Efficiency Evaluation of Public Hospitals to Improve Decision Making in the Kingdom of Saudi Arabia

Thesis submitted in accordance with the requirements

for the degree of Doctor of Philosophy by:

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Abstract

The Kingdom of Saudi Arabia (KSA) has experienced increase in health expenditure and the demand for healthcare services. Health statistics indicate inefficiency in resource utilization within the healthcare system, particularly in the hospital sector. This thesis assessed the efficiency of health service provision in public hospitals and demonstrated the factors that affect hospital efficiency as well as provided useful recommendations to improve efficiency, based on stakeholders' experiences, using a combination of quantitative and qualitative analysis.

First, the systematic review of public hospitals efficiency studies revealed that such studies were limited in number and showed methodological deficiencies. The meta-analyses confirmed that methodology and assumption choices had a substantial impact on the efficiency measurements. Although there was no consensus regarding the most appropriate technique to measure efficiency, most existing studies relied on Data Envelopment Analysis (DEA), applying input-orientation assumption.

Second, by applying DEA, the technical efficiency of the public hospitals was measured, and the characteristics of high-performing hospitals were explored. The analysis found that most hospitals were technically inefficient with the average score of 76% and the variations in efficiency scores across hospitals depended on the capacity (hospital size) and geographic location. Moreover, findings revealed that many hospitals were operating at suboptimal scale size, which indicated the need for possible changes in the production capacity to facilitate the optimal utilization of health resources to provide the current level of health services.

Third, the tobit and two-part regression models estimated the impact of the external factors (demographic and socioeconomic characteristics of catchment populations) on the efficiency estimates. Population density share of children and people in poverty, incidence of infectious disease in the catchment area appeared to be significantly associated with the efficiency of the hospitals. Based on the findings, the decision of resource allocation should consider these external factors to improve utilization of health services among the target populations towards achieving better efficiency.

Fourth, Key-Informant Interviews using a semi-structured guideline were conducted among the policy-makers, regional health authority and hospital mangers under the MOH to identify the components of performance in the public hospitals, the barriers to the efficiency as well as informing tool for feasible recommendations to improve the efficiency in such hospitals. The stakeholders explained the barriers that face hospital performance, including challenges in health regulations, centralization of decision-making, shortage of health workers, inefficient allocation of health resources, population demands and an indigent health-information system. The findings recommended developing strategic health plans, effective health administrations and hospital objectives in the light of aims of the health affairs in the KSA and the healthcare needs of the community. Also, there was a need for appropriate allocation mechanisms of health resources and medical personnel across the public hospitals. Moreover, it was recommended to secure the autonomy for hospital managements with adequate supervision on hospital performance. Enhancement of employment conditions, training programmes for the health workers and monitoring on the performance and quality of service delivery appeared to be essential for improving hospital efficiency.

In sum, the knowledge gaps on the efficiency in public hospitals in the KSA, that have been identified in the systematic review has been further investigated by empirical analyses using multiple national datasets. Several hospitals have been operating at inefficient levels, which could be explained by both internal (inputs and outputs) and external (demographic and socioeconomic characteristics of catchment populations) factors. The findings of the quantitative analyses were broadly supported by the qualitative investigations. Finally, based on this research, we made recommendations to guide the policy-makers for amending policies towards for achieving efficiency in the public hospitals in the KSA.

Declaration

I declare that this thesis is the result of my own work and has not been presented previously, except where work which has formed part of jointly-authored publications as has been included. The contributions of the candidate and other authors to this work has been described below. I confirm that the appropriate credit has been given where reference has been made to others' works.

Chapter 3 is based on Alatawi, A., Ahmed, S., Niessen, L. and Khan, J. (2019). Systematic review and meta-analysis of public hospital efficiency studies in Gulf region and selected countries in similar settings. Cost Effectiveness and Resource Allocation. The candidate's contribution was in the conception of the study, literature search, study selection, data extraction, data analysis, interpretation, writing and drafting of the manuscript. Sayem participated in the revision of study selection, data extraction and analysis. Niessen and Khan gave suggestions on the study design, review process and drafting of the manuscript. Alatawi is the corresponding author.

Chapter 4 is based on Alatawi A., Niessen, L. and Khan, J. (2020). Efficiency evaluation of public hospitals in Saudi Arabia: an application of data envelopment analysis. BMJ Open. The candidate's contribution, with the supervision of Niessen and Khan, was in conceptualizing the research question, study design and settings and literature search. Alatawi conducted the data collection on the field, variable extraction and all data analysis. Alatawi interpreted the findings and wrote the manuscript. Niessen and Khan contributed and gave suggestions on the research process. Alatawi is the corresponding author.

Chapter 5 is based on Alatawi A., Niessen, L. and Khan, J. (2020). Determinants of Technical Efficiency in Public Hospitals: The Case of Saudi Arabia. Health Economics Review. The candidate's contribution, with the supervision of Niessen and Khan, in conceptualizing the research question, study design and settings and literature search. Alatawi collected data and extracted variables. Alatawi also conducted the data analysis, interpretation, and writing of the manuscript. Niessen and Khan contributed and gave suggestions on the research process. Alatawi is the corresponding author.

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Dedication

To my Father and Mother who taught me to work hard for the things that I aspire to achieve, loved and supported me unconditionally…

To my wife, Lila, who has been a constant source of support, help and encouragement…

To my children, Shyhana and Talal for being in my life…

To all those who have been there for me when I needed them, to everyone who lighted my way someday…

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ABBREVIATIONS

ARAMCO	Arabian American Oil Company
BCC	Banker, Charnes and Cooper model
CEBHI	Compulsory Employment-Based Health Insurance
CCR	Charsen, Cooper and Rhodes model
CR	Corresponding Researcher
CRS	Constant Return to Scale
DEA	Data Envelopment Analysis
DHA	District Health Administrator
DMU	Decision-Making Units
DRS	Decreasing Returns to Scale
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
HM	Hospital Manager
IRS	Increasing Return to Scale
KIs	Key Informants
KPIs	Key Performance Indicators
KFSH & RC	The King Faisal Specialist Hospital and Research Centre
KSA	Kingdom of Saudi Arabia
MOH	Ministry of Health
MENA	The Middle East and North Africa
MPSS	Most Productive Scale Size

NTP	National Transformation Program
OECD	Organization for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
OOP	Out-of-Pocket payment
PPP	Public-Private Partnership Models
RTS	Returns to Scale
SR	Saudi Riyal
SFA	Stochastic Frontier Analysis
SSIs	Semi-structured Interviews
TE	Technical Efficiency
UAE	United Arab Emirates
UHC	Universal Health Coverage
USD	United States Dollar
VRS	Variable Returns to Scale

Chapter 1

Introduction

The growing pursuit for efficiency in healthcare has become a central objective of policymakers within most health systems. Health policies worldwide, aim at effective, efficient, and equitable healthcare systems, which is a requirement to achieve Universal Health Coverage (UHC) (WHO, 2010). This is stated in item 3.8 of the Sustainable Development Goals, declared by the United Nations in 2015 (WHO, 2019; Goal 3 | Department of Economic and Social Affairs, 2020).

The Kingdom of Saudi Arabia (KSA), has experienced a substantial increase in population growth, life expectancy, lifestyle diseases, which consequently have increased the demand for health services and health spending in recent decades (Khoja, 2017; Ardent Advisory & Accounting, 2015; Ram, 2014). In KSA, public expenditure on health was 64.1% of the total health expenditure, which constitutes 5.2% of GDP, corresponding to a per capita health expenditure of 1,093 US$ in the year 2017 (World Bank, 2020).

Health expenditure has increased by 24.7% from the year 2013 to 2017 (MOH, 2017). However, health statistics by the Ministry of Health (MOH) showed considerably lower availability of services, given the high health expenditure in the KSA compared with other countries, which indicated inefficiency in the utilization of health resources (World Bank, 2019). In 2016, the KSA had 2.23 hospital beds per 1,000 population, which is a lower ratio than the high-income countries (with an average of 4.2 beds per 1,000 population) and also lower than the global average (2.7 beds per 1,000 population). (World Bank, 2019). Further, the Saudi healthcare surveys showed

inefficiency of several public healthcare facilities according to the MOH strategy plan in 2010 (MOH, 2010).

According to the World Health Report in 2010, it was estimated that about 20-40% of all health spending (between $1.3-$2.6 trillion) was wasted globally due to inefficiency in healthcare systems. Moreover, this loss of health resources due to hospital-related inefficiency was estimated to be $300 billion annually (WHO, 2010; Elovainio & Evans, 2013).

Hospital efficiency is essential for the efficiency of the overall health system, as hospitals are the main consumers of health resources. For instance, Hanson et al., 2002 found that public hospitals consumed a significant bulk (about 40%) of the total health budget in the sub-Saharan African countries. Kelly et al., in 2016, argued that public hospitals shared 44% of the national health spending in the United Kingdom in 2012/13. Similar findings were observed in a broad range of literature and systematic reviews worldwide (Hollingworth, 2003; Yip & Hafez, 2015; Varabyova & Müller, 2016; Kiadaliri et al., 2013). Therefore, it is vital to conduct efficiency analysis of public hospitals and identify the causes of inefficiency, to make decisions that ensure effective utilization of public resources (Jacobs et al., 2006).

Given the scarcity of scientific studies on the efficiency of the public health sector - or hospital efficiency in particular - further research is vital to improve health policy and regulations in KSA. Therefore, research on this topic is particularly relevant to identify the determinants of efficiency for helping the policymakers to work towards better healthcare resource allocation and efficient healthcare system.

1.1 Aim and Objectives

1.1.1 Aim

This PhD thesis aims to assess the healthcare efficiency in public hospitals and demonstrate the factors that affect hospital efficiency due to internal factors such as resource allocation and utilization within the hospitals as well as external factors in the community. This research further aims at extracting the experience and knowledge of stakeholders of the public health system in order to contribute to feasible recommendations for developing health policies in the KSA.

1.1.2 Objectives

To address the thesis aim, the following objectives are deemed necessary.

Objective	Question	Method
1. To understand the application and factors influencing efficiency assessments in public hospitals in the Gulf Cooperation Countries (GCC) region and countries in similar settings.	What can we learn from previous studies on efficiency in the GCC regarding methodological approaches used and the effects on efficiency measurement application in public hospitals?	Systematic review and meta-analysis using multivariate regressions
2. To measure the technical efficiency of public hospitals and identify the causes of inefficiency and estimate the optimal levels of the resources	What is the level of efficiency and performance in public hospitals? What are the reasons for inefficiency? What are the optimal levels of resources utilization?	Analysis using data envelopment analysis (DEA)
3. To identify external factors that determine differences in the efficiency level of public hospitals	What are the environmental, organizational and community characteristics factors that influence efficiency in public hospitals?	Empirical analysis investigating the association using multivariate regressions
4. To identify the factors that affect hospital efficiency from stakeholders' perspectives and create information tools based on scientific knowledge to contribute to feasible policy recommendations.	What are the barriers to efficiency and utilization of health resources in public hospitals? What are the practical options to improve the efficiency of public hospitals in Saudi Arabia?	Quantitative analysis using semi-structured interviews and thematic analysis

1.2 Background

1.2.1 Saudi Arabia

The Kingdom of Saudi Arabia (KSA) is the largest state (area) in the Middle East and a major economic and political force in the Arab world (Walston et al., 2008). The KSA is a high-income country and one of the richest and fastest-growing countries in the Middle East and North Africa region (MENA). It is the largest producer and exporter of oil, has the most extensive reserves of oil globally, accounting for 25% of total oil source in the world, and is a respected member of the Organisation of Petroleum Exporting Countries (OPEC) (Almalki et al., 2011; The World Bank, 2020). The discovery and exploration of oil, which constitutes the major share of the country's revenues, has enabled the Saudi economy to develop rapidly, and this has impacted positively on the society. In 2018, the GDP per capita was 20,819.75 US$, compared with 19,262 US$ in 2010 (Almalki et al., 2011; The World Bank, 2020; Walston et al., 2008; Albejaidi, 2010).

The KSA occupies about four-fifths of the Arabian Peninsula with a surface area of 2,149,690 sq. km. (The World Bank, 2020). The KSA has borders with Jordan, Kuwait and Iraq in the north; United Arab Emirates (UAE), Bahrain and Qatar and the Gulf in the east; Oman in the southeast; Yemen in the south; and the Red Sea in the west and northeast (Figure 1.1) (Mufti, 2000; The World Bank, 2020).

Figure 1. 1 Saudi Arabia, country map and neighbouring countries. Source, Google Map/ Saudi Arabia.

Saudi Arabia has a homogeneous population, sharing common language, religious and cultural values (Al-Farsy, 1990). The population consists of 57.5% males (The World Bank, 2020). The reason for this demographic structure (higher proportion males) is likely to relate to the presence of many expatriate male residents who are working in the country (Albejaidi, 2010). The population is young with 70% under the age of 40 years (Global Health Exhibition. 2019). More than 25% are under 15 years, and 71.6% of populations are between 15 to 64 years, as well as 3.3% of the population over the age of 65 years in 2018 (The World Bank, 2020).

According to the World Bank, the country has a total Saudi population of 33.7 million in 2018, compared with 27.1 million in 2010 and 22.67 million in 2003 and it is expected to reach 77.2 million by 2050 (The World Bank, 2020; Albejaidi, 2010;

Albert et al., 2018). This is an expected outcome as the annual population growth rate for 2010 to 2018 was 2.6% per annum, and the total fertility rate was 2.3. In addition, there is a high birth rate (17.8 per 1000 population) and declining mortality rate among infants and children under 5 years of age to 7.1 per 1000 in 2018. The life expectancy at birth increased in the recent years to 73.8 years for men and to 76.6 years for women in the KSA (The World Bank, 2020).

The improvement in population health, including life expectancy estimates, is mostly attributable to the obligatory vaccination programmes implemented by the government since 1980 (Almalki et al., 2011). However, this unprecedented growth has led to increased demands for essential services and facilities including health care, while at the same time, generating economic opportunities (Mohanty et al., 2016; Albert et al., 2018).

1.2.2 Overview of healthcare in Saudi Arabia

Establishing a modern and potent health system was one of Saudi Arabia's most important targets, even before the foundation of the Kingdom of Saudi Arabia in 1932 when health care was provided only by local healers and traditional practitioners. The KSA government, under article 31 of the national constitution, guarantees free medical care to all Saudi citizens and expatriates in public healthcare facilities (Albejaidi, 2010). The first public health department was established in 1925 by a royal decree from King Abdelaziz. The department was responsible for funding and monitoring free health care for the population and pilgrims. Then, the crucial advance in healthcare was the establishment of the Ministry of Health (MOH) in 1950 under another royal decree (Almalki et al., 2011).

The Saudi government introduced the first five-year National Development Plan in 1970 to promote progress in several services areas, including healthcare. From 1970 to 1989, the Saudi healthcare system achieved a complete transformation, as the government developed the necessary infrastructure of hospitals, primary healthcare and research facilities (Albejaidi, 2010).

The transformation of Saudi's health system was marked by a fast evolution, which mirrored the development of the country. The current process of planned expansion of its economy has also influenced the healthcare sector (Walston et al., 2008; Al-Hanawi et al., 2019).

The Saudi government has shown a commitment to improving the health of the population and developing healthcare services. The government in 2018 has allocated a fund of SR 146.5 billion (US$ 39 billion) for health services, which corresponded to 15% of the government budgetary allocations (Saudi Arabian Monetary Authority, 2018). According to a World Health Organization (WHO) assessment of health systems, the KSA healthcare system was ranked as the 26th out of 191 countries in 2000, meaning that the KSA ahead of most of Arabian Gulf countries including the United Arab Emirates (27th), Qatar (44th) and Kuwait (45th), as well as many healthcare systems in developed countries such as Canada (30th), Australia (32nd) and the USA (37th) (WHO., 2000; Al-Hanawi et al., 2019).

In 1970 in the KSA there were only 74 hospitals with 9,039 beds. Nowadays, Saudi citizens have access to thousands of hospitals and primary healthcare centres in a rapidly evolving healthcare system (Walston et al., 2008; Almalki et al., 2011). The current statistics from the MOH for the year 2017 show that the total number of all hospitals was 484 with 72,981 beds in Saudi Arabia (Figure 1.2).

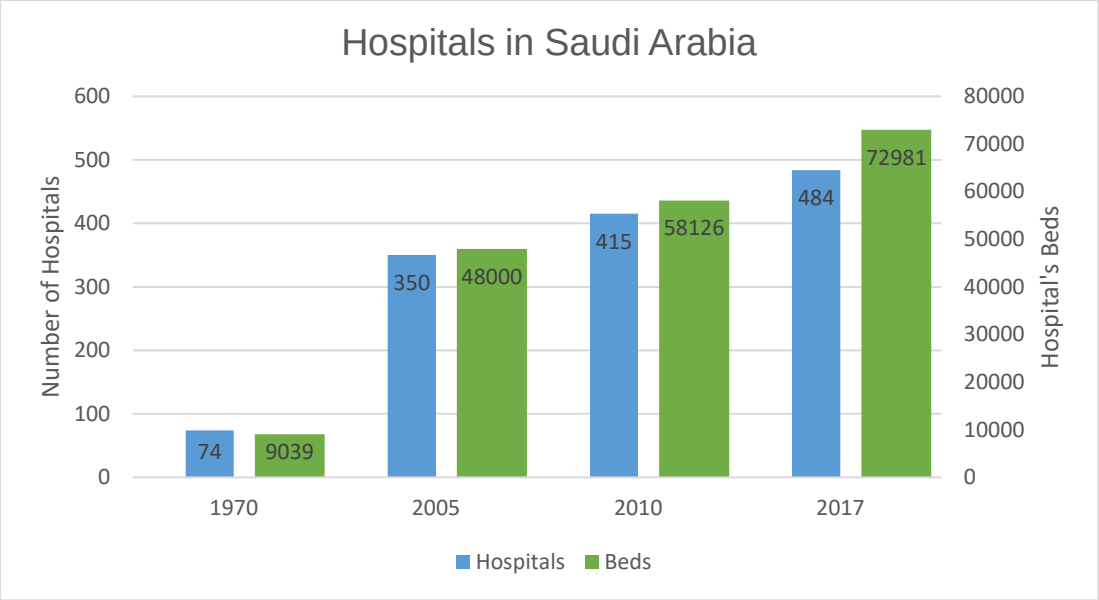

Figure 1. 2 Number of hospitals and hospital's beds in Saudi Arabia (MOH, 2017).

By the end of the 1980s, there were 1,640 primary health centres throughout the country, and this increased to 2,361 in 2017 (MOH, 2017; Albejaidi, 2010).

1.2.3 Structure of the healthcare providers in Saudi Arabia

The Ministry of Health (MOH) is the primary provider of healthcare services in the KSA with the estimated percentage of 60% (MOH, 2015). MOH facilities, which are located in both urban and rural areas in the KSA, ensure free access to healthcare for all citizens and expatriates who work in public sectors. Moreover, MOH is responsible for strategic health planning, formulating health policies, supervising all health services delivery programs, and monitoring all other health-related activities in both the public and private sectors (Almalki et al., 2011).

Other government agencies share 19.3% of the healthcare provision in KSA. These government agencies include military medical services like the Saudi Arabian Ministry of Defence, Army Forces medical services and Security Forces medical services, Saudi Arabian National Guard health affairs, the Ministry of Home Affairs, the Ministry of Interior affairs, the Ministry of Higher Education hospitals (teaching hospitals), the Arabian American Oil Company (ARAMCO) hospitals, and the Royal Commission in Jubail and Yanbu health services. In addition, it includes referral hospitals that provide tertiary health services like, King Faisal Specialist Hospital and Research Centre (KFSH & RC) (Al-Homayan et al., 2013; Almalki et al., 2011; Walston et al., 2008). The private sector contributes to 20.7% of health care delivery in the KSA through private clinics and hospitals (Almalki et al., 2011).

The healthcare delivery system in the KSA can be divided into three levels; primary (health care centres), secondary (general hospitals), and tertiary (specialist hospitals), which are either affiliated to the MOH, other governmental sectors, or the private sector (Al-Homayan et al., 2013; Albejaidi, 2010). Primary healthcare centres deliver healthcare services that are preventive, curative and promotive. This includes vaccination and disease control, management of chronic diseases (like hypertension and diabetes), dental treatments, dispensing necessary drugs and health education. Hospitals provide secondary care, like surgical operations, specialist medical interventions for clinical conditions, rehabilitative services, emergency and intensive care services. The medical cases that need more complex levels of care are usually transferred to specialized hospitals, e.g. KFSH & RC. (Al-Homayan, et al., 2013; Almalki et al. 2011).

The Saudi Vision 2030 and the national transformation program (NTP), which aimed for a national development plan across all economic and service sectors as a

roadmap for the economic development of the KSA, have focused on developing the healthcare system (Global Health Exhibition. 2019). The MoH has developed a Healthcare Transformation Strategy Plan as a part of the Vision 2030 and the NTP which comprise three elements: Health and quality of life; Quality of service and containing the costs; and Health outcomes. The MOH has identified that certain key healthcare indicators, such as the number of healthcare practitioners, healthcare-related universities, hospitals, medical centres, life expectancy and infant mortality rate, have shown significant improvement over the past years. (Frank, 2019; Global Health Exhibition. 2019).

The 2030 Vision focused on achieving more participation from the private sector by encouraging international and local investments in several key organizations such as healthcare (Al-Hanawi et al., 2019; Global Health Exhibition. 2019). Privatization of government services and health facilities is expected to support meeting the goals set out in Vision 2030 to increase the private sector's contribution to GDP from 40% to 65% in 2030. The MOH launched public-private partnership (PPP) models to enhance the private sector participation in spending and service providing by increasing the private healthcare expenditure from 25% to 35% of total healthcare expenditure in 2030 (Frank, 2019; Global Health Exhibition. 2019; Al-Hanawi et al., 2019).

1.2.4 Financing of the healthcare sector in Saudi Arabia

The government finances the public sector annually from the general government budget, largely from revenue derived from oil and gas production. The MOH is the primary consumer of public funds with 77.6% of the public health expenditure and

financed by governmental national health allocation model through annual budget bases (Al-Homayan, et al., 2013; Alkhamis et al., 2014; MOH, 2010).

During 2017, the KSA government allocated SR 67.7 billion ($18.1 billion) to the MOH's budget, making 7.61% of the total government budgets. KSA government spending on health was 64.1% of the country's overall health expenditure, which corresponds to 3.4% of GDP for that year; whereas, the total health expenditure constitutes 5.2% of the GDP with a per capita health expenditure of 1,093 US$ (MOH, 2017; World Bank, 2020). The plan appropriated by the Saudi government for the MOH involving the governmental budget, the proportion of MOH to the government budget and percentages of public and private expenditures to the total health expenditures are shown in Table 1.1.

Table 1. 1 General health expenditures and government budget (2013-2017) (SR=Saudi Riyal)

Year	Government budget billion SR	MOH budget billion SR	Percentage of MOH to the government budget	Percentage of government expenditure of total health expenditures	Percentage of government health expenditure (%GDP)	Percentage of private health expenditure of total health expenditure
2013	820	54.3	6.63	69.6	3.1	30.4
2014	855	59.9	7.02	71.4	3.7	28.6
2015	860	62.3	7.25	68.5	4.1	31.5
2016	840	58.9	7.01	66.7	3.9	33.3
2017	890	67.7	7.61	64.1	3.4	35.9

Source; MOH Statistical yearbook, (2017); The World Bank, (2019).

The public healthcare expenditure in KSA increased by 24.7% between 2013 to 2017, and from 6.63% to 7.61% as a share of the general spending on healthcare to the total government spending in 2017 (table 1.1) (MOH, 2017). Although the government expenditures are moderately high compared with other countries in the region and high-income countries (e.g. MENA countries and the United States), the percentage of government health expenditure (%GDP) was considerably lower (3.9%) than several industrialized nations in 2016, as shown in Figure 1.3 (The World Bank, 2019). For instance, it is observed that the high-income countries and OECD members spend on health 7.8% of GDP, which is much higher than the KSA.

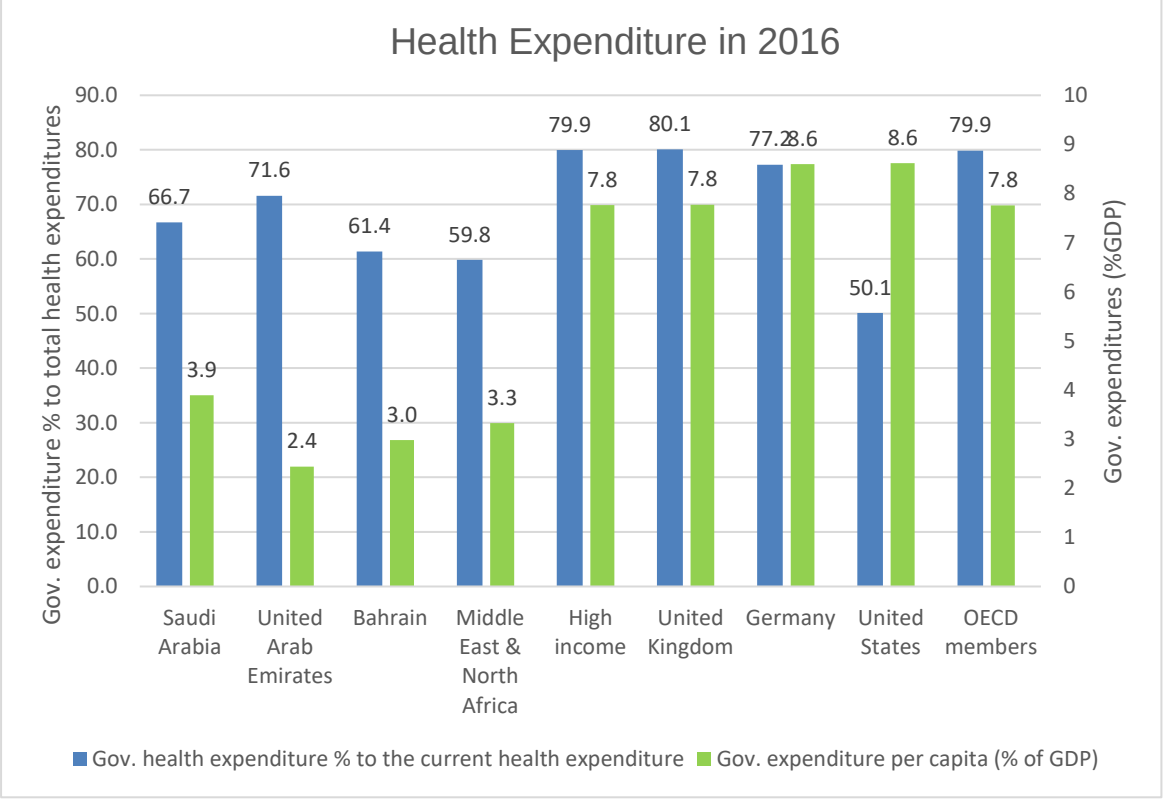

Figure 1. 3 Percentage of government health expenditure to total expenditures and government expenditure per capita in 2016. Source; The World Bank, 2019.

The major source of finance in the private sector was out-of-pocket payment (OOP) of individuals and voluntary private insurance; whereas expatriates who work in most principal companies received voluntary health insurance from their employers as one of their recruitment benefits (Alkhamis et al., 2014). However, there were health insurance companies widespread in the Saudi market without regulations (Mufti, 2000).

Health care is free of charge for Saudi citizens and the public sector's employees. Therefore, the health insurance system only concerns expatriate employees in the private sector. In 2006, the government launched the Compulsory Employment-Based Health Insurance (CEBHI) scheme for the expatriates who work in Saudi's companies. Since then, health insurance has been compulsory for all foreign-resident workers in the KSA. The implementation of the CEBHI had increased the private insurance and reduced the OOP payments consequently (Alkhamis et al., 2014).

The actual percentage of private expenditure of total health expenditure has increased from 30.4% to 35.9% during the period 2013-2017 (Table 1.1) (MOH. 2017). On the other hand, the government expenditure of total health expenditures has reduced from 69.6% to 64.1% at the same time, which indicates the growing private sector in the participation in healthcare in the KSA. The private sector has been proliferating in the past several years and expanded its services, especially in highly urban areas since the advent of interest-free loans from the government to construct private facilities (Walston et al., 2008).

Healthcare services are provided free of charge to all registered patients in public facilities, which are funded by the government resources that owns a great deal of oil

wealth, which means affordable care for patients regardless of whether they pay for health insurance or not. For these patients, despite being insured by private health insurance companies, no payments are made from the health insurance companies to the service providers as the patient does not pay residence fees, pharmacy drugs or doctor's fees in the public facilities (Albejaidi, 2010).

The general health expenditure per capita (current US $) in Saudi Arabia was $276.96 in the year 2000. This increased to $700.73 in 2017 (Figure 1.4). The red line in the figure shows the growth of the healthcare expenditure on the constant rise until 2014 reaching the amount of $ 916.94, then the indicator decreased to $ 700 in 2017 (The World Bank. 2019).

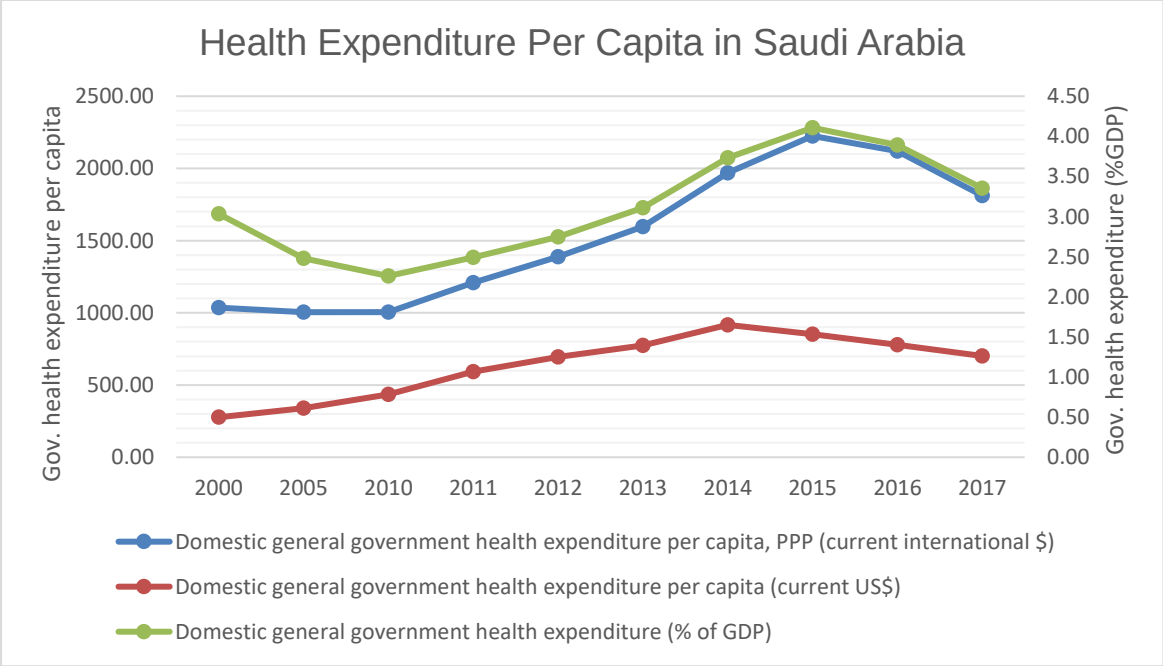

Figure 1. 4 Domestic general government health expenditure per capita (current US$), PPP and % of GDP. Source; The World Bank, 2019.

Furthermore, the latest value for general health expenditures per capita (blue line), in

PPP in US $ was $1811.31 USD in 2017. Over the past years, the value for this indicator fluctuated between 2,225 in 2014 and 847.04 in 2008 (The World Bank. 2019). In addition, the general health expenditure per capita as a percentage of the GDP (green line) started at 3% in 2000 and reached its lowest value in 2008 with 1.89%. The proportion achieved the highest value (4.11%) in 2015, then reduced again to 3.35% in 2017 (The World Bank. 2019).

1.2.5 Ministry of Health (MOH)

The Ministry of Health (MOH) is responsible for managing the country's healthcare system. Its functions include strategic planning, formulating health policies, supervising all health services delivery programmes, also monitoring and controlling all other health-related activities in both the public and private sectors. The MOH is the principal government agency entrusted with the provision of 80% of healthcare services in the public sector through 20 regional directorates-general of health affairs in the country (Albejaidi, 2010; Almalki et al., 2011).

The MOH provides healthcare services in three levels: primary, secondary and tertiary. Primary health centres supply primary care services, both preventive and curative, referring health cases that require more advanced care to public hospitals (the secondary level of healthcare), whereas complex cases that need advanced care are transferred to central and specialized hospitals (the tertiary level of healthcare) (Al-Yousuf, et al., 2002; Albejaidi, 2010).

The MOH provides healthcare services through a network of primary healthcare centres numbering 2,361 at 2017 located in both large cities and small towns (MOH,

2017). The primary health centres are the first line of healthcare services provide adequate health services to the people as they are responsible for the provision of essential healthcare services, like therapeutic, diagnostics and preventive services. Even with the importance of the primary healthcare services as the gateway to other healthcare levels in the country, there has been an increase in the number of reported cases of chronic diseases like cardiovascular diseases and diabetes (Albert et al., 2018). These cases are referred to the secondary health facilities, while more complicated cases are referred to the tertiary healthcare. (Albejaidi, 2010; Al-Yousuf et al., 2002).

The secondary healthcare (general hospital) is a significant component of the healthcare system in KSA because patients are referred from primary healthcare centres for further and comprehensive treatment (Almalki et al., 2011). Most of the secondary healthcare facilities are provided at the district level in the 282 general hospitals, with a total number of beds of 43,080 managed by the administration of district health (MOH, 2017). Hospitals in the tertiary level of healthcare services offer highly specialised care to people with chronic conditions, or complex and critical cases, most of whom are referred from general hospitals (e.g. KFSH & RC) (Albejaidi, 2010). Given the current situation of the healthcare in KSA, this research focused on the general hospitals that affiliated to the MOH.

1.2.6 Resources and challenges

Despite the high investment in the healthcare sector by the Saudi government in the past decades, there persist several issues that pose challenges to the health care system. For instance, rapid population growth and life expectancy, limited financial

resources, drops in the oil prices, changing in disease patterns, high demand resulting from free services, poor accessibility to some health care facilities, lack of a national health information system and shortage of Saudi health professionals (Almalki et al., 2011; Al-Hanawi et al., 2019).

The Saudi Arabian economy (oil-dependency) declined because of less income from oil revenue due to low oil prices in the recent years. This resulted in Saudi Arabia suffering a decrease in oil rent as a percentage of the annual GDP from 40.01% in 2014 to 19.43% in 2016. Saudi Arabia's GDP growth also fell from 4.11% in 2015 to -0.74% in 2017 (McIntosh, 2020). The government of KSA prioritized healthcare spending even during periods of low oil prices. Although the 2014 oil price collapse led to a $137.46 decrease in Saudi health expenditure per capita from 2014-2016, health and social services still took up 12% of the 2016 Saudi budget expenditure – the second-highest of any sector amidst this period of low oil prices (The World Bank, 2020; McIntosh, 2020), Thus, efficiency of public hospitals (government funded) is essential for sustainability of the healthcare system.

In 2016, the country had 2.23 beds per 1,000 population and MOH had 1.3 bed per 1,000 populations, which were a lower ratio than the global average of 2.7 beds per 1,000 population. Therefore, the capacity of public healthcare services is sometimes challenged, especially during the Hajj season during which healthcare services may be provided free to pilgrims. The government plans to double the current hospital bed capacity by 2050 (Albert et al., 2018; Almalki et al., 2011).

Changes in disease patterns from communicable to chronic diseases becoming more prevalent is a challenge to the Saudis and an increased burden to existing healthcare services. Mortality related to non-communicable diseases increased from 67% in 2000

to 73.2% in year 2016 (The World Bank, 2020). During 2017, the diabetes prevalence was 17.8% in the age group 20-79 years (over 3.8 million cases) compared with 9.97% in MENA countries. In 2016, obesity reached high level and became one of the highest in the MENA region with 29.9% of men and 43.5% of women being obese, compared with a total of 27% in Oman and 27.8% in the UK. In 2016, 25% of the male population were smokers compared with 23% in 2010. The prevalence of hypertension in 2015 stood at 23.3% among adults, one of the highest in the GCC region, compared with 15% in the UK and 20% in UAE (Albert et al., 2018). However, the causes of death by communicable diseases in KSA decreased from 17.5% in 2000 to 10.6% in 2016, whereas the world figure was 31% in 2000 and reduced to 20.1% in 2016 (The World Bank, 2020).

The Saudi healthcare system is challenged by the shortage of local health care professionals, such as physicians, nurses, pharmacists and allied health personnel. The majority of health workers are expatriates, and this leads to a high rate of turnover and instability in the health workforce. The healthcare in KSA is suffering from the lack of trained Saudi healthcare professionals as well as reliance on foreign experts (Almalki et al., 2011; Al-Hanawi et al., 2019).

According to the MOH in 2017, the total health workforce in all health sectors in the KSA comprised 423, 940 personnel, of which more than half (214,094) work in the MOH (MOH, 2017). In healthcare sectors, Saudis constitute 29.5% of all physicians, 36.7% of nurses, and 22.2% of pharmacists, whereas Saudis constitute a larger share (74.7%) of the allied health personnel, like lab technicians, radiologists (Figure 1.5). In the MOH, Saudis constitute 36% of physicians, 57.9% of nurses and 93% of both pharmacists and other health personnel (Figure 1.5) (MOH, 2017).

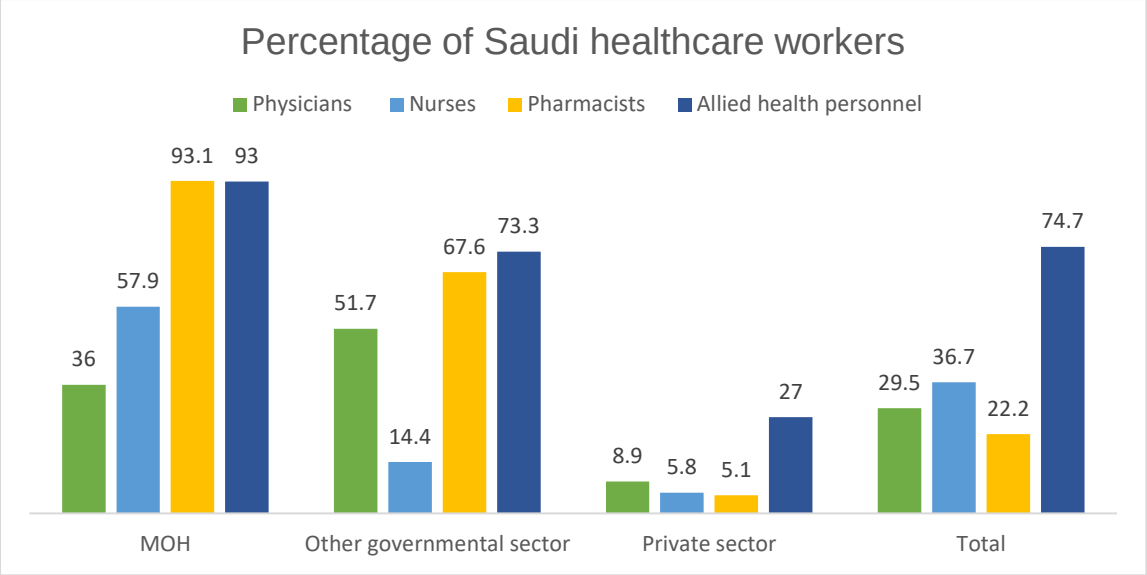

Figure 1. 5 Distribution of Saudi health workers in the MOH, other government and private health care sectors in Saudi Arabia, 2017. Source: MOH, 2017.

