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Measuring the Effect of Size on Technical Efficiency of the United Arab Emirates Hospitals

Ashraf Mahate[1], Samer Hamidi[2] & Fevzi Akinci[3]

[1] Adjunct Professor in Economics, Hamdan Bin Mohammed Smart University, Dubai, United Arab Emirates

[2] Associate Professor, School of Health and Environmental Studies, Hamdan Bin Mohammad Smart University, Dubai, United Arab Emirates

[3] Associate Dean and Professor, The William G. McGowan School of Business, King's College, Wilkes-Barre, PA, USA

Correspondence: Samer Hamidi, Associate Professor, School of Health and Environmental Studies, Hamdan Bin Mohammad Smart University, Dubai, United Arab Emirates, Tel: 971-(4)-424-1089. Email: s.hamidi@hbmsu.ac.ae

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Abstract

Objective: The main purpose of this study is to estimate the technical efficiency of the United Arab Emirates (UAE) hospitals and examine the effect of hospital size on estimated technical efficiency scores.

Methods: Using 2012 data from Ministry of Health, Dubai Health Authority, and Health Authority in Abu Dhabi, we employed a nonparametric method, data envelopment analysis (DEA), to estimate the technical efficiency of 96 private and governmental hospitals in the UAE. Efficiency scores are calculated using both Banker, Charnes, and Cooper (BCC) and Charnes, Cooper, and Rhodes (CCR) models.

Results: The average technical efficiency of the UAE hospitals is estimated at 59% based on the BBC model and at 48% based on the CCR model. The optimal size of a hospital in the UAE is between 100 to 300 beds. We also found evidence of economies of scope between the provision of outpatient and inpatient care in the UAE hospitals.

Conclusion: Our findings indicate that only one third of the UAE hospitals are technically efficient. There is evidence to suggest that there are considerable efficiency gains yet to be made by many UAE hospitals. Additional empirical research is needed to inform future health policies aimed at improving both the technical and allocative efficiency of hospital services in the UAE.

Keywords: hospital effect size, technical efficiency, economies of scale, economics of scope, United Arab Emirates

1. Introduction

Located in the Arabic Gulf, the United Arab Emirates (UAE) consists of seven emirates and covers an area of about 83,600 km^2. The population is made up of several different demographic groups from different cultural and socioeconomic backgrounds. The UAE National Bureau of Statistics estimates the population to grow by 5.6% by the end of 2012, to 7.6 million from 7.2 million in 2011 (National Bureau of Statistics, 2011). The population consists of 13% nationals, and 87% expatriates (UAE National Report, 2013). When compared to the neighboring countries with regard to the level of spending on health services, the UAE ranks better than most of the countries in the region. The life expectancy at birth in the UAE has risen from 75.3 years in 2005 to an estimated 76.5 years in 2013. The probability of dying under 5 years of age was 8 per 1000 live births, and infant mortality rate of 5.3 per 1,000 live births compared to 4.1 in OECD countries (WHO, 2013). According to the latest Human Development Index value for 2012, the UAE ranks 41st out of 187 countries globally with a score of 0.818, which puts it in the very high human development category.

Although the UAE healthcare system is a blend of private and public sector provision, it is tightly regulated by several regulators at the federal and emirate level. These regulators are the Ministry of Health (MOH) which represents the federal government, Health Authority-Abu Dhabi (HAAD) which represents the local government of Dubai, and Dubai Health Authority (DHA) which also represents the local government of Dubai. In recent years, a number of significant developments have taken place in healthcare policy in the UAE; the most notable one being that the Emirate of Abu Dhabi, which is the largest Emirate, has implemented a universal coverage insurance scheme that covers both nationals and expatriate residents. Under the initiative, the public providers of medical services are bundled under the Abu Dhabi Health Services Company (SEHA), which controls a market share of roughly one third of the outpatient and two thirds of the inpatient sectors within the Emirate. In addition to the revenue generated from insurance premiums, SEHA receives direct funding from the Abu Dhabi Department of Finance both for ongoing operational costs as well as for capital projects. Most of the larger SEHA hospitals have international management partners such as Johns Hopkins International, Cleveland Clinic, and VAMed. The dominant private providers operate hospitals that also serve as large polyclinics for outpatient traffic, the largest of which are Al-Noor and New Medical Centre (NMC) Hospital. The Emirate of Dubai is also undergoing major developments based on the recent Health Insurance Law where a mandatory insurance scheme is to be fully effective by 2016 to achieve universal coverage.

