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Efficiency evaluation of public hospitals in Kuwait: An application of data envelopment analysis

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Abstract

Background: Kuwait overall health expenditure, in 2019, was 5.5% from the gross-domestic product and the state is the biggest healthcare provider in secondary and tertiary hospitals. Hospital efficiency and productivity are, therefore, an important issue to analyse, specifically in terms of number of visits to outpatient clinics, the number of surgical procedures performed, bed turnover and bed occupancy. Data envelopment analysis has been used to provide insights in the understanding of this growth in other countries.

Methods: Data envelopment analysis (DEA) was used to estimate technical and scale efficiency scores for seventeen public hospitals in Kuwait from 2015 to 2019 using a two-stage DEA. Technical efficiency scores were regressed against institutional characteristics using Tobit regression to investigate the determinants of efficiency differences amongst hospitals.

Results: The mean technical efficiency score for all hospitals was 75%, and it improved by 1% since 2015. The mean pure technical efficiency score was 85% in 2015 and improved to 86% in 2019. The mean scale efficiency score was 89% in 2015 and decreased to 88% in 2019. Only five hospitals were constantly technically and scale efficient. Tobit regression showed that hospital efficiency was significantly associated with the hospital level (secondary or tertiary), number of beds, bed occupancy rate and the average length of stay.

Conclusions: Most public hospitals in Kuwait were not technically and scale efficient, but improvements were observed in the overall scores and pure technical efficiencies of these hospitals throughout the study. The identification of the factors influencing efficiency is crucial for hospital managers and policymakers to take evidence-based decisions to improve the technical efficiency of the main health-producing units in the country.

Keywords: Technical efficiency; Scale efficiency; Hospital efficiency; Data envelopment analysis; Public hospitals; Kuwait

1. Introduction

Many governments across the globe are concerned about the unsustainable growth in healthcare expenditure, with limited evidence as to how to measure this growth and what mechanisms can be used to contain it. Studying and measuring efficiencies in the healthcare systems can help governments to better discern and detect inefficiencies, establish evidence-based levers for change and, ultimately, enable better cost control and containment of growth (1). In a health system efficiency is believed to be related to the connection between system inputs (i.e. manpower, capital or

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equipment) and either intermediate outputs (waiting times, number of individuals treated, etc.) or final health outcomes (life years gained or quality-adjusted life years (QALYs)) (2). Two main types of efficiency are largely mentioned in the health system literature: technical and allocative efficiency. The aim of technical efficiency is either to increase the level of outputs with the same level of inputs or to maintain the same level of outputs by utilising fewer inputs (3). Allocative efficiency is on the other hand attained by directing health resources towards interventions that would optimise health gains (4).

The efficiency concept of this study is based on the explanation of Farrell (5), which states that a hospital is technically efficient if it produces the maximum level of outputs with a given level of inputs, or if it produces a certain level of outputs with the least possible inputs. Identifying the hospital's outputs is crucial to measure its efficiency. The number of visits to outpatient clinics, the number of surgical procedures performed, bed turnover and bed occupancy, among others, are considered potential outputs when evaluating hospital efficiency (6).

Data envelopment analysis has been used to provide insights in the understanding of this growth in countries like Canada, Iran and Malaysia (7-9).

According to the World Bank data, in Kuwait, the overall health expenditure as part of the gross domestic product (GDP) has increased from 2.9% in 2014 to 5.5% in 2019, and the domestic general government health expenditure as a percentage of general government expenditure has increased from 5.6% in 2014 to 8.9% in 2019 (10). The per capita health expenditure increased from $1,285 in 2014 to $1,759 in 2019 (10). In 2018, the total health expenditure in the country was $7,08 billion (10). In 2019, the domestic general government health expenditure made up around 87% of the total health expenditure, while out-of-pocket payments accounted for 11.8% of the total health expenditure (10), which makes the State the biggest healthcare payer in the country. Public hospitals in Kuwait are divided into secondary (general) and tertiary (specialised) care hospitals. There aren't any recent reports available that describe how much of the general Ministry of Health (MoH) budget is dedicated to fund public hospitals. However, previous research studies stated that, historically, more than 60% of the MoH budget is consumed by secondary and tertiary care public hospitals (11), and the remainder 40% of the MoH's budget is consumed by primary care and public health provision.