The rates of physicians and nurses in The KSA are 2.4 and 5.7 respectively per 1,000 of population, which are lower than those in other high-income countries such as,Australia (3.6 and 12.7 per 1000), Qatar (2.8 and 6.6 per 1000), Canada (2.6 and 10 per 1000), France (3.2 and 9.7 per 1000) and the United States of America (2.6 and 8.6 per 1000) in 2016 (The World Bank, 2020).

Thus, practical strategies to retain and attract more Saudis into the medical workforce and health professions are required for sustainability of the health system. It is also important to provide appropriate health education and training programmes that aim to substitute the large expatriate workforce to meet the increasing health needs in the Saudi health care system (Almalki et al., 2011; Al-Hanawi et al., 2019).

Chapter 2

Methods in Efficiency Analysis

The previous chapter discussed the Saudi Arabian setting, including the health system, the Ministry of Health and the health facilities. In this chapter, efficiency measurement methods are presented to construct the basis of the methodology used in the empirical studies in the following chapters.

In the first section, the theoretical background of the efficiency and production as well as the concepts of efficiency are provided. In the next section, the methodology of efficiency in healthcare and efficiency assessments in public sector are accompanied by a literature review of the methods used in published studies. The third section discusses the different methodological approaches used in hospital efficiency measurements and evidences based on literature reviews. The final section of this chapter describes the data sources used in the empirical studies.

2.1 Theoretical background

2.1.1 Efficiency and Productivity

In the general sense, efficiency relates to the wise and careful use of scarce resources to gain the best possible benefit from them at the lowest possible cost. At first glance, this seems simple enough, but since the middle of the 20th century, there have been many attempts to determine exactly what efficiency means.

The terms productivity and efficiency are often used interchangeably in economic contexts, which is unfortunate since they are not exactly same (Jacobs, et al. 2006).

Productivity is the ratio of the valued outputs that an organization produces to the inputs used in the production process (Lovell, 1993). The productivity remains the ratio of two scalars (outputs to inputs); thus, the concept of productivity may embrace but is not confined to the concept of efficiency (Jacobs et al., 2006). Efficiency can be described as the distance between the quantity of input and output, and the amount of input and output that defines a frontier, the best possible frontier for that entity (Daraio, & Simar, 2007). Lovell in 1993, defined efficiency in terms of a comparison between observed and optimal values of its output and input of a production unit. In other words, the ratio of observed to maximum potential output obtainable from the given input, or the ratio of minimum potential to observed input required to produce the given output of production possibilities. The efficiency concept can be expressed mathematically as follows:

$$\theta_o = \frac{Virtual\ output_o}{Virtual\ input_o}, o\epsilon\ (1, 2, \dots n\} \quad (1)$$

However, efficiency and productivity are two cooperating concepts. The measures of efficiency are more accurate than productivity, since the efficiency involve a comparison with the most efficient frontier, while productivity is mainly based on the ratio of outputs on inputs (Daraio, & Simar, 2007).

The basic concept of efficiency is shown in Figure 2.1 (from Jacobs et al., 2006), which demonstrates the simple case of one input and one output. The OC line indicates the efficient frontier and under constant returns to scale. A technically efficient organization would operate on this line. Any inefficient organization would lay below OC line. For instance, an inefficient organization (P_0), the ratio $X_0P_0/X_0P^*_0$

offers an indication of how it is far from the production frontier, or how it is inefficient; therefore we can measure its efficiency level (Jacobs et al., 2006).

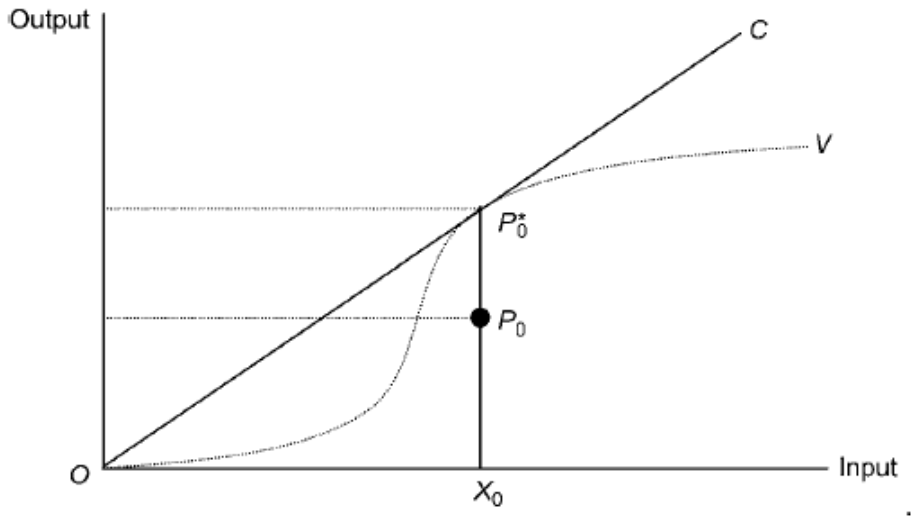

Figure 2. 1 Efficiency notion under constant returns to scale.

In general, when multiple inputs and multiple outputs are used, the overall efficiency (eff_0) of an organization ($_0$) is equal to the ratio of the weighted sum of outputs to the weighted sum of inputs. The organization ($_0$) consumes a vector of M inputs X_0 and produces a vector of S outputs Y_0, its overall efficiency is calculated by applying weight vectors U and V as following:

$$eff_0 = \frac{\sum_{s=1}^{s} u_s \, y_{s0}}{\sum_{m=1}^{m} v_m \, x_{m0}} \qquad (2)$$

Where, Y_{s0} is the amount of the $_{(s)}$ output produced; U_s is the weight given to the $_{(s)}$ output; X_{m0} is the amount of the $_{(m)}$ input consumed; V_m is the weight given to the $_{(m)}$ input.

2.1.2 Efficiency Concepts

There are two concepts of efficiency which are commonly used in economics: allocative and technical efficiency. Allocative efficiency is the allocation of resources to provide the optimal mix of inputs and outputs and maximize the benefits; whereas technical efficiency is using the least amount of inputs to produce given amount of outputs (Yip & Hafez, 2015; Hollingsworth, 2008).

Based on Leibenstein's concept in 1966, allocative efficiency occurs when a provider chooses a combination of inputs in accurate proportions in relation to their prices; this enables the provision of the selected output with minimal average costs; alternatively, when the output mix is that which maximizes revenue, given output prices (Blatnik et al., 2017). When allocative efficiency is achieved, then no other allocation of resources can make at least one individual better off without making worse off for another person, which satisfies the pareto optimality (Jacobs et al., 2006). Thus, allocative efficiency is different from equity; an allocatively efficient situation may, therefore, be inequitable in some cases (Yip & Hafez, 2015).

The definition of efficiency was presented by Koopmans (1951) in the analysis of production function and also by Debreu (1951) who established the measurement of coefficient of resources utilization. Farrell in 1957 defined technical efficiency as a relative notion, i.e., a notion that is relative to the best-observed practice in the reference set or comparison group. Technical efficiency is producing a maximum amount of outputs from a given amount of inputs or producing given outputs with minimum inputs quantities (Farrell, 1957; Hollingsworth, 2008). When an organization is technically efficient, it operates on its production frontier. Productive efficiency which relates to technical efficiency and economies of scale, meaning that

more of a unit that can be produced, the lower the costs of each unit will be (Farrel, 1957; Suhartano, 2017).

Allocative and technical efficiency together create a unit of cost efficiency or economic efficiency, which is defined as a product between the technical efficiency and allocative efficiency. Thus, the cost efficiency can be achieved only by using the minimal amount of necessary inputs for production, and by combining inputs in a way that secures the production amount of the chosen output with the minimum costs (Blatnik et al., 2017).

The economic efficiency in health care means that individual choices between goals and alternatives and the ways in which they are achieved, which is designed to make the maximum overall benefit from available resources of the healthcare institution. The method of achieving this efficiency is the relative valuation of benefits and relative costs of different options (Afzali, & Mahmood, 2009; Fragkiadakis et al., 2016).

2.2 Healthcare Efficiency

2.2.1 Efficiency Analysis in Healthcare

The measurement of efficiency in healthcare services is a complex and challenging task since there are conceptual challenges, multiple objectives, and measurement errors in the application (Jacobs et al., 2006). The World Health Report in 2000 was devoted to the measurement of health system efficiency, since then, efficiency analysis has been the topic of much research and international concern (WHO, 2010). Pioneering studies by Farrell (1957) developed tools to a high level of analytic

sophistication that can be applied to measure the productive efficiency of the health care systems (Jacobs et al., 2006).

Yip and Hafez (2015) carried out an analysis of efficiency in healthcare services in ten different countries, focusing on forms of inefficiency of healthcare services and health policy and also the countries' experiences to overcome these inefficiencies. They found that there were many interpretations of efficiency, which led them to recommend that a framework for evaluation and measurement of efficiency should be developed in order to meaningfully inform and influence policy (Yip and Hafez, 2015).

Hollingsworth in 2003 described the progress reported in the public literature, covering all publications up to year 2002. He examined 189 published studies of the efficiency variations and production functions in health care, of which about half of those were in the hospital sector, and the majority of studies used Data Envelopment Analysis (DEA) (Hollingsworth, 2003).

Varabyova and Müller in 2016, conducted a systematic review and meta-analysis of published studies of health care efficiency in the Organisation for Economic Co-operation and Development countries (OECD). Also, they conducted cross-country comparisons and quality assessment of the studies, and evaluated the characteristics of the efficiency models, methodological issues and policy implications (Varabyova, & Müller, 2016).

Kiadaliri and colleagues in 2013 reviewed 29 studies on the efficiency evaluations in the Iranian hospitals. DEA was applied in all reviewed studies. They found the studies had methodological deficiencies and availability including low quality of the

data and made recommendations to the Iranian decision makers for improvements (Kiadaliri et al., 2013).

Two efficiency studies in the Saudi health sector context used DEA analysis but were hampered by data deficiencies (Helal and Elimam in 2017; El-Seoud in 2013). Alharbi (2018) and Al-Hanawi (2019) invested the Saudi health system and raised concern about the challenge of healthcare information systems to provide reliable data for measuring efficiency accurately. Alharbi (2018) stated that "the failure to have implemented Health Data Standards, in accordance with International organization for standardization specifications", which captured one of the main Saudi problems.

Later, some efficiency studies on the Saudi Arabian healthcare system used a DEA framework for evaluating its technical efficiency, such as Mousa & Aldehayyat, 2018 and Aldabahi, et al., 2020. The DEA was a commonly used and successful approach in measuring performance efficiency of hospitals as well as the healthcare systems due to flexibility of application. We, therefore, employed the DEA framework for analysis Saudi Arabian public hospitals in this thesis.

2.2.2 Efficiency Assessment in Public Health Sector

In the public sector, healthcare faces several challenges that make measuring efficiency more difficult. One reason for this complexity is the lack of competition in health provision since the government acts as a monopoly in the public sector (Jacobs et al., 2006; Yip and Hafez, 2015). The public sector belongs to all citizens and, therefore, while we can determine the costs of inputs such as equipment, staff,

infrastructure and medicines, we face the problem of determining the value of output as no one pays for the services from their own pocket (Czyzewski et al., 2016).

In public health systems, efficiency depends on the functions such as the generation of resources, the financing model, the organization of the systems and the way of providing health services, which are the functions that are affected by underlying institutional characteristics and development of the system (Al-Hanawi et al., 2019). On the other hand, efficiency contributes to the final objectives of the health systems, expressed in terms of gains in health and equity in health, financial protection and equity in the financing, and with the responsibility of the health system meeting the needs of the population (Fried et al., 1993). In this framework, efficiency is considered to be one of the conditions to achieve the objectives of the universal access and coverage strategy, either in terms of proper use in relation to the population's health needs, quality of services or universal financial protection (WHO, 2019; Fried et al., 1993).

In most economies, the state finances health services, including public hospitals, and is interested in having the services provided with quality and efficiency. The lack of control and evaluation of these two attributes (quality and efficiency) in health services will be reflected in the long run by a decrease in the ability of the state to provide all social services (Al-Hanawi et al., 2019). On the other hand, the measurement of abstract concepts such as quality and efficiency of health services needs a quantitative operationalization that allows comparisons in time and space and the determination of patterns that would enable the identification of failures and/or achievements (Al-Hanawi et al., 2019).

However, for many public goods, price is not the main criterion in determining the efficiency of healthcare services. This is because they must be provided regardless of existing prices (Almalki et al. 2011; Jacobs et al., 2006). The absence of profit in the public sector also means that institutions are not at risk of bankruptcy; as the funds are secured by the state budget (Al-Hanawi et al., 2019). If funds are insufficient, the state debt will increase, but the entire system will not fail. Thus, resource allocation in the public sector often suffers from inefficiency. It has also been argued that the resources are not provided where they would most benefit at a given moment (Le Grand, & Robinson, 2017).

Additionally, many public organizations are not operating on the frontier based on the monopoly principle so that X-inefficiency would be applicable in this case (Farrel, 1957) as there is no competition or pressure on supply, and providers have no incentive to work on innovations to improve public services or goods (Fried et al., 1993). However, they are not interested in contributing to its efficiency, either due to lack of information or due to low benefits resulting from potential improvements in the sector. Various non-economic factors, often of a qualitative nature, also influence the efficiency of the public sector (Kim & Wang, 2019). Examples include government decisions, public budget spending and legislation that need to be taken into account when measuring efficiency. These factors are taken into account in efficiency models in the competitive market, which inevitably is a subjective assessment.

2.3 Methods in Hospital Efficiency Assessment

Hospital care plays a predominant role in healthcare globally. It has a high social significance, as hospital care is a target for people with the most serious health

problems and is frequently the most expensive element of the health system due to the specialized and technologically advanced care provided (Alomran, 2019; Walston et al., 2008).

Since the vast amount of health resources go towards funding hospitals, there is a great and growing interest in investigating the efficiency of hospitals with the driving force for such concern being value for money. Public hospitals consume around 40% of the total health budget in the sub-Saharan African countries according to Hanson and her colleagues in 2002. In comparison, in the UK in 2012/2013, this sector consumed almost 44% of the health spending (Kelly et al., 2016). Thus, as hospitals are key consumers of health resources, hospital efficiency is critical to the efficiency of the overall health system (Hollingsworth, 2003). Also, the continuous evaluation of the efficiency of hospital care with its social and economic implications is imperative for the health sector (Hanson et al. 2002).

However, the concept of efficiency in hospitals has been used in different ways and with some confusion due to the diversity of objectives, objects of analysis and contexts of application to healthcare. In fact, the debate on health policies has been raised, in some cases, in terms of contradiction between health equity objectives and health efficiency objectives. This thesis aims to recognize different applications of the concept of technical efficiency to understand the efficiency in the public hospital context.

The empirical approaches are used to assess hospital efficiency, which requires a calculation of the ratio between inputs and outputs. Inputs in healthcare include funding, capital (like, number of beds), human resources (labour), physical infrastructure, medical equipment and information system (Jacobs et al., 2006; Yip &

Hafez, 2015) which can be quantified, while outputs used in hospitals efficiency studies were healthcare activities (e.g. number of outpatient and inpatient services, number of surgeries) and health outcomes (e.g. mortality rate and quality of life), which are not so easily quantifiable in monetary values. (Afzali, & Mahmood, 2009; Jacobs et al., 2006).

Several methods have been used to measure the hospital efficiency, mainly through frontier analysis methods, either using non-parametric data envelopment analysis (DEA) or as parametric stochastic frontier analysis (SFA), which compare the hospital performance to an estimated efficient frontier comprising the best-performing hospitals (Jacobs et al. 2006; Hollingsworth, 2003). However, there are other methods for measuring and optimizing efficiency in the healthcare sector. For instance, Free Disposal Hull (FDH), developed by Deprins, Simar and Tulkens (1984), is a more general version of the DEA estimator and relies only on the free disposability assumption; meaning if a specific pair of input and output is producible, any pairs of more input and less output are also producible. Malmquist index, which is a very helpful tool for the analysis of productivity change over time in the public sector (Coelli, Rao and Battese 1998). Also, the statisticians developed multilevel (or hierarchical) models to reflect the multilevel nature of organizations explicitly (Hill & Goldstein, 1998).

The parametric methods, like SFA, assume a particular functional form of the production function, such as a Cobb-Douglas production function or a Translog function. On the other hand, methods can be statistical or non-statistical. The statistical methods tend to make assumptions of the stochastic nature of the data, including the stochastic frontiers, which allow assessment for statistical 'noise' as opposed to deterministic. Non-statistical methods tend to be non-parametric (and

deterministic) such as DEA; whereas statistical methods like SFA, are based on frontier regression models tend to be parametric (and stochastic). (Jacobs, 2001; Barrow, & Wagstaff, 1989).

2.3.1 Data Envelopment Analysis

Data envelopment analysis (DEA), for many years, has been the predominant method of efficiency assessments among healthcare and hospital efficiency studies, for instance, Hollingsworth, 2003; O'Neill et al., 2008; Al-Refaie et al., 2014; Kohl et al., 2019; Khushalani & Ozcan, 2017; Chowdhury & Zelenyuk, 2016; Rouyendegh et al., 2016, to name but a few of the 8,370 articles listed on the scientific databases.

DEA is an efficiency approach, initiated by Farrell (1957) and operationalized as linear programming estimators by Charnes, Cooper and Rhodes (1978). DEA is a data-driven approach (non-parametric) method, meaning that location of the efficiency frontier is determined by the data, which can compare inputs and outputs without having to make statistical assumptions. DEA defines the efficiency or maximum productivity curve, considering the optimal output to input ratio. It assumes that the realized values of the inputs and outputs are known and seeks for each organization under evaluation with replacement rates including relative weights between inputs and outputs that maximize their relative efficiency (Podinovski, 2016; Fried et al., 1993).

The organization or the decision-making unit involved (DMU) that employs less input amounts than others to produce the same amount of outputs can be considered technically efficient, which create the efficiency frontier based on 'best-observed practice DMU' (Jacobs et al., 2006; Charnes et al., 1978). Inefficient DMUs are

'enveloped' by the efficiency frontier (boundary), and efficiency scores are calculated relative to this frontier (see Figure 2.1). In other words, the efficiency score of each DMU unit is the relative distance from that frontier (Cooper et al., 2007; O'Neill et al., 2008).

DEA has been the most commonly used method for measuring the relative efficiency in hospitals, due to many advantages over other methods. DEA is able of handling multiple inputs and outputs stated in different measurement units. Management has strong preferences about the relative importance of various factors in the model. No restrictions are imposed on the functional form relating inputs to outputs, as DEA (deterministic) does not require any specification of the underlying functional form that relates the inputs with the outputs. The differences in DMUs sizes can be dealt with by adopting models that provide variable returns to scale, without bias to small organizations. Also, more than one DMU can be classified as efficient, composing the frontier of relative efficiency and serving as a benchmark for the performance of other organizations (Charnes et al., 1994; Borisov et al., 2012).

However, DEA has some limitations (Charnes et al., 1994; Jacobs et al., 2006; Khezrimotlagh et al., 2019). One of the drawbacks is related to the sample size. DEA application requires a large and homogeneous sample. A greater number of DMUs will increase the chances of finding units near the production frontier. Another problem is of analyzing factors that cannot be aggregated because of DEA’s reliance on individual data sets. Similar problems occur with correlated input and the output in the data. Also, DEA models do not consider any accidental error or deviation, as it has no accommodation for noise or random error effects, because that the scores are derived from DEA and the relevant envelopment surface are not statistically

estimated but calculated. (Charnes et al., 1994; Jacobs et al., 2006; Khezrimotlagh et al., 2019).

Bootstrapping DEA

Bootstrapping means using thousands of random selections of ‘pseudo samples’ from the observed sample. ‘Pseudo’ estimates can then be obtained from each of these samples, which form an empirical distribution of the estimators. Hence, this distribution approximates the true sampling distribution (Assaf and Matawie, 2009). The bootstrapping approach used to correct the possible biased estimations in DEA-efficiency scores and to overcome the correlation problem of the efficiency scores. Also, it used to provide consistent inferences in explanation of the determinants of the DEA efficiency estimates (Assaf and Matawie, 2009).

However, the nature of the DEA-efficiency scores (limited between 0 and 1) imposes some complications on the bootstrapping process, which will lead to inconsistencies in the measures (Simar and Wilson, 1998). Thus, Simar and Wilson in 1998 and then in 2000 adopted a smoothed bootstrapping procedure to overcome this problem (based on density estimates of the sample) (Simar and Wilson, 1998; 2000). Nevertheless, there are more correlations expected between the input/output variables and the environmental variables in the DEA model. Therefore, Simar and Wilson (2007), developed a double bootstrapping procedure, in the second-stage analysis to calculate the standard errors of the estimates (Simar and Wilson, 2007).

DEA Model Formulation

The DEA formulation is presented below, developed by Charnes, Cooper, and Rhodes (1978), (CCR) model. DEA is a non-parametric, deterministic technique, which defines technical efficiency (TE) as the ratio of a weighted sum of outputs of a DMU divided by a weighted sum of its inputs. The linear programming as following:

$$Max \quad = \frac{\sum_{r=1}^{s} u_r \, y_{r0}}{\sum_{i=1}^{m} v_i \, x_{i0}} \tag{2}$$

$$Subjected\ to \quad \frac{\sum_{r=1}^{s} u_r \, y_{rj}}{\sum_{i=1}^{m} v_i \, x_{ij}} \leq 1 \quad j = 1, 2, \ldots n$$

$$u_r \geq 0, v_i \geq 0 \qquad r = 1, \ldots\ldots, s, \qquad i = 1, \ldots\ldots, m$$

where:

n= number of decision-making units (DMUs),

m= inputs, s= outputs.

x_{ij}= quantity of input i (i=1,…., m) used by DMU_j (j=1,….., n); and,

y_{rj}= quantity of output r (r= 1,….., s) produced by DMUj (j=1,….., n)

ur= weight attached to output (r=1,…., s) and

vi= weight attached to input (i = 1,….., m) are weights.

The constraints in the above model limit all efficiency scores to a maximum value of unity (value in the range from 0 to 1). The variables ur and vi are quantified in efficiency of DMUs, that are obtained by solving the maximization problem. Thus, it

evaluates the performance of each DMU0 relative to the performance of all j = 1,…, n DMUs. These same weights are assigned to all DMUs (O'Neill et al., 2008).

For those organizations that are considered inefficient, improved contributions are presented with the establishment of performance goals. It can be applied to different orientations, enabling the verification of the evolution of the efficiency of organizations and the study of the factors that contributed to their growth or decline. It provides a multifaceted view of efficiency, allowing for an analysis of the factors that contribute most to its achievement, while the obtained indicator proves to be easy to interpret.

Constant and Variable Return to the Scale

DEA efficiency analysis under constant returns to scale (CRS) was developed by Charnes, Cooper and Rhodes in 1978 (CCR). The CCR model was modified by Banker, Charnes and Cooper in 1984 (BCC) model. It is a more flexible model that considers variable return to scale (VRS) when measuring efficiency in Figure 2.2 (source Jacobs et al. 2006), meaning that the effective boundary will have a convex nature (Charnes et al., 1978; Banker et al., 1984). Thus, VRS may be appropriate when not all DMUs can be operating at an optimal scale (Cooper et al., 2007).

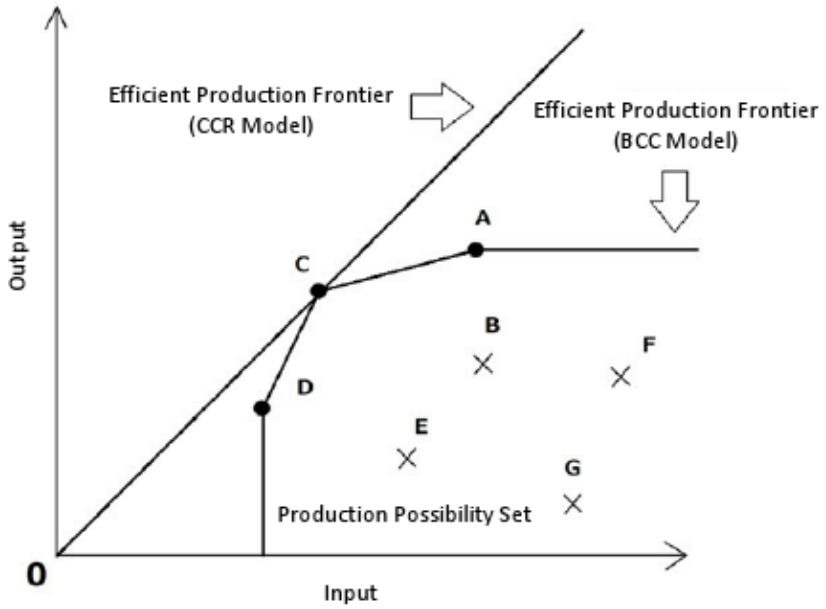

Figure 2. 2 CCR model and BCC model.

The returns to scale express how the quantity produced by an organization varies as the use of all the factors involved in the production process varies in the same proportion (Charnes, et al., 1978). Banker determined the Returns to Scale (RTS) using the optimal value of the free variable in the multiplier model. The model works on the principle of optimizing weights of inputs and outputs to find the maximum value of the efficiency unit (Banker et al., 1984). If there is an equal increase in all production factors (input), leading to the same proportionate amount of increase in production (output), then we experience CRS. Increasing Returns to Scale (IRS) meaning the increase in all production factors (inputs) resulted in more production (outputs). On the other hand, when an equal increase in all production factors lead to less production, we have Decreasing Returns to Scale (DRS) (Banker et al., 1984; Lovell, 1993). The technical properties of long-term production of an organization can show different types of returns to scale for different production ranges.

The choice of CRS or VRS is an important decision and depends on the analyst's understanding of the market constraints faced by the firms within a particular sector. If the CRS technology is inappropriately applied when, say, all hospitals are operating at a sub-optimal scale, then the estimates of technical efficiency will be confounded by scale efficiency effects. Several hospital efficiency studies applied both the VRS and CRS models to distinguish "scale efficiency" from "pure technical efficiency". Scale efficiency can be calculated by estimating the difference between the two frontiers; CRS and VRS (figure 2.2) (O'Neill et al. 2008; Suhartano, 2017; Cooper, 2013).

Input and Output Orientation Analysis

DEA including the input orientation approach, based on the input requirements in use and efficient boundaries, aims at reducing the input amounts by as much as possible while keeping the current output level fixed. Meaning that the output level remains unchanged and input quantities are decreased proportionately till the DMU reaches the frontier. This orientation is generally adopted when the decision-maker has a control on inputs but not on the outputs. For example, the public hospitals which are committed to offering public services, are interested in the management of the inputs towards minimization. A hospital could proportionally reduce its use of doctors and nurses, given the number of treatment services it provides, and move towards the frontier for being technically efficient. (Daraio & Simar, 2007; Jacobs et al., 2006). On the other hand, the output orientation analysis aims to maximize output levels with the current input consumption. This approach holds the input bundle unchanged while expands the output level until the frontier is reached.

In practice, whether the input or output-oriented measure is more appropriate would depend on whether input conservation is more important than output expansion or not. (Deprins et al., 1984; Daraio & Simar, 2007).

2.3.2 Stochastic Frontier Analysis

The stochastic frontier analysis (SFA) was proposed by Aigner, Lovell, & Schmidt in 1977, which aimed to expand the deterministic frontier and include the random error of the production function. The SFA, like DEA method, as frontier analysis uses the distance function, measuring the technical efficiency of a DMU in relation to the efficient provider, situated on the frontier production function or frontier cost function (Blatnik et al., 2017). The SFA is a parametric method, as opposed to the non-parametric DEA, assume a particular functional form of the production function, such as a Cobb-Douglas production function or a Translog function. SFA is also a statistical method, meaning it tends to make assumptions of the stochastic nature of the data, including the stochastic frontiers, which allow assessment for statistical 'noise' in the data, unlike the deterministic model, like DEA (Jacobs, 2001; Barrow, & Wagstaff, 1989). SFA follows the conventional statistical process of specifying an econometric model, as follows:

$$y\mathrm{i} = a + bx\mathrm{i} + e\mathrm{i} \qquad (3)$$

where y= the output; i= number of observations, i= 1, . , I; a= constant; x= vector of explanatory variables; b= association between the dependent and explanatory variables; e= residual.

The SFA has several advantages in measuring technical efficiency. SFA includes well-developed statistical tests to investigate the validity of the model specification. SFA can also differentiate efficiency levels between data uncertainty and pure inefficiency (Chen, 2007). A further advantage is that the SFA can estimate cost-inefficiency in the technical inefficiency because efficiency estimates will be sensitive to which output is chosen for deflation (Rosko & Mutter, 2008).

2.4 Data Sources

The principle data source used in this thesis is the Administration of Statistics and Information, and Administration of Research and Studies in the Ministry of Health in Saudi Arabia. This secondary data is based on the annual hospital standardized examination reports for the year 2017, which is a compulsory requirement by the Ministry of Health to be reported by all hospitals in this sector. The strategies of quality assurance were applied to the data of the Ministry of Health for reducing data errors like outliers, inconsistency and missing values (MOH, 2010). Since data quality is critical in secondary data analysis, it should be noted here that the data used a fundamental format, based on the official statistical, informational and research databases in the Ministry of Health (Ree & Carretta, 2006). Other sources, such as published statistics from the General Department of Statistics and Information in the Ministry of Health, like the Annual Statistical Book for the years 2015-2017 and The Health Strategic Plan 2010-2020 from The Ministry of Health, have also been used as references for validation. In addition, various governmental policies and legislative documents relating to the Saudi health care system and published work, are used to provide information about the health sector reforms in

general, and the changes in financial and managerial regulation of hospitals in particular. For the purpose of this research, the data analyzed is limited to data on general public hospitals, which play crucial roles in the hospital sector as well as the health system.

As the application of the efficiency analysis requires a homogeneous (comparative) sample that use similar inputs (health resources) to produce similar outputs (health services and activities), we focused on examining the technical efficiency for general hospitals. In this thesis, general public hospitals are defined as hospitals which provide all types of health services and are owned by the government and affiliated to the Ministry of Health. There are 97 general hospitals affiliated to the Ministry of Health, and we removed six of them, due to missing data and, therefore, the dataset consists of 91 general hospitals. The general hospitals included 54% of the total active hospital beds provided by the Ministry of Health in Saudi Arabia. The hospitals are distributed over 64 cities, affiliated to 20 administrative districts, located in five geographical regions of the country. Two main sets of data have been constructed. The first data set is the input and output variables, which is used to measure the efficiency scores of the hospitals. The second data set is used to investigate the impacts of external factors, including environmental, institutional, demographic and socio-economic characteristics of catchment population on hospital efficiency.

The other source of data used in this thesis is obtained through a qualitative methodology of semi-structured interviews with the key informant (KIs) in the Ministry of Health in Saudi Arabia. The KIs were health system stakeholders drawn from public health facilities and the Ministry of Health, including policymakers, hospital managers, middle managers, district health managers, and health regulators. The KIs, through their designated position, were able to extract the barriers of hospital

efficiency in general and the specific factors that influence efficiency and performance in respect to input, output and production process. In addition, we sought suggestions, recommendations and feasible steps for improving efficiency in public hospitals. Further demonstration of data sources and variable used are provided in the corresponding chapters. Ethics approval was attained from the Ethics Committee of Institutional Review Board (IRB) of King Fahad Medical City, affiliated to the Ministry of Health in Saudi Arabia (IRB log No. 18-166E) is attached (Appendix A). In addition, the IRB approval from Research Ethics Committee of the Liverpool Scholl of Tropical Medicine was obtained for the qualitative research (Appendix E).

Chapter 3

Systematic Review and Meta-Analysis of Public Hospital Efficiency Studies in Gulf Region and Selected Countries in Similar Settings

The previous chapter established an understanding of the methodological aspects and options of efficiency measurement in the healthcare system. In this chapter, we systematically reviewed the scientific papers on efficiency of public hospitals within the context of the Gulf countries and comparable settings. This chapter thus aims to review the methods of measuring efficiency and compare national settings to extract evidence, thus, to inform future efficiency studies of health facilities.

3.1 Introduction

The requirement for an efficient, equitable and effective healthcare system is a dominant concern in all nations. This is certainly true in the Gulf Cooperation Council (GCC) countries, which have experienced considerable population growth and increased life expectancy during recent decades. These factors have, in turn, increased the demand for healthcare services (Khoja et al., 2017; Ardent Advisory & Accounting, 2015). In these countries, average government spending on healthcare is 73% of the total health expenditure, corresponding to 3.2% of GDP in 2013 (WHO, 2014; MOH, 2015). Yet while public spending on healthcare is remarkably high in the GCC nations, in comparison with several high-income countries, it is rather low as a share of the GDP (Dieleman et al., 2017). It has been observed that in GCC

countries, a mere of 2.0 hospital beds are allocated per 1,000 of the population; in contrast, the corresponding figure in other high-income countries is on average 9.0 (Ram, 2014; The World Bank, 2018).

Although GCC states (high-income) spend more than twice as much on healthcare than upper-middle income countries (USD 1,100-2,000 per capita for GCCs versus USD 505 per capita), the number of hospital beds per 1,000 population is fewer, at around 2.0 versus 3.4 hospital beds per 1,000 (World Bank, 2018). These statistics indicate inefficiency in utilization of health resource within the GCC countries. The healthcare expenditure in GCC states was expected to rise from USD 55 billion to USD 69.4 billion between 2014 and 2018 (Khoja et al., 2017; Ardent Advisory & Accounting, 2015). Moreover, the demand for healthcare services in the GCC is expected to increase by 240%, and thus to require more hospital beds, with a total of almost 162,000 beds to be provided by 2025 (Mourshed et al., 2007). Considering the observed imbalance between health spending and service availability across the countries, effective use of resources is essential to the achievement of efficiency in health systems (MOH Strategy Plan, 2010).

Many governments worldwide must evaluate the efficiency of their health sectors, to ensure that public money is used to best effect (Jacobs et al., 2006). Several efficiency-related concepts have been used in such efficiency analysis, including theories of technical, allocative, cost and overall efficiency. Of these concepts, the technical efficiency approach is the most commonly used, which based on Farrell's concept that "a unit that produces the maximum amount of output from a certain input, or produces a given output with the minimum amount of inputs, can be recognized as technically efficient" (Farrell, 1957; Hollingworth, 2003). The efficiency of the hospital is crucial for the efficiency of the healthcare system, as hospitals are

primary consumers of health resources (Hanson et al., 2002; Hollingworth, 2003). For example, in many sub-Saharan African countries, public hospitals consumed around 40% of the total public health budget, according to Hanson and colleagues in 2002. Others found that the public hospitals expended 44% of all national health expenditure in the UK during 2012 and 2013.

Globally, assessments of hospital efficiency have been conducted using various methods, mostly through frontier analysis approaches either as non-parametric like data envelopment analysis (DEA) or parametric like stochastic frontier analysis (SFA) (Varabyova & Müller, 2016). The frontier analysis methods compare hospitals' actual performance against an estimated efficient frontier, which is considered to be achieved by the best-performing hospitals (Hussey et al., 2009; Kiadaliri et al., 2013). Since the results of any efficiency assessment depend significantly on the variables used in the estimation models, thus the selection of input and output variables is a vital step in the measurement of such comparative performance (Afzali et al., 2009). The literature has focused on labour force (e.g. health workers) and capital (e.g. hospital beds) as input variables, while few studies have included consumable resources, like medications (Jacobs et al., 2006; Afzali et al., 2009). The types of outputs used in efficiency studies include healthcare activities, for instance, the number of inpatient services, number of surgeries; and health outcomes (e.g. mortality rate) (Jacobs et al., 2006).

Despite global interest by researchers and policymakers, considerable uncertainty exists as to whether the techniques applied in efficiency analysis are sufficiently developed to be useful. There is little consensus concerning the appropriateness of the efficiency methods and estimation techniques that policymakers need to make decisions about efficient resource allocation. (Hussey, et al., 2009). Nevertheless,

while there is a growth in the research of hospital efficiency (supply-side), the demand-side (e.g. health policy) remains under-researched (Hollingsworth, 2006). Many studies in the field of public health have focused on the efficiency of primary health services, neglecting the secondary-level of hospital services in the process (Dutta et al., 2014). In general, there is a scarcity of empirical works on the efficiency of public hospitals, and such a shortage is particularly noticeable in the GCC countries.

3.1.1 Aims

To our best knowledge, there is no existing systematic review of studies that examines efficiency of public hospitals in the Gulf countries. This chapter aims to review the current literature systematically and synthesize the findings on efficiency studies of public hospitals in the GCC region and in countries that are comparable in terms of income level, health provision and demographic characteristics. This review summarises the included studies regarding their characteristics and capacity in order to describe the performance of healthcare and assess variances in efficiency estimates.

Since examination of differences in hospital efficiency measurements can yield valuable evidence, explored experiences in comparable countries have been incorporated into the analysis to enhance the understanding of how efficiency studies have been performed. Such knowledge could influence policy decisions in the GCC countries; it also guides the empirical analysis in the following chapters. Also, we perform a meta-analysis of the efficiency estimates reported in the reviewed studies, to analyze the stability of the efficiency findings.

3.2 Methods

3.2.1 Search Strategy

During July and August 2017, we searched in six electronic databases, namely Pubmed, Medline, Cinahl, Econlit, Embase and Cochrane, to identify relevant efficiency studies in English-language and indexed at any time. A combination of medical subject heading (MeSH) terms and text words (ti, ab, kw) were used to search in the databases to ensure a broad range of studies were screened (Cote et al., 2016). The notification alert of the relevant databases was activated for any potential papers that met the search words. The search algorithm was used as following: ("efficiency" OR "efficienc*" OR "productiv*" OR "inefficien*" OR "performance" OR "efficiency of production" OR "data envelopment analysis" OR "DEA" OR "stochastic frontier" OR "SFA" OR "parametric" OR "non-parametric" OR "non-parametric" OR "healthcare efficiency" OR "health care efficiency")

AND ("Hospital*" OR "Public Hospitals" OR "Public Health Centre" OR "Secondary Care" OR "Tertiary Care" OR "Government* Hospitals" OR "General* Hospitals")

AND ("High Income" OR "Gulf Countr*" OR "GCC" OR "Upper-Middle" OR "Middle Income" OR "Middle East" OR "Islamic Countries" OR "Single-Payer Health System" OR "Saudi Arabia" OR "saudi" OR "kuwait" OR "bahrain" OR "qatar" OR "united arab emirates" OR "emirates" OR "oman" OR "Iran" OR "Turkey"). The protocol of the systematic review was registered in PROSPERO (ID: CRD42017074582) and is available in full on the NIHR HTA programme website. The search process complied with the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009)

We identified the studies that evaluated healthcare efficiency and production assessments in public hospitals, in the GCC countries and in similar settings. All of the countries included in the analysis have either high or upper-middle income as defined by the World Bank, have a single-payer health system and shared similar demographic characteristics (World Bank, 2017). Subsequently, the research was extended through looking through the reference sections of the identified studies in the databases and in the grey literature. Moreover, the grey literatures (Google scholars and Web of Science) were also manually searched using the search words mentioned earlier, to identify more relevant articles because some efficiency measures relevant to the GCC states may not have been included in the published literature databases.

