



**EXAMINING RELATIVE EFFICIENCY OF
JORDANIAN PUBLIC HOSPITAL BY USING DATA
ENVELOPMENT ANALYSIS (DEA)**

By

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LIST OF ABBREVIATIONS

DEA	Data Envelopment Analysis
DMUs	Decision-Making Units
MOH	Ministry of Health
PHC	Primary Health Care
HS	Health Sector
HR	Human Resources
HCQ	Health Care Quality
TQM	Total Quality Management
ECM	Efficiency Contribution Measure
EMS	Efficiency Measurement System
SFA	Stochastic Frontier Analysis
IRS	Increasing Return to Scale
EE	Economic Efficiency
DRS	Decreasing Return to Scale
CE	Cost Efficiency
BBC	Banker, Charnes and Cooper Model
CCR	Charnes, Cooper and Rhodes Model
CRS	Constant Returns to Scale
OTE	Ordinary Technical Efficiency
LHDs	Local Health Departments
LPHO	Local Public Health Operations
NACCHO	National Association of County and City Health Officials
OECD	Organization for Economic Co-Operations and Development
WHO	World Health Organization
QALYs	Quality-Adjusted Life Years
SE	Scale Efficiency
SPSS	Statistical Package for Social Sciences
TE	Technical Efficiency
RE	Relative Efficiency
PE	Productive Efficiency

Pemeriksaan Kecekapan Relatif terhadap Hospital-Hospital Kerajaan di Jordan dengan menggunakan Analisis Penjejakan Data (DEA)

ABSTRAK

Sistem penjagaan kesihatan menghadapi cabaran baharu sepanjang masa. Peraturan-peraturan baharu, teknologi baharu, dan organisasi-organisasi baharu dibentuk secara berterusan seiring dengan perubahan yang berlaku terhadap dasar-dasar awam. Pengurus penjagaan kesihatan perlu bertindak balas terhadap cabaran-cabaran ini dengan ritma pengukuran prestasi dalam membuat keputusan. Kecekapan hospital dan pusat penjagaan kesihatan adalah kebimbangan utama bagi kerajaan, yang sering memberi pembiayaan yang besar kepada organisasi perubatan dan hospital. Para pemimpin dan pengurus perlu membuat keputusan terhadap langkah-langkah prestasi dan kecekapan bekerja. Kajian ini bertujuan untuk mengukur kecekapan prestasi hospital-hospital kerajaan di Hashemite Kingdom Jordan, bagi jangkamasa 2013 hingga 2016. Model Analisis Penjejakan Data (DEA), menurut skala skala pemulangan (CSR or CCR) dan skala pembolehkan untuk kembali (VSR or BCC) digunakan untuk mengukur kecekapan teknikal sepuluh (10) buah hospital kerajaan yang beroperasi di Jordan, menggunakan lima (5) pembolehkan input (sumber hospital) dan lima (5) pembolehkan output (perkhidmatan yang disediakan di hospital). Perisian Python digunakan untuk membuat analisis DEA yang digunakan dalam kajian ini. Keputusan analisis kajian mendapati bahawa hospital-hospital kerajaan di Jordan beroperasi mengikut ukuran idealnya sebanyak 93%, dan tidak ada hubungan yang signifikan secara statistik antara saiz hospital dan tahap kecekapan. Berdasarkan model CCR, hospital-hospital berkenaan didapati mempunyai purata kecekapan teknikal sebanyak 90.3%, yang membawa maksud bahawa mereka dapat menyediakan tahap perkhidmatan yang sama dengan menggunakan hanya 90.3% sumber daya semasa. Seterusnya, dapatan daripada model CCR menunjukkan bahawa 12 daripada 40 hospital adalah 100% cekap, dan tahap kecekapan berada dalam lingkungan 59.4% hingga 100%. Sebaliknya, berdasarkan model BCC, didapati bahawa 14 daripada 40 buah hospital adalah 100% cekap dalam tempoh kajian yang sama. Kecekapan semua unit berada dalam lingkungan 73.9% hingga 100%. Skor kecekapan purata bagi semua unit adalah 93.5% yang bermaksud bahawa hospital-hospital kerajaan di Jordan secara kolektifnya menyumbang sebanyak 6.5% sumber yang belum diterokai yang boleh dicapai melalui peningkatan perkhidmatan yang diberikan kepada pesakit; jika analisis data mengambil kira saiz operasi mereka ketika analisis dijalankan. Kementerian Kesihatan Jordan boleh menggunakan model DEA dalam mengukur prestasi hospital kerana ciri-ciri tersendiri yang tidak terdapat dalam kaedah analisis tradisional yang digunakan sebelum ini. Kajian ini menyarankan bahawa hospital-hospital kerajaan yang tidak mempunyai tahap keberkesanan maksimum perlu melaksanakan pengagihan semula sumber dan mengoptimumkan penggunaan sumber yang sedia ada. Kementerian Kesihatan Jordan berminat menyediakan pangkalan data yang tepat kepada aktiviti unitnya, dan juga untuk membangunkan buletin Pusat Maklumat Kesihatan di Jordan untuk penyebaran maklumat.

