0.998	0.831	3
Internal Medicine	0.637	0.707	0.417	0.587	13
Obstetrics and Gynecology	0.767	0.944	1.000	0.904	1
Cardiovascular Surgery	0.698	0.695	0.419	0.604	12
Cardiology	0.686	0.809	0.499	0.665	8
Neurology	0.630	0.653	0.393	0.559	15
Orthopedics and Traumatology	0.917	0.719	0.455	0.697	5
Plastic and Reconstructive Surgery	0.650	0.867	0.574	0.697	6
Mental health and diseases	0.785	0.333	0.333	0.484	17
Urology	0.688	0.876	0.618	0.727	4

In addition, the multidimensional analysis of bed utilization performance criteria was performed. It was analyzed with a scatter diagram to determine the relationship between bed usage performance indicators. A multidimensional scattering graph of bed performance indicators and grey relational analysis results are given in Figure 1.

In this study, based on the data obtained from the GRA method, the bed use performance of the clinics was evaluated by multidimensional analysis. Bed utilization performance of clinics was evaluated in two categories as efficient and inefficient. The findings from the GRA was divided into four regions according to the bed use performance of the clinics by a multidimensional scattering graph.

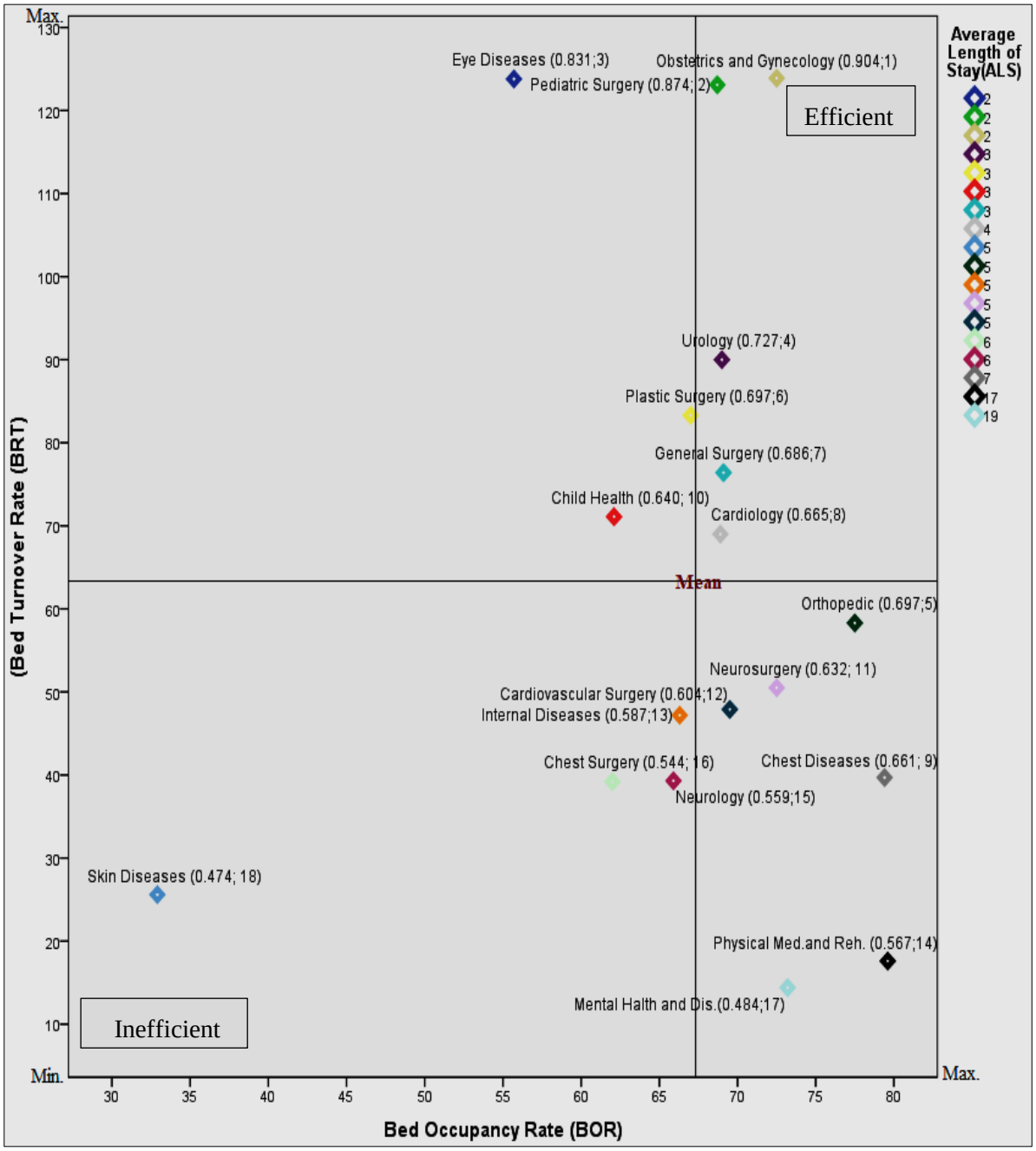

Figure 1. Multidimensional scattering graph of bed performance indicators

Similar results were obtained when GRA and Multidimensional scattering graphs were compared. According to the results of both methods, the most productive department was found to be obstetrics and Gynecology and the most inefficient department was skin diseases.