3.2.2 Inclusion and Exclusion Criteria

A study to be included in this review had to satisfy the following inclusion criteria: (1) a study has to empirically estimate efficiency and reported technical efficiency scores. (2) The unit of analysis must be a public hospital. (3) A study must have been based on the Gulf region (GCC) or similar countries. We excluded studies that failed to assess the efficiency of healthcare facilities empirically; for example, studies that explained efficiency techniques and described methods, but did not include empirical analysis of data (descriptive papers). Also, studies that focused only on the private sector were excluded, as well as studies that applied measures other than efficiency estimates, for instance, productivity change over time but without reporting efficiency scores.

3.2.3 Region Selection

We sought relevant literature conducted in the GCC countries (Saudi Arabia, United Arab Emirates, Kuwait, Qatar, Bahrain and Oman). We found that Iran and Turkey share similar characteristics with the GCC states, in that both have an upper-middle income, are located in the Middle East and have a public health system funded mostly by the government (i.e. a single-payer system). Furthermore, Iran and Turkey, like the GCC nations, share Islamic cultures, and they experience patterns of demand for health services and activities that resemble those of the GCC countries (Albert et al., 2018).

3.2.4 Selection of Studies

The search for potential articles in the databases was performed working closely with the librarian's supervision to refine the search strategy. The titles and abstracts of all resulting articles were independently screened by two authors (AA and SA), to ascertain whether they met the eligibility criteria and thus, to reduce the possibility of selection bias. Then, full texts of all included articles were screened in parallel and separately by two reviewers (AA and SA), to determine whether they met inclusion criteria. Disagreements were resolved by peer discussion, and any differences that could not be resolved were referred to a third member of the review team (JK).

3.2.5 Data Extraction

The data extraction was performed independently. For each study, data extracted comprised: year of publication, studied country, income category of that country, the

number of hospitals included in the study, the proportion of non-public hospitals in the sample, data source and collection year, type of hospital (general and/ or specialized), input and output variables, estimation methods, technology orientation, model specification, second-stage analysis and sensitivity analysis, as well as all the estimated efficiency scores (CRS, VRS and scale efficiency scores).

3.2.6 Quality Assessment

The quality of the reviewed studies was evaluated according to four dimensions that were developed by Varabyova and Müller in 2016, based on the quality appraisals of economic evaluations and efficiency measurement literatures (Hollingsworth, 2008; Drummond et al., 2005). The quality dimensions address reporting, external validity, bias and power, as shown in Appendix B. The reporting dimension ensures that the study provides adequate information to provide a dispassionate evaluation of the findings. The external validity element addresses the inclusiveness of the study sample. The bias dimension examines the data accuracy, appropriateness of the methods used, presence of outliers, and the potential bias in second-stage analysis. The power dimension assessed whether the authors successfully provided evidence to support the study findings (Varabyova & Müller, 2016).

3.2.7 Meta-analysis

We performed a meta-analysis of the reported findings, to evaluate the consistency of efficiency estimates that came from the various studies. For studies that used panel data and provided a separate score for each year, we calculated the weighted average of these estimates, based on the number of units estimated and the score of

that year, and calculated a pooled technical efficiency (TE) score. The independent-samples T-Test was used to compare the estimated mean of the TE based on different features of the included studies (e.g. methods of estimations such as DEA, SFA; income category of the countries). We applied bivariate Spearman's rank correlations between efficiency scores and the related variables in the reviewed studies, to test the internal validity of the findings, for instance, methods, income levels, production assumptions and the number of hospitals. In the logistic regression model, we categorized the TE scores into two levels: 0.8 and above and less than 0.8 for use as the dependent variable. We choose 0.8 as the nearest number for the calculated mean of efficiency score in our sample (0.792). Also, hospital with efficiency score of 80% or more is considered technically efficient according to numerous efficiency literatures, for example empirical work by Mehertak, M. et al, 2014. Furthermore, we used a number of input and output variables, income category of the study's country (high or upper-middle), a number of hospitals, estimation method (DEA or SFA), the orientation of analysis (Input or output), the specification of the model (CRS or VRS), and quality estimated scores as explanatory variables. We included these characteristics because previous literatures indicated that heterogeneity in the sample could affect estimated efficiency scores (Kiadaliri et al., 2013). Data were analyzed using IBM SPSS statistic, version 24, as well as STATA version 13.

3.3 Results

The database search yielded 1,128 titles and abstracts. We deleted 98 duplicate titles and excluded 994 irrelevant records through title and abstract screening. Six

papers were also eliminated because there was no English-language version available of them. After that, 30 full-text articles were assessed for eligibility, and 16 articles were excluded as they did not satisfy the inclusion and exclusion criteria. In the reference tracking, we identified four more records; also, another four publications were identified by a manual search of the relevant grey literature. Finally, twenty-two studies that satisfied our inclusion criteria were included in the review and in the meta-analysis. Figure 3.1 summarises the four phases of the systematic literature search following PRISMA guidance.

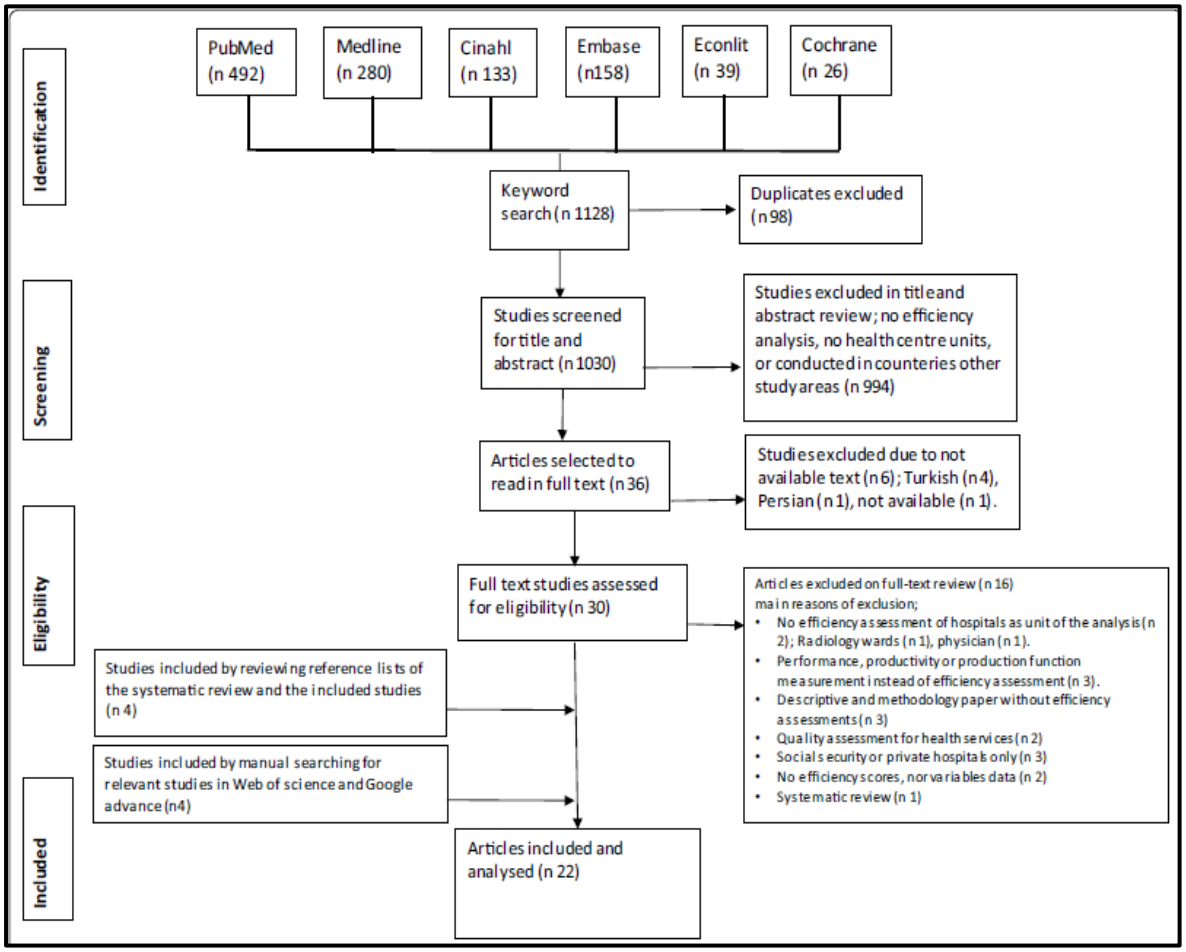

Figure 3. 1 The flow of included studies through phases of the systematic review

Table 3.1 Summary of characteristics of the reviewed studies

No.	Study	Publication year	Country	No. of Hospitals	Inputs	Outputs	Methods of Analysis	Second stage	Quality
1	Yusefzadeh et al.,	2013	Iran	23	Bed, doctors, other personnel	Outpatients, occupied day bed	DEA	NA	**75%**
2	Ahmadkiadaliri et al.	2011	Iran	19	Physician, specialist, nurses and others. bed	Outpatient, inpatients days, surgeries, BOR	DEA	NA	**83%**
3	Helal & Elimam,	2017	Saudi Arabia	270	Bed, doctors, nurses, other personnel	Outpatient, inpatients, No radiology, laboratory,	DEA	NA	**67%**
4	Gok & Sezen,	2013	Turkey	348	Bed, specialist physicians, non-physicians	BUR, BTR, surgery, births, outpatient inpatient days, discharge.	DEA	Logit regression analysis, correlation, mean difference.	**92%**
5	Gok & Altindag,	2015	Turkey	251	Specialized physicians, non-sp. physicians, bed	BUR, BTR, surgery, births, outpatient inpatient days,	DEA, MPI	correlations, mean differences	**92%**
6	Hatam et al.,	2010	Iran	21	Bed, physicians. Nurses, other personnel	BOR, bed, patient admissions, OBD, ALS, BTR	DEA, MPI	NA	**62%**
7	Mehrtak et al.,	2014	Iran	18	Bed, physician, nurse, other professionals	Surgeries, discharges, BOR	DEA, Pabon Lasso	NA	**77%**
8	Kalhor et al.,	2016	Iran	54	Doctors, nurses, medical personnel, beds.	Patients days, outpatient, surgery, ALS.	DEA	Group comparison	**85%**
9	Rezaee & Karimdadi,	2015	Iran	288	Health personals, equipment, bed	Inpatient, outpatient, special patients, bed, BOR	DEA	NA	**42%**
10	Shahhoseini et al.,	2011	Iran	12	Physician, nurse, other staff, bed	inpatient days, ALS, BOR, outpatient, operations	DEA	NA	**75%**
11	Ozgen et al.,	2015	Turkey	1103	Bed, specialist, general doctor, nurse, and other	Discharges, day-care, surgeries, outpatient, emergency care	DEA	Multivariate Tobit regression	**69%**

12	Sahin & Ozcan,	2000	Turkey	80	Bed, specialist, general doctor, nurse, others, Revolving expenditure	Outpatient, discharged, Hospital mortality rate	DEA	Mean difference	**75%**
13	Sahin et al.,	2011	Turkey	352	Bed, physician, nurses, others, operational expenses.	Outpatient, Inpatient, surgeries	DEA, MPI	NA	**77%**
14	Jandaghi et al.,	2010	Iran	8	Physicians, nurse, paramedics, administrative, hospital costs	Outpatient, emergency client, bed day	DEA	NA	**58%**
15	Farzianpour et al.,	2012	Iran	16	Physicians, nurses, beds	Inpatients, outpatient, ALS	DEA	NA	**50%**
16	Atilgan et al.,	2015	Turkey	332	Physician price, ancillary price, administrative price, capital price	Outpatient, inpatient	SFA	Translog cost function specifications. Generalization assessment.	**77%**
17	Atilgan,	2016	Turkey	429	Physician, ancillary, administrative staff, bed	Outpatient	SFA	Restricted and unrestricted effect of Cobb-Douglas and Translog model specifications.	**92%**
18	Atilgan,	2016	Turkey	459	Physician, ancillary, administrative staff, bed	Inpatient discharge, patient days	SFA	DISCH and PATDAY model specification, correlations.	**85%**
19	Sheikhzadeh et al.,	2012	Iran	11	Specialist physician, general professional, support staff, bed	Emergency patients, outpatient, inpatient	DEA	Multiple linear regression, correlation	**75%**
20	Mahate & Hamidi,	2016	United Arab Emirates	96	Physician, dentist, nurse, midwife, pharmacist, AHP, administrator, other, bed	Inpatient, outpatient, ALS	DEA	Correlation analysis	**83%**
21	El-Seoud,	2013	Saudi Arabia	20	Specialist, nurse, allied health, bed	Outpatient, inpatient, laboratory, radiology	DEA	NA	**58%**
22	Ramakrishnan,	2005	Oman	20	Bed, doctor, other professionals.	Outpatient, inpatient, major, minor surgical procedures	DEA, MPI	Mean comparison	**62%**

Notes: DEA, data envelopment analysis; BOR, bed occupancy rate; BUR, bed utilization rate; BTR, bed turnover rate; MPI, Malmquist productivity index; OBD, occupancy bed days; ALS, average length of stay; SFA, stochastic frontier analysis.

Table 3.1 summarises the most prominent characteristics of the reviewed studies. The publication dates ranged from 2000 to 2017. Of all, only four studies were conducted in high-income Gulf countries: two from Saudi Arabia, one from the United Arab Emirates and one study from Oman. The remaining 18 studies were conducted in upper-middle income countries: 10 in Iran and the remaining eight in Turkey. The number of hospitals per study sample on average was 192 hospitals (median 67) and varied from 8 to 1,103 hospitals.

Fifteen studies used cross-sectional data, where 7 used panel data. The health reports, hospital records or annual statistics databases were the sources of data in these studies. Regarding the methodology used, 19 of the 22 reviewed studies used non-parametric methods, and the remaining applied parametric approaches. Among non-parametric methods, data envelopment analysis (DEA) was used in nineteen studies. Other non-parametric methods included Malmquist Productivity Index (MPI) in 4 studies and Pabon lasso analysis in one study: both of these methods were used along with the DEA in these studies. Stochastic frontier analysis (SFA) was the exclusive parametric technique and used in three studies from Turkish hospitals. The efficiency had been assessed in light of several concepts, including technical-, pure-technical and scale-efficiency, with a focus on technical efficiency (TE) in the reviewed studies.

The included studies were diverse in the model specifications they applied to estimate the technical efficiency of public hospitals. Among the studies that applied DEA applications, twelve used both constant and variable return to the efficiency scale (CRS & VRS), where four applied variable return to scale (VRS), and three studies used constant return to scale (CRS). The three SFA studies used two model specifications in each to assess the efficiency scores, including Translog and Cobb-

Douglas models (Table 3.1). Considering the orientation of the technology, most of the studies (82%) relied on input orientation, aiming at minimization the health resources (inputs) for a fixed level of output. However, four studies conducted in GCC countries aimed to enhance the provision of health service by applying output orientation.

The inputs used in the efficiency analysis of the studies are presented in Table 3.1; the median was four input variables per study with a mean of 3.9 (range: 2–6 variables). Dominant inputs were the capital (number of beds) and labour (number of human forces with different professional categories) variables. Three studies (Sahin & Ozcan, 2000; Sahin et al., 2011; Jandaghi et al., 2010) used capital expenses in the inputs, and one study (Atilgan et al., 2015) comprised prices of capital and labour. Several output dimensions were used in the efficiency models: the mean was 3.7 (range: 1–7 variables), and the median was 3.5. Output variables were health care activities and direct patient services, e.g. number of outpatient and inpatient services. Seven studies used bed turnover rate (BTR), bed utilization rate (BUR) and bed occupancy rate (BOR), also five studies used the average length of stay (ALS), while one study (Sahin & Ozcan, 2000) used mortality rate in its hospitals as an output variable.

The last column in Table 3.1 shows the quality assessment scores of the four dimensions: reporting, external validity, bias, and power for each included study (see Appendix B). The mean quality score was 73%, and the median was 75%; scores ranged from 41% to 92%. The reviewed studies frequently missed points on several dimensions. In the reporting dimension, five studies lacked an explanation of the underlying economic model, and seven failed to address the limitations in their discussions. In the external validity, the model assumption and appropriateness of

the benchmarks were missing in eight studies. In the bias dimension, fourteen of the studies (64%) neither addressed nor discussed the potential presence of outliers and data accuracy. Also, only half of the studies (n=11) conducted a second stage analysis. Nineteen of the 22 reviewed studies (86%) had not generated confidence intervals of the efficiency estimates to reveal statistical power, while just ten studies conducted second-stage sensitivity analysis.

Technical efficiency (TE) estimations of the reviewed studies were varied from 0.47 to 0.98, with an average of 0.792, standard error (SE) 0.03 (Table 3.2). The average TE score was 0.778 (SE 0.104) in the GCC, where the corresponding score of the upper-middle countries was 0.796 (SE 0.031).

Table 3. 2 Technical Efficiency (TE) Scores

	Mean	Standard Error SE	Median	Min	Max
Pooled Technical efficiency TE	0.792	0.030	0.828	0.470	0.980
Pure/managerial TE	0.876	0.035	0.935	0.590	0.976
Scale TE	0.892	0.027	0.940	0.670	0.981
Data envelopment analysis DEA	0.791	0.035	0.846	0.470	0.980
Stochastic frontier analysis SFA	0.801	0.036	0.776	0.755	0.871
Upper-middle income (n=18)	0.796	0.031	0.800	0.557	0.980
High income (n=4)	0.778	0.104	0.859	0.470	0.923

Moreover, the mean estimate of pure or managerial TE (VRS) score was 0.87 (SE: 0.035), while scale efficiency was 0.89 (SE: 0.027). To examine the consistency of efficiency measurements and the effect of the model choices on the efficiency scores, we conducted a meta-analysis of the estimated 25 TE scores reported in the reviewed studies.

The Spearman's rank correlations were applied between TE and predictor variables, to test the internal validity of findings. That included; methods of analysis, orientation and specification of the efficiency models, number of inputs and outputs variables used, number of hospitals in the samples, countries of the analysis taken place and income categories in the reviewed studies (provided in Table 3.3).

Table 3. 3 Spearman's rank correlation between the efficiency scores and different characteristics of the studies

Spearman's rho		**Technical Efficiency**	**Number of Hospitals**	**Income Categories**	**Orientation of the Model**
Technical Efficiency	Correlation Coefficient	1.000	-0.519**	0.201	0.279
	Sig. (2-tailed)	.	0.008	0.336	0.262
	N	25	25	25	25
Number of Hospitals	Correlation Coefficient	-0.519**	1.000	-0.201	-0.076
	Sig. (2-tailed)	0.008	.	0.336	0.765
	N	25	25	25	25
Income Categories	Correlation Coefficient	0.201	-0.201	1.000	0.818**
	Sig. (2-tailed)	0.336	0.336	.	0.000
	N	25	25	25	25
Orientation of the Model	Correlation Coefficient	0.279	-0.076	0.818**	1.000
	Sig. (2-tailed)	0.262	0.765	0.000	.
	N	25	25	25	25
****. Correlation is significant at 0.01 level (2-tailed).**					

Notes: Income categories of the studied country (high or upper-middle); orientation of the efficiency model (input or output)

Generally, we found that the correlations were low, and some were even negative. The number of hospitals in the samples was correlated negatively with the TE

scores, indicating that the models with small sample sizes had provided higher efficiency estimates. Moreover, a logistic regression model (Table 3.4) confirmed this relationship between the number of hospitals included in the studies and the efficiency scores, with an odds ratio (OR) of 0.081 (95% confidence interval CI 0.005: 1.300; P-value = 0.07). Also, there was a significant correlation (82%) between the countries' income category and the orientation of the efficiency model. Moreover, studies conducted in high-income countries used output orientation models, which pursued the output-maximization objective while keeping inputs fixed. The studies performed in upper-middle income countries, however, used input orientation models that aimed to minimize the resources used while keeping output constant.

Table 3. 4 Logistic regression between technical efficiency scores and model specifications

Variables	Description	Odds ratio OR (95% Coefficient interval)
Methods	SFA (Ref=DEA)	0.700 (0.028;73.113)
Income Categories	High Income (Ref= Upper Middle Income)	3.337 (0.157;70.739)
Number of Hospitals	Continuous	0.081* (0.005;1.300)
Number of Inputs/Outputs	Continuous	0.436 (0.028;6.848)
Constant		4.345 (0.494;38.245)

*Notes: *P<0.10*

3.4 Discussion

The remarkable growth of healthcare expenditure in many countries during the recent decades has directed attention to the analysis of efficiency and performance of public sectors to provide policymakers with evidence-based knowledge on which

to base informed decisions (Dieleman et al., 2017; Jakovljevic & Ogura, 2016). We reviewed the studies that measured technical efficiency of public hospitals in GCC countries. Within this context, we also evaluated the effect of model characteristics on the reported efficiency scores using meta-analysis based on 25 extracted scores from the 22 studies. Most of the studies were found in six scientific databases, but this did not yield studies of GCC countries. We had to search the grey literatures like Google scholars for Gulf-focused papers, which were not found in the scientific databases since efficiency analysis is relatively a new approach of research in the Gulf region. All studies found as published literature and those sourced as grey literature were mutually exclusive. To our knowledge, this is the first attempt to conduct a systematic review and quantify the effect of model specifications on efficiency scores in the GCC states and comparable countries.

3.4.1 Techniques and orientations

The DEA was the dominant method by which public hospital efficiency was measured in the reviewed studies; however, just three studies applied the SFA method, all conducted in Turkey (Atilgan et al., 2015; Atilgan, 2016a; Atilgan, 2016b). In the Gulf region and Iran, efficiency was exclusively measured by DEA, and other systematic reviews have also found the same method to be common internationally (Hollingworth, 2003; Hollingworth, 2008). The use of DEA is justified by its capability to handle multiple input and output variables in different units, and its functional flexibility in practical application as observed in previous chapter 2 (Jacobs et al., 2006; Hollingsworth, 2014).

The reviewed studies originating from Turkey and Iran primarily applied the technology of input orientation, where output was fixed, and the researchers explored proportional reduction in the inputs. The input-orientation approach is very practical given that hospital managers and policymakers have more control over inputs than they have over outputs (health services), as shown in previous research (O'Neill et al., 2008; Pelone et al., 2015). On the other hand, two of the four studies arising from Gulf countries applied the output orientation model (Ramakrishnan, 2005; Mahate & Hamidi, 2016), while the remaining two studies employed both input and output orientation model (Helal & Elimam, 2017; El-Seoud, 2013). Hence, the health-related policy objective within the GCC was to retain the inputs and explore proportional expansion in the outputs. This approach matches the target of Gulf governments, which is to increase the provision of national and domestic healthcare services to meet the growing demands for healthcare. In such countries, this was the primary goal of healthcare development strategy plans (Albejaidi, 2010; Ardent Advisory & Accounting, 2015). Furthermore, this approach was appropriate because the reduction of the current health resources is not the priority of the Gulf nations' health strategies, at least in past years (Mahate & Hamidi, 2016; Ardent Advisory & Accounting, 2015).

The meta-analysis displayed no significant differences between the estimated efficiency in both orientations of efficiency analysis. Because of the scarcity of efficiency estimates and the related knowledge in Gulf region, we therefore encourage further investigations and more research in this area. Ideally, such study should be undertaken using a variety of technology orientations, considering goals and functions of the public hospitals.

3.4.2 Indicators

The reviewed studies often had limitations, which included aggregation of inputs, mainly in the labour category, (Ahmadkiadaliri et al., 2011) and aggregation of costs of different types of capital and labour prices (Atilgan et al., 2015). Outputs were mainly focused on healthcare activities, ignoring health outcomes and offering no adjustment for differences in the case-mix or the quality of care across the sample hospitals. This might be the reason for high-efficiency scores in some hospitals, despite a low quality of care (Pelone et al., 2015). Further limitations were heterogeneity in the sample hospital (e.g. number and size of hospitals; health activities of the hospitals), which might have affect efficiency scores since in general, the studies did not make any appropriate adjustments considering such heterogeneity. Many studies failed to describe the reasons of inefficiency, did not try to evaluate the misspecification in efficiency models and lacked internal validity of efficiency findings, which could twist the policy implications. Moreover, like Varabyova and Müller in 2016, we found that the quality assessment of the studies showed frequent failure to report production theory and the absence of justification and rationalization of model assumption choices, reporting the study limitations and existence of outliers. The earlier limitations raised many issues of accuracy, reliability and generalizability of the studies. We recommend that researchers concentrate on the efficiency model characteristics and related methodological issues and encourage transparent reporting of the relevant findings.

We observed, like others, that scarcity of data may cause many of the limitations. Most of studies included in this review selected their variables based on the availability of secondary data sources, rather than collecting new and more relevant data to construct the best possible measure of the performance (Afzali & Mahmood,

2011; Pelone et al., 2015). It has been argued by Afzali and colleagues (2009) and Hollingsworth (2003) that many hospital databases suffer from lacking data regarding a broad range of hospital functions, activities and quality of care, including preventive care, health promotion and staff developments. The Ardent Advisory & Accounting report in 2015 confirms that the same data discrepancies occur in the GCC countries. Therefore, improving hospitals' databases, through collection a high-quality data and processing techniques, the inclusion of data from different health provision levels, and capture of valid data that reflects the demand, quality of care and pattern of services around healthcare are critical steps towards better hospital efficiency studies (Afzali et al., 2009; Afzali & Mahmood, 2011). These improvements would enhance further efficiency research by indicating the weaknesses in the healthcare production process, and consequently, would guide the policy-decision makers to potential reforms in the region.

3.4.3 Meta-analysis

The findings from the meta-analysis showed no significant differences in the estimated efficiency scores, regardless of the analysis approach employed, i.e. SFA and DEA. Among the Turkish studies, three studies used SFA methods and five applied DEA. Although SFA reported higher efficiency scores, the differences were not statistically significant, and such finding was along the same lines as most previous reviews (Hollingworth, 2003; O'Neill et al., 2008).

Technically, in the DEA method, the entire distance from the decision-making Unit (DMU) to the efficient frontier (best performing DMU) measures the inefficiency. In contrast, in SFA, this distance includes both inefficiency and an estimation error.

Consequently, the inefficiency shows higher values in DEA (and lower scores) than in SFA even if when using the same data (Hossain et al., 2012). Although the choice of DEA or SFA has an impact on the results, there is no agreement in efficiency literature as to which of these two methods reflects the best practice (Jacobs et al., 2006; Hollingsworth, 2008). However, the choice of non-parametric and/ or parametric methods in analysis depends on the specification of the production function, the assumptions around the distribution of the error components, production orientations and the perspective of selecting returns to scale assumptions (Varabyova & Müller, 2016; Hollingsworth, 2008). Also, the analysis in this study found that DEA studies that applied VRS assumption reported higher efficiency scores, though not to a significant extent, compared with those which used CRS assumptions since the DEA under VRS assumption has tightly enveloped the data and more hospitals were placed on the frontier, as observed in the previous chapter (Figure 2.2) (Cooper et al., 2007; Jacobs et al., 2006).

The meta-analysis found a negative relationship between the sample size and the estimated efficiency scores, as observed in other studies (Ozgen et al., 2015; Farzianpour et al., 2012). Similar findings have been described in previous literature, which argued that inflated efficiency scores might occur with the small sample size due to sparsity problems. Sparsity problems imply that a hospital could be considered efficient just because there was no comparator within the sample (Hollingworth, 2003; Hollingworth, 2008; Kiadaliri et al., 2013). Furthermore, overestimates of efficiency scores in the DEA method can be occurred if the number of hospitals is small relatively to the number of input and output variables (Hollingsworth, 2014). Several empirical analyses have had a small sample size in comparison with the combined number of variables used and reported high-

efficiency scores (Ahmadkiadaliri et al., 2011; Hatam et al., 2010; Shahhoseini et al., 2011; Jandaghi et al., 2010; Farzianpour et al., 2012). To overcome such problems, Hollingsworth (2014) suggested that the number of units used in efficiency assessment must be at least three times the combined counts of inputs and outputs altogether. Further development for the efficiency models is required, that to meet the complexity of production functions in the public hospitals and demonstration of the efficiency findings.

3.4.4 Limitations

Although the comprehensive literature search across several databases in the current review, we might have missed some relevant scientific papers. To overcome this, we searched in the references and looked in grey literature to find more studies. The findings regarding SFA could be better justified if more than three studies had been found for critical analysis in the current review. Despite a few limitations, the study site chosen for our review (the Gulf countries) may generate strong interest among researchers, policymakers, stakeholders and academics. Another interesting point arising from the review of the Gulf studies is that the output-orientation was mostly chosen to the input-orientation, whereas studies originating in other countries commonly used the input-orientation.

Unfortunately, we found it inapplicable to report the results with forest plot as we reviewed limited number of studies (22) from 8 different countries. We found one study per country in some cases (e.g. United Arab Emirates and Oman) or two studies per country, e.g. Saudi Arabia. Also, only 3 studies applied SFA and only 4 used output orientation. Forest plot per each of these factors with the focus on

efficiency scores (dependent variable) is inapplicable in these cases. Furthermore, the nature of these efficiency studies is comparative analysis which is different from randomised trails and epidemiological studies and consequently adds further obstacle to apply forest plot. Thus, many systematic reviews and meta-analysis of efficiency studies often do not apply forest plot (for instance, Kiadaliri et al., 2013; Varabyova & Müller, 2016).

3.5 Conclusions and Recommendations

The systematic review in this chapter is the first to focus on the Gulf region and expected to participate in the body of knowledge that may be used to plan future efficiency research and policy. The review has suggested that the methodology choices and the technology assumptions exert an influence on the efficiency assessments, as found in literature reviews worldwide.

The number of studies that conducted in the Gulf region was remarkably limited, and the quality of the reviewed studies was poor in comparison with other relevant studies from other countries. The data used in the studies had considerable deficiencies for performing high-quality efficiency estimations. The GCC country studies applied the output-orientation, unlike the reviewed studies in other countries that considered the input-orientation. Assessments should, however, take the resource allocation policy in public hospitals into account while planning further efficiency analysis.

The recommendations could be useful to researchers and policymakers. To create evidence-based scientific knowledge for policymaking, research of public hospital efficiency should develop compatible, high-quality data: this should cover all

healthcare activities and services, and health outcomes. Efficiency analyses of public hospitals, which are currently rare in the Gulf region, should be conducted on a larger scale in order to create more and validated, knowledge for use in policymaking. Such new research should employ different methodologies, and assumptions and sensitivity analyses, to confirm the findings of public hospital efficiency. Researchers should make the base-case analyses considering the strategic plans and goals of the governments about resource allocations in public hospitals. Health stakeholders should utilize the knowledge arising from the efficiency studies in Gulf region to convince their policymakers to develop or amend policies following national requirements, to make the best practical use of such research in relation to policy planning and practice.

In the next chapters, we proceed to the empirical studies, including the assessment of efficiency and the determinants of efficiency in the Saudis' public hospitals in addition to quantitative analysis of stakeholder's perspectives.

Chapter 4

Evaluation of Efficiency and its Determinants of Public Hospitals in Saudi Arabia: An Application of Data Envelopment Analysis and Regression Models

Previously, Chapter 1 noted that healthcare demand and health expenditure in Saudi Arabia had grown rapidly. Chapter 2 presented the rationale of efficiency in healthcare and useful techniques of analysis. Chapter 3 summarized and assessed the efficiency measurements that have been undertaken in the Gulf region and some middle-income countries in similar settings. In this chapter, we analyze the performance of public hospitals in Saudi Arabia and identify the contextual factors that drive inefficiency using data envelopment analysis. Also, possible savings (slack-analysis), effective utilization of health resources and suggestions to improve the performance of public hospitals. In addition, we investigate the effect of the external environmental and institutional factors on the efficiency and the performance of the hospitals.

4.1 Introduction

In relation to the growing demand for health care and the expenditure, securing an efficient, equitable and effective healthcare system is both a national and global imperative. The United Nations have recognized the vital role of healthcare systems to the formulation of the UHC goals (WHO, 2019). The KSA has also experienced

substantial population growth, increased life expectancy and the proliferation of lifestyle-related diseases. These have increased the demand for healthcare services at a time of scant health resource (Khoja et al., 2017; Ardent Advisory & Accounting, 2015; Ram, 2014).

During 2016, the KSA government spending on health was 66.7% of the country's total health expenditures, which corresponds to 3.9% as a share of GDP (The World Bank, 2019). The healthcare expenditure in KSA increased by 24.7% between 2013 to 2017 (Table 4.1) (MOH, 2017; Khoja et al., 2017; Ardent Advisory & Accounting, 2015). During 2015, while public spending on health is remarkably high in comparison to several high-income countries (71.3% for KSA versus 61.2% for high-income countries), the number of hospital beds is noticeably lower (The World Bank, 2019). Only 2.7 hospital beds per 1,000 population are allocated in KSA, whereas the corresponding figure in other high-income countries is 8.9 on an average (The World Bank, 2019; Ram, 2014). In other words, the cost of each hospital-bed in the KSA is remarkably high compared to other high-income countries.

Table 4. 1 Budget appropriations for the MOH with respect to government budget (SR = Saudi Riyal)

Year	Government Budget Billion SR	MOH Budget Billion SR	Percentage of MOH to the government budget	No. of Hospitals	No. of Beds
2013	820	54.3	6.63%	268	38,970
2014	855	59.9	7.02%	270	40,300
2015	860	62.3	7.25%	274	41,297
2016	840	58.9	7.01%	274	41,835
2017	890	67.7	7.61%	282	43,080

Source; Ministry of Health; Statistical yearbook, 2017.

While many strategic plans had been undertaken to promote the efficient use of resources, this has been shown to be insufficient to meet the rising demand for health services and expenditure in the KSA (Mourshed et al., 2007; MOH Strategy Plan, 2010). The health care providers seem to find it challenging to deliver adequate health provision using current resources (Albejaidi, 2010). Considering the observed imbalance between service availability and healthcare spending, better utilization of resources is necessary to achieve efficiency in the healthcare system of KSA (MOH Strategy Plan, 2010). It is thus vital to investigate how existing resources can be used more efficiently to meet the increasing demand for healthcare services.

Globally, governments conduct efficiency assessments of their healthcare sectors to ensure that public funds are effectively utilized and facilitate the process of meeting the UHC goals (WHO, 2019). Efficiency evaluation is carried out under many concepts, such as technical, allocative, cost and overall efficiency; among these, the technical efficiency approach is most commonly used (Jacobs et al., 2006). The latter is based on Farrell's theory in 1957, which introduced a measure of technical efficiency based on the relative notion of comparing the inputs and outputs of set entities, called decision-making units (DMUs) (Farrell, 1957).

The efficiency of the healthcare system is based mainly on hospital efficiency, as hospitals are principal consumers of health resources. This was observed in a broad range of efficiency literature worldwide and discussed in the previous chapters (Hanson et al., 2002; Hollingworth, 2003; Kelly et al., 2016).

In general, there is a scarcity of empirical works and scientific studies on the efficiency evaluation of public hospitals and determinants of inefficiency in the context of KSA. In chapter 3, the systematic review of public hospital efficiency

studies in the Gulf region including the KSA has shown the number of studies to be limited. Therefore, efficiency analysis can be considered a novel approach to research in the Gulf and KSA. The review found only two studies conducted in KSA context: a study by Helal and Elimam in 2017, which assessed the efficiency of health services at districts level in the KSA; and an efficiency analysis conducted in 2013 of 20 public hospitals, under the management of the private sector, which found that around 60% of the study sample had not achieved an efficient score (Helal & Elimam, 2017; El-Seoud, 2013).

Generally, hospital efficiency has hitherto been measured by frontier analysis methods, either through non-parametric DEA or parametric SFA). These techniques compare a hospital performance against an estimated efficient frontier, which comprising the best-performing hospital (Jacobs et al., 2006; Hussey et al., 2009). Literature reviews of efficiency studies have often identified DEA to be the dominant method of public hospital efficiency analysis among studies reviewed as provided in the previous chapters (Hollingworth, 2003; Hollingworth, 2008; Kiadaliri et al., 2013; Varabyova & Müller, 2016).

The literature of efficiency highlights that the performance of public hospitals is affected not only by the internal factors but also by external factors beyond the control of the hospital management, which may have an influence on technical efficiency (Kontodimopoulos et al., 2007; Mitropoulos et al., 2016; Ahmed et al., 2019; Cheng et al., 2015). Although the external factors are not used to construct the frontier analysis (e.g. DEA analysis), their effect on efficiency measurement needs to be investigated in further analysis (Mitropoulos et al., 2016). More specifically, these external factors are represented by the environmental variables that are related to demographic characteristics of the catchment area of the hospitals, and

organizational structures (Simar & Wilson, 2007). Therefore, in the last few years, several studies on hospital efficiency have focused on examining the determinants of inefficiency (Ahmed, et al., 2019; Gok & Sezen, 2013; Cheng et al., 2015; Kontodimopoulos et al., 2007). The effects of the determinant factors on the inefficiency scores were estimated in these studies.

4.1.1 Public health sectors in KSA

The KSA government maintains full access and free medical care to all citizens in public health facilities, under article 31 of the national constitution, as described in Chapter 1 (Albejaidi, 2010). The MOH is the main provider of healthcare services in KSA, administering 60% of all provisions and consequently the leading provider of health services in the public sector (Almalki et al., 2011; MOH, 2015).

As noted in Chapter 1, the MOH delivers primary, secondary and tertiary healthcare through 2,361 primary healthcare centres and 282 hospitals, including 43,080 beds throughout the country (MOH, 2017; Almalki et al., 2011). Public (MOH-affiliated) hospitals in KSA can be classified broadly into two main groups: general and specialized hospitals. General hospitals provide a wide range of health services, while the specialized hospitals deliver health services for specific health conditions or to a particular group of beneficiaries. These public hospitals are located in various geographic locations in KSA and serve populations of different demographic characteristics and health needs, which may affect the hospital efficiency, as observed in other studies (Albejaidi, 2010; Atilgan, 2016; Al-Homayan et al., 2013).

4.1.2 Aims

This chapter aims to conduct a performance assessment of the MOH-administered general hospitals in the KSA. We measure the technical efficiency of the public hospitals and identify the sources of inefficiency, as well as estimate the optimal levels of health resources. The analysis is enriched by employing information about the hospital's geographic location and the capacity (number of beds). Then, we investigate empirically the external factors that may affect the efficiency and emphasis the environmental characteristics and organizational factors that influenced the efficiency based on the demand for healthcare services of the public hospitals. The findings will be useful to decision- and policy-makers for policy reformation to optimize the use of health resources in public hospitals and therefore improve the efficiency of healthcare systems.

