Title: Measuring the efficiency of public hospitals in Kuwait: a two-stage data envelopment analysis and a qualitative survey study

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Electronic copy available at: https://ssrn.com/abstract=3416095
Abstract

Background and objective: Due to the drop in oil prices in recent years, the Kuwaiti economy faces challenges in public sector financing. Recently, the government has introduced economic reforms to improve public sector efficiency, including public healthcare. Within the healthcare sector, the efficiency of public hospitals is of particular interest as they consume the largest portion of health funding in Kuwait, as is common elsewhere. The current study aimed to measure technical and scale efficiencies of fifteen public hospitals in Kuwait for the period of 2010 to 2014. In addition, the study aimed to investigate the factors affecting hospital efficiency.

Methods: A two-stage data envelopment analysis (DEA), combining DEA and Tobit regression, as well as qualitative semi-structured interviews were used. First, technical and scale efficiency scores for hospitals were estimated using the DEA method. Second, technical efficiency scores were regressed against institutional characteristics using Tobit regression to investigate the determinants of efficiency differences in hospitals. The data for the two-stage DEA was obtained from ‘Health, Kuwait,’ an annual report published by the Kuwait Ministry of Health. For the qualitative study, semi-structured interviews were carried out with fourteen public and private hospital managers to explore their perception and experience of factors affecting hospital efficiency.

Results: The mean technical efficiency score for all hospitals was 85.8% over the study period, an improvement of 2% since 2010. The mean pure technical efficiency score was 79.6%, improving from 75% in 2010 to 81.2% in 2014. The mean scale efficiency score was 91.8%, improving from 87.6% in 2010 to 94.2% in 2014. Only three hospitals (20%) were constantly technically and scale efficient throughout the study period. Tobit regression showed that hospital efficiency was significantly associated with the average length of patient stay. The findings also showed that the larger hospitals (i.e. hospitals with more than 400 beds) were potentially more technically and scale efficient. Findings from the qualitative study revealed that both external and internal factors affect the efficiency of hospitals in the study context. External factors commonly included implementing legislative changes and decreasing bureaucracy, while internal factors included increasing bed capacity and improving qualifications and training of human resources.

Conclusion: The findings of this study showed that the majority of public hospitals in Kuwait were not technically and scale efficient, but some improvements was observed in their efficiency over 2010-2014 time period. The study also identified potential factors, both external and internal, that affected the efficiency of hospitals in Kuwait. The findings of this study provide useful information for the decision makers in Kuwait in order to develop strategies for improving the public hospitals’ efficiency.
**Introduction**

In 1962, the Constitution of the State of Kuwait was implemented, which included Articles 11 and 15 ensuring health provision (2). In accordance with the above-mentioned articles, a ‘Health for All’ policy was adopted by the government to provide access to comprehensive and high-level quality health services by all (1).

Currently, the country’s economy is experiencing a decline caused by a drop in oil export returns (3), the main source of healthcare financing. In addition, a rapid increase in health expenditure in the country, due to increased demand for services, has made the situation more challenging (1). The increase in healthcare demand has been attributed to multiple factors. There was an increase in the total population in the country from about 1.6 million in 1995 to 4.1 million in 2017, as well as an increase in the total life expectancy at birth from 72.7 to 74.8 for the same years (4). Additionally, the increase in demand for advanced services is believed to be the result of the growing health awareness in the population (1).

In response to these challenges, the government of Kuwait issued a six-point economic reform policy document in March 2016 that included ‘boosting the public sector’s efficiency’ and ‘launching administrative and institutional reforms by means of upgrading the efficiency of general and financial administration’ (5).

Providing sustainable health care financing is a challenge for many countries facing increasing demand for healthcare services and cost inflation of these services (6). Since hospitals consume a large portion of the health care budget and are large health production facilities that have diverse resource inputs, such as buildings, health and administrative personnel, drugs, and equipment, the focus of health decision makers is often drawn to the efficiency of these facilities to rationally distribute human and capital resources (6-8). Many researchers have evaluated the technical efficiency of hospitals in in Europe (9-14), North America (15, 16), Asia (6, 17-22), and Africa (23-29). In Kuwait, only one article was found that attempted to measure the efficiency of public health care and the cost associated with its inefficiencies. That article was published in 1999 (30).

This study aims to measure the technical and scale efficiencies of secondary and tertiary public hospitals in Kuwait for the period 2010 to 2014, using a data envelopment analysis (DEA) approach.
This study also aims to identify the factors affecting the efficiency of hospitals. It is believed that this study will provide decision makers in the Kuwaiti health sector with useful information to develop strategies for improving public hospital efficiency.