The study aims to evaluate the technical and scale efficiencies of secondary and tertiary level public hospitals in Kuwait for the period 2015 to 2019, using data envelopment analysis (DEA) method. This study also aims to identify the contributing factors that affect the efficiency of public hospitals in an attempt to provide policymakers in the country's health sector with relevant, reliable and useful information to make more informed decisions and act in accordance with to cost controls and a sustainable healthcare system.

2. Material and methods

Data Envelopment Analysis (DEA) is the most widely used technique for measuring the efficiency of smaller units within a health system such as hospitals, as well as health systems as a whole (12-14). It is a non-parametric method that uses a linear programming technique for analysing the relative efficiencies of individual Decision-Making Units (DMUs) in relation to multiple inputs and outputs (15). In this method, each DMU is compared against the estimated efficient frontier, which comprises the best-performing units (13).

The ability to measure technical efficiency is among the several advantages of DEA (16). Another advantage of this approach is its ability to easily deal with multiple inputs and outputs (13, 17-21), even if they were heterogeneous (22). And, contrary to statistical regression analysis, DEA has the simplicity of not having prior or complicated standard assumptions (17, 18, 22, 23). The ability to provide useful information for developing strategies to eliminate areas of inefficiency is another advantage of this approach (20).

Despite the advantages mentioned above, DEA has some disadvantages, which include its inability to take into account socioeconomic and environmental factors when measuring the technical efficiency of DMUs (24, 25), and it can only analyse the efficiency of homogeneous units (20). Another disadvantage of this approach is its sensitivity to sample size, therefore it is crucial to have a large sample when applying DEA (24-26). Moreover, the inability to distinguish true inefficiency from random variation is another weakness of this method (20, 21, 27). DEA is sensitive to high-performing outliers, the efficiency frontier may therefore change if these outliers were not identified (28).

Charnes, Cooper and Rhodes (29) have developed a model to measure the technical efficiency of a DMU in relation to other DMUs by incorporating multiple input and output variables (30). The measured relative efficiency score of a DMU falls between 0 (completely inefficient) and 1 (completely efficient). There are two programming models to measure technical efficiency, under the assumption of constant returns to scale (CRS in model 1) and variable returns to scale (VRS in model 2) (30).

Model 1. DEA weights model, input-oriented, CRS	**Model 2.** DEA weights model, input-oriented, VRS
$\text{Eff} = \underset{u_r, v_i}{\text{Max}} \sum_r u_r y_{r j_0}$	$\text{Eff} = \underset{u_r, v_i}{\text{Max}} \sum_r u_r y_{r j_0} + u_0$
s.t.	*s.t.*
$\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \le 0; \quad \forall j$	$\sum_r u_r y_{rj} - \sum_i v_i x_{ij} + u_0 \le 0; \quad \forall j$
$\sum_i v_i x_{i j_0} = 1$	$\sum_i v_i x_{i j_0} = 1$
$u_r, v_i \ge 0; \quad \forall r, \forall i.$	$u_r, v_i \ge 0; \quad \forall r, \forall i.$

Where (30)
Yrj = the amount of output r produced by hospital j,
xij = the amount of input i used by hospital j,
ur = the weight given to output r, (r = 1 ,..., t and t is the number of outputs)
vi = the weight given to output i, (i = 1 ,..., m and m is the number of outputs)
n = the number of hospitals,
j0 = the hospital under assessment

Banker, Charnes and Cooper (31) developed an input-oriented model, where an inefficient unit is made efficient through the proportional reduction of its inputs while keeping its outputs constant, and this model was used in this study. The model assesses whether a hospital is producing on an optimal scale, which is also known as scale efficiency (30-32). The scale efficiency score is the result of the division of the CRS technical efficiency (TE) score by the VRS technical efficiency (TE) score (33). Scale efficiency is the degree to which a hospital is producing at an optimal scale (32). On the other hand, the technical efficiency that is related to operation and is not attributed to departures from optimal scale is known as managerial efficiency or pure technical efficiency (32). One of the justifications for using the Banker, Charnes and Cooper model in this study is the idea that hospital managers will have more control in modifying levels of input rather than output, which was the case with other studies (32-34).

