



Health Systems Efficiency in Arabic Countries Region: Using Data Envelopment Analysis

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Abstract :

This study seeks to identify the Arab countries that are more efficient than others in utilizing their profitability concerning health resources. It evaluated the technical efficiency of the Arab countries for the year 2020 by employing data obtained from the WHO's Global Health Observatory. As per the results of the study, the health systems of the most efficient countries were found to be in Algeria, Bahrain, Iraq, Jordan, Kuwait, Morocco, Qatar, and Tunisia. In contrast, inefficient countries in the health system were Egypt, the United Arab Emirates, Oman, Lebanon, and Saudi Arabia.

Key Words: Efficiency, Resource allocation, Health care economics and organizations, data envelopment analysis model, Arabic Countries Region.

JEL Classification : I11, C14.

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Introduction :

Generally, the health system is an important service sector and one of key indicator of development (Jakovljevic M et al, 2020). . Over the past two decades, health efficiency has become a significant topic of interest for both researchers and policymakers. It is important to consider that better health is a fundamental factor in well-being and human happiness. (Sabatini, 2011)

Health systems have become a significant part of the global economy . As GDP increases, health expenditure generally rises accordingly . The share of health spending in the budgets of low- and middle-income countries is increasing. Getzen and Jakovljevic observed that changes in GDP growth rates have significantly impacted global health expenditure patterns. Consequently, national health spending has increased worldwide. It appears that emerging economies are taking up a larger share of global medical spending, while the share of wealthier countries is decreasing (Jakovljevic M, 2020)

Assessing the efficiency of health systems is an important concern for policymakers, especially as recent years have seen an increased demand for health services. This demand logically leads to higher public spending in the sector,



accompanied by a rise in the number of doctors, hospital beds, medical devices, and hospital construction. On one hand, these factors serve as indicators of health system efficiency. On the other hand, there are factors outside the health system's control, such as environmental issues (e.g., air pollution), economic factors (e.g., individual income), social and institutional differences (e.g., governance quality), and demographic factors (e.g., population age structure). Exploring the factors that influence health system efficiency continues to be of significant interest. The majority of countries, including Arab ones, aim to improve their health sectors by striving for universal health coverage to ensure everyone has access to health services. To achieve this coverage, each community or country must consider several factors, including establishing effective health and financing systems, relying on modern technology, and maintaining a well-trained human resource. In recent years, there has been an increase in health system spending, including in Arab countries. These countries have involved experts, managers, and decision-makers to find new methods to reduce costs and raise efficiency.

Data Envelopment Analysis (DEA) emerges as a tool that uses mathematical programming to measure similar units with multiple inputs and outputs on an efficiency scale. It is one of the quantitative methods used to rationalize managerial decisions at the level of decision-making units.

Research Problem: Based on the aforementioned discussion, the main research problem can be posed as follows: **What are the degrees of variation in the efficiency of health systems among the Arab countries being examined?**

Study Hypotheses: To answer the research problem, the following hypothesis has been formulated:

- The efficiency levels of health systems vary among the Arab countries being studied.

Study Objectives: The study aims to:

- Understand the data envelopment analysis (DEA) method as a tool used for measuring efficiency.
- Determine the efficiency metrics for the health sector in the selected Arab countries using DEA models.
- Identify the most efficient Arab countries in delivering health services in the year 2020.

Study Methodology: The method and the subject are methodologically related, making them interconnected issues. The nature of the subject determines the method to be followed to fully comprehend its key aspects. Thus, it can be said that the study relied on the descriptive method for its theoretical framework. This method is characterized by collecting various information to provide a comprehensive overview of each aspect of the study and to describe the phenomenon. For the practical study, the study adopted a case study approach for the health sector in the



Arab countries, applying the data envelopment analysis (DEA) method to measure efficiency indices for the sector.