Kata kunci: DEA, Kecekapan, Prestasi, Hospital, dan Jordan

Examining Relative Efficiency of Jordanian Public Hospital by using Data Envelopment Analysis (DEA)

ABSTRACT

The healthcare system always encounters new challenges that include new regulations, new technologies, and new organizations in response to the changing public policy. Managers of healthcare sectors are in need to respond to these new challenges with appropriate and sound performance measure before a precise decision-making is made. Hence, the efficiency of hospitals and health care centres is a major concern for governments, which often provide substantial funding to medical organizations and hospitals. Leaders and managers need decision-making such as performance and efficiency measures. Therefore, this study aims to measure the efficiency of the government hospitals' performance in the Hashemite Kingdom of Jordan, during the period of 2013 until 2016. The DEA method, according to the constant return to scale (CRS or CCR), and variable scale to return (VSR or BCC) was applied to measure the relative efficiency of ten public hospitals in Jordan, by using five of the input variables (hospitals resources) and five of the output variables (services provided in hospitals). The Python-DEA software was used to run the analysis. The study concludes that the public hospitals in Jordan operate according to their ideal size by 93%, and there is no statistically significant relationship between hospital size and the efficiency degree. Hospitals under the study have an average relative efficiency of 90.3% according to the CCR model, which means that they can provide the same services level using only 90.3% of their current resources. 12 out of 40 hospitals were 100% efficient according to the CCR model, and the degrees of efficiency ranges from 59.4% to 100%. On the other hand, according to the BCC model, 14 out of 40 hospitals were 100% efficient in the same period. The efficiency of all units was between 73.9% and 100%. The average efficiency score for all units was 93.5% which means that hospitals of the Ministry of Health, Jordan collectively account for 6.5% of untapped resources that can be accessed by improving the services provided to patients if the analysis takes into account the size of their operations when performing the analysis. The Jordanian Ministry of Health can adopt the DEA models in measuring hospital performance because its distinctive features are not available in the traditional methods used. Based on the findings, it is suggested that hospitals that do not have a full efficacy degree should adopt the redistribution of resources and ensure optimal uses of current resources. The Jordanian Ministry of Health is keen on providing accurate databases to the activities of its units and developing the bulletins of the Jordanian Health Information Centre to spread the information.

Keywords: DEA, Efficiency, Performance, Hospitals, and Jordan

CHAPTER 1: INTRODUCTION

1.1 Overview

Government service institutions, like health sector institutions in many countries, are currently facing severe restrictions on the resources allocated to them, and these organizations can make efficient use of their resources to meet the changing needs of beneficiaries. The efficient use of these resources includes the provision of clear and accurate data on resource distribution and its effect on health services' efficiency and performance (Du, 2017).