**Methods**

**Study setting**

In Kuwait, the share of total health expenditure from gross domestic product (GDP) has increased from 2.5% in 2000 to 3.9% in 2016 and public health expenditure as percentage of total government expenditure increased from 5.2% in 2000 to 6.2% in 2016 (4). But a substantial change was apparent in the increase in the per capita health expenditure, which increased from $462.6 per capita in 2000 to $1,068.3 per capita in 2016. In the fiscal year 2011-2012, total health expenditure was around 1.8 billion Kuwaiti Dinars (KD) (around USD$5.9 billion). In that period, government expenditure on health made up 82% of the total health expenditure, while out-of-pocket was 16% of the total health expenditure in the country (1). More recently, public health expenditure made up 83.9% of total health expenditure in 2016, making the State the biggest healthcare provider in the country (4).

Health services provided by the Ministry of Health (MOH) are divided into three main levels: primary, secondary and tertiary care. In addition to these, the MOH also provides other services such as dental health, occupational medicine, preventative medicine, treatment abroad and services during the Hajj season (1). **Figure 1** shows describes MoH spending.

As shown in **Figure 1**, more than 60% of MoH resources are consumed by secondary and tertiary healthcare providers. Secondary healthcare providers consist of six general hospitals with outpatient, inpatient and emergency departments. Each of these hospitals provides medical services to the people living in the governorate that these facilities serve.
Efficiency concepts

Palmer and Torgerson (31) explain that efficiency in a health system is associated with the connection between system inputs (proxies of cost such as capital, labour or equipment) and either intermediate outputs (numbers of treated individuals, waiting time, etc.) or final health outcomes (quality adjusted life years (QALYs) or life years gained). In the health system literature, two main types of efficiency are widely mentioned: technical and allocative efficiency. Technical efficiency aims at either maintaining the same level of outputs with less inputs, or more output with the same level of inputs (32). Whereas allocative efficiency is believed to be achieved by directing health funds towards interventions that would optimize health gains (33).

Farrell (34) explains that a hospital is technically efficient if it was producing a certain level of outputs with the least inputs, or if it was producing the maximum level of outputs with a certain level of inputs, and this efficiency concept is the base of the current study. Mangusson (14) argued that evaluating the technical efficiency of hospitals allows the comparison of their real use of inputs and outputs rather than costs and ‘profits’. It is believed that hospitals’ outputs must be clearly identified in order to measure their efficiency. Potential outputs can be number of outpatient visits, number of surgical interventions, number of patient-days, bed turnover and bed occupancy, among others (35).

Data Envelope Analysis (DEA)

DEA is the most frequently used technique for measuring the efficiency of a health system as a whole, or of smaller units within a health system such as hospitals (36-38). It is a non-parametric approach.
that uses a linear programming technique for analysing the relative efficiencies of individual Decision Making Units (DMUs) with respect to multiple inputs and outputs (36, 39-43).

DEA has several benefits, including its capacity to measure technical efficiency (44). It is also characterised by its ability to deal with multiple outputs and multiple inputs easily (38, 45-51), even if they were heterogeneous (6). Additionally, it has the advantage of the simplicity underlying this approach in terms of not having prior or complicated standard assumptions as is the case with statistical regression analysis (6, 50, 51). Additionally, it can provide useful information for developing strategies to eliminate areas of inefficiency (48).

DEA does also have disadvantages. It cannot take into account socioeconomic and environmental factors when measuring technical efficiency of DMUs (45, 52), and can only analyse the efficiency of homogeneous units (48). Additionally, it is desirable to have a large sample when applying this method because it is sensitive to sample size (45, 53). The inability to differentiate true inefficiency from random variation is another disadvantage of DEA (48, 49, 54). This approach also has sensitivity to high-performing outliers, so the efficiency frontier may change if such outliers were not detected (55).

Using the model developed by Charnes, Cooper, and Rhodes (called the CCR-model) (56), multiple output and input variables are incorporated to measure technical efficiency of a DMU in relation to other DMUs (25). The calculated relative hospital efficiency scores fall between 0, completely inefficient, and 1, being completely efficient. There are two programming models to calculate technical efficiency, under the assumption of constant returns to scale (CRS in model 1) and variable returns to scale (VRS in model 2) (25).