The private health sector is very active in UAE and constitutes about 25% of total health expenditures. Nevertheless, the private health sector is more vibrant in the Emirate of Dubai and constitutes about 67% of the total health expenditures. However, in UAE public hospitals represent about one third of the total number of facilities, but treat about 60% of the total number of patients. Across the country, public hospitals are far larger and better staffed than those owned by the private sector. In terms of doctors, the difference is two and half times as large. In the case of nurses and hospital beds, the difference is almost four times as large. The nurse to doctor ratio is 3 to 1 for the government sector while it is only 2 to 1 for private sector establishments. The most striking difference in staffing between the two is in the case of pharmacists where the average value for public hospitals is 1 for every 2 doctors while in private hospitals the ratio is 1 pharmacist for every 10 doctors. In terms of the number of inpatients and outpatients treated, the nurse to doctor ratio is one and half times as large. These findings suggest that private sector providers tend to have smaller and more specialized services.

The method of payment for inpatient hospital services in the Emirate of Abu Dhabi is based the diagnosis related groups (DRGs). However, in the other six Emirates, the reimbursement method is based on fee for service. So, the private sector is specialized in services that require low resources, while the public sector is specialized in more complicated services subsidized by the government. As such, private sector providers do not offer a comprehensive range of specialties and tend to focus on areas which require short inpatient treatment, which results in far shorter average lengths of stay. As can be seen from Table 1, private sector hospitals have an average length of stay of 1.48 days compared to 14 days for public hospitals. Across the different Emirates, there is very little difference as far as the size of hospital is concerned. Abu Dhabi tends to have slightly larger hospitals when compared across all the different parameters. This can be explained by the type of ownership-namely the private and public sector.

Table 1. Summary Statistics of the UEA Hospitals

			Inputs							Outputs		
	No	Measure	Doctors	Dentists	Nurses	Pharmacists	Technicians Admin, Clerks	Number of Beds	Inpatients	Total Outpatients	ALOS
Gov't	31	Mean	125	2.97	381	61	208	195	7,188	170,617	14.12
		Median	77	2.00	195	18	111	148	5,938	139,300	4.11
		St Dev.	143	4.63	415	107	276	162	7,701	137,980	46.13
Private	65	Mean	51	3.37	99	6	106	55	4,658	124,524	1.48
		Median	35	2.00	72	4	67	38	2,601	75,833	1.11
		St Dev.	43	3.88	92	7	131	58	5,337	150,486	1.94
MOH	15	Mean	61	2.40	200	13	105	143	6,905	130,714	24.10
		Median	44	1.00	193	12	108	138	6,100	134,085	4.09
		St Dev.	43	2.90	114	8	52	68	4,627	68,215	65.91
SEHA	12	Mean	172	4.67	462	129	324	206	3,667	202,400	4.78
		Median	100	2.00	274	65	146	135	1,500	128,250	4.60

		St Dev.	190	6.40	505	150	411	208	4,279	196,117	2.65
		Mean	222	-	813	39	244	356	18,813	224,908	4.75
DHA	4	Median	215	-	847	45	259	379	21,246	247,701	3.50
		St Dev.	146	-	536	29	144	185	13,996	108,218	3.59

Notes. UAQ has only one hospital and hence the standard deviation cannot be calculated.

In the current system of the Emirate of Abu Dhabi, medical insurance can be purchased from the 39 authorized insurance providers, 50 authorized brokers, and 13 authorized third party administrators. Although the healthcare insurance market in Abu Dhabi has increased to over 1 million members, it tends to be highly concentrated. Almost 60% of the market is controlled by the three payers Daman (28.6%), Oman Insurance (16.4%), and Abu Dhabi National Insurance Company (ADNIC) (14.5%). The recent insurance reform created 3 broad categories of health plans: Thiqa, Basic, and Enhanced. The Thiqa program is the most comprehensive but limited to the UAE nationals. The Basic product is for individuals with limited income and dependents of non-nationals who are not eligible to be covered by the non-national's employment based insurance. The Enhanced product is for individuals with above the income threshold set by the regulations for the Basic product and available to all non-nationals.

Hamidi et al. (2014) recently reported that the type of insurance coverage has a positive correlation with hospital usage in the UAE. The authors found that individuals on the Thiqa policy make more than 4 times the number of in-patient claims than those on the basic and enhanced policy. In the case of outpatient claims, it is four and half as much as the basic and three times that of the enhanced policyholders. In addition, Hamidi et al. (2014) also found that the average cost of treatment for those on the basic and enhanced policies is roughly similar but those on the Thiqa policy cost 50% more. The authors argue that there may be evidence to support the claim that Thiqa policyholders may be encouraged to conduct additional tests or treatments which may not be medically necessary. This supplier-induced demand may negatively impact the efficiency of the hospitals that cater to Thiqa policyholders. Supplier-induced demand and moral hazard forced the HAAD to implement a 50% coinsurance rate on pharmaceuticals in the private sector, with the entitlement of obtaining pharmaceuticals prescribed in the private sector from public sector pharmacies that are free of charge.

