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# تقييم كفاءة أداء المستشفيات الحكومية العراقية باستخدام طريقة تحليل مغلف البيانات (DEA) في عام 2023

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**المستخلص:**

يسعى هذا البحث من خلال مواضيعه النظرية والعملية إلى تقييم كفاءة أداء المستشفيات الحكومية في العراق لعام ٢٠٢٣ بصورة شاملة من خلال الاعتماد على أسلوب تحليل مغلف البيانات (DEA)، إذ ان زيادة كفاءة المستشفيات الحكومية العراقية تعد من الأمور بالغ الأهمية وذلك لكونها تقدم خدمات رعاية صحية عالية الجودة في العراق وسط قيود الموارد وزيادة متطلبات الرعاية الصحية بزيادة عدد السكان، إذ ان ما تواجهه المستشفيات الحكومية في العراق من تحديات كبيرة في تطوير وتحديث استخدام الموارد في المستشفيات والحفاظ على خدمات رعاية صحية عالية الجودة يعد من اساسيات المشاكل الصحية التي تحتاج الى معالجة فورية في العراق، ولذا فان فهم واستدراك مدى كفاءة أداء المستشفيات أمرًا حيويا لاتخاذ قرارات مستنيرة وتخصيص الموارد حول ذلك من خلال الميزانيات المالية العراقية، ولذا قام الباحث بالاستعانة ببرنامج تحليل مغلف البيانات (DEA) للتوصل الى تقييم الكفاءة النسبية للمستشفيات الحكومية في العراق لعام ٢٠٢٣، وتعد طريقة تحليل مغلف البيانات من الطرق غير البارامترية التي تقارن كفاءة وحدات الفنية (المستشفيات الحكومية العراقية) من خلال قياس قدرتها على التحويل المدخلات في المخرجات، والهدف الأساسي من ذلك هو تقييم كفاءة أداء المستشفيات الحكومية في العراق لعام ٢٠٢٣ باستخدام تحليل مغلف البيانات (DEA)، بالإضافة إلى ذلك، يسعى البحث إلى تحديد المجالات المحتملة للتحسين وإبلاغ قرارات السياسة لتعزيز تقديم خدمات الرعاية الصحية، وكشفت الدراسة عن نتائج منها بلوغ متوسط الكفاءة النسبية لجميع المستشفيات في المحافظات الجنوبية الى ٩٩.٥٢٢٥%، بينما بلغ في

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المحافظات الأخرى ٩٨.٨٧٣%، وهذا يشير إلى أن المستشفيات في المحافظات الجنوبية يجب أن تستخدم ٩٩.٥٢٢٥% من مدخلاتها الحالية (مثل عدد الأطباء وطاقم التمريض والطاقم الطبي المساعد) للحفاظ على مستويات مخرجاتها الحالية (زيارات المرضى والفحوصات المخبرية وخدمات الأشعة) بكفاءة، وبمعنى آخر يجب عليهم خفض مدخلاتهم بنسبة ٠.٤٧٧٥% مع الحفاظ على نفس مستويات الخدمة لتحقيق الكفاءة الكاملة.

**كلمات مفتاحية:** تقييم، القطاع الصحي، التحليل الإحصائي، المتغيرات التحليلية، كفاءة الخدمات الصحية.

**Evaluating the Performing Efficiency of Iraqi State Hospitals Using the Data Envelopment Analysis Method (DEA) in 2023**

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## Abstract

This research aims to evaluate the performance efficiency of government hospitals in Iraq for the year 2023 using the Data Envelopment Analysis (DEA) method. The efficiency of Iraqi government hospitals is crucial for delivering high-quality healthcare services to the population amidst resource constraints and increasing healthcare demands. These hospitals face challenges in optimizing resource utilization and maintaining high-quality healthcare services, making understanding their performance efficiency vital for informed decision-making and resource allocation through the Iraqi financial budgets. DEA was utilized to assess the relative efficiency of government hospitals in Iraq for 2023, a non-parametric method comparing the efficiency of decision-making units (Iraqi government hospitals) by measuring their ability to convert inputs into outputs. The primary objective is to evaluate the performance efficiency of government hospitals in Iraq for 2023 using DEA, identifying potential areas for improvement and informing policy decisions to enhance healthcare service delivery. The study revealed results showing the average relative efficiency for hospitals in southern provinces to be 99.5225%, while in other provinces, it was 98.873%. This suggests that hospitals in southern provinces need to utilize 99.5225% of their current inputs (such as doctors, nursing staff, and medical assistants) to maintain their current output levels (patient visits, lab tests, and radiology services) efficiently, meaning they must reduce their inputs by 0.4775% while maintaining the same service levels to achieve full efficiency.

**Keywords:** Evaluation, Medical sector, Data analysis, Statistical metrics, Cross-sectional variables, Primary health efficiency.

## Methodological and Conceptual Aspects

### 1-1. Introduction

The health of people is considered a fundamental issue for the survival and development of countries. Good health is essential for any process of social or economic development, as individuals are the cornerstone and pivotal factor of this development. Therefore, the health services provided in each country are among the most crucial pillars for achieving societal well-being, a responsibility that all governments commit to fulfilling. This commitment stems from the understanding that improving health services yields economic and social benefits for all segments of society.

Consequently, in the past two decades, many governments worldwide have initiated reforms aimed at enhancing the performance of their health systems.

One motivating factor for these efforts is the observation that developed countries allocate approximately 14% of their Gross Domestic Product (GDP) to health, which is double the expenditure of countries like Sweden and Japan, where health spending is around 7%.

This discrepancy raises several questions about the allocation of resources to health care and its impact on societal development.

In developing countries, the scarcity of financial resources intensifies the challenge, as governments possess limited means and tools for obtaining financial support, such as increasing tax rates and fees, to fund the healthcare system.

Given this context, questions regarding the adequacy of health services and their cost-effectiveness from a social perspective arise. These inquiries prompt a reevaluation of the capacity to meet the population's needs and the

JOBS مجلة العلوم الأساسية
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العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

alignment of the healthcare system's supply with the demand for health services.

In the pursuit of enhanced performance, health systems can learn from one another through benchmarking, where effective organizational methods and best practices are shared to achieve the objectives of each health system.

However, the process of comparing health system performances across countries is complex and the results can be challenging to interpret. This complexity arises from the diverse histories, management styles, funding mechanisms, service distribution models, and foundational principles of different health systems.

Additionally, economic characteristics, social and demographic factors, and the absence of a standardized indicator that encapsulates the value of a health system's outputs further complicate comparisons.

The intangible nature of health services and the varying goals across health systems add to this difficulty. For instance, the UK health system prioritizes rapid response to treatment demands, while the US system focuses on equity and minimizing individual financial burdens.

Moreover, the reliance on limited individual surveys to assess the goals and priorities of global health systems, as was the case with the WHO's 2000 report based on website visitor surveys covering only 125 countries, is inadequate.

Such assessments demand more comprehensive methods, including broad-based discussions and meetings, to foster a more unified understanding of performance standards and priorities within health systems.