2.1. Two-stage DEA analysis

A second stage was added to this study to try and identify the potential factors affecting the technical efficiency of public hospitals in the country. During this stage, a regression analysis was performed in which hospital efficiency scores from the first stage were used as dependent variables and some institutional factors as independent variables. The criteria for choosing the independent variables was based on the availability of data, the context of the study and the literature review. The calculated efficiency scores in the first stage of the study were regressed against the chosen independent variables using Tobit model, which is a censored regression analysis model. This model is widely used in two-stage DEA since the scores have only a positive probability of scoring one of the two corner values (between 0 and 1), and is believed to be adequate in regressing efficiency scores against exogeneous variables (35). Data analyses were conducted using R version 4.1.3.

2.2. Data variables

The data for this study was obtained from The National Center for Health Information, MoH. Data of seventeen hospitals, six general secondary care hospitals and eleven specialised tertiary level hospitals, for the years from 2015 to 2019, were analysed in this study. Some hospitals were excluded from the sample because the data was not available for the whole period of the study, or that their services were limited to outpatient clinics hence were not comparable DMUs. Data from the year 2020 onwards was excluded from the analysis because the entire health system in Kuwait was severely affected by the COVID-19 pandemic.

Based on the use of similar variables in other studies (11, 13, 36-41), and the availability of domestic data, four input and two output variables were selected for the first stage DEA. Input variables included the total number of beds (a widely used proxy for capital in hospital efficiency studies (40, 42)) and three labour inputs including the total number of doctors, nurses and non-medical workers. Outpatient variables on the other hand were total number of visits to outpatient clinics and total number of discharges (a proxy for number of admissions).

In the second stage of the analysis, hospital size (i.e. total number of beds), bed occupancy rate, average length of stay and the level of care for a hospital (secondary or tertiary) were the chosen independent variables. The criteria for choosing these variables was based on the availability of the data and their use in previous studies (11, 22, 37, 39, 42-44).

3. Results

A summary of the statistics of inputs and outputs for public hospitals in Kuwait for the years 2015 to 2019 is shown in Table 1.

Table 1 Descriptive statistics of inputs and outputs of public hospitals in Kuwait, 2015-2019

		Number of beds	**Number of doctors**	**Number of nurses**	**Non-medical workers**	**Outpatient visits**	**Number of discharges**
2015	Mean	417	335	918	562	181076	13187
	Median	361	203	764	478	143658	8613
	Std. Dev.	285	310	711	378	169532	13177
2016	Mean	420	352	960	586	182633	13761
	Median	414	217	871	475	139862	8360
	Std. Dev.	287	331	742	414	175611	13781
2017	Mean	419	367	964	598	185103	13493
	Median	414	210	877	475	132049	8274
	Std. Dev.	293	355	747	429	175016	13388
2018	Mean	418	367	964	598	170880	13067
	Median	372	210	877	475	108006	8101
	Std. Dev.	295	355	747	429	156717	13180
2019	Mean	418	389	916	566	179584	13033
	Median	362	219	860	450	113416	7726
	Std. Dev.	294	394	706	436	164129	12796
Average	Mean	418	362	944	582	179855	13308
	Median	372	212	860	475	132049	8274
	Std. Dev.	284	342	714	408	164365	12952

Table 2 shows the DEA results. Five hospitals (29%) were consistently technical and scale efficient for the entire five-year period. The overall mean technical efficiency (CRS) was score was 75% over the entire study period, and it improved by 1% since 2015. The overall mean pure technical efficiency score (VRS) was around 85%, which improved from 85% in 2015 to 86% in 2019. Figure 1 illustrates the changes of efficiency scores during the period 2015-2019.