I. Literature review

- (Marwân-al-Qays B et al, 2016) Researchers investigated how well 18 countries in the Middle East and North Africa (MENA) used their healthcare resources between 1995 and 2012. Their findings suggest that simply spending more money on healthcare in this region doesn't always result in better health for the population or a perfectly efficient healthcare system.
- (Dhaoui, 2019) This study investigates how efficiently healthcare systems in 18 Middle Eastern and North African countries utilized resources between 1997 and 2014. They employed the Data Envelopment Analysis (DEA) technique, considering both the resources used (inputs) and the health outcomes achieved (outputs). To gain a deeper understanding, the researchers performed a cluster analysis across the three time periods (1997, 2005, 2014). This analysis examined how efficiently countries produced health outcomes and the health outcomes themselves. Interestingly, the study found that countries on the efficient frontier, meaning they were using resources most effectively, included those with both high and modest health outcomes. This suggests that achieving good health outcomes isn't necessarily dependent on the highest spending but rather on efficient resource allocation.
- (Lila ZIANI, 2020) This research underscores the importance of efficient resource management in healthcare systems for achieving desired outcomes. It echoes a growing concern in developing countries, particularly the Maghreb region within MENA. The research uses the Data Envelopment Analysis (DEA) method to assess the efficiency of the health systems in Maghreb countries. DEA is a valuable tool for benchmarking healthcare systems and identifying areas for improvement.
- (Seddighi, 2020) This study compared the efficiency of healthcare systems in 27 developing countries, including both high-income and mid-income nations. They used a method called Data Envelopment Analysis (DEA) to see how well these systems used their resources to achieve health outcomes. The study found that countries spending more on healthcare tended to be more efficient, especially when looking at health outcomes achieved (output-oriented DEA). Additionally, the factors affecting efficiency lined up with what economic theory predicts. This suggests that while spending more can improve efficiency, there might be other factors at play as well. Here's an additional note: The concept of "positioning" of Tunisia's health system efficiency can be simplified to how Tunisia compares to other countries in the study.
- (El Wahab, 2021) This research assessed the effectiveness of health expenditure in GCC nations, with a particular emphasis on Kuwait from 2000



to 2017. The research found that public spending in the health sector is inefficient. This suggests that there is room for improvement in health care delivery without necessarily increasing spending. In other words, health sector outcomes could be enhanced by 35% without any additional expenditure, and similar results could be attained by cutting public spending by 23%.

- (El Hussein, 2022) Researchers examined how well healthcare systems in 20 Arab countries used their resources in 2010 and 2019. They used a special method called Data Envelopment Analysis (DEA) to compare these systems. DEA helps identify the most efficient systems by looking at what they put in (resources) compared to what they got out (health outcomes).
 - The study found that in 2019, most Arab countries could improve their efficiency by 0.4% to 16%. In fact, only six countries were using their resources as well as possible.
 - This research also looked at factors that might influence how efficient a healthcare system is. By understanding these factors, policymakers can make better decisions about how to improve their healthcare systems.

II. Methods:

The difficulty of defining output in healthcare systems is considered as one of the main approaches that distinguished healthcare systems from other systems. Therefore, DEA, is frequently used for performance analysis in sectors or systems where it seems difficult to identify inputs and/or outputs.

The credit for developing the DEA method goes to Charnes-Cooper-Rhodes. Data Envelopment Analysis (DEA) is a mathematical programming method utilized to estimate the technical efficiency of schools. This approach involves assessing a set of inputs and outputs without considering their prices. DEA determines the relative efficiency of Decision-Making Units (DMUs) by calculating the ratio of total outputs to total inputs for each entity and comparing these ratios across various entities. If an entity achieves the best efficiency ratio, it becomes an "efficient frontier," and the inefficiency of other entities is measured relative to this efficient frontier using mathematical methods. The efficiency index of an entity ranges between the value of one (1), representing complete efficiency, and zero (0), representing complete inefficiency. (Klimberg, 2008)

The reason this method is named Data Envelopment Analysis (DEA) is because the administratively efficient units are at the forefront and envelop the inefficient administrative units. There fore, the data enveloped by the efficient units are analyzed

Efficiency, in mathematical terms, is defined as the ratio of the weighted outputs to the weighted inputs:



$$\text{Efficiency} = \frac{\text{weighted sum of outputs}}{\text{weighted sum of inputs}}$$

Generally, there are two approaches to enhance inefficient units and reach the efficiency limit (Jeremic V, et al, 2012):

- Input Reduction: Decreasing the amount of resources used while maintaining the same level of output.
- Output Increase: In the context of Data Envelopment Analysis (DEA), increasing output without a corresponding increase in resource utilization is a key objective.