4.2 Methods

4.2.1 Selection of hospitals and data sources

The application of the DEA requires a homogenous and a comparative sample that use similar inputs to produce similar outputs. This analysis focused on examining the technical efficiency for general hospitals (Jacobs et al., 2006; Cooper et al., 2007).

Efficiency literature argues that the hospitals under evaluation should be of the same type and provide the same health services and activities. This is because inclusion of divergent specialist units in the same sample would confound the results, since frontier techniques are susceptible to outliers (Varabyova & Müller, 2016; Hollingsworth, 2008). Noticeably, specialized hospitals often lack types of some

secondary service like surgical operations that rarely occur in the psychiatric hospitals. Such hospitals, if included, will appear as inefficient while surgery is considered as one of the hospital outputs (Kiadaliri et al., 2013; Hollingsworth, 2008; Pelone et al., 2015). Therefore, we excluded specialized hospitals from this analysis.

Similarly, the smallest hospitals (those with less than 100 beds) deliver primary care services and lack secondary and tertiary health services. Consequently, they miss a significant number of essential output variables, for example (inpatient services, laboratory testing and surgical operations) compared to larger hospitals. In this study, we also excluded the smallest hospitals to ensure greater homogeneity in performance evaluation across the units (Jacobs et al., 2006; Cooper et al., 2007). In Figure 4.1, the flowchart shows the selection process of the study sample.

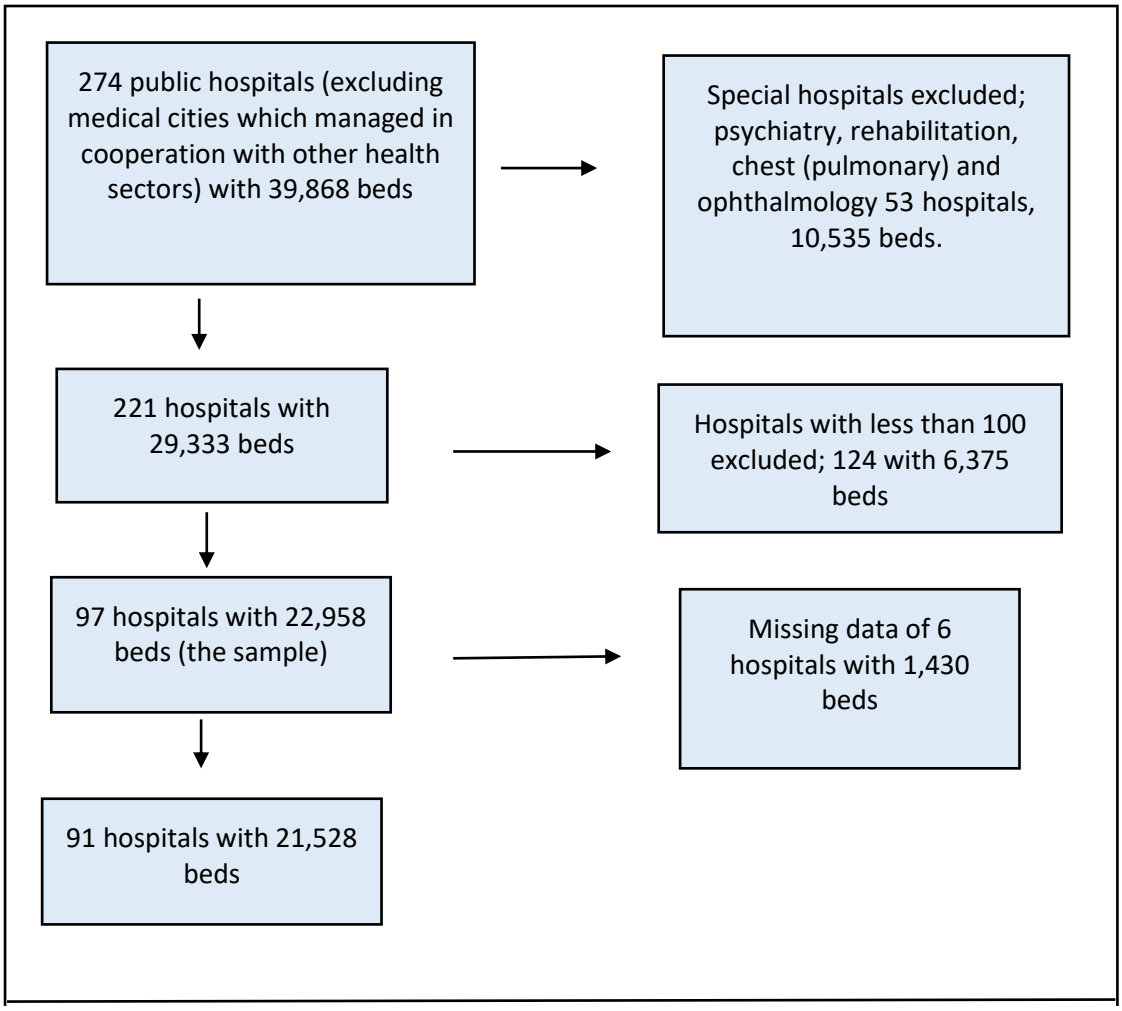

Figure 4. 1 The flowchart of inclusion and exclusion of the study's hospitals, MOH, 2017

Ultimately, the homogenous hospitals used in the analysis included 21,528 out of 398,68 (54%) of total active hospital beds that provided by the MOH in KSA. Initially, the assessment included 97 general hospitals; then, we removed six hospitals due to missing data (input and output variables were missing in 6 hospitals). The data of hospital input and output variables and population characteristics in each hospital catchment area for the year 2017 was collected from official statistics, and research databases in the Administration of Statistics and Information and Administration of Research and Studies, which affiliated with the MOH, following approval from the

designated authority as provided in Appendix A. Data collection took place from May to July 2018. The sample hospitals are located in 64 cities, affiliated to 20 administrative districts in five geographic regions, namely, central, west, east, north and south regions, as provided in Figure 4.2.

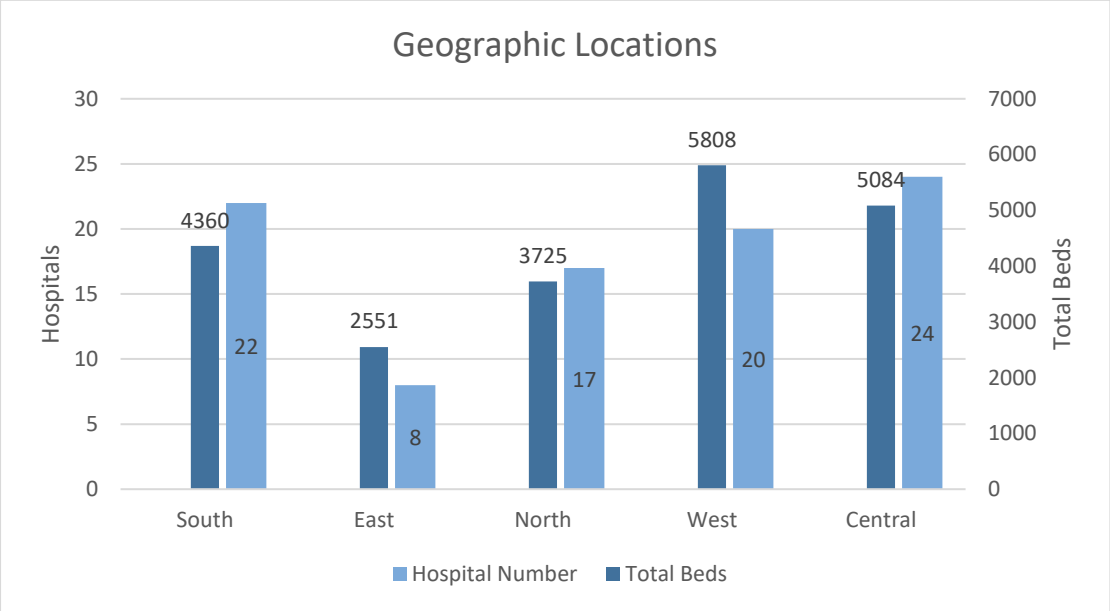

Figure 4. 2 Number of hospitals and hospital beds in each geographic location, 2017

The general hospitals in this chapter are classified into four groups based on their capacity (number of beds): small (100 to 200 beds), lower-medium (200 to 299 beds), upper-medium (300 to 499 beds) and large-size (500 or more beds) hospitals, similar to categorizations found in previous literature of hospital efficiency (Gok & Sezen, 2013). Figure 4.3 shows the number of hospitals and hospital beds in each category of capacity. The list of the included hospitals is also provided in Appendix C. However, these hospitals are affiliated, organized and financed by the MOH, and do not have autonomy in terms of funding or organizational structure. Thus, the DEA

model was applied for these 91 hospitals. After that, the efficiency scores were presented for each capacity and each geographic location.

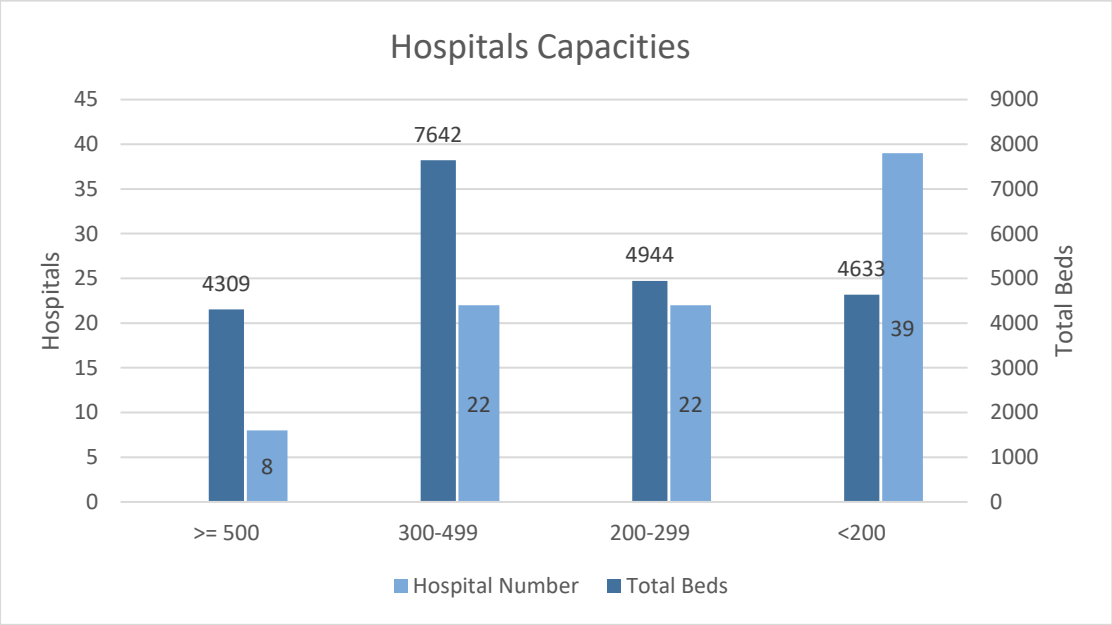

Figure 4. 3 Number of hospitals and hospital beds in each capacity, 2017

4.2.2 Input and output variables

Selection of the input and output variables is a critical step in the performance assessment because the results of any efficiency measurement depend significantly on the variables used in the estimation models. The literature has focused on capital (e.g. the number of beds) and labour (e.g. health professionals) as input variables, while some studies included consumable resources like medications (Jacobs et al., 2006; Afzali et al., 2009). The main categories of output used in healthcare-related efficiency studies were healthcare activities (for instance, number of outpatient visits, number of surgeries, inpatient services) and health outcomes (e.g. mortality rate) (Jacobs et al., 2006; Varabyova & Müller, 2016; Kiadaliri et al., 2013).

In this study, we selected the hospital outputs that depend on the selected inputs, which cover a wide range of health services and health resources used by public hospitals. Notably, four inputs and six outputs were chosen based on the availability of the data in the KSA context, which were rationally approved in previous theoretical and empirical studies (Jacobs et al., 2006; Hollingworth, 2003; Hollingsworth, 2008).

The input variables selected were: 1) the number of hospital beds; 2) the number of full-time physicians; 3) the number of full-time nurses and 4) the number of full-time allied health personnel, i.e. pharmacists, medical radiologists, midwives, health technicians and physiotherapists that were employed in the hospital. The output variables chosen in this analysis are: 1) outpatient visits (number of patients received outpatient treatment in the year 2017); 2) discharged patients (number of patients receiving inpatient medical services during a year); 3) the total number of surgical procedures during the year; 4) number of radiological investigations taken place in a hospital; 5) number of laboratory tests conducted in the hospital during the year and 6) hospital mortality rate (ratio of inpatient deaths during the hospitalization to the total number of inpatients that year). The final output variable of mortality rate is an indicator of the service quality and health outcomes in the hospitals, as argued by Sahin and Ozcan, 2000. The reduction in the mortality rate and increase quantity of life might signify an improvement in the health outcomes of the hospital under investigation. Therefore, the mortality rate could be a proxy for a weighted health quality measure in the assessment (Ahmed et al., 2019; Sahin and Ozcan, 2000). The inverse value for mortality rate (one divided by the mortality rate) is included in the estimate as an output value, meaning that the hospitals with higher mortality rate would have a smaller ratio as output values (Sahin & Ozcan, 2000). As the model assumes that outputs and inputs are isotonic, meaning that increased input reduces

efficiency and increased output increases efficiency. This correction is important; otherwise, a higher mortality rate would mistakenly contribute to a better hospital outcome (Ahmed et al., 2019).

The number of hospitals (DMUs in the DEA context) should be at least two times larger than the sum of inputs and outputs (Dyson et al., 2001). Also, Hollingsworth in 2014 suggested that the number of units used in efficiency assessment should be at least three times the total number of inputs and outputs. That is important to reduce the possibility of technical errors that may occur during analysis, for example, the sparsity problem discussed in Chapter 3. In accordance with the above-mentioned rule of thumb, in this chapter, 91 hospitals are included, which is more than three times the combined count of input and output variables.

4.2.3 External factors

After DEA analysis, we assessed the variation in the efficiency levels of public hospitals and to what degree the differences in the efficiency scores can be explained by the observed external factors (demand factors), such as health status and demographic and socioeconomic characteristics of the populations in the catchment area in each hospital. In other words, we examined the factors that influence healthcare utilization concerning the demographic and socioeconomic structure of the population variables in the catchment area of each public hospital that predict the efficiency scores.

However, the external variables, i.e. environmental and institutional factors, which were not under the control of the hospital efficiency analysis, need to be considered in the additional evaluation, as such factors are a potential source of inefficiency

(Mitropoulos et al., 2016; Muñiz, 2002). External variables are usually involved in a second phase of the analysis to explain the reasons why a public hospital is inefficient (Cordero et al., 2015). The efficiency evaluation of a hospital should explicitly include the external factors; however, it could be argued that if such variables were not involved in the evaluation of technical efficiency, the results obtained would not be operationally valid (Muñiz, 2002).

The external variables have been selected based on literature review of the efficiency analysis of public hospitals and the effect of these variables on the production of healthcare services (Cordero et al., 2015; Cheng et al., 2015; Ahmed et al., 2019). Factors that affect the efficiency of public hospitals are classified as institutional, i.e. hospital size/ number of beds, and environmental factors, i.e. demographics of population in the catchment area, socioeconomics, like poverty indicators (financial hardship), and health status, e.g. cases of chronic and infectious disease and the related treatment activities (Cheng et al., 2015; Cordero et al., 2015).

The following environmental factors, including demographic and socioeconomic factors, were selected: (1) number of population in the hospital catchment area (registered in the selected public hospitals); (2) percentage of Saudi and non-Saudi population; (3) percentage of female and male; (4) proportion of 0-5 years old children, proportion of 5-15 years old children, proportion of 15-45 years old population, proportion of 45-65 years old, and proportion of the elderly population with more than 65 years old; (5) number of populations who faced financial hardships during the treatment and required hospitalization for more than three months because of financial causes (indicator of the poverty in hospital area); (6) number of the cases supported by the public social administrations for economic

reasons within the hospital area (indicator of the poverty in hospital area); (7) cases statistics of infectious and parasitic disease, and the chronic disease cases (like, diabetes and cardiovascular diseases) that were treated in the hospital; (8) number of the dispensed prescriptions from pharmacy department in treating chronic or infectious disease; (9) geographic location of the hospital, i.e. central, western, eastern, northern and southern regions (Appendix D). All data of the external variables were from 2017.

4.2.4 First stage: Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a non-parametric approach that is based on linear programming as provided in previous chapters. It was developed for calculating the relative efficiencies of a set of comparable entities, called Decision Making Units (DMUs), which evaluated as the ratio of the total weighted output to the total weighted input (Cooper et al., 2007; Hollingsworth, 2014). In DEA, each hospital is compared against the estimated efficient frontier, which comprises the best-performing hospitals (Hussey et al., 2009; Kiadaliri et al., 2013).

DEA has been already the commonly used technique for measuring technical efficiency in healthcare. In a broad range of systematic reviews, we can observe that DEA is the predominant method for public hospital efficiency assessment (Hollingsworth, 2003; Hollingsworth, 2008; Alatawi et al., 2019). DEA is widely applicable since it does not need any a priori specification of the underlying functional form that relates the inputs with outputs. Moreover, the use of DEA is justified by its ability to incorporate multiple inputs and outputs in different units of analysis (Jacobs et al., 2006; Hollingsworth, 2014).

Several DEA models have been developed to analyze the technical efficiency based on Farrell's theory. The most well known for the DEA models is the CCR model developed by Charnes, Cooper and Rhodes in 1978, which assumes that production has constant returns to scale (CRS). Also, the BCC model developed by Banker, Charnes and Cooper in 1984, under the assumption of variable returns to scale (VRS) has also been often applied (Jacobs et al., 2006; Hollingsworth, 2003). The choice of CCR or BCC model is based on the context of problem under examination, i.e. the technology linking the inputs to the outputs in the transformation process (Jacobs et al., 2006).

Generally, the CCR model whereby the efficiency frontier has a constant slope (CRS), meaning that any change in the inputs results to an equal change in the outputs (Cooper et al., 2007). Constant returns to scale CRS may be adopted when machines are involved in the production process, which roughly means that the production outputs can be doubled by doubling the levels of inputs. However, when employees (health workers) participate in the process, then it is naive to expect that they could work at a constant rate. Nevertheless, it is suggested when DEA analysis conducted from the decision-maker point of view that aims to measure efficiency regardless of any managerial factors (Gok & Sezen, 2013).

The CCR efficiency assessment may be affected if the DMUs are not operating on the optimal scale size since the CRS does not distinguish between the scale and pure (managerial) technical efficiency (Chuang et al., 2011). If the efficiency analysis is applied from the managerial perspective, a BCC technology assumption will be more appropriate to understand if the scale of operations or provider's practice affects the productivity (Gok & Sezen, 2013; Gok & Altindag, 2015). Scale efficiency can be defined as the ratio of CRS to VRS efficiency scores and provides evidence

on whether the DMU is operating on the optimal scale size (Hollingsworth, 2003; Varabyova & Müller, 2016). Nevertheless, the efficiencies of DMUs can be comprehensively analyzed using both CRS and VRS assumption for more realistic changes in the production process, and implications in the real world (Jacobs et al., 2006; Cooper et al., 2007). Other systematic reviews have reported similar findings where studies applied both CRS and VRS assumptions in efficiency measurements. (Varabyova & Müller, 2016; Pelone et al., 2015)

Rationally, the commonly used orientations in DEA analysis are input orientation (i.e. minimization of the inputs with the given amount of outputs) and the output orientation (i.e. inputs are held constant, and outputs are proportionally increased) (Cooper et al., 2007). Previous empirical studies have argued that hospitals have relatively little control over their outputs (for instance, expanding surgical operations or diagnostic tests), but more control over the inputs (e.g. medical devices), since they have the social responsibility to provide medical care through the public hospitals in general (Chuang et al., 2011). Therefore, most studies adopt the input orientation for efficiency assessment of the hospitals (Varabyova & Müller, 2016; Pelone et al., 2015; O'Neill et al., 2008). In a few studies, the output orientation was adopted in response to specific strategic health plans of some countries aimed to expand healthcare provision during a specific period (Mahate & Hamidi, 2016; Ramakrishnan, 2005). However, in this analysis, we aim to estimate the optimal levels of the health resources without deteriorating levels of the health services that the public hospitals provide. In this way, we provide potential savings that could be made in the hospital sector to the central authorities.

The efficiency of a given hospital can be defined as the ratio of the weighted sum outputs (total virtual outputs) to the weighted sum inputs (total virtual inputs), with the

weights being obtained in favour of each evaluated DMU by the optimization process. Assuming that *n* DMUs, each using *m* input to produce *s* output. We represent the vector of inputs for DMU *j* is $X_j = \left(x_{1j}, \dots, x_{mj}\right)^T$ and the vector of outputs is $Y_j = \left(y_{1j}, \dots, y_{rj}\right)^T$.

The model (1) is formulated and solved for each hospital to calculate its efficiency score. The variables of $\eta = (\eta_1, .., \eta_m)$ and $\omega = (\omega_1, .., \omega_s)$ are the weights associated with the inputs and the outputs, respectively. These weights are calculated in a way that they provide the highest possible efficiency score (100%) for each hospital $_{jo}$ under estimation.

The input-oriented BCC model that provides efficiency for the hospital $_{jo}$ under the VRS assumption is given below:

$$
\begin{aligned}
& max\ e_{j_0} = \frac{\omega Y_{j_0} - \omega_o}{\eta X_{j_0}} \\
& s.t. \\
& \frac{\omega Y_j - \omega_o}{\eta X_j} \leq 1, \quad j = 1, \dots, n \qquad (1) \\
& \eta \geq 0, \omega \geq 0
\end{aligned}
$$

Notice that by excluding the free of sign variable ω_o from the model (1), the CCR model is obtained. The fractional model (1) can be transformed into a linear program by applying the Charnes and Cooper (1962) transformation (C-C transformation hereafter). The transformation is accomplished by considering a scalar $t \in \Re^+$ such as $t\eta X_{j_0} = 1$ and multiplying all terms of the model (1) with *t>0* so that $v = t\eta$, $u = t\omega$, $u_o = t\omega_o$.

The linear equivalent of the model (1) is formulated as:

$$
\begin{aligned}
& max\, uY_{j_0} - u_0 \\
& s.t. \\
& vX_{j_0} = 1 \\
& uY_j - u_0 - vX_j \leq 0, \;\; j = \\
& 1, \ldots, n \\
& v \geq 0, u \geq 0
\end{aligned}
\qquad (2)
$$

Once an optimal solution v^*, u^*, u_o^* of the model (2) is derived, the input-oriented BCC-efficiency $e_{j_0}^*$ for the hospital$_{jo}$ under evaluation is obtained directly from the objective function.

Banker et al. (1984) have determined the returns to scale (RTS) using the optimal value of the free variable u_o in the multiplier model (2). Given the point (x_0, y_0) that lies on the efficient frontier, the returns to scale in this point are identified by the following three conditions:

1. Increasing returns to scale (IRS) prevail at (x_0, y_0) if and only if $u_o^* < 0$ for all optimal solutions. Meaning an equal increase in all production factors (inputs) will result in more production (i.e. outputs).
2. Decreasing returns to scale (DRS) prevail at (x_0, y_0) if and only if $u_o^* > 0$ for all optimal solutions; meaning the increase in all production factors would lead to lesser production.
3. Constant returns to scale (CRS) prevail at (x_0, y_0) if and only if $u_o^* = 0$ in any optimal solutions, where an equal increase in all production factors led to the

same amount of growth in the production. In other words, these units operating on the optimum scale size or the most productive scale size (MPSS).

The DEA analysis has conducted by using Improvement management software (PIM-DEA version 3.2).

4.2.5 Second stage: Regression analysis

Descriptive statistics of the hospital efficiency score and the external factors (demand for healthcare) were presented initially, reflecting the mean values and correlation between the variables (Table 4.3). Efficiency scores were compared against each environmental and institutional variables of the public hospitals, using the Spearman's rank correlation as a non-parametric measure of statistical dependence between two variables (Greaves et al., 2012).

Several techniques have been developed to include the effect of the external factors into the production process in estimating efficiency scores through DEA. In this context, we found numerous studies which regressed the efficiency scores by the environmental variables, applying either the Tobit regression model or Ordinary Least Square estimation (Simar & Wilson, 2007; McDonald, 2009).

In this study, the Tobit regression model was employed to measure the association between the inefficiency scores and the explanatory variables (external factors). Since the efficiency scores range between 0 and 1, some of the data tend to concentrate on these boundary values (i.e., censored for DMUs with a value at one), thus, ordinary least squares might be inappropriate in this context (Kontodimopoulos, et al., 2007; McDonald, 2009; Cheng et al., 2015).

For convenience, in the Tobit regression, we assumed a censoring point at zero in the model. As a result, the efficient hospitals would have a score of zero and the inefficient ones would have a score greater than zero (Cheng et al., 2015). We transformed the CRS and VRS technical efficiency scores into inefficiency scores of CRS and VRS (McDonald, 2009; Zere, 2000) and left censoring at zero as following:

Inefficiency score = (1/Technical efficiency score) – 1 (1)

This transformation of the dependent variable (CRS scores) would, reverse the signs of the coefficients in the regression model (Cheng et al., 2015). It means that the negative coefficient of any factor with the inefficiency scores would reflect a positive coefficient with the efficiency scores.

We also applied the Two-part model to assess the effect of the explanatory factors on the CRS efficiency scores, because the Tobit model cannot adjust for the assumption that the same variables and the same parameters control censorship and non-censorship (O'Donnell et al., 2008). In the two-part model, we estimated the censorship in the first part of the model and non-censorship in the second one. In the first part, the dependent variable was considered to have a dichotomous nature for explaining the variations between the public hospitals with and without full efficiency scores. In the second part, the variations among the inefficient hospitals (scores more than zero) were explained by the independent variables.

The CRS inefficiency scores were regressed to estimate the association between technical efficiency and the selected institutional and environmental factors. The data analysis was conducted using STATA SE (version 16).

4.3 Results

4.3.1 Hospital characteristics

Descriptive statistics concerning the input and output variables of the 91 general hospitals during 2017 are presented in Table 4.2. The hospital size on average is 237 beds, with a range between 100 to 711 beds. Full-time physicians per hospital ranged from 38 to 894, with an average of 212. The number of nurses is between 74 and 1,930, and on average 495. The full-time allied health personnel ranged from 37 to 1,149, with a mean of 280.

Table 4. 2 Descriptive statistics of inputs and outputs of the general hospitals

	Mean	Standard Deviation	Min	Max
INPUTS				
Hospital beds	236.6	137.6	100	711
Physicians	212.3	168.7	38	894
Nurses	495.2	403.6	74	1,930
Allied Health Personnel	280.1	219.1	37	1,149
OUTPUTS				
Outpatient visits	72,986.5	72,475.3	1,785	466,608
Discharged patients	26,016.4	55,856.4	19	503,216
Surgical operations	2,638.4	2,151.2	172	9,464
Laboratory tests	965,840.8	1,095,415.6	794	5,512,774
Radiology Investigations	53,531.4	46,788.7	107	221,980
Hospital mortality rate	0.0224	0.0212	0.0003	0.125

Regarding the outputs, the average number of patient visits to the department of outpatient is 72,986 and ranged from 1,785 to 466,608 visits per hospital. Discharged

patients who received inpatient services during 2017 was on average 26,016, ranging from 19 to 503,216. Surgical operations were ranged from 172 to 9,464, with a mean of 2,638 surgeries per a hospital. The averages for laboratory and radiology tests are 965,840 and 53,531 respectively during 2017. The average mortality rate was 2.24%.

4.3.2 Population characteristics

The descriptive statistics of selected environmental factors of the public hospitals are presented in Table 4.3. Total number of populations of the catchment areas of the 91 hospitals are 6,609,215 persons, with the average of 72,629 and a standard deviation (SD) of 71,474 per hospital as well as ranging from 1,785 to 466,608 in each catchment area. The majority of the hospital catchment areas were Saudi populations (on average 90.7% and SD 6.05%), compared with non-Saudis (on average 9.3%). The percentage of female was higher than male, with average of 55.8% (SD 7.6%) compared with 44.2% for male. Most of the included populations were adults and the age ranged between 45 to 65 years (on average 37% and SD 12.97%), followed by 15 to 45 years old (on average 27.8% and SD 14.14%). The percentage of the elderlies (>65 years) was relatively high (average 20.5%). However, the number of children population was relatively lower than in any other age groups. Percentage of 0-5 years old children was 7%, and the corresponding proportion of 5-15 years old was 6.9%.

Table 4. 3 Descriptive statistics of environmental factors

Variable	Mean	SD	Quartiles		
			25%	50% (Median)	75%
Population of catchment area (n)	72,629	71,474	26,865	56,528	89,036
Saudi (%)	90.7	6.05	87.53	91.81	95.62
Non-Saudi (%)	9.3	6.05	4.38	8.19	12.47
Male (%)	44.2	7.6	41.05	44.77	49.51
Female (%)	55.8	7.6	50.49	55.23	58.95
Children 0-5 years (%)	7.0	7.12	2.20	4.34	8.44
Children >5-15 years (%)	6.9	3.39	4.22	6.65	8.48
Adults >15-45 years (%)	27.8	14.14	18.68	25.36	38.43
Adults >45-65 years (%)	37.0	12.97	28.21	38.82	44.49
Elderly >65 years (%)	20.5	9.89	12.20	19.13	27.39
Infectious disease (%)	17.6	14.40	3,366	8,362	16,707
Chronic disease cases (%)	82.4	14.40	27,996	47,119	91,789
Antimicrobial prescriptions (n)	480,160	678,679	45,200	156,484	597,543
Chronic-meds prescriptions (n)	1,206,603	1,695,256	94,652	326,030	1,790,810
Population with financial Hardship (n)	813	1,232	215	510	943
Population with social-economic support (n)	45954.5	6,428.9	1198	2206	4249

Furthermore, the number of infectious and peracetic disease cases in 2017 on average was 15,590, corresponding to 17.6% of total registered populations. Registered cases with chronic diseases, e.g. cardiovascular, diabetes and nervous system diseases, on average were 72,558 or 82.4% of the total population. Patients

received, on average, 480,160 (SD 678,679) antimicrobial prescriptions dispensed from the hospital pharmacy department. They also received the benefits of 1,206,603 (SD 1,695,256) dispensed prescriptions on average for chronic disease medications. However, 813 patients on average in each catchment area faced financial hardship during treatment and required hospitalization for more than three months because of economic reasons. The cases that were supported by the public social administration for economic reasons within the hospital catchment area were on average, 4,595 during 2017.

4.3.3 Efficiency analysis

Table 4.4 presents the results of the first stage analysis, i.e., DEA models, including summary statistics of the average technical (CRS and VRS) efficiency, and scale (SE) efficiency scores, as well as the return to the operation scale. The efficiency scores of the individual hospitals are provided in (Appendix C).

Table 4. 4 Technical efficiency scores and returns to the scale of the public hospitals in KSA

	CRS technical efficiency	VRS technical efficiency	Scale efficiency	CRS [N (%)]	IRS [N (%)]	DRS [N (%)]
All hospitals (n=91)						
Mean	0.76	0.87	0.87	34 (37.4)	40 (44)	17 (18.6)
Std. Dev.	0.23	0.18	0.18			
Min	0.11	0.30	0.19			
No. full score	22 (24.2%)	47	25			
Large hospitals: >=500 beds (n= 8)						
Mean	0.65	0.75	0.87	2 (25)	1 (12.5)	5 (62.5)
Std. Dev.	0.27	0.30	0.13			
Min	0.28	0.30	0.59			
No. full score	1 (12.5)	4	1			
Upper-medium hospitals: 300-499 beds (n= 22)						
Mean	0.76	0.80	0.94	7 (31.8)	5 (22.7)	10 (45.5)
Std. Dev.	0.19	0.19	0.07			
Min	0.39	0.41	0.76			
No. full score	3 (13.6)	7	3			
Lower-medium hospitals: 200-299 beds (n= 22)						
Mean	0.73	0.79	0.90	10 (45.5)	10 (45.5)	2 (9.1)
Std. Dev.	0.25	0.19	0.18			
Min	0.11	0.50	0.22			
No. full score	4 (18.2)	4	4			
Small hospitals: 100-200 beds (n= 39)						
Mean	0.79	0.96	0.82	15 (38.5)	24 (61.5)	0 (0)
Std. Dev.	0.23	0.09	0.22			
Min	0.19	0.67	0.19			
No. full score	13 (33.3)	31	13			

CRS, Constant Returns to Scale; VRS, Variable Returns to Scale; DRS, Decreasing Returns to Scale; IRS, Increasing Returns to Scale; SD, Standard Deviation.

The average technical efficiency (CRS score) for MOH general hospitals was 0.76, with the standard deviation (SD) of 0.23, which indicates that the public hospitals could decrease the use of all their inputs by 24% on average, without any reduction in the services provision. The VRS technical efficiency score on average is 0.87 (SD 0.18). The distribution of hospitals across the technical, pure technical and scale efficiency scores is shown in Figure 4.4.

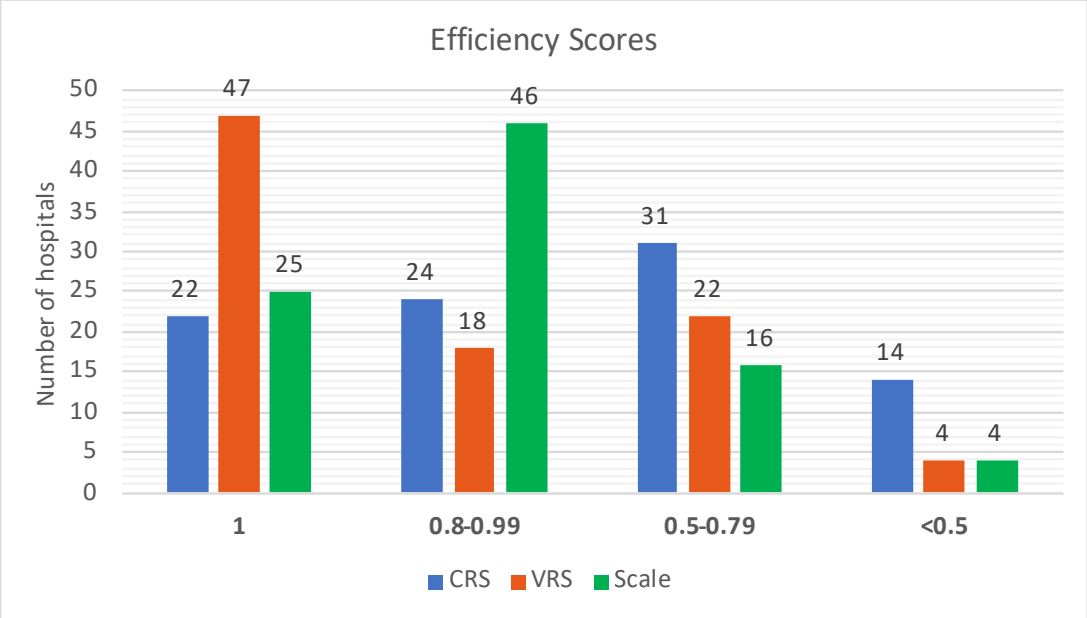

Figure 4. 4 Distribution of hospitals across technical efficiency scores of technical (CRS), pure technical (VRS) and scale efficiencies

The lowest reported efficiency score is 0.11; however, 22 hospitals out of 91 (24.2%) are efficient on both technically and scale, which indicates these hospitals utilize their inputs optimally (see Appendix C). Of the inefficient hospitals, 55 hospitals (60.4%) reported technical efficiency scores of at least 0.50 (Figure 4.4), but 14 hospitals (15.4%) reported efficiency scores below 0.50. Average pure technical efficiency (managerial efficiency) and scale efficiency scores were both 0.87 with

(SD 0.18). While 47 hospitals (52%) reported an efficient score on VRS (pure efficiency), only 25 (27%) hospitals were efficient on the scale (Table 4.3). We conducted DEA sensitivity analysis by removing one variable a t a time (see Appendix C.4). Changing in the efficiency scores of each hospital in the sensitivity analysis has validated the current model with the selected variables.

Concerning the returns to scale, we have found 34 hospitals (37.4%) operated under CRS, while 40 hospitals (44%) operated under IRS, and 17 hospitals (18.6%) under DRS. However, the hospitals that were operating on either IRS or DRS needed to adjust their capacity to operate on the optimal scale size, i.e., at the CRS, which would be required to achieve the technical efficiency.

Table 4.4 presents the efficiency scores of 91 hospitals for each capacity (hospital size category). From the capacity perspective, the small hospitals had higher levels of technical (CRS and VRS) efficiencies than the medium (both lower- and upper-medium) and the large-size hospitals. The small hospitals had on average technical efficiency score of 0.79 (SD 0.23); one-third of the small hospitals were technically and on the scale efficient. The average technical efficiency of the lower-medium hospitals was 0.73 (SD 0.25), with a higher proportion of inefficient hospitals (81.8%) than that for the small hospitals. Though upper-medium-sized hospitals reported a slightly higher average efficiency score of 0.76 (SD 0.19), fewer hospitals in this category reported an efficient score, meaning a higher proportion of inefficiencies (86.4%). The large-size hospitals were the least efficient when compared to other categories. The average technical efficiency of the large hospitals was 0.65 (SD 0.27) and only one hospital of this category was technically efficient.

Concerning scale-efficiency scores, upper-medium (0.94) and lower-medium (0.90) sized hospitals operated at a more optimal scale than small (0.82) or large-size hospitals (0.87). Moreover, 45.5% of the lower-medium hospitals operated on the CRS or most productive scale size (MPSS), followed by small hospitals (38.5%). Nevertheless, most of the remaining hospitals in these two categories, i.e. the lower-medium (45.5%) and the small size (61.5%) hospitals were operating on IRS. On the contrast, most large-size hospitals (62.5%) showed DRS, and two of them were on CRS, indicating a need to downsize the hospitals in this category to improve their technical efficiency. Similarly, 45.5% of the upper-medium-sized hospitals operated on DRS and one-third of this category was operating on CRS.

Table 4.5 shows the average efficiency scores across five geographical regions; however, that based on the analysis of all 91 hospitals together. Hospitals in the central region achieved the highest average technical efficiency score of 0.83 (SD 0.18), followed by the eastern hospitals with an average score of 0.80 (SD 0.28). Hospitals in the western region of KSA reported the least average efficiency score, 0.68 (SD 0.20).