In 2015, 2016, 2017, 2018 and 2019, out of 17 hospitals, six (35%), five (29%), five (29%), six (35%) and seven (41%) hospitals respectively had a technical efficiency score of 1 (fully efficient). The average pure technical efficiency (VRS) scores were 85%, 83%, 84%, 85% and 86% respectively for the five years of the study. These findings indicate that if all of the hospitals were operating efficiently, they could have produced their current levels of output with 15%, 17%, 16%, 15% and 14% reductions in their existing inputs, or could have alternatively produced more outputs by the same percentages using their current levels of input for the consecutive years of the study.

The mean scale efficiency score was around 89% over the five-year period, which decreased from 89% in 2015 to 88% in 2019. The analysis of scale efficiency has shown that nine (53%), eight (47%), six (35%), seven (41%) and ten (59%) hospitals displayed constant returns to scale in the period 2015-2019, which means that they were operating at their most productive scale sizes. The average scale efficiency score in the sample was 89% in 2015, 87% in 2016, 90% in 2017 and 2018, and 88% in 2019.

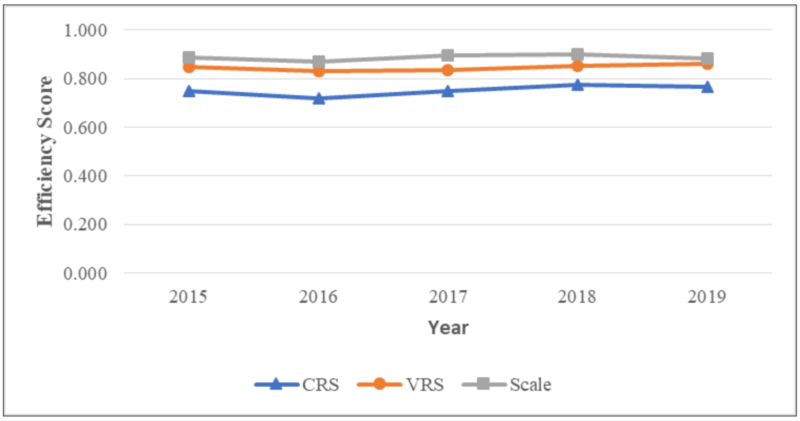

Figure 1 Changes in efficiency scores over the 2015-2019 period

Table 2 Technical and scale efficiency scores for Kuwait public hospitals, 2015-2019

Hospital	2015			2016			2017			2018			2019		
	CRS	VRS	Scale	CRS	VRS	Scale	CRS	VRS	Scale	CRS	VRS	Scale	CRS	VRS	Scale
Sabah Hospital	0.72	0.72	1.00	0.69	0.69	1.00	0.63	0.63	1.00	0.65	0.65	1.00	0.71	0.71	1.00
Amiri Hospital	0.84	0.84	1.00	0.82	0.88	0.92	0.83	0.86	0.97	0.84	0.85	0.99	0.78	0.78	1.00
Mubarak Hospital	0.69	0.81	0.86	0.67	0.74	0.90	0.71	0.76	0.93	0.71	0.76	0.93	0.74	0.80	0.92
Farwaniya Hospital	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adan Hospital	1.00	1.00	1.00	0.91	1.00	0.91	0.92	0.95	0.97	0.97	0.99	0.98	1.00	1.00	1.00
Jahra Hospital	0.90	1.00	0.90	0.91	1.00	0.91	0.91	1.00	0.91	0.97	1.00	0.97	0.91	1.00	0.91
Razi Hospital	0.65	0.67	0.97	0.69	0.70	0.98	0.93	0.94	0.99	1.00	1.00	1.00	1.00	1.00	1.00
Physical Medicine and Rehabilitation	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Maternity Hospital	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chest Hospital	0.67	0.67	1.00	0.57	0.57	1.00	0.58	0.59	0.99	0.64	0.64	0.99	0.61	0.61	1.00
Infectious Disease Hospital	0.37	0.54	0.68	0.32	0.54	0.58	0.41	0.64	0.64	0.36	0.55	0.65	0.30	0.54	0.55
Mental Health Center	0.70	0.72	0.97	0.53	0.58	0.92	0.54	0.58	0.93	0.73	0.77	0.94	0.76	0.79	0.96
Ibn Sina Hospital	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Kuwait Cancer Control Center	0.48	0.48	0.99	0.45	0.45	1.00	0.44	0.45	0.99	0.42	0.45	0.93	0.47	0.52	0.91
Palliative Care Center	0.24	1.00	0.24	0.24	1.00	0.24	0.33	1.00	0.33	0.35	1.00	0.35	0.20	1.00	0.20

