

The efficiency of healthcare systems in the Arab countries: a two-stage data envelopment analysis approach

Healthcare systems in the Arab countries

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Abstract

Purpose – This study aims at evaluating the technical efficiency (TE) of healthcare systems in the Arab region and exploring the key factors that affect the efficiency performance.

Design/methodology/approach – The study applies a two-stage Data Envelopment Analysis (DEA) approach to a sample of 20 Arab countries. In the first stage, a DEA model is used to calculate the TE scores of the examined healthcare systems in 2019 and 2010, following both the output and input orientations of efficiency. In the second stage, a censored Tobit model is estimated to investigate the determinants of healthcare efficiency.

Findings – DEA results of 2019 indicate that achievable efficiency gains of the Arab countries range from 0.4% to 16% under the output and input orientations, respectively. Six countries are efficient under both orientations. Although the average efficiency scores of the Arab countries have deteriorated between 2010 and 2019, Djibouti and Sudan had the greatest efficiency improvements between the two years. Bahrain, Mauritania, Morocco and Qatar proved to be efficient in 2010 and 2019 under the two orientations of efficiency and according to the two DEA specifications followed. The Tobit model reveals that corruption and government health expenditure tend to have an adverse impact on healthcare efficiency.

Originality/value – The author evaluates healthcare efficiency and healthcare's efficiency determinants in the Arab countries. Regardless Arab countries' diversity, these countries are facing common health challenges, including diminishing role of governments in healthcare financing; increased out-of-pocket healthcare spending; poor healthcare outputs and prevalence of health inequities resulting from weak governance institutions. Comparing the efficiency of healthcare systems between 2010 and 2019 gives insights on the potential impact of the Arab spring uprisings on healthcare efficiency. Moreover, examining the determinants of healthcare efficiency allows for better understanding of how to improve the efficiency of healthcare systems in the region.

Keywords Technical efficiency, Healthcare systems, Arab countries, Data envelopment analysis, Health resources, Health outputs, Tobit

Paper type Research paper

1. Introduction

The private and social returns to investment in healthcare systems are non-controversial (*see for example Arora, 2001; Finlay, 2007; Tompa, 2002; Cole and Neumayer, 2005*). While the availability of health resources is a necessary condition for a successful healthcare system, the efficient allocation of these resources is a critical issue to provide accessible health services at an optimum cost and acceptable quality (*Radojicic et al., 2020*). With the global resource scarcity, governments need to examine the efficiency of their healthcare systems rather than just allocating further resources to these systems.

JEL Classification — I10, I19, C14, C34, C50

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Through better management of health resources, countries with inefficient health systems can achieve better results in terms of input savings or output improvements. The empirical assessment of the efficiency of healthcare systems, however, encounters a number of methodological issues. On one hand, measuring health efficiency needs the identification of appropriate and valid indicators that measure both health outputs and health inputs. On the other hand, since health outputs are not solely determined by health-related resources, other factors need to be considered when examining the efficiency of healthcare systems, such as socio-economic and life-style factors (Ahmed *et al.*, 2019; Radojicic *et al.*, 2020).

In response to these challenges, different approaches have been developed to evaluate healthcare systems' efficiency, including the Data Envelopment Analysis (DEA) approach. This approach is one of the most widely used non-parametric approaches to measure technical efficiency (TE) in services sectors, such as healthcare systems. Studies that apply this approach include Banker *et al.* (1984), Zere *et al.* (2006), Hribernik and Kierzenkowski (2013), Aristovnik and Obadic (2014), Ozcan (2014), Dutu and Sicari (2016), Ahmed *et al.* (2019), Meddeb (2019), Dhaoui (2019), Seddighi *et al.* (2020), Top *et al.* (2020) and El Husseiny (2021).

Analyzing the efficiency of healthcare systems is a relevant issue for the Arab region. While Arab countries are diverse in terms of area, population density, economic conditions and many other socio-economic and life-style features, they face common health challenges. One of the main challenges that face Arab countries is the diminishing role of the Government in financing the healthcare systems in favor of the private sector with an aim to improve efficiency, quality and equity of healthcare services (Kronfol, 2012a). For instance, the relative share of government health expenditure in current health expenditure has decreased from 22.5 to 10.2% in Yemen, from 73.9 to 49.4% in Iraq, from 32.5 to 22.7% in Sudan and from 66.7 to 51.2% in Jordan, between 2010 and 2019. In contrary, the relative share of the out-of-pocket health expenditure in current health expenditure has risen sharply in some Arab countries, reaching almost 81% in Yemen, 67.4% in Sudan, 62.7% in Egypt and 61.8% in Comoros in 2019, compared to the world average of 18% [1].

Furthermore, health inequities between different socio-economic groups of population exist in many Arab countries, where health status and the distribution of health services vary significantly by gender, age, geographic area, ethnic group and income level (Kronfol, 2012b). This pattern, along with the widening of other social and economic inequities, has resulted from the poor governance and high corruption levels that have provided the impetus for the Arab uprisings (Batniji *et al.*, 2014).

As such, cross-country evaluations of the efficiency of healthcare systems in the Arab region could help in highlighting the key areas of best practice and providing lessons that allow countries to learn from each other.

In light of this context, the current study aims at contributing to the existing literature by measuring the TE of healthcare systems in the Arab region using a two-stage DEA approach, shedding light on the evolution between the two years 2010 and 2019. In the first stage of analysis, a DEA model is used to calculate the relative efficiency scores of the health systems covered by the study under both input and output orientations. Then, in the second stage, a Tobit regression model is estimated to identify the main factors contributing to the efficiency of the examined health systems. To the best of the author's knowledge, this topic has never been examined at the level of the Arab countries using a two-stage DEA approach. The relevant study of Meddeb (2019) applies a single-stage DEA model to a sample of 18 Middle East and North Africa (MENA) countries [2] over the period 1995–2011 using an input orientation. Furthermore, Dhaoui (2019) applies a two-stage DEA approach to a sample of 18 MENA countries [3] for the years 1997, 2005 and 2014 using both input and output orientations. Yet, the DEA specification adopted in the mentioned study includes only one output variable, namely life expectancy at birth.

Following this introduction, the paper comprises of four sections. [Section 2](#) introduces a brief review of the literature on the application of DEA approach to the health sector. [Section 3](#) describes the methods, data and model specification. [Section 4](#) discusses the findings. Finally, [Section 5](#) concludes incorporating some relevant policy implications.

