THE RELATIVE EFFICIENCY OF JORDANIAN PUBLIC HOSPITALS USING DATA ENVELOPMENT ANALYSIS AND PABON LASSO DIAGRAM

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ABSTRACT

This study aims at investigating and measuring the relative efficiency of public hospitals performance in Jordan, during the period (2006-2008), using DEA and Pabon-Lasso Diagram. The results indicate that the average efficiency of those hospitals is varied and ranges between (73%) to (100%). The average of the relative efficiency of the sample hospitals over the study period is 94%. Of 15 hospitals, the number of efficient hospitals increased from 7 in 2006 to 9 in 2007, but decreased to 8 in 2008. The results are compared with old efficiency scores of the same hospitals reported in the literature. This comparison leads to signify that the efficiency of public sector hospitals in Jordan is varied over time, due to decreasing public expenditures on health care per capita. However, the results concerning ratio analysis in explaining efficiency are inconsistent; implying that these institutions are either having poor management or they treat long stays diseases.

JEL: C61, C67, D02, H11, H51, I12

KEYWORDS: Hospitals, Efficiency, DEA, Pabon Lasso, Jordan.

INTRODUCTION

The concept of performance brings together the concepts of quality, efficiency and effectiveness. Hospitals, amongst other organizations, need to know how well they are performing and to have effective means of assessing and improving the quality of care they are providing. This requires measures that are meaningful, interpretable, and of demonstrable value in helping to improve performance (Thomson et al., 1997). Estimating efficiency in the medical field is more difficult than in other fields since the output (health gain, cure or marginal health improvement) is difficult to measure, due to the non-parametric measurable characteristics of hospitals' products. Performance indicators for hospitals are important for internal management to evaluate and improve various hospital functions and for external stakeholders like investors, insurers, patients and public.

This study provides evidence on the performance efficiency of fifteen public hospitals in Jordan during the period (2006-2008), using a multi-criteria non-parametric analysis technique known as Data Envelopment Analysis (DEA), as well as plotting the results on the Pabon Lasso graph to interpret efficiency. It aims at identifying the relatively efficient hospitals and the relatively inefficient ones, based on DEA. In addition, the results will be compared with Al-Shammari's (1999) results of the same fifteen public hospitals 20 years ago (1991-1993). The Pabon Lasso model has also proved to be one of the most useful for comparing the performance of different hospitals. The results of this study are expected to be beneficial to policy makers and the relevant hospital management to develop an assessment system to measure performance of their hospitals.

The remainder of the study is presented as follows: Part II reviews the theoretical background of the study, including: performance measurement, hospital efficiency, ratios, and DEA. Part III reports the Jordanian health sector as the institutional background of the study. While part IV is devoted to the data, methodology, empirical results and analysis of the findings. Finally, part V concludes the study and provides recommendations.

LITERATURE REVIEW AND BACKGROUND

There are different models of hospital performance assessment. These are (WHO, 2003) (1) the Balanced ScoreCard (BSC), which integrates four performance dimensions: financial dimension, customer dimension, internal business process and learning and growth. This model is adopted by Canadian hospitals (Chan and Ho, 2000). Ba-Abaad (2009) provides a review of literatures employed this model. (2) The Danish Model which focuses on (a) a clinical perspective, such as admission, assessment, investigation, evaluation, discharge, follow-up; (b) the patient's perspective comprising information, communication, coordination, continuity, patients´ rights, patient safety; and (c) an organizational perspective, including public information, leadership, human resources, research , education and risk management; and (3) Quality Indicator Project (Maryland Hospital Quality Indicator Project (MHA QI Project®), which is a clinical, outcomes-based research project that allows health care industry participants to understand and improve their performance at their facility. It is a complex model as it incorporates hundreds of measures making it the largest performance quality analysis program available.

There is no consensus about the appropriate performance measurement approach in the health services (Veillard et al., 2003). The most common models are based on ratio analysis and Pabon-Lasso diagram, accounting methods, and frontier approaches (Mohammed, 2004). These are explained in the followings.

Ratio Analysis and Pabon Lasso Diagram

Ratio measurements include the number of outpatient visits per doctor or nurse; or in the case of inpatient care, average length of stay, bed occupancy and turnover rates.

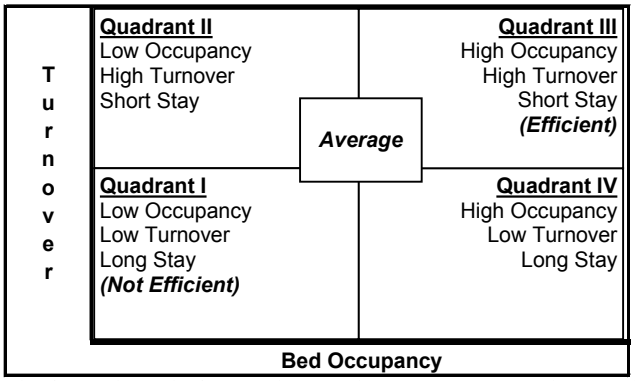
There are three main hospital indicators to assess performance (Sherman, 1984). These are (1) Bed Occupancy Rate (BOR), which measures the percentage of beds occupied by the patients in the year, reflecting the efficiency in the use of hospital resources. (2) Bed Turnover Rate (BTR), which measures the average number of inpatients per bed in the year, as an indicator of the efficiency of hospital resource use. (3) Average Length of Stay (ALOS), which measures the average duration of inpatient hospital admissions (mean number of days from admission to discharge).