Table 4. 5 Technical efficiency scores and returns to the scale of the hospitals categorized by geographic location

	CRS technical efficiency	VRS technical efficiency	Scale efficiency	CRS [N (%)]	IRS [N (%)]	DRS [N (%)]
South region hospitals (n= 22)						
Mean	0.75	0.89	0.83	9 (40.9)	9 (40.9)	4 (18.2)
Std. Dev.	0.25	0.18	0.23			
Min	0.11	0.41	0.22			
No. full score	4 (18.2)	13	4			
East region hospitals (n =8)						
Mean	0.80	0.85	0.90	4 (50)	1 (12.5)	3 (37.5)
Std. Dev.	0.28	0.21	0.16			
Min	0.27	0.50	0.54			
No. full score	1 (12.5)	4	1			
North region hospitals (n =17)						
Mean	0.75	0.84	0.90	7 (41.2)	9 (52.9)	1 (5.9)
Std. Dev.	0.28	0.23	0.20			
Min	0.19	0.30	0.19			
No. full score	6 (35.3)	9	6			
Central region hospitals (n =24)						
Mean	0.83	0.89	0.93	10 (41.7)	11 (45.8)	3 (12.5)
Std. Dev.	0.18	0.16	0.10			
Min	0.49	0.50	0.69			
No. full score	8 (33.3)	12	8			
West region hospitals (n =20)						
Mean	0.68	0.85	0.81	4 (20)	10 (50)	6 (30)
Std. Dev.	0.20	0.17	0.17			
Min	0.37	0.42	0.46			
No. full score	3 (15)	9	3			

CRS, Constant Returns to Scale; VRS, Variable Returns to Scale; DRS, Decreasing Return to Scale; IRS, Increasing Returns to Scale; SD, standard deviation.

On the other hand, the percentage of efficient hospitals in the north (35.3%) and the central (33.3%) regions were higher than in other areas. The eastern, southern and western regions had a higher proportion of inefficient hospitals. Both central and southern regions reported a relatively higher VRS (pure-technical) efficiency score of 0.89. In the terms of scale efficiency scores on average, the central region hospitals (0.93), and the hospitals in the north- and east (both 0.90) were operating at a more optimal scale size than those in the west (0.81) and the south (0.83) region hospitals. Half of the sample hospitals in the eastern region were operating on CRS or (MPSS), followed by hospitals in the central and north region hospitals (both 41%). The analysis also revealed that 52.9 % of the northern region hospitals were operating on IRS, while 37.5% of the east region hospitals were operating on DRS.

4.3.4 Slack amounts

The performance analysis identified the slacks, which were either excess inputs utilization or shortages of output production. Thereby, inefficiently used inputs or not sufficiently produced outputs could be determined by the health care management. Table 4.6 revealed the average amount of slack in hospitals that were deemed inefficient. These findings represented the combined scores of slack for all inefficient hospitals, considering each input and output. The actual and target values of inputs and outputs, as well as the percentage of change in each hospital, are provided in Appendix C. Table 4.6 also shows the proportion of change (slacks) in the number of inputs or outputs on average that required to eliminate the inefficiencies and achieve target levels.

Table 4. 6 Slacks evaluation for inefficient hospitals

Input slacks	Mean (SD)	Percentage of change
Hospital beds	48.4 (76.6)	-20.4%
Physicians	47.5 (72.6)	-22.4%
Nurses	102.9 (173.1)	-20.8%
Allied Health Personnel	58.38 (98.3)	-20.84%
Output slacks		
Outpatient visits	8866.1 (23712)	12.2%
Discharged patients	3700.6 (8214.2)	14.2%
Surgical operations	282.6 (730.9)	10.7%
Laboratory tests	66105.6 (140332.4)	6.8%
Radiology Investigations	2204.6 (6944.1)	4.1%
Mortality rate	0.006 (0.014)	21.7%

Regarding the inputs, results show that an excess of physicians was the leading cause of inefficiencies in public hospitals. A feasible and achievable reduction in the number of physicians was, on average, 22.4% of the current number of physicians (compared with the quantities presented in Table 4.2). The next most considerable slack was observed in the allied health personnel with an excess utilization by 20.8%. The surpluses of hospital beds and nurses were also important sources of inefficiency and should be reduced by on average 20.4% and 20.8%, respectively. In addition to input reductions, the average number of services should be increased to meet targets.

The average number of outpatients and hospitalized inpatient could be increased by 12.2 % and 14.2 % respectively, to meet the target efficiency. Surgical operations conducted within these hospitals should be increased by 10.7%. Moreover, the

laboratory and radiological tests should be increased by 6.8% and 4.1% respectively, to enhance the efficiency of the hospitals. Furthermore, the quality of health services in public hospitals could be improved by decreasing the mortality rate of hospitals from 0.0224 to 0.0162. The public hospitals thus should consider the need to deliver health services to more patients through the effective utilization of their existing resources.

4.3.5 Second-stage analysis

We estimated Spearman rank correlations between the inefficiency scores [(1/TE) – 1] of CRS, VRS and scale efficiency and the external and environmental variables in Table 4.7.

Table 4. 7 Spearman correlation of inefficiency association with external variables

External factors	CRS	P-value	VRS	P-value	Scale	P-value
Population (n)	-0.3416	0.0009	-0.0558	0.5991	-0.3606	0.0004
Hospital bed (n)	0.1029	0.332	0.4398	0.00	-0.1626	0.1236
Non-Saudi (%)	0.048	0.6514	0.097	0.3605	0.0494	0.6419
Female (%)	-0.1869	0.0761	-0.0464	0.662	-0.2130	0.0427
Children (0-5 years) (%)	-0.4763	0.00	-0.2083	0.0476	-0.5310	0.00
Adults (15-45 years) (%)	-0.0626	0.5558	0.0603	0.5699	-0.0987	0.3518
Elderly (>65 years) (%)	0.0936	0.3776	-0.0603	0.5704	0.1271	0.2298
Infectious disease (%)	-0.5521	0.00	-0.3643	0.0004	-0.5300	0.00
Anti-microbial pres. (n)	-0.0876	0.4092	-0.0152	0.8864	-0.0027	0.9797
Chronic dis. pres. (n)	-0.0764	0.4715	0.0135	0.8991	-0.0275	0.7957
Financial hardships (n)	-0.4694	0.00	-0.2343	0.0254	-0.5261	0.00
Social support (n)	-0.2450	0.0193	-0.0292	0.7838	-0.3220	0.0019

CRS, constant return to scale; VRS, variable return to scale; Non-Saudi, percentage of non-Saudi; Female, the proportion of female; Infectious disease, percentage of infectious diseases, Anti-microbial pres., amount of antimicrobial dispensed medications; Chronic dis. pres., chronic medications dispensed; Financial hardships, the number of the population faced financial hardships; Social support, a number of received benefits of social-economic support.

The analysis of inefficiency scores against the environmental factors shows that 6 out of the 12 factors had a significant correlation at risk levels ranging between 1% to 10%. Nevertheless, the external variables were more associated with CRS and scale inefficiency in comparison with VRS inefficiency (4 variables were significant).

The most significant associations were between inefficiency scores and population statistics in the catchment areas, proportion of children, the prevalence of infectious diseases, and the number of populations who faced financial hardships during the

treatments. Also, there were significant associations between efficiency scores and the percentage of women in the catchment area and the presence of population in need of social-economic support.

It was observed a strong and significant association between VRS efficiency score and the number of hospital beds (capacity). We applied the Breusch–Pagan test which showed the coefficient of 1.43 (p-value of 0.157), indicating the absence of heteroskedasticity among the variables (Appendix D). Also, the correlation matrix (Appendix D.3) showed an absence of multicollinearity between the independent variables.

The Tobit regression analysis was employed to relate technical inefficiency scores to the external variables, while we controlled for the hospitals' geographic location. We also applied the Two-part model to control censorship and non-censorship, which could not be addressed in the Tobit model. The results are presented in the Table 4.8.

Table 4. 8 Tobit regression and Two-part model analysis (N=91)

Explanatory variable	Tobit model	Two-part model	
	Coefficient (SE)	1st part	2nd part
		Coefficient (SE)	Coefficient (SE)
Population (n)	-0.548***(0.179)	-12.568*(7.199)	-0.343 (0.259)
Female (%)	0.030 (0.020)	-0.296 (0.270)	0.016 (0.024)
Non-Saudi (%)	0.029 (0.021)	0.255 (0.295)	0.029 (0.023)
Children (0-5 years) (%)	-0.058**(0.029)	-0.100 (0.264)	0.041 (0.042)
Adults (15-45 years) (%)	0.034***(0.013)	0.145 (0.146)	0.039***(0.014)
Elderly (>65 years) (%)	0.040**(0.018)	0.213 (0.210)	0.069***(0.021)
Infectious disease (%)	-0.041***(0.015)		
Anti-microbial pres. (n)	0.109 (0.075)	0.472 (0.528)	0.020 (0.062)
Chronic dis. pres. (n)	-0.222**(0.100)	-0.743 (0.751)	-0.298***(0.109)
Financial hardship (n)	-0.506**(0.197)	-19.054*(11.473)	-0.487**(0.235)
Social support (n)	0.489**(0.193)	10.443* (6.305)	0.495**(0.231)
Region Category			
Middle	0.183 (0.506)	16.495 (2621.05)	0.240 (0.567)
North	0.137 (0.545)	9.223 (2621.03)	0.566 (0.615)
South	0.370 (0.496)	11.972 (2621.04)	0.237 (0.564)
West	-0.007 (0.508)	4.765 (2621.02)	-0.023 (0.574)
Constant	4.165**(2.040)	40.710 (2621.12)	4.325*(2.603)
var (CRS)	0.970 (0.166)		
LR chi2(15)	63.89	85.22	2.17
Prob> chi2	0.00***	0.00***	0.021**
Pseudo R2	0.238	0.846	0.193
Log-likelihood function	-102.285	-7.719	-94.416

*A negative coefficient indicated a positive association with CRS, and a positive coefficient meant a negative association with CRS. SE, standard error. Non-Saudi, percent of non-Saudi; Female, the proportion of female; Infectious disease, percentage of infectious diseases, Anti-microbial pres., amount of antimicrobial dispensed medications; Chronic dis. Pres., chronic prescriptions dispensed; Financial hardship, a number of the population faced financial hardship; Social support, number received benefits of social-economic support. * Significant at the 0.10 level, two-tailed test. **Significant at the 0.05 level, two-tailed test. ***Significant at the 0.01 level, two-tailed test.*

Regarding the environmental factors, number of catchment population (p= 0.003) and percentage of children (0-5 years) in the hospitals' catchment area (p= 0.047) were statistically significant and the assumed negative signs with technical inefficiency indicating that the hospitals with high population density and more proportion of children in the catchment area, have higher efficiency scores. The negative coefficients, in the Tobit model, indicate a positive association with CRS scores, where positive coefficients mean negative association with the CRS scores. Nevertheless, the proportions of adults (i.e.15-45 years) and elderly (>65 years) in the catchment populations exhibited a significant association with positive sign (p= 0.009) and (p= 0.025) respectively, indicating that the hospitals with a higher percentages of adults and elderly were inefficient. However, the percentage of female (p= 0.132) and non-Saudi (p= 0.161) in the catchment populations had no significant association with inefficiency scores.

Number of populations with infectious diseases (p= 0.007) and number of chronic medication prescriptions that dispensed from pharmacy departments (p= 0.029) were statistically significant with negative associations to the technical inefficiency. It indicates that the hospitals that served patients with infectious diseases and dispensed more chronic medication prescriptions achieved higher efficiency scores. However, antimicrobial prescriptions show no such association (p= 0.151).

The number of populations that faced financial hardships during the treatment was statistically significant with inefficiency scores (p=0.012), and the negative coefficient was indicating that more populations with financial hardships in the catchment areas experienced a higher efficiency. Moreover, the number of populations who received financial support from social administration were statistically significant with the inefficiency scores (p=0.013).

The first stage of the two-part model found that number of populations in the catchment area (p= 0.081), the number of population who faced financial hardship (p= 0.097) and those who received financial support (p= 0.098) were significantly associated with hospital efficiency. In the second stage of the two-part model, the financial hardship cases (p= 0.039), financial support (p= 0.032) and the chronic prescriptions (p= 0.007), in addition to the proportion of elderly (p= 0.001) and adult (p= 0.008) populations showed significant association with the efficiency scores. Our control variable, i.e. geographic locations of the hospitals (institutional factor), showed no significant association with the technical inefficiency scores in any of the regression models.

4.4 Discussions

This chapter evaluated the technical efficiency of the public hospitals in the KSA, using data envelopment analysis. Also, we measured the effects of the external factors of the hospitals (environmental characteristics of the population in the catchment areas) on the technical efficiency. The analysis revealed that 75% of sample hospitals could not utilize their intact resources to generate the specified outputs. The average technical efficiency (CRS score) was 0.76, indicating that the hospitals could produce their current level of outputs (health services) with 76% of inputs (health resources), and thereby achieve efficiency. The efficiency scores ranged from 0.11 to 1.00 (Figure 4.4), revealing considerable variations in efficiency scores among the public hospitals.

Furthermore, the average VRS technical efficiency and scale efficiency scores were both 0.87. This finding indicated that the inefficiency might be due to administrative

gaps to overcome the limitations in managing internal operations in the hospitals and the external environmental factors. Notably, a study by Helal and Elimam in 2017, which assessed the efficiency of health services at district level in KSA based on the MOH data in 2014, found the average efficiency score to be (0.92), and 45% of the health districts had achieved the technical efficiency score. Furthermore, the efficiency analysis of 20 public hospitals, under the private sector managements in KSA, found that 60% of the study sample had not reached the efficient score, with an average score of 0.84 (El-Seoud, 2013).

4.4.1 Capacity (Hospital size)

The results presented here of this study suggest that the small hospitals were relatively more technically efficient than medium-sized and large hospitals (Table 4.4). Other efficiency studies reported similar findings; for example, Gok and Sezen in 2013 found that small hospitals achieved higher efficiency scores than medium and large-sized ones. This might be due to the different locations and missions of small and large hospitals (Gok & Sezen, 2013; Gok & Altindag, 2015). In this study, small hospitals were mainly located in peripheral cities and towns in KSA, which lacked other providers of public or private healthcare. Service provision in these hospitals might be relatively high compared to the health resources used. Nevertheless, large-size hospitals (500 or more beds) tended to be in larger cities in urban areas, where many other health providers shared the delivery of healthcare in the areas with high-density of population, which might have caused a relatively decreased level of health service production in respect to the inputs used.

Regarding the different missions (activities) of each category, the large hospitals consumed a huge amount of resources to meet the various requirements of comprehensive care (Gok & Sezen, 2013). Some of these were teaching hospitals, though teaching activities were not counted in the outcome measurements and appeared to be inefficient (Afzali et al., 2009). In such large hospitals, treatment processes may be more complicated, and some of the production activities of these hospitals could not be measured as the hospital outcomes (Shahhosini et al., 2010).

The findings showed that 57 hospitals (62.6%) were operating at non-optimal scale size, 44% were operating on the IRS, while 18.6% were on DRS (Table 4.4). This showed that the efficiency of healthcare in KSA might be enhanced through downsizing the hospitals on DRS and reallocating these resources in the hospitals operating in the IRS. Furthermore, five out of the eight large hospitals (500 or more beds) were operating on DRS, suggesting that in order to improve efficiency, they needed to reduce their capacity. This findings and suggestions were supported by other research findings (Kiadaliri et al., 2011).

Moreover, this study found that 61.5% of the small hospitals had been operating on the IRS and none was on DRS. It can thus be argued, like Kiadaliri and colleagues (2011), that increase of the capacity (inputs) of this category would be increased by reallocating resources from the larger hospitals for improving efficiency. The efficient scale of public hospitals was observed in medium-sized hospitals (200 to 499 beds). While half of the hospitals located in the eastern region were operating on the most productive scale size (CRS), three of them were operating on the DRS. More than half (53%) of the hospitals in the north were operating on IRS, where 30% of western region hospitals that reported the lowest efficiency scores, were operating on DRS.

4.4.2 Geographic location

This analysis found that hospitals located in the western region were less efficient than hospitals located in other regions. The hospitals in the central region appeared to be the most efficient. Atılgan in 2016 reported in the same line as these findings, i.e. location-specific variances in efficiency scores for the general MOH hospitals in Turkey. Literatures argued that this could be due to case mix and/or case severity differences between hospitals (Atilgan, 2016). It is observed that five out of eight large hospitals in our sample were located in the west region. It could be argued that hospitals in the western region might be treating more complex and/or severe cases than hospitals in the other regions, which might have led to different levels of efficiency scores in hospitals across regions in KSA (Kiadaliri et al., 2013). Another explanation could be that the hospitals in this region consumed more inputs in anticipation of the annual pilgrimage season, for which the government of KSA allocates more resources to these hospitals.

Regardless of the capacity or location-based performance differences, improving the scale efficiency of hospitals would require long-term efforts, reflected in amendments to health policies, strategic plans and the autonomy of hospital-managers (Kiadaliri et al., 2011). The prevailing accessibility of health services should not be worse while reallocating the resources to the other hospitals until the Pareto optimality was achieved (Jacobs et al., 2006).

Use of the DEA can identify sources of inefficiency through the slack analysis, which made it possible for hospital managers and health policy-makers to reach informed decisions (Gok & Altindag, 2015). This analysis showed that the number of full-time physicians was a slightly higher notable reason for inefficiency than other factors, with an average excess of 22.4%, from an input perspective (Table 4.6 & Appendix

C.3). Other inputs in labour variables that showed an excess in use were in the number of nurses and the allied health personnel, in addition to the excess number of hospital beds (capital variable). The analysis also revealed that shortage of outputs production, e.g. hospitals needed to increase the number of outpatients and hospitalized inpatient services on average by 12.2% and 14.2% respectively, to be technically efficient.

For instance, the hospital 43 (H43) achieved technical efficiency score of 81% (see Appendix C). To improve the efficiency, this hospital is required to decrease the number of beds (capacity) by 5%, physicians by 18%, nurses by 6% and the allied health personnel by 5%. This hospital (H43) should also increase the number of surgical operations by 28% and laboratory investigations by 25% as well as improve the quality in health care services by reducing hospital's mortality rate, as provided in Appendix C.

Given these findings, health policymakers may consider redeploying the labour forces from inefficient hospitals to more efficient ones. Public hospitals can consider taking measures for utilizing existing beds effectively to increase the efficiency (Gok & Altindag, 2015; Kiadaliri et al., 2011). Such actions can be undertaken as we observed in this study that many large hospitals had been operating on DRS, while most of the small hospitals were operating on the IRS (Table 4.4). However, healthcare administrators must assess the legal conditions and regulations for the effective use of medical capacity in light of the findings of the slack analysis.

4.4.3 Determinants of efficiency

The second-stage analysis explained the differences in technical efficiency levels of the public hospitals by the external factors (institutional and environmental characteristics of the population in the catchment areas) of the hospitals and estimated the magnitude of their influence. This investigation is essential in identifying the factors that affect the performance of these hospitals and in creating evidence for formation the relevant health policies to achieve the optimal level of health resources (Alvarez & Crespi, 2003).

The Spearman correlation results showed strong associations between inefficiency scores (CRS, VRS, and scale inefficiency) and most of the external variables. Furthermore, the Tobit regression and Two-part models exhibited that the environmental and institutional factors had a significant influence on the inefficiency scores. The hospital efficiency scores were significantly associated with the population's density in the catchment area (Coef. -0.548, 95% CI: -0.904; -0.192). In other words, hospitals with larger catchment populations had a higher chance to be technically efficient. Similar findings were observed in other studies (Ahmed, et al., 2019; Chen, 2016). The reason of such association could be explained by that the higher population density and related several healthcare needs might be the major drivers of the demand for healthcare and subsequently higher utilization of many health services in public hospitals (Lu et al., 2007). This increased utilization in response to the higher demand might have increased the services production from a given hospital (hospital outputs) and lead to higher efficiency scores consistent with technical efficiency definition by Farrell (1957).

On the other hand, the resources/inputs allocation in the public hospitals, which were used to produce the hospital outputs, might not have done in view of the size of the

population in the catchment area, but was affected by the hospital capacity (number of beds). Hence, there are possibilities of wastage of health-resource in the hospitals with small catchment population, which could affect the efficiency scores significantly (Ahmed et al., 2019). We also observed that, though the proportion of female and non-Saudis in catchment area showed an association with efficiency scores in the correlation model, the Tobit regression did not confirm these associations.

The analysis presented that hospital efficiency scores were associated significantly with the percentage of children with a negative coefficient (meaning higher efficiency), but in positive coefficients (meaning lower efficiency), with adults and elderlies, meaning that the older age groups had opposite effects on efficiency scores (Tables 4.7 & 4.8). It means that the efficient hospitals had a higher proportion of children, but lower proportion of adult and elderly (Tobit model and the 2nd part of the two-part model). It can be argued that these children (0-5 years) might have a higher level of morbidity and a higher need and demand for healthcare services, especially in their early years of life, which resulted in more health services utilization in the hospitals (Klitkou et al., 2017). Numerous types of hospital services were utilized mainly by the children compared to older patients, for example, immunization services in the outpatient department in the hospitals. Nevertheless, we found that public hospitals with a large percentage of adults and elderly in their catchment areas had a higher chance of the inefficiency. These findings were in the line with some previous studies (Cordero, 2015).

The Tobit model indicated a strong association between the percentage of the population with infectious diseases and inefficiency scores (coefficient -0.041, p=0.007). A similar association was found between efficiency scores and number of dispensed prescriptions for chronic medications (coefficient -0.222 p=0.029). It

indicates that the public hospitals that served more patients with infectious diseases and dispensed more chronic medication prescriptions, lead to higher efficiency scores. The probable demonstration could be found in the treatment process of infectious disease in the hospitals; meaning these patients often required acute treatment during short period, like one visit to an outpatient clinic followed by initiation of the antibiotic course for each patient. In contrast, the chronic disease patients who required further comprehensive treatment, but over a longer period of several months in some cases based on the clinical needs, might have consumed a smaller number of services, given health resources, which, thus, contributed to less technical efficiency of the hospitals.

Chronic disease prescriptions were gradually growing due to the increasing prevalence of cases, particularly diabetes and hypertension in Saudi Arabia (Chapter 1) (Ardent Advisory & Accounting, 2015; Almalki, 2011). These common chronic diseases required medication treatment during the lifetime of the patients and, thus, prescriptions were dispensed from the pharmacy department in each public hospital. This number of dispensed medications for chronic disease, was one of the critical hospital outputs in the KSA, which improved the overall performance of the hospitals.

The populations who faced financial hardships and those who received financial support from the social administration in the catchment areas, as indicators of poverty, were associated significantly with inefficiency scores ($p=0.012$ and $p=0.013$). Thus, it implies that the public hospitals serving a higher percentage of the population in poverty were relatively more efficient than the hospitals with a lesser proportion of such people. Similar findings were observed by other researchers and justified that the poorer people utilized more services due to free access to public hospitals (Hafidz et al., 2018). Further, many studies argued that the poorer people

appeared to be more frequently in illness and need more healthcare services (BMA, 2017). The findings could be attributable to the fact that public hospitals were more utilized by deprived people than the wealthier, which facilitated more service production compared to the hospitals with a lower proportion of patients with poverty (Hafidz et al., 2018; Sun & Luo, 2017).

4.4.3 Policy implications

During recent years, KSA has been facing the global trends of rising healthcare costs in addition to the high growth rate of population and high prevalence of chronic diseases. The government thus realized that the current healthcare financing system with oil revenue is unsustainable (Al-Salem, 2018). It, therefore, can be argued that the optimal use of the existing health resources, which is a fundamental requirement for achieving UHC advised by WHO in 2010 can appropriately be applied for KSA context. The application of these findings is useful for the high-income states, and the Gulf countries in particular, which have similar health financing systems and comparable demand for health services, as provided in Chapter 3 (Ardent Advisory & Accounting, 2015; Ram, 2014; Alatawi et al., 2019). The findings from this current analysis of KSA public hospitals showed that there is a broad scope for improving efficiency in the utilizing healthcare resources in the hospital sector.

The efficiency in the health resource allocation should be improved by considering the different demographic and socioeconomic indicators, as well as the health status of the catchment populations (i.e. population density, poverty, health indicators and service utilization) (Chen, 2016). The MOH should pay more attention to equality based on different population characteristics when building and amending the health

policies and planning (Graham, 2018). It is vital to ensure the appropriate allocation mechanisms of healthcare resources and to improve the utilization of health services in the target populations for securing efficient and equitable health services to achieve the universal healthcare coverage (Graham, 2018).

The policymakers should consider the appropriate usage of resources within hospitals, as well as the reallocation of resources across hospitals, given the findings of the research in public sector efficiency and responding to the healthcare needs of the population (Sutton & Lock, 2000). To improve healthcare outcomes, it is required to reduce the gap between health care provision, health status and population needs and more attention should be paid to the hospitals that serve high-density populations, more children, and a higher percentage of poverty and high incidence of infectious diseases (Sutton & Lock, 2000). Also, it is important to engage the primary healthcare centres in supporting health service provisions, especially in terms of infectious disease control and the follow-up of the chronic disease cases, e.g. diabetic and hypertensive patients, in the region (Mitropoulos et al., 2016). Such policy and practice initiatives may support the efficient use of healthcare resources to guaranteeing the best value for money, which should contribute significantly towards achieving the UHC in KSA.

It is important to comprehend the contributions of the external factors and population demands to the efficiency of healthcare services since they significantly influence health care utilization towards efficiency. We encourage the healthcare stakeholders to understand both the supply- and demand-sides of the healthcare system. Moreover, future research must consider the specific population needs and service profiles of the public hospitals, as well as the influence of the need for accessibility and utilization of healthcare services. Conducting further technical and allocative

efficiency research should consider environmental and institutional factors specifically for each category (based on capacity and locations) of the hospitals. Additionally, it is vital to indicate the current weaknesses in healthcare production processes to guide policymakers in potential reforms of healthcare policies and directives.

It had been argued by Afzali and colleagues (2009), and Hollingsworth (2003) that many hospital databases consist of inadequate data on a broad range of hospital functions and care, e.g. preventive care, health promotions and staff development activities. Improving hospital's databases through high-quality data collection and processing techniques - including data from different provision levels, capturing accurate data that reflects the severity of cases and relevant health services, quality of care and pattern of activities are highly important. Such concern about databases was observed in a broad range of publications and was discussed in the previous chapter (Afzali et al., 2009; Afzali et al., 2011). Such improvement would facilitate additional efficiency research by indicating the weaknesses in healthcare production processes; consequently, it would guide policymakers in potential reforms of health policy and directives in the KSA.

4.4.4 Limitations

This study faced challenges of finding data on economic values of the inputs, also lack of data on severity of cases, case mix and the quality of services of the output variables. However, we could use the mortality rate as the proxy for the quality of services, as observed in broad range of literatures. Also, it was challenging to find data on the poverty headcount or proportion of people who living below the poverty

line in the catchment areas, as this information was not available in either Saudi or the global data sources (e.g. World Bank). Therefore, we used two variables as the poverty indicators in the hospital area: number of populations who faced financial hardships during the treatment and number of cases investigated and economically supported by the public social administrations in KSA.

The catchment population statistics that referred to the number of populations in the hospital's area, who registered in the relevant (nearby) public hospitals. The number of catchment population might be inaccurate from time to time and difficult to measure exactly, as patients often referred themselves to the hospitals that were closer to the patients' residence or more easily accessible, rather than those to which they were assigned, especially in a high-density urban area where many hospitals were located in the city. The borderline between the secondary care facilities and the primary centres was often unclear due the absence of the referral system in KSA. Also, many hospital variables for DEA and second-stage analysis were missing in several hospital, which resulted in excluding six hospitals from our analysis. Thus, development of the information health system is critical to optimize the hospital records and future assessments.

The analysis of this chapter used two stages i.e., DEA analysis to assess the efficiency and the determinants of efficiency in the public hospitals, similar to the methodology approaches of several literature in this context. In some studies, the bootstrapping DEA was also applied to obtain the bias corrected estimates and the confidence intervals of efficiency scores as well as to overcome the correlation problem of efficiency scores and to provide consistent inferences in explaining the determinants of health care (Assaf and Matawie, 2009). We, in this study conducted several analysis to address the possible biasness. We applied DEA sensitivity

analysis (Appendix C), heteroscedasticity test and multi-collinearity test (Appendix D) to identify any possible biased estimations in DEA and found no such problems in the data. In addition, in our regression models (second stage analysis), we tested the inferences about the effects of external variables using. Application of bootstrapping was thus not necessary in this context.

The efficiency assessment is devoted on how to utilize the resources of the health sector optimally to provide the current levels of health services. Consequently, we rationally adopted input orientation in the measurement. However, the DEA methodology also permits the assumption of the output orientation. The analysis did not apply output-oriented DEA models because outputs of a different type (like, product manufacturing) than the ones used in the current study (health services) would need to be available.

This chapter provides the optimal levels of resources that render efficient for each hospital, given the health services levels that each one provides. After estimating the optimal levels of resources, a different and important assessment of examining the allocation of health resources among the hospitals is needed in future research. Regardless of these limitations, the study site (KSA), and sources of data might create strong interest among policy-makers, researchers, and academics. It should be noted that this is first research study of the technical efficiency based on official data from KSA, that has considered public hospital capacities, geographical locations and population characteristics.

4.5 Conclusions

The study showed that inefficiency exists in most of the public hospitals, and they could reduce their inputs by 24% without any reduction of the service provision.

Small-sized hospitals and hospitals in the central region of KSA were relatively more efficient. Moreover, a high proportion of hospitals were operating at non-optimal scale size, while an efficient scale of the operation was found in medium-sized hospitals.

The DEA findings suggest that it would be helpful to adjust the production capacity by downsizing hospitals operating on DRS and reallocating the related resources to hospitals on the IRS, as found in the scale analysis. Performance analysis shows that the surplus of the health workers and a shortage of health services to be significant causes of inefficiency, implying that health care managers might redeploy the labour forces for the effective utilization of medical capacity.

The findings from second-stage analysis indicate that the efficiency scores of public hospitals were associated significantly with the population’s density of the catchment areas, the percentage of children, populations in need, infectious diseases cases and the number of dispensed prescriptions. Worldwide, MOHs should pay more attention to the performance of public hospitals, considering the healthcare needs and demographic characteristics of the catchment populations.

The possible reallocation of health resources must take place without compromising patients' current access to public hospitals and considering demographic and socioeconomic factors of the population Any improvement in the scale efficiency would require long-term efforts by the adjustments of the health policies and goals as well as securing the autonomies of the hospital's management. This will require further collaboration on health administrative, policy-planning of resource allocation and daily operations management to meet the administrative gap to overcome the external factors and managing the internal operations of the hospitals.

Further assessment and research are needed in technical and allocative efficiency spheres in addition to the determinants of efficiency to generate evidence-based knowledge focused on the causes of inefficiency and challenges in healthcare products in the public sector and to guide the possible reforms of the health policies and goals for public hospitals in KSA and the globe.

Chapter 5

Factors Influencing the Efficiency of Public Hospitals in Saudi Arabia: A qualitative study Exploring the Stakeholders' Perspectives and Suggestions for Improvement

In the previous chapters, we discussed the performance evaluations of public hospitals in the Gulf region and similar countries. In Chapter 4, we estimated technical efficiency of public hospitals using Data Envelopment Analysis with the consideration to hospital capacity and geographic location. Then, we assessed the determinants of hospitals' efficiency and focusing on demographics and socio-economics characteristics of the population of the catchment areas of the hospitals that contribute to better understand the demand of health services. This qualitative chapter contributes to strengthen the validity of the earlier quantitative assessments and fill in possible gaps in available literature on hospital efficiency. Chapter 5 aimed to explain the production process in the public hospital, highlight potential weakness and create information tools based on the scientific knowledge for providing feasible recommendations.

5.1 Introduction

The Kingdom of Saudi Arabia (KSA), has experienced a substantial increase in population growth and lifestyle diseases, which have increased the demand for health services and health spending during the past years (Khoja, 2017; Ardent Advisory & Accounting, 2015; Ram, 2014). Public expenditure on health was 67.8% of total health expenditure, corresponds to 3.9% of GDP in 2016. Such expenditure increased in health by 24.7% between 2013 and 2017 (MOH, 2017; World Bank, 2019).

Globally, rising healthcare expenditure coupled with the growing demand for healthcare services has called for the development of effective, equitable and efficient healthcare systems, including in the KSA (Varabyova & Müller, 2016; Pelone et al., 2015). The World Health Report in 2010 estimated that about 20-40% of all health spending (between $1.3-$2.6 trillion) is wasted globally due to health system inefficiencies, with hospital-related inefficiency accounting for around $300 billion annually (WHO, 2010; Elovainio & Evans, 2013). Hospital level efficiency is critical to the overall efficiency of any health systems according to a broad range of literature and systematic reviews worldwide (Hanson et al., 2002; Hollingworth, 2003; Kelly et al., 2016; Alatawi et al., 2019; Varabyova & Müller, 2016; Kiadaliri et al., 2013). Therefore, it is important to conduct efficiency analysis of public hospitals and identify the causes of inefficiency, to ensure effective utilization of public resources (Jacobs et al., 2006).

The constitution of the KSA guarantees free access to medical care to all citizens in the public sector's facilities across the country (Albejaidi, 2010). The Ministry of Health (MOH) is the primary provider of healthcare services govern a large share of

the total national health expenditure (MOH, 2015). In addition to providing primary, secondary and tertiary healthcare services, the MOH is responsible for developing health strategies and policies as well as supervising health service delivery programs, health education and monitoring of all health-related activities (MOH, 2017; MOH, 2010; Almalki et al., 2011).

Empirical evidence on the efficiency assessment of public hospitals in KSA is scant: systematic review and meta-analysis of studies in the Gulf region yielded only two studies on KSA, as observed in Chapter 3 (Alatawi et al., 2019).

The scientific literatures emphasize that the performance of hospitals is influenced by internal and external factors, and that performance improvement requires an understanding of the influencing factors and components as well as cooperation of policy and management staff of the hospital (Kontodimopoulos et al., 2007; Mitropoulos et al., 2016). Consequently, this qualitative investigation was conducted with key health system stakeholders based on their professional experiences to better understand the reasons for inefficiency in public hospitals in KSA and explore potential mechanisms for improving hospital performance, as observed in previous efficiency literature, using the qualitative approach (Abelson et al., 2011; Afzali, 2011; Nzioki et al., 2015). This study will fill in important gaps in available literatures on hospital efficiency and strengthen the validity of an earlier quantitative assessment (Chapter 4).

5.1.1 Aim

The experience of decision-makers and health professionals at different levels, like ministry, district health and hospital, would be particularly useful for understanding

about the current status and potential for improvement of the public hospital efficiency in the KSA. It is thus expected that this qualitative study will contribute to feasible recommendations for developing health policies and directives for reaching efficiency in the public hospitals. The findings will also guide and support further efficiency studies and periodical monitoring of quality improvement and performance of health services. The key objectives of this study are to: 1) identify the factors that affect hospital efficiency from health systems stakeholders' perspectives; 2) illustrate the desired mix of inputs and outputs and service utilization in public hospitals; and 3) propose recommendations for policy makers based on scientific-knowledge to assist the reform of health policies and directives to enhance the efficiency and quality of health services in the public hospitals.

5.2 Method

5.2.1 Study design

The study employs a qualitative methodology, interviewing the key informants (KIs) with semi-structured interviews (SSIs) as the data collection tool and subtracted in a standard manner the qualitative information. SSIs were conducted with health system stakeholders drawn from public health facilities and the MOH, including policymakers, hospital managers, district health managers, and health regulators. The SSIs were designed to identify and describe the barriers of hospital efficiency and the specific factors that influence efficiency and performance in respect to the use of inputs, outputs and production processes. In addition, we sought suggestions, recommendations and feasible steps for improving efficiency in the public hospitals of the KSA.

5.2.2 Study participants

The study participants were drawn from the three levels of the health system: the national level (MOH), the district level and the hospital level. Participants included former and current seniors of MOH officials, across all Saudi provinces and districts who held relevant positions (ministerial level), district health administrators (district level), and hospital managers (hospital level). These selected key informants, who through their positions and duties were able to identify the factors that affected hospital performance in respect to inputs, outputs and daily mechanisms for contributing to our study objectives were included as the study participants.

5.2.3 Sampling and recruitment process

We employed purposive and snowball sampling techniques to choose the study participants, thus, best suited to the overall goal of this study (Abelson et al., 2011). The key informants at the level of the designated positions were selected based on the objectives of this research, in addition to relevant findings of previous empirical analyses (Nzioki et al., 2015; Afzali et al., 2011). We purposively selected the key informants in consultation with the local academic colleagues and the supervisors, who have professional experience in health organizations as well as based on information obtained during the initial quantitative study (Chapter 4). We identified stakeholders, who based on their role in the MOH, were deemed would provide meaningful information to help in addressing the study objectives. During the recruitment process, we reviewed the organizational charts of the health policy regulators in the MOH across the country. Particular attention was given to

individuals who held cross-sectoral roles, including strategy operation and performance.

Initially selected potential participants were reviewed by the academic colleagues, who have professional experience in public hospitals and familiarised with the organizational structure of the MOH. The final list was achieved by consensus among research team members, securing participants from all three healthcare levels (Nzioki et al., 2015). The prospective participants were contacted by telephone or e-mail to ascertain their willingness to participate in the study. Executive and administrative assistants have been copied in the e-mail invitation to ensure receipt and timely response. A reminder was sent three days after initial contact to confirm that the invitation was received and under consideration. A follow-up by telephone call was initiated after three e-mail contact attempts with no response (Abelson et al., 2011).

The SSIs were conducted face-to-face or through Skype call by the corresponding researcher (CR). During the Key informants' interviews, the CR asked the interviewee to recommend other experts in his/her field who can provide more information to meet our questions (snowball sampling) (Kimani et al., 2020). It was expected that such a snowball method would improve the representation of expert opinions on the factors influencing the efficiency of public hospitals. For example, during the interview with the district's health manager, CR asked him to recommend a local administrative with professional experience in hospital performance and management. The CR had a discussion with the research team about the eligibility of the potential new participants, then contacted him/her through a recruitment process to confirm his/her participation in the interviews (Abelson et al., 2011). During the recruitment process we contacted 34 KIs, however, 20 stakeholders accepted to

participate and were included in this study. The characteristics of the participants are presented in Table 5.1.

Table 5. 1 Characteristics of the study's participants (N= 20)

Participants n= 20	**N (%)**
Sex (Male)	20 (%100)
Age (years)	
25-35	1 (%5)
36-45	11 (%55)
46-55	6 (%30)
>55	2 (%10)
Official position	
MOH officials	4 (%20)
District health administrators	5 (%25)
Hospital managers	11 (%55)
Experience (years)	
2-5	3 (%15)
5-10	8 (%40)
10-15	6 (%30)
>15	3 (%15)

5.2.4 Interviews and data collection

Data collection was conducted by the CR between July and September 2019 using the semi-structured interviews (SSIs). Topic guides were developed based on qualitative literature on hospital efficiency and covered a range of different aspects of the efficiency of hospital-based health services (see appendix E), including the concept of efficiency; variables for service delivery in public hospitals; factors affecting efficiency at the hospital level; resources for health services delivery (inputs

and outputs); mechanisms for hospital performance; and recommendations for improvement (Abelson et al., 2011; Nzioki et al., 2015; Afzali et al., 2011).

The KIs had professional experience and administrative knowledge of the variables used and transformation process (from inputs to outputs) that were undertaken in the hospitals. We ensured that the KIs understood the interview questions and efficiency concept before collection the answers. Therefore, the interviews were conducted in Arabic as it's the first language of both the CR and the participants, then the interviews were translated to English.