2. Data Envelopment Analysis and efficiency of healthcare systems: literature review

Measuring the performance of healthcare systems is one of the research areas that attract the attention of both researchers and policy makers. Different approaches have been adopted in this regard. For instance, [Pereira et al. \(2020\)](#) develop a multi-criteria decision analysis (MCDA) approach to rank nine of the European health systems with *Beveridgian* financing to identify the weaknesses of the Portuguese National Health. In addition, [Pereira and Marques \(2022\)](#) focus on the importance of regulatory mechanisms, such as sunshine regulation to ensure the adequate functioning of healthcare systems in terms of accountability and transparency. Using MCDA approach, the authors propose a sunshine regulatory model to the public hospitals in Portugal.

Yet, TE (i.e. the relationship between inputs and outputs) of healthcare systems is commonly assessed using different parametric and non-parametric methods that are based on the concept of the efficiency frontier. In contrast to the parametric or econometric approaches to measure relative efficiency (i.e. stochastic frontier analysis and data frontier analysis), the DEA approach is considered more flexible and easier to calculate as it merely depends on the input and output data. Indeed, this approach does not require a prior specification of the functional form of the production process or its underlying assumptions. However, DEA estimates of relative efficiency depend largely on the size of the sample and its composition as well as the input and output variables used ([Mandl et al., 2008](#); [Aristovnik and Obadic, 2014](#); [Dutu and Sicari, 2016](#); [Meddeb, 2019](#); [Dhaoui, 2019](#)).

DEA, as one of the most popular non-parametric approaches to measure TE, is a linear programming-based statistical technique that constructs the efficiency frontier utilizing the input-output data of a set of homogenous Decision-Making Units (DMUs). The estimated frontier represents the best practices. As such, DMUs alongside the curve are considered efficient and are assigned a score of 1, while those which deviate from the efficiency frontier are considered relatively inefficient and are assigned an efficiency score less than 1. Hence, potential efficiency gains of the inefficient DMUs can be measured by their relative distance from the frontier ([Mandl et al., 2008](#); [Hribernik and Kierzenkowski, 2013](#); [Dutu and Sicari, 2016](#); [Meddeb, 2019](#); [Dhaoui, 2019](#); [Ahmed et al., 2019](#); [Top et al., 2020](#)).

As illustrated by [Figure 1](#), the output and input orientations of the DEA approach measure the potential output improvements and input savings, respectively, that inefficient DMUs can have by moving to a point on the efficiency curve.

While the original idea on measuring relative efficiency using the DEA approach was introduced by [Farrell \(1957\)](#), the idea has been extended by [Charnes et al. \(1978\)](#) and [Banker et al. \(1984\)](#), who introduced the Constant Returns to Scale (CRS) model (i.e. Charnes, Cooper and Rhodes (CCR)) and the Variable Returns to Scale (VRS) model (i.e. Banker, Charnes and Cooper (BCC)), respectively.

Since the outputs or performance of the health sector can be influenced by a set of non-discretionary or exogenous factors which are not necessarily under the direct control of the DMUs or policy makers, being far away from the efficiency frontier does not necessarily imply the existence of inefficiencies within the system itself. Rather, this may reflect the influence of the environmental factors that proxy institutional, structural and other country-specific features, including the socio-economic characteristics. Hence, efficiency analyses are often carried out involving two main stages. While the first stage aims at measuring the

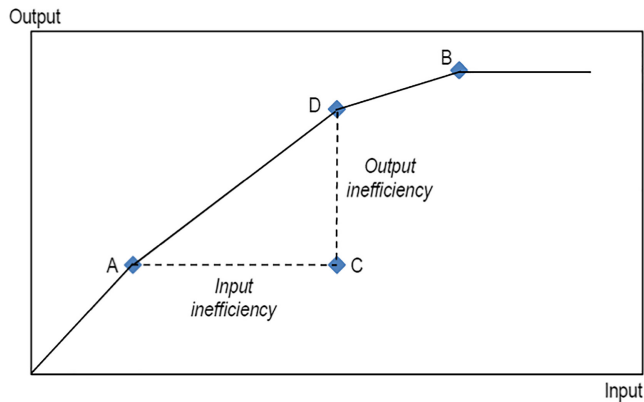


Figure 1.
Efficiency frontier

Source(s): The figure is based on Mandl *et al.* (2008) and Hribernik and Kierzenkowski (2013)

relative TE scores of the DMUs, the second stage seeks to identify the key determinants of inefficiency using an econometric model (Mandl *et al.*, 2008).

The review of the relevant empirical literature reveals that healthcare systems are among the main sectors that have been extensively investigated by efficiency analyses using the DEA technique. The previous studies, however, vary mainly in terms of their samples, input and output variables, efficiency orientations and number of stages involved in analysis.

In terms of the samples covered, the studies of Hribernik and Kierzenkowski (2013), Dutu and Sicari (2016), and Radojicic *et al.* (2020) focus on countries of the Organization of Economic Cooperation and Development (OECD). Examples of the studies that cover developing countries include Seddighi *et al.* (2020) on Eastern Mediterranean countries, Dhaoui (2019) and Meddeb (2019) on countries of the MENA region; Top *et al.* (2020) on African countries and El Husseiny (2021) on lower-middle-income countries. In addition, Ahmed *et al.* (2019) cover a sample of 46 healthcare systems in Asian countries.

Regarding the variables used as health outputs in the DEA specification, life expectancy at birth and infant survival rate are among the most commonly used variables (*see for instance* Hribernik and Kierzenkowski, 2013; Dhaoui, 2019; Meddeb, 2019; Ahmed *et al.*, 2019; Top *et al.*, 2020; Seddighi *et al.*, 2020; Radojicic *et al.*, 2020; El Husseiny, 2021). As for the health input variables, healthcare expenditure, whether as percentage of Gross Domestic Product (GDP) or in per capita terms, is on top of the list followed by the variables that proxy human resources (i.e. physicians density and nurses density) and physical resources (i.e. hospital beds density) (*see* Radojicic *et al.*, 2020).

In some of the reviewed studies, both input and output orientations of efficiency are followed (*see for instance*, Hribernik and Kierzenkowski, 2013; Dutu and Sicari, 2016; Dhaoui, 2019; El Husseiny, 2021). Yet, other studies have chosen to follow either the input-oriented or the output-oriented approach (*see for example*, Meddeb, 2019; Ahmed *et al.*, 2019; Seddighi *et al.*, 2020; Top *et al.*, 2020). Similarly, while some researchers apply a single-stage DEA model in their efficiency analyses (i.e. Hribernik and Kierzenkowski, 2013; Dutu and Sicari, 2016; Meddeb, 2019; Seddighi *et al.*, 2020), others utilize a two-stage approach (i.e. Dhaoui, 2019; Ahmed *et al.*, 2019; Top *et al.*, 2020; El Husseiny, 2021).

It is noteworthy that the majority of studies that applied the DEA approach to measure TE of healthcare systems have followed the VRS assumption since it is more flexible and realistic than the CRS assumption. In addition, the VRS assumption allows to measure pure TE (Ahmed *et al.*, 2019; Dhaoui, 2019; Top *et al.*, 2020).