The model used in this study is an input-oriented model, which was developed by Banker et al (57), where an inefficient unit is made efficient through the proportional reduction of its inputs while its output proportions are held constant. It is possible, by using this model, to assess whether a hospital is producing on an optimal scale, which is known as scale efficiency (17, 25). This model allows for the division of total technical efficiency (CRS) to pure technical efficiency (VRS) and scale efficiency (17). According to Coelli (58) the scale efficiency score is equal to the CRS technical efficiency (TE) score divided by the VRS technical efficiency (TE) score. The degree to which a hospital is producing at an optimal scale is, on the other hand, known as scale efficiency (17). Technical efficiency that is
not attributable to departures from optimal scale and is related to operation is known as pure technical efficiency or managerial efficiency (17). It is believed that hospital managers have more control in altering the level of inputs rather than outputs, and this is one of the justifications for choosing the input-oriented model (17, 59).

**Model 1.** DEA weights model, input-oriented, CRS

\[
\text{Eff} = \text{Max} \sum_{r, i} u_r y_{rj} v_i \\
\text{s.t.} \\
\sum_{r} u_r y_{rj} = \sum_{i} v_i x_{ij} = 1; \quad \forall j \\
\sum_{i} v_i x_{ij} = 1; \quad \forall r, \forall i; \\
u_r, v_i \geq 0; \quad \forall r, \forall i.
\]

**Model 2.** DEA weights model, input-oriented, VRS

\[
\text{Eff} = \text{Max} \sum_{r, i} u_r y_{rj} + u_0 \\
\text{s.t.} \\
\sum_{r} u_r y_{rj} - \sum_{i} v_i x_{ij} + u_0 \leq 0; \quad \forall j \\
\sum_{i} v_i x_{ij} = 1; \quad \forall r, \forall i; \\
u_r, v_i \geq 0; \quad \forall r, \forall i.
\]

Where (25)

- \(Y_{rj}\) = the amount of output \(r\) produced by hospital \(j\),
- \(x_{ij}\) = the amount of input \(i\) used by hospital \(j\),
- \(u_r\) = the weight given to output \(r\), \((r = 1, \ldots, t)\) and \(t\) is the number of outputs
- \(v_i\) = the weight given to input \(i\), \((i = 1, \ldots, m)\) and \(m\) is the number of inputs
- \(n\) = the number of hospitals,
- \(j_0\) = the hospital under assessment

**Two-stage DEA analysis**

In order to identify the potential factors affecting the technical efficiency of the hospitals, a second stage was added to this study. In this second stage, a regression analysis was performed, in which hospital efficiency scores from the first stage were used as dependent variables and a number of institutional factors were used as independent variables. Independent variables were selected on the basis of literature review, the context of study and availability of data. The efficiency scores calculated in the first stage were regressed against these variables using Tobit regression analysis. This analysis model, known as censor regression, is widely used in two-stage DEA since the scores have only a positive probability of attaining one of the two corner values (between 0 and 1), and is believed to be sufficient in regressing efficiency scores against exogenous variables (60).

Both stages of the DEA analyses were conducted using Stata version 14 (StataCorp, College Station, Texas 77845 USA).
Data and variables

The data for this study was obtained from the ‘Health, Kuwait’ annual report published by the MOH’s Department of Statistics. The analysis will include data from 2010 to 2014 relating to a total of fifteen hospitals; six general hospitals at the secondary level and nine specialized hospitals at the tertiary level. The Center for Palliative Care and the Urology Center were not included in the analysis due to a lack of data for the study period. Additionally, some specialized centers were excluded from the sample because they only provide outpatient services and were therefore not comparable DMUs.

Based on the use of similar variables in other studies (19, 21, 23, 29, 38, 61) and the availability of local data, four input- and two output-variables were selected for the first stage DEA. Input variables included the number of beds (which is usually used as a proxy for capital inputs in hospital efficiency studies(10, 61)) and three human resources inputs including total number of doctors, nurses, and non-medical workers. Output variables were total outpatient visits and total number of discharges (a proxy for admissions).

Hospital size (i.e. total number of beds), bed occupancy rate, average length of stay and hospital type (general or specialised) were the independent variables used in the second stage of the analysis. The institutional variables were chosen based on the data availability and the evidence from the previous studies (6, 10, 18, 21, 62).

Semi-structured interviews

To better understand potential factors affecting hospital efficiency in Kuwait, qualitative semi-structured interviews were conducted with 14 hospital managers from the public and private sectors. Participants received information sheets that explained the objectives of the study, and provided written informed consent to participate. They were asked open-ended questions about the meaning of hospital efficiency; factors they believe would affect hospital efficiency; and the steps they would take to improve the efficiency of their hospitals. The data were analysed using thematic analysis to identify overall themes and patterns.
Results

Descriptive results

Table 1 provides a summary statistics of input and output variables of secondary and tertiary level hospitals in Kuwait for the years 2010 to 2014. On average, number of beds, doctors, nurses, non-medical workers, outpatient clinics visits, and number of discharges for the whole period of the study and for all hospitals were 444, 307, 853, 603, 182,057, and 14,534 respectively.