Pabon Lasso (1986) developed a method of graphical analysis that allows an easier combination of these three hospital efficiency indicators for meaningful comment on the efficiency with which hospitals are operating. Pabon Lasso graph is a technique that interprets hospital efficiency using such indicators, which is a common practice among hospital managers around the world. Pabon-Lasso diagram, see figure 1, utilizes such ratios of hospitals for comparison (Bahadori et al., 2011), to plot the hospitals in the four quadrants of the figure.

In figure 1, Quadrant I is characterized by low bed occupancy rate (BOR) and low bed turnover (BTO) and therefore under-utilization. This may be related to a higher number of beds than needed and/or a low demand for hospitalization. Low (BTO) and low (BOR) indicate a surplus of hospital beds relative to the existing demand. Quadrant II is characterized by a higher than average (BTO) and a lower than average (BOR). This may be related to a higher number of beds than needed and/or unnecessary hospitalizations, and/or a high number of normal deliveries. High BTO and low BOR characterize the unnecessary

hospitalizations, an oversupply of beds, or using beds for simply observing patients. Quadrant III is characterized by an efficient utilization of resources, since the occupancy and turnover ratios are higher than the average. High BTO and high BOR characterize hospitals that have reached an appropriate level of efficiency, with relatively few vacant beds at any time. Quadrant IV is characterized by a higher than average bed occupancy and a lower than average turnover. A high proportion of severe patients and or a high proportion of long term cases, and or unnecessary long stay may cause this situation. The area near the centre is where average hospitals are located. Hospitals have low BTO and high BOR are serving patients with serious, chronic illnesses or have an unnecessarily long average length of stay (Pabon Lasso, 1986).

Figure 1: Pabon-Lasso Diagram



This figure shows the four quadrants Pabon Lasso Diagram. These quadrants are formed by the intersection of the average bed occupancy rate (BOR) and the average bed turnover rate (BTO) for the same category of hospitals. Source: Pabon Lasso (1986).

Plotting the hospitals according to occupancy and turnover makes sense only if the hospitals have similar characteristics. Public hospitals are likely to accept more complicated cases than private hospitals and therefore they should be considered separately. Once the hospitals with the same characteristics are plotted on the Pabon Lasso graph, it is possible to group them in the four quadrants and to rank them according to average, lower or higher than average utilization. However, efficient utilization should be interpreted with caution. Variation within the same category of hospitals distorts the average. In addition, efficient utilization does not equate to performance in terms of standard and quality of care (Govender et al., 2004).

Accounting Methods

Accounting methods provide unit cost estimates of, for example, admissions, bed-days, surgical procedures and outpatient visits. The main advantage of this method is that the average service cost estimates are often used in the financial analysis documents such as National Health Accounts (Barnum and Kutzin, 1993).

Statistical methods use ordinary least square (OLS) regression analysis that can handle multiple inputs and outputs that hospital efficiency analysis requires. However, these variables are not directly useful in identifying inefficiencies within a hospital (Sherman, 1984).

DEA Model

Frontier approaches include Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). The choice of measurement method depends largely on the audience, the use of the estimates and the data available (Mohammed, 2004).This study will use DEA.

DEA is an efficiency measurement procedure developed by Charnes, Cooper and Rhodes (1978) to evaluate the efficiency of public sector non-profit organizations. It is a linear programming based model which evaluates the relative efficiency of decision making units (DMUs), with multiple inputs and outputs. DMUs refer to the collection of firms, departments, divisions or administrative units with the same goals and objectives, and which have common inputs and outputs. DEA identifies a subset of efficient "best-practice" DMUs and for remaining DMUs, the magnitude of their non-efficiency is measured by comparing to a frontier constructed from the efficient DMUs. In short, DEA provides management with information regarding the relatively best practice hospitals in the observation set and locates the relatively inefficient hospitals by comparison with the best practice ones. In addition, it indicates the magnitude of these inefficiencies.

The DEA approach constructs a hypothetical composite unit which is the best-practice unit made up of a subset of units that should be emulated by a given inefficient unit in order to improve the efficiency of its operation. That is, the performance of each DMU is measured relative to the performance of all other DMUs. The unit being evaluated can be judged relatively inefficient if the composite unit requires less input to obtain the output achieved by the unit being evaluated, or judged relatively efficient if the composite unit requires as much input as the unit being evaluated. DEA results help in identifying the relatively inefficient DMUs and providing insights into ways to improve productivity of these relatively inefficient units while maintaining or even increasing the volume of services provided by DMUs (Coelli et al., 2005).

DEA is an advantageous hospital efficiency measure over other measures, mentioned above, because it is consistent with the economic theory in that it locates inefficiencies rather than measuring efficiency based on averages. Also, it can simultaneously consider multiple inputs and multiple outputs, and direct management's attention toward the particular factors that exhibit the greatest effect on operational efficiency. In addition, it does not require a common measurement unit for the factors. Finally, it can determine where resources might best be applied in order to reduce inefficiencies (Rutledge et al., 1995).

