



DATA ENVELOPMENT ANALYSIS AND PERFORMANCE IN HEALTH SECTOR

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Abstract

This study aims to identify the Data Envelopment Analysis (DEA) measurements and the efficiency of hospitals performance in Jordanian health sector, through the knowledge level of the application of the principles of DEA in the Hospitals in Jordan, from the viewpoint of its employees, and to identify the most DEA principles applied in the Hospitals as seen employees and activating the role of interested and administrators Jordan hospitals, and other hospitals to apply the principles of DEA management and work on enhancing them as well as to identify the requirements of the overall quality of the Healthcare system and to identify the appropriateness of the Healthcare system at the hospitals in Jordan to DEA measurements. So is the problem of the study in a survey DEA principles applied in the hospitals of Jordan, as perceived by its

employees through a principles of quality requirements in healthcare, follow-up of the healthcare process, the development of human resources, and administration decisions. The study found many of the recommendations the most important need to focus senior management in health sectors on the process of applying the principles of DEA to improve the system of hospitals process and guide the process of decision-making in Jordanian hospitals

Keywords: DEA, Efficiency, Performance, Hospitals, Jordan

INTRODUCTION

The quality of health services now is the focus of attention of the health sector in the Kingdom, academics and all segments of society, especially in light of the changes that are subject to this sector today in order to improve the quality and efficiency of these services and achieve the desired goals. The health sector is one of the sectors most in need of research and study, to identify its contribution to the aspirations of society and to overcome the obstacles that prevent it and how to overcome them (Pourreza, Alipour, Arabloo, Bayati, & Ahadinezhad, 2017). In addition, the health sector does not depend on the technical development and services it provides to its beneficiaries, but rather on following up the changes in its internal environment, but on following up the changes in its local and international external environment in order to achieve the best results and to improve the general level of its performance through continuous knowledge of everything new in this area. Due to the lack of studies on the performance of this vital sector and the focus of availability on certain aspects such as beneficiary satisfaction, there is a need for further studies aimed at shedding light on this subject, which helps health service providers in the Kingdom to promote these services and achieve their objectives.

Furthermore, Data envelopment analysis (DEA) is a mathematical model that uses linear programming to measure the relative efficiency of a number of decision-making units - the administrative organs - by determining the optimal mix of its inputs (hospital resources) and its output (hospital services) based on actual performance. It aims to identify and 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 (Girginer, Köse, & Uçkun, 2015). The huge numbers of government hospitals in Jordan require that those who are responsible for them properly think in line with the aspirations of those receiving health services with their employees to provide health services within the required level.

Problem Statement

The health sector in Jordan is one of the economic and social sectors to which the state attaches great importance. This is reflected in the ongoing reforms in the health sector. The rehabilitation and development of hospitals is an integral part of the government program represented by the Ministry of Health. And the quality of the health service provided. This is indicative of the state's interest in this vital health sector, which affects all segments of society. The Hashemite Kingdom of Jordan offers secondary and tertiary health services to its residents through a distinguished system of government hospitals and private sector hospitals, 24 hours a day through its qualified human resources (Diab & Ajlouni, 2015).

The Ministry of Health in Jordan adopts the simple direct method, such as: bed Occupancy Rate - Nurse for each bed - Bed turnover rate - Number of reviewers to measure the performance of health services provided in hospitals - Annual report of the Ministry of Health, 2015, 2016), A method that does not provide a measurement of the relationship between hospital inputs and outputs, can be relied upon to assess the efficiency and effectiveness of policies and procedures to achieve the required efficiency through quantitative tools that can provide reliable information in evaluating the performance efficiency of health services provided in public hospitals in the Hashemite Kingdom of Jordan .

According to Helal & Elimam (2017), providing quality health services to society is one of the biggest challenges faced by hospital administrators and the health centers, as these services are directly related to the health, lives, and the ability of individuals to give and produce. Aims 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 government hospitals on an economic basis and the implementation of the health insurance system.