Table 1. Descriptive statistics of inputs and outputs of secondary and tertiary public hospitals in Kuwait, 2010-2014

| Year | Median | Mean | STDEV | Median | Mean | STDEV | Median | Mean | STDEV | Median | Mean | STDEV |
|------|--------|------|-------|--------|------|-------|--------|------|-------|--------|------|-------|
|       | Beds   | Doctors | Nurses | Non-medical workers | Outpatient visits | Number of discharges |
| 2010  | 416    | 196    | 656    | 484    | 168944 | 12144 |
|       | 423    | 268    | 800    | 579    | 152992 | 14361 |
|       | 257    | 205    | 511    | 295    | 99026  | 12715 |
| 2011  | 418    | 205    | 718    | 501    | 165387 | 12118 |
|       | 447    | 281    | 834    | 590    | 162185 | 14444 |
|       | 271    | 219    | 522    | 299    | 105728 | 12664 |
| 2012  | 409    | 219    | 715    | 505    | 160287 | 12087 |
|       | 448    | 297    | 845    | 603    | 166341 | 14405 |
|       | 270    | 236    | 538    | 310    | 115437 | 12946 |
| 2013  | 408    | 231    | 729    | 509    | 181270 | 12267 |
|       | 450    | 330    | 852    | 620    | 215564 | 14735 |
|       | 277    | 274    | 551    | 317    | 158991 | 13399 |
| 2014  | 418    | 263    | 765    | 503    | 164904 | 12073 |
|       | 453    | 359    | 933    | 622    | 213202 | 14727 |
|       | 281    | 289    | 605    | 326    | 163647 | 13243 |
| Average | 414    | 223    | 717    | 500    | 168158 | 12138 |
|       | 444    | 307    | 853    | 603    | 182057 | 14534 |
|       | 271    | 245    | 545    | 309    | 128566 | 12993 |

First stage DEA: efficiency results

Table 2 presents the DEA results. Three hospitals (20%) were constantly technical and scale efficient for the whole period. The mean technical efficiency score was 86% over the study period, and it improved by 2% since 2010. The mean pure technical efficiency score was around 80%, which
improved from 75% in 2010 to 81% in 2014. **Figure 2** shows the changes of efficiency scores during the period 2010-2014.

In 2010, 2011, 2012, 2013 and 2014, out of the 15 hospitals, approximately six (40%), seven (47%), seven (47%), eight (53%) and eight (53%) hospitals respectively had a technical efficiency score of 1 (fully efficient). The average pure or managerial technical efficiency (VRS) scores were 84%, 86%, 87%, 87% and 86% respectively during the five years under consideration. This finding implies that if the hospitals were operating efficiently, they could have produced 16%, 14%, 13%, 13% and 14% more output using their current levels of input, or could produce their current levels of output with 16%, 14%, 13%, 13% and 14% reductions in their existing inputs.

The mean scale efficiency score was 92%, which improved from 88% in 2010 to 94% in 2014. Based on the analysis of scale efficiency, it can be illustrated that in period of 2010-1014: four (27%), six (40%), five (33%), eight (53%) and six (40%) hospitals displayed constant returns to scale, which means that they were operating at their most productive scale sizes. The average scale efficiency score in the sample was 86% in 2010, 92% in 2011, 90% in 2012, 95% in 2013 and 94% in 2014.
Table 2. Technical and scale efficiency scores for the Kuwait public hospitals, 2010–2014