DEA models can be categorized based on their orientation. The input-oriented approach focuses on minimizing inputs to achieve technical efficiency, ensuring the unit operates within the efficiency frontier without altering output levels. Conversely, the output-oriented approach aims to identify the necessary increase in outputs to reach the efficiency frontier, maintaining constant input levels (Seddighi, 2020)

According to the World Health Organization, most of the Arab countries were regarded as decision making units (DMU's) in this study. However, as a result of the lack of statistical data during the research for the respective period, Afghanistan, Djibouti, Somalia, Sudan, Syria and Yemen were omitted. The findings are presented using the BCC and also the CCR approaches (Charnes, Cooper & Rhodes), in a hybrid input and output approach (Varabyova Y, Schreyögg J, 2013). Even with the above, the discussion will focus on the output-based strategies since the aim of the health system is to increase health outcome rather than the aim of resource conservation and reduction of inputs. (Hadad S and al, 2013)

In the analysis, most Arab countries were treated as decision-making units (DMUs) according to World Health Organization guidelines. However, six countries—Afghanistan, Djibouti, Somalia, Sudan, Syria, and Yemen—were excluded due to unavailable data during the study period.

The results are presented using two models: BCC and CCR (Charnes, Cooper & Rhodes model), which incorporate both input-centered and output-oriented approaches. The analysis and discussion primarily focus on the output-oriented approach, as the objective of the health system is to maximize health outcomes rather than merely conserving resources and minimizing inputs. (YA, Ozcan, 2014)

IV. Data envelopment analysis model for healthcare production function:

To conduct a meaningful efficiency evaluation, the DEA method requires selecting homogeneous decision-making units that operate in comparable environments in terms of opportunities and constraints (Khaled, 2022)

The input and output definitions are provided in Table 1. For the DEA analysis, the research data were sourced from the World Health Organization's Health Surveillance Section, 2020.

**Table 01 : « Inputs and outputs definition of data envelopment analysis »**

Source	Parameter	Name	
WHO health observatory	X1	Nursing and midwifery personnel (per 10 000 population)	Input
WHO health observatory	X2	Hospital beds (per 10 000 population)	
WHO health observatory	X3	Medical Doctors(per 10 000 population)	
WHO health observatory	Y1	infant-mortality-rate (per 10 000 population)	Output
WHO health observatory	Y2	life-expectancy-at-birth	

Source: Prepared by authors

The data presented in Table 1 represent the essential inputs and outputs used in the Data Envelopment Analysis (DEA) to evaluate the efficiency of healthcare systems. The inputs—nursing and midwifery personnel, hospital beds, and medical doctors—capture the critical healthcare resources necessary for service delivery. These parameters provide a quantitative basis for assessing the capacity and infrastructure of health systems.

The outputs—infant mortality rate and life expectancy at birth—are widely recognized indicators of healthcare outcomes. A lower infant mortality rate reflects the effectiveness of maternal and child health programs, while higher life expectancy indicates the overall success of the healthcare system in promoting long-term population health.

By combining these inputs and outputs, the DEA model offers a robust framework for assessing technical efficiency. The choice of inputs ensures that the analysis considers the core resources required for healthcare delivery, while the selected outputs focus on health system performance in achieving key health outcomes. This approach enables the identification of inefficiencies and highlights opportunities to optimize resource allocation for improved outcomes.

The parameters outlined in Table 1 provide the foundation for evaluating the relative efficiency of healthcare systems in the study. They ensure comparability across systems while emphasizing the importance of both resource utilization and outcome achievement in determining overall efficiency.

**Table 2: « Data entered into the software »**

Country	Hospital beds	Nursing and midwifery personnel	Medical	infant-mortality-rate	Life expectancy at birth
Algeria	19	15	Doctors	20	66
Bahrain	17	25	17	6	66
Egypt	14	19	9	17	63
United Arab Emirates	14	57	8	7	66
Iraq	13	20	25	22	63
Jordan	15	33	7	13	68
Kuwait	20	74	23	7	70
Lebanon	27	17	26	6	66
Morocco	10	14	21	18	64
Oman	15	41	7	10	65
Qatar	13	92	20	6	67
Saudi Arabia	22	55	25	6	64
Tunisia	22	25	26	14	67
Average	17	37.46	13	11.69	66