Given these challenges, it seems prudent to rely on objective mathematical methods and to distance oneself from subjective factors such as personal opinions, desires, and intuitions, especially in a critical sector like healthcare. In this context, Data Envelopment Analysis (DEA) stands out as a technique that employs mathematical programming to identify the most efficient units or entities.

A key strength of DEA is its ability to determine which units are more efficient relative to others without requiring detailed understanding of the operational style and methods of the units being assessed. This approach allows for a comprehensive evaluation of efficiency across various entities.

The DEA (Data Envelopment Analysis) method for calculating efficiency utilizes objective weights in a process akin to multi-criteria evaluation.

It focuses on the outcomes of the health system rather than its outputs, to circumvent the issue of harmonizing the objectives of various health system activities. This approach also mitigates the risk of misinterpreting efficiency indicators due to factors external to the health system.

DEA is a quantitative method that has evolved as an effective alternative for rationalizing decision-making processes. It is founded on a scientific basis, steering clear of the randomness and intuition that have become increasingly inadequate due to the rapid economic and technological changes worldwide.

These changes have introduced complexity and challenges to decision-making. Consequently, the adoption of a clear scientific methodology, which leverages quantitative methods to rationalize decisions, has become imperative.

**1-2.Research Statement**

Iraqi government hospitals face technical challenges such as outdated infrastructure, a shortage of medical equipment and supplies, and an insufficient number of trained healthcare professionals.

These issues contribute to a lack of services and healthcare, impacting patient care and overall hospital efficiency. Thus, the research problem can be articulated through the following questions:

1. Is there a deficiency in the performance efficiency and the level of health services provided by the government hospitals in the study?
2. Does the efficiency and service level vary among government hospitals based on their geographic distribution across governorates?
3. What are the key recommendations to rectify inefficiencies in hospitals demonstrating lower performance?

**1-3.Objectives**

The research aims to assess the productive efficiency of Iraqi government hospitals through Data Envelopment Analysis (DEA), with the objective of:

1. Identifying benchmark hospitals for each inefficient hospital within the same governorate, taking into account the environmental conditions under which they operate.

2. Determining efficient hospitals that have utilized the minimum necessary inputs to produce their current level of outputs, showcasing optimal resource usage.
3. Identifying inefficient hospitals that possess underutilized resources, which are not being effectively employed to generate the desired outputs. The study will also estimate the extent to which inputs in these inefficient hospitals need to be reduced to achieve efficiency.

**1-4. Significance**

The research assesses the operational efficiency of government hospitals in Iraq, crucial for optimizing resource utilization and improving healthcare quality. Utilizing Data Envelopment Analysis (DEA) offers insights into effective decision-making and resource allocation, vital for addressing healthcare challenges.

Findings inform policy decisions, promoting accountability and transparency in public healthcare management. Ultimately, this study aids in enhancing patient care, fostering a healthier population, and maximizing the impact of healthcare investments in Iraq.

**1-5.Hypothesis**

The performance levels of government hospitals in Iraq vary, leading to differences in relative efficiency based on each hospital's ability to optimally utilize its resources and deliver health services.

**1-6.Data and Source**

One of the crucial approaches to selecting inputs and outputs is to consult the expertise of field professionals, specifically from government hospitals across various Iraqi governorates, coupled with the hospitals' past experiences.

Inputs and outputs were selected based on the combined expertise of the researcher in health administration and some employees within the Iraqi Ministry of Health. It has been identified that significant inputs and outputs influencing the efficiency of hospitals in Iraqi governorates include: the number of doctors, nursing staff, auxiliary medical groups, and centers as inputs; and the number of outpatient visits, laboratory tests, and patients using radiology services as outputs.

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العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

An important consideration was ensuring a balance between the number of inputs and outputs and the administrative units (governorates) being evaluated. For this study, health data at the governorate level for the year 2023 was utilized.

**1-7.Methods and Tools**

The research addresses a phenomenon identified through observations in Iraqi hospitals, employing a systematic approach to assess the relative efficiency of hospitals across various governorates and environments.

The study utilizes Data Envelopment Analysis (DEA) on specific data from hospitals in Iraqi governorates. Primarily, this data was sourced from the annual health statistical report published by the Ministry of Health in Iraq for the year 2023-2024.

The focus was on measuring the production efficiency, defined as the ability of government hospitals in the study sample to deliver a range of outputs (health services) using the least possible health inputs, based on the concept of production efficiency.

Production efficiency, which refers to the capability of hospitals to deliver a range of outputs (health services) using the minimum necessary health inputs, was assessed.

For this purpose, inputs to the system included the number of doctors, beds, nurses, and other health personnel, while outputs comprised the number of inpatients, outpatient visits, and the number of deaths.

The efficiency of the hospitals in the research sample in producing their health services was determined using the XL-DEA software and Microsoft Excel.

These tools facilitated the measurement of the hospitals' production efficiency (inputs) and the testing of the research hypothesis through an analytical-standard approach.

The analysis of metrics in this model was conducted in two phases:

1. The first phase involves calculating the performance efficiency of hospitals and their surgical facilities.
2. The second phase computes the overall performance scores of the hospitals comprehensively across all decision-making units.

JOBS مجلة العلوم الأساسية Journal of Basic Science
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العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

The research will incorporate various theoretical studies from administrative literature to support its objectives. It will also employ both parametric and non-parametric approaches to measurement. The hospitals under evaluation are viewed as decision-making units that utilize diverse inputs to generate a range of outputs in healthcare.

The model aims to enhance hospital performance efficiency through specific input and output measures. The optimal efficiency score for hospitals is 1, indicating that hospitals achieving this score are deemed fully efficient. Conversely, hospitals with an efficiency score below 1 are considered less efficient.

**1-8.Previous Studies**

Reviewing research literature on the productive efficiency of health performance is a crucial starting point for this study. The theoretical framework for constructing the research model, along with its intellectual underpinnings, delineates the philosophical boundaries of the topic. Notably, several studies have provided detailed analyses on measuring the productive efficiency of hospitals, including; (Adel Asgari Safdar, 2014: P253-257)

In research concerning efficiency measurement, Data Envelopment Analysis (DEA) is often complemented by parametric methods such as the Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA), and Distribution-Free Approach (DFA).

These methods are primarily focused on assessing economic efficiency, a concept that encompasses more than just technical efficiency.

The study investigates the determination of optimal levels and structures of inputs and outputs, taking into account market price responses.

Fundamental efficiency is described as the ratio of output to input. Efficiency improvement can be attained by either increasing output, decreasing input, or achieving a combination of both, with the essential condition being that the rate of output increase must exceed the rate of input increase.

Conversely, in scenarios where both outputs and inputs are diminishing, the reduction in outputs should be at a slower rate compared to the reduction in inputs.

The concept of production efficiency is grounded in specific standards, with the first systematic exploration of efficiency theory introduced by Farrell at the University of Cambridge in 1957.

This foundational work has influenced the majority of subsequent studies on healthcare efficiency in hospitals. In a comprehensive review of hospital efficiency studies conducted between 1990 and 2008, 265 efficiency measures were employed across 172 studies.