With 31 public and 65 private hospitals as well as a number of new health care facilities planned, one would assume that the country is well resourced. However, the delivery system is based on a primary health care approach and hence does not deal with the underlying issues leading to inefficiencies and inherent weaknesses. Treatment abroad is also another challenge, where a very large number of patients elect to have their treatment overseas leading to under-utilized services and facilities. Efficiency levels may increase if overseas treatment is replaced with domestic provision. Also, greater domestic provision of healthcare services will allow the country to develop more advanced areas of medical treatment. Other weaknesses within the UAE healthcare system that impact efficiency levels include: (1) the absence of a single regulator for licensing medical staff which limits their ability to move from one employer to another, (2) heavy usage of hospital based services even for minor illnesses and the need for strengthening primary health care and referral systems which will allow the hospital based services to focus on acute illnesses, (3) an incomplete national health information system capable of catering for information needs at the Emirate and federal levels, and (4) shortage of capable staff, with expatriates comprising 80% of doctors and over 90% of nurses.

This research employs the efficient frontier approach to evaluate the efficiency of both private and government owned hospitals in the UAE. The main purpose of the study is to examine whether the level of efficiency of hospitals is dependent on their size. Traditional economics theory suggests that larger operational units are able to benefit from economies of scale. This research seeks to understand whether this is true for labor-intensive sectors such as healthcare. We expect that larger hospitals will be able to benefit from greater economies of scale and hence will be more efficient.

It is expected that a clear understanding of the efficiency of the current level hospital services in the UEA will allow healthcare managers as well as policy makers to make better choices and lead to the optimal usage of resources.

2. Background

A key question in the provision of healthcare is about scale; whether smaller hospitals are more or less efficient than larger ones. All hospitals require a relatively large investment in capital for items such as buildings, equipment, and specialized staff. With such high levels of capital expenditure, especially in equipment, a high rate of utilization is needed to make it financially viable. Therefore, there is a strong argument to support larger hospitals than smaller ones. At the same time, hospitals are not like traditional factories where the same product can be produced endlessly. Instead, hospitals are complex organizations where every illness is different based on the patient and it may be the case that it is easier to manage and operate a smaller hospital than a larger one. Economic theory argues that as the size of an operation increases, it benefits from reduction in costs commonly referred to as economies of scale. In microeconomics, the concept of returns to scale concerns "…whether the productive efficiency of resource inputs rises, falls, or remains unchanged when the usage of all inputs is increased in the same proportion" (Thompson & Formby, 1993, p. 188).

In the healthcare sector, it is argued that smaller hospitals suffer from higher cost structures and lower capacity levels, thus making them relatively inefficient when compared to larger facilities. Posnett (1999), using a sample of UK hospitals, finds that there is a 'U- shaped' relationship between the efficiency of a hospital and its size. Thus, a hospital benefits from economies of scale up to a certain point. Thereafter, it experiences diseconomies of scale or an increase in cost due to an expansion in size. Posnett (1999) finds that hospitals with less than 200 beds benefit from increasing returns to scale. The optimal size of a hospital ranges from 200 to 400 beds, and subsequently diseconomies to scale take place. Interestingly, the study finds that it is more efficient to have a hospital with two smaller units of up to 400 beds rather than a single site hospital of 800 beds.

Further support for economies of scale is found by Keeler and Ying (1996), who argue, "larger hospitals get sicker, more expensive patients". Interestingly, the researchers found a small decrease in returns to scale, but this may be due to the fact that they emphasized very large hospitals which may have been beyond their optimal level. Additional support for larger hospitals is found by Gaynor et al. (2005) by using mortality rates. The results show that the probability of death due to heart surgery is considerably lower in high volume hospitals, which can be attributed to scale and size. Using a similar methodology, Gobillon and Milcent (2010) found that mortality tends to be lower when patients are treated at a few large hospitals rather than many small ones. Morikawa (2010) finds there seems to be a positive relationship between the size of the hospital and its productivity. In fact, the study argues that the size of the hospital is economically significant and when the size doubles, productivity increases by 10%. In the case of the UAE, with one hospital for every 89,000 residents, it may be the case that many are operating below their optimal level. Therefore, a few but large hospitals with a range of specialties and skilled personnel may be more economically viable.