Overview of Health System in Jordan

Health care services in Jordan are supplied by the following providers (MOH, 2006, 2007 and 2008): (1) The public sector, including the Ministry of Health (MOH), the Royal Medical Services (RMS) for the military and their dependents, the Jordan University Hospital (JUH) and King Abdullah University Hospital (KAUH) of Jordan University of Science and Technology (JUST). (2) The private sector, and (3) the international and charitable sector. Table 1 provides key data about the demographic and health related ratios during the period (2004-2008).

It can be seen from table 1 that life expectancy has increased from 71.5 years in 2004 to 73 years in 2008; and infant mortality rate has decreased from 22 per 1000 live birth in 2004 to 19 in 2008. In addition, the numbers of health care staff has improved during the period 2004-2008. For example, physicians (dentists) increased from 22.4 (7.3) per 10000 population in 2004 to 24.9 (8.7) in 2008. Similar trends are shown with nurses and pharmacists figures.

MOH is the main institutional source of primary and hospital care in Jordan. According to the MOH (2008), MOH operates an extensive primary care network, consisting of 240 Peripheral health clinics, 375 primary health centers, 416 maternal and child health clinics, 68 comprehensive health centers, 313 dental clinics, and 12 chest disease centers. Table 2 presents some data about hospitals and the main ratios during the period (2004-2008).

Table 1: Key Data about the Demographic and Health Related Ratios During the Period (2004-2008)

Country Demographic and Health Data	**2004**	**2005**	**2006**	**2007**	**2008**
Population	5,350,000	5,485,000	5,600,000	5,723,000	5,850,000
Adult Male Illiteracy Rate (%of15+Years of Age)	5.6	4.8	5.1	4.3	4.1
Adult Female Illiteracy Rate (%of15+Years of Age)	15.1	13.1	13.7	11.6	11.4
AVERAGE	**10.3**	**9**	**9.3**	**7.9**	**7.7**
Crude Birth Rate (Per 1000 Population)	29	29	29.1	29.1	28
Population Growth Rate	2.6	2.5	2.3	2.2	2.2
Average Persons Per Family	5.4	5.4	5.4	5.4	5.4
Total Fertility Rate	3.7	3.7	3.7	3.6	3.6
Life Expectancy at Birth (Years) Male	70.6	70.6	70.6	71.6	71.6
Life Expectancy at Birth (Years) Female	72.4	72.4	72.4	74.4	74.4
AVERAGE	**71.5**	**71.5**	**71.5**	**73**	**73**
Crude Death Birth (Per 1000 Population)	7	7	7	7	7
Infant Mortality Rate (Per 1000 Live Birth)	22	22	22	19	19
Maternal Mortality Rate (Per 100,000 Live Birth)	41	40.3	41	41	N/A
Dependency Ratio (%)	70.4	70.4	68.2	68.4	68.2
Unemployment Rate (%)	12.5	14.8	14	13.1	12.7
Physician (Per 10,000 Population)	22.4	23.5	24.5	26.7	24.9
Dentist (Per 10,000 Population)	7.3	7.6	8.2	8.5	8.7
Nurse (All Categories) (Per 10,000 Population)	32.5	29.4	33	33.6	33.2
Pharmacist (Per 10,000 Population)	12.6	12.9	12	14.1	13.2

This table shows some general population and health statistics in Jordan during the period 2004-2008. Source: MOH (2008)

Table 2: Hospitals and its Related Ratios during the Period (2004-2008)

Hospitals and Health Centers Data	**2004**	**2005**	**2006**	**2007**	**2008**
Hospital Numbers	97	98	101	103	103
Hospital Beds	9,820	10,079	11,049	11,043	11,200
Ministry of Health Hospital Beds	3,606	3,638	4,235	4,250	4,333
Royal Medical Services Hospital Beds	1,801	1,917	2,119	2,131	2,129
Jordan University Hospital Beds	540	536	531	531	522
King Abdulla University Hospital Beds	304	388	457	489	504
Private Sector Hospital Beds	3,569	3,600	3,707	3,642	3,712
Hospital Utilization					
Hospital Bed Per 10,000 Population	17	17	19	18	18
Admission Per 1,000 Population	122	128	130	140	142
Average Occupancy Rate (%)	63.3	64.1	60.9	63.7	65.1
Average Length of Stay (Days)	3.3	3.2	3.2	3.1	3.2
Average Death Rate (%)	1.4	1.5	1.4	1.5	1.4
Ministry of Health Centers					
Comprehensive Health Centers	53	57	58	64	68
Primary Health Centers	349	368	370	377	375
Peripheral Health Centers	250	238	243	238	240
MCH Centers	365	385	406	416	419
Chest Disease Centers	12	12	12	12	12
Dental Clinics	260	274	274	285	313
Ministry of Health Budget of the Total Government Budget (%)	6	5.7	6.1	5.6	7.4
Per Capita of GDP (Jordanian Dinar)	1,515.6	1,662.4	1,805.1	1,966.7	2,425.6

This table shows some hospital and health centers statistics and ratios in Jordan during the period 2004-2008. Source: MOH (2008)

Table 2 exhibits that hospital numbers (beds) in Jordan increased from 97 (9820) in 2004 to 103 (11200) in 2008. This growth represents more than the population growth, hence hospital utilization indicators have improved significantly. This is due to the increasing budget of the Ministry of Health from 6% of the total government budget to 7.4%. However, this ratio is still less than that in the developed countries.