Data Envelopment Analysis (DEA) and Efficiency in Performance of Health Sector

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. Efficiency can be defined as achieving the maximum output possible using the available inputs or producing the desired output with minimum input. DEA assumes that not all organizations are efficient. It allows a couple of inputs and outputs to be used in a linear programming model that develops a single rating of effectively for every commentary used to measure technical efficiency, scale efficiency, a locative efficiency, congestion efficiency, technical change, DEA requires input and output portions if manufacturing affectivity is examined and can be used with each cross-sectional and panel statistics (Dong et al., 2017).

Data envelopment analysis (DEA) without difficulty comprises a couple of inputs and outputs besides the requirement for a frequent denominator of measurement. This makes it specifically appropriate for inspecting the effectively of hospitals as they use a couple of inputs to produce many outputs. Furthermore, it offers unique input and output aims that would make an inefficient medical institution surprisingly efficient. It additionally identifies environment-friendly peers for those hospitals that are now not efficient. This helps the inefficient hospitals to emulate the functional organization of their peers so as to improve their efficiency (Silwal & Ashton, 2017).

Research activities on data envelopment analysis (DEA) have grown rapidly recently. As it has proved its importance and ability to measure efficiency in various sectors, especially in the health sector, DEA is a methodology for performance evaluation and benchmarking where multiple performance measures are present. DEA, first delivered by means of Charnes et al., (1978), is a non-parametric programming approach to measuring the relative efficiency of peer decision-making gadgets (DMUs) with more than one inputs and outputs (Wang et al., 2015). In healthcare, 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 affectivity in the United States as properly as around the world at exclusive tiers of decision-making units. For example, Sherman (1984) was first in the usage of DEA to evaluate basic health center effectivity (Li & Dong, 2015).

Data envelopment analysis (DEA) 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 distinguish DEA from other performance assessment techniques are the identifying factors which are most favorable and effective techniques of improving the performance, versus suggesting average methods for performance improvements (Nayar, Ozcan, Yu, & Nguyen, 2013).

A considerable amount of literature has been published on (Hadipour, Kavousi Kelashomi, Salari, & Motamed, 2017) Applications of DEA Using Efficient or inefficient Frontiers in Evaluating the Efficiency of Rural Healthcare Centers. The study used to be conducted to observe the efficiency of rural healthcare facilities (Health Houses) which include Output-Oriented efficiency, input-oriented efficiency, constructive efficiency, pessimistic affectivity and effectively range in Lingered County in Guillen province. DEA studies have been widely used around the world to determine efficiency in health services, (Girginer et al., 2015). Efficiency analysis of the clinical departments of a public hospital in Eskisehir by using DEA. to determine the effectively of the surgical and scientific services of a public health center in Eskisehir, -

Turkey, in evaluating the affectivity of clinical services, the whole quantity of surgical operations is not used as an output variable due to the fact surgical operations are now not performed by means of medical services - and a single output model is prepared for scientific services.

METHODOLOGY

The study measures the efficiency of government hospitals in the Hashemite Kingdom of Jordan. The theoretical basis for the research is Farrell's (1957) dimension of productive efficiency. The technological efficiency of both hospital classes used to be determined using data envelopment evaluation (DEA) which was produced with the aid of Charnes, Cooper, and Rhodes based on Farrell's work. According to Ferrier and Valdmanis (2004), data envelopment analysis offers exceptional advantages to find out about medical institution efficiency. The researcher uses DEA to measure the performance efficiency of government hospitals. Constant Return to Scale (CCR) and variable return to scale (BCC), the DEA assumes the availability of data m_1 of input and m_2 of output for n enterprises where the vector x_j is the input signal and the y_i vector is a symbol of output, j is the symbol of the institution and the calculation of this model is either in either input method, input attention to efficiency by reducing these inputs to maximize output Or using output-oriented, the focus is on the output and how to maximize it with the lowest input. In this study, Python-DEA software was effectively dealt with to process and analyze secondary research data.

Data envelopment analysis (DEA) is a proven method for effectivity evaluation with over 35 years of use and is also a familiar methodology that healthy the lookup objectives of this study (Ozcan, 2014). The definition of data envelopment analysis (DEA) was first introduced by Farrell (1957), followed by Charnes et al, (1978) as a mathematical development approach to the development of production frontiers and the measurement of efficiency relative to the made frontiers. Charnes et al. (1978) suggested an auto product that had an insight orientation, with the presumption of frequent returns to scale (CRS). Studies that came after considered others' sets of assumptions. Banker, Charnes, and Cooper (1984) were the first to introduce the assumption of variable returns to size (BCC), (Ozcan, 2014).