Urology Center	0.46	0.98	0.47	0.40	1.00	0.40	0.49	0.85	0.58	0.52	0.85	0.61	0.53	0.88	0.60
Zain Hospital	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean	0.75	0.85	0.89	0.72	0.83	0.87	0.75	0.84	0.90	0.77	0.85	0.90	0.76	0.86	0.88
Median	0.72	0.98	1.00	0.69	1.00	0.98	0.83	0.94	0.99	0.84	0.99	0.99	0.78	1.00	1.00
Standard deviation	0.25	0.18	0.22	0.26	0.20	0.23	0.24	0.19	0.19	0.25	0.18	0.19	0.26	0.18	0.22
Coefficient of variation	33.3	21.4	24.8	36.8	24.4	26.8	32.6	22.6	21.5	31.9	21.5	20.6	34.5	20.4	25.3

Note. CRS=constant returns to scale technical efficiency (overall technical efficiency); VRS=variable returns to scale technical efficiency (pure technical efficiency); Scale=scale efficiency

Table 3 Total input reductions and/or output increases needed to make inefficient hospitals efficient, 2015-2019

		Number of beds	**Number of doctors**	**Number of nurses**	**Non-medical workers**	**Outpatient visits**	**Number of discharges**
2015	Shortfall/excess	585	419	2430	965	3020	541
	Total actual values	7082	5698	15614	9557	3078293	224184
	% of total actual values	8.3%	7.4%	15.6%	10.1%	0.1%	0.2%
2016	Shortfall/excess	466	862	5631	1335	36254	3114
	Total actual values	7132	5978	16319	9968	3104753	233943
	% of total actual values	6.5%	14.4%	34.5%	13.4%	1.2%	1.3%
2017	Shortfall/excess	526	531	3578	1768	4579	6176
	Total actual values	7127	6234	16382	10169	3146754	229377
	% of total actual values	7.4%	8.5%	21.8%	17.4%	0.1%	2.7%
2018	Shortfall/excess	536	576	3709	1749	4706	0
	Total actual values	7098	6234	16382	10169	2904968	222134
	% of total actual values	7.5%	9.2%	22.6%	17.2%	0.2%	0.0%
2019	Shortfall/excess	586	173	2095	187	4677	0
	Total actual values	7110	6621	15570	9619	3052921	221564
	% of total actual values	8.2%	2.6%	13.5%	1.9%	0.2%	0.0%

Second stage DEA: results of Tobit regression analysis

Generally, public hospitals in Kuwait are operating at a high level of efficiency but there is room for further efficiency gains. Table 3 shows the total amount of increases in outputs and/or decreases in inputs needed to make less efficient hospitals fully efficient for the period of the study. In 2016, the less efficient hospitals combined had 16,319 (34.5%) more nurses than needed to be efficient, which was the largest percentage among all variables in the study. In 2015, a reduction of 8.3% in the number of beds, 7.4% in the number of doctors, 15.6% in the number of nurses and 10.1% in the number of non-medical workers would be required to reach full technical efficiency, while keeping the level of outputs constant. Alternatively, an increase of 0.1% in outpatient visits and 0.2% in discharges would make the hospitals fully efficient for the same year while holding input levels constant. In 2019 on the other hand, hospitals could be more technically efficient if they were able to decrease their input levels by 8.2% fewer beds, 2.6% fewer doctors, 13.5% fewer nurses and 1.9% fewer non-medical staff, while keeping their level of outputs constant. While utilising the same level of inputs, the output increase required to make hospitals fully efficient would otherwise be 0.2% in outpatient visits.