4. Discussion

A significant portion of the cost in hospitals is due to poor management of patient beds [22]. Reducing the costs of use in hospitals is very important. BOR, BRT, and ALS is an important parameter in assessing hospital bed performance. BOR and BTR that high rate indicates are used efficiently, while the low rate indicates that the patient beds are used inefficiently. ALS is efficient being low, while a high is regarded as inefficient [20].

In this context, the most efficient department was obstetrics and gynecology while the most inefficient department was the skin diseases clinic. Mental health and physical medicine departments BOR and ALS are high. The eye and pediatric surgical departments BRT are high, the mean ALS has been found to be low, but the BOR is below average. The results indicate that although six clinics have an outstanding performance, four clinics exhibited poor performance and eight clinics were found to have moderate performance (Figure 1). In this study, hospital bed use performance was different according to departments. There are many reasons for this condition. The most important reason is that some diseases are treated in a short period of time and some are treated in a long period of time. For example, while mental health diseases are treated in hospital in a long time, in obstetrics, patients are treated in a very short time. The departments can take place in different regions in Figure 1 because of their unique characteristics.

In this study, hospital bed use performance was different according to departments. There are many reasons for this condition. The most important reason is that some diseases are treated in a short period of time and some are treated in a long period of time. For example, in mental health and disease patients are treated in hospital for a long time, while in obstetrics, patients are discharged in a very short time. Because of the unique characteristics of the clinics, they can be located in different regions in Figure 1.

Decision-making approaches in health services aim to select the most appropriate alternatives by evaluating many conflicting criteria together. The main reason for determining the performance levels of hospital clinics is to prevent waste of resources during the hospitalization process [21]. There are many academic studies on bed use performance in Turkey. These studies were usually done with the Pabon Lasso model [20, 22-24]. Pabon Lasso model developed by Pabón Lasso (1986), is a graphical technique that uses bed occupancy rate, bed turnover rate and the average length of stay indicators to measure relative hospital performance [25]. This model is considered to be an alternative method that makes it possible to measure performance with a simple graph and is easier to understand than other performance measurement models [26]. Bed use efficiency is considered as one of the most important performance indicators in evaluating performance in hospitals and monitoring costs [9]. Appropriate utilization of beds allocated for a particular department will help to increase the efficiency of the discharge process. It is recommended that bed utilization indices be used routinely to assess, analyze and improve the available resources [4]. Using the beds of public hospitals in the same province or region in terms of efficient use of public resources will have a positive impact on the financial sustainability of both the university and the ministry of health hospitals [27].

In a study evaluating hospital bed use performance in Turkey, it was found that 23% of clinics performed very well, while 18% had very low productivity [20]. In Turkey, 25% of hospitals affiliated with the Ministry of Health were found to be performing good bed use [23]. The bed occupancy rate, bed turnover rate and stay day averages of universities and hospitals in Turkey increased in 2017

compared to 2014. Analysis of productivity found that while 18% of hospitals were in the most efficient region in 2014, this figure rose to 29% in 2017 [28]. In a study analyzing hospital bed performance in Iran; the overall ALS, BOR and BTR rates were 4.1 days, 68.9% and 61.1 respectively[29]. Health centers and hospitals bed performance in Uganda, the average indicators ALS; 3.63 days, BTO; 74.0 times per year and BOR; 49.3% were obtained.

5. Conclusions and Recommendations

Hospitals make up a significant share of health spending, and inefficient use of patient beds directly increases hospital costs. Hence, in order to provide quality, efficient and cost-effective health care, and bed performance should be evaluated regularly by hospital managers. The Ministry of Health should take into consideration the situation of physicians and nurses when planning beds in hospitals in Turkey. Hospital managers should also consider bed usage performance indicators while allocating beds to departments.

One of the most important problems with bed use in hospitals is unnecessary hospitalization. Therefore, it is recommended to prepare treatment protocols to prevent unnecessary hospitalizations in hospitals. A hospital has to manage the beds of all its clinics effectively according to supply and demand. Hospitals allocate a certain number of beds to clinics. However, the application to the relevant clinic is more or less during the year. While the bed occupancy rate of one clinic of the hospital is high, other clinics are sometimes less than the demand. In order to reduce inpatient costs, the average length of hospitalization should be shortened.

GRA is one of the most common techniques used in recent years as a guide to the solution of multi-criteria decision-making problems. GRA can evaluate the activities of hospitals and their bed use performance, identify potential inefficiencies related to bed use of hospitals and conduct performance rankings. It is therefore recommended that this method be used frequently in decision-making stages in hospitals. The reasons for the inefficiency of inefficient departments should be identified and strategies should be developed to make them efficient. The efficiency scores of the departments indicate how close they are to use their maximum bearing performance capacities. Therefore, it is recommended that inefficient departments should be reduced in the number of beds and concentrate on outpatient services. In order to determine the performance of hospital beds in more detail, it is recommended to researchers using Data Envelopment Analysis (DEA) method which includes efficiency.

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