EFFICIENCY MEASUREMENT IN JORDANIAN HEALTH SECTORS USING DEA: A REVIEW OF EXISTING LITERATURE AND THE NEW AVENUE OF RESEARCH

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Abstract

The role of the data envelopment analysis (DEA) in the efficiency measurement in health sectors has received a significant attention in research. Researchers have examined how to measure efficiency of hospitals using the DEA. Point of fact, this DEA is one of the most commonly used efficiency measurement methods in health care. In DEA, the selection of input and output variables is a very important issue for assessing efficiencies of decision-making units such as hospitals. Recently, literature provides evidence that efficiency measurement in the healthcare sector is important for some aspects. The DEA is seen to be a system that is likely to

reach a higher performance level without a large increase in input, and environmental factors causing the system inefficiency can be identified, as well regular measurement of efficiency is effective over time in monitoring and assessing how to conduct reforms that promote technical and allocative efficiency in a hospital. The literature to date seems to provide diversity in terms of the studies conducted. e.g., more than half of the 52 studies (approx. 62 %) selected hospital as a decision-making unit. The most frequently used input variables were identified as the number of doctors and the output variable was the number of outpatient visits. This conclusion suggests that the effectiveness of the DEA must be improved and future studies should further investigate the role of DEA on measuring efficiently the performance of hospitals. Finally, this review of the literature has the possible to help policymakers and researchers to evaluate the hospital performance and hence enhancing its monitoring on its efficiency by using DEA.

Keywords: Efficiency, Hospitals, Data envelopment analysis, Healthcare, Efficiency Measurement, Jordan

INTRODUCTION

Government service organizations, including the health sectors in many countries, are currently facing significant constraints on the resources allocated to them, and these organizations should use their resources efficiently to meet the changing and increase the needs of beneficiaries. The optimal use of these resources requires the availability of clear and accurate data on the flow of resources and their impact on the efficiency and performance of health services (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 using 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 including 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).

Health services, which are one of the development indicators of societies, are important to all countries. Due to the acceleration of globalization, the advancement of technology, the increasing awareness of healthcare users and the rising the costs of health services, healthcare providers should be more careful in providing healthcare services and evaluate the efficiencies of their services. Today, the needs are endless, but the resources to fulfil them are limited. For this reason, one of the most important elements of competition in a changing and developing world is the effective and efficient use of resources. It is necessary to measure whether resources are used efficiently, to determine the level in which they are used efficiently, to make comparisons between countries or companies operating in the same sector or producing similar products /services.

In the Hashemite Kingdom of Jordan, the health services provided by the Ministry of Health have witnessed remarkable progress in all aspects of preventive and curative care, maternal and child care, and others in a record period in which remarkable progress is achieved as an indicator of health status. Despite the great achievements attained, the health sector faces many challenges. It is important to continue to raise the efficiency of health services to provide them with the necessary money or other needs and to ensure that they are available to the entire population (Ministry of Health Strategic Plan 2015-2019). In fact, the Jordanian Ministry of Health has its aim to develop the health sector including the provision of therapeutic care and improve the efficiency of its performance, and this development of appropriate regulation of the operation in government hospitals is being built on an economic basis.

The Jordanian health system is under great pressure to provide exceptional health services in the context of limited resources and the circumstances surrounding it due to regional conflicts and the influx of displaced persons and refugees. Hospitals are the most important components of this health system. There are many factors that increase these pressures, the most important of which is the increase in the expectations of the receiving community for health services, the decrease in government support (Gözde, 2017). The purpose of this study is see the efficiency measurement implemented in Jordanian health sectors, more specifically, the use of DEA in which this study reviews the existing literature and suggesting a new avenue of research.

Measuring Efficiency

What do we mean by efficiency, or more generally, by saying that one decision making unit (DMU) is more efficient than another DMU? Relative efficiency in DEA provides us with the following definition, which has the advantage of avoiding the need for assigning measures of relative importance to any input or output (Giorgio et al., 2016). Efficiency is attained by any DMU if and only if none of its inputs or outputs can be improved without worsening some of its other inputs or outputs. In most management or social science applications, the theoretically

possible levels of efficiency will not be known (Hernandez, Sebastian, Hernández, & Sebastián, 2014). In addition, efficiency can be defined as achieving the maximum output possible using the available inputs or producing the desired output with minimum input (Rezaei, Dopeykar, Barouni, Jafari, & Gharibi, 2016).