The efficiency of hospitals is a major concern for governments, which often provide substantial funding to these hospitals through the Ministry of Health and its authorities. Leaders and managers need to evaluate investments in health, and realistic decision-making, such as performance and efficiency analysis (Bao & Bardhan, 2017). Healthcare organizations are required to achieve efficiency; they have to reduce costs, turning off waste of resources, and optimal use of resources (Wang & Gao, 2017).

According to Helal and Elimam (2017), providing quality health services to society is one of the biggest challenges faced by hospital administrators and health centers, as these services are directly related to the health, lives, and the ability of individuals to give and produce. Point of fact, governments aim to develop the health sector that includes the provision of therapeutic care and improve the efficiency of its performance, and the development of appropriate regulation of the operation in governmental hospitals on an economic basis and the implementation of the health insurance system (Wang & Gao, 2017).

In some aspects, measuring the efficiency of the healthcare sector is of utmost importance. There is a likelihood that higher performance can be attained by a system in the absence of a large rise in input, and the causes of system inefficiency can be identified via environmental factors, as constant efficiency measurement over time is proficient in monitoring and gauging the best way to formulate restructurings that stimulate efficient relative allocation in a hospital (Hadipour, Kavousi Kelashomi, Salari, & Motamed, 2017).

In the Hashemite Kingdom of Jordan, the Ministry of Health has provided health services that have witnessed remarkable progress in all aspects of preventive and curative care, maternal, childcare, and others in time by which notable improvement is realized in indicators of health status. Despite the great achievements achieved, the health sector faces many challenges. It is important to continue to raise the efficiency of health services and ensure that they are available to the entire population (Ministry of Health, 2015).

Compared with the advanced states, Jordan exhibit a high degree of population growth, inadequate natural resources as well as middle-income rate. Indicators revealed an increase in the number of populations from 4.2 million in 1994, to about 6.5 million in 2013, as published by the Department of Statistics, while the results and statistics indicate that the population of Jordan 10 million by the end of 2016. The levels of birth rate in Jordan are still among the highest in comparison with the advanced countries, (Ministry of Health, 2015). Figure 1.1 shows the distribution and size of the population in Jordan relative to the area that is small compared to other countries.

Efficiency measurement via statistics data envelopment analysis has been verified to be a fantastic approach. The application of DEA to health care evaluation has come to be a vital and attractive lookup topic over the years in fields such as management, health care administration, and public policy (Wang, Wang, Su, & Du, 2015).

It aims to identify inefficiencies in the use of resources available to these institutions, and the most appropriate allocation of these resources by assessing the quality of their inputs and outputs. Quite recently, the measurement of the efficiency of decision-making units (DMUs) is only possible through the use of DEA in distinct sectors such as the health sector. Several studies have assessed the efficiency of hospitals, health centers, and the overall healthcare system by using DEA in a different setting (Wang & Gao, 2017). This study aims to measure the performance of hospitals of the Ministry of Health in the Hashemite Kingdom of Jordan by measuring the efficiency of the performance of public hospitals, using the DEA. (Qarashay & Alzubi, 2018).

1.2 Background of the Study

The population of Jordan is assuming to be 9798000 million with an 87,000 area per square kilometers (General Statistics Book, 2016), while in terms of accessibility to health and performance, the Jordanian health sector is perceived to be among the finest in the region, and as compared to other developing nations, the uneven distribution of resources makes it inefficient and at the same expensive. Regardless of the relative rate of an educated population, the rate of adult illiteracy stood at 9.9%. Reports from the health sector revealed positive indicators with a life expectancy of 73.5% at birth, as well as an infant mortality rate of 17 per 1,000 live births (Ministry of Health, 2016). Notwithstanding, there seems to be a continuous rise in the population of Jordan. The reproductive rate stood at 3.7 children per woman in terms of the total fertility rate while

the population under the age of 15 years is 41% (i.e. entering their prime fertile years) (Ministry of Health, 2016). Simultaneously, the number of oldies in the population has increased due to an increase in the death rate. The increased expenditure in health care raises a few concerns as a result of these factors.