The interviewer (CR) scheduled a convenient time and place for the interview after discussion with the key informants. Participants were furnished with full information about the study without discussing any quantitative results that were found earlier by the CR. The participants were informed that the participation was entirely voluntary, and they could withdraw themselves anytime from the research. Formal letters of Information were distributed to the participants and their consent was obtained before the interview started (see appendix E). Each interview lasts for approximately one hour. They were recorded digitally with permission from the participants and complemented with handwritten notes.

5.2.5 Data management and analysis

The audio recordings of all interviews have been summarized to extract key themes and illustrative quotes from each interview question. After completion of each SSI, verbatim transcription and translations were performed immediately using the audiotapes and interview notes. Each transcript was verified by giving the interviewee the chance to review the initial transcripts for approval before analysis.

All final transcripts were translated into English by the CR, with the quality assurance provided by a local professional translator (Abelson et al., 2011).

Data were entered and stored in anonymized form into password-protected Excel spreadsheets to enhance data confidentiality. Based on recommendations from the General Data Protection Regulation (GDPR) for data security (Veale et al., 2018), the names and other identifiable information of the participants were not recorded or where necessary (like designated positions in MOH) were anonymized. However, after completion of this research, all data will be erased from files and destroyed after three years to ensure that it would not be used in future.

A thematic analytic technique was employed to systematically generate themes from the data (Ritchie et al. 2013). Systematic searching of text for categories and themes was the key point of the analysis, which was appropriate for interdisciplinary and collaborative scheme projects (Ritchie et al., 2013). This technique combined deductive and inductive analyses of textual data and produced a coding framework. The themes and codes were selected through a combined approach: deductively based on previous literature (Alatawi et al., 2020a; Alatawi et al., 2020b) and the specifics of this research question, also inductively from the obtained data in the transcripts of the interview's answers (Kimani et al., 2020).

A thematic coding framework was developed through multiple reads of the transcripts to understand overlapping and emerging issues. The framework ensured data summarization and careful explanation of participant's own opinion before interpretation by the research team. The CR and other members of the research team reviewed the framework and definitions of each theme/code for consistency and understanding before the commencement of coding using QSR NVivo. Then, we

applied 'code' that demonstrated the interpreted information from the interviews for systematic comparison with other components of the data. The conducted codes (Nodes) had then been refined the final coding framework. The emerging issues during coding were discussed during regular meetings with research team members (Kimani et al., 2020). QSR NVivo 12® software was used to identify co-occurring codes and provide opportunities to explain codes or/and part of the text. The interpreted findings under each main theme or category were presented for the identification of critical challenges, remedies, and possible solution to overcome hospital inefficiency.

5.2.6 Ethical consideration

Ethics approval was obtained from the ethics review committees of the King Fahad Medical City, the Ministry of Health (IRB log No. 18-166E) and Research Ethics Committee (REC) at the Liverpool School of Tropical Medicine (Ref: 19-036; dated: 18/06/2019) (see appendix E).

5.3 Results

The participants reported several factors that influence the efficiency and performance mechanisms of public hospitals in KSA as well as challenges and solutions to the performance. These are grouped into three thematic categories: (1) components of public hospital performance in respect to health services (outputs) and health resources (inputs) in addition to health demand in the community; (2)

factors and challenges influencing the utilization of health resources and efficiency; and (3) feasibility options and recommendations to improve hospital efficiency.

5.3.1 Performance components for public hospitals

5.3.1.1 Health services provision

The majority of key informants (KIs) and health care providers noted that inpatient and outpatient services were the most frequent health services provided by public hospitals. A public hospital manager (HM) said, "*The hospital ensures the provision of diagnostic and therapeutic services to patients at first contact, conducted through 16 outpatient clinics located in the outpatient department*". Similarly, a district health administrator (DHA) mentioned, "*Inpatient and intensive care hospital services are mainly provided by secondary care hospitals*".

Many KIs identified that emergency services were commonly demanded from the hospitals "…*especially the treatment of accidents and fractures*" as stated by an HM. However, most of the KIs noted that surgical services were required in many treatment episodes and to support health outcomes in hospital. A HM said: "*Surgical therapeutic services, including cardiology, neurosurgery, ophthalmology, obstetrics & gynaecology, urology, orthopaedics and general surgery, are main surgery services provided by the hospitals*".

Supportive therapeutic and diagnostic medical services were also identified by almost all participants as important in health services delivery in the hospitals. A MOH official stated: "*Support Services, e.g. laboratory, radiology, pharmacy and nutrition, are common services required to produce health outcomes and necessary for clinical decisions in most clinical cases in the hospitals*".

A HM and a DHA indicated that preventive procedures are fundamental to improving health outcomes, the later noted: "*Preventive Services (Vaccinations - Health Awareness - Infection Control) are essential to improve public health*". Other three HMs specified that health education is very vital in the service delivery, stating that: "*Community participation in health awareness through public health events is very helpful to prevent overload on health providers*".

On the other hand, two KIs indicated that all health services are important to comprehensively respond to health needs. A DHA stated: "*For all health services without exceptions, the priority is based on the demand, the type and scope of service, as well as the hospital capacity, specialization and the, requested service that according to the MOH objective in providing comprehensive medical services. For example, if 80% of the completed services in the surgery department, then, the hospital has a priority for surgery*".

The KIs justified the selection of the services according to three reasons: First, the MOH health strategic plans, health management and the hospital objectives. A participant noted: "*The selection of service is made according to the health plans of the government and the scale of service and clinical capacity of hospitals in line with the objectives of the MOH and objectives of the hospital*". Second, based on the hospital speciality, a HM said: "*This classification is considering the scope of service and clinical capacity and speciality of hospitals. Since this hospital is a Trauma centre, we focus on the provision of emergency, surgery and haemorrhage treatments as a priority in our services*". Third, based on the community demands for specific services, a DHA stated: "*This selection is based on the needs of the community in the area surrounding the hospital and its nearby environment, which*

led to establishing the service area of the facility to be in response to the need of the patients and demands of the community".

5.3.1.2 Health services demanded by the communities

The KIs identified emergency, outpatient and pharmacy services as the most commonly demanded health services by the communities. A DHA said "*The most demanded health services are emergency, outpatient and pharmacy services, especially in the hospitals located in a place near to the pilgrim's or international roads or a high incidence of chronic diseases areas. These services are to deliver fast to the patients on the same day (when they seek care) as patients dislike long waiting for scheduled appointments. The reason for this demand is due to the poor performance of the nearby primary health centres, which caused a decrease in the patient's confidence in the primary care centres*".

Several KIs noted that the demand for health services in public hospitals could be influenced according to socio-economic characteristics of the patients. A HM said: "*The elderly and low-income people have a greater need for general health services such as emergency, outpatient and pharmacy services as compared to younger and higher-income people who can benefit from the private sector. Those with intermediate and higher education, especially those with health education, benefit more from their ability to determine the starting point of their treatment journey instead of coming to the emergency department as the first contact*".

5.3.1.3 Health resource utilization in hospitals

All key informants mentioned that the contracted health workers, across the different health specialities, are the backbone of hospitals as health service provisions depend mainly on the clinical staff. Most of the KIs noted that capital resources and infrastructure are essential resources to deliver health services in the hospitals. A MOH official stated: "*The clinical capacity of the hospital and (medical and non-medical) devices are the essential resources in the public hospitals*".

Many KIs identified that the periodically consumable supplies, such as medicines and dressing materials, are essential to providing health services for patients in hospitals. In addition, they suggested allocating specific budget in each hospital to purchasing theses supplies without delay. A HM described: "*Funds for the purchasing supplies and medicines should be done by the hospital itself considering the need of the hospital (with control of the authorities over the expenditure) in order to reduce purchasing time and accelerate the treatment process*".

5.3.2 Barriers to efficiency and utilization of health resources in public hospitals

5.3.2.1 Hospital management

The KIs identified the barriers that affect the performance in public hospitals. Most of the participants noted ineffective management of health resources and weak administrative leadership, as well as, lack of competent hospital managers due to poor qualifications of health leaders and poor supervision over them, are the main challenges of efficiency in the public hospitals. A DHA said: "*There have been observed poor administrative and leadership performance among some hospital*

leaders and department heads in the management of health resources. These health leaders lack the required ability to utilize existing resources and to find solutions for the best mix of resources to meet the requirements of health services".

Several KIs indicated that the lack of clear objectives and goals of the hospitals and lack of advanced strategic planning are major obstacles to the performance. A DHA said: "*There is a blurred vision of health managements, lack of clarity of the aim of hospitals, no clear objectives, lack of clear goals and advanced strategic plans for the hospital to make the best use of medical specialities and health resources, reflecting the needs of patients in the nearby area for comprehensive health services*".

5.3.2.2 Monitoring of the performance

Many KIs indicated that poor supervision and the follow up by the MOH, which has often led to failure to meet the standards in health service provision, is an important barrier to efficiency in public hospitals. For instance, according to some KIs, there is a lack of annual assessment and identification of causes of resource waste, as well as, lack of application of policies and procedures, i.e. applying reward and punishment concept for health practitioners. A MOH official stated: "*The standards of health service provision are not followed, which exacerbate critical health conditions and reduce quality and safety and have a huge impact on medical intervention. There is a lack of supervision and follow-up from the MOH and Health Affairs*".

5.3.2.3 Centralization of the decision making

Many KIs claimed that centralization of the decision-making at the MOH, especially in terms of the distribution of health resources and job descriptions for medical practitioners are major barriers to efficiency in public hospitals. A HM said: "*One of*

the major problems is the centralized decision-making for distribution of resources (e.g. health workers) without referring back to the specific plans of hospital managements. It should be conducted according to population density and needs for health services in the area".

Some of the KIs have claimed that lack of autonomy of hospital managers is a factor of inefficiency, as they have an essential role in hospital performance. A HM stated: "*Giving autonomy to hospital managers has a significant impact on hospital performance as a manager is the first leader of operational efficiency in the hospital. Managers require powers to reward and punish the staff, and it would have a great impact to raise productivity. Also, it is required to overcome routine obstacles that may be behind the failure to provide on-time health service to the patients. Nevertheless, there must be control and monitoring from the MOH affairs*".

5.3.2.4 Health workers

Further, some KIs have indicated that poor performance of the medical practitioners and lack of relevant training programmes, which lead to poor medical outputs and poor quality of services, are reasons for inefficiency. A DHA stated: "*There are poor performance and lack of experience and technical skills of health practitioners, administrators, and hospital management to provide medical services. In addition, there is a lack of ongoing training programmes for health staff to highlight the importance of hospital performance and development*".

Many KIs noted that the shortage of professional medical staff is a major barrier to hospital performance, especially those of rare specialities such as neurosurgery. It is due to the high competition on theses specialities with other health care organizations, like the private sector. The public hospitals fail to offer attractive

incentives to such staff in comparison with those other sectors. Moreover, poor allocation of current specialists, for instance, highly specialized doctors in some hospitals treat just a few cases during the year, while other MOH hospitals with higher demand lack these specialists.

A HM stated: "*Lack of health professionals is a major issue in the hospital, where most of the specialists prefer higher wages and better work conditions, which often are available in private hospitals. Unfortunately, there is no attraction or encouragement for them in public hospitals, for example, there is no recognition of their efforts or favourable promotions. In addition, the public hospitals lack the optimal allocation of the existing specialists. Thus, the shortage of professional staff leads most hospitals to fear of the responsibility to provide critical treatments, which reduces the trust and number of patients*".

5.3.2.5 Hospital location

The geographic location of hospitals plays an important role in accessibility to health service, which affects service demand, production, and hospital performance, according to many KIs. A HM stated: "*The geographical location of the hospital, if far from the patients and absence of transportations or other service providers in their area, are obstacles to hospital performance and the demand for health services. This problem of accessibility also leads to worsening the health conditions for most patients in urgent need".*

5.3.2.6 Catchment populations

Several KIs described that demand for health services could be changed based on different seasons in the year and type of health service. For instance, during school time of the year, paediatrics and vaccination health services were most demanded

compared with other services. A HM said: "*The patient's demand for hospital services also vary across seasons of a year, for example, we face more demand for health services during winter compared to summer*".

Many KIs argued that patients' high expectations and misunderstanding of health services are serious challenges of hospital performance. A DHA said: "*We face challenges of hospital performance as the patients have high expectations in respect to the services they will receive. For instance, lack of understanding of the disease's nature and awareness about the suitable health clinics where they should seek healthcare, lead to long waiting time in emergency departments even for minor injury cases. Eventually, patients will lose confidence in hospital services*".

A summary of the barriers that affect the efficiency and utilization of health resources in public hospitals is provided in figure 5.1 below.

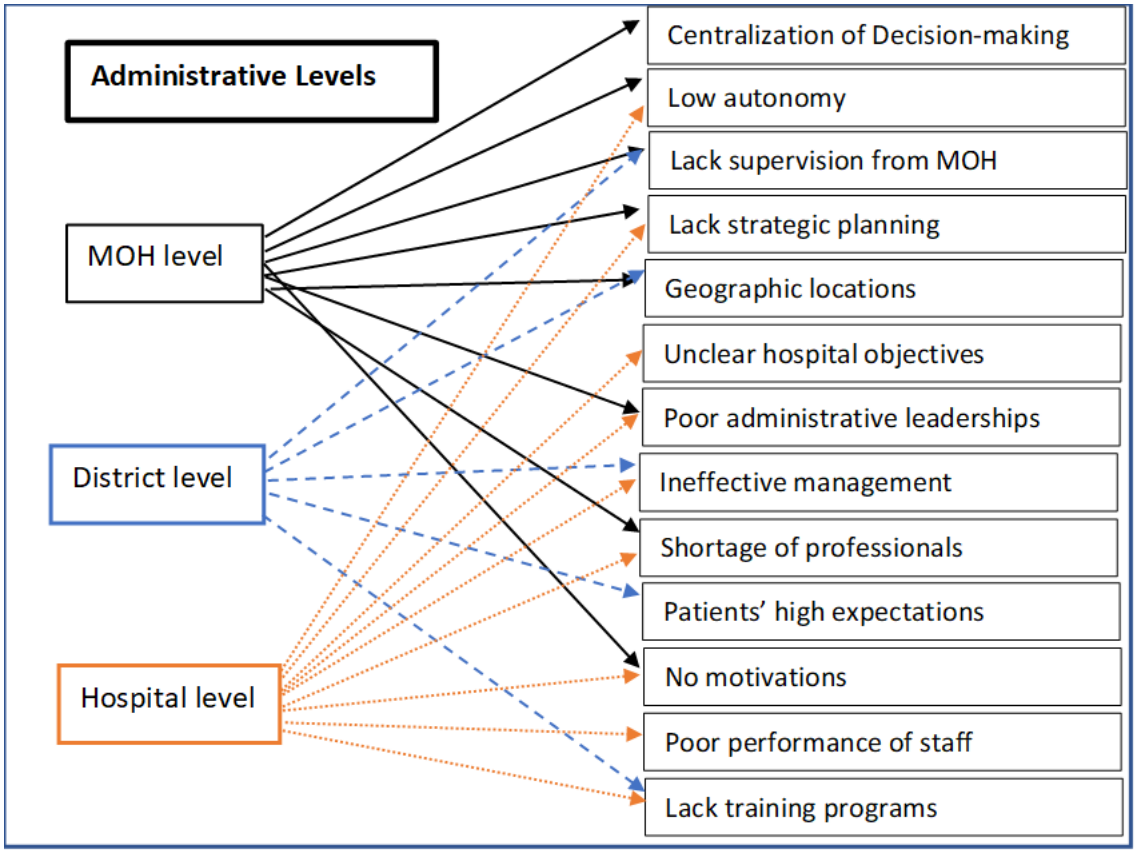

Figure 5. 1 Summary of barriers of efficiency and utilization of health resources in public

5.3.3 Feasible recommended options to improve the efficiency of public hospitals

The study participants discussed the potential changes needed in the current health system to improve the efficiency of public hospitals.

5.3.3.1 Hospital objectives

They noted the need for the objectives of the hospitals to be set in the light of the MOH aims and develop the relevant strategic plans. A MOH official stated: "*The hospitals need to adopt MOH aims in developing strategic plans in line with the capabilities, logical ambition and the needs of the patients and the community (catchment area) of that hospital. The strategic planning should be conducted by the*

hospital staff through teamwork in order to specify the clear goals of that hospital and identify the clinical tasks for improving health outcomes as well as specify the job description of each practitioner".

5.3.3.2 Hospital management

Most of the participants noted the importance of developing an explicit criterion for selection of hospital managers and health leaders and link their performance to MOH plans and hospital objectives through periodical meetings and direct supervision by the health affairs in MOH. A HA in MOH stated: "*We need to establish specific criteria and set standards by the health committees to select hospital leaders at the level of the Health Affairs in MOH and each district for deploying new and competent hospital managers. The right choice of leadership should follow the sense of 'the employee is for the job; not the job is for the employee'. It is also important to start a training programme supervised by the MOH for all health leaders focusing on the practical steps to achieving the objectives of the hospital and improving the performance.*"

Many KIs have emphasized the need for decentralization of decision-making and securing more autonomy of hospital managers in the reallocation of health resources to improve hospital performance. A HM said: "*To improve the performance, we need decentralization of hospital management and involve health workers and communities in decision-making. For instance, we need to enhance the authority of hospital managers to facilitate the provision of medical staff, equipment and consumables at no time. It is also important that the hospital managers have authority for reallocation of resources from one department to another, following the need and demand for services*."

5.3.3.3 Efficiency assessments and resource allocation

Almost all the KIs recommended the need to investigate the determinants of inefficiency in some hospitals, also to conduct studies that compare the efficient hospitals with those with low-efficiency and drawing lessons to improve the efficiency in the public hospitals. They also supported the need to reallocate health resources from inefficient hospitals to those with higher efficiency, based on the findings of efficiency analysis and considering the community demands.

A MOH official mentioned: "*There must be an analytical study of the causes of the waste in hospital resources and find practical solutions to treat it. It is also important to examine the reasons for the superiority of the performance in some hospitals and generalize their experience to benefit other hospitals. Then, relocation of resources can be considered to increase the utilization of health resources on the basis of regular meetings with health affairs in the region and the decision-makers for studying the redistribution of resources, ensuring that such actions do not negatively affect the delivery of the current level of services to the community*".

All participants emphasized the need for applying the policy and procedures to assess the efficiency in the public hospitals, like through mandatory assessments and follow-up monitoring programmes by the MOH. Such actions should include hospital performance through patterns and quality of services delivered, based on therapeutic evidence of clinical cases and utilization of health resources. It should additionally include the feedback of patient's experiences and field visits of the health affairs in the region.

A DHA said: "*We need to develop a transparent performance measurement system under the supervision of MOH at several levels of service delivery. We need to take*

several measures, for example, creating a unit in each hospital and connect to MOH to measure the performance, based on the evaluation of health services on quantitative and qualitative measures, health resources used to produce these services as well as considering the patients' feedback on their consumed services. In addition, it is important to perform regular field visits and establish key performance indicators in all disciplines, which should be published periodically from the MOH in order to create competition among the public hospitals".

Further, a HM stated: "*The MOH has recently placed follow-up mechanisms, for instance, established key performance indicators (KPI) for hospitals and linked to MOH, which consisted of 150 indicators covering the patterns, type and quality of services. They have also initiated the hotline for patients' complaints 937 and the secret shopper programme (unexpected visits to hospitals, in order to evaluate the provided services).*".

5.3.3.4 Education of efficiency concepts

Several KIs raised the importance of education on efficiency among health workers and leaders, application of further efficiency research on public hospitals, and learn from the experiences of other hospitals to guide the policy implications. In addition, they put emphasis on developing training programmes about the effective utilization of health resources among health workers at all levels. A DHA said: "*To enhance performance in hospitals, it is essential to educate and train and also raise awareness of health practitioners about the importance of operational efficiency of hospitals and value of health services. Exchange of experiences between health sectors is important as the low performing hospitals can be benefited from the successful experiences of the high-efficiency hospitals. For example, rotation of*

doctors among primary health centres and hospitals may enhance patients' confidence in doctors of primary care centres. Further, a new hospital manager can contact the previous one to get the benefit from his/her experience. Additionally, it is important to apply the implications of efficiency research findings and link to improvement not only at the operational level but also at the level of leadership development".

5.3.3.5 Health practitioners

Most of the KIs demonstrated the necessity for solving the shortage of specialized staff in public hospitals and they also highlighted the need for improving the attraction factors for the current health workers. They suggested the need to activate part-time recruitment of specialized practitioners and to develop measures to attract such professionals to the hospitals, including performance-based promotion as incentives. A HM noted: "*The MOH should consider activating the part-time temporary contracts (e.g. LOCUM) to overcome the need for specialized medical services (e.g. neurosurgery), especially in the hospitals with a limited number of cases. It is thus important to eliminate pressure on the referral hospitals in order to reduce waiting time for operations. It is also needed to establish a system of encouragement, including promotions for health workers to retain them in the hospital by avoiding escapes to the competing hospitals***".**

Some KIs claimed that the low efficiency of the hospitals was due to lack of training programmes on skill development and performance improvement of staff, as well as, resource optimization and management. A DHA said: "*To overcome this, it is suggested to develop continuous education and training programmes to improve the performance of the health workers and the quality of services they deliver,*

considering the standard of health quality and patient safety. In addition, teaching programmes should be monitored by MOH and designed to optimize the use of health resources and raise awareness about the importance of operational efficiency. ".

5.3.3.6 Health education

The majority of the KIs explained the importance of supporting the awareness about health services through health education in the communities, understanding the patients' health needs and improvement of the scope of service and demand for health in the hospitals. A HM said: "*I encourage to promote health education in the communities to raise the level of patients' awareness of health services they receive and gain the patient trust in the hospitals. Such awareness can be reached through community participation in periodical meetings with health affairs, also, through media and social networks. Raising awareness among patients aims at understanding the health needs and defining the scope of services in nearby hospitals to determine the demand for services and the expected results of services in the public hospitals*".

5.3.3.7 Health information

Majority of the KIs discussed the poor statistics of medical information about the treated patients, health resources used, and health services delivered in the hospitals, which have negatively affected the performance assessments, and any future plan. They explained the need for establishing an integrated recording system of all provided services and patients data that are linked to other providers of health care and monitored directly by the heath affairs in KSA. The hospitals also need to train their practitioners on data recording of clinical cases, services and the resources used.

A HM stated: **"***We need to establish health reporting systems units in each hospital focusing on patient's information, medical history and clinical cases, linking electronically with other departments, hospitals, the health affairs in the region and the MOH. This integrated database also should include health resources and services provided (quantity and quality) in the hospitals in order to unify policies and procedures and reduce the differences with guiding policies*".

5.4 Discussion

This study examined the views of a range of health system stakeholders on the barriers to efficiency in public hospitals in KSA and measures to mitigate these. We reviewed components and mechanism of performance in the public hospitals, factors that affect the efficiency, barriers, and remedial actions from the viewpoints of MOH decision-makers and health professionals in the KSA. The findings of this chapter are in the same line of the observations in our quantitative studies (Chapter 4). The KIs' answers for each question were in the same direction as 70-95% of the answers were agreed. This study, being the first of its kind in KSA is expected to provide valuable insights to improve efficiency in public health facilities.

5.4.1 Hospital performance

We found that the essential health services that public hospitals should deliver to the population consist of inpatient, outpatient, emergency, surgery services, preventive care (like, vaccinations), and supportive medical services like pharmacy, laboratory

and radiology services. These vital services, which have a fundamental role of hospital performance, are provided in public sector secondary care facilities and tertiary level hospitals worldwide as discussed in Chapter 1 and 2 (Ahmed, et al., 2019; Kiadaliri et al., 2013; Lu et al., 2007). In the KSA, the services were chosen for three reasons: the strategic plans of the MOH; the objectives of the public hospitals and its scope of services; and the community need and demand for health services.

Emergency care, outpatient care and pharmacy services were mainly demanded by the communities in the catchment areas of the hospitals, which was observed in other studies in Saudi Arabia (Siddiqui & Ogbeide, 2002; Alyasin & Douglas, 2014). This demand is due to easy access and availability of these services in the public hospitals. In addition, poor performance and quality of health services in other health providers in the hospital's area, I.e. primary care services (Aldhamadi & Alzahrani, 2019). We suggest enhancing the incorporation of primary care centres in service provisioning beside the hospitals through developing the referral policy and better coordination among primary care centres, hospital administration and the MOH (Alyasin & Douglas, 2014).

The community demand for health services can be changed according to the demographic and socio-economic characteristics of the populations. For instance, the utilization of health services in the public hospitals was higher among the elderly, low-income and less-educated populations, according to the KIs. Similarly, several previous empirical researches argued that more impoverished and older people utilized more services due to their free access to public hospitals (Hafidz et al., 2018; Ranstad et al., 2014). In addition, our quantitative research (chapter 4) found that

socioeconomic characteristic of the population (like low-income people), had significant impact on hospital efficiency.

As addressed by the KIs, the health resources (inputs) that mainly were utilized in public hospitals were health practitioners and administrators (labour forces); capital resources, like infrastructures and medical devices as well as consumable supplies (like, medicines) and consistent funds for purchasing medical supplies (like, bandages and surgery tools). This scenario was in the same line of some other research findings from the public hospital performance studies in Chapter 3 (Jacobs, et al., 2006; Varabyova & Müller. 2016; Alatawi et al., 2020a).

5.4.2 Barriers of efficiency and options for improvement

One of the key barriers to improve efficiency identified in this study was ineffective administrative leadership and poor management of the public hospitals. The KIs, therefore, suggested the urgent need for developing selection criteria of hospital managers and health leaders, paying attention to the qualifications and work experiences of the managers, since their roles seem to be the key of the hospital performance. The KIs further recommended for the need for direct supervision of performance of the managers by the Health Affairs and the MOH. A similar study conducted by Perera and his colleagues in 2000, also found that the hospital management, and the characteristics of the managers, including qualifications and administrative experiences, could influence hospital efficiency.

The KIs discussed the impact of centralized decision-making and lack of autonomy of hospital managers on hospital efficiency. This discussion was supported by the previous literature which argued that more autonomy of the managers and flexibility

over the management of health resources, procurement and services delivery process in response to people's need, would have a significant impact on hospital efficiency (Afzali et al., 2011; Sahin et al., 2011; Hanson et al., 2002; Walford & Grant, 1998).

In addition, the unclear objectives of hospitals and lack of advanced strategic planning in service delivery and insufficient supervision by the MOH were essential barriers to hospital efficiency. Therefore, it can be suggested that the hospital administrators and staff should have a clear understanding about the hospital goals, relevant strategic plans and specification of the role of each health worker following the aims of the MOH as well as the need for health services of the community. Previous literatures revealed the link between strategic health plans based on clear objectives and their positive impact on hospital efficiency (Abelson et al., 2011; Ozgen et al., 2015).

The poor performance of medical staff and lack of training programs on effective utilization of health resources were indicated as the critical determinants of inefficiency as the health practitioners were the cornerstone of hospital performance and service delivery. For improving efficiency, it is thus important to develop the training programmes and monitor the hospital staff for improving the performance of health practitioners and quality of services they deliver by, for instance, applying policy and procedures of key performance indicators (KPI) for health practitioners in each hospital. Performance monitoring, training programmes, and reward and recognition of staff have a significant impact on operational efficiency, which are commonly found in the literature on hospital performance (Cogin et al., 2016; Afzali et al., 2009; Kumar et al., 2019).

The shortage of professional staff, particularly in rare specialities, and lack of motivations as well as the misallocation of current health workers were significant barriers of hospital performance towards efficiency as observed also by Cogin et al., 2016. The challenge of retention of health professional was due to the absence of the factors of attractions to retain in public hospitals, for example, low salaries and poor working conditions. In comparison with other providers (like private facilities), which offer better benefits package for recruitment, public hospitals become unattractive for many health professionals. The factors of attraction for retention of health professionals and suggested solutions were commonly discussed in the literature as well as in the Saudi context (Scheffler et al., 2008; Kumar et al., 2019; and Albrithen & Yalli, 2013). Following the recommendations of the KIs and findings of previous literatures, we suggest giving emphasize for improving the work conditions in addition to fair salaries, promotions and encouragements for health workers, to retain them in the public hospitals. Additionally, the scope for recruiting part-time staff of rarely specialized services, for instance, locum contracts, should be useful in this context.

The KIs discussed the patient's high expectations of health services, changing demands for services and geographic location of the hospital that affect the hospital efficiency. Several literatures argued that the high expectations of the patients regarding health services, and their contrary experiences they have on the other hand, had a significant effect on the demand for health and consequently the production of health services in the hospitals (Crisafulli, 2019; Afzali et al., 2009). It is thus required to expand the awareness about health services availability for the communities through public health educational events, social media as well as print and electronic media. Also, policymakers may pay attention to understand the health

needs among different populations and review the scope of services in the public hospitals accordingly (McColl-Kennedy et al., 2017).

There are growing needs for education on operational efficiency and hospital performance concepts and training programmes for health workers to arrive at more value for money in the hospitals. It will also be important to conduct further technical and allocative efficiency assessments of public hospitals periodically and exchange the knowledge from such assessments with healthcare providers and public hospitals. The research-based learning of successful experiences needs to be disseminated for policy implications and future strategic plans. Previous investigations observed that education and training of health workers have positively improved their performance and productivity, which should be included in the hospital's policies to hence a significant impact on the efficiency of public hospitals (Onyango & Wanyoike, 2014; Xu et al., 2018).

The KIs emphasized the poor statistics of health information regarding patient status, services delivery and quality of care in the hospitals, which made it difficult to assess the performance of the hospitals. This finding was supported by an investigation of Hollingworth in 2003. It was also noted that there was a continuing need for establishing an integrated recording system of all health providers and facilities, linked with each other, under the supervision of the Health Affairs and the MOH. The integrated reporting system should contain patient's information, medical history and clinical cases, services provided (patterns and quality) and health resources used as well as the treatment procedure. According to a broad range of scientific publications, a developed and integrated reporting system in healthcare was useful to understand the production mechanisms, extracting knowledge from previous mistakes to prevent them from happening again. Such an integrated reporting

system also contributed to the improvement in patient safety and effective utilization of health services in the public hospitals (Leistikow et al., 2017; Sari et al., 2007; Hollingworth, 2003).

5.4.3 Policy recommendations

The efficiency analysis of the public hospitals has become an urgent demand and should be required by the MOH in the KSA, according to the decision-makers. We, therefore, encourage MOH to implement the policy and procedures in the hospital's performance assessments and regular monitoring of hospital's service delivery as well as follow-up of the utilization of health resources in the light of strategic objectives of the healthcare plans. For instance, appropriate actions should be taken to measure the performance of each hospital based on quantitative and qualitative evaluation of health services, considering the patients' feedback, and the utilization of health resources. It, thus, will help identify the weaknesses in performance and find the best mix of health resources, which may contribute to reform evidence-based policymaking through a specific action plan for the given hospitals. Such directives were observed in the previous literature in their findings and suggestions (McNatt et al., 2015; Blass et al., 2016; Elovainio & Evans, 2013).

The health administrators in MOH are required to understand the findings of efficiency analysis, and the reasons for inefficiency in some hospital and compare with better performed ones and relevant factors. It appeared to be important to evaluate the underlying factors (inputs and outputs) that affect the performance (both internal and external) of the hospitals so that lessons can be taken for future benefits from the mistakes and also from the successful experiences to improve the scientific

knowledge of hospital efficiency. We, thus, encourage the application of scientific findings about the reallocation of health resources from lower to higher efficiency. In this context, we give emphasis on the manager's autonomy in the process of redistribution of resources. It should be noted here that similar findings and recommendations were observed in the various scientific literature (Alatawi, et al., 2020a; Alatawi et al., 2020b; Kiadaliri et al., 2011; Gok & Altındağ, 2015; Jacobs et al., 2006).

5.4.4 Limitations

The small sample size (20 senior health professionals) might be a limitation for the generalizability of the findings. To mitigate this limitation, we employed purposive and snowball sampling techniques which enabled us to identify participants who through their positions, were able to contribute meaningfully for addressing the study objectives. The key informants were from different levels of the health systems, which enabled us to capture a wide range of views to understand the factors of inefficiency to create feasible recommendations based on real-life experience. We, further, kept the saturation of information under consideration in our analyses, which we found adequately addressed as all answers of the different KIs were in the same direction.

5.5 Conclusions

The health system stakeholders' views include factors that affect the performance and efficiency of public hospitals and remedial measures. The key informants

described the health resource categories that were utilized in public hospitals, the health services delivered to the population according to the health regulations and strategic plans, the scope of hospital services, and the need and demand for health services in the community, i.e. catchment area of the hospitals.

We identified ineffective hospital management, lack of strategic planning and goals, weak administrative leadership, and absence of monitoring the hospital performance might have a potential impact on hospital efficiency. The shortage of professional staff, lack of motivations and poor retention of health workers within the hospitals, poor performance of medical staff and lack of training programmes, along with the centralized decision-making procedure had considerable influence on hospital efficiency. The barriers towards hospital efficiency even include lack of an integrated system of health informatics about service delivery and quality of care. Further, the insufficient information about the need of healthcare among the target population might have hindered the performance assessments and consequently did not succeed to reform health policies in response to the community need. It was also noticed that the patient's expectations about health services and the changing demand for healthcare in relation to the socio-economic characteristics of the population might not have been considered adequate to adjust the efficiency goal accordingly.

The hospital administration should have a clear view of the objectives of the hospitals and develop the strategic plans in the light of MOH aims and the healthcare need of populations with various characteristics in the community. More autonomy of the hospital managers for flexibility over the management of health resources, procurement and service delivery process has been strongly suggested to meet the health needs of the target population. Moreover, it is important to develop the

selection criteria of hospital managers along with the MOH close supervision of hospital performance, were suggested, to enhance efficient management towards overall hospital efficiency. For improving the performance of health workers, the need for appropriate training programmes and application of the policy and procedures in the monitoring of staff performance and quality of services got great attention from the key informants. Enhancing the employment conditions through support and rewards for the health workers and developing the scope for part-time recruitment for critical health specialist appeared to be necessary. There is a requirement for establishing an integrated record system (information system), linking the healthcare providers and health affairs, got high importance among the key informants.

Bases on our current investigation, we recommend expanding the awareness about hospital efficiency and effective utilization of health resources among health workers and communities. More studies are essential for further verification of the findings of this research. We, therefore, emphasize to conduct more efficiency assessments to understand the reasons for inefficiency and factors of improvement, to extract lessons that would support the policy implications and the future strategic plans. We also encourage the application of efficiency research findings with respect to the reallocation of health resources to improve the utilization of health resources and better value for money in the public hospitals.

Chapter 6

Discussion and Conclusion

The empirical investigations of the previous chapters of this thesis have estimated the efficiency of health care services in public hospitals in the Kingdom of Saudi Arabia and explored the determining factors of efficiency levels as well as feasible options for improvements by employing quantitative and qualitative research methods. This chapter discusses the thesis' findings and limitations and offers policy recommendations to improve the efficiency in the healthcare delivery system and efficiency evaluations.

6.1 Discussion of Research Findings

This thesis has provided empirical evidence on the relative efficiency of public hospitals in Saudi Arabia, employing a wide range of hospital's efficiency indicators. We found consistent and robust results, showing the same directions of the effects of various variables on the efficiency measurements while using different methods. The empirical findings in the chapters involved measurement of efficiency levels and the analysis of factors determining efficiency, in addition to the key informants' perspectives about efficiency barriers in hospitals and, finally, recommendations for improvements. Our analysis included all the 91 general hospitals, spread over 20 administrative districts in the Kingdom, implying that this research has a strong national representation. To the best of our knowledge, this thesis is the first to use national datasets available in Saudi Arabia to include a wide range of factors

determining the efficiency of public hospitals. In addition, a qualitative analysis of the views of policymakers and high-level health sector officials was conducted.

The actions towards efficiency in resource utilization would contribute to the ongoing global challenge of achieving universal health coverage, declared in the target 3.8 of the Sustainable Development Goals (SDGs) by the United Nations (Goal 3. Sustainable Development Knowledge Platform, 2020). Our current research appears to be useful for addressing both the national interest of the Saudi Arabian public health system and the global mission of UHC. Such findings would be also helpful for high-income nations, Gulf countries and the MENA region.

Our comprehensive systematic review of efficiency measurements of public hospitals (Chapter 3) yielded valuable evidence to develop a conceptual framework from which to approach the measurement of efficiency performed through the empirical investigation in the thesis. The number of efficiency studies in the Gulf region was limited; also, they have considerable deficiencies in terms of the quality and methodological applications in comparison with relevant studies in other regions. This review shows the need for conducting further efficiency research in public hospitals and to guide policymakers to identify appropriate indicators, data and methodological approaches to measure and evaluate efficiency. Also, the meta-analysis in this chapter suggested that methods, technology assumptions, analysis orientation and variables used, have a substantial impact on efficiency assessments in the reviewed studies. For instance, 86% of the reviewed studies applied DEA analysis in efficiency estimates as observed in a wide range of reviews globally (Varabyova, & Müller, 2016; Kiadaliri et al., 2013; Pelone et al. 2015).

The DEA is a widely applicable method for efficiency assessment in the public hospitals since it does not require prior specification of the underlying functional form and its ability to include multiple input and output variables in different units of assessment (Hollingsworth, 2003; O'Neill et al., 2008). Thus, we applied the DEA method in the empirical efficiency analysis in Chapter 4. The review further showed that most of the studies (82%) relied on input orientation, aiming to minimize the health resources, while the Gulf and Saudi studies applied output-orientation. The strength of this thesis is the consideration to develop an 'empirical benchmark' of the results from efficiency analysis using input orientation. Moreover, since the hospitals have more control over the inputs than the production of the outputs, the input orientation analysis was considered more appropriate in the context of public hospital efficiency analysis, as observed in literatures globally (Cooper et al., 2007; Chuang et al. 2011; O'Neill et al., 2008). We, therefore, applied the input-orientation in our analysis.

The relative efficiency of the public hospitals (MOH-general hospitals) in the KSA found that most of the hospitals were technically inefficient (Chapter 4). The average efficiency score was 76%, indicating that hospitals could have reduced health resources by 24% without any reduction in health service provision. Small-size hospitals and central region hospitals were relatively more efficient than larger hospitals and those located in other geographic locations. This chapter also revealed that many hospitals (62.6%) were operating on a sub-optimal scale size; whereas the efficient scale of the operation was observed in the medium-sized hospitals (200-499 bed).

The findings in this chapter suggested to adjust the production capacity by downsizing the hospitals operating on DRS (i.e. large hospitals) and reallocating

their resources to the hospitals on IRS (i.e. small hospitals), as reflected in the scale analysis (Gok, & Sezen, 2013; Afzali, & Mahmood, 2009; Gok, & Altındag, 2015). DEA analysis showed that the surplus of the health workers and shortage of health services as main reasons of inefficiency, also, the misallocation of health workers was a significant barrier to hospital efficiency (chapter 5). Implying that decision-makers might redeploy their labour forces for effective utilization of medical capacity in the light of MOH legal conditions and regulations in the KSA (Gok, & Altındag, 2015; Kiadaliri et al., 2011; Cogin et al., 2016).