Among these, 162 studies assessed the performance efficiency of hospitals, while the remainder evaluated the efficiency of individual physicians. Input and output measures were utilized in 55.5% of the cases, with the rest employing econometric and mathematical programming techniques as their primary methodologies.

According to Hussey et al. (2009), the most prevalent methodologies in this field are Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). (An Zhang, Wen -7881)

Since its development in the 1970s, the use of Data Envelopment Analysis (DEA) has broadened to include efficiency measurements across various sectors such as education, health, agriculture, industry, engineering, sports, among others. In the Arab world, DEA is relatively new to scientific research. (Talal Ayed Al-Ahmadi, 2009, p14) Bahramuz was one of the pioneers, discussing this topic in Arabic in 1996.

Subsequent contributions include those by Hilal in 1997, Al-Shadoukhi, Talal Ayed Al-Ahmadi in 2009, Al-Azzaz in 2000, Babiker in 2002, Al-Shaabi in 2004, Fahmi in 2007, and the study by Al-Hayali and Al-Naimi in 2014.

In building the theoretical framework that ties DEA to measuring production efficiency, it's essential to examine significant studies on DEA's application in the health sector.

Originally employed within the public sector, DEA's success and versatility have facilitated its extension to the private sector. The education sector, in particular, was a forerunner in adopting this method, leading to numerous relevant studies.

In the healthcare sector, which ranks as the second major government area of focus after education, the application of Data Envelopment Analysis (DEA) was pioneered by Sherman in 1984 through a series of practical studies.

JOBS مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

Sherman conducted evaluations using data from multiple studies, specifically targeting a group of teaching hospitals in the United States. His analysis revealed areas of relative inefficiency and provided insights into factors contributing to inefficiency that traditional methods, such as ratio and regression analyses, failed to clarify. (Sherman, H, 1984, pp: 922-923)

Moore et al. (1990) conducted a study to compare the efficiency of resource allocation between government and non-profit hospitals. They employed an advanced Data Envelopment Analysis (DEA) model aimed at minimizing the input costs of the units being examined. (Morey, 1990, pp: 71-83)

In 1993, Finkler and Wirtschofter conducted a study on maternity wards across nine hospitals in Southern California. Concurrently, in the United Kingdom, a study employed the Data Envelopment Analysis (DEA) method to assess the efficiency of public clinics in three English regions.

Another investigation aimed at identifying underperforming hospitals, suggesting potential closures among non-governmental hospitals in the United States. The goal was to illustrate that inefficiency could be an indicator of the need to close a hospital. (Bahormoz, 1998; pp 97-121)

The findings indicated that although efficiency is a positive metric, its ability to predict the necessity for hospital closure is relatively limited. Numerous other studies have been conducted to evaluate hospital efficiency, including the research by Sola and Prior in 2001. (Al-shammari, 1999; pp 469-488)

Researchers have identified areas of relative inefficiency within healthcare facilities and hospitals across various global regions, including India and Scotland, as illustrated by Parkin and Hollingsworth in 1997.

In an upcoming study, the Data Envelopment Analysis (DEA) method will be applied to assess the efficiency of health service performance in primary healthcare centers and hospitals across the Iraqi governorates. Quantitative methods will be used to measure efficiency in this setting.(Bhat, 2001)

Hospital managers aim to lower healthcare costs by implementing strategies that enhance the productive efficiency of care and boost the performance of the Ministry of Health in delivering services.

Data Envelopment Analysis (DEA) aids in understanding the outputs from DEA models, highlighting their strengths and limitations. Additionally, by

JOBS مجلة العلوم الأساسية
Journal of Basic Science
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العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

conducting case studies on hospitals, we offer a practical guide for developing, refining a DEA model, and interpreting its results. (Steering Committee, 1997)

This research benefits officials responsible for government health services in the Iraqi Ministry of Health, aiding hospital managers and staff in enhancing and delivering services in a cost-effective manner. It also contributes to improving the efficiency of resources utilized in providing essential services to the community.

**Data Analysis**

**2-1. Data envelopment analysis**

Farrell's 1957 study aimed to measure the production efficiency of a model with a single input and output, avoiding any assumptions about the production function's form. This approach was expanded by Charnes, Cooper, and Rhodes in 1978 into a model accommodating multiple inputs and outputs.

They relied on the concept of part optimality, which posits that a decision-making unit is considered inefficient if it's possible for another unit or a combination of units to produce the same quantity of outputs with fewer inputs without increasing any other resource.

Conversely, a decision-making unit is deemed Pareto efficient if increasing output without increasing any input or decreasing any output is impossible without increasing some inputs or decreasing other outputs. (William W.Cooper, 2006; P141)

The Data Envelopment Analysis (DEA) method has been applied across various decision-making units, including banks, retail stores, supermarkets, automobile manufacturers, hospitals, schools, public libraries, and universities.

A notable feature of this model is its independence from personal judgments about the weights assigned to each input and output, allowing for an objective assessment of efficiency. (Kuah, CT, 2012; p6)

The Data Envelopment Analysis (DEA) model is versatile, applicable to both public and private sector entities, including hospitals, the US Air Force, universities, municipalities, judicial systems, commercial enterprises, and even the performance evaluation of entire countries and regions.

It extends to assessing the efficiency of diverse units like security agencies, educational institutions, financial institutions, and individuals within these organizations.

DEA is employed to gauge the efficiency of Decision-Making Units (DMUs). Recent advancements in DEA methodology have allowed for the analysis of two-stage processes, wherein the outputs from the first stage serve as inputs to the second stage.

This two-stage DEA model not only furnishes an overall efficiency rating for the entire process but also provides efficiency measures for each individual stage.

A study by Wade D. Cook in 2012 introduced a method to pinpoint inefficiencies within DMUs operating within a two-stage DEA framework, enhancing the model's diagnostic capabilities. (Yao Chen, 2012; PP 138-142)

In Data Envelopment Analysis (DEA), "envelopment" pertains to the concept where more efficient organizations define the boundaries that encompass less efficient ones within a group.

In other words, efficient organizations set the benchmark and, by comparison, highlight the inefficiencies of other organizations. Thus, in DEA, the data representing various organizational performances is analyzed, and efficiency scores are assigned ranging from zero to one.

Units that attain an efficiency score of one are considered efficient and lie on the efficiency frontier, which essentially envelops the less efficient organization. (William W.Cooper, 2006; PP 4-9)

One of the key advantages of Data Envelopment Analysis (DEA) is that it does not require the specification of an explicit mathematical formula for the production function. It can handle multiple inputs and outputs, making it an effective tool for measuring the efficiency of comparable Decision-Making Units (DMUs), such as hospitals, to identify which one efficient and which are not.

DEA is a contemporary quantitative method and a form of linear programming. This non-parametric model measures the relative efficiency of units with similar functions, helping decision-makers identify top-performing units and pinpoint weaknesses in less efficient ones.

DEA's approach, which can be considered non-parametric, utilizes linear programming to focus on estimating overall productivity in sectors like healthcare and ranks hospitals based on their efficiency scores.