The preceding definition is therefore replaced by emphasizing its uses with only the information that is empirically available as in the following definition. Relative or Technical efficiency: technical efficiency is attained by any DMU if and only if, compared to other observed DMUs, none of its inputs or outputs can be improved without worsening some of its other inputs or outputs. Relative efficiency of the unit, when compared to its peer groups, is the amount of input that could be eliminated or the amount of output increased without worsening any other input or output. The peer groups might change over time or as the result of managerial decisions, because of changing the production technology or merging with other entities (Kose, Uçkun, & Girginer, 2014). 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 for the purpose of detecting 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.
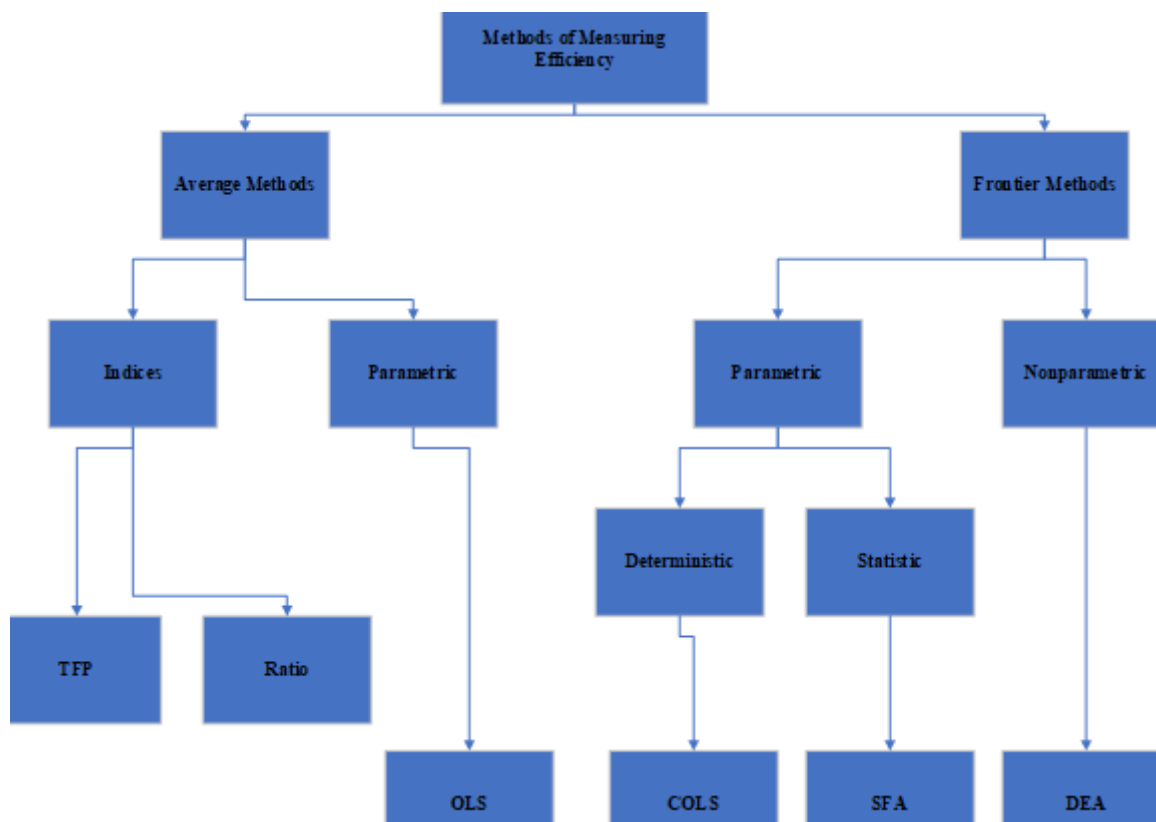

Figure 1 Classification of Efficiency Measurement Method (Jamasb & Pollitt 2001)

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 relationship 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).