DATA AND METHODOLOGY

This section starts by reporting the data used in the study, then presenting the results of DEA efficiency scores, Pabon Lasso graph and, finally, discussing the results.

The Data

Annual data were collected from Annual Statistical Reports published by the MOH for 15 public hospitals for the period (2006-2008). Hospitals are shown in the tables and are coded with letters (A, B, C, D... O). Hospital A is the largest public hospital in Jordan, B is the second largest and so on. Since DEA operates better when the number of DMUs exceeds the number of the combined total of inputs and outputs by at least twice (Drake and Howcroft, 1994), 3 inputs and 3 outputs are selected for the 15 hospitals.

The input data, shown in table 3, are: (1) The annual number of bed days, which is the number of beds multiplies by 365 day; (2) Number of physicians per year, which includes all physicians who are full-timers, no part-timers are employed; and (3) Number of health personnel per year, such as nurses, lab technicians, physical therapists and pharmacists, who are full-timers, no part-timers are employed.

Table 3: Inputs Data for Each Hospital in Each Year during the Period (2006-2008)

Hospital Code & Name / Outputs	Bed Days			Physicians			Health Personal		
	2006	2007	2008	2006	2007	2008	2006	2007	2008
A (Al-Basheer)	338,720	338,720	336,165	558	621	557	1,619	1,479	1,425
B (Princess Basma)	73,730	73,730	73,730	220	214	245	499	536	592
C (Al-Zarqa)	109,500	109,500	109,500	183	204	219	466	445	451
D (Al-Husein/Salt)	55,480	55,480	55,480	176	156	170	392	379	388
E (Al-Mafraq)	21,900	24,090	27,375	36	36	37	214	26	216
F (Jarash)	49,275	49,275	49,275	49	48	46	276	282	303
G (Ma'an)	44,530	47,815	47,815	34	33	35	160	205	191
H (Al-Iman/Ajloun)	38,325	38,325	38,325	45	44	42	254	260	281
I (Al-Karak)	50,005	45,625	45,625	85	93	101	313	309	344
J (Al-Tutanjee / Madaba)	47,085	47,085	47,815	98	10	105	280	275	292
K (Al-Ramtha)	22,265	22,265	37,960	45	43	45	254	175	232
L (Al-Shunah-South)	17,155	17,520	17,520	35	37	32	119	114	127
M (Ghor Al-Safi)	22,630	29,930	29,930	38	37	43	135	138	154
N (Abu-Obaidah)	16,790	16,790	16,790	32	35	34	161	154	157
O (Mua'th Bin Jabal)	11,680	11,680	29,930	30	36	34	144	146	155
TOTAL	**919,070**	**927,830**	**963,235**	**1,664**	**1,647**	**1,745**	**5,286**	**4,923**	**5,308**

This table shows the input ratios for 16 public hospitals in Jordan during the period 2006-2008.

Table 3 reveals that the total bed days, number of physicians and health personnel in the 15 public hospitals increased from 919070, 1664 and 5286 in 2006 to 963235, 1745 and 5308 in 2008, in that order. The output data, reported in Table 4, are: (1) The annual number of patient days; (2) Number of minor surgical operations per year; and (3) Number of major surgical operations per year. Table 4 demonstrates that the total patient days, minor and major operations in the 15 public hospitals increased from 656057, 21122 and 17625 in 2006 to 656976, 21284 and 19411 in 2008, respectively.

Table 4: Outputs Data for Each Hospital in Each Year during the Period (2006-2008)

Hospital Code & Name / Outputs	Patient Days			Minor Operations			Major Operations		
	2006	2007	2008	2006	2007	2008	2006	2007	2008
A (Al-Basheer)	235,316	243,798	241,378	6,375	5,750	5,875	7,419	8,041	8,477
B (Princess Basma)	61,883	61,848	67,714	425	158	117	1,516	1,332	1,443
C (Al-Zarqa)	83,087	68,123	80,940	5,575	5,177	5,957	2,354	1,629	2,690
D (Al-Husein/Salt)	38,891	39,435	40,752	1,851	264	2,874	1,726	1,629	1,598
E (Al-Mafraq)	15,699	1,648	18,300	405	403	254	149	144	102
F (Jarash)	30,068	30,590	28,277	1,041	1,159	992	490	610	556
G (Ma'an)	28,274	28,763	28,452	176	246	308	380	402	407
H (Al-Iman/Ajloun)	26,442	28,235	27,701	843	895	811	313	360	373
I (Al-Karak)	29,335	29,625	30,369	671	1,084	1,079	963	1,105	1,351
J (Al-Tutanjee / Madaba)	32,518	31,478	31,878	1,596	1,374	1,400	1,241	1,326	1,285
K (Al-Ramtha)	26,442	11,215	12,600	843	613	631	481	372	449
L (Al-Shunah-South)	10,582	12,750	12,239	150	73	89	120	217	175
M (Ghor Al-Safi)	16,866	20,259	20,372	407	402	453	161	3,231	285
N (Abu-Obaidah)	12,234	11,840	10,602	452	338	246	177	170	144
O (Mua'th Bin Jabal)	8,420	8,864	5,402	312	348	198	135	179	76
TOTAL	**656,057**	**628,471**	**656,976**	**21,122**	**18,284**	**21,284**	**17,625**	**20,747**	**19,411**

This table shows the output ratios for 16 public hospitals in Jordan during the period 2006-2008.