In contrast, the parametric (or econometric) approach relies on econometrics, using production or cost functions as a foundation and emphasizing the characteristics of these functions in determining economies of scale, which is among its most recognized applications. (Filippaki et al, 2012; p279)

Which are classified under the barometric entrance category: (Berndt and Laurits R, 1973; 81-113)

1. Cobb-Douglas production function: This function is well-known for its simplicity and the assumption of constant returns to scale, often used to represent the relationship between two or more inputs (typically labor and capital) and the amount of output produced. (William Sher, 1981; pp239-243)
2. Constant Elasticity of Substitution (CES) production function: Introduced by Arrow, Chenery, Minhas, and Solow in 1961, the CES production function allows for a varying degree of substitutability between inputs, unlike the Cobb-Douglas function which assumes a fixed substitution ratio.
3. Bell production function (also known as the Hubbert curve): This function is commonly used in the context of natural resources, particularly to model the life cycle of resource extraction and depletion. (Laurits R, 1973; pp28-35)
4. Leontief production function: Characterized by fixed input coefficients, this function implies that inputs cannot be substituted for one another. It's often used in input-output analysis.
5. Meta production function: A concept used to represent a technology frontier that encompasses the best technology available from a set of technologies.

JOBS مجلة العلوم الأساسية
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Online-ISSN 2791-3279
العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

6. Logarithmic transformation production function: This refers to the application of a logarithmic transformation to a production function, which can linearize non-linear relationships and simplify the estimation of production elasticities.
7. Stochastic frontier analysis (SFA): This is a method used to estimate production efficiency, incorporating random errors and inefficiency terms to account for deviations from the frontier.
8. Distribution-Free Approach (DFA) to efficiency analysis: Unlike SFA, DFA does not assume a specific distribution for the inefficiency term, making it a non-parametric method.

**2-2. Constant Return to Scale (CCR-CRS)**

The CCR model, named after its developers Charnes, Cooper, and Rhodes, is predicated on the assumption of Constant Returns to Scale (CRS).
This implies that the Decision-Making Units (DMUs) under evaluation are assumed to be operating at a level where an increase in inputs leads to a proportional increase in outputs. (William W. Cooper, 2006; pp 67-70)
In other words, if inputs are scaled up by a certain percentage, outputs are expected to rise by the same percentage. This model is particularly suitable for assessing the efficiency of units that are operating at their optimal size. (Zahraa; 2014)
The concept suggests that a change in the quantity of inputs used by a unit has a consistent effect on the quantity of services (outputs) it produces.
This principle is known as the property of constant returns to scale (CRS). Building on Farrell's work from 1957, Charnes et al. in 1978 developed DEA as an input-oriented model under the CRS assumption. This assumption posits that any increase in inputs leads to a proportional increase in outputs.
When inputs are decreased while outputs remain constant, inefficiency is assessed based on the inputs.
Contrary to this input-oriented approach, output-oriented DEA models have been developed, where inputs are kept constant, and inefficiency is measured based on outputs.
Coelli et al. in 2005 observed that both output and input-oriented models identify the same efficient set through linear programming, which does not

encounter statistical issues such as bias in the DMUs, due to the symmetric nature of the equations involved. (E. Kelly, 2012; PP63-77)

**2-3. Variable Return to Scale (VRS-BCC)**

The BCC model, named after Banker, Charnes, and Cooper, expands upon the foundational CCR model they initially developed. Recognizing the limitations of the CCR model for units not operating at their optimal size, the BCC model introduces the concept of Variable Returns to Scale (VRS).

This means that an increase in the inputs of decision-making units by a certain percentage does not necessarily lead to a proportional increase in outputs; the change could be more or less. The BCC model evaluates two types of efficiency: technical efficiency and scale efficiency.

Distinct from the CCR model, which assumes constant returns to scale, the BCC model assesses technical efficiency in the context of the units' scale of operations.

It allows for variable returns to scale—whether fixed, increasing, or decreasing—thus accommodating the variability in the relationship between input quantities and service outputs. (Boljuncic,Valter, 2006; pp63-75)

The Variable Returns to Scale (VRS) measure, as introduced by Banker, Charnes, and Cooper in 1984, accounts for the range of efficiencies and posits that outputs will not necessarily change proportionally with inputs.

Unlike the Constant Returns to Scale (CRS) assumption, which suggests that all producers operate at an efficient scale, VRS acknowledges that not all producers function at their optimal scale.

Therefore, if discrepancies in efficiency scores arise under different scale return assumptions, it indicates the presence of inefficiency in the analysis.

In this study, the input-oriented DEA model was evaluated under both DEA and CRS assumptions. Efficiency scores were calculated using DEA-specific parametric software developed by Cook and Zhou in 2008. (E. Kelly, 2012; PP63-77)

Data Envelopment Analysis (DEA) models, specifically CCR and BCC, incorporate two variations based on the orientation of the Decision-Making Units (DMUs) whose production efficiency is being evaluated.

For DMUs that are input-oriented, meaning their objective is to minimize the amount of inputs while delivering a specified quantity of outputs, the CCR-I (Input-oriented CCR model) or BCC-I (Input-oriented BCC model) is employed to identify efficient units.

Conversely, for DMUs that are output-oriented, aiming to maximize the output quantity with the given inputs, the CCR-O (Output-oriented CCR model) or BCC-O (Output-oriented BCC model) is utilized to determine efficient units (Zahraa, 2014). (William W.Cooper, 2006; Pp 85-89)

**2-4. (Multiplicative model)**

This model, attributed to Charnes, Cooper, Siford, and Stetz, is fundamentally based on logarithmic linearity and interprets productivity in accordance with the Cobb-Douglas approach. (Charnes, A., Cooper, 1982; PP223-224)

**2-5. Additive model**

The model is attributed to Charnes, Cooper, Golany, Seiford, and Stutz, and it explains efficiency outcomes in line with the economic principle of Pareto optimization. (Charnes, A., Cooper, W, 1983; PP101-103)

For the Input-Oriented CCR Model:

$$\text{Max } \theta 0 = \sum jn = 1\ , ujyj0$$

subject to

$$\sum im = 1, vixi0 = 1$$

$$\sum jn = 1, ujyjk - \sum im = 1, vixik \leq 0$$

$$vi \geq 0, uj \geq 0, \text{ for all } i, j$$

For the Input-Oriented BCC Model:

$$\text{Max } \theta 0 = \sum jn = 1, ujyj0 + u0$$

subject to

$$\sum im = 1, vixi0 = 1$$

JOBS مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

$$\sum jn = 1, ujyjk - \sum im = 1, vixik + u0 \leq 0$$
$$vi \geq 0, uj \geq 0, u0 \text{ free in sign, for all } i, j$$

BCC-1 (Input-Oriented BCC Model)
The BCC model assumes variable returns to scale (VRS). The input-oriented BCC model (BCC-1) modifies the CCR model by adding a convexity constraint:

$$\sum jn = 1\lambda j = 1$$

**3-2. Output-Oriented Models**

For output-oriented models, the objective is to maximize output production without increasing the level of inputs.
The DEA models in output orientation are formulated as follows:
CCR-0 (Output-Oriented CCR Model)
The output-oriented CCR model (CCR-0) is formulated as:
Max $\phi$
Subject to:

$$\sum jn = 1\lambda jyrj \geq \phi yro, r = 1,2, \ldots, s$$
$$\sum jn = 1\lambda jxij \leq xio, i = 1,2, \ldots, m$$
$$\lambda j \geq 0, j = 1,2, \ldots, n$$

Where $\phi$ is the efficiency score of the DMU under assessment, seeking to maximize output.
BCC-0 (Output-Oriented BCC Model)
The output-oriented BCC model (BCC-0) includes the same convexity constraint as the input-oriented BCC model:

$$\sum jn = 1\lambda j = 1$$

These DEA models provide a framework for evaluating the efficiency of DMUs by comparing the weighted sums of inputs and outputs, allowing for the identification of best-practice frontiers and the calculation of efficiency scores relative to these frontiers.