Related to the issue of scale is that of scope and whether it is efficient to combine outpatient and inpatient care at the same facility. From a clinical perspective, the merging of both services may make sense because an outpatient that undergoes diagnostic examination may be admitted as an inpatient due to the seriousness of the illness. Similarly, an inpatient tends to have follow-up visits after being discharged as an inpatient. There is a strong clinical argument that to ensure continuity of patient treatment, the same team needs to treat the patient, whether as an inpatient or outpatient. However, from a managerial viewpoint, it may be more efficient to separate inpatients and outpatients through independent facilities so that the daily flow of traffic can be better managed. From a cost perspective, it can be argued that the more specialized and higher paid clinical staff should focus on the more serious cases, which tend to be largely inpatient based, while the routine activities associated with outpatients can be carried out by lower paid less experienced medics. Studies that have tended to use cost functions to measure economies of scale, such as Preyra and Pink (2006), find evidence to support a positive relationship with cost reduction. However, the problem with cost functions is that they change over time and inconsistencies tend to exist between regions even within the same country.

3. Methodology

In this study, we start with the premise that an efficient firm is one that operates on the production possibility frontier (PPF), and any deviation from this is considered to be either random statistical noise or firm level inefficiency. The former is assumed to be out of the control of the firm and is usually normally distributed. The latter measures the extent to which a firm is away from the optimal level of production. In the healthcare sector, efficiency can be decomposed into three main types. First, prior studies have estimated the technical efficiency, which is a measure of whether the productive resources are employed in the most technologically efficient manner. Technical efficiency in the healthcare sector implies that the organization should be able to use its inputs, including the infrastructure (e.g. medical facilities, beds etc.), labor (medical and non-medical staff), and capital to achieve outcomes which can be intermediate such as the number of patients treated or final (e.g. lower mortality rates, longer life expectancy, etc.). The second type of efficiency reported by prior studies is allocative efficiency. This is the ability of an organization to use its inputs in the most optimal proportions, based on their relative prices and available technology. In the case of healthcare, allocative efficiency can be considered to be the change from one type of procedure to another, whereby each requires a different set of inputs with differing prices. Therefore, the choice as to which procedure is used is based on the relative costs of these different inputs. The combined impact of allocative and technical efficiency determines the total economic efficiency.

Data envelopment analysis (DEA) is a nonparametric method used in this study to estimate the efficiency of 96 private and governmental hospitals in UAE. The most prevalent DEA model formulation is the model developed by Charnes, Cooper, and Rhodes (1978) (CCR model), that has been modified by Banker, Charnes, and Cooper (1984) (BCC model). In order to examine whether the hospitals in this study increased the output of resources while keeping the level of inputs constant, we used an output-oriented model with a constant and increasing returns to scale assumptions. For estimating hospitals' efficiency, we used two DEA models; CCR and BCC models. The CCR model works on the concept of constant-return-to-scale, while the BBC model works on the concept of variable-return-to-scale. The efficiency computed from BCC model is pure technical efficiency (PTE) (Debnath, 2009), whereas the efficiency computed from the CCR model is the overall technical efficiency (OTE). Scale efficiency (SE) means the efficiency due to scale difference between constant-return-to-scale and variable-return-to-scale (Joo et al., 2011). SE presents the impact of scale size on efficiency of a hospital and is measured by dividing the CCR efficiency by the BCC efficiency (Banker et al. 1984). OTE reflects the ability of a hospital to obtain the maximum output from a given set of inputs. PTE reflects the proportion of technical efficiency, which is attributed to the efficient conversion of inputs to output given the scale size.

The basis of the DEA technique is a measure of efficiency derived from a ratio of weighted outputs to weighted inputs as shown in equation (1) below, where

j= 1,2,…….., n decision making units,

r = 1,2,…….., t, outputs

i = 1,2,…….., m inputs

Equation (1)

$$h = \frac{\sum_{r=1}^{t} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}}$$

yrj = amount of output r for unit j

xrj = amount of input r for unit j

ur = weight assigned to output r

vr = weight assigned to input r

The weights u and v according to Charnes et al. (1978) CCR model are assigned so as to produce a measure of efficiency for each decision making unit (hospital).