Recently, the DEA approach has been utilized in different ways to assess the performance of healthcare systems. For instance, [Pereira et al. \(2021a\)](#) use the DEA approach to build composite indicators (CIs) as aggregators of key performance indicators. The developed CIs are used to assess the multidimensional performance aspects of Portuguese public hospitals from the perspectives of users and providers. In addition, [Pereira et al. \(2021b\)](#) use the DEA technique to propose an innovative approach to estimate convergence in the context of health performance assessments based on CIs.

3. Methods, model specification, and data

3.1 DEA model and its variables

The current study utilizes the DEA approach to calculate the relative TE scores of healthcare systems in a set of 20 Arab countries adopting both the input and output orientations.

On one hand, the output-oriented approach seems appropriate for the low- and middle-income Arab countries where health resources are relatively low and health outcomes are relatively poor. Hence, exploiting the existing level of health resources to improve health outputs could be a major concern for policy makers in those countries. On the other hand, measuring the potential savings in healthcare resources while maintaining health outputs unchanged could be informative to policy makers in the high-income Arab countries, where relatively high levels of health resources, including healthcare spending, are observed. Comparing the efficiency scores based on the two orientations gives insights on whether “resource utilization” or “resource exploitation” is the main issue that a healthcare system needs to focus on for the sake of efficiency improvement.

The VRS assumption is adopted in the DEA model in the current study since it is more flexible and realistic than the CRS assumption, given the fact that healthcare systems of the examined countries are non-homogenous and they operate under different conditions. In addition, the high variability in the values of the variables that proxy health inputs and outputs makes the VRS assumption more appropriate for a fair assessment of efficiency performance of healthcare systems that use numerous resources and produce multiple outputs. Furthermore, the VRS assumption seems more appropriate when DMUs are not operating at an optimum scale as it allows for measuring pure TE and scale activities separately (*see for example: Ahmed et al., 2019; Dhaoui, 2019; Top et al., 2020; El Husseiny, 2021*). The adoption of the multiplier formulation approach is guided by the relevant literature on healthcare efficiency analyses, including [Meddeb \(2019\)](#), [Ahmed et al. \(2019\)](#), [Dhaoui \(2019\)](#), [Seddighi et al. \(2020\)](#), [Top et al. \(2020\)](#) and [El Husseiny \(2021\)](#).

The DEA approach can be represented mathematically by a constrained optimization problem where the objective is to maximize the efficiency score of each DMU, which is measured as the weighted sum of outputs relative to the weighted sum of inputs, under the constraint that the efficiency score of any DMU should not exceed 1. This can be represented as follows ([Banker et al., 1984](#)):

$$\begin{aligned} \text{Max. } E_q &= \frac{\sum_{i=1}^r u_i y_{iq} + u_0}{\sum_{j=1}^m v_j x_{jq}} \\ \text{s.t. } \sum_{i=1}^r u_i y_{iq} + u_0 &/ \sum_{j=1}^m v_j x_{jq} \leq 1; (q = 1, 2, \dots, n) \\ u_i, v_j &\geq \varepsilon > 0; u_0 \in \mathbb{R} \end{aligned} \tag{1}$$

where “ E_q ” is the efficiency score of DMU q ; “ y_{iq} ” is the value of the output i of the DMU q ; “ x_{jq} ” is the value of the input j of the DMU q ; “ r ” is the number of outputs; “ m ” is the number

of inputs; “ u_i ” and “ v_j ” are the weights assigned by the DEA to output i and input j , respectively, to reach the degree of efficiency and “ n ” is the number of DMUs included in the sample.

As mentioned in the literature review section, the DEA scores are very sensitive to the size and composition of the selected sample as well as the number of the input and output variables included in the model relative to the number of the DMUs. Some studies suggest that the number of DMUs should be at least three times the number of inputs and outputs used in the DEA model (Golany and Roll, 1989; Hollingsworth and Peacock, 2008).

In this study, two variables are chosen as health outputs, namely life expectancy at birth and infant survival rate, which is based on infant mortality rate per 1,000 live births. These two variables are on top of the five-most commonly used output variables in healthcare efficiency analyses according to a review conducted by Radojicic *et al.* (2020). Indeed, these two output variables have appeared in many relevant empirical studies (*see for instance*: Hribernik and Kierzenkowski, 2013; Dhaoui, 2019; Meddeb, 2019; Ahmed *et al.*, 2019; Seddighi *et al.*, 2020; Top *et al.*, 2020; Radojicic *et al.*, 2020; El Husseiny, 2021).

We calculate infant survival rate based on infant mortality rate using the formula adopted by Seddighi *et al.* (2020) as follows:

$$\text{ISR} = 1 - (\text{IMR}/1000) \quad (2)$$

where ISR is infant survival rate and IMR is infant mortality rate.

This transformation is made to ensure that a higher value of health outputs represents a positive situation for efficiency.

Three variables are chosen as inputs of healthcare systems for the DEA model in the current study. These variables are current health expenditure as percentage of GDP; physicians density measured as the number of physicians per 1,000 population and hospital beds density measured as the number of hospital beds per 1,000 population. These variables are on top of the five-most commonly used input variables in the efficiency analyses of healthcare systems according to a review conducted by Radojicic *et al.* (2020). Health expenditure as percentage of GDP provides an indication on the level of financial resources allocated to health relative to other uses, reflecting the social priority that is given to the health sector in the whole economy. Physicians’ density and hospital beds’ density provide good proxies for the human and physical resources allocated to healthcare systems. While the two output variables used in our DEA model are highly correlated (i.e. the correlation coefficient is around 0.9), the calculated correlation coefficient of each pair of the three input variables is relatively low, which is less than 0.5. Yet, a high correlation between the variables used as outputs in DEA analyses is common in the relevant literature.

Data on the chosen input and output variables are collected for a sample of 20 Arab countries (all Arab countries excluding Somalia and Palestine due to insufficient data availability) in the 2 years of 2010 and 2019 [4]. Evaluating the efficiency scores at multiple time points is a preferable practice as it allows to observe the improvement or deterioration in the efficiency level over time and, consequently, to identify whether policy changes have led to better or worse efficiency. In addition, actual efficiency can be masked by irregularity or turbulence if only one time point is observed (Radojicic *et al.*, 2020). The selection of year 2019 is due to the fact that it represents the most recent year for which data on the two chosen output variables are consistently available for all countries covered by the study. In addition, comparing the efficiency levels of healthcare systems in the Arab region between 2010 and 2019 provides insights relating to the potential impact on healthcare systems’ efficiency of the institutional and political changes that have followed the Arab spring uprisings of 2011.