Source: data World Health Organization

Table 2 provides detailed data on healthcare system inputs and outputs for the selected Arab countries, offering insights into resource distribution and health outcomes. The inputs include hospital beds, nursing and midwifery personnel, and medical doctors, while the outputs are infant mortality rate and life expectancy at birth. These figures highlight the disparities in healthcare resource allocation and performance among the countries studied. The average number of hospital beds across the region is 17 per 10,000 population, with Lebanon having the highest availability at 27 and Iraq and Qatar the lowest at 13. While a higher number of hospital beds can indicate better capacity to address healthcare needs, the results suggest that infrastructure alone is not sufficient to guarantee efficiency or improved health outcomes. For example, Lebanon's high number of hospital beds does not translate into significantly better life expectancy compared to other countries. The availability of nursing and midwifery personnel shows considerable variation, with an average of 37.46 personnel per 10,000 population. Qatar stands out with 92 personnel, while Morocco has the lowest at 14. This disparity indicates differences in healthcare workforce investment across countries. A higher density of nursing personnel, as seen in Qatar, can support preventive care and improve health service delivery. However, the efficiency of their utilization is crucial to translating these resources into better health outcomes. In terms of medical doctors, the regional average is 13 per 10,000 population. Kuwait and Tunisia lead with 26 doctors, while



Jordan and Iraq report the lowest densities at 7 each. This variation in medical workforce availability suggests differing capacities to provide specialized and primary care. Countries with fewer medical doctors may face challenges in meeting population health demands, particularly in addressing complex health conditions. For the outputs, the infant mortality rate averages 11.69 deaths per 10,000 population, ranging from a low of 6 in countries like Bahrain and Qatar to a high of 22 in Iraq. Lower infant mortality rates reflect stronger maternal and neonatal health systems, whereas higher rates indicate gaps in prenatal and postnatal care. Similarly, the average life expectancy at birth is 66 years, with Kuwait achieving the highest at 70 years and Egypt and Iraq the lowest at 63. These differences in life expectancy highlight variations in the overall effectiveness of healthcare systems in promoting population health and longevity. The data reveals important trends in resource allocation and utilization. Some countries, like Qatar and Bahrain, achieve strong health outcomes with relatively moderate input levels, indicating efficient healthcare delivery. In contrast, countries such as Lebanon and Egypt struggle to achieve comparable outcomes despite significant resources, suggesting inefficiencies in their health systems. These findings emphasize the importance of not just increasing healthcare resources but also ensuring their optimal allocation and utilization to improve outcomes. By examining these inputs and outputs, Table 2 lays the groundwork for further efficiency analysis using the DEA model, which can identify best practices and highlight areas for improvement in healthcare systems across the region.

Table 3: « Health system efficiency ranking out put »

Country	Technical efficiency	Scale efficiency
Algeria	1	0.58
Bahrain	1	0.80
Egypt	0.93	0.99
United Arab Emirates	0.83	0.87
Iraq	1	1
Jordan	1	0.72
Kuwait	1	0.54
Lebanon	0.66	0.68
Morocco	1	1
Oman	0.73	0.95
Qatar	1	0.84
Saudi Arabia	0.46	0.98
Tunisia	1	0.59
Average	0.89	0.78

Source: Authors' computation using DEA program outputs.



Based on the data presented in Table 3, the most efficient health systems among Arab countries were identified in Bahrain, Algeria, Iraq, Morocco, Jordan, Qatar, Kuwait, and Tunisia. Conversely, the countries with less efficient health systems included Egypt, Oman, Lebanon, Saudi Arabia, and the United Arab Emirates.

This section examines the application of the output-oriented model, which aims to maximize output levels given the current levels of input consumption. This evaluation was conducted through the analysis of technical efficiency and scale efficiency.

The average technical efficiency for all countries was 0.98, indicating a high capability of the health systems in the sample countries to maximize outputs given the available resources. Notably, eight countries achieved a perfect efficiency index of 100 percent, namely (Algeria, Bahrain, Iraq, Jordan, Kuwait, Morocco, Qatar, Tunisia), while Saudi Arabia obtained the lowest technical efficiency (0.91).

The average scale efficiency for all countries was (0.72), which was the degree to which health systems can expand according to the size of their operations, as two countries, Iraq and Morocco, achieved a complete scale efficiency of 100 percent, and we find that the lowest competence efficiency obtained by Lebanon (0.46), followed by Saudi Arabia (0.49).

Table 4: « Health system efficiency in studied countries using the data envelopment analysis method Out put »

Inefficient country	Reference countries	Inefficiency score
Egypt	Iraq	0.42
	Morocco	0.58
Emirates	Qatar	0.68
	Morocco	0.32
Lebanon	Jordan	0.27
	Morocco	0.34
	Tunisia	0.39
Oman	Qatar	0.70
	Morocco	0.30
Saudi Arabia	Qatar	0.31
	Morocco	0.69

Source: Authors' computation using DEA program outputs.