These findings also suggested that any possible reallocation of the resources must take place without compromising patients' current access to public hospitals until Pareto optimality is achieved. The findings of the chapter could benefit the inefficient health facilities to benchmark their system and performance in the light of the efficient hospitals within each capacity and geographic location. The findings of this chapter were also supported by the findings of the qualitative analysis (Chapter 5). The relocation of resources from inefficient to efficient hospitals can be considered on the basis of regular meetings with health affairs in the district, hospital management and the decision-makers in MOH for studying the process of redistribution of resources. This process aims to increase the utilization of health resources and ensure that such actions do not negatively affect the delivery of the current level of services to the community.

In addition to efficiency analysis in public hospitals, we empirically investigated the external factors that may affect the efficiency and identify the factors that determine differences in the efficiency levels of public hospitals (Chapter 4). The empirical analysis revealed that hospital efficiency and performance were significantly influenced by external factors. The statistically significant associations were

observed between ‘hospitals efficiency scores’ and specific factors including the number of people in the hospital's catchment area, percentage of children (0-5 years old), the prevalence of infectious diseases cases, and dispensed prescriptions, number of populations who faced financial hardships during treatments, and those who received financial support.

The findings of this chapter indicated that the hospitals which serve more patients with the previous characteristics (significant factors that influenced efficiency scores) are relatively more technically efficient, which has been observed in the literature (Chen, 2016; Hafidz et al., 2018; Lu et al., 2007; Sun & Luo, 2017; Klitkou et al., 2017; Sutton & Lock, 2000; Graham, 2018). These findings suggested improvement of health policies and planning in respect to hospital efficiency and resource allocation with consideration to the variations in demographic, socio-economic and health status of the catchment populations (i.e., population density, poverty, health indicators and services utilization in catchment area). Policymakers should pay extra attention to ensure the appropriate allocation mechanisms of health resources and to expand utilization of health services amongst the target populations to secure efficient and equitable health services in the KSA (Al-Hanawi et al., 2018).

The complementary qualitative study (in Chapter 5) filled in the qualitative gaps in available information and enhanced our findings on hospital efficiency and strengthened the validity of the findings of the quantitative assessments conducted in investigations on hospital efficiency and its external determining factors (chapter 3 and 4). In this chapter, the key informants identified the health resource categories utilized in public hospitals, the health services delivered to the population in respect to the health regulations and strategic plans and the scope of services of a public hospital, as well as the need and demand for health services in different

communities, which were aligned with findings from Chapters 3 and 4 of this thesis. The qualitative investigations also identified new output variables, which could be used in hospital efficiency research, for instance, the emergency and preventive services (e.g. Infection Control) are important services in public hospitals. This investigation also found valuable input variables, e.g. consumable resources in the public hospitals, which can be included for assessing efficiency in future research. We further observed that barriers to hospital efficiency include ineffective management, lack of strategic planning and goals, weak administrative leadership and absence of monitoring and supervision as well as centralized decision-making. In addition, shortage of professional staff, lack of motivation and poor retention of health workers within the hospitals, poor performance of medical staff, and lack of training programmes, had considerable influence on hospital efficiency.

This analysis also noted that expectations about health services and changing demand for healthcare in relation to the socio-economic characteristics of the population may have changed and not been considered adequately in adjusting efficiency goals, as found in the analysis of determinants of inefficiency (chapter 4). Chapter 5 also revealed that there is a lack of an integrated health informatics system about service delivery, quality of care as well as insufficient information about the target population, which might have hindered the performance assessments and consequently did not succeed to reform health policies in response to community needs. Similar findings of Chapter 4 which also were observed in related literature (Perera et al., 2000; Sahin et al., 2011; Ozgen et al., 2015; Jacobs et al., 2006; Kumar et al., 2019; Scheffler et al., 2008; Crisafulli, 2019).

Feasible recommendations, based on the KIs' experiences, could be applied in hospitals and in other health care facilities to create more benefits to the health

system. The hospital administration should develop hospital objectives and strategic plans in the light of MOH aims and healthcare needs of populations in the communities. More autonomy for hospital managers and flexibility over the management of health resources, procurement, and service delivery process, is required.

Also, these findings emphasized to enhance the effective management of hospitals by developing the selection criteria of hospital managers based on their qualification and work experiences, as well as close supervision on the performance of health management. Moreover, it was suggested to establish appropriate and continuous training programmes and close monitoring mechanism of the health workers' performance and quality of service delivery.

This qualitative investigation also supported a remarkable finding of chapter 4, that is the importance of the application of efficiency findings with respect to the reallocation of health resources in the utilization of resources and medical capacity. The qualitative analysis suggested that the reallocation of health resources should follow the findings of efficiency analysis, scale of operations, hospital size and location as well as characteristics of catchment populations, as found in Chapter 4. Enhancing employment conditions through support and rewards for the health workers and developing scope for part-time recruitment, were strongly suggested.

A need to establish an integrated record system, linking the healthcare providers and health affairs was acknowledged as a highly important action. In the light of the empirical investigations, this chapter recommended expanding awareness about hospital efficiency and effective utilization of health resources among health workers and communities. Further efficiency investigations were considered to be essential

for additional verification of the findings and to extract lessons that support the policy implications and the future strategic plans.

6.2 Limitations

This PhD research faced some challenges in finding data for trend analysis of hospital efficiency in the KSA. We focused on only one year because the available data sources lacked the required variables of previous period, which hindered the application of productivity change assessments. There were also insufficient data on the severity of cases, case mix and the quality of services in the output variables. We, therefore, employed the mortality rate as the proxy for the quality of services. However, availability of the quality variable would help to enrich further analysis for robust findings that to build more accurate health policies. Though we had intended to assess allocative and economic efficiency, we failed to do so due to lack of data on hospital costs or input prices in the available data. Hence, this research focussed on the measurement of the technical efficiency of the public hospitals.

The data on poverty headcount in the KSA was not available either in Saudi or global data sources that because the government does not release statistics regarding this indicator or definition of poverty line in the country. Therefore, establishing new poverty databases, through collection of relevant statistics and setting a clear definition of poverty in the county is vital for better research. These improvements would enhance further efficiency research by understanding population characteristics and needs, and consequently, would guide the policy makers to potential reforms in the country. This study used two variables as the poverty indicators in the hospital areas, namely, the populations who faced financial

hardships during the healthcare treatment; and the number of cases which were economically supported by the public social administration.

Also, the number of catchment populations of the hospitals might be inaccurate sometimes, as patients often referred to the hospitals that were nearby or easily accessible, rather than those to which they were assigned. It was challenging to measure the number of catchment populations precisely in the absence of a referral system that links the service providers. The improvements in the referral health system are thus vital to optimize the patient health records. Further, many hospital variables were missing for DEA and second-stage analysis, which resulted in exclusion of six hospitals from our analysis. Thus, development of the health information health system is critical to optimize the hospital records and future assessments.

The sample of participants (20 KIs) in the qualitative research could have been larger. However, the key informants were from three different levels of the health systems, which enabled to capture a wide range of views and in the same direction (saturation of information) to understand the factors of inefficiency and create practical recommendations based on their experience.

The quantitative chapter used two stages DEA analysis, similar to the methodology approaches of several literature in this context. In some studies, the bootstrapping DEA was also applied to obtain the bias corrected estimates and the confidence intervals of efficiency scores. We conducted several sensitivity analysis and diagnostic tests, which did not show any potential biasness (sensitivity analysis for DEA, multicollinearity, heteroskedasticity and so forth) and thus application of bootstrapping was not necessary. We applied DEA based efficiency analysis

considering input-orientation, while some other used output-orientation. Our justification for the choice of orientation was that the health administration and decision making in the public sector have more control over the inputs than the production of the outputs, as observed in Chapter 3. The choice was justified further by the facts that the public health system does not have control over the demand for health services, which influences the output level in the public facilities in contrast to, for instance, the manufacturing sector (e.g. car industry).

6.3 Policy Recommendations

Based on our research about efficiency of public hospitals in the KSA, we like to make following recommendations to the policy-makers, particularly in the Ministry of Health and their underlying institutions in district and hospital level to consider for improving efficiency:

- Decision-makers should develop a process of efficient use of resources within the public hospitals and its reallocation based on the findings of the efficiency analysis.
- A possible reallocation of hospital beds based on efficiency findings is needed, through downsizing some hospitals that are operating on DRS and reallocating these resources to hospitals on the IRS, without compromising patients' current access to health services.
- Decision-makers and hospital administrators must build a clear hospital objective and develop relevant strategic health plans and specification for hospital outcomes in the light of MOH aims and the need for health services in the catchment areas.

- Policy-makers should establish selection criteria for recruitment of the hospital managers based on work experience and management qualifications and provide them with appropriate management courses and keep them under close supervision by the MOH.
- Policy-makers are required to promote more autonomy for hospital managers and flexibility over the management, redistribution and procurement of health resources, as well as service delivery process and daily operations.
- Policy-makers should emphasize on establishing the concept of operational efficiency and hospital performance among the health workers and managers, in order to improve the utilization of health resources.
- In the light of the research findings, redeploying of labour forces from inefficient hospitals to efficient ones is necessary, following the legal framework and MOH regulations for the effective use of medical capacity.
- Policy-makers must give emphasis on improving work conditions and flexibility of employment contracts, including fair salaries, promotions, reward and recognition for the current health workers to retain them within the public hospital sector.
- Policy-makers should consider activating the scope for recruiting part-time staff, especially of rarely specialized services through locum contracts.
- Policy-makers are required to establish and develop training programmes for improving the performance and quality of services that health workers provide.

- Policy-makers should activate the monitoring programmes for health workers by applying particular procedures for monitoring service delivery, like, KPI and “secret shopper”.
- Policy-makers should consider demographics and socio-economic characteristics, as well as the levels of health awareness of the community with regard to reallocation of health resources for securing efficient and equitable access to health services of different populations.
- Policy-makers and district health authority should expand the awareness about health services availability in the hospitals for the communities through, for instance, health education, print- and electronic media.
- Decision-makers are required to enhance the engagement of the primary healthcare centres in service provisioning beside public hospitals, especially in terms of the infection control and follow-up of the chronic conditions.
- Improving health information databases is highly important, for instance, collection of high-quality data from all provision levels (primary, secondary and tertiary), data on severity of cases, relevant medical procedures and quality of care in the hospitals.
- Policy-makers are required to establish referral system linking all health providers across different sectors using health information system, which should include demographic and socio-economics status of the registered populations to optimize the hospital records.

6.4 Further Research

The empirical investigation carried out in this thesis has contributed to raise new questions related to the understanding of efficiency in the health resources for the healthcare system in Saudi Arabia. In this thesis, we found several health information systems and databases that include inadequate data on a broad range of hospital functions, service production, quality care and health profiles.

Thus, stakeholders are required to improve hospital's databases through collection and processing high-quality data. The valid data should cover all levels of service provision and capture the health demand, pattern of activities, the severity of cases and quality of health care, which are critical steps towards active monitoring for hospital services. Key, relevant stakeholders are required to establish an integrated recording system of all health facilities, which should contain patient's information, medical history and clinical cases, services provided, and treatment procedures used as well as the health resources used.

Such a comprehensive reporting system would contribute to improvements in patient safety and effective utilization of health services and be useful to understand the production mechanisms in public hospitals by extracting knowledge from different experiences of health facilities for enhancements. These improvements would enhance further efficiency research by indicating the weaknesses in the healthcare production process. Further, it guides the policy and decision-makers to potential reforms (Leistikow et al., 2017; Sari et al., 2007; Hollingworth, 2003).

Further research could be carried out to understand the production process and its efficiency at the national level by extending the variety of inputs, outputs, institutional and environmental factors in addition to population characteristics and utilization of

healthcare services. Also, efficiency research could be extended in terms of subjects (like types of performance assessments), methodology (like SFA) and the samples under consideration. Regarding the sample, future research could be employed for primary care centres or hospitals under other providers (like the private sector or between hospital's departments). These investigations would provide useful information and explanations for different levels of performance within or between hospitals, and thus extract further suggestions for the improvement of hospital efficiency.

It is important to conduct further technical, allocative and cost-efficiency (economic efficiency) assessments of public hospitals periodically and exchange knowledge from such assessments between healthcare providers and policy-makers. It, thus, will help to create a complete picture about efficiency status and identify the weaknesses in the performance and find the best mix of health resources. This will contribute to develop evidence-based policies and future strategic plans as well as practical action-plans (McNatt et al., 2015; Blass et al., 2016; Yip & Hafez, 2015; Elovainio & Evans, 2013).

Many oil-producing developing countries, like KSA, have oil-dependent economies since that oil contributing the majority of their exports and government revenues. The current fall in oil prices worldwide due to the COVID-19 pandemic is limiting the ability of these countries to finance service delivery in public sectors, particularly in health sector. In March of this year, the International Energy Agency (IEA) estimated that several oil-producing countries would likely see a drop in their net income in 2020 on average of 50%-85% compared with 2019, based on an oil price of USD 30 per barrel (IEA; 2020). The KSA economy suffered a severe impact as a budget deficit of 9 billion US dollars in the first quarter of 2020.

On the 2nd of March 2020, KSA reported its first COVID-19 confirmed case and the total number of cases in November reached around 351,000 according to the MOH. It is, however, expected that Saudi Arabia would be able to control the pandemic faster than other countries (Algaissi et al., 2020). In response to COVID-19 pandemic, KSA improved the public health system and infection control policies and measures. On the other hand, this situation is expected to have a negative impact on efficiency of healthcare system since that production of several health services in hospitals (e.g. outpatients, scheduled surgeries, laboratory services) has been affected due to lockdowns and restrictions (Algaissi et al., 2020).

A study in Saudi Arabia showed a significant decrease in cardiovascular cases that admitted to outpatient and inpatient in public hospitals during COVID-19 in comparison with pre-COVID 19 era with evidences of delayed presentation from time of symptom to reperfusion (Daoulah et al., 2020). However, there have been significant concerns regarding appropriate personal protection of healthcare workers and concerns for patients staying away from hospitals for the fear of being infected, which decreased the delivery of health services and the efficiency of public hospitals. The existing financing of the public healthcare sector through oil revenues in KSA, which has been affected due to the drops in the oil prices, and increasing demand for health services, urge for addressing the efficiency of resource utilization.In sum, this research is an attempt to provide an empirical investigation of healthcare efficiency in public hospitals in the KSA and demonstrates the factors that influence hospital efficiency in regard to the resource allocation and service utilization within the hospitals as well as external factors in the community. We also explained the factors and barriers that affect hospital performance based on the experience of

stakeholders in the public health system, which contribute to the feasible recommendations for developing health policies and directives.

The findings of this research highlighted the importance of the efficiency assessment in the public hospitals in particular, and the healthcare system in general, in order to build and develop appropriate health policies for the future development towards maximizing healthcare delivery with the given resources. In addition to the findings of this thesis, the aforementioned future potential studies in the efficiency of public hospitals should be useful for enriching the knowledge-base for utilizing public fund in consideration to the value-for-money approach to achieving the Universal Health Coverage in Saudi Arabia as well as in the countries in the similar setting.

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APPENDICES

Appendix A

Appendix related to Chapter 2

Appendix A.1

Approval of dataset collection from the Ethics Committee of Institutional Review Board (IRB) of King Fahad Medical City, (IRB log No. 18-166E).

Kingdom of Saudi Arabia
Ministry of Health
King Fahad Medical City
(162)

المملكة العربية السعودية
وزارة الصحة
مدينة الملك فهد الطبية
(١٦٢)

مدينة الملك فهد الطبية
King Fahad Medical City

IRB Registration Number with KACST, KSA: H-01-R-012
IRB Registration Number with OHRP/NIH, USA: IRB00010471
Approval Number Federal Wide Assurance NIH, USA: FWA00018774

April 5, 2018
IRB Log Number: 18-166E
Department: External
Category of Approval: EXEMPT

Dear Ahmed Alatawi,

I am pleased to inform you that your submission dated March 29, 2018 for the study titled '**Evaluation of health services efficiency of public hospitals in Saudi Arabia**' was reviewed and was approved according to ICH GCP guidelines. Please note that this approval is from the research ethics perspective only. You will still need to get permission from the head of department or unit in KFMC or an external institution to commence data collection.

We wish you well as you proceed with the study and request you to keep the IRB informed of the progress on a regular basis, using the IRB log number shown above.

Please be advised that regulations require that you submit a progress report on your research every 6 months. You are also required to submit any manuscript resulting from this research for approval by IRB before submission to journals for publication.

As a researcher you are required to have current and valid certification on protection human research subjects that can be obtained by taking a short online course at the US NIH site or the Saudi NCBE site followed by a multiple choice test. Please submit your current and valid certificate for our records. Failure to submit this certificate shall a reason for suspension of your research project.

If you have any further questions feel free to contact me.

Sincerely yours,

Prof. Omar H. Kasule
Chairman, Institutional Review Board (IRB)
King Fahad Medical City, Riyadh, KSA
Tel: + 966 1 288 9999 Ext. 26913
E-mail: okasule@kfmc.med.sa

F M C
Approved
05 APR 2018
I R B

Appendix A.2

Approval of the Ministry of Health for the data collection in Saudi Arabia (ID 1439-1437318)

٢٠١٨/٤/٩ sahel.moh.gov.sa/...
وزارة الصحة
09-04-2018 23-07-1439
1439-1437318
http://sahel.moh.gov.sa/web/RePrintBarcode

المملكة العربية السعودية
وزارة الصحة
الوكالة المساعدة للتخطيط والبحوث
الإدارة العامة للبحوث والدراسات

وزارة الصحة
Ministry of Health

الموضوع: بحث الطالب/ أحمد العطوي.

سعادة/ مدير عام الإدارة العامة للإحصاء والمعلومات بوزارة الصحة المحترم

السلام عليكم ورحمة الله وبركاته،،،

إشارة إلى موضوع الطالب / **أحمد ضيق الله العطوي**، المبتعث من جامعة الجوف لدراسة درجة الدكتوراه في تخصص **"إقتصاديات الصحة"** بكلية ليفربول للطب المداري بجامعة ليفربول بالمملكة المتحدة، رقم الهوية الوطنية (١٠٤٢٣٤٤٧٠٣) وعنوان الرسالة:

" تقييم كفاءة الخدمات الصحية بالمستشفيات العامة بالمملكة العربية السعودية"

نحيطكم علماً بأن الطالب قد إستوفى كافة المستندات المطلوبة وتمت مراجعتها من قبل اللجان المعنية بالإدارة العامة للبحوث والدراسات ولجنة الأخلاقيات بمدينة الملك فهد الطبية بوزارة الصحة، وتمت الموافقة على تسهيل مهمة إجراء هذا البحث، وحيث أن الطالب سينفذ دراسته في الإدارة العامة للإحصاء والمعلومات بوزارة الصحة.

وعليه، نأمل من سعادتكم التفضل بالإطلاع والإيعاز لمن يلزم بتسهيل مهمته بعد موافقة الجهات المختصة لديكم، لجمع البيانات اللازمة بما يضمن أن لا يكون هناك أي تأثير على خدمة المراجعين خلال قيامه بمهام بحثه، مع العلم بأن وزارة الصحة تضمن حقوقها في نتائج هذا البحث من خلال إتفاقية المشاركة في البيانات والتي تم توقيعها بين الطالب والإدارة العامة للبحوث والدراسات.

وتفضلوا بقبول خالص تحياتـــي ،،،

مرفق مستندات وملخص المقترح البحثي،،،،

مدير عام الإدارة العامة للبحوث والدراسات

ص. عذاري فيصل العتيبي

الرمز البريدي: ١٢٢٣٤ ص.ب الرياض: ٨٥٥٦ فاكس: ٠١١٤٧٣٥٠٣٨ هاتف: ٠١١٤٧٣٥٠٣٩
e-mail: research@moh.gov.sa

Appendix A.3

Application letter for MOH

University of Liverpool

Liverpool School of Tropical Medicine LSTM

Pembroke Place Liverpool
L3 5QA UK
Phone No: +44(0)151 705 3100

To whom it may concern

General Directorate for Research and Studies
GDRS-MoH- KSA

Dear Sir,

I write to bring to your kind attention that MSc/PhD student *Ahmed Alatawi* is a candidate in the Faculty of …LSTM University of Liverpool

The research topic is "Evaluation of Health Services Efficiency of Public Hospitals in Saudi Arabia"

Student Affiliation:

With permission of the Ministry of Health in Saudi Arabia, he/she may collect data from the following: General hospitals that affiliated to Ministry of health in Saudi Arabia

He/she has pre-approved explanatory statements for those interested in participating. The main instrument for data collection will be… Observation of secondary datasets….
On completion of the study, the GDRS-MoH-KSA will be provided with the findings of the study through a final report and a copy of the thesis and data will be shared according to the Data Share Agreement with GDRS-MoH, KSA.

If you have any questions please do not hesitate to contact me.

Yours sincerely

Name & Signature: Prof. Louis Niessen

Affiliation: Professor in health economics, LSTM.

Email: louis.niessen@lstmed.ac.uk

Stamp

Appendix A.4

Approval signature on application request form

الرقم
التاريخ
المرفقات

المملكة العربية السعودية
وزارة الصحة

سعادة مدير عام الإدارة العامة للإحصاء والمعلومات **المحترم**

السلام عليكم ورحمة الله وبركاته ،،،

بناءً على الطلب المقدم لنا من / أحمد ضيف الله العطوي ، والمرفق .

نفيد سعادتكم بأن الباحث مبتعث لدراسة الدكتوراه في بريطانيا بناء على اتفاقية وزارة الصحة مع جامعة ليفربول كلية الطب المداري .

نأمل منكم التعاون مع الباحث وتزويده بالبيانات التي يحتاجها لإتمام بحثه .

شاكرين لسعادتكم دوم تعاونكم لما يخدم الصالح العام .

مع أطيب تحياتي ،،،

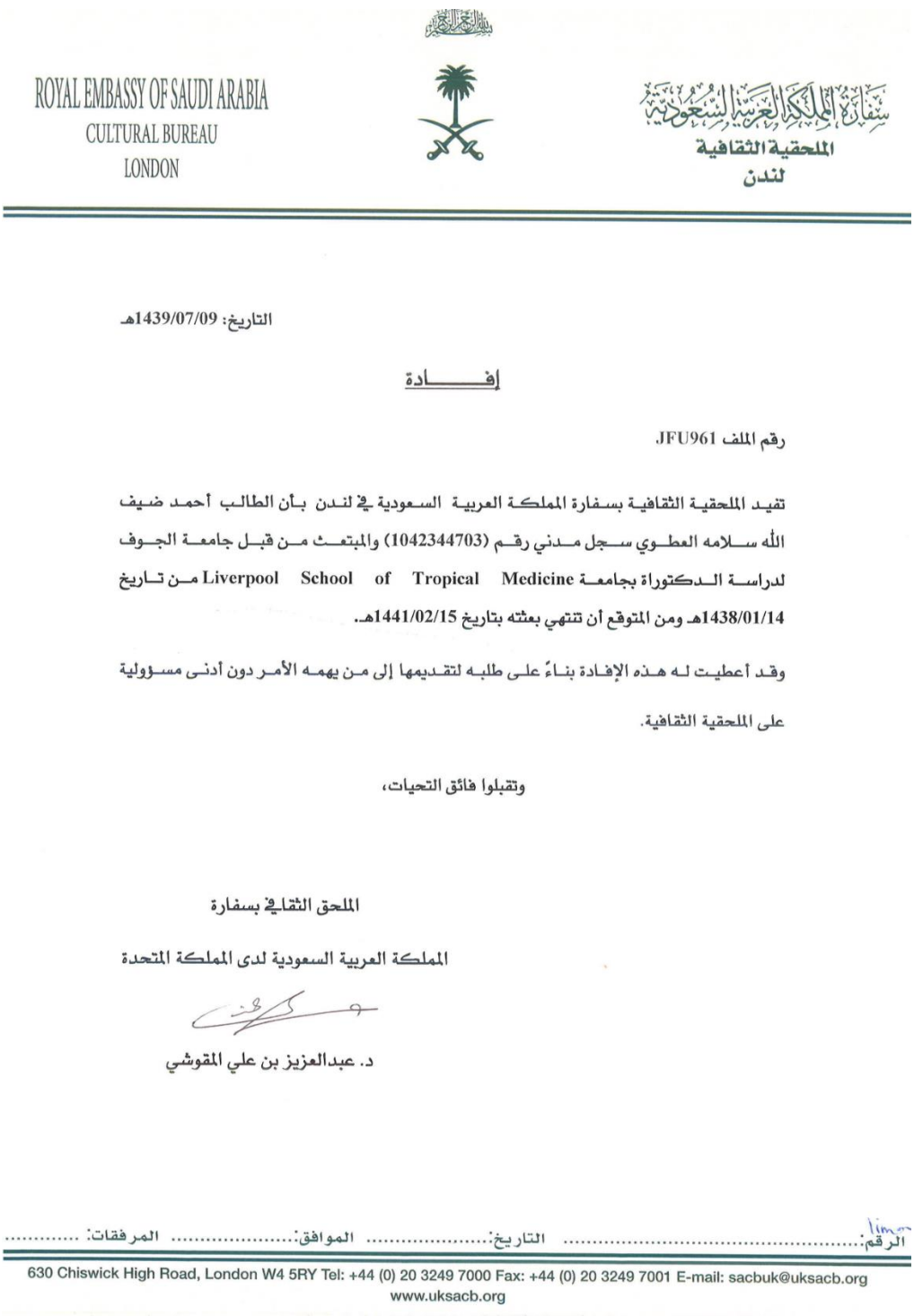
مدير عام

الإدارة العامة لنواقل المرض والأمراض المشتركة

د. محمد بن حسن الزهراني

Appendix A.5

Research acknowledgement from the sponser (Royal Embassy of Saudi Arabia in London)



بسم الله الرحمن الرحيم

ROYAL EMBASSY OF SAUDI ARABIA
CULTURAL BUREAU
LONDON

سفارة المملكة العربية السعودية
الملحقية الثقافية
لندن

التاريخ: 1439/07/09هـ

إفـــــادة

رقم الملف JFU961

تفيد الملحقية الثقافية بسفارة المملكة العربية السعودية في لندن بأن الطالب أحمد ضيف الله سلامه العطوي سجل مدني رقم (1042344703) والمبتعث من قبل جامعة الجوف لدراسة الدكتوراة بجامعة Liverpool School of Tropical Medicine من تاريخ 1438/01/14هـ ومن المتوقع أن تنتهي بعثته بتاريخ 1441/02/15هـ.

وقد أعطيت له هذه الإفادة بناءً على طلبه لتقديمها إلى من يهمه الأمر دون أدنى مسؤولية على الملحقية الثقافية.

وتقبلوا فائق التحيات،

الملحق الثقافي بسفارة

المملكة العربية السعودية لدى المملكة المتحدة

د. عبدالعزيز بن علي المقوشي

الرقم:..... التاريخ:..... الموافق:..... المرفقات: .....

630 Chiswick High Road, London W4 5RY Tel: +44 (0) 20 3249 7000 Fax: +44 (0) 20 3249 7001 E-mail: sacbuk@uksacb.org
www.uksacb.org

Appendix A.6 Application forms

Application form. 1

Form IRB-10.06 **Request for Exempt Status** Effective Date: KFMC Institutional Review Board			
A. Date	27-3-2018		
B. Study Title:	Evaluation of health services efficiency of public hospitals in Saudi Arabia		
C. Principal Investigator (include degree):	Ahmed Alatawi, Mcs., health economics.		
Department:	Clinical sciences-LSTM		
Phone: +44(0)151 705 3100	Email: Ahmed.alatawi@lstmed.ac.uk		
D. Status of Principal Investigator:	PhD student in Health Economics		
[check all that are possible here to include in final form: Graduate student: ☒ Consultant ☐ Faculty ☒ Resident ☐ Medical Student ☐ Other:			
E. Faculty sponsor (student protocols): NA: ☐			
Faculty mailing address NA: ☐	Liverpool School of Tropical Medicine Pembroke Place Liverpool L3 5QA UK		
F. Study sponsor: NA: ☐	Saudi Arabian Cultural Bureau in London		
Contract Research Organization (if applicable): NA: ☐			
G. Funding Information:	☐ Extramural	☐ Intramural	☐ No Funding
Funding Status:	☐ Planned	☐ Pending	☐ Funded
Funding Source(s):	☒ Government	☐ Industry	☐ Foundation
Agency/Sponsor/Program: NA: ☐			
Funding Agency's Grant or Contract No.: NA: ☐			
H. Approval letter from site research is to be performed is attached Yes: ☐ NA: ☐			

Study Description (include procedures involved and sufficient information to justify exempt status):
The aim of this research is to assess the healthcare efficiency in public hospitals and demonstrate the related. Subsequently, decision makers can improve health policies, enhance efficiency and quality of public hospitals in Saudi Arabia. The study designed to investigate the magnitude of healthcare resources used in individual public hospitals. In addition to, compare the efficiency levels of individual health services. Analysis of efficiency scores in the public hospitals according to input and output variables to estimate the technical, allocative for the overall efficiencies, in response to previous objectives. Simultaneously, evaluate efficiency level of public hospitals and estimate the factors influence it, with respect to internal hospital and external environmental elements that demonstrate the performance level. The impact of specific hospital and socio-economic characteristics on efficiency measurements, particularly quality-related determinants, and demonstration of hospital utilization factors that explain efficiency level in public hospitals. Through determining supply and demand, inspecting the input and social factors that influence efficiency of each output in the hospital, to specify the factors influence the efficiency, and provide the recommendations to enhance efficiency of hospital resources. Explanation of study findings from stakeholder perspective, to provide more virtual of efficiency level, influenced factors of in/efficiency and feasible recommendation toward practical policies for efficient hospital services. Methods of the research included; Descriptive analysis; Overview the components of Saudi's public hospital system describe of capacity and services characteristics regarding input and outputs. Parametric and non-parametric applications, including tools of stochastic frontier and data envelopment analysis, measuring the efficiency scores in the public hospitals according to input and output variables to estimate the technical, allocative efficiencies

Draft 2 - vaz

Page 1 of 3

and the corresponded factors. Inputs will consist of number of beds, health professionals and consumable resources per year. In the other hand, output included; number of outpatients, inpatient length of stay, general surgeries, mortality rate, bed turnover and occupancy rates and number of pharmacy prescription dispensing. All the required information is related to hospital performance and based on a secondary dataset that available in the ministry of health, No information of biological or clinical experiment, not any intervention that involve participants, also no identifications for personal or institutes information.

Statement of Investigator:
I believe this proposal is exempt from full IRB review, as described in exempt category(ies) [3 & 4] Listed on Page 2 of this form. I will not begin any study activities until notified of approval of Exempt Status by the KFMC IRB. I agree to abide by the assurances on Page 3 of this form.

Printed Name of PI:
Ahmed Alatawi

Signature of Principal Investigator (PI) Date

Printed Name of the supervisor:
Professor Louis Niessen

Signature of Department Chairman ☐ OR: Date 27-3/18
Signature of the supervisor ☐

IRB Approval:

Name Date

Signature IRB Number

3.1. Exempt Categories for Research:

(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

(3) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

(4) Research and demonstration projects which are conducted by or subject to the approval of Department or Agency heads, and which are designed to study, evaluate, or otherwise examine: (i) Public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

(5) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe.

Investigator Assurances for Exempt Studies

NOTE: Research that is determined to be Exempt from IRB review is not Exempt from protection of the human subjects. The following criteria to protect human subjects must be met:

- The investigator assures that all investigators and co-investigators are trained in the ethical principles, and relevant regulations and institutional policies governing human subject research;
- The investigator assures that human subjects will voluntarily consent to participate in the research when appropriate (e.g., surveys, interviews) and will provide subjects with pertinent information, e.g. risks and benefits, contact information for investigators, and IRB chair, etc.;
- The investigator assures that human subjects will be selected equitably, so that the risks and benefits of the research are justly distributed.
- The investigator assures that the IRB will be immediately informed of any information, unexpected or adverse events that would increase the risk to the human subjects and cause the category of review to be upgraded to Expedited or Full Review;
- The investigator assures that the IRB will be immediately informed of any complaints from participants regarding their risks and benefits; and
- The investigator assures that confidentiality and privacy of the subjects and the research data will be maintained appropriately to ensure minimal risk to subjects.

Application form. 2

Kingdom of Saudi Arabia

Ministry of Health

General Administration for Researches & Studies

المملكة العربية السعودية

وزارة الصحة

الإدارة العامة للبحوث و الدراسات

RS-MOH Data Share Agreement This Agreement sets forth the terms and conditions under which the Provider will disclose certain data and protected health information, the party holding the data ("Provider") you request will be shared with you, the Data Recipient, for purposes outlined in the [Project Title] Proposal	**إتفاقية تبادل بيانات الدراسات البحثية – وزارة الصحة** تستعرض هذه الإتفاقية الشروط و الأحكام التي سيقوم بموجبها المزود بالكشف عن بعض البيانات و معلومات الصحة المحمية، ويتم تبادل البيانات التي يتم طلبها بين الطرف الحاصل عليها ("المزود") ومتلقي البيانات للاغراض التي تم بيانها في عرض [عنوان المشروع].
Study Information: • **Provider Name : GDRS-MOH** • **Recipient Name PI : Ahmed Alatawi** • **Protocol Title :** • **Date :** • **Brief description of the research:** Ministry of Health MOH is the main provider of healthcare services in Saudi Arabia SA 60%, with pub health expenditure constitutes 75% of total healthcar expenditure in the whole country. Although many strategic plans had been conducted to reduce the spending, healthcare services still inefficient to meet increasing demand in SA. Subsequently, Improved qu and performance of healthcare delivery with the excit resources is a fundamental goal of the health system. rising demand for healthcare, the increasing expenditures and reducing healthcare budgets, propo priority setting at the top of the research projects, pay due attention to the performance of hospitals in publi sector and providing policymakers with tools to bette inform their decisions. The aim of this research is to measure the healthcare efficiency in public hospitals and demonstrate the fac which affected hospital efficiency. Subsequently, deci makers can improve health policies and enhance efficiency and quality of public hospitals in SA. Furthermore, assessment of the magnitude of healthc resources used in individual public hospitals, and comparative efficiency levels of individual health services. Demonstration of the impact of specific hosp and socio-economic characteristics on efficiency measurements, particularly quality-related determina Methods of the research included; systematic review demonstrate an existing literature measuring healthc efficiency, and identification of the key elements in pu hospital efficiency. Descriptive analysis; Overview the components of Saudi's healthcare system, describe of capacity and services characteristics of public hospita Parametric and non-parametric applications, includin	**معلومات الدراسة:** • **إسم المزود: الإدارة العامة للبحوث بوزارة الصحة** • **إسم المتلقي (الباحث الرئيس):** • **عنوان البروتوكول:** • **التاريخ:** • **وصف مختصر للبحث:**

tools of stochastic frontier and data envelopment analysis, measuring the efficiency scores in the public hospitals according to input and output variables to estimate the technical, allocative efficiencies and the corresponded factors. Finally, a survey of the stakeholders to explain the research findings and pro more virtual of efficiency level to develop feasible recommendation toward more efficient hospital servi

- **The purpose of this research is to:** Provide complete description of the purpose of the research project:

The findings from this research are expected to contribute to overall improvement in health efficiency, and performance, utilizing an excised health resources in Saudi Arabia. Thus, introduced reform policies to increase the supply of services and improve their quality to meet the rising demand. Implementations of the research will present a valuable information regarding the factors that progress the efficient use of public resources in the hospital sector and the processes that must be in place. Also, this information will guide and support further efficiency studies and periodical monitoring to improve quality and performance of health services. For Saudi's health planning authorities, Finding the optimal mix of health resources and type of health facility to stretch limited health care resources and improve technical efficiency. In addition, providing more autonomy for the hospital's authorities to monitor the facilities and reduce resource's squandering, to empower these hospitals to serve more population. Moreover, improve managerial capacity and health information systems that allow monitoring and evaluation of health system performance to improve transparency and accountability in future. Certainly, an efficiency of hospital sector, as the main consumer of health resources, is crucial for the efficiency of the overall health system. However, scarcity of scientific studies on the efficiency of this vital sector, the need remains for further studies that aim to bring more light on this subject, to help those in charge of health services in Saudi Arabia to promote these services qualities and achieve ultimate goals. For this, the healthcare and hospital efficiency analysis, which is fundamental to achieving Universal Health Coverage UHC, is one of the essential tools that should be guided by the decision-makers in Saudi Arabia and the globe.

- **الغرض من هذا البحث هو:**

يتم تقديم وصف كامل للغرض من المشروع البحثي:

• **The recipient agrees to use the information solely in the following manner:** Provide complete description of all proposed uses of the data set: **Data will be used in purposes of this research a the requirement of this degree (PhD).**	• **يوافق المتلقي على إستخدام المعلومات فقط بالطريقة التالية:** يتم إدراج وصف كامل للإستخدامات المقترحة لمجموعة البيانات:
• **Recipient agree to limit access to the information to the following individuals or classes of individuals:** Provide complete list of all individuals, or classes of individuals, who will access the limited data set: Only the recipient and his academic supervisors (Prof. Louis Niessen and Dr Jahangir Khan), have allow to access to the data. Also, data will be anonymous and all identifications will be omitted and stored in secure storage areas by this research team.	• **يوافق المتلقي على الحد من الإطلاع على المعلومات على الأفراد و فئات الأفراد التالية:** يتم إدراج قائمة كاملة بكافة الأفراد، أو فئات الأفراد، الذين سيطلعون على مجموعة البيانات المحدودة:
Conditions and Stipulations:	**الشروط و الإشتراطات:**
Recipient further agrees to the following conditions and stipulations:	يوافق المتلقي أيضا على الشروط و الإشتراطات التالية:
1. The information will not be used or further disclosed other than as permitted by this agreement or as otherwise required by Saudi Law.	1. لن يتم إستخدام المعلومات أو الكشف عنها بخلاف ما هو مسموح بهذه الإتفاقية أو بخلاف ذلك على النحو المطلوب بالقانون السعودي.
2. Appropriate safeguards will be implemented as described above to prevent use or disclosure of information other than as provided for by this agreement.	2. سيتم تطبيق الضمانات المناسبة على النحو الموضح أعلاه للحيلولة دون إستخدام المعلومات أو الكشف عنها بخلاف ما هو منصوص عليه في هذه الإتفاقية.
3. Information set will not be re-identified.	3. لن يُعاد تحديد مجموعة المعلومات.
4. Individuals whose information is contained in the information will not be contacted.	4. لن يتم التواصل مع الأفراد المدرجة معلوماتهم في المعلومات.
5. You will use the information only for the research purposes described above.	5. سيتم إستخدام المعلومات فقط للأغراض البحثية الموضحة أعلاه.