During this stage, the estimated technical efficiency scores in the first stage were regressed against a group of institutional variables, including the level of care provided (secondary or tertiary), number of beds, bed occupancy rate and average length of stay to determine if these factors have influenced the technical efficiency of the hospitals. Table 4 shows the results of the regression analysis. The results confirm that all the institutional variables mentioned above affected public hospitals' efficiency. It was found that the hospital number of beds and the occupancy rate of these beds were significant determinants of hospital technical efficiency; demonstrating that the greater number of beds and the higher bed occupancy rate the higher overall (CRS) technical efficiency ($p<0.05$). When looking at scale efficiency, it was found that tertiary care hospitals were more efficient than secondary care hospitals ($p<0.05$), hospitals with higher number of beds and lower average length of stay were more scale efficient ($p<0.01$) and hospitals with high bed occupancy rate were more scale efficient ($p<0.001$).

Table 4 Results of Tobit regression analysis

	(1)	**(2)**	**(3)**
	CRS TE	**VRS TE**	**Scale**
Tertiary	0.105121	-0.015040	0.170886*
	(0.116042)	(0.116788)	(0.087750)
Number of beds	0.000307*	-0.000038	0.000298**
	(0.000181)	(0.000189)	(0.000134)
Bed occupancy rate, %	0.004161*	0.001763	0.005520***
	(0.002408)	(0.002473)	(0.001808)
Average length of stay, days	-0.002892	-0.000415	-0.003838**
	(0.002415)	(0.002510)	(0.001824)
Constant	0.434839**	0.894209***	0.464546***
	(0.171435)	(0.173447)	(0.128744)
Observations	85	85	85
Pseudo R^2	0.114	0.011	0.343
χ^2(df = 4)	11.58	0.90	23.48
p-value	0.021	0.925	<0.001

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4. Discussion

Using DEA, this study evaluated the technical efficiency of secondary and tertiary public hospitals in Kuwait in the period 2015-2019. The analysis showed that five hospitals (29%) were consistently technical and scale efficient over the five-year period. The average CRS technical efficiency score was 0.75 over the study period, demonstrating that hospitals could produce their current level of outputs with 75% their currently used inputs to achieve maximum technical efficiency. The analysis also revealed considerable differ-ences in efficiency scores among hospitals since the efficiency scores ranged from 0.20 to 1.00. Furthermore, the average VRS technical efficiency score was 0.85, which signifies a room for managerial improvements. The results of this study show that a higher per-centage of public hospitals were technically efficient when compared to the work of Al-sabah et al (11), where 20% of public hospitals were technically efficient in the period 2010-2014 in Kuwait.

The results from this study had some similarities and differences when compared to other studies in the region. Alatawi et al (45) have found that the average CRS and VRS technical efficiency scores of public hospitals in Saudi Arabia were 0.76 and 0.87 respectively, which was close to the results of this study. Mahate et al (46), however, found that one third of hospitals in the United Arab Emirates were technically efficient, which is slightly higher than our findings. Ahmadkiadaliri et al (32) found that 53% of hospitals in South of Iran were technically inefficient, which is lower than the 71% technically inefficient hospitals found in the current study.

The use of DEA can help hospital managers and policy-makers to reach informed decisions since it has the ability to identify sources of inefficiencies (47). The literature suggests that overstaffing is one of the known sources of technical inefficiencies in hospitals (48, 49). Osmani (22) explains that close evaluation of the excess in medical and non-medical manpower is crucial for decreasing inefficiencies in hospitals. Similar to other studies in the region (45), the current study revealed that public hospitals in Kuwait combined had an excess of number of beds, doctors, nurses and non-medical staff in the period 2015-2019. One finding stands out which is the excess of more than 34% of nurses working in public hospital in the year 2016. Generally, the current findings are in line with what Burney et al (50) concluded in 1999 that an oversupply of beds and nurses caused relative inefficiencies in the production of health services in Kuwait back then.