Data envelopment analysis is applied to the assessment of homogeneous units, which in the case of this study, are hospitals. DEA deals with multiple inputs and multiple outputs, which helps us to measure the performance of hospitals. (Basarkar & Saxena, 2016). The unit of assessment is normally known as a DMU, of which a DMU converts inputs into outputs. Therefore, the method of study in this research is as follows.

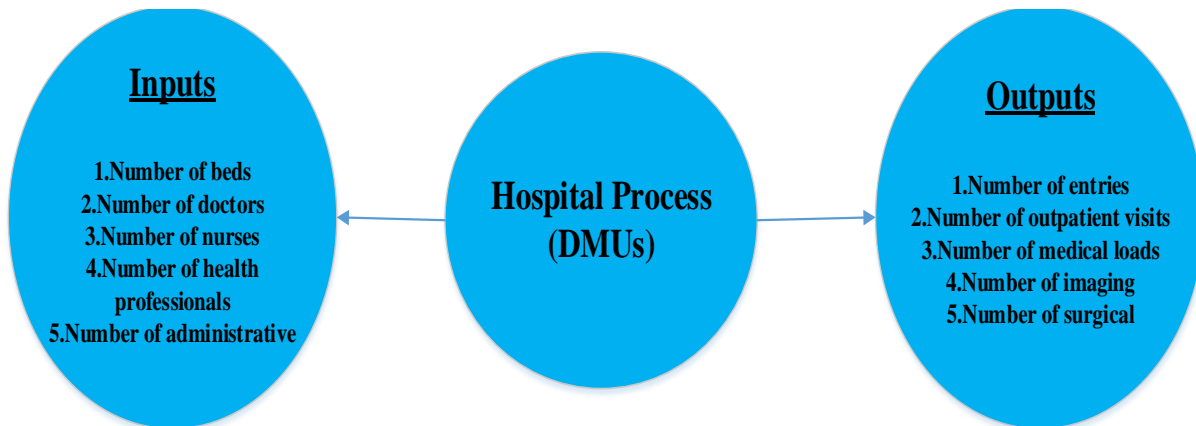


Figure 1. The Proposed Model of Research

ANALYSIS AND RESULTS

Conducting the data envelopment analysis in python-DEA software by writing the equation in python-DEA and entering the inputs and outputs data and the decision-making units, after that solving the mathematical equation in the python-DEA. It means, Descriptive statistics of inputs and outputs. Foundress a correlation matrix between inputs and outputs. Data from this study were obtained from the Jordanian Ministry of Health, which conducts annual surveys of Jordanian hospitals in the Hashemite Kingdom of Jordan through annual reports in which all work, activities, and procedures are collected throughout the year in hospitals. For the years 2013 to 2016. Annual hospital data reports have been used extensively in previous hospital studies. The research focuses on government hospitals in 2013, 2014, 2015, and 2016. The researcher uses data envelopment analysis (DEA) to measure the performance efficiency of government hospitals. The efficiency of hospitals is calculated using Constant Return of Scale (CCR), and Variable Return of scale (BCC).

The study sample consisted of ten hospitals. All data included in the analysis were collected from 2013 until the end of 2016. The study is applied to thirty-two hospitals of the Ministry of Health in Jordan.

Results of DEA-CCR

After the program run throw for each year, the program will able to show all year's graph that will show the results for each hospital in all years in the database and compare the results with other hospitals results in all years as shown in Figure 2. The Fig shows all results for each hospital compared with other hospitals to give a general overview and easy to read the efficiency rate for each hospital every year with the other hospitals. Some hospitals start low in

the score but with the years start shows better progress and some hospitals start high in some years and end in a low score for efficiency compared with the other hospitals.