The weights are calculated by maximizing the efficiency ratio of the DMU subject to the constraint that the efficiency ratios of all the DMUs computed with the same weights have an upper bound of 1. Equation (2) is converted into a linear programming problem in order to obtain the DEA efficiency measure for a group of DMUs as shown in Equation (2) below:

Equation (2)

$$\frac{Max}{\{u_r, v_i\}} h_0 = \frac{\sum_{r=1}^{t} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}}$$

$$subject\ to$$

$$\frac{\sum_{r=1}^{t} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \qquad j = 1, \cdots, n (for\ all j)$$

The u's and v's are variables of the problem and are constrained to be greater than or equal to some small positive quantity ε in order to avoid any input or output being ignored in computing the efficiency. The solution to the above model gives a value h, the efficiency of the unit being evaluated. If h = 1 then this unit is efficient relative to the others. But if it is less than l then some other units are more efficient than this unit, which determines the most favorable set of weights. This flexibility can be a weakness because the judicious choice of weights by a unit possibly unrelated to the value of any input or output may allow a unit to appear efficient.

To solve the model, we need to convert it into linear programming formulation, which is as follows:

Equation (3)

$$
\begin{array}{ll}
Max \quad h = \sum_r u_r y_{ry_0} & \\
subject\ to & dual\ variable \\
\sum_i v_i x_{ij_0} = 100(\%) & Z_0 \\
\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \le 0, \quad j=1,\cdots,n & \lambda_j \\
-v_i \le -\varepsilon \qquad i=1,2,\cdots,m & s_i^+ \\
-u_r \le -\varepsilon \qquad r=1,2,\cdots,t & s_r^-
\end{array}
$$

We call this formulation the CCR model after the original work by Charnes, Cooper and Rhodes (1978). The dual model can be constructed by assigning a dual variable to each constraint in the primal model and constructing a new model on these variables. This is shown below.

Equation (4)

$$
\begin{aligned}
& Min\ 100Z_0 - \varepsilon \sum_i s_i^+ - \varepsilon \sum_r s_r^- \\
& subject\ to \\
& \sum_j \lambda_j x_{ij} = x_{ij_0} Z_0 - s_i^+,\ i=1,\cdots,m \\
& \sum_j \lambda_j y_{rj} = y_{rj_0} + s_r^-,\ r=1,\cdots,t \\
& \lambda_j,\ s_i^+,\ s_r^- \ge 0,
\end{aligned}
$$

The dual variables (λ's) are the shadow prices related to the constraints limiting the efficiency of each unit to be no greater than 1. Binding constraint implies that the corresponding unit has an efficiency of 1 and there will be a positive shadow price or dual variable. Hence positive shadow prices in the primal, or positive values for the λ's in the dual, correspond to and identify the peer group for any inefficient unit.

The above models assume the constant return to scale. If we add a variable to the model, we can construct a DEA model with the variable return to scale. Variable returns means that we might get different levels of output due to reduced performance or economics of scale. Banker, Charnes, Copper (1984) proposed the following DEA model, which we call BCC model. BCC Model is as follows:

Equation (5)

$$
\begin{aligned}
& Max\ \ h\ \ = \sum_r u_r y_{rj_0} - u_0 \\
& subject\ \ to \\
& \sum_i v_i x_{ij_0} \ = 100(\%) \\
& \sum_r u_r y_{rj} - \sum_i v_i x_{ij} \le u_0, \quad j = 1, \cdots, n \\
& -v_i \le -\varepsilon \quad i = 1, \cdots, m \\
& -u_r \le -\varepsilon \quad r = 1, \cdots, t
\end{aligned}
$$

The efficiency computed from the BCC model is pure technical efficiency, whereas the one from the CCR model is the aggregate measure of technical and scale efficiency. Therefore, pure scale efficiency can be defined to be CCR efficiency over BCC efficiency (Banker, Charnes, Cooper, 1984). The major advantage of DEA is that it avoids having to measure output prices which are not available for transactions and services and fee based outputs. However, the DEA method is non-stochastic and does not capture random noise and any deviation from the estimated frontier is interpreted as being due to inefficiency. So, the concern with the DEA model is that by a judicious choice of weights, a high proportion of units will turn out to be efficient and DEA will thus have little discriminatory power. The first thing to note is that a unit which has the highest ratio of one of the outputs to one of the inputs will be efficient, or have an efficiency very close to 1 by putting as much weight as possible on that ratio and the minimum weight 0 on the other inputs and outputs. Previous research implies that the number of units evaluated should be greater than 2 times the total number of variables. Another concern regarding DEA analysis is that a unit can appear efficient simply because of its pattern of inputs and outputs, not because of any inherent efficiency. This can be resolved by imposing a minimum weight, thus ensuring that each input and output plays some part in the determination of the efficiency measure. At the same time, a maximum limit can be imposed on the weights to avoid any input or output being over-represented. With DEA it is also not possible to conduct statistical tests of the hypothesis regarding the inefficiency scores.