The statistical relationship between the variables can be determined using the Spearman correlation coefficient. The correlation coefficient r is defined by Relation:

$$r=1-\frac{6\cdot\sum Nn=1D2}{N\cdot(N2-1)}$$

where N = number of elements, D = difference between x_n and y_n, i.e., two rows, r = correlation coefficient.

**Procedures**

By applying the proposed model to evaluate production efficiency, the analysis will be conducted on two levels:

1. The first level involves analyzing the results of the production efficiency assessment of Iraqi government hospitals.
2. The second level focuses on analyzing the results of evaluating the production efficiency of surgical theaters in Iraqi government hospitals.

The implications of production efficiency, including scale efficiency, returns to scale, and benchmark hospitals, will be elucidated through the use of Data Envelopment Analysis (DEA) to measure production efficiency (input-oriented).

The research sample will be examined as follows:

4-1.(south and west of Iraq) Iraqi government hospitals

(١)Table

shows input and output data in Iraqi government hospitals for the year2023 (south and west of Iraq)

| I | H | G | F | E | D | C | B | A |
|---|---|---|---|---|---|---|---|---|
| **The patients** | **The number of deaths** | **Number of patients** | **Number of tests** | **Nurses** | **Number of doctors** | **Bed number** | **Professionals** | **Governorate** |
| ٧٦٤٣٣٨٢ | ١٤٧٢٣ | ٦٢٧٣٢٥ | ١٦٢٣١٨٧٢ | ٨٢٢٦ | ٧٥٤٣ | ١١٧٧٨ | ١٥٢٢٢ | **Baghdad** |
| ٢٥٠٨٥٢٨ | ٥٢٥٤ | ٢٥٨٠٦٧ | ٥٩٢٧٥٩٥ | ٢٩٣٣ | ٢٠٤٩ | ٤٩٩٢ | ٤٨٢١ | **Basra** |
| ٩٨٢٧٤٨ | ١١٩٣ | ٧٩٠٢٩ | ١٧٨٩٢٨٩ | ٢٠١٩ | ٥٥٧ | ١٧٣٤ | ١٢٩٤ | **Maysan** |

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد الحادي و العشرون
٢٠٢٤م /١٤٤٥هـ

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ١٢٤٤٣٢٨ | ١٧٣٩ | ٩٠٧٤٨ | ٢٦٩٠٦٩٧ | ٣٨٢١ | ٨٨٧ | ١٩٩٠ | ٢٢٩٤ | **Diwaniyah** |
| ٧٣٦٢٤٩ | ١١١٩ | ١١٢٩٢٨ | ٢٧٤١٩٠٧ | ٢٨٦٧ | ٧٩٨ | ١٨٩٢ | ٢١٧٤ | **Diyala** |
| ١٧٩٣٥٩٧ | ١٥٨٣ | ١٢٧٢٩٣ | ٢٢٠٠٠٦٤ | ٢٢٦١ | ١٠٤٨ | ١٨٤٧ | ١٩٩٨ | **Anbar** |
| ١٩١٥٧٢١ | ٣٣٤١ | ١٩٢٤٨٩ | ٤٠٢٨٤٥٧ | ٣٧١٩ | ١٥٦٦ | ٢٢٣١ | ٣٨٨١ | **Babylon** |
| ٢٨٤٧١٨٢ | ١٨٥٩ | ٨٩٣٨٢ | ٢٣١٥٩٦٢ | ٢٤٦٧ | ١٠٤٣ | ١٤٩٢ | ١٨٤٢ | **Karbala** |
| ١٤٨٦٢٢٢ | ١٨٥٧ | ١١٧٥٥٢ | ١٩٢٧٦٨٩ | ١٧٢٩ | ١٠٢١ | ١٩٢٤ | ٢٩٠١ | **Wasit** |
| ٩٤٨١٠٢ | ٢٧٩٢ | ١٤٨٥٩٢ | ٢٧٠٠٠٨٠ | ٧١١٣ | ١٠٤٢ | ٢٣٤١ | ١٨٢٣ | **Dhi Qar** |
| ١٨٢٣٩٢١ | ١٠٠٩ | ٧٢٢٧٠ | ١١٠٢١٨٩ | ١٠٨٣ | ٥٧٣ | ١٤٨٨ | ١١٢٣ | **Double** |
| ١٨٤٩٥٨٢ | ٣٩٤٨ | ١٢٠٣٢٩ | ٤١٨٩٧٦٩ | ٢٩٠٤ | ١٢٨٢ | ١٨٢٣ | ٣٤٤١ | **Najaf** |

The data in Table 2 reveals that the hospitals in the governorates of Basra, Maysan, Diwaniyah, Anbar, Babil, Karbala, Wasit, Dhi Qar, Muthanna, and Najaf achieved an efficiency score of 1.0000 according to both variable and constant returns to scale models, and their scale efficiency also reached 1.0000.

This indicates they are operating at the optimal production volume, achieving full efficiency. This is a commendable achievement for these hospitals, showcasing their capability to utilize resources effectively to deliver health services efficiently. It is imperative for these hospitals to sustain their efficiency and exemplary status.

Conversely, the hospitals in Baghdad Governorate achieved a technical efficiency score of 1.0000, suggesting they are technically efficient. However, under the constant returns to scale model, their efficiency was lower at 0.9497.

This discrepancy between the efficiencies under variable returns to scale and constant returns to scale models suggests that these hospitals are not operating at an optimal size. Their scale efficiency scores varied between 0.7550, 0.9035, 0.1933, 0.9516, 0.9281, and 0.8958, indicating a need for adjustment in their production volume to reach optimal efficiency.

The relative inefficiency in overall productivity of these hospitals is attributed to management's inability to address internal challenges effectively.

The hospitals in Diyala Governorate did not achieve full efficiency, with their efficiency scores being 0.9622 under the variable returns to scale model and 0.9594 under the constant returns to scale model. Their scale efficiency was 0.9930, indicating they are operating with a decreasing return to scale.

As a result, their benchmark units are the hospitals in Basra, Maysan, and Babil Governorates. The primary cause of the overall productive inefficiency in these hospitals is attributed to the senior management's inability to effectively address environmental or external challenges, which adversely affect the quality of services provided (outputs).