Data on the health output and input variables are extracted from the Global Health Observatory (GHO) database of the World Health Organization (WHO) as well as the World Development Indicators (WDI) database of the World Bank.

3.2 Tobit model and its variables

Health outcomes are influenced by several environmental factors (i.e. socio-economic and lifestyle factors) that are not necessarily controlled by the health systems. For that reason, health efficiency analyses are usually undertaken using a two-stage DEA approach. While in the first stage, relative efficiency scores are calculated by the DEA model, an econometric regression model, most commonly a censored model, is applied in the second stage of analysis to examine the impact of the environmental factors on health efficiency.

Following the relevant empirical literature on healthcare efficiency analyses, a Tobit model is estimated to examine the determinants of health efficiency in the Arab countries. This can be justified by the fact that TE scores range between “0” and “1”, and many DMUs may have an efficiency score equal to unity. Hence, several empirical studies have utilized a Tobit model that is censored from the left at zero as a suitable approach for investigating the impact of the environmental factors on health efficiency (see for instance [Dhaoui, 2019](#); [Ahmed et al., 2019](#); [Top et al., 2020](#), [El Husseiny, 2021](#)). It is noteworthy that scholars such as [Simar and Wilson \(2007\)](#) have criticized the use of the Tobit model in the second stage of efficiency analyses due to the potential bias of the DEA scores, recommending the use of bootstrap methods instead. Yet, other scholars like [Afonso and St. Aubyn \(2011\)](#) have empirically proved that both the censored Tobit regression and bootstrap algorithms yield similar results.

We follow the practice of using technical inefficiency (TIN) scores rather than TE scores as the dependent variable in the Tobit model. This allows to keep the dependent variable in the Tobit model censored from the left at zero ([Ozcan, 2014](#)). The following formula is used based on [Zere et al. \(2006\)](#), [Ahmed et al. \(2019\)](#), and [Top et al. \(2020\)](#):

$$\text{TIN score} = (1/\text{TE score}) - 1 \tag{3}$$

In this case, TIN scores range between zero (i.e. full efficiency) and infinity (i.e. full inefficiency). Hence, a Tobit regression model with a left-censoring point at zero can be applied. The estimated coefficients in this case would reflect the effect of a given variable on health inefficiency.

Following [Tobin \(1958\)](#), the standard Tobit model is given by the formula as follows:

$$\begin{aligned} y_i^* &= x_i'\beta + \varepsilon_i; \quad \varepsilon_i \sim \text{iid}(0, e^{-2}) \\ y_i &= \max\{y_i^*, 0\} \quad i = 1, 2, \dots, n \end{aligned} \tag{4}$$

Where “ y_i^* ” is a latent random variable which is observed as “ y_i ” if it is positive and is otherwise observed as equal to zero. The error term “ ε_i ” is independent normal with mean zero and precision $e^2 > 0$ ([Dhaoui, 2019](#); [Top et al., 2020](#)).

The Tobit model in the current study is estimated for a cross-sectional dataset comprising of 20 observations. Six variables are considered in the estimated model as follows:

$$\begin{aligned} \text{TIN}_i &= \alpha_0 + \alpha_1 \text{middle_income}_i + \alpha_2 \text{govhexp_totgovexp}_i + \alpha_3 \text{prihexp_hexp}_i \\ &+ \alpha_4 \text{CPI}_i + \alpha_5 \text{pop_dns}_i + \alpha_6 \text{obesity}_i + \epsilon_i \end{aligned} \tag{5}$$

where: “ i ” refers to DMU (i.e. country’s healthcare system); “ TIN ” is the DEA’s technical inefficiency score; “*middle-income*” is a dummy variable that considers if the country belongs to the middle-income group as per the World Bank’s classification of 2019; “*govhexp_totgovexp*” is government health expenditure as percentage of total government expenditure; “*prihexp_hexp*” is private health expenditure as percentage of current health

expenditure; “*pop_dns*” is population density; “*CPI*” is the corruption perception index; “*obesity*” is a measure of the prevalence of obesity among adults and “ ε ” is the error term.

The choice of the explanatory variables included in the Tobit model is guided by the relevant literature. Some studies on healthcare efficiency analyses have considered a measure of income per capita level due to its expected favorable impact on health efficiency (see for instance Alexander, 2003; Hsu, 2013; Hribernik and Kierzenkowski, 2013; Dutu and Sicari, 2016; Dhaoui, 2019; Ahmed *et al.*, 2019; Radojicic *et al.*, 2020). In our sample, 13 out of the 20 Arab countries examined belong to the middle-income group, 6 countries belong to the high-income group, and 1 country is classified as a low-income country. As such, we include a dummy variable for the middle-income countries “*middle_income*” to examine whether the efficiency performance of these countries significantly differ from the other countries in the covered sample.

A measure of government health expenditure “*govhexp_totgovhexp*” is considered to examine the assumption that a higher level of government expenditure on health as percentage of total government expenditure is associated with lower efficiency of healthcare systems. Furthermore, “*prihexp_hexp*” is included to examine whether countries with a higher level of private health expenditure as percentage of current health expenditure have more efficient healthcare systems. In other words, this variable measures the effect of the financing structure of healthcare systems on health efficiency. Similar measures are considered by Dhaoui (2019).

The corruption perception index “*CPI*” is also added to the Tobit model of this study. The values of this variable range from 0 (highly corrupt) to 100 (most clean). We include this variable in our analysis following the general intuition that corruption has an adverse impact on the efficiency performance of healthcare systems. A similar measure has been used by Dhaoui (2019) and Adil *et al.* (2016).

Population density “*pop_dns*”, measured as the number of people per square km of land area, is one of the variables that have been considered by healthcare efficiency analyses (see for example Adam *et al.*, 2011; Hsu, 2013; See and Yen, 2018; Ahmed *et al.*, 2019; Dhaoui, 2019). Since a higher population density implies a larger population being served over a given area, this variable is expected to affect health system performance positively (See and Yen, 2018). In addition, countries of the Arab region largely vary in terms of population density; hence, it is expected that this variable could contribute to explaining the variability of health systems’ efficiency performance in the examined countries.

Finally, prevalence of obesity among adults “*obesity*”, measured as the percentage of defined population with a body mass index (BMI) of 30 kg/m² or higher, is considered as one of the factors that could negatively affect the performance of healthcare systems. Indeed, according to a review conducted by Radojicic *et al.* (2020), a measure of this variable is considered by a number of empirical studies on healthcare efficiency.

All explanatory variables are measured in 2019 except for obesity, for which the most recent data available for the examined countries corresponds to 2016. Data on population density are extracted from the World Bank’s WDI database. Data on CPI are driven from the Transparency International. Data on government health expenditure as percentage of total government expenditure, private health expenditure as percentage of current health expenditure and obesity are extracted from the WHO-GHO database.