The health institutions in Jordan have to keep up to date with advancements in technology and apparently, physical infrastructure is good. Despite that, problems persist in the health sector working environment. For instance, there is a lack of up to date activities concerning the managerial and marketing aspect, a decline in the rate of occupancy, shortage of professional staff, deficiency in an organization between the delivery system, and multiple public and private financing (Jordan Times, 2014). The occupancy rate in the Jordanian hospital bed approximately stood at 62.2 % (Ministry of Health, 2015) which is beneath the normally conventional standard of 80 %.

Concerning the data reported by Jordan National Health Accounts (NHA (2013), a total of almost 450 million Jordanian Dinars (JD) was spent by Jordan on the health sector, accounting for about 9.12% of the total GDP. JD 210 (US\$281) was estimated to be the health expenditure per capita in 2004. The proportion of GDP spent on health care as revealed by the NHA results is perceived to be extremely high. Even so, it might be difficult to sustain the level of expenditure due to the low rates of economic growth and the large population (M. M. Ajlouni et al., 2013). In 2003, statistics have that there are 22.6 physicians and at the same time, in all categories 29.3 nurses per 10,000 population in Jordan, respectively. These indicators which average 25 physicians per 10,000 persons are close to those found in the Organization for Economic Co-operation and Development (OECD) countries regarding the physician per population ratio, which is averagely more than the 8 per 10,000 reported in the Middle East and North African (MENA) region. The percentage of hospital beds (17.7) per 10,000 in Jordan is averagely the same as those in

the MENA region and probable lesser than either the United States (44 beds per 10,000) or OECD countries (83 beds per 10,000) (M. M. Ajlouni et al., 2013), Ministry of Health, (2015).

Table 1.1 Population and Health Information over the Years (2016 - 2012)

No	Statement	2012	2013	2014	2015	2016
1	Population	6388000	6530000	6675000	9531712	9798000
	The illiteracy rate among the population aged 15 and over					
2	Males	3.5	3.7	3.7	3.4	3.4
	Females	10	10.1	9.8	9.5	9.4
	Rate	6.7	6.8	6.7	6.4	6.4
3	Crude birth rate per 1000 population	28.1	28.1	28.6	–	23.0
4	Population growth rate	2.2	2.2	–	5.3	2.4
5	The average size of the family	5.4	5.4	–	4.8	4.8
6	Total Fertility Rate	3.5	3.5	3.5	3.5	3.38
	Life expectancy at birth					
7	Males	71.6	72.4	72.7	72.7	72.5
	Females	74.4	76.7	76.7	76.6	74.0
	Rate	73.0	74.4	74.4	74.4	73.2
8	Crude mortality per 1000 population	7.0	7.0	6.1	6.1	6.1
9	Infant mortality rate per 1000 live births	17.0	17.0	17.0	17.0	17.0
10	Maternal mortality rate per 100,000 births	–	–	19.0	19.0	19.0
11	(%) Dependency ratio	68.2	68.2	68.1	61.4	61.4
12	(%) Unemployment rate	12.2	12.6	11.9	13.0	13.0
13	Doctors rate per 10,000 people	27.1	28.6	29.4	22.2	14.1

14	Average number of dentists per 10,000 people	10.0	10.4	10.3	7.1	7.1
15	Nurse rate (legal, participant, midwife, assistant) per 10,000	46.6	44.8	45.3	24.8	26.4
16	Pharmacist rate per 10,000 people	16.3	17.8	18.3	12.7	15.5

- Source of Population and Vital Information Department of Statistics, DHS 2013.

- Source of Health Information (Ministry of Health).