Table(2)Average production efficiency (input) (production for Iraqi (south and west of Iraq) government hospitals

| egree of The d efficiency of constant returns to scale(CCR) . | Volume yield | Degree of volumetric efficiency | Degree of efficiency of variable returns to scale (VRS) . | Governorates |
|---|---|---|---|---|
| 0.9497 | decreasing | 0.9497 | ١ | **Baghdad** |
| 1 | Fixed | 1 | ١ | **Basra** |
| 1 | Fixed | 1 | ١ | **Maysan** |
| 1 | Fixed | 1 | ١ | **Diwaniyah** |
| 0.9594 | decreasing | 0.9930 | 0.9662 | **Diyala** |
| 1 | Fixed | 1 | 1 | **Anbar** |
| 1 | Fixed | 1 | 1 | **Babylon** |
| 1 | Fixed | 1 | 1 | **Karbala** |
| 1 | Fixed | 1 | 0.7769 | **Wasit** |
| 1 | Fixed | 1 | 0.6079 | **Dhi Qar** |
| 1 | Fixed | 1 | 0.5643 | **Double** |
| 1 | Fixed | 1 | 0.4080 | **Najaf** |

Source: Prepared by the researcher based on the outputs of theXL-DEA data envelopment analysis program

**4-2. Iraqi government hospitals in the northern region**

(٣) Table

shows input and output data in Iraqi government hospitals for the year2023 in the northern region

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

Table (3): the northern -Input and output data in Iraqi government hospitals region

| I | H | G | F | E | D | C | B | A |
|---|---|---|---|---|---|---|---|---|
| **The patients** | **The number of deaths** | **Number of patients** | **Number of tests** | **Nurses** | **Number of doctors** | **Bed number** | **Professionals** | **Governorate** |
| ٢٨٠٤٧٢٧ | ٤٥٧٨ | ٢٩٤٤٨٠ | ٦٦٢٧٤٩٢ | ٤٨٥٩ | ٢٨٢٢ | ٣٨٤٢ | ٤٧٨٣ | **Nineveh** |
| ٧١٧٤٨١ | ١٨٢٧ | ١٠٥٢٢٩ | ٢٩٨٣٧٧٧ | ٢٢٧٥ | ٨١٩ | ١٣١٢ | ١٨١١ | **Kirkuk** |
| ١٠٩٤٨٢٩ | ١٧٧٢ | ٨٥٠٩٩ | ٢٣٨٤١٩٢ | ١٣٨٥ | ١٢٣٩ | ١٦٠١ | ٢٢٢٧ | **Salahaddin** |
| ١٠٠٢٣٨٤ | ٢٩٤٢ | ١٩٢٨٣٢٢ | ٤٦٠٢٨٣٧ | ٤٧٥٢ | ٢٨٤٢ | ٢٦٢٦ | ٣٠١٦ | **Erbil** |
| ٧٥٢٣٩٢ | ١٧٦٥ | ١٢٨٧٤١ | ٢٩٣٧١٦٥ | ١٧٩٢ | ١٠٢٣ | ١٦٨٧ | ١٠٨٠ | **Dohuk** |
| ٧٢٤٣٤٥ | ٢٥٨٢ | ٢٨١٤٧٦ | ٢٨٤٩٢٠٢ | ٣٨٨١ | ٢٣١٢ | ٢٩٦٥ | ٢٨٢٧ | **Sulaymaniyah** |

The data in Table 4 shows that the hospitals in the Nineveh, Kirkuk, Dohuk, and Sulaymaniyah governorates have achieved full efficiency, with their productive efficiency reaching 1.0000 under both variable and constant returns to scale models.

Their scale efficiency also reached 1.0000, and they are operating under constant returns to scale. This demonstrates that they have attained full efficiency and are operating at an optimal production volume, showcasing their capability to utilize resources effectively. These hospitals should strive to maintain their high level of performance and distinguished status.

In contrast, the hospitals in Erbil Governorate achieved an efficiency score of 1.0000 under the variable returns to scale model, but they did not reach full efficiency under the constant returns to scale model, where their efficiency was 0.9324.

This shortfall is attributed to their inefficiency in scale, as they have not attained their optimal production volume and are operating under decreasing returns to scale.

**Table (4) Average performance and efficiency of Northern Iraqi hospitals**

| The degree of efficiency of constant returns to scale(CCR) . | Volume yield | Degree of volumetric efficiency | Degree of efficiency of variable returns to scale | Governorates |
|---|---|---|---|---|

JOBS مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

| | | | (VRS) . | |
|---|---|---|---|---|
| ١ | Fixed | ١ | ١ | **Nineveh** |
| ١ | Fixed | ١ | ١ | **Kirkuk** |
| ١ | Fixed | ١ | ١ | **Salahaddin** |
| 0.9324 | decreasing | 0.9324 | ١ | **Erbil** |
| 1 | Fixed | 1 | ١ | **Dohuk** |
| 1 | Fixed | 1 | ١ | **Sulaymaniyah** |

Source: Prepared by the researcher based on the outputs of theXL-DEA data envelopment analysis program

### 4-3. Measuring the Average Relative Efficiency of Surgical Wards in Government Hospitals of the Southern Region of Iraq

(٥)Table

shows the surgical halls in Iraqi government hospitals in the southern region

| G | F | E | D | C | B | A |
|---|---|---|---|---|---|---|
| **Minor ionsoperat** | **Intermediate operations** | **Major operations** | **Number of surgeries** | **Number of doctors** | **Surgery bed** | **Governorate** |
| ١٣٢٢٢٦٦ | ٧٨٩٢٣ | ٥٦٩٢٨ | ٦٦٤٥٣ | ٢٦٨ | ٦٨٣ | **Baghdad** |
| ٥٦٩٢٧ | ٢٥٧٢٩ | ٢١٧٢٣ | ١٦٣٢٦ | ٢٧ | ٣٥٤ | **Basra** |
| ١٩٨٤ | ٦٠٣٧ | ٢٧٤٨ | ٤٤٨١ | ٦٦٤ | ٩٢ | **Maysan** |
| ١٧٥٤٨ | ٩٤٨٤ | ٩٤٧٢ | ٩٠٧٥ | ٤٤ | ١٨١ | **Diwaniyah** |
| ٥٨٢٩ | ١٥١٩٤ | ٨٠٢١ | ٩٠٤٢ | ٤٢ | ١٣٨ | **Diyala** |
| ١٩٩١٥ | ١٤٨٢٩ | ١٣١٥٦ | ١١٣٧٥ | ٤٧ | ١٢٣ | **Anbar** |
| ٨٢٧٢ | ١٥٧٢٩ | ١٤١١٩ | ١٢٩٩٥ | ٥١ | ١٥٢ | **Babylon** |
| ١٠٧٨٢ | ٦٤١١ | ٦٥٨٢ | ٥٩٩٥ | ٤٤ | ١٧٧ | **Karbala** |
| ٢٢٩٤٩ | ٧٩٣٩ | ١٩٩٨٩ | ٩٦٦٥ | ٣٦ | ١٣٨ | **Wasit** |
| ٦٧٢٩٣ | ١١١٨٢ | ١٣٤٢٣ | ٩٦٤٢ | ٣٥ | ١٤٧ | **Dhi Qar** |
| ٣٠٠٩٠ | ٤٣٩٢ | ٤٤٢٩ | ٥٠٣٢ | ٢٦ | ١٦٨ | **Double** |
| ٤٠٣٨٤ | ١٠٨١٨ | ١٢٨٤٢ | ١٣١١٦ | ٥٤ | ١٠٧ | **Najaf** |

The data in Table 6 shows that the hospitals in the governorates of Baghdad, Diyala, Anbar, Dhi Qar, and Najaf have achieved full efficiency, with their production efficiency scores reaching 1.0000 according to both variable and constant returns to scale models.