Tables A1 and A2 in appendix present the descriptive statistics of the variables used in the DEA and Tobit models, respectively.

4. Results and discussion

In this section, we present and discuss the main findings of the estimated two-stage DEA model.

4.1 Findings of the DEA model

4.1.1 Output-oriented approach. Table 1 presents the output-oriented TE scores of the examined healthcare systems in the two years 2019 and 2010. As the results indicate, the output efficiency gains that health systems in Arab countries can achieve, on average, are limited. In particular, Arab countries, in average, have an opportunity to improve their health outputs (i.e. life expectancy at birth and infant survival rates) by almost 0.4% using the same level of resources (i.e. healthcare spending, physicians and hospital beds).

The results of 2019 indicate that 6 out of the 20 examined countries have efficient healthcare systems, and thus, they are located on the efficiency curve. These countries are Bahrain, Djibouti, Mauritania, Morocco, Qatar and Sudan. As depicted by Figure 2, countries with inefficient health systems whose efficiency scores are less than 1 can achieve output efficiency gains that range from 0.1% in Egypt, Lebanon, Saudi Arabia and UAE to 1.5% in Algeria by better exploitation of existing resources. The data also reveal that Qatar and Bahrain are the most referenced countries for inefficient countries (i.e. Qatar and Bahrain are referenced 11 and 9 times, respectively, for inefficient countries).

Comparing the results of 2019 with those of 2010 indicates that overall output-oriented efficiency of healthcare systems in the examined countries had a slight deterioration between

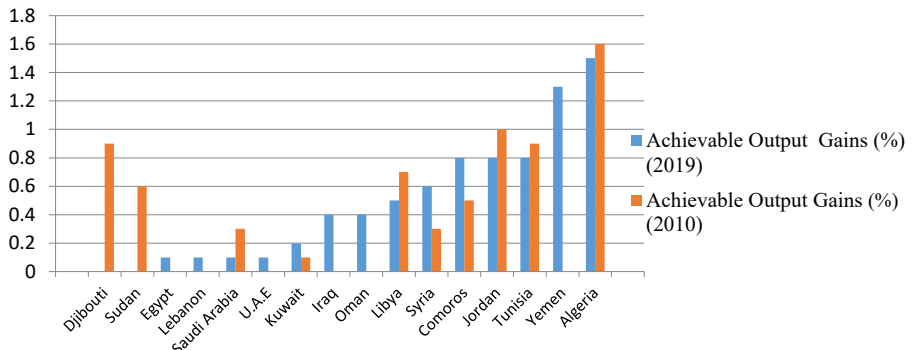
Country	2010			2019		
	TE score	Rank	Peer countries	TE score	Rank	Peer countries
Algeria	0.984	9	Bahrain, Morocco and Qatar	0.985	9	Qatar and Bahrain
Bahrain	1	1	–	1	1	–
Comoros	0.995	4	Mauritania and Yemen	0.992	7	Sudan and Bahrain
Djibouti	0.991	7	Mauritania, Yemen and Egypt	1	1	–
Egypt	1	1	–	0.999	2	Morocco, Sudan and Bahrain
Iraq	1	1	–	0.996	4	Bahrain, Morocco and Sudan
Jordan	0.99	8	Bahrain	0.992	7	Qatar
Kuwait	0.999	2	Oman, Qatar and Bahrain	0.998	3	Qatar
Lebanon	1	1	–	0.999	2	Qatar and Bahrain
Libya	0.993	6	Qatar and Bahrain	0.995	5	Qatar and Bahrain
Mauritania	1	1	–	1	1	–
Morocco	1	1	–	1	1	–
Oman	1	1	–	0.996	4	Qatar and Bahrain
Qatar	1	1	–	1	1	–
Saudi Arabia	0.997	3	Qatar and Bahrain	0.999	2	Qatar
Sudan	0.994	5	Qatar, Yemen, Morocco and Mauritania	1	1	–
Syria	0.997	3	Iraq, Mauritania, Qatar and Bahrain	0.994	6	Bahrain, Qatar, Djibouti and Mauritania
Tunisia	0.991	7	UAE and Bahrain	0.992	7	Qatar and Bahrain
UAE	1	1	–	0.999	2	Qatar
Yemen	1	1	–	0.987	8	Morocco, Mauritania and Qatar
Average	0.997			0.996		

Table 1. Output-oriented technical efficiency (TE) scores of Arab countries' healthcare systems (2019 compared to 2010)

Note(s): VRS assumption is adopted in the specification of the estimated DEA model

Source(s): The table is made by the author based on the DEA's calculations

Figure 2. Potential output improvements in the inefficient countries (%) (Output inefficiency)*



Note(s): *Measured as $[1-TE \text{ score}] * 100$

Source(s): Author's calculations based on the DEA's model results

the two years, from 99.7 to 99.6%. This indicates that healthcare systems of the Arab countries have not been subject to significant changes after the Arab Spring in terms of the overall output-oriented efficiency score. Yet, Djibouti and Sudan had the greatest efficiency improvements between 2010 and 2019. More specifically, the relative efficiency of healthcare systems of Djibouti and Sudan has increased from 99.1% and 99.4%, respectively, to 100%, indicating full efficiency, between 2010 and 2019 (see Table 1 and Figure 2). Similar to the situation in 2019, Bahrain and Qatar are the most referenced as peer countries for the inefficient countries in 2010.

The average output-oriented efficiency scores calculated in our study slightly exceed the estimates of Dhaoui (2019) calculated for a sample of 18 MENA countries. According to the mentioned study, output-oriented efficiency scores average around 98.2%, 98.5% and 97.9%, in 1997, 2005 and 2014, respectively. This slight difference in the efficiency estimates can be explained by the different samples covered (i.e. MENA countries versus Arab countries). In addition, the mentioned study follows a different specification for the DEA model according to which life expectancy at birth is used as a single health output variable, whereas health expenditure per capita, physicians' density and hospital beds' density are used as inputs. Yet, according to the mentioned study, 4 out of the examined 18 countries proved to be consistently efficient over the 3 examined years. These countries are Djibouti, Morocco, Qatar and Yemen, which are among the fully efficient countries in our study in at least one of the two years examined.

Our findings also support the hypothesis that healthcare systems in low- and middle-income countries can be as efficient as the systems in high-income countries. For instance, Djibouti, Mauritania, Morocco, Sudan, Egypt, Iraq, Lebanon and Yemen have fully efficient healthcare systems in at least one of the two years examined by our study although they do not belong to the high-income group of Arab countries.