There is no general consensus as to which inputs and outputs to use when estimating hospital efficiency and the choice is related to the hospital model used. We believe that a production model of a hospital best describes the case in the UAE and since hospitals are assumed to convert inputs into outputs using their preferred production process. The data consists of inputs to hospital production in the form of capital and labor, and outputs from production. Labor inputs are measured by the number of people employed in each hospital, and we use full-time equivalent staff to measure labor input. Six input variables were included in the efficiency analysis: (1) the number of Full Time Equivalent (FTE) doctors, (2) the number of Full Time Equivalent (FTE) dentists, (3) the number of FTE nurses and midwives, (4) the number of FTE pharmacists and allied health professionals, (5) the number of FTE administrators and other staff which included all staff other than previous categories, and (6) the number of hospital beds in each hospital to represent capital inputs.

Ideally one would like to use the final outcome which for any society is the improvement in the health of its population. However, two issues arise in measuring such an output. First, it is seldom possible to attribute the improvement in the population to a particular hospital. Second, in the absence of the ability to measure the final outcome, we use the intermediate measures. Three output variables of hospital production were included: (1) the number of inpatients which was measured as the total number of admitted patients within a year, (2) the number of outpatient which was measured as total yearly number of attendances at outpatient clinics in each hospital including the emergency visits, (3) the average length of stay which was measured by dividing the total number of overnight days spent by inpatients at the hospital by the total number of inpatients. Data were collected from the annual reports of DHA, and HAAD in 2012 (HAAD 2012, DHA 2012). The input and out variables for each hospital are listed in Table 2.

Table 2. Input and Output Variables and Operational Definitions

Input Variables	Operational Definitions
1. Doctors	This is defined as the number of medical doctors that are employed on a full time equivalent basis. In the UAE all practicing medical staff needs to be registered by either a federal regulator such as the Ministry of Health, a particular Emirate based agency such as the Dubai Health Authority, or a free zone such as Dubai Healthcare City. In this study we do not differentiate doctors by specialty.
2. Dentists	This is defined as the number full time equivalent dentists that are working at the hospital in question. Like doctors, all dentists have to be registered with one of the three regulators; federal, emirate, or free zones.
3. Nurses and midwives	These are full time equivalent nursing staff regardless of rank or specialty. As with doctors, all nursing staff have to be registered with one of the three regulators.
4. Pharmacists and allied health professionals (AHP)	These are full time equivalent pharmacists and AHP that are registered with one of the three regulators.
5. Administrators and other staff	These are both administrative and ancillary staff that are employed by the hospital. There is no process of registering this category of staff. This study does not differentiate between the type and rank of staff in this category.
6. Number of hospital beds	This is defined as beds that are available for overnight stay. This definition excludes beds which are available purely for day care or out-patient recovery.
Output variables	Operational Definitions
1. Inpatients	This is defined as any patient treatment that requires any period of overnight stay.
2. Outpatients	This is defined as any patient treatment received at the hospital that does not require any period of overnight stay. As many of the hospitals do not separately report accident and emergency treatment, we have combined these with the outpatient figure.
3. Average length of stay	This is the total number of overnight days spent by inpatients at the hospital divided by the total number of inpatients.

4. Results

Our key hypothesis seeks to determine whether the efficiency score is related to the size of the hospital. Measuring the size of a hospital is a rather complex concept as there are a number of different bases that can be used. In this study, we examine the size of a hospital using five different bases: the number of doctors, nurses, hospital beds, outpatients, and inpatients. We calculated efficiency scores using the BBC and CCR methods, and then we tested the difference in mean efficiency scores using an independent t-test as shown in Table 3. Our results showed that only one third of the UAE hospitals are technically efficient. We did not find any statistically significant differences in the efficiency levels between the 10 smallest and largest hospitals when compared to the number of doctors, nurses or beds. We found evidence of statistically significant differences between large and small hospitals when it comes to inpatients. We are led to believe that the flow of inpatients is a strong reason for hospital efficiency.