Table 1.2 The Demographic and Health Information during the Years 2012 to 2016

No	Statement	2012	2013	2014	2015	2016
1	Total hospitals	106	103	104	104	110
2	Total hospital beds in the Kingdom	12106	12081	12497	13115	13731
3	Hospital beds in the Ministry of Health	4612	4618	4783	5077	5177
4						
5	Hospital beds in medical services	2383	2439	2269	2551	2917
6	University of Jordan Hospital	544	534	577	599	599
7	King Abdullah University Hospital	526	501	523	538	542
	Hospital beds in the private sector	4041	3989	4345	4350	4496
8	Average bed per 10,000 people	18	18	18	14	14
9	Percentage of entries per 1000 persons	141	141	139	93	99
10	Percentage of occupancy	62.8	63.9	50.3	62.7	60.4
11	Average stay	3.1	3.0	2.3	3.1	3.0
12	Hospital mortality rate%	1.6	1.7	1.7	1.9	1.7
13	Number of comprehensive health centers in the Ministry of Health	92	95	98	99	102
14	Number of primary health centers in the Ministry of Health	372	375	377	378	380
	Number of health centers in the Ministry of Health	211	205	202	198	194

15	Number of maternity and childhood centers in the Ministry of Health	444	448	452	460	464
16						
17	Number of Chest Diseases Centers in Ministry of Health	12	12	12	12	12
18	Number of dental clinics in the Ministry of Health	384	387	397	402	405
19	The budget of the Ministry of Health from the general budget (%)	6.3	6.7	8.0	8.1	7.7
20	Average per capita GDP at market price in Jordanian Dinar	3439	3653	3811	2795	2801

- The gross domestic product according to the general statistics for 2016 (27444.9) million dinars.

- Source of population and vital information (Department of Statistics).

- Source of health information (Ministry of Health).

1.2.1 Measuring Efficiency

The process of measuring efficiency as a first step to detect the status and determine what is being consolidated, but this process is not easy to multiply and develop the art of measuring efficiency to detect the real status of the efficiency of the units to measure efficiency. Two important steps were conducted by identifying the suitable measurements as ratio analysis and frontier analysis, (Azadeh, Aryaee, Zarrin, & Saberi, 2016). The classification of efficiency measurement methods is presented in Figure 1.2.

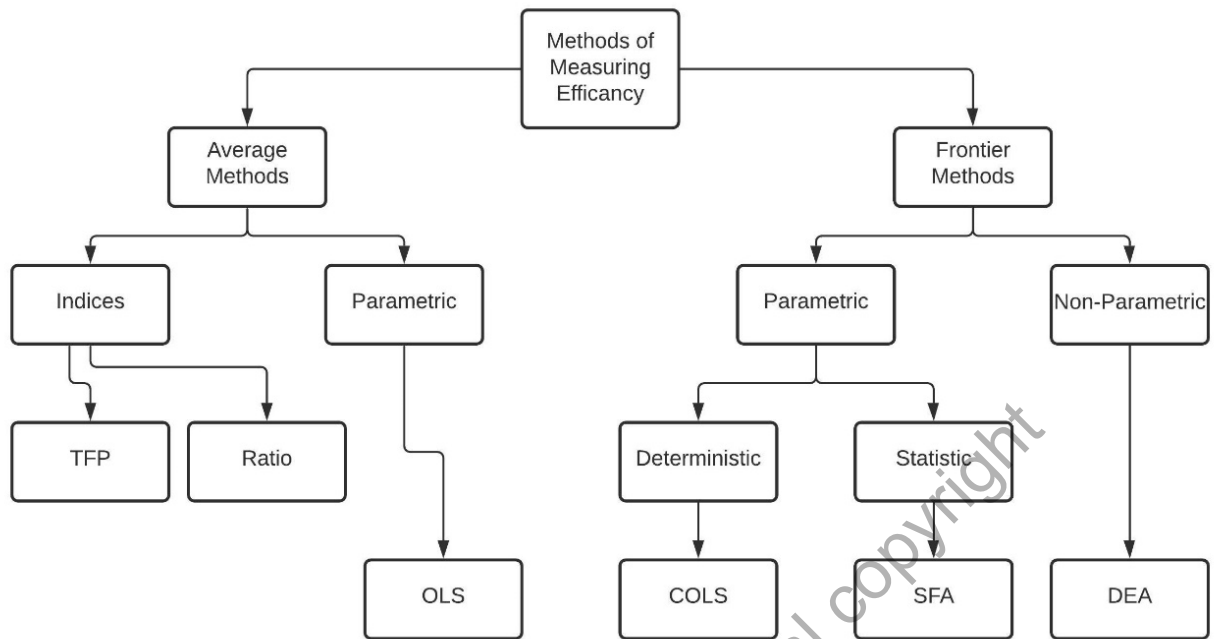


Figure 1.2 Classification of Efficiency Measurement Methods (Jamansb & Pollitt, 2001)