The results of the Tobit regression revealed that all the institutional variables used in the analysis influenced public hospitals' efficiency. It was found that tertiary level (specialized) hospitals were more scale efficient than secondary level (general) hospitals. This is in line with what Lee and colleagues (44) found, which was that specialised hospitals were more efficient when compared to general hospitals. Kounetas and Papathanassopoulos (42) also found that in Greece, the technical efficiency of a hospital was affected by the hospital type (Regional, Prefectual or University). The results of the current study also revealed that the greater number of beds in a hospital and the higher bed occupancy rate the higher overall (CRS) technical efficiency and scale efficiency. This is in line with the findings of Chisholm and Evans (51) that indicate that underutilisation of services such as low utilisation of beds is a cause of inefficiency in hospitals. It was also found in the current study that the lower average length of stay was associated with higher scale efficiency.

The limitations to this study should be addressed to improve future research. The first limitation is related to the criticism of Simar and Wilson (52) naivety of the of the censored Tobit regression analysis used in the second stage of the DEA. Applying a double bootstrap truncated model is one way of overcoming this limitation. The second limitation is the lack of data related to the severity of diseases and quality of care delivered in hospitals, which disallowed the study to determine to what extent the inefficiency might be caused by differences in quality of care. The third limitation is related to the size of the sample. As mentioned in the methods section, it is desirable to have a large sample size when applying DEA. In this study however, the sample included 17 hospitals which was the total number of public hospitals that provided inpatient and outpatient services in Kuwait in the period 2015-2019. The fourth limitation is also related to the application of DEA. While it is desirable to have a homogeneous sample, six hospitals were secondary level hospitals and eleven were tertiary level hospitals.

List of abbreviations

- CRS – constant returns to scale technical efficiency
- DEA – Data envelopment analysis
- DMUs – Decision-making units
- GDP – Gross-domestic product
- MoH – Ministry of Health
- QALYs – quality-adjusted life years
- VRS - variable returns to scale technical efficiency

5. Conclusion

This study has measured the technical and scale efficiency of 17 public hospitals in Kuwait identifying the input reductions and/or output increases needed to make inefficient hospitals more or fully efficient. The study also reveals the room for improvement in the performance of public hospitals since most of these hospitals were not operating at technically efficient levels. Such improvements could be achieved by decreasing inputs (i.e. number of beds and number of medical and non-medical workers) and/or increasing outputs (outpatient clinic visits and number of admissions).

Furthermore, the study provided insight into some of the institutional factors affecting the efficiency of hospitals in the country (level of care, number of beds, bed occupancy rate and average length of stay).

This study has provided hospital managers and policy makers with useful evidence in formulating future reform plans. The findings from the current analysis of public hospitals in Kuwait suggests that there is room for improving efficiency in the utilisation of healthcare resources. Additionally, the identification of the factors influencing efficiency helps in reaching informed decisions to improve the technical efficiency of the main health-producing units in the country. Repeating similar analyses routinely would also help them in identifying ways for best practice, given the availability of accurate and timely data.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare that they have no competing interests.

Availability of data and materials

The data presented in this study are available on request from the corresponding author.

Author's contributions

Conceptualization, A.M.A. and A.D.A.; methodology, A.M.A. and A.D.A.; software, A.M.A.; validation, A.D.A and E.K.; formal analysis, A.M.A., A.D.A and E.K.; investigation, A.M.A.; resources, A.M.A.; data curation, A.M.A.; writing—original draft preparation, A.M.A.; writing—review and editing, A.D.A. and E.K.; visualization, A.M.A.; supervision, A.M.A.; project administration, A.M.A.; funding acquisition, A.M.A. All authors have read and agreed to the published version of the manuscript.

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