4.1.2 Input-oriented approach. Table 2 presents the input-oriented TE scores of healthcare systems in the 20 Arab countries covered by the study in 2019 compared to 2010. The results of 2019 indicate that healthcare systems in the Arab region can save around 16% of their health resources while achieving the same level of health outputs [5].

Similar to the case under the output orientation, our input-oriented TE scores calculated for the Arab region exceed the estimates of Dhaoui (2019) on a sample of 18 MENA countries. According to the mentioned study, the efficiency scores averaged around 79%, 83.6% and 78.7% in 1997, 2005 and 2014, respectively. Our results can also be compared with the

Country	2010			2019		
	TE score	Rank	Peer countries	TE score	Rank	Peer countries
Algeria	0.843	5	Bahrain, Qatar, Morocco and Mauritania	0.662	12	Bahrain, Morocco, Djibouti and Qatar
Bahrain	1	1	–	1	1	–
Comoros	0.826	7	Mauritania	0.74	9	Sudan and Mauritania
Djibouti	0.86	4	Mauritania and Morocco	1	1	–
Egypt	1	1	–	0.964	2	Bahrain, Sudan and Morocco
Iraq	1	1	–	0.913	4	Bahrain, Sudan, Mauritania and Morocco
Jordan	0.723	11	Bahrain, Qatar and Morocco	0.737	10	Morocco and Qatar
Kuwait	0.983	2	Bahrain, Qatar and Oman	0.668	11	Qatar, Bahrain and Morocco
Lebanon	1	1	–	0.814	7	Bahrain and Qatar
Libya	0.823	8	Bahrain, Oman and Iraq	0.575	14	Bahrain, Djibouti and Qatar
Mauritania	1	1	–	1	1	–
Morocco	1	1	–	1	1	–
Oman	1	1	–	0.885	6	Bahrain, Mauritania, Qatar and Morocco
Qatar	1	1	–	1	1	–
Saudi Arabia	0.788	9	Iraq, Bahrain, Qatar and Oman	0.641	13	Qatar, Bahrain and Morocco
Sudan	0.832	6	Yemen, Qatar and Mauritania	1	1	–
Syria	0.967	3	Bahrain, Qatar, Oman and Iraq	0.925	3	Mauritania, Bahrain, Djibouti and Qatar
Tunisia	0.729	10	Bahrain, Qatar, Mauritania and Morocco	0.641	13	Bahrain, Morocco, Djibouti and Qatar
UAE	1	1	–	0.894	5	Bahrain, Qatar and Morocco
Yemen	1	1	–	0.742	8	Mauritania, Qatar, Bahrain and Djibouti
Average	0.919			0.84		

Table 2. Input-oriented TE scores of Arab countries' healthcare systems (2019 compared to 2010)

Note(s): VRS assumption is adopted in the specification of the estimated DEA model

Source(s): The table is made by the author based on the DEA's calculations

findings of [Meddeb \(2019\)](#) on a sample of 18 MENA countries over the period 1995–2011. According to that study, the VRS TE score, under input orientation, ranges from 66% to 99.7%, based on three different DEA specifications adopted.

At the country level, 6 out of the 20 examined countries have fully efficient healthcare systems in 2019. These countries are the ones which proved to be fully efficient under the output orientation, namely Bahrain, Djibouti, Mauritania, Morocco, Qatar and Sudan.

As revealed by [Figure 3](#), input efficiency gains that inefficient healthcare systems can achieve through better utilization of their health resources range from around 3.6% in Egypt to almost 42.5% in Libya in 2019. Among the six fully efficient countries reported by our study, Bahrain and Qatar are the most referenced as peer countries for inefficient countries.

A comparison of the DEA results between 2010 and 2019 reveals that the overall input-oriented efficiency level in the Arab region has significantly deteriorated from 91.9% to 84%. In fact, all of the examined countries, except for Sudan, Djibouti, Jordan, Morocco, Mauritania,

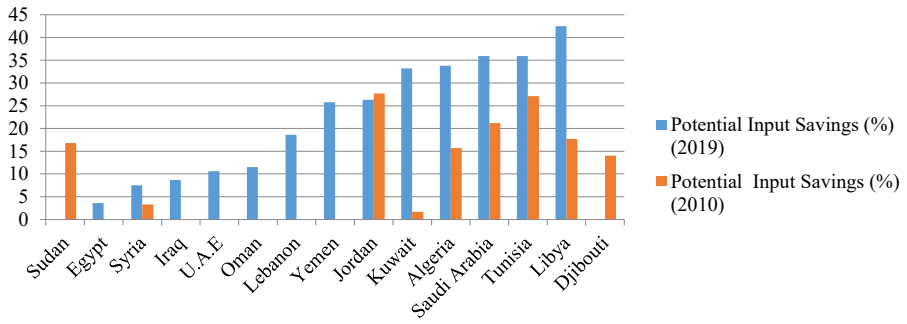


Figure 3. Potential input savings in the inefficient countries (%) (Input inefficiency)*

Note(s): *Measured as $[1-TE \text{ score}] \times 100$

Source(s): Author's calculations based on the DEA's model results

Qatar and Bahrain have experienced a considerable deterioration in their input-oriented efficiency scores between the two years. As such, while the output-oriented efficiency performance of healthcare systems in the Arab region does not show a considerable change between 2010 and 2019, the deterioration in the input-oriented efficiency scores might reflect the adverse impact of the political and institutional instability that have followed the Arab Spring uprisings on the utilization of health resources.

The highest efficiency improvements between the two examined years are reported for Sudan and Djibouti, where the relative efficiency score has significantly increased from 83.2% and from 86%, respectively, in 2010 to 100% in 2019 (see Table 2 and Figure 3).

Similar to the case under the output orientation, findings of the input orientation show that healthcare systems of the low- and middle-income countries can be as fully efficient as the ones in high-income countries.

Our findings in terms of the input-oriented TE scores are supported by the findings of two studies applied to the MENA countries, namely Meddeb (2019) and Dhaoui (2019). In the former study, Bahrain, Djibouti, Qatar, Sudan and Yemen have been among the fully efficient MENA countries under the input orientation. In the later study, Djibouti, Qatar and Yemen have proved to be among the consistently efficient countries in the MENA region under the input orientation in the three examined years of 1997, 2005 and 2014.

4.2 Robustness analysis

We estimate the DEA model using a different specification to test if this will lead to a considerable change in the results. In the new specification, current health expenditure as percentage of GDP is excluded. The other two input variables of physicians' density and hospital beds' density as well as the two output variables of life expectancy at birth and infant survival rate are kept in the new specification. The new model is estimated using data of 2019 and 2010 under the output and input orientations of efficiency following the VRS assumption.