| Hospital name                                | 2010 CRS | 2010 VRS | 2010 Scale | 2011 CRS | 2011 VRS | 2011 Scale | 2012 CRS | 2012 VRS | 2012 Scale | 2013 CRS | 2013 VRS | 2013 Scale | 2014 CRS | 2014 VRS | 2014 Scale |
|----------------------------------------------|----------|----------|------------|----------|----------|------------|----------|----------|------------|----------|----------|------------|----------|----------|------------|
| Sabah                                        | 0.795    | 0.832    | 0.956      | 0.813    | 0.845    | 0.962      | 0.755    | 0.788    | 0.959      | 0.783    | 0.795    | 0.985      | 0.781    | 0.860    | 0.908      |
| Amiri                                        | 0.767    | 0.832    | 0.922      | 0.901    | 0.926    | 0.973      | 0.898    | 0.903    | 0.994      | 0.873    | 0.894    | 0.977      | 0.829    | 0.871    | 0.952      |
| Mubarak Alkabeer                             | 0.754    | 0.832    | 0.906      | 0.864    | 0.892    | 0.968      | 0.841    | 0.909    | 0.925      | 0.810    | 0.850    | 0.953      | 0.772    | 0.804    | 0.961      |
| Farwaniya                                    | 0.994    | 1.000    | 0.994      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      |
| Adan                                         | 0.912    | 0.960    | 0.950      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      |
| Jahra                                        | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 0.991    | 1.000    | 0.991      | 1.000    | 1.000    | 1.000      | 0.929    | 1.000    | 0.929      |
| Al-Razi                                      | 0.657    | 0.677    | 0.970      | 0.628    | 0.683    | 0.920      | 0.654    | 0.727    | 0.900      | 0.543    | 0.543    | 1.000      | 0.543    | 0.555    | 0.979      |
| Physical Medicine and Rehabilitation        | 0.321    | 0.696    | 0.461      | 0.269    | 0.686    | 0.392      | 0.364    | 0.854    | 0.427      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      |
| Maternity                                    | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      |
| Chest Diseases                               | 0.615    | 0.726    | 0.847      | 0.635    | 0.705    | 0.900      | 0.583    | 0.664    | 0.878      | 0.581    | 0.628    | 0.926      | 0.668    | 0.674    | 0.992      |
| Infectious Diseases                          | 0.659    | 1.000    | 0.659      | 0.994    | 1.000    | 0.994      | 0.683    | 1.000    | 0.683      | 0.864    | 1.000    | 0.864      | 0.626    | 1.000    | 0.626      |
| Psychological Medicine                       | 0.411    | 0.552    | 0.745      | 0.518    | 0.598    | 0.866      | 0.541    | 0.669    | 0.808      | 0.532    | 0.630    | 0.845      | 0.601    | 0.625    | 0.961      |
| Ibn Sina                                     | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      |
| Kuwait Cancer Control Center                 | 0.367    | 0.504    | 0.728      | 0.415    | 0.498    | 0.833      | 0.443    | 0.501    | 0.884      | 0.482    | 0.640    | 0.754      | 0.430    | 0.524    | 0.820      |
| Kuwait Allergy Center                        | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      | 1.000    | 1.000    | 1.000      |
| **Mean**                                     | 0.750    | 0.841    | 0.876      | 0.802    | 0.856    | 0.920      | 0.784    | 0.868    | 0.897      | 0.831    | 0.865    | 0.953      | 0.812    | 0.861    | 0.942      |
| **Median**                                   | 0.767    | 0.832    | 0.950      | 0.901    | 0.926    | 0.973      | 0.841    | 0.909    | 0.959      | 0.873    | 1.000    | 1.000      | 0.829    | 1.000    | 0.979      |
| **Standard deviation**                       | 0.24     | 0.17     | 0.16       | 0.25     | 0.17     | 0.16       | 0.23     | 0.16     | 0.16       | 0.2      | 0.17     | 0.08       | 0.2      | 0.18     | 0.1        |
| **Coefficient of variation, %**              | 32.2     | 20.7     | 18.3       | 30.9     | 20.4     | 16.9       | 28.8     | 18.7     | 17.7       | 24.1     | 20.0     | 7.89       | 24.3     | 21.0     | 10.7       |

Note: CRS=constant returns to scale technical efficiency (overall technical efficiency); VRS=variable returns to scale technical efficiency (pure technical efficiency); Scale=scale efficiency
Hospitals in Kuwait are already operating at a high and increasing level of efficiency but the opportunity for further efficiency gains exists in this context. Table 3 illustrates the total amount of input reductions and/or output increases needed to make less efficient hospitals fully efficient for the years 2010-2014. In 2010, the less efficient hospitals combined had 765 (19.1%) more doctors than needed to be efficient, which was the largest percentage among all variables in the study. For the same year, hospitals could be more technically efficient if they were able to decrease their input levels by 7.9% fewer beds, 9.2% fewer nurses and 5.3% fewer non-medical workers, while holding their level of outputs constant. Alternatively, an increase of 12.5% in outpatient visits and 0.3% in discharges - while keeping inputs constant - would improve efficiency for the same year. In 2014 on the other hand, a reduction of 8.9% in the number of beds, 9.7% in the number of doctors, 8.2% in the number of nurses and 7.1% in the number of non-medical staff would be required to reach full technically efficiency - while keeping the level of outputs constant . Alternatively, for the same year, the level of output increase required to make hospitals efficient would be 6.2% in outpatient visits, while utilizing the same level of inputs.