Table 3. Efficiency Scores by Size of Hospital

	CCR			BCC		
	Mean	**Median**	**St Dev**	**Mean**	**Median**	**St Dev**
By Doctors						
10 Largest Hospitals	60.66	63.49	41.21	90.50	96.88	12.34
10 Smallest Hospitals	44.56	14.89	47.97	79.96	100.00	37.19
T-Test of Difference in Means	0.805			0.851		
By Nurses						
10 Largest Hospitals	54.27	41.84	41.13	80.33	92.12	28.28
10 Smallest Hospitals	27.78	9.79	38.66	69.29	100.00	43.84
T-Test of Difference in Means	1.484			0.669		
By Beds						
10 Largest Hospitals	47.66	27.40	38.87	78.35	86.01	25.16
10 Smallest Hospitals	50.64	44.08	46.60	69.29	100.00	43.84
T-Test of Difference in Means	-0.155			0.567		
By Outpatients						
10 Largest Hospitals	61.94	69.86	40.73	93.63	100.00	10.70
10 Smallest Hospitals	16.84	5.08	30.25	52.25	50.41	46.65
T-Test of Difference in Means	0.704			2.734		
By Inpatients						
10 Largest Hospitals	71.72	98.73	36.19	93.30	100.00	10.82
10 Smallest Hospitals	18.35	5.08	30.93	53.85	58.39	45.78
T-Test of Difference in Means	3.545			2.652		

When we changed our analysis to look at the top and bottom 30 hospitals, we found a strong size effect to take place in the UAE hospitals. The results of the BCC model presented in Table 4 indicated that the top 30 hospitals have two and half times the number of doctors and three and half times the number of nurses as the inefficient ones. We found that efficient hospitals have over 100 inpatient beds with an average bed size of 121. Similarly, the number of patients treated between efficient and inefficient hospitals is significantly different. The average number of inpatients treated by inefficient hospitals is 1,292, while for efficient hospitals it is 8,533. There is also a difference in the number of outpatients treated at 41,942 for inefficient hospitals compared to 222,581 for efficient ones. Such stark differences point out the fact that there are positive economies of scale in the UAE healthcare which are being achieved by the larger facilities.

Table 4. Difference between Top 30 Efficient and Non-Efficient Hospitals

	Bottom 30 Hospitals by Efficiency Scores		Top 30 Hospitals by Efficiency Scores	
	CCR	**BCC**	**CCR**	**BCC**
Size (Average)	Doctors =62	Doctors =37	Doctors =84	Doctors =94
	Nurses =160	Nurses =90	Nurses =228	Nurses =250
	Beds=99	Beds=53	Beds=113	Beds=121
	Inpatients=2,653	Inpatients=1,292	Inpatients=8,113	Inpatients=8,533
	Outpatients=69,992	Outpatients=41,942	Outpatients=205,491	Outpatients=222,581

5. Discussion and Conclusion

Hospitals represent one of the most complex and expensive operational units in a health system (Hatam et al, 2013; Chul-Young et al, 2013). In UAE, one of the main problems in increasing hospital efficiency has been the ability to recruit and retain qualified and experienced healthcare professionals at all levels, and consistent underutilization of existing hospital facilities and services (Mahate & Hamidi, 2016). In addition, demographic factors such as aging population, high birth rate, and expatriate majority have resulted in increased healthcare expenditures. UAE currently faces the challenge of adapting the provision of its services to meet changing demographics while simultaneously trying to run an efficient health system. The dynamics of private versus government role in improving system efficiencies are not yet well understood. Similar to other developed nations, UAE has undertaken a series of reform initiatives to improve the efficiency of hospitals over the past four decades. However, limited empirical studies have been conducted to document the impact of the previous reforms on hospitals' efficiency in UAE.

This study was undertaken to estimate the relative technical efficiency of the UAE hospitals and to investigate the effect of hospital size on estimated technical efficiency scores. Technical efficiency scores for 96 private and governmental hospitals were estimated using nonparametric DEA. We also examined the association between hospital size and technical efficiency scores. Based on our empirical results, we concluded that only one third of the UAE hospitals are technically efficient. Therefore, there are efficiencies yet to be obtained by a considerable number of hospitals studied in this research. Ignoring the operational inefficiencies existing in inefficient hospitals could have serious consequences for their ultimate survival in an increasing competitive marketplace in the future. Inefficient UAE hospitals need to work much harder to become or remain attractive to both public and private payers.

Overall, our empirical results on hospital effect size are consistent with those of earlier studies confirming the general conclusion that hospital size has an influence on technical efficiency, with larger size hospitals achieving higher levels of efficiency. We are led to support studies such as Posnett (1999) that find that hospitals with less than 200 beds can achieve economies of scale through growth. However, we feel that the demographic nature of the UAE implies that the efficiency size level is more around 100. Interestingly, we found that hospitals with more than 300 beds, although being efficient, are less so than those in the 100 to 300 group. Therefore, we are to believe that the optimal size of a hospital in the UAE is between the 100 to 300-bed size after which diseconomies set in. We also find evidence to support that economies of scope exist between the provision of inpatient and outpatient care. We observe that the top 30 efficient hospitals have a high correlation between the treatment of inpatient and outpatients. We believe that clinical staff are far better utilized when a hospital has inpatient and outpatient care. Although our literature review pointed out that there is also a strong relationship between the provision of inpatient and outpatient care with quality and mortality rates, this is beyond the scope of this research and future work may examine this question.