The results of the reduced version of the DEA model in 2019 under output orientation indicate that the overall TE of healthcare systems in the Arab countries is 99.6% in average, which is identical to the average score calculated by the DEA's basic specification. Additionally, the six countries that are found to have fully efficient healthcare systems under the basic specification in 2019, namely Bahrain, Djibouti, Mauritania, Morocco, Qatar and Sudan are found to be fully efficient under the reduced specification as well. Moreover, similar to the case under the basic DEA specification, Qatar and Bahrain are the most referenced countries for the inefficient countries, whereas Algeria ranked the last in terms of the TE

score in 2019. The results of the reduced DEA model of 2010 reveal that the overall efficiency score is 99.6%, which is very close to the value of 99.7% that is observed under the basic specification. All countries which have full efficiency in 2010 under the basic specification, except for Oman and Iraq, are found to be fully efficient under the reduced specification as well. Two further findings of the basic model of 2010 proved to be robust under the reduced specification. First, Bahrain is the most referenced country for the inefficient countries. Second, Djibouti had the greatest efficiency improvement under the output orientation between 2010 and 2019 followed by Sudan.

Under the input orientation, the DEA reduced model of 2019 indicates that healthcare systems of the examined countries are inefficient, in average, with an overall efficiency level of around 80.7%. The same six countries which are efficient under the input orientation of the basic specification, namely Bahrain, Djibouti, Mauritania, Morocco, Qatar and Sudan are efficient under the input orientation of the reduced model. Libya ranked the last with a score of 45%. The results of 2010 show that the overall average efficiency score of the examined health systems is around 85.2%. The countries which are found to be fully efficient in 2010 under the input orientation of the basic model, except for Iraq and Oman, proved to be efficient under the reduced model as well, with Bahrain being among the most referenced countries. A comparison between the efficiency scores of 2010 and 2019 under the input orientation shows that Djibouti and Sudan had the greatest improvement (i.e. the efficiency level of Djibouti sharply increased from 67.4% to 100%).

The results of the reduced version of the DEA model prove the robustness of the findings reached by the basic specification under both efficiency orientations. In particular, three findings show robustness under the two DEA specifications adopted. First, Bahrain, Mauritania, Morocco and Qatar proved to have fully efficient healthcare systems in 2010 and 2019 under both efficiency orientations. Second, healthcare systems of Bahrain and Qatar are among the most referenced systems for the inefficient Arab countries in 2010 and 2019 under the two efficiency orientations. Third, Djibouti and Sudan had the greatest output- and input-oriented efficiency improvements between 2010 and 2019.

4.3 Findings of the Tobit model

The Tobit model, as specified in the previous section, is estimated using the DEA TIN scores as the dependent variable. Two variants of the Tobit model are estimated based on the efficiency orientation adopted. The findings of the two variants are presented in [Table 3](#).

The results of the estimated Tobit model show that the dummy variable “*middle_income*” has a negative coefficient that is significant only at the 10% level under the two orientations. This indicates that middle-income Arab countries tend to perform better than high- and low-income Arab countries. As such, we may conclude that per capita income level does not seem to be among the significant determinants of healthcare systems’ efficiency in the Arab region. It is noteworthy that [Dhaoui \(2019\)](#) could not find a significant relationship between the efficiency of healthcare systems and the income group to which a country belongs in a sample of 18 MENA countries.

Regarding the variables that reflect the financing structure of healthcare systems, the findings reveal that the relative share of government health expenditure in total government expenditure “*govhexp_totgovexp*” is significantly and positively correlated with health inefficiency under the two orientations. Countries in which the Government allocates a higher share, out of its total spending, to the health sector have less-efficient healthcare systems, compared to those countries with lower levels of health-related government spending. This finding is aligned with the results of [Dhaoui \(2019\)](#), who found a detrimental effect of government health expenditure as a percentage of total government expenditure on health efficiency in MENA countries. At another front, our results do not show that the financing

Dependent variable Explanatory variables	Output-oriented TIN		Input-oriented TIN	
	Coefficient	Std error	Coefficient	Std error
<i>c</i>	-0.001134	0.007854	-0.015939	0.362367
<i>middle_income</i>	-0.005091*	0.003535	-0.301228*	0.162136
<i>govhexp_totgovexp</i>	0.001206**	0.000601	0.067129**	0.027315
<i>prhexp_hexp</i>	0.000131	8.49E-05	0.003149	0.003909
<i>CPI</i>	-0.000220**	0.000110	-0.012374**	0.004987
<i>pop_dns</i>	-5.78E-06	4.14E-06	-0.000310*	0.000180
<i>obesity</i>	5.39E-05	0.000169	0.010071	0.007809
<i>Error distribution</i>				
SCALEC (8)	0.004855***	0.000961	5.069215***	0.043741
Mean dependent var	0.003885		0.230674	
SE of regression	0.004889		0.205633	
Sum squared resid	0.000287		0.507419	
Log likelihood	50.67875		-2.650495	
Avg log likelihood	2.533938		-0.132525	
Left censored obs	6		6	
Uncensored obs	14		14	
Right censored obs	0		0	
Total obs	20		20	

Table 3. Tobit model results **Note(s):** (*), (**) and (***) indicate the significance of the estimated coefficient at 10%, 5% and 1% levels of significance, respectively

structure of healthcare systems, measured by the relative share of private health expenditure in current health expenditure, has a significant impact on health efficiency under both orientations. Hence, the hypothesis that healthcare systems which are mainly financed by the private sector are more efficient than those systems that are mainly financed by the Government does not seem to be valid for the Arab region.

The coefficient of the variable that measures corruption “*CPI*” is found to be significant at the 5% level, and it has the expected negative sign under both efficiency orientations. [Dhaoui \(2019\)](#) has reached a similar finding on a sample of 18 MENA countries. Our finding supports the general intuition that better governance, as manifested in lower corruption levels, enhances efficiency of service provision. Healthcare systems in Arab countries with relatively low corruption levels (i.e. high *CPI* values) tend to be more efficient than those that operate in highly corrupt countries. This indicates that corruption in Arab countries is associated with losses in health resources and health outputs. On one hand, corruption pushes health managers to utilize an amount of health resources that is greater than what is actually needed to achieve a certain level of health results. On the other hand, corruption might constrain healthcare systems from producing the maximum level of health outputs given the available resources. This might also explain the deterioration of the average efficiency score between 2010 and 2019 as depicted by the DEA’s first stage of analysis under the input orientation. Indeed, the average corruption level of the Arab countries has increased between these two years.

The coefficient of population density “*pop_dns*” is found to have the expected negative sign. Yet, while this coefficient is insignificant under the output orientation, it shows poor significance (i.e. at 10% level) under the input orientation. This indicates that countries with higher population density tend to have more efficient healthcare systems, a finding that is supported by [Ahmed et al. \(2019\)](#), [See and Yen \(2018\)](#) and [El Husseiny \(2021\)](#). The coefficient of the prevalence of “*obesity*” is found to be positive as expected, but it is insignificant under both orientations.