Their scale efficiency also reached 1.0000, indicating they are operating at an optimal size for production. This signifies full efficiency and highlights these hospitals' capability to optimally utilize their resources in delivering health services, underscoring the importance of maintaining their efficiency and exemplary status.

Conversely, the hospitals in the Basra, Maysan, and Muthanna governorates achieved full production efficiency (1.0000) under the variable returns to

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

scale model but did not attain full efficiency under the constant returns to scale model, with scores of 0.9627, 0.7986, and 0.7227, respectively. Basra's hospitals experienced decreasing returns to scale, whereas Maysan and Muthanna saw increasing returns.

The hospitals in the Diwaniyah, Babil (referred to as Babylon), Karbala, and Wasit governorates fell short of full efficiency, with their scores being 0.9200, 0.8705, 0.9590, and 0.9094, respectively, according to the variable returns to scale model.

Furthermore, under the constant returns to scale model, the hospitals in Babil, Karbala, Wasit, and Muthanna did not achieve full efficiency, with scores of 0.9924, 0.7352, 0.9956, and 0.7727, respectively.

**Table(6)** Average production efficiency input (production for Iraqi government hospitals in the southern region)

| The degree of efficiency of constant returns to scale(CCR) . | Volume yield | Degree of volumetric efficiency | Degree of efficiency of variable returns to scale(VRS) . | sGovernorate |
|---|---|---|---|---|
| ١ | Fixed | 1 | ١ | **Baghdad** |
| 0.9627 | decreasing | 0.9627 | ١ | **Basra** |
| 0.7986 | growing | 0.7986 | ١ | **Maysan** |
| 0.9200 | Fixed | 1 | 0.9200 | **iwaniyahD** |
| 1 | Fixed | 1 | 0.9662 | **Diyala** |
| 1 | Fixed | 1 | 1 | **Anbar** |
| 0.8639 | growing | 0.9924 | 0.8705 | **Babylon** |
| 0.7529 | growing | 0.7852 | 0.9590 | **Karbala** |
| 0.9042 | decreasing | 0.9996 | 0.9045 | **Wasit** |
| 1 | Fixed | 1 | 1 | **Dhi Qar** |
| 0.7227 | growing | 0.7227 | 1 | **Double** |
| 1 | xedFi | 1 | 1 | **Najaf** |

researcher based on the outputs of the the Source: Prepared byXL-DEA data envelopment analysis program

### 4-4. Measuring the average relative efficiency of surgical wards in Iraqi government hospitals in the northern region

(٧)Table

put data for Iraqi government hospitals in the northern shows input and out region

| G | F | E | D | C | B | A |
|---|---|---|---|---|---|---|
| **Minor operation s** | **Intermediate operations** | **Major operations** | **Number of surgeries** | **Number of doctors** | **Surgery bed** | **Governorate** |

JOBS مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

| | | | | | | |
|---|---|---|---|---|---|---|
| ٣٣٧١٢ | ٤٨٢٧٥ | ٣٠٣٠٤ | ٢٢٦٤٥ | ٨٥ | ٢٦٦ | **Nineveh** |
| ١٩٢٢٢ | ١٢٤٩٧ | ١٢٠٤٣ | ٤٨٣١ | ٤٩ | ١٨٩ | **Kirkuk** |
| ١٠٢٨٤ | ٩٥٤٣ | ٥٤١٩ | ٥٧٢٧ | ٤٧ | ٩٥ | **Salahaddin** |
| ٧١٧٢ | ٢٧٣٣٤ | ٢٢١١٧ | ٤٢ | ٧٤ | ٤٥٢ | **Erbil** |
| ٩٨٩١ | ٢٠٨٢٥ | ١١٩٣٢ | ٣٣٤٢ | ٣٠ | ٢٥١ | **Dohuk** |
| ١٨٢٠٥ | ٢٤٩١٩ | ١٧١٦٣ | ١ | ٤٥ | ٤٤٢ | **Sulaymaniyah** |

The data presented in Table 8 shows that the hospitals in the Nineveh, Kirkuk, Dohuk, and Sulaymaniyah governorates have achieved full efficiency, with their productive efficiency scores reaching 1.0000 according to both variable and constant returns to scale models.

Their scale efficiency also reached 1.0000, indicating they are operating under constant returns to scale.

This achievement signifies that these hospitals have attained full efficiency and are operating at an optimal production volume, demonstrating their capability to optimally utilize their resources. It is crucial for these hospitals to sustain their efficiency and their exemplary status.

However, the hospitals in the Kirkuk and Erbil governorates did not achieve full efficiency. Under the variable returns to scale model, their efficiency scores were 0.8950 and 0.8287, respectively. Furthermore, under the constant returns to scale model, their efficiency scores were 0.7563 and 0.9474, respectively.

The scale efficiency for the hospitals in Kirkuk Governorate was characterized by increasing returns to scale, whereas in Erbil, it was marked by decreasing returns to scale.

In the case of Salah al-Din Governorate, the hospitals achieved full efficiency with a score of 1.0000 according to the variable returns to scale model, but under the constant returns to scale model, their efficiency was 0.844, also indicating increasing returns to scale.

Table (8) Average productive efficiency of surgical wards in Iraqi northern hospitals

| The degree of efficiency of constant returns to scale(CCR) . | Volume yield | Degree of volumetric yefficienc | Degree of efficiency of variable returns to scale(VRS) . | Governorates |
|---|---|---|---|---|
| 1 | Fixed | 1 | ١ | **Nineveh** |
| 0.6769 | Increasing | 0.7563 | 0.8950 | **Kirkuk** |
| 0.8446 | Increasing | 0.8446 | 1 | **Salahaddin** |

| | | | | |
|---|---|---|---|---|
| 0.8287 | decreasing | 0.9474 | 0.8287 | **Erbil** |
| ١ | Fixed | 1 | 1 | **Dohuk** |
| ١ | edFix | 1 | 1 | **Sulaymaniyah** |

Source: Prepared by the researcher based on the outputs of theXL-DEA data envelopment analysis program

**4-5. Stagnation in inputs and surplus in outputs and the reference governorates for each of the inefficient hospitals:**

The Data Envelopment Analysis (DEA) method not only identifies inefficient units but also provides efficiency ratios for benchmark units, which serve as references for improving performance to achieve the desired efficiency levels.

Hospitals that have not met the required efficiency benchmarks, such as those in Diyala, are advised to adjust their operations based on their benchmark units.