**Second stage DEA: Results of Tobit regression analysis**

At the second stage of the DEA, technical efficiency scores estimated at the first stage were regressed against a group of hospital level variables, including type of hospital (general or specialized), number of beds, bed occupancy rate and average length of stay, in order to determine the factors affected the technical efficiency of the hospitals. **Table 4** shows the results of the regression analysis. The results show that the average length of stay is a significant determinant of hospital technical efficiency; indicating that the higher the average length of stay, the lower overall (CRS) technical efficiency (p<0.05) and lower scale efficiency (p<0.001). A higher number of beds was also found to be associated with higher scale efficiency (p<0.05).
Table 3. Total input reductions and/or output increases needed to make inefficient hospitals efficient, 2010-2014

| Year | Total actual values | Shortfall/excess | % of total actual values |
|------|---------------------|------------------|-------------------------|
|      | Beds    | Doctors | Nurses | Non-medical workers | Outpatient visits | Number of discharges |
| 2010 |         |         |        |                    |                   |                      |
|      | 6338    | 4014    | 11995  | 8680              | 2294882           | 215417               |
|      | 498     | 765     | 1102   | 461               | 287086            | 656                  |
|      | 7.9%    | 19.1%   | 9.2%   | 5.3%              | 12.5%             | 0.3%                 |
| 2011 |         |         |        |                    |                   |                      |
|      | 6703    | 4219    | 12504  | 8850              | 2432773           | 216658               |
|      | 631     | 517     | 1047   | 892               | 214941            | 243                  |
|      | 9.4%    | 12.3%   | 8.4%   | 10.1%             | 8.8%              | 0.1%                 |
| 2012 |         |         |        |                    |                   |                      |
|      | 6714    | 4462    | 12676  | 9051              | 2495121           | 216073               |
|      | 654     | 572     | 1124   | 957               | 239975            | 1921                 |
|      | 9.7%    | 12.8%   | 8.9%   | 10.6%             | 9.6%              | 0.9%                 |
| 2013 |         |         |        |                    |                   |                      |
|      | 6756    | 4947    | 12786  | 9296              | 3233456           | 221032               |
|      | 606     | 520     | 957    | 615               | 237967            | 0                    |
|      | 9.0%    | 10.5%   | 7.5%   | 6.6%              | 7.4%              | 0.0%                 |
| 2014 |         |         |        |                    |                   |                      |
|      | 6793    | 5378    | 14000  | 9327              | 3198023           | 220901               |
|      | 602     | 524     | 1151   | 658               | 199824            | 35                   |
|      | 8.9%    | 9.7%    | 8.2%   | 7.1%              | 6.2%              | 0.0%                 |

Moreover, we explored the relationship between efficiency scores and hospital size, in terms of the number of beds (Figure 3). The results show that larger hospitals (with more than 400 beds) are generally more technically and scale efficient.

**Qualitative interviews**

To better understand the potential factors affecting efficiency of the hospital in the context of Kuwait, qualitative semi-structured interviews were conducted with 14 hospital managers from public, private and military sectors. Twenty managers from the public and private sector hospitals in Kuwait were approached to take part in an interview. Six declined and 14 participated. Among the 14 participants, 2 (14%) were female, ten had Kuwaiti nationality (71%), eight (57%) were from public hospitals, nine (64%) had a postgraduate qualification in health management and nine (64%) had management experience of 10 years or more. A detailed description of the participants’ characteristics is presented in Appendix 1.
Table 4. Result of Tobit regression analysis

| (1)   | (2)   | (3)   |
|-------|-------|-------|
| CRS TE| VRS TE| Scale |
| Tertiary | -0.0654 | -0.126 | 0.0638 |
|   | (0.0989) | (0.0927) | (0.0543) |
| Number of beds | 0.000212 | 0.000152 | 0.000207*** |
|   | (0.000180) | (0.000172) | (0.0000970) |
| Bed occupancy rate, % | -0.00161 | -0.00768*** | 0.00168 |
|   | (0.00258) | (0.00291) | (0.00141) |
| Average length of stay, days | -0.00480*** | -0.000727 | -0.00509*** |
|   | (0.00208) | (0.00196) | (0.00114) |
| Constant | 0.971*** | 1.421*** | 0.807*** |
|   | (0.174) | (0.193) | (0.0949) |
| N   | 75    | 75    | 75    |
| Pseudo R² | 0.221 | 0.227 | 0.474 |
| χ²   | 16.23 | 15.21 | 27.23 |
| p-value | 0.003 | 0.004 | 0.000 |