Frontier Analysis

The frontier analysis comprises two approaches: a non-parametric approach, data envelopment analysis (DEA); and a parametric approach, stochastic frontier analysis (SFA). Both approaches estimate the production frontier from cross-sectional sample data (Mogha, Yadav, & Singh, 2015) and have been increasingly employed in research to measure the relative efficiency of healthcare services (Rouyendegh, Oztekin, Ekong, & Dag, 2016). Data envelopment analysis (DEA) developed by Charnes et al. (1978), involves using mathematical programming to construct a frontier linear such that no observed point should lie outside it. This technique identifies providers' performance by benchmarking with the fully efficient providers lying at the frontier (Piran et al., 2016).

Data Envelopment Analysis (DEA) can be measured using input-oriented and output-oriented approaches. Input-oriented efficiency is the maximal proportional contraction of all inputs that allows health facilities to produce the same level of services. Under the assumption of output-oriented efficiency, each facility is required to maximize health care services while maintaining the amount of health care resources used constantly (Wang et al., 2016).

Data Envelopment Analysis (DEA)

The data envelopment analysis method has emerged as a new quantitative tool of operational research tools to measure production efficiency by optimizing the mix of input and output of similar management units and outputs in order to determine the relative technical efficiency level of each unit (device) to the other set of units, the term relative technical (Ozcan, 2014). This approach emerged mainly as a part of a scientific study comparing the performance of a range of educational areas in the United States. The method quickly attracted the attention of many scientists, thinkers, and practitioners of quantitative methods, criticism and then it has been applied in the public and private sectors (Cheng, Lu, & Shen, 2013). Data envelopment analysis (DEA) is a mathematical model that uses a linear programming to measure the relative

efficiency of a number of administrative devices by determining the optimal mix of its input group and output group on their actual performance (Johnson & Ruggiero, 2014).

The data envelopment analysis method is based on the Farrell (1957) efficiency definition, which states that the method is based on the use of economic theory known as Pareto's ideal, which states that the device is inefficient if another or a combination of other devices can produce at least the same amount of output produced by this device in the quantity less for some inputs and no increase in any other input, and the unit is efficient if it is achieved the opposite. Therefore, it is noted from the previous definition that the following, the need for a number of organs or branches known as DMUs (Mujasi et al., 2016).

These units operate in the same area as a group of hospitals, primary health care centers or health directorates in different administrative regions DMUs (devices) use the same set of inputs and outputs based on the above, it is usually assumed that there is a complex fictitious DMU that includes comparator comparison units with one input and one output so that their inputs are the weighted mean of the inputs of all devices or branches. The imaginary unit outputs are calculated using the same weights used to calculate inputs by calculating the weighted average for the outputs of all units. The relative efficiency of any device or branch for other devices is calculated by solving the following fractional linear programming model known as the CCR model of Charnes, Cooper & Rhodes (Jat & Sebastian, 2013).

The data envelopment analysis method is unique from other techniques since it has the capability of introducing innovative alternatives for enhancing performance. The theoretical backbone and framework of DEA is linear programming. The fundamental principle of linear programming is providing an optimization platform. Consequently, what distinguishes DEA from other performance assessment techniques is the identifying factors that are the most favorable and effective techniques of improving the performance versus suggesting average methods for performance improvements (Nayar et al., 2013).

LITERATURE REVIEW

Many studies have been conducted in this field of research (e.g., Campanella et al 2017; Cheng, Lu, & Shen, 2013; Wang, & Gao, 2017; Wang, Wang, Su, & Du, 2015). Campanella et al 2017 attempted to see the hospital efficiency in which how these hospitals spend less maintaining quality. In other words, their study aimed to provide by implementing the DEA a useful methodological framework in order to investigate the technical efficiency cares in hospitals. The finding of their study indicated that DEA could be of considerable value for hospitals managers and policy makers that need an explicit and reproducible method to

supports their decision for resources allocation. The context of their study was among 50 hospitals in Italy.