The Pabon Lasso model is also applied to assess the performance of the fifteen public hospitals in Jordan. This type of analysis is used for quick identification of poorly performing hospitals and finding appropriate strategies to correct the inefficiency. The indicators were also derived from the Annual Statistical Reports published by the MOH for 15 hospitals for the period (2006-2008). The indicators are presented in Table 5.

Table 5 illustrates that the total number of admissions in the 15 public hospitals increased from 206809 in 2006 to 656976 in 2008. While the mortality rate of 1.3% did not changed, the occupancy rate (bed turnover ratio) decreased from 72.4% (87.5%) in 2006 to 65.5% (82.8) in 2008, correspondingly.

RESULTS

This study uses DEA online software to obtain the results. The DEA efficiency scores for the 15 hospitals in each year during the period (2006-2008) are documented in table 6.

In table 6, the relatively efficient best-practice hospitals are given an efficiency score of 100%, while the relatively inefficient ones are given efficiency score less than 100%.

In 2006, 8 of the 15 hospitals have inefficiencies in one or more aspects of their operations. The distribution of inefficient hospitals over efficiency scores ranged from 78.9% to 99.9%. The relatively most inefficient hospital with 78.9% efficiency score indicates that efficient hospitals can obtain at least the level of each output that this hospital obtained by having available no more than 78.9% of input resources required by such hospital. This also means that this hospital should be able to produce its actual output level with 78.9% of the available resources, i.e. or using 21.1% less of each input.

Table 5: Ratio Indicators of Each Hospital in Each Year during the Period (2006-2008)

Hospital Code & Name / Outputs	No. of Admissions			Mortality Rate %			Occupancy Rate (OCC) %		
	2006	2007	2008	2006	2007	2008	2006	2007	2008
A (Al-Basheer)	66,733	74,646	73,467	2.0	2.1	1.9	96.3	72.0	73.1
B (Princess Basma)	16,467	16,351	18,028	1.3	1.6	1.1	83.9	85.1	91.6
C (Al-Zarqa)	26,861	22,296	28,607	1.7	1.3	1.4	75.9	62.2	73.3
D (Al-Husein/Salt)	15,103	15,389	15,705	2.1	1.6	1.7	70.1	69.3	73.3
E (Al-Mafraq)	5,229	5,042	5,001	3.2	3.0	3.6	71.7	69.8	70.5
F (Jarash)	12,651	13,166	11,957	1.4	1.2	1.5	61.0	62.1	57.2
G (Ma'an)	6,680	7,010	6,675	0.9	0.4	0.5	63.5	62.0	59.3
H (Al-Iman/Ajloun)	9,881	10,614	10,625	1.5	1.1	1.2	96.0	73.3	72.1
I (Al-Karak)	10,648	10,996	11,156	1.5	1.5	1.3	58.7	62.4	66.4
J (Al-Tutanjee / Madaba)	10,955	10,960	11,085	1.7	1.6	1.6	69.6	66.9	66.5
K (Al-Ramtha)	6,778	6,267	6,926	0.5	0.6	1.1	58.0	51.2	40.0
L (Al-Shunah-South)	3,650	4,089	4,141	0.1	0.3	1.0	61.7	72.8	69.7
M (Ghor Al-Safi)	5,300	6,081	6,175	0.5	0.5	0.5	74.5	67.7	67.9
N (Abu-Obaidah)	4,450	4,278	4,263	0.4	0.7	0.3	72.9	70.5	63.0
O (Mua'th Bin Jabal)	3,417	4,101	2,350	0.5	0.6	0.4	72.1	75.9	39.0
TOTAL/AVERAGE	**206,809**	**213,293**	**218,169**	**1.3**	**1.2**	**1.3**	**72.4**	**68.2**	**65.5**