Standard errors in parentheses
*p < 0.1, ** p < 0.05, *** p < 0.01

Participants expressed their perception of factors affecting the efficiency of their hospitals as well as factors that would help in improving hospital efficiency. The factors reported by participants can be grouped into two broad categories: External and internal factors. External factors include the presence of a national strategic health plan, legislative changes, bureaucracy in the system and autonomy of hospitals/hospitals’ managers, provider payment mechanisms (mainly salary), and communications between hospitals. Internal factors include bed capacity, qualifications and training of human resources, procurement and utilisation of equipment, the use health information system (HIS), as well as the accountability of staff and users.
**Discussion**

The literature suggests that a common cause of technical inefficiency is the sub-optimal or unnecessary use of certain resources such as excessive hospitalization (7). Other causes of technical inefficiency include overstaffing and weak purchasing or distribution systems (63, 64). Another example of inefficiencies found in hospitals is the under-utilisation of services (e.g. low utilisation of beds), which may be observed when hospitals show diseconomies of scale when they depart from their optimal level of efficiency by deciding to enlarge (7).

This study measured the technical efficiency of secondary and tertiary public hospitals in Kuwait. It was found that three hospitals (20%) were constantly technical and scale efficient, and therefore 80% of hospitals could have made efficiency gains during the study period. The percentage of less efficient hospitals in this study is high when compared to a study of the efficiency of general hospitals in South of Iran, which found that 53% of hospitals were technically inefficient (17). Mahate et al (22) found that one third of hospitals in the United Arab Emirates were technically efficient. Studies conducted in two settings in Sub-Saharan Africa showed that 74% of hospitals in Kenya (25), and 40% of hospitals in Zambia were technically efficient (28).

The results from this study are comparable to the work of Burney et al (30), who assessed the cost of inefficiencies in the public health care system in Kuwait. They concluded that there were relative inefficiencies in the production of health services in the country at that time. They believed that an over supply of beds and nurses caused an excess of 18% in total health expenditure in Kuwait.

As explained in other studies, in order to decrease the inefficiencies in hospitals, there should be close evaluation of the excess in medical and non-medical manpower (6). The results of this study showed that a hospital’s size has an effect on its efficiency, which was supported by other studies (21, 28, 61). It was found that the larger hospitals were potentially more technically and scale efficient. This is in line with the findings of studies conducted by Kiadaliri et al in the South of Iran (17) and Watcharasriroj and Tang in Thailand (65).

The results of the Tobit regression revealed that the average length of stay was significantly associated with overall technical efficiency of the hospitals. Previous studies (18, 66) have found similar results.
where there was a negative association between the average length of stay and technical efficiency. There was no statistically significant association between technical efficiency with other institutional factors such as bed occupancy rate and level of specialisation. This was not the case in previous studies. For example, Lee et al (62) have found that hospitals that were more specialised, were also more efficient. Moreover, Kounetas and Papanastassopoulos (10) described that the hospital type (Regional, Prefectural, or University) affected the technical efficiency of hospitals in Greece.

Other factors that were believed to affect hospital efficiency were explored through semi-structured interviews with hospital managers in the country. Managers believed that there were external factors, such as changes in regulations, financing/provider payment mechanisms, and centralization (i.e. less autonomy for hospitals), which affected efficiency of the hospitals. Dalmau-Atarrodona and Puig-Junoy (67) have shown that healthcare regulations as well as the presence of competitors would affect hospital efficiency scores. Alternatively, Tiemann and Schreyögg (68) argued that resources were used more efficiently after converting hospitals to a private for-profit status in Germany, for example. Hu et al (20) have concluded that there was a negative relationship between government subsidy and hospital’s efficiency when they evaluated the effect of a health insurance reform in China. Another study from Norway has shown that the introduction of activity-based financing has improved the technical efficiency of hospitals (69). Most participants described increasing their autonomy would increase the efficiency of their hospitals, which was supported by studies from other settings (19). The use of health information systems, on the other hand, was believed to increase the efficiency of a hospital by several participants. This was supported by a study in Thailand, which showed that there was a positive relation between the use of IT and the efficiency of public hospitals (65). Additionally, the use of technology was found to decrease scale inefficiencies in Greek hospitals (10).