Ozcan and Luke (1993) examined how hospital characteristics influence technical efficiency using a sample of 3,000 urban hospitals in the United States. They found that hospital ownership and percentage of Medicare were significantly related to technical efficiency, and hospital size was consistently and positively related to efficiency due to economies of scale. Watcharasriroj and Tang (2004) used DEA to measure the technical efficiency of 92 public nonprofit hospitals in Thailand and found that large hospitals (at least 500 beds) significantly operate more efficiently than smaller hospitals and IT positively contributes to the efficiency for both large and small hospitals. Tiemann and Schreyögg (2009) evaluated the efficiency of public, private for-profit, and private non-profit hospitals in Germany. The authors found a significant positive association between hospital size and efficiency for a panel of 1,046 hospitals for the period of 2002 to 2006. In a cross-sectional study from 2005 to 2007, Hatam et al (2013) used DEA to measure the technical efficiency of 64 general hospitals in Iran and found that larger hospitals achieved higher technical efficiency as compared to their smaller counterparts. Asmild et al (2013) recently studied the productive efficiency of 141 public hospitals in two Canadian provinces and found that the hospitals in the larger, more urban areas consistently outperform their counterparts in the smaller, more rural area in terms of technical efficiency. Chul-Young et al also (2013) concluded that hospital size significantly influences performance. The researchers found medium-size hospitals (126-250 beds) in Tennessee to be more efficient than their smaller counterparts. Private hospitals in UAE have not reached their optimal scale yet. There is still room for expansion of outputs and reduction of unit costs. However, increasing the level of outputs requires an increase in demand for health, which is beyond the control of the hospital.

The attainment of technical efficiency without sacrificing quality represents an important goal of public payers (McCallion et al., 2000). The DEA analysis can be used as a diagnostic technique by the Ministry of Health or other federal agencies in the UAE for monitoring purposes to identify technically inefficient hospitals and to provide needed technical support to improve their economic performance in an increasingly competitive marketplace. Furthermore, national and international benchmarking of hospital performance of the UAE hospitals can provide additional insights on sources of hospital inefficiency.

Although our study advances previous research efforts regarding the effect of hospital size on technical efficiency, there are a number of limitations that should be considered when assessing the results.

First, the DEA model can only identify relative and not absolute inefficiencies when applied to a data set. Therefore, efficient hospitals identified in this research are not necessarily technically efficient in an absolute sense. There might still be some room for further improvement in their technical efficiency. Small case studies of selected inefficient and efficient hospitals would be extremely helpful not only to confirm the results of the DEA analysis but also to identify potential areas for improvement in the future.

Second, since this study used cross-sectional data to measure the technical efficiency of the UEA hospitals, it was not possible to draw causal inferences about the impact of hospital size on estimated technical efficiency scores. For the very same reason, we could not assess the changes (negative or positive) in efficiency scores obtained with the DEA methodology over time. It is important to measure the technical efficiency of a firm over time to better understand how it responds to external pressures (like increased competition, reduced reimbursements, etc.) in terms of making necessary operational adjustments. Therefore, future studies should use longitudinal data to assess the changes in hospital efficiency measures over time and address the issue of causality.

Third, in order to compare efficiency scores across hospitals, the quality of output must also be controlled for (Rosko, 1990). Increased quality is generally believed to require more highly trained personnel and more intensive care. Requiring more resources will make the efficiency score lower for hospitals that provide higher quality care (Fizel & Nunnikhoven, 1993). In short, a hospital may appear to be less efficient simply because its users received more intensive use of resources associated with the provision of a higher quality of care. Some researchers argue that a higher quality of care will actually reduce resource use and make a provider more efficient (Berwick, Godfrey & Roessner, 1991). By including a control in the model for quality indicators, these potential effects can be examined directly. Therefore, future assessment of hospital technical efficiency in the UAE should incorporate direct measures of case-mix and quality indicators to provide a fair comparison of technical efficiency among hospitals.

Fourth, since no data were available on input prices, this research could not address the issue of allocative efficiency in the UAE hospitals. Indeed, hospitals found to be technically efficient might not be allocatively efficient. Assuming the availability of reliable input prices, future work should assess both the technical and allocative efficiency of the UAE hospitals.

Finally, more advanced modeling techniques such as Tobit regression modeling should be used in future research to find out how various economic, structural, and demographic factors affect hospital efficiency in the UAE.

Competing Interests Statement

The authors declare that there is no conflict of interests regarding the publication of this paper.

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