5. Conclusion and policy implications

This study evaluates the efficiency of healthcare systems in 20 Arab countries using a two-stage DEA approach. In the first stage of analysis, a DEA model is used to calculate the TE scores of the examined healthcare systems in 2019 compared to 2010. In the second stage, a Tobit model is estimated to identify the determinants of inefficiency. The findings of the first stage of analysis show that overall efficiency level of healthcare systems in the Arab countries ranges between 99.6% and 84% based on the output and input orientations, respectively.

The findings also reveal that there has been a significant change in the overall efficiency score of healthcare systems in the Arab region between 2010 and 2019 under the input orientation. This indicates that the determinants of healthcare efficiency in the Arab countries have been subject to major changes between the two years. Indeed, there is evidence that the Arab Spring uprisings and their associated political and institutional changes have negatively affected the performance of the healthcare systems in the Arab region. Yet, Djibouti and Sudan had the greatest efficiency improvements between 2010 and 2019 under the two orientations.

As a robustness check, a different specification of the DEA model is estimated using data of 2019 and 2010. Three of the main findings of the DEA's basic model are found to be robust under the two orientations of the reduced model. First, health systems of Bahrain, Mauritania, Morocco and Qatar are efficient in the two examined years. Second, Bahrain and Qatar are among the most referenced countries for the inefficient Arab countries in the two examined years. Third, Djibouti and Sudan had the greatest efficiency improvements between 2010 and 2019.

The findings of the Tobit model reveal that both government health expenditure as a percentage of total government expenditure and corruption have an adverse impact on health efficiency under both orientations. In addition, no empirical support has been found for the hypothesis that health systems in high-income countries are necessarily more efficient than those that operate in low- and middle-income countries. This finding is also supported by the results of the DEA's first stage of analysis, as the efficiency frontier includes both middle- and high-income countries. Furthermore, the structure of healthcare financing does not seem to have a significant impact on health efficiency.

Based on the findings of the current study, we argue that healthcare systems in the Arab countries have the potential to achieve considerable input efficiency gains if they could better utilize their available resources.

Efficiency of healthcare systems in the examined countries can be enhanced by improving the governance structures of these systems focusing on transparency, control of corruption and rule of law issues. To do so, governments of the Arab countries may consider utilizing big-data analytics and techniques in the formulation and implementation of healthcare policies. This might help in reducing the waste of health resources and enhancing the efficiency, effectiveness and success rates of health policies. The choice of appropriate incentives for health workforce and the revision of health financing schemes can also help in improving the efficiency of healthcare systems in the examined countries.

Based on the findings of the second stage of analysis, Arab countries need to exert extra efforts to control corruption at all levels as these efforts seem to have a positive impact on health efficiency. In contrary, while calls for higher public spending on health, whether as a percentage of GDP or as a share of total public spending, are common in developing countries, these calls need to be treated with caution. Improving the efficiency with which healthcare resources are used rather than simply allocating more funds to healthcare systems seems to be the right tactic in the Arab countries. In fact, higher levels of government health expenditure as percentage of total public expenditure tend to reduce rather than improve the efficiency of healthcare systems in the examined countries. As such, governments of the Arab countries may consider strengthening their public financial management systems and

improving the quality of their budgetary institutions. Reforms in these areas could focus on introducing fiscal rules and budget ceilings, enhancing the internal and external audit systems and ensuring fiscal transparency throughout the whole budget cycle.

While this paper examines the efficiency of healthcare systems in the Arab region using a two-stage DEA approach, the topic can be extended in further directions in the future research. One of these directions is to expand the time period examined. Another direction is to evaluate the efficiency of healthcare systems in the examined countries using a parametric approach, like Stochastic Frontier Analysis. Investigating the determinants of healthcare efficiency in the second stage of analysis could also be conducted using the bootstrap approach rather than the Tobit model. A different direction could also be comparing the results of our study with those studies that examined larger samples of countries including the Arab region. Examining the relative efficiency scores of healthcare systems at the local level could also be informative to policy makers, especially with the recent calls for localizing the sustainable development goals, including the goal on “good health and well-being”.

Notes

1. These figures are based on the statistics of the WDI of the World Bank.
2. These countries include Iran as well as the Arab countries covered by our sample except for Comoros, Mauritania and Iraq.
3. These countries include Iran as well as the Arab countries covered by our sample except for Comoros, Mauritania and Sudan.
4. It is noteworthy that in cases where data on physicians' density and hospital beds' density is not available for 2010 and 2019, lagged data of the closest years available are used instead. In addition, since data on health expenditure as percentage of GDP in 2019 are not available for Yemen, Syria and Libya, data of 2015, 2012 and 2011, respectively, are used instead.
5. It is noteworthy that input-oriented TE scores are usually lower than output-oriented TE scores. This can be explained by the different way in which TE score is calculated according to each orientation. While under output orientation the efficiency score reflects the potential increase in outputs keeping inputs unchanged, the input-oriented TE score reflects the potential savings in the amount of inputs while keeping the outputs level unchanged.

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Further reading

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Variable/ statistics	2019					2010				
	Life expectancy at birth	Infant mortality rate	Current health expenditure as percentage of GDP	Physicians density	Hospital beds density	Life expectancy at birth	Infant mortality rate	Current health expenditure as percentage of GDP	Physicians density	Hospital beds density
Mean	73.185	20.670	4.921	1.413	1.608	71.372	25.465	4.319	1.317	1.738
Median	74.830	15.600	4.655	1.295	1.450	73.675	16.700	3.860	1.209	1.750
Maximum	80.230	50.200	8.650	2.753	3.200	79.110	62.500	8.170	3.727	3.700
Minimum	64.320	5.300	1.080	0.187	0.400	60.060	7.300	1.870	0.157	0.400
Standard deviation	5.116	16.458	1.706	0.943	0.685	5.819	19.752	1.635	0.983	0.802

Table A1.
Descriptive statistics of the DEA model's variables

Table A2.
Descriptive statistics of
the Tobit model's
variables

Variable/ statistics	Output- oriented TIN	Input- oriented TIN	govhexp_totgovexp	prihexp_hexp	pop_dns	CPI	Obesity
Mean	0.004	0.231	7.524	43.893	229.272	35.750	24.980
Median	0.002	0.124	7.050	44.095	86.135	35.000	27.350
Maximum	0.015	0.739	13.430	82.030	2104.056	71.000	37.000
Minimum	0.000	0.000	2.230	13.040	3.852	13.000	6.900
Standard deviation	0.005	0.239	3.160	19.853	471.718	16.144	9.407

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