This study has provided evidence that could be useful to managers and policy makers in formulating reforms to improve the efficiency of public hospitals. The government of Kuwait aims to improve the efficiency of public services in the country, including health services, due to the current economic situation. The technical efficiency as well as factors influencing the efficiency could help health policy makers to make informed decisions to improve the technical efficiency of the main health-producing units in the country. Most hospitals were found to be technically inefficient suggesting that there is room for improvement in this domain. Additionally, any health reform that aims to improve the performance of local health services should take into consideration the factors that were found to influence the technical efficiency of hospitals. Similar studies have emphasised on the importance of
studying other dimensions of performance, such as quality and equity in addition to efficiency, in order to have a comprehensive picture of the performance of hospitals (19, 67).

**Limitations**

It is important to note that in order to improve future research in this field, the limitations that faced this study should be taken into consideration. Firstly, there were some limitations related to the method that was used in the second stage of this study. Simar and Wilson (70) argue that tobit regression in the second stage of DEA constitutes a mis-specification. They explain that tobit estimation in the second stage produces biased and inconsistent estimates when compared to their truncated model (70). Secondly, this study was unable to determine to what extent the inefficiency might be caused by quality of care variations due to the lack of data about variables reflecting severity of diseases and quality of care provided in hospitals. Just as other researchers recommended, in order to improve quality of future studies measuring hospital efficiency, more efforts need to be made in developing appropriate indicators reflecting quality of care in hospitals (17). Thirdly, when applying DEA, it is desirable to have a large sample size. The sample size for the current study is 15 hospitals, which is the total number of public hospitals that provided inpatient and outpatient services in Kuwait during 2010-2014. Fourthly, the data used in this study is outdated but it was used because of uniformity reasons. Alsabah hospital, which is a secondary level hospital, was divided to two administratively independent hospitals, Alsabah (secondary) hospital and Zain (tertiary) ENT hospital in 2015. This division resulted in a disparity in the variables that were used in the two stages on the analysis. Additionally, the allergy center, which was one of the efficient hospitals throughout the study period, stopped providing inpatient services starting in the year 2015. So for this hospital, one of the variables that were used in the analysis would be lost. Fifthly, it is desirable to have a homogeneous sample when applying DEA. However, in the current study, six hospitals provided general services whereas nine hospitals provided mainly specialized services in addition to some general services.

**Conclusion**

This study has quantified the technical and scale efficiency of 15 public hospitals in Kuwait, and identified the input reductions and/or output increases needed to make inefficient hospitals efficient. The results show that the majority of the public hospitals are not operating at technically efficient levels, indicating room to improve the performance of these hospitals. This study also provided an insight into the factors affecting the efficiency of hospitals. Health policy makers in Kuwait can extract
useful information from this study to develop concrete strategies to improve hospital efficiency. Replicating the analyses performed in this study on a routine basis for public healthcare facilities would help in identifying ways of best practice, but this would not be easy to achieve unless timely and accurate data is available.
### Appendix 1: qualitative sample characteristics

| Sample Characteristics | n(%) |
|------------------------|------|
| **Gender**             |      |
| Females                | 2 (14.3%) |
| Males                  | 12 (85.7%) |
| **Age (in years)**     |      |
| <40                    | 1 (7.1%) |
| 40-49                  | 7 (50%) |
| 50-59                  | 5 (35.7%) |
| 60≤                    | 1 (7.1%) |
| **Nationality**        |      |
| Kuwaiti                | 10 (71.4%) |
| Non-Kuwaiti            | 4 (28.6%) |
| **Hospital type**      |      |
| Public (secondary)     | 3 (21.4%) |
| Public (tertiary)      | 4 (28.6%) |
| Private                | 6 (42.9%) |
| Military               | 1 (7.1%) |
| **Professional background** | | |
| Medical                | 9 (64.3%) |
| Dentistry              | 1 (7.1%) |
| Administrative         | 3 (21.4%) |
| Other                  | 1 (7.1%) |
| **Role**               |      |
| Hospital director      | 9 (64.3%) |
| CEO                    | 4 (28.6%) |
| CFO                    | 1 (7.1%) |
| **Higher degree in hospital management** |      |
| Yes                    | 9 (64.3%) |
| No                     | 5 (35.7%) |
| **Total experience (in years)** |      |
| <15                    | 1 (7.1%) |
| 15-19                  | 4 (28.6%) |
| 20-24                  | 6 (42.9%) |
| 25-29                  | 2 (14.3%) |
| 30≤                    | 1 (7.1%) |
| **Years in managerial role** |      |
| <5                     | 3 (21.4%) |
| 5-9                    | 7 (14.3%) |
| 10-14                  | 5 (35.7%) |
| 15≤                    | 4 (28.6%) |
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