In addition, Cheng, Lu, and Shen (2013) conducted a study to explore the health care resource allocation efficiency among 23 countries and cities in Taiwan. Their study found that the results of DEA indicated that some counties and cities had a long history regarding the low relative technical efficiencies, and the multi-dimensional scaling (MDS) results indicated that the allocation of healthcare resource was clearly unbalanced with low efficiency. Furthermore, Wang and Gao (2017) carried out a study to identify the hospital efficiency determinants as well as to expound how improving the performance of Maternal and Child Health Hospitals (MCHH) in terms of their efficiency and productivity. The study concluded that the county-level MCHHs' overall operational efficiency, in Guangxi, had been found low and they in need for some improvement. Additionally, the study pointed out that the differences in regional economic influence the hospitals' performances. Consequently, the study recommended in such cases the administrations of health have to optimize and adjust, for the different areas, the resource investments.

Moreover, Wang et al (2015) investigated a study to see the adoption of the non-parametric technique of DEA in order to handle the multiple inputs as well as outputs' feature in the industry of healthcare to identify the performance of hospitals. The study was among 19 hospitals locating Shanghai, during 2008-2013. The study indicated that even though most hospitals found to own a relatively high efficiency, a few other hospitals were extremely seen to have low in their efficiency scores. Therefore, such study could be useful as it helps decision makers identifying the inefficiency areas and how to improve them. All these studies used DEA to measure the efficiency of hospital but they are out of Jordan context.

In addition, some other studies were conducted for the same purpose. The following table shows the hospital efficiency measurement presented in some past studies. These studies used DEA to measure the efficiency of hospitals.

Table 1 Hospital Efficiency Measurement

Authors	Model	Variables	
		Inputs	**Outputs**
Karahan and Dinç (2018)	DEA models CRS & VRS	(1)No of beds (2)No. of doctors (3)No. of nurses	(1)No. of Outpatient visits. (2)No. of inpatient visits.
Singh, Singh, & Singh (2017)	DEA – outputs CRS & VRS orientation.	(1)No. of doctors (2)No. of nurses (3)No. of pharmacists	(1)No. of Outpatient visits. (2)No. of inpatient visits.

Orabah et al (2017).	DEA models CRS & VRS –input and output orientation.	(1)No. of doctors (2)No. of nurses	(1)No. of Outpatient visits. (2)No. of inpatient visits.	Table 1…
Mogha Yadav and Singh (2016).	DEA models CRS and VRS assumptions using output orientation.	(1)No of beds (2)No. of doctors (3)No. of nurses	(1)No. of Outpatient visits (2)No. of number of major surgery. (3)No of number of minor surgery. (4)No. of patients entries	
Cheng et al. (2015)	DEA & Malmquist index	(1) No. of physicians; (2) No. of nurses; (3) Actual number of open beds.	(1) Outpatient and emergency visits; (2) Inpatient Days.	
Torabipour, Najarzadeh, Arab, Farzianpour, & Ghasemzadeh (2014)	DEA-input(VRS) & Malmquist index	(1)Number of nurses, (2) Number of occupied beds, (3) Number of physicians.	(1) No. of outpatients and inpatients, (2) average of hospital stay, (3) No. of major operations.	
Abou El-Seoud (2013)	DEA-output oriented - CRS, Input oriented VRS	(1) No. of doctors. (2) No. of nurses. (3) No. of beds. (4)No. of Allied Health.	(1) Visits reviewers (2) No. of inpatients (3) Patients benefiting from radiography (4) Laboratory tests.	

DISCUSSION

Data envelopment analysis (DEA) is a linear programming-based technique for measuring the relative performance of organizational units where the presence of multiple inputs and outputs makes comparisons difficult. In the Hashemite Kingdom of Jordan, the health services provided by the Ministry of Health have witnessed a remarkable progress in all aspects of preventive and curative care, maternal, childcare, and others in a record period in which remarkable progress is achieved 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). Jordan is a small country with a population of 9798000 million and an area of 87,000 square kilometers (General Statistics Book, 2016). While the Jordanian health sector performs well in

terms of access and health outcomes, which are among the finest in the region and, among other developing countries, it is both expensive and inefficient, and there are geographic misdistributions of resources. The population is relatively well educated with an adult illiteracy rate of only 9.9 %. Health indicators are also relatively positive, with a life expectancy at birth of 73.5 years, and an infant mortality rate of 17 per 1,000 live births (Ministry of Health, 2016). However, the population of Jordan is growing. The total fertility rate is 3.7 children per woman of reproductive age and 41% of the population is under the age of 15 years (i. e. entering their prime fertile years) (Ministry of Health, 2016). At the same time, a decline in the death rate has increased the number of elderlies in the population. These factors raise concerns for increasing expenditure on health care.