1.2.1.1 Ratio Analysis

In addition to the fact that this approach gives us an effective indicator, it is also one of the easiest methods of calculating performance, especially efficiency. The method results in giving us information about the association between one input and one output. Often, many ratios must be calculated to monitor different dimensions of performance across similar units or units at different intervals, and this is true at the hospital level as a health area. (Mujasi, Asbu, & Puig-Junoy, 2016).

The Ratio Analysis (RA) is used to measure efficiency, basically for a comparison of the inputs and outputs ratio among health institutions. The input to output ratios and the cost of input to output ratio are two types of ratio for technical efficiency and economic efficiency respectively (Bitran, 1992). There is typically just one type of input and one type of output in RA. For instance, the bed occupancy rates are estimated through

the use of several beds and bed-days as input and output. On the other hand, the Pabon Lasso model (1986) can also be used to perform ratio analysis across a range of inputs at the same time (Obure et al., 2016). The use of multiple ratios produces different results that impede the health manager's process of comparing performance analysis. This shows the limitations in the method of analysis using ratios, where health managers are often unable to accurately determine the fixed reference that contains all the health inputs and outputs of the hospital (Anthun, Kittelsen, & Magnussen, 2017).

1.2.1.2 Frontier Analysis

There are two approaches to frontier analysis which are the DEA also known as the non-parametric approach and the Stochastic Frontier Analysis (SFA), also known as a parametric approach. The cross-sectional sample data are used to estimate the production frontier for both approaches (Sandeep Kumar Mogha, Yadav, & Singh, 2015) and have been often used in the study to gauge the relative efficiency of healthcare services (Rouyendegh, Oztekin, Ekong, & Dag, 2016). Charnes et al. (1978) developed the DEA which uses mathematical programming to construct a frontier linear in a way that no observed point should be placed outside it. This method detects the providers' performance by benchmarking with the entirely efficient providers lying at the frontier (Piran et al., 2016).

The input-oriented and output-oriented approaches can both be used to proxy the DEA. The highest proportional contraction of all inputs which permits health institutions to generate the same level of services is the input-oriented efficiency. The assumption of output-oriented efficiency postulates that while sustaining the volume of health care resources that is used continually, every of the facility is vital to make the most of health care services (Wang et al., 2016).

1.3 The Definition of Efficiency

What do we mean by efficiency, or more generally, does a unit more efficient than other units? relative efficiency in DEA provides us with the following definition, which helps to sideline the need for allotting measures of relative significance to any input or output (Giorgio et al., 2016). The DMU assists to achieve efficiency when it is not possible to improve any of the inputs or outputs without making some of its other inputs or outputs worst. Theoretically likely rates of efficiency will not be identified as applicable in most management or social science (Hernandez, Sebastian, Hernández, & Sebastián, 2014).

The prior definition for that reason is switched by highlighting its uses with only the data that is practically available just like in the following definition. In comparison with other DMUs, technical efficiency is only achievable when none of its inputs or outputs can be enhanced without making some of its inputs or outputs becoming worst. However, as compared to its peer groups, the relative efficiency of the unit is the rate of input that could be eradicated or when the degree of output rises without making worst any other input or output. Over time, there could be changes in the peer groups or due to changing the production technology or integrating with other entities, because of managerial decisions (Kose, Uçkun, & Girginer, 2014).

1.3.1 Measures and Definitions of Data Envelopment Analysis (DEA)

Measuring the efficiency of hospitals will contribute to the improvement and development of health services provided and the satisfaction of the beneficiaries of these services. Studies explicate the definition of efficiency to be attaining the best possible output by using the accessible inputs or generating the preferred output with the least