Hospital Code & Name / Outputs	Length of Stay (LOS)			Bed Turnover Ratio (TIN) %		
	2006	2007	2008	2006	2007	2008
A (Al-Basheer)	3.5	3.3	3.3	71.9	80.2	81.6
B (Princess Basma)	3.8	3.8	3.8	81.3	82.2	89.0
C (Al-Zarqa)	3.1	3.0	2.8	89.5	74.8	95.0
D (Al-Husein/Salt)	2.6	2.6	2.6	99.4	98.5	103.3
E (Al-Mafraq)	3.0	3.2	3.7	87.3	79.7	70.6
F (Jarash)	2.4	2.3	2.4	93.6	97.5	88.4
G (Ma'an)	4.2	4.1	4.3	54.7	55.2	51.0
H (Al-Iman/Ajloun)	2.7	2.7	2.6	94.0	101.2	101.2
I (Al-Karak)	2.8	2.7	2.7	77.7	84.4	89.3
J (Al-Tutanjee / Madaba)	3.0	2.9	2.9	85.7	84.4	84.7
K (Al-Ramtha)	1.9	1.8	1.8	111.4	104.6	80.2
L (Al-Shunah-South)	2.9	3.1	3.0	77.7	85.3	86.3
M (Ghor Al-Safi)	3.2	3.3	3.3	85.4	74.1	75.3
N (Abu-Obaidah)	2.7	2.8	2.5	96.9	93.0	92.5
O (Mua'th Bin Jabal)	2.5	2.2	2.3	106.6	128.4	53.0
TOTAL/AVERAGE	**3.0**	**2.9**	**2.9**	**87.5**	**88.2**	**82.8**

This table shows hospital ratios for the sample that will be used in Pabon Lasso Diagram during the period 2006-2008.

However, the number of inefficient hospitals decreased in 2007 to 6 hospitals. Four of the inefficient hospitals in 2006 increased their scores in 2007. Nevertheless, in 2008, inefficient hospitals increased to 7 hospitals, with 4 hospitals remained relatively inefficient during the period of the study. Unexpectedly, one hospital witnessed a sharp decrease in its efficiency score in 2008 with a score of 28%.

The results are almost consistent with Al-Shammari (1999), who measured the same 15 sample hospitals during the period 1991-1993. He reported that the number of inefficient hospitals decreased from 8 in 1991 to 6 hospitals in 1992 and further to 4 inefficient hospitals in 1993. In addition, comparing the efficiency of the same hospital between 1993 (Al-Shammari, 1999) and 2008 (this study) shows that the number of efficient hospitals decreased from 11 in 1993 to 8 hospitals in 2008; and, consequently, the average efficiency score dropped from 98% in 1993 to 90% in 2008. In fact, 6 hospitals (A, C, D, F, G

and I) maintain their 100% score of efficiency; 2 hospitals (B and H) improved their efficiency scores; and 7 hospitals (E, J, K, L, M, N and O) deteriorated their efficiency scores, particularly 3 hospitals (M, N, and O) which were fully efficient in 1993.

This result might be explained by that the level of fixed and working capital investments in the public hospitals had not been enough to match the higher level of population growth rate. While the annual population growth rate is around 3%, government expenditures on public health care and hospitals is remain almost constant, taking into consideration the inflation rate in health care materials and supplies.

Table 6: DEA Efficiency Scores for Each Hospital in Each Year during the Period (2006-2008)

Hospital Code & Name	DEA Efficiency Scores			
	2006	**2007**	**2008**	**AVERAGE**
A (Al-Basheer)	100.0%	100.0%	100.0%	**100.0%**
B (Princess Basma)	100.0%	100.0%	100.0%	**100.0%**
C (Al-Zarqa)	100.0%	100.0%	100.0%	**100.0%**
D (Al-Husein/Salt)	100.0%	100.0%	100.0%	**100.0%**
E (Al-Mafraq)	**94.9%**	**88.0%**	**89.8%**	**90.9%**
F (Jarash)	100.0%	100.0%	100.0%	**100.0%**
G (Ma'an)	100.0%	100.0%	100.0%	**100.0%**
H (Al-Iman/Ajloun)	**99.9%**	100.0%	100.0%	**100.0%**
I (Al-Karak)	**85.8%**	**93.3%**	100.0%	**93.0%**
J (Al-Tutanjee / Madaba)	100.0%	100.0%	**97.2%**	**99.1%**
K (Al-Ramtha)	**89.2%**	**77.1%**	**72.9%**	**79.7%**
L (Al-Shunah-South)	**78.9%**	**93.2%**	**89.4%**	**87.2%**
M (Ghor Al-Safi)	**98.2%**	100.0%	**95.5%**	**97.9%**
N (Abu-Obaidah)	**94.2%**	**92.3%**	**79.3%**	**88.6%**
O (Mua'th Bin Jabal)	**90.5%**	**99.8%**	**28.1%**	**72.8%**
AVERAGE	**95.4%**	**96.2%**	**90.1%**	**93.9%**

This table shows hospital efficiency scores as a product of DEA computation during the period 2006-2008.

Efficiency Scores

In addition to the identification of inefficient hospitals and their efficiency reference set, the DEA online software provides additional insights on how to improve the efficiency of the hospital. Table 7 provides the results that pertain to either the potential reduction in the usage of inputs (-) or the potential increase in the production of outputs (+) to increase efficiency for each inefficient hospital during the period (2006-2008).

Table 7 suggests that, to improve the efficiency, practices (in Al-Mafraq, Al-Karak, Al-Tutanje/Madaba, Al-Ramtha, Al-Shuna-South, Ghor Al-Safi, Abu Obaidah and Muath Bin Jabal hospitals) should work either to reduce the inputs of bed days, physicians and health personnel, and/or to increase the potential output of patient day, and minor and major operations.