As Jordan is a growing country and many challenges face the Kingdom, especially, after the Arab Spring, the study regarding the use of DEA is almost neglected according to the best knowledge of the researcher. In other words, despite the large number of studies conducted to measure the efficiency of health services in hospitals using multivariate models throughout the world and the Arab region, Jordan as a special context is seen to be marginalized from applying these models to the health sector in which they aim at measuring the levels of efficiency levels in government hospitals and help provide a clear vision and set achievable goals that can be met by government health providers in the Kingdom to meet the pressures they face by optimizing the available resources (Blatnik Bojnec, & Tušak, 2017).

This kind of marginalization could be because the DEA is considered a new method to be used in health sectors. In this regard, Li and Dong (2015) state that, in healthcare sectors, the first introduced of DEA dates to 1983, in the work of Nunamaker and Lewin, who measured pursuits nursing service efficiency. Since then data envelopment evaluation has been used broadly in the assessment of health center technical effectiveness in the United States as properly as around the world at exclusive tiers of DMUs. For example, Sherman (1984) was first in the usage of DEA to evaluate basic health center effectiveness.

The data envelopment analysis (DEA) method is designed to measure the efficiency of the decision-making unit, and in general decision making unit (DMU) is responsible for converting inputs into outputs (health system components in the present research subject and then the health system as a whole), so that the performance can be assessed in the clinical field, DMU is seen to be each unit has a certain degree of freedom of decision making and can include: banks, warehouse departments, central markets, companies, hospitals, universities, etc. (Radhakrishnan, 2014). DEA has been found to be a powerful tool when used appropriately.

The most important advantages of the DEA method:

1. No need to develop any hypotheses (mathematical formula) for the function that links dependent variables (outputs) and independent variables (inputs).

2. It does not need to specify previous weights for input and output, but rather for the model it automatically selects. It also does not specifically specify the prices of those inputs and outputs.

3. This method combines efficiency between internal efficiency (quantity and quality) and external efficiency. The method can deal with descriptive variables that are difficult to measure such as customer satisfaction with the services provided.

4. This method is more important when measuring efficiency in the government sector where it is not possible to give specific prices for services such as education, health, security, etc.

5. The method can use multiple inputs and multiple outputs with different measurement units. The method provides a lot of detailed information that helps management identify deficiencies and weaknesses in the units being evaluated, and work to remedy deficiencies during the evaluation process of those units.

6. Proven to be beneficial in uncovering relationships that continue to be hidden for different methodologies.

7. The sources of inefficiency can be analyzed and quantified for each and every evaluated unit.

CONCLUSION AND AVENUE FOR RESEARCH

The primary purpose of this paper is to provide a comprehensive review of the empirical literature that investigated the efficiency measurement in Jordanian health sectors in particular and more widely using DEA. The study is expected to enhance the understanding of the policymakers, and researchers about the role of DEA related to the relative efficiency of hospital performance. It is found that the recent studies were concerned with DEA as a tool of measuring performance of hospital and some other organizations such as banks.   . Overall, review outcomes indicate that the DEA plays an important role in measuring the efficiencies of hospitals in particular. Additionally, empirical studies are almost neglected in Jordanian context. Therefore, future studies may consider these review outcomes and further investigations regarding the role of DEA on measuring the performance of hospitals are recommended in Jordanian contexts. In other words, future studies may consider other a group of variables to be investigated such as beds, doctors, administrators, health professionals and nurses as input variables and outpatient visits, laboratory tests, surgeries, entries, and imaging.

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