The analysis specifies these benchmark units, which for Diyala hospitals include Basra (0.0082), Maysan (0.5795), Babil (0.2110), Dhi Qar (0.0949), and Najaf (0.1064). By emulating the practices and performance levels of these reference units, Diyala hospitals can work towards attaining the necessary efficiency.

The analysis suggests that while the overall performance scores of the hospitals were satisfactory, Diyala hospitals, in particular, have the potential for improvement given their large size and diverse range of medical specialties.

This indicates that a more concerted effort is required for these hospitals to enhance their operational efficiency. The DEA provides ratios for benchmark units that guide inefficient units on how to address their shortcomings and achieve the required performance levels, whether through maximizing outputs or minimizing inputs.

Additionally, the analysis offers insights into which hospitals in the reference governorates each governorate should look to for guidance in overcoming inefficiencies.

The analysis also outlines the necessary improvements for hospitals in less efficient governorates to attain efficiency.

For hospitals in Diyala Governorate, which are identified as inefficient, there are two primary strategies to achieve overall efficiency:

JOBS
مجلة العلوم الأساسية
Journal of Basic Science
Print -ISSN 2306-5249
Online-ISSN 2791-3279
العدد الحادي و العشرون
٢٠٢٤م/١٤٤٥هـ

Output approach: Inefficient hospitals in Diyala Governorate, with their current level of inputs, have the potential to reach full efficiency by increasing their outputs to match the benchmarks set by efficient hospitals in other governorates.

Specifically, they should aim to increase their patient intake by 0.0274 as per Basra's standards, 0.4379 according to Maysan's performance, 0.1389 following Babil's metrics, 0.2585 in line with Kirkuk, and 0.1372 to match Dhi Qar's efficiency. This includes enhancing the number of patient visits, laboratory tests, and the utilization of radiological imaging services.

Remarkably, these improvements in service outputs can be achieved without proportionally increasing the inputs such as the number of beds and nursing staff.

The analysis suggests a deficiency in health performance across various governorates. To understand the underlying causes of this performance gap and to identify the issues, one can examine the analysis results to determine which input variables (contributing factors) and outputs (results) are responsible for this shortfall.

The analysis reveals that the deficiency arises from certain underutilized inputs and discrepancies in outputs.

In the case of Diyala Governorate hospitals, the analysis attributes the performance shortfall to specific inputs, including the number of doctors, beds, nursing staff (both male and female), laboratory tests, and other health personnel.

Similarly, outputs such as the number of inpatient admissions, patient admissions, and the incidence of deaths were not at optimal levels. Therefore, these variables need to be effectively managed to address the deficiencies and enhance health performance in Diyala's hospitals.

There is also a second strategy, the input approach: To achieve full efficiency, Diyala hospitals need to align their performance with that of efficient hospitals in other governorates, such as Basra (reducing the number of beds by 0.0096 and doctors by 0.096, and the number of nursing staff and other health personnel by 0.0096) and Maysan (reducing other health personnel by 0.5062).

This adjustment in inputs is necessary to reach the efficiency levels observed in Basra and Maysan hospitals.

## Conclusions and Recommendations

### 5-1. Conclusions

1. The analysis of benchmark units for hospitals with low efficiency levels, which exhibit poor production efficiency, has proven crucial for pinpointing areas in need of improvement. Identifying these hospitals enables focused monitoring and guidance to boost their operational performance. This strategy facilitates targeted interventions designed to rectify inefficiencies, thereby improving their overall efficiency.
2. Hospitals achieving high production efficiency exemplify their dedication to embracing advancements and striving for excellence in education, learning, and community service. Their commitment to quality and leadership establishes them as leaders in the healthcare sector, both regionally and globally. Their emphasis on continual improvement and innovation secures their prominent status in the international healthcare community.
3. The Data Envelopment Analysis (DEA) method has provided a valuable framework for evaluating study variables by including multiple Decision-Making Units (DMUs), such as different hospitals. This method accommodates the varied and complex nature of inputs and outputs within these units, leading to a comprehensive evaluation of current production efficiency. By addressing the nuances of factors influencing efficiency, DEA facilitates a detailed examination that offers insights for enhancing operational efficiency across various hospitals.
4. Identifying benchmark hospitals for those yet to achieve full efficiency, as determined by production efficiency measurements, is vital for the improvement and advancement of Iraqi healthcare facilities. Utilizing these benchmarks allows for targeted efforts to enhance the efficiency of Iraqi hospitals towards achieving full efficiency. This initiative not only benefits the local healthcare system but also contributes to the broader development of Arab hospitals, enhancing their capacity and efficiency to address the region's changing healthcare demands.
5. The average relative efficiency of all hospitals in the southern governorates was 99.5225%, whereas in the northern governorates it was 98.873%. This indicates that hospitals in the southern governorates must utilize 99.5225% of their current inputs (such as the number of doctors,

nursing staff, and auxiliary medical personnel) to maintain their current output levels (patient visits, laboratory tests, and radiology services) efficiently. In other words, they must reduce their inputs by 0.4775% while maintaining the same service levels to achieve full efficiency.

**5-2. Recommendations**

1. Hospitals need to prioritize the training and skill development of their staff, especially doctors, due to its significant impact on enhancing performance compared to other hospitals. Continuous professional development is essential for improving the quality of patient care and operational efficiency.
2. It's crucial for hospitals with lower performance scores to enhance their production efficiency. This improvement can be achieved by focusing on key inputs such as the qualifications and efficiency of medical staff, including doctors and nurses, as well as optimizing the use of available beds. Hospitals should invest in advanced technology and leverage its capabilities to further enhance service quality and efficiency.
3. Implementing the performance evaluation model proposed by this study in various departments across other Iraqi hospitals is recommended. Additionally, incorporating other relevant factors and metrics could enrich the assessment, providing a more comprehensive understanding of hospital performance and areas for improvement.
4. To attain a prominent ranking among internationally recognized hospitals, Iraqi hospitals must stay abreast of advancements in healthcare methodologies and enhance their performance to achieve higher standings.
5. There is a significant need for Iraqi hospitals to engage in knowledge exchange with their Arab and international counterparts through cultural agreements and by organizing and participating in global conferences and seminars. Such collaboration can foster mutual learning and improvement.
6. It is essential for the Iraqi healthcare sector to pursue development within a competitive framework, embracing modern technology in healthcare practices, and striving to deliver services that combine cost-efficiency, superior quality, and optimal productivity. Additionally, these services should be offered at competitive prices to meet the demands of a global healthcare market.
7. Hospitals in the research sample that did not achieve full efficiency should emulate the benchmark hospitals identified during the efficiency assessment. By adjusting their input and output ratios with the designated weights, these hospitals can attain full efficiency.

8. Implementing contemporary management strategies in healthcare is crucial for enhancing production capabilities, maximizing benefits, and mitigating health risks.

9. Enhancing production efficiency is achievable through the employment of qualified healthcare professionals who possess extensive experience in modern medical practices and are capable of earning patient trust. Promptly addressing patient needs and optimizing resource utilization are essential for delivering high-quality healthcare services efficiently.

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