Pabon Lasso Diagram

Pabon Lasso graph divides hospitals into 4 categories, as shown in Figure 1. The results for the 15 hospital performance assessment by Pabon Lasso are shown in Figure 2. The three graphs show that it is more useful to compare the indicators of the hospitals with one another than the indicators of each hospital used in isolation.

Table 7: The Potential Reduction in the Usage of Inputs and/or Increase the Outputs for Each Inefficient Hospital during the period (2006-2008)

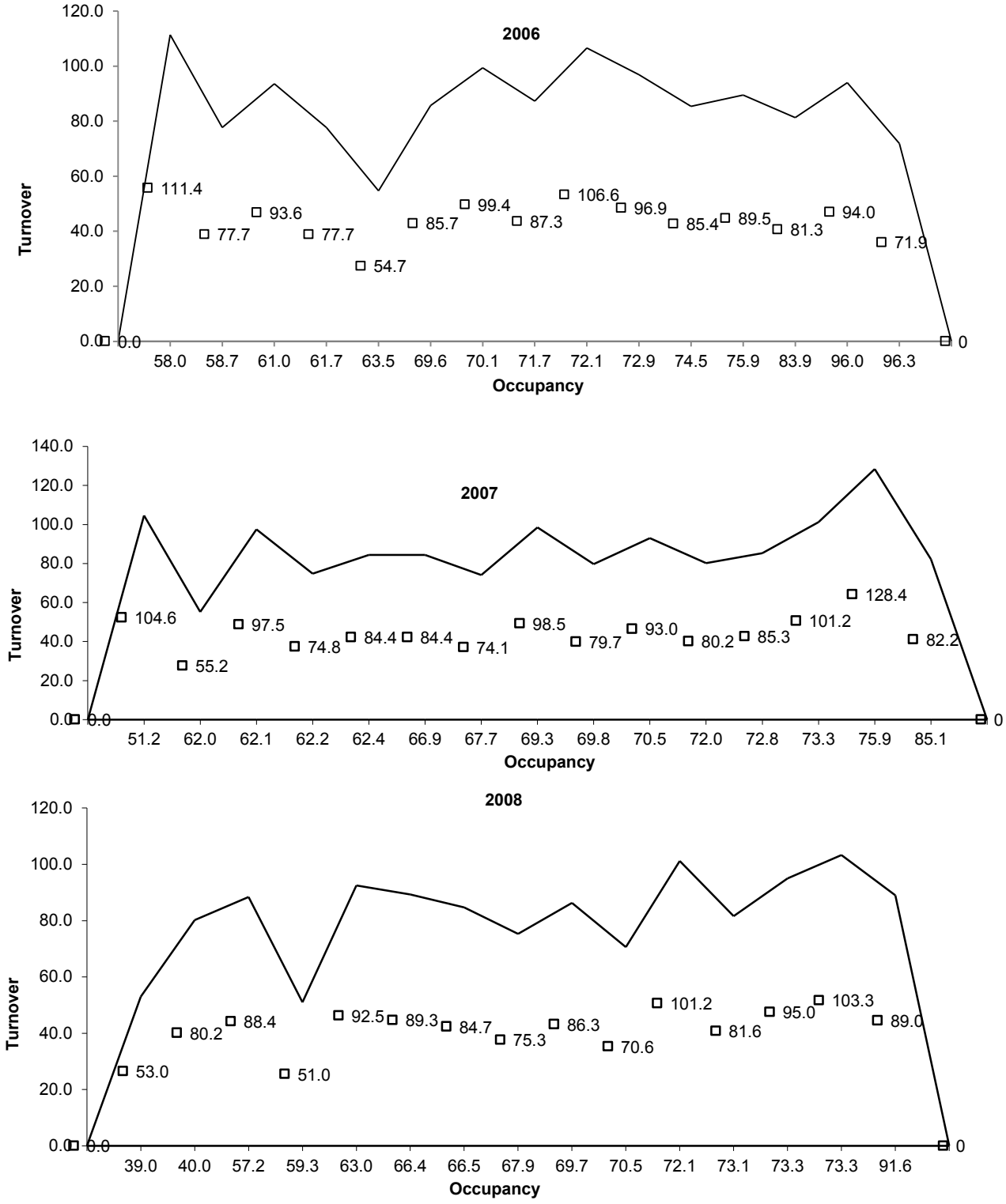
Hospital Code & Name	INPUTS								
	Bed Days			Physicians			Health Personal		
	2006	2007	2008	2006	2007	2008	2006	2007	2008
A (Al-Basheer)									
B (Princess Basma)									
C (Al-Zarqa)									
D (Al-Husein/Salt)									
E (Al-Mafraq)	-5%	-12%	-10%	-5%	-12%	-14%	-59%	-35%	-16%
F (Jarash)									
G (Ma'an)									
H (Al-Iman/Ajloun)									
I (Al-Karak)	-14%	-7%		-14%	-7%	0%	-32%	-27%	
J (Al-Tutanjee / Madaba)			-3%			-3%			-3%
K (Al-Ramtha)	-11%	-23%	-53%	-10%	-22%	-27%	-31%	-46%	-67%
L (Al-Shunah-South)	-22%	-7%	-11%	-21%	-7%	-11%	-44%	-7%	-11%
M (Ghor Al-Safi)	-2%		-4%	-2%		-4%	-30%		-4%
N (Abu-Obaidah)	-6%	-8%	-21%	-5%	-8%	-21%	-54%	-30%	-39%
O (Mua'th Bin Jabal)	-10%	-1%	-74%	-19%	-8%	-72%	-60%	-78%	-72%