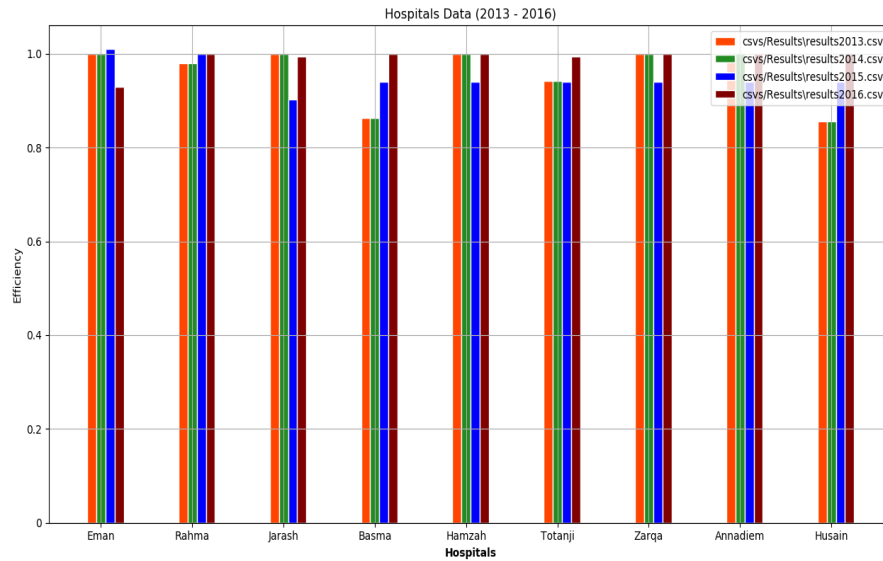


Figure 2. Technical Efficiency for All Hospitals with DEA-CCR During 2013 to 2016

Input components can be used to calculate changes between unit efficiency, as well as output components by, to correspond to the limited balance between the number 10 variables and the number of units when using (DEA) models, so there are 10 key components of the original variable variables, corresponding to 40 decision units. Using the PY-DEA program with the remaining data volume selected, the results are found in Table 4.6. As follows.

Table 1. Technical Efficiency for All Hospitals DEA-CCR During 2013 to 2016

Hospital Name (DMUs)	Technical Efficiency scores DEA-CCR			
	(TE) 2013	(TE) 2014	(TE) 2015	(TE) 2016
Al-Eman Hospital	100%	100%	100%	100%
Rahma Hospital	100%	100%	99.7%	99.6%
Basma Hospital	100%	100%	97.5%	99.3%
Annadiem Hospital	100%	100%	99.8%	77.4%
Totangy Hospital	100%	100%	98.9%	74.6%
Husain Hospital	100%	100%	59.4%	98.2%
Jarash Hospital	98.3%	98.3%	96.9%	79.8%
Zarqa Hospital	94.2%	94.2%	99.9%	91.9%
Hamzeh Hospital	86.3%	86.3%	85.5%	78.1%
Karak Hospital	85.5%	85.5%	99.6%	77.8%

Results of DEA-BCC

Assuming constant efficiency compared to scale, the BCC model assumes varying efficiency compared to scale. Using varying efficiency to scale leads to the provision of highly accurate analysis by using technical efficiency according to efficiency values resulted from a scale. (Li & Dong, 2015).

Also, after the program run throw for each year, the program will able to show all year's graph that will show the results for each hospital in all years in the database and compare the results with other hospitals results in all years as shown in the Figure below. The Fig shows all results for each hospital compared with other hospitals to give a general overview and easy to read the efficiency rate for each hospital every year with the other hospitals. Some hospitals start low in the score but with the years start shows better progress and some hospitals start high in some years and end in a low score for efficiency compared with the other hospitals.