Table 4 highlights the health system efficiency of the studied Arab countries, focusing on inefficient countries, their reference counterparts, and the corresponding inefficiency scores derived from the Data Envelopment Analysis (DEA) method. The



results provide insights into which countries serve as benchmarks for improving efficiency and the degree of inefficiency present in the underperforming systems.

The table identifies Egypt, the United Arab Emirates, Lebanon, Oman, and Saudi Arabia as inefficient countries in terms of healthcare delivery. These countries are evaluated against reference countries—those that achieved full efficiency in the DEA model. For example, Egypt, with inefficiency scores of 0.42 and 0.58, is benchmarked against Iraq and Morocco, respectively. These scores indicate that Egypt's healthcare system would need to improve its outputs or better utilize its inputs by 42% to 58% to reach the efficiency levels of its reference countries. Similar trends are observed for other inefficient countries, with Morocco appearing frequently as a reference, indicating its strong performance in achieving health system efficiency with limited resources.

The United Arab Emirates shows inefficiency scores of 0.68 and 0.32 relative to Qatar and Morocco. Despite having a well-resourced healthcare system, its inability to achieve comparable health outcomes highlights potential systemic inefficiencies or issues in resource utilization. This underscores the importance of studying the policies and practices of reference countries like Qatar, which combine moderate inputs with strong health outcomes.

Lebanon's inefficiency scores range from 0.27 to 0.39, with Jordan, Morocco, and Tunisia serving as reference countries. This suggests that Lebanon's healthcare system could significantly improve by emulating the practices of these more efficient systems. The frequent appearance of Morocco and Tunisia as benchmarks highlights their exemplary resource utilization and effectiveness in delivering health outcomes despite relatively lower resource availability.

Oman and Saudi Arabia also demonstrate inefficiency, with Oman needing to reduce inefficiencies by 30% to 70% compared to its reference countries, Qatar and Morocco. Similarly, Saudi Arabia exhibits inefficiency scores of 0.31 and 0.69 relative to the same reference countries. These findings suggest that both nations, despite their substantial investments in healthcare infrastructure, face challenges in maximizing the outputs derived from their inputs.

The frequent appearance of countries like Morocco, Qatar, and Tunisia as reference points underscores their role as models of healthcare efficiency in the region. Their ability to achieve strong health outcomes with optimal resource use serves as a guide for inefficient systems to refine their policies and practices. These countries demonstrate that efficiency is not solely dependent on the quantity of resources but also on how effectively these resources are managed and utilized.

The Table 4 reveals that inefficient countries can improve their healthcare performance by adopting strategies from benchmark systems. This includes optimizing resource allocation, improving healthcare delivery mechanisms, and addressing systemic inefficiencies. These findings provide actionable insights for policymakers to enhance health system efficiency across the region.



Conclusion

The empirical analysis models have proven their effectiveness in measuring the actual efficiency of non-profit organizations that have homogeneous inputs and outputs, in addition to the ability of these models to identify where the efficiency is lacking in the inputs and outputs and how to reach full efficiency.

There is a variation in the level of technical or scale efficiency with input-oriented or output-oriented approaches among the countries under study.

Data Envelopment Analysis (DEA) is considered one of the important methods used by analysts, managers, and decision-makers to evaluate and compare the efficiency of sectors, including healthcare, to determine the extent to which one outperforms the others, and to suggest improvements that can be made to achieve complete efficiency compared to other countries.

The DEA method assesses each country based on the inputs and outputs of various decision-making units relative to a benchmark country, such countries that have been '100%' efficient in this study as compared to the other countries, were able to achieve the same outputs with lower or equal inputs requirements. Therefore, if Morocco and Bahrain were found to be 'fully efficient' in this analysis, it means that they employed artificial inputs associated with actual health care services, which in this context are hospital beds, nursing and midwifery personnel, medical doctors to a lesser degree with respect to healthy life expectancy and infant survival rates than their counterparts in those other countries.

Countries like Lebanon and Saudi Arabia, which exhibit higher inefficiencies, often have significantly larger inputs such as hospital beds, nursing and midwifery personnel, and medical doctors, either individually or in combination. However, when comparing outputs such as healthy life expectancy at birth and infant survival rates, the differences are not substantial.

There are countries that have not yet achieved full efficiency in their health systems. This can potentially be addressed by expanding the utilization of available resources and optimizing their allocation, thereby moving closer to achieving full efficiency.



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