Hospital Code & Name	OUTPUTS								
	Patient Days			Minor Operations			Major Operations		
	2006	2007	2008	2006	2007	2008	2006	2007	2008
A (Al-Basheer)									
B (Princess Basma)									
C (Al-Zarqa)									
D (Al-Husein/Salt)									
E (Al-Mafraq)				154%	1%	83%	194%	64%	162%
F (Jarash)									
G (Ma'an)									
H (Al-Iman/Ajloun)									
I (Al-Karak)	2%			32%					
J (Al-Tutanjee / Madaba)	0%		2%						
K (Al-Ramtha)	11%		4%						
L (Al-Shunah-South)				15%	153%	161%	140%	24%	27%
M (Ghor Al-Safi)				176%		13%	197%		97%
N (Abu-Obaidah)				50%			91%	52%	41%
O (Mua'th Bin Jabal)							65%	63%	35%

This table shows the potential reductions in the inputs and/or increase the outputs for each inefficient hospital during the period (2006-2008). (-) indicates potential reduction in the usage of inputs, (+) potential increase in the production of outputs, and (shaded cell) indicates efficient use of the designated variable.

Efficient hospitals in this study fall into Zone 3 of the Pabon Lasso graph. These institutions can reach an ideal level of performance through appropriate service management and conforming to the current admission and hospital stay standards. However, hospitals that fell into Zone 4 with high average long stay ratio and low (BTO). A situation that felt to be due mainly to the nature of the diseases treated in these centers. Broad strategies for enhancing the performance of Zone 4 hospitals include a shift towards outpatient services and efforts to overcome shortages and improve management.

Figure 2: Pabon Lasso Graph for the 15 Hospitals for Each Year during the Period (2006-2008)



These figures show Pabon Lasso diagrams for the 15 public hospitals in years 2006, 2007 and 2008, respectively. TIN is bed turnover ratio and OCC is the occupancy rate. The alphabetical letters (A, B, C …,and O) in the diagrams are designated for hospital names as identified in the tables above.

Nevertheless, hospitals that fell into Zone 1 indicate poor performance and inefficient usage of resources. One short-term strategy to address this problem could include a halt to hospital expansion for the time being. At the same time, every effort should be made to identify and correct factors contributing to the present state of poor efficiency. Finally, those hospitals that fall in Zone 2 are characterized by excess bed supply, unnecessary bed supply and the use of beds for patient observation.

CONCLUDING COMMENTS

This study aimed at measuring the relative efficiency of public hospitals performance in Jordan, during the period (2006-2008). It employed a non-parametric mathematical programming model (DEA) to measure hospital efficiency, and a graphical analysis (Pabon-Lasso Diagram) to interpret efficiency. The study used 3 input variables: the annual number of bed days, number of physicians per year and number of health personnel per year; and 3 output variables: the annual number of patient days, number of minor surgical operations per year and number of major surgical operations per year, for 15 public hospitals in Jordan for the period (2006-2008).

The results indicate that the average efficiency of public hospitals in Jordan during the period (2006–2008) is varied and ranges between (73%) to (100%). The average of the relative efficiency of the sample hospitals over the study period is 94%. Of 15 hospitals, the number of efficient hospitals increased from 7 in 2006 to 9 in 2007, but decreased to 8 in 2008.

The results are compared with Al-Shammari (1999), who measured the same 15 sample hospitals. This comparison leads to signify that the efficiency of public sector hospitals in Jordan is varied over time, due to decreasing public expenditures on health care per capita, in real not nominal values. On the other hand, the analysis shows that large hospitals strongly outperform small and medium ones in terms of efficiency. This might lead to conclude that hospital size is a determinant of efficiency.

However, the results concerning ratio analysis in explaining efficiency implies that efficient hospitals fall into Zone 3 of the Pabon Lasso graph. Inefficient hospitals fell into Zone 1, 2 and 4. This inconsistency implies that these institutions are either having poor management or they treat long stays diseases.

Efficiency scores show how close hospitals to using their maximum performance capacity. Thus, it is recommended that inefficient public hospitals need to improve their efficiency and performance, by either (1) appropriate service management, (2) conforming to the current admission and hospital stay standards, (3) shift towards outpatient services, and/or (4) encourage resources employment efficiency by better handing expenses.

Due to the limitations of the variables included in the model, the results of the study should be taken with cautious. Quality of health care inputs, i.e. staff and equipments, and health care outputs and satisfaction are among the missing factors in the model. Future research is recommended to incorporate these factors into the model. We recommend use of the DEA technique in assessing and measuring performance of hospitals because it can be used regardless of their types and seeks to address the limitations of other models. However, more research employing advanced DEA modeling should be devoted to analyze the impact of other regulatory-specific and hospital-specific variables on efficiency such as quality of health care services.

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