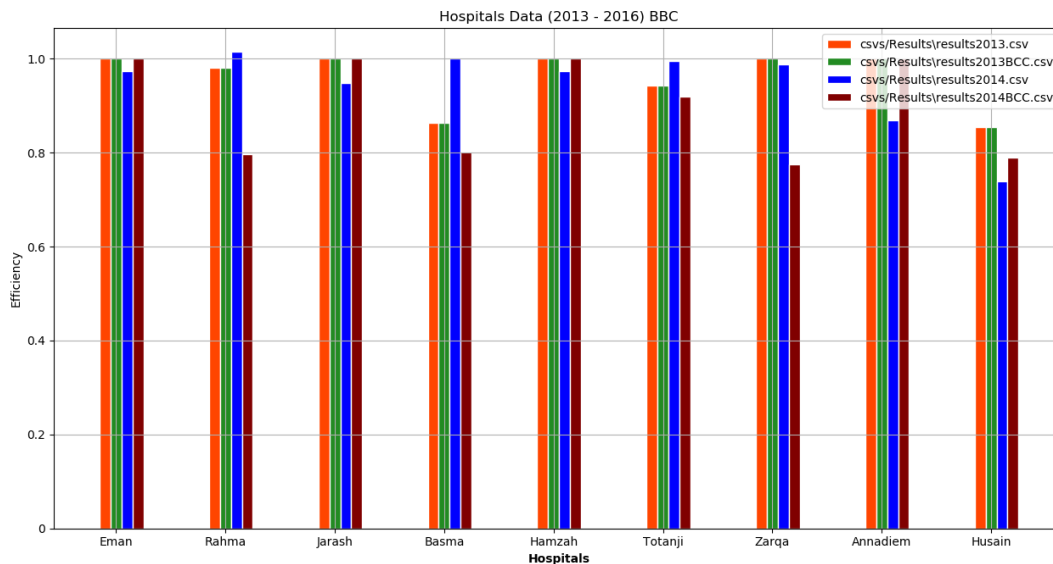


Figure 3. Technical Efficiency for All Hospitals with DEA-BCC During 2013 to 2016

It was observed that the technical efficiency throughout the sample decreased in 2016, before it was somewhat high in 2015, relative to the variable return of scale (BCC). Overall technical efficiency increased from 83% in 2015 to 90% in 2016. This means that hospitals were able to produce the same amount of production using 7% less input. The turning point was also seen in the period around the reforms. While efficiency increased from 92% in 2013 to 96% in 2014 then remained fairly constant. However, some of the hospitals under evaluation are very effective in terms of the size of their operations (Table 2).

Table 2. Technical Efficiency for All Hospitals DEA-BCC During 2013 to 2016

Hospital Name (DMUs)	Technical Efficiency scores DEA-BCC			
	(TE) 2013	(TE) 2014	(TE) 2015	(TE) 2016
Basma Hospital	100%	100%	94.8%	100%
Rahma Hospital	100%	100%	97.3%	100%
Al-Eman Hospital	100%	100%	77.2%	98.6%
Totangy Hospital	100%	99.9%	97.3%	99.9%
Husain Hospital	100%	99.9%	86.8%	100%
Annadiem Hospital	99.9%	100%	98.8%	77.5%
Jarash Hospital	98%	98%	100%	79.7%
Zarqa Hospital	94.2%	94.2%	99.4%	91.9%
Hamzeh Hospital	86.3%	86.3%	100%	80.3%
Karak Hospital	85.5%	85.5%	73.9%	78.9%

CONCLUSION

This research opens up a new way of measuring hospital efficiency. Although the methodologies developed in this study are specific to the assessment of government performance in Jordan, they could be generalized to measure the levels of hospital efficiency in general by selecting suitable inputs and outputs. This study also opens up a new way of incorporating the environmental factors in DEA scores. Using methods that have not been implemented previously in the assessment of hospital performance in Jordan is one of the main motivations behind the current research. It is hoped that this study will encourage future research on data envelopment analysis (DEA) applications using the (CCR) approach of constant return of scale, as well as on applications of the (BCC) approach of variable return of scale (Wang et al., 2015).

Data envelopment analysis (DEA) does not rank the efficient hospitals, but only identifies them as 100% efficient, which means that additional information would be required to enable comparisons between efficient hospitals. Therefore, the super-efficiency approach by (Khani et al., 2012), which is a statistical method for ranking DMUs in the DEA literature, could be adopted for future research. Similarly, other methodologies in the DMUs ranking field, such as the cross-efficiency approach of (Valdmanis, 1992), the neutral DEA model of Wang & Chin (2010), and the new super-efficiency DEA method of (Cheng et al., 2015) could be implemented. The use of more specific inputs and outputs is also worth considering in the process of obtaining results that are more accurate. Among these inputs is the quality of staff (nurses, doctors, and specialists) such as their qualifications and experience. Among these

outputs are hospital patient survival rate and the associated mortality rate. (Feroz, Raab, Schultz, & Ulleberg, 2017).

The efficiency of hospital performance is the key to ensuring that hospitals benefit from their assets in achieving high health performance. Therefore, methods for measuring current performance efficiency always need treatment and development to reach the best results that clarify hospitals' efforts to achieve efficiency. With regard to a number of hospitals that have lower efficiencies than others, they must improve their performance by focusing on the variables that affect the change of their performance ratios, and this performance can be improved by employing those variables and the correct performance of the inputs and the performance of the inputs in the form High.

The results of the analysis of the reference units for the hospitals that obtained a little degree of efficiency (with low productive efficiency) helped in referring to any of these hospitals for the purpose of follow-up and work according to their levels to treat and improve the performance of their less efficient operations. Hospitals that have achieved high production efficiency are evidence that they are keeping pace with current developments and are working hard to achieve leadership and excellence in the fields of education and learning, and community service, to reach an advanced position between Arab and international hospitals.

The data envelopment analysis method provided a good possibility in analyzing the study variables, by dealing with more than one decision-making unit (multiple hospitals), as well as assimilating the diverse and complex nature of its inputs and outputs and providing adequate results in measuring the current production efficiency. There are reference hospitals for hospitals that did not reach the level of full efficiency, which the research reached after measuring the productive efficiency, which contributes to improving and developing Jordanian hospitals and raising their degree of efficiency to the level of full efficiency.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations can be made:

- The Jordanian ministry of health can increase the efficiency of the services provided in public hospitals in Jordan by adopting a policy of redistributing its resources according to the results of the study to raise the efficiency of inefficient hospitals and reduce the work pressure from efficient hospitals.
- Data envelopment analysis models can be used at different levels (hospitals, specialized departments, departments), provided that they comply with the parameters of their use, the most important of which is the homogeneity of the units under measurement, and the availability of the necessary data.

- This tool can be used to measure the quality of health services as well as the efficiency of its performance by using variables that provide indicators of the quality of service provided such as average length of stay, infection rates, patient waiting for rates, and other quality indicators.
- The Jordanian ministry of health can review the results of this study and work to take advantage of the efficiency degrees of the hospitals in question and adopt the proposed improvements to reduce the current costs and use them to expand and develop services provided to citizens.
- Despite the importance of this study, it is not only reliable in measuring the efficiency of the performance of public hospitals in Jordan. Quality and equity in the distribution of services.
- Because health services have a very large number of inputs and outputs, each group represents a facet of this service, it is good to apply a data envelopment analysis model to reach a more comprehensive measurement of these services.
- The possibilities of data envelopment analysis models go beyond measuring the efficiency of hospitals but can be used to measure quality, planning, and others through the use of appropriate variables and models. Differences in performance between these hospitals.

In recent years, limitation of resources in health services, which is an important issue for individuals and community life, the continuous increase in health expenditures, changes in disease structure, innovations in medical science and technology and also competition among service providers require health services to be delivered effectively and efficiently. For this reason, businesses continuously measure their efficiency. Data envelopment analysis (DEA) is one of the widely used efficiency measuring method in the literature, (Yazdian et al., 2016). But, there is no common DEA model to meet the needs of all businesses, (Raei, Yousefi, Rahmani, Afshari, & Ameri, 2017). Each Business chooses the appropriate input and output variables according to their structure. The selection of input or output variables is an important issue that varies depending on what you want to see as an output, which inputs or environmental factors are more likely to affect this output. Therefore, the input and output variables used to compare the relative efficiencies of decision-making units are selected with great care and accuracy, (C. Chen, Achartari, Majkut, & Sheu, 2017).

Moreover, in order to measure health outcomes, the appropriate analytical method which combines the possible number of inputs and outputs should be defined, (Kakemam et al., 2016). Data envelopment analysis is also often used for efficiency measurement in health care. The selection of input and output variables is also very important for the health sector. In general, it is very difficult to find appropriate variables according to the nature of health services, to obtain accurate input and output data and to access reliable databases where uniform definitions for input and output variables related to the healthcare are involved in, (S K Mogha et al., 2016).

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