6. Recipient-investigator agrees to take the appropriate safeguards to prevent unauthorized use or disclosure of the information.	6. يوافق الباحث المتلقي على إتخاذ الضمانات المناسبة للحيلولة دون الإستخدام أو الكشف غير المصرح به للمعلومات.
7. Upon learning of any use or disclosure of information not provided for by this agreement, such unauthorized use or disclosure will be reported to the holder within 15 days of becoming aware of such use a disclosure.	7. عند العلم بأي إستخدام أو كشف للمعلومات غير منصوص عليه في هذه الإتفاقية، يتم الإبلاغ عن ذلك الإستخدام أو الكشف غير المصرح للمالك خلال 15 يوما من علمه بذلك الإستخدام أو الكشف.
8. Any individuals or organizations, including subcontractors, to whom the information is provided, must first agree to the same restrictions and conditions set forth in this agreement.	8. يجب على أي أفراد أو مؤسسات، بما في ذلك المقاولين من الباطن، الذين يتم تقديم المعلومات لهم، الموافقة أولا على نفس القيود والشروط المنصوص عليها في هذه الإتفاقية.
10. Recipient and Provider understand and agree that individuals who are the subject of PHI are not intended to be third party beneficiaries of this agreement.	9. يفهم و يوافق المتلقي و المزود بأن الأفراد موضوع المعلومات الصحية المحمية لا يقصد بهم أن يكونوا أطرافا أخرى مستفيدة في هذه الإتفاقية.
11. Each party agrees that it will be responsible for its own acts and the results thereof to the extent authorized by law and shall not be responsible for the acts of the other party or the results thereof.	10. يوافق كل طرف على أنه سيكون مسئولا عن تصرفاته و النتائج المترتبة عليها إلى الحد المصرح به قانونا و أنه لن يكون مسئولا عن تصرفات الطرف الآخر أو النتائج المترتبة عليها.
Term and Termination: 1. The term of this agreement shall be effective as of [insert effective date], and shall remain in effect until the research proposed is completed, after which you agree to destroy or return safely and promptly to Provider all information.	**المدة و الإنهاء:** 1. يبدأ سريان مفعول هذه الإتفاقية إعتبارا من [يتم إدراج تاريخ سريان الإتفاقية]، و تبقى سارية المفول و نافذة حتى يتم إستكمال البحث المقترح، و بعد ذلك يوافق الطرف على إتلاف أو إعادة كافة المعلومات للمزود بشكل سليم و على الفور.
2. Upon the Provider's knowledge of a material breach of this agreement by the Data Recipient, the Provider shall provide an opportunity for Data Recipient to cure the breach or end the violation. If efforts to cure the breach or end the violation are not successful within the 15 days period specified by the Provider, the Provider shall discontinue disclosure of PHI to the Data Recipient.	2. عند علم المزود بأي مخالفة مادية لهذه الإتفاقية من قبل متلقي البيانات، يمنح المزود لمتلقي البيانات الفرصة لتصحيح المخالفة أو إنهاء الإنتهاك. و إذا لم تنجح جهود تصحيح المخالفة أو إنهاء الإنتهاك خلال فترة الـ 15 يوما التي يحددها المزود، يتوقف المزود عن الكشف عن المعلومات الصحية المحمية لمتلقي البيانات.
3. The Data Recipient agrees to destroy study data according to the following specifications:	3. يوافق متلقي البيانات على إتلاف بيانات الدراسة وفقا للمواصفات التالية:
• [Insert any specifications regarding the destruction of data pieces here].	• [يتم إدراج أي مواصفات تتعلق بإتلاف البيانات].
• Unless otherwise required by Saudi law, the Data Recipient will destroy Data Set(s) no later than [insert Month Day Year of data destruction here] (i.e., within X year(s) of the study end date on [insert Month Day Year of study end date here]). The Data Recipient will notify the Holder with	• مالم يُنص على خلاف ذلك بالقانون السعودي، سيقوم متلقي البيانات بتدمير مجموعة (مجموعات) البيانات في مدة لا تتجاوز [يتم إدخال يوم و شهر و عام إتلاف البيانات] (أي، خلال X عام (أعوام) من تاريخ إنتهاء الدراسة بتاريخ [يتم إدخال يوم وشهر و تاريخ إنتهاء الدراسة]. و سيقوم

written confirmation of the destruction via email or other memo.	متلقي البيانات بإبلاغ المزود بتأكيد خطي بالإتلاف عبر البريد الإلكتروني أو أي مذكرة أخرى.
• When printed material containing confidential information is discarded, it is loaded, transported and stored under supervision (using a chain of custody control process) until the material can be recycled into paper pulp.	• عندما يتم التخلص من المواد المطبوعة التي تحتوي على معلومات سرية، فيتم تحميلها، و نقلها و تخزينها تحت إشراف (بإستخدام سلسلة من عملية مراقبة العهدة) إلى أن يتم إعادة تدوير المواد إلى لب ورق.
4. This agreement shall not be amended, altered, or changed except by written documentation agreed to and executed by both parties.	4. لا يتم تعديل هذه الإتفاقية، أو تغييرها، أو تبديلها إلا بوثيقة خطية تتم الموافقة عليها و توقيعها من قبل الطرفين.
Ownership of Data:	**ملكية البيانات:**
All data shall remain exclusively owned by the disclosing party and its use by other parties shall be governed by the following:	**تبقى كافة البيانات ملكا خالصا و حصريا للطرف المصرح و يُنظم إستخدامها من قبل الطرف الآخر بالتالي:**
1. Information may be disclosed to study sites provided solely as necessary to perform obligations in connection with the research project for which such data are provided under this agreement. Such uses and disclosures shall also be in compliance with applicable laws and regulations, protocols, consent forms, if any, IRB approvals.	1. يجوز الكشف عن المعلومات لمواقع الدراسة المنصوص عليها حصرا على أنها ضرورية لأداء الإلتزامات المتصلة بالمشروع البحثي و الذي يتم تقديم هذه البيانات له بموجب هذه الإتفاقية. و تكون عمليات الإستخدام و الكشف هذه متفقة مع القوانين و الأنظمة و المطبقة، و البروتوكلات، و نماذج الموافقة، إن وجدت، و موافقات لجنة أخلاقيات البحوث.
2. No party shall use the names, logos, symbols or trademarks of another party or the other party's affiliates or related entities, without the express written permission of the other party, except that parties may identify each other in annual reports and like documents that generally describe or refer to the research project.	2. لا يقوم أي طرف بإستخدام الأسماء، و الشعارات، و الرموز والعلامات التجارية الخاصة بالطرف الآخر أو التابعين للطرف الآخر أو الكيانات ذات العلاقة دون الإذن الخطي الصريح من الطرف الآخر، بإستثناء أنه يجوز للأطراف تمييز بعضهم البعض في التقارير السنوية و الوثائق المماثلة التي تصف بشكل عام المشروع البحثي أو تشير إليه.
3. The Provider retains any and all tangible and intangible rights to the information.	3. يحتفظ المزود بأي من وكافة الحقوق المادية و غير المادية للمعلومات.
4- Recipient abides to submit a final draft of the research including the results (or published paper) to the provider or uploading it to the research data base at MOH electronic site.	**4. يلتزم الطرف المتلقى بتزويد الطرف المزود بنسخة نهائية من البحث أو الدراسة شاملة النتائج (أو نسخة من البحث منشورة بإحدى الدوريات العلمية) أو رفعها بقاعدة البيانات البحثية بموقع وزارة الصحة.**
5. The Products created by the Data Recipient shall be owned by the Data Recipient. Products jointly created by both the Data Recipient and the Holder shall be jointly owned.	5. تكون المنتجات التي يتم إنشاؤها من قبل متلقي البيانات ملكا لمتلقي البيانات. و بالنسبة للمنتجات التي يتم إنشاؤها بشكل مشترك من قبل كل من من متلقي البيانات ومالكها ، فتبقى مملوكة بشكل مشترك.
6. The Data Recipient agrees not to use or disclose the Data Set for any purpose or secondary use other than the reporting purposes outlined above or as required by Saudi law.	6. يوافق متلقي البيانات على عدم إستخدام مجموعة البيانات أو الكشف عنها لأي غرض أو إستخدام ثانوي بخلاف أغراض الإبلاغ المحددة أعلاه أو على النحو المطلوب بالقانون السعودي.

7. The Data Recipient agrees to report to the Provider any use or disclosure of the Data Set not provided for by this agreement, of which it becomes aware, including without limitation, any disclosure of PHI to an unauthorized subcontractor, within ten (10) business days of its discovery.	7. يوافق متلقي البيانات على إبلاغ المزود بأي إستخدام أو كشف لمجموعة البيانات غير منصوص عليه بهذه الإتفاقية، قد يطلع عليه، بما في ذلك على سبيل المثال لا الحصر، أي كشف للمعلومات الصحية المحمية لأي مقاول من الباطن غير مصرح له، خلال عشرة (10) أيام عمل من إكتشافه لذلك.
8. The Data Recipient agrees not to identify the information contained in the Data Set, contact the individual, or publish or disclose publically any PHI.	8. يوافق متلقي البيانات على عدم تحديد المعلومات المدرجة في مجموعة البيانات، أو التواصل مع الفرد، أو نشر أي معلومات صحية محمية أو الكشف عنها للعامة.
Security The Data Recipient agrees to use appropriate administrative, physical, and technical safeguards to prevent use or disclosure of the Data Set other than as provided for by this agreement.	**الأمن** يوافق متلقي البيانات على إستخدام الضمانات الإدارية، و المادية و الفنية المناسبة للحيلولة دون إستخدام مجموعة البيانات أو الكشف عنها بخلاف ما هو منصوص عليه في هذه الإتفاقية.
• All data will be stored in secure storage areas or on digital media that has been password protected, encrypted, or otherwise secured for storage and transfer.]	• [سيتم تخزين كافة البيانات في مناطق تخزين آمنة أو على وسائل إلكترونية تتم حمايتها بكلمة مرور، أو تشفيرها أو بخلاف ذلك تأمينها للتخزين و النقل].
Publications and Presentations The Data Recipient should submit an application for publication to the General Directorate for Research and Studies –MOH prior to publication in local or international journals.	**النشر والمطبوعات** لا يحق للطرف المتلقي بنشر نتائج الدراسة في المجلات العلمية المحلية أو العالمية إلا بعد الحصول على موافقة خطية على النشر من الإدارة العامة للبحوث والدراسات بوزارة الصحة .
The parties signing below agree to the conditions enumerated above.	**يوافق الأطراف الموقعون أدناه على الشروط التي تم تعدادها أعلاه.**
Authorized representative of the Provider or the facility releasing the data set: **MOH** Signature of authorized representative of the provider or the facility releasing the data set	**الممثل المخول من قبل المزود أو المنشأة المصدرة لمجموعة البيانات:** **هذا الجزء خاص بوزارة الصحة** توقيع الممثل المخول من قبل المزود أو المنشأة المصدرة لمجموعة البيانات

Name of authorized representative:……. Title of authorized representative Recipient:……. Name of facility:…… Address:……. Phone:……. e-mail:…… Fax:…… Date: ……..	إسم الممثل المخول: …… منصب الممثل المخول: …… المتلقي: …… إسم المنشأة: …… العنوان: …… رقم الهاتف: …… البريد الإلكتروني: …… الفاكس: …… التاريخ: ……
To be fulfilled by PI  Signature of Recipient Recipient Name:…….Ahmed Alatawi…… Recipient Institution:…… Liverpool School of Tropical Medicine Address:…… Pembroke Place Liverpool L3 5QA UK…… …… Phone:…… +44(0)151 705 3100 …… e-mail:…ahmed.alatawi@lstmed.ac.uk…… Fax:…… Date: ……26/3/2018……..	**يملأ بمعرفة الباحث الرئيس:** …… **توقيع المتلقي** إسم المتلقي: …… مؤسسة المتلقي: …… العنوان: …… رقم الهاتف: …… البريد الإلكتروني: …… الفاكس: …… التاريخ: ……

Application form. 3

King Fahad Medical City **Academic & Training Affairs** **Research & Scientific Publication Center**	وزارة الصحة مدينة الملك فهد الطبية King Fahad Medical City	**مدينة الملك فهد الطبية** **الإدارة التنفيذية للشئون الأكاديمية والتدريب** **مركز البحوث والنشر العلمي**

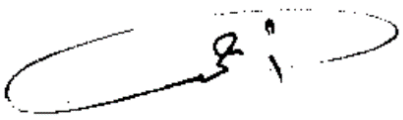
External Investigators' Statement

Investigators form outside King Fahad Medical City (KFMC) should:

- ☐ Abide by all KFMC regulations and policies.
- ☐ Be responsible for the safe and ethical conduct of the research
- ☐ Participates in the selection of study subjects according to the recruitment strategy
- ☐ Performs and/or supervises the conduct of study-related procedures
- ☐ Monitors the safety of the study subjects and investigational staff
- ☐ Collects accurate and verifiable data and other essential study documents
- ☐ Collect data only as approved by the IRB for his/her study
- ☐ Be responsible for follow the IRB regulations and apply Good Clinical Practice standards when dealing with human subject research.
- ☐ Ensures adequate close-out of the study
- ☐ Respect all colleagues and assistant staff

I hereby state that I have read and understand the above rules, by my signing this I do agree to stick to it.

Investigator Name: Ahmed Alatawi

Investigator Signature: 

Date: 26-3-2018

Application form. 4

المملكة العربية السعودية

وزارة الصحة

الإدارة العامة للبحوث والدراسات

خطاب تعريف **GDRS-MoH Cover Letter**	
Student Name: **Ahmed Dhaifallah Alatawi**	إسم الطالب / الطالبة:
Specialty: **Health Economists**	التخصص:
Affiliation at KSA: **Faculty of Pharmacy- AlJouf University**	مكان العمل بالمملكة:
Country: United Kingdom	(البلد المبتعث إليها) للطلاب المبتعثين:
College: Liverpool School of Tropical Medicin	الكلية:
University: University of Liverpool	الجامعة:
Degree: Master ☐ Ph.D ■ Others ☐	الدرجة: ماجستير ☐ دكتوراه ☐ أخرى ☐
Research Title: **Evaluation of Health Services Efficiency of Public Hospitals in Saudi Arabia**	عنوان البحث باللغة العربية:
General Public Hospitals that affiliated to Ministry of health in Saudi Arabia	منشآت وزارة الصحة المراد إجراء البحث بها:
ahmed.alatawi@lstmed.ac.uk	البريد الإلكتروني:
1042344703	رقم السجل المدني:
201171663	الرقم الأكاديمي:
00447491496786	رقم الجوال:

Application form. 5

Form IRB-10.10.01

Minimal Risk Informed Consent Template

إقرار بالموافقة المستنيرة علي المشاركة في بحث علمي يشتمل علي الحد الأدنى من المخاطر

Effective Date: KFMC Institutional Review Board

NO participants for this study (Observation on Secondary data)

Protocol Number:	**NA**	**رقم البحث العلمي:**
Name of Subject:	**NA**	**اسم المشارك:**
Medical Record Number:	**NA**	**رقم السجل الطبي:**

Study Title: Evaluation of Health Services Efficiency of Public Hospitals in Saudi Arabia — **عنوان البحث العلمي:**

Principal Investigator: Ahmed Alatawi — **الباحث الرئيس:**

Address: ahmed.alatawi@lstmed.ac.uk — **العنوان:**

Telephone: — **رقم الهاتف:**

1- Why Is This Study Being Done? — 1. ما سبب القيام بهذا البحث العلمي ؟

2. How Many People Will Take Part in This Study? — 2. كم عدد الأشخاص المفترض مشاركتهم في هذا البحث العلمي؟

3- What is involved in the Study? — 3. ماذا يتضمن هذا البحث العلمي؟

4- Study location:

4. موقع إجراء هذا البحث العلمي:

5- What is Expected of Me During the Study?

5. ما المطلوب مني خلال هذا البحث العلمي؟

6- How Long Will I Be in This Study?

6. كم مدة مشاركتي في هذا البحث العلمي؟

How long will the individual subject's participation last?

7- Can I Stop Being in This Study?

7. هل يمكنني إنهاء المشاركة في هذا البحث العلمي؟

You can decide to stop at any time. Taking part is purely voluntary.

المشاركة طوعيه محضة ويمكنك أن تنهيها في أي وقت تشاء.

8- What are the Benefits of This Study?

8. ما هي فوائد هذا البحث العلمي؟

[Eg, No benefits:]:

[على سبيل المثال, لا توجد فوائد]:

There will be no direct benefit to you from taking part in this study. Study results may be useful to the patients in the future.

لن تكون هناك أي فائدة مباشرة لك من المشاركة في هذا البحث العلمي. نتائج هذا البحث قد تكون مفيدة للمرضى في المستقبل.

9- What are the Risks of This Study?

9. ما هي المخاطر المتوقعة من المشاركة في هذا البحث العلمي؟

10- What if I am Injured Because I Took Part in This Study?

10- ماذا سيحدث إذا أصابني ضرر جراء المشاركة هذا البحث العلمي؟

If you are injured as a result of being in this study, treatment will be provided by ……..at no cost to you.

إذا حدث أن أصبت بضرر نتيجة مشاركتك في هذا البحث العلمي، ستقدم لك مستشفى .....العلاج دون أي تكلفة لك.

11- What are the Costs of This Study?

11- وما هي تكاليف المشاركة في هذا البحث العلمي؟

There are no costs to you if you take part in this study.

لا توجد تكاليف للمشاركة في هذه هذا البحث العلمي.

12- Will I Be Paid for Taking Part in This Study?

12-هل هنالك اجر مقابل المشاركة في هذا البحث العلمي؟

13- What are the Alternatives?

13- ما هي البدائل؟

14- Will My Information Be Kept Private?

14-هل سيتم الحفاظ علي معلوماتي بسرية؟

Your personal information will be kept private. It will be given out only if required by law. Your personal information will not be used in any reports.

معلوماتك الشخصية سيتم الحفاظ عليها بسرية تامة. ولا تعطي إلا إذا اقتضى الأمر وذلك في حدود النظم والقوانين المطبقة بهذا الخصوص. معلوماتك الشخصية لن تستخدم في أي تقارير.

15- What are My Rights if I Take Part in This Study?

15- ما هي حقوقي إذا شاركت في هذا البحث العلمي؟

Taking part in this study is your choice. You may choose to take part or not to take part. If you decide to take part in the study, you can quit at any time. There will be no penalty to you for your decision. Your medical care will not change.

المشاركة في هذا البحث العلمي هي بمحض اختيارك. يمكنك أن تختار المشاركة أو لا. إذا قررت أن تشارك في هذا البحث العلمي، يمكنك التوقف في أي وقت تشاء. وإذا لم تشارك لن تكون هناك أي عقوبة لك, ولا تتأثر الرعاية الطبية المقدمة لك بسبب هذا القرار.

16- Who Do I Call if I Have Questions or Problems?

16- بمن يمكنني الاتصال إذا كان لدي أسئلة أو مشاكل؟

If you have questions about the study, you can call PI at xxxx. If you have any questions about “rights of human subjects,” you may call the Chairman of the IRB at . If you have an emergency, call .

إذا كانت لديك أسئلة عن هذا البحث العلمي ، يمكنك الاتصال بالباحث الرئيس على هذا الرقم . إذا كانت لديك أي تساؤلات حول "حقوق الاشخاص موضوع البحث، " يمكنك الاتصال برئيس لجنة أخلاقيات البحث العلمي (IRB) على الرقم . إذا كان لديك مكالمة طارئة اتصل ب .

CONSENT:

إقرار بالموافقة

Subject

المشارك في البحث

I will receive a signed copy of this consent form.

أقر أنا بأن هذا البحث العلمي وإجراءاته قد تم شرحها لي. لقد سمح لي بأن اسأل كل سؤال لدي الآن. ويمكنني أن اسأل أي أسئلة إضافية في أي وقت لاحق. كما يمكنني إنهاء المشاركة في هذا البحث العلمي في أي وقت دون أن تتأثر الرعاية الصحية المقدمة لي.

سأحصل على نسخة موقعة من الإقرار بالموافقة.

Subject Signature _____

توقيع المشارك _____

Date: 26-3-2018

التاريخ / /

Time (AM ☐ PM ☐)

الوقت (ص ☐ م☐)

Person Obtaining Consent:

الشخص الحاصل علي الإقرار بالموافقة

I have explained the nature and purpose of the study and the risks involved. I have answered and will answer questions to the best of my ability. I will give a signed copy of the consent form to the subject.

أقر بأنني قد شرحت بصورة كاملة, طبيعة هذا البحث العلمي والغرض منه وما ينطوي عليه من مخاطر. ولقد أجبت على جميع الأسئلة بقدر الإمكان. سأعطي نسخة موقعة من الإقرار بالموافقة للمشارك المذكور أعلاه.

Signature of Person Obtaining Consent

توقيع الشخص الحاصل علي الإقرار بالموافقة

Date / /

التاريخ: / /

Time (AM ☐ PM ☐)

الـوقـت ص ☐ م☐

يتم ملئ هذا الجزء بواسطة الباحث الرئيس

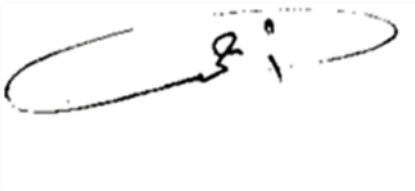
To be filled by PI

Principal Investigator Name:

إسم الـبـاحث الـرئـيس:

Signature :

الـتـوقـيـع:



الـتـاريـخ:

Date: 26-3-2018

Time (AM ☐ PM ☐

الـوقـت ص ☐ م☐

Application form. 6

King Fahad Medical City **Academic & Training Affairs** **Research & Scientific Publication Center**	وزارة الصحة مدينة الملك فهد الطبية King Fahad Medical City	**مدينة الملك فهد الطبية** **الإدارة التنفيذية للشئون الأكاديمية والتدريب** **مركز البحوث والنشر العلمي**

STATEMENT

By signing below, I confirm that I will use no research instruments and/or instructional materials including standardized tests, surveys, questionnaires, interview questions, observation protocols, etc. in the implementation of my research study other than those I have submitted to the External Research Review Committee (ERRC). I confirm that in the event I want to modify any aspect of this study, I will submit the modification(s) to the External Research Review Committee for review and approval before implementation begins. Confidentiality, dignity and ethical rights for all participants should be strictly guaranteed.

By signing below, I confirm that KING FAHAD MEDICAL CITY will not be identified in any reports, publications, or/and presentations about this study, unless approved by ERRC. Data should be presented anonymously.

I agree to provide a copy of the completed study to the Research Center at KFMC.

Printed Name of PI: Ahmed Alatawi

Signature:

Date: 26-3-2018

Appendix A.7 Certificate of protection human participants course

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Ahmed Alatawi** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 12/13/2017.

Certification Number: 2580793.

Appendix B

Appendix related to Chapter 3

The quality assessment checklist

Item	Scores
Reporting	
1. Is the hypothesis/objective of the study clearly described?	yes (1) no/unclear (0)
2. Is the underlying economic theory of production/cost properly described? (e.g., is the economic justification for selecting input- vs. output orientation given?)	yes (1) no/unclear (0)
3. Are the input and output variables clearly defined and their inclusion justified?	yes (1) no/unclear (0)
4. Are the main findings of the study clearly presented with reference to study objectives?	yes (1) no/unclear (0)
5. Are the study limitations discussed (e.g., omitted variables)?	yes (1) no/unclear (0)
External validity	
6. Is the sample inclusive enough (appropriate benchmark)?	yes (1) no/unclear (0)
7. Is the assumption of a common technology addressed/tested (e.g., developing and developed countries analyzed together)?	yes (1) no/unclear (0)
Bias	
8. Are the data accurate enough to answer the questions, particularly the output data (only quantity or also quality output measures)?	yes (1) no/unclear (0)
9. Are the techniques (parametric, non-parametric or both) used to assess the main outcomes appropriate?	yes (1) no/unclear (0)
10. Has the dataset been examined for the presence of outliers?	yes (1) no/unclear (0)
11. Is the problem of convergence due to dimensionality properly addressed?	yes (1) no/unclear (0)
12. If the second-stage analysis is undertaken,are any statistical problems accounted for?	yes (1) no/unclear (0) not applicable (N/A)
Power	
13. Have the sensitivity analyses been conducted?	yes (1) no/unclear (0)
14. Are the confidence intervals for efficiency estimates generated?	yes (1) no/unclear (0)

Reference; Varabyova, Y., and Müller, JM. (2016).

Alatawi et al. Cost Eff Resour Alloc (2019) 17:17
https://doi.org/10.1186/s12962-019-0185-4

Cost Effectiveness and Resource Allocation

REVIEW Open Access

Systematic review and meta-analysis of public hospital efficiency studies in Gulf region and selected countries in similar settings

Ahmed Alatawi[1,2*], Sayem Ahmed[1,3,4], Louis Niessen[1,5,6] and Jahangir Khan[1,3,4]

Abstract

Background: The assessment of hospital efficiency is attracting interest worldwide, particularly in Gulf Cooperation Council (GCC) countries. The objective of this study was to review the literature on public hospital efficiency and synthesise the findings in GCC countries and comparable settings.

Methods: We systematically searched six scientific databases, references and grey literature for studies that measured the efficiency of public hospitals in appropriate countries, and followed PRISMA guidelines to present the results. We summarised the included studies in terms of samples, methods/technologies and findings, then assessed their quality. We meta-analysed the efficiency estimates using Spearman's rank correlations and logistic regression, to examine the internal validity of the findings.

Results: We identified and meta-analysed 22 of 1128 studies. Four studies were conducted in GCC nations, 18 came from Iran and Turkey. The pooled technical-efficiency (TE) was 0.792 (SE ± 0.03). There were considerable variations in model specification, analysis orientation and variables used in the studies, which influenced efficiency estimates. The studies lacked some elements required in quality appraisal, achieving an average of 73%. Meta-analysis showed negative correlations between sample size and efficiency scores; the odd ratio was 0.081 (CI 0.005: 1.300; P value = 0.07) at 10% risk level. The choice of model orientation was significantly influenced (82%) by the studied countries' income categories, which was compatible with the strategic plans of these countries.

Conclusions: The studies showed methodological and qualitative deficiencies that limited their credibility. Our review suggested that methodology and assumption choices have a substantial impact on efficiency measurements. Given the GCC countries' strategic plans and resource allocations, these nations need further efficiency research using high-quality data, different orientations and developed models. This will establish an evidence-based knowledge base appropriate for use in public hospital assessments, policy- and decision-making and the assurance of value for money.

Keywords: Gulf countries, Systematic review, Technical efficiency, Public hospitals, Data envelopment analysis, Stochastic frontier analysis

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Cost Effectiveness and Resource Allocation

CORRECTION Open Access

Correction to: Systematic review and meta-analysis of public hospital efficiency studies in Gulf region and selected countries in similar settings

Ahmed D. Alatawi[1,2*], Sayem Ahmed[1,3,4], Louis Niessen[1,5,6] and Jahangir Khan[1,3,4]

Correction to: Cost Eff Resour Alloc (2019) 17:17
https://doi.org/10.1186/s12962-019-0185-4

Please note that following publication of the original article [1], two errors have been flagged by the authors.

Firstly, the article has been processed with the wrong article type: it is not a 'Review', but rather a 'Research article'.

Secondly, the initial of the corresponding author's middle name is missing in the original article; please see the corrected name in the author list of this Correction.

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Reference
1. Alatawi AD, Ahmed S, Niessen L, Khan J. Systematic review and meta-analysis of public hospital efciency studies in Gulf region and selected countries in similar settings. Cost Eff Resour Alloc. 2019;17:17. https://doi.org/10.1186/s12962-019-0185-4.

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Appendix C

Appendix related to DEA analysis

Appendix C.1: List of the sample hospitals

Hospital ID	Name	City	Health District	Geographic Location	Capacity
H01	مستشفى الأمير مشاري بن سعود بن عبد العزيز	Albahah	Albahah	South	330
H02	مستشفى الملك فهد بالباحة	Albahah	Albahah	South	320
H03	مستشفى الملك فهد بالهفوف	Alehsa	Alehsa	East	575
H04	مستشفى الأمير سعود بن جلوي	Alehsa	Alehsa	East	250
H05	مستشفى الملك فيصل بالإحساء	Alehsa	Alehsa	East	200
H06	مستشفى الملك عبد العزيز	Skaka	Aljouf	North	300
H07	مستشفى الامير متعب بن عبدالعزيز	Skaka	Aljouf	North	300
H08	مستشفى طبرجل العام	Tebarjal	Aljouf	North	200
H09	مستشفى القريات العام	Alqerqyat	Alqerqyat	North	240
H10	مستشفى عسير المركزي	Aseer	Aseer	South	450
H11	مستشفى محايل	Mahail	Aseer	South	170
H12	مستشفى خميس مشيط	Alkhamees	Aseer	South	150
H13	مستشفى سراة عبيدة العام	Sarat	Aseer	South	110
H14	مستشفى ظهران الجنوب العام	Dahran	Aseer	South	100
H15	مستشفي المـجاردة	Almajardah	Aseer	South	100
H16	مستشفى رجال المع	Rejal almaa	Aseer	South	100
H17	مستشفى احد رفيده	Ahad Rafeedah	Aseer	South	100
H18	مستشفى الملك عبد الله ببيشة	Beeshah	Beeshah	South	360
H19	مستشفى تثليث	Tathleeth	Beeshah	South	110
H20	مجمع الدمام الطبي	Adammam	Eastern	East	491
H21	مستشفى القطيف المركزي	Alqateef	Eastern	East	335
H22	مستشفى الجبيل العام	Aljubiel	Eastern	East	200
H23	مستشفى الملك فهد بالمدينه	Elmadinah	Elmadinah	West	523
H24	مستشفى ينبـــع	Yanbu	Elmadinah	West	300
H25	مستشفى أحـــد بالمدينة	Elmadinah	Elmadinah	West	261
H26	مستشفى الامير عبدالمحسن بالعلا	Alola	Elmadinah	West	128
H27	مستشفى الانصار بالمدينه	Elmadinah	Elmadinah	West	100
H28	مستشفى خيبر العام	Khaibar	Elmadinah	West	100
H29	مستشفى الملك خالد بحائل	Hael	Hael	North	310
H30	مستشفى حائل العام	Hael	Hael	North	245
H31	مستشفى الملك خالد العام بحفرالباطن	Hafer Elbaten	Hafer Elbaten	East	300
H32	مستشفى حفر الباطن المركزي	Hafer Elbaten	Hafer Elbaten	East	200
H33	مستشفى الملك فهد المركزي بجازان	Jazan	Jazan	South	450

H34	مستشفى الأمير محمد بن ناصر بجازان	Jazan	Jazan	South	200
H35	مستشفى جيزان العام	Jazan	Jazan	South	150
H36	مستشفى صـبياء العام	Sabia	Jazan	South	150
H37	مستشفى صـامـطـة العام	Samtah	Jazan	South	150
H38	مستشفى أبو عريش العام	Abu Areesh	Jazan	South	130
H39	مستشفى بـيـش العام	Beeshah	Jazan	South	100
H40	مستشفى الملك فهد بجدة	Jeddah	Jeddah	West	711
H41	مستشفى الملك عبد العزيز ومركز الأورام بجدة	Jeddah	Jeddah	West	436
H42	مستشفى شرق جده	Jeddah	Jeddah	West	300
H43	مستشفى رابغ العام	Rabegh	Jeddah	West	120
H44	مستشفى الثغر بجدة	Jeddah	Jeddah	West	100
H45	مستشفى اضم	Adm	Jeddah	West	100
H46	مستشفى النورالتخصصي بمكه	Mecca	Mecca	West	500
H47	مستشفى الملك عبدالعزيز بمكة	Mecca	Mecca	West	300
H48	مستشفى الملك فيصل بالششه بمكه	Mecca	Mecca	West	300
H49	مستشفى حراء العام	Mecca	Mecca	West	279
H50	مستشفى الملك خالد بنجران	Najran	Najran	South	330
H51	مستشفى نجران العام	Najran	Najran	South	200
H52	مستشفى شروره العام	Sharorah	Najran	South	100
H53	مستشفى عرعر المركزي	ARAR	North border	North	350
H54	مستشفى طريف العام	Turaif	North border	North	200
H55	مستشفي عبد العزيز بن مساعد بن جلوي	ARAR	North border	North	110
H56	مستشفى رفحاء العام	Rafha	North border	North	100
H57	مستشفى الملك فهد التخصصي ببريدة	Buraidah	Qassim	Middle	430
H58	مستشفى بريده المركزي	Buraidah	Qassim	Middle	300
H59	مستشفى الملك سعود بعنيزة	Unaizah	Qassim	Middle	294
H60	مستشفى الرس العام	Alrras	Qassim	Middle	250
H61	مستشفى البكيرية العام	Alqaseem	Qassim	Middle	135
H62	مستشفى المذنب العام	Almezanab	Qassim	Middle	130
H63	مستشفى البدائع العام	Albadayea	Qassim	Middle	120
H64	مستشفى القنفذة العام	Qunfethah	Qunfedah	West	150
H65	مستشفى جنوب القنفذة	Qunfethah	Qunfedah	West	100
H66	مستشفى الأمير محمد بن عبدالعزيز	Riyadh	Riyadh	Middle	500
H67	مستشفى الملك خالد بالخرج	Alkharj	Riyadh	Middle	350
H68	مستشفى اليمامة بالرياض	Riyadh	Riyadh	Middle	300
H69	مستشفى الملك سلمان بالرياض	Riyadh	Riyadh	Middle	244
H70	مستشفى الإيمان	Riyadh	Riyadh	Middle	207
H71	مستشفى الملك خالد بالمجمعة	Almajmaah	Riyadh	Middle	204
H72	مستشفى الدوادمي	Eldawadmi	Riyadh	Middle	200
H73	مستشفى القويعية	AlQuwiayah	Riyadh	Middle	200
H74	مستشفى الإمام عبد الرحمن الفيصل	Riyadh	Riyadh	Middle	200
H75	مستشفى الزلفي	Azulfi	Riyadh	Middle	170

H76	مستشفى شقراء	Shagra	Riyadh	Middle	150
H77	مستشفى وادي الدواسر	Wadiadwaser	Riyadh	Middle	150
H78	مستشفى عفيف العام	Afif	Riyadh	Middle	130
H79	مستشفى حريملاء	Huraimela	Riyadh	Middle	100
H80	مستشفى الأفلاج العام	Alaflaje	Riyadh	Middle	120
H81	مستشفى حوطة بني تميم	Hotah	Riyadh	Middle	100
H82	مستشفى السليل	Asaleel	Riyadh	Middle	100
H83	مستشفى الملك فهد التخصصي	Tabuk	Tabuk	North	500
H84	مستشفى الملك خالد بتبوك	Tabuk	Tabuk	North	270
H85	مستشفى الوجه العام	Tabuk	Tabuk	North	200
H86	مستشفى ضباء	Dhuba	Tabuk	North	100
H87	مستشفى حقل	Haql	Tabuk	North	100
H88	مستشفى تيماء العام	Taimma	Tabuk	North	100
H89	مستشفى املج	Ummloge	Tabuk	North	100
H90	مستشفى الملك عبد العزيز التخصصي	Taif	Taif	West	500
H91	مستشفى الملك فيصل	Taif	Taif	West	500

Appendix C.2: Technical efficiency scores and returns to the scale of the public hospitals

Hospital ID	CRS technical efficiency	VRS technical efficiency	Scale efficiency	Return to Scale RTS	Peers (Frequencies)
H01	0.85	0.86	0.99	CRS	6
H02	0.78	0.93	0.84	DRS	5
H03	0.93	1.00	0.93	DRS	5
H04	0.89	0.89	0.99	CRS	3
H05	0.27	0.50	0.54	CRS	2
H06	0.57	0.58	1.00	IRS	5
H07	0.66	0.66	1.00	CRS	3
H08	1.00	1.00	1.00	CRS	19
H09	1.00	1.00	1.00	CRS	3
H10	0.87	0.94	0.93	DRS	6
H11	1.00	1.00	1.00	CRS	5
H12	0.91	1.00	0.91	IRS	1
H13	0.20	0.91	0.22	CRS	3
H14	1.00	1.00	1.00	CRS	23
H15	0.57	1.00	0.57	IRS	0
H16	0.79	1.00	0.79	IRS	10
H17	0.93	1.00	0.93	IRS	1
H18	0.58	0.59	0.98	CRS	3
H19	0.67	1.00	0.67	IRS	3
H20	0.98	1.00	0.98	DRS	5
H21	0.88	0.89	0.99	CRS	4
H22	0.45	0.55	0.81	IRS	6
H23	1.00	1.00	1.00	CRS	17
H24	1.00	1.00	1.00	CRS	4
H25	0.80	0.81	0.99	CRS	6
H26	0.50	0.80	0.63	IRS	5

H27	1.00	1.00	1.00	CRS	40
H28	0.53	1.00	0.53	IRS	0
H29	1.00	1.00	1.00	CRS	17
H30	0.98	1.00	0.98	IRS	5
H31	0.98	1.00	0.98	DRS	1
H32	1.00	1.00	1.00	CRS	1
H33	0.39	0.41	0.95	DRS	3
H34	0.79	0.79	0.99	CRS	4
H35	0.62	0.69	0.89	CRS	4
H36	0.99	1.00	0.99	IRS	2
H37	1.00	1.00	1.00	CRS	14
H38	1.00	1.00	1.00	CRS	4
H39	0.76	1.00	0.76	IRS	1
H40	0.48	0.82	0.59	DRS	4
H41	0.63	0.72	0.87	DRS	7
H42	0.58	0.62	0.94	IRS	5
H43	0.81	0.95	0.85	IRS	5
H44	0.80	1.00	0.80	IRS	6
H45	0.64	1.00	0.64	IRS	2
H46	0.82	1.00	0.82	DRS	3
H47	0.73	0.76	0.96	IRS	4
H48	0.54	0.60	0.89	IRS	6
H49	0.73	0.84	0.87	DRS	6
H50	0.79	1.00	0.79	DRS	1
H51	0.11	0.50	0.22	IRS	3
H52	0.84	1.00	0.84	IRS	6
H53	0.65	0.67	0.96	DRS	6
H54	0.95	0.98	0.97	IRS	6
H55	1.00	1.00	1.00	CRS	6
H56	1.00	1.00	1.00	CRS	8
H57	1.00	1.00	1.00	CRS	6

H58	0.96	1.00	0.96	DRS	4
H59	1.00	1.00	1.00	CRS	17
H60	1.00	1.00	1.00	CRS	11
H61	0.96	0.97	0.99	IRS	8
H62	1.00	1.00	1.00	CRS	4
H63	0.98	1.00	0.98	IRS	1
H64	0.40	0.67	0.60	IRS	4
H65	0.46	1.00	0.46	IRS	0
H66	0.49	0.50	1.00	CRS	6
H67	0.73	0.96	0.76	DRS	5
H68	0.49	0.51	0.97	IRS	10
H69	0.85	0.88	0.97	CRS	5
H70	0.91	0.92	0.99	DRS	6
H71	0.69	0.78	0.88	IRS	5
H72	0.71	0.79	0.90	IRS	6
H73	0.60	0.65	0.92	IRS	6
H74	0.77	0.79	0.97	IRS	9
H75	1.00	1.00	1.00	CRS	3
H76	1.00	1.00	1.00	CRS	2
H77	0.60	0.78	0.77	IRS	5
H78	0.76	0.83	0.92	IRS	5
H79	0.71	1.00	0.71	IRS	0
H80	1.00	1.00	1.00	CRS	5
H81	0.69	1.00	0.69	IRS	1
H82	1.00	1.00	1.00	CRS	20
H83	0.28	0.30	0.92	IRS	6
H84	0.52	0.58	0.90	IRS	6
H85	0.47	0.57	0.82	IRS	5
H86	0.19	1.00	0.19	IRS	0
H87	0.66	1.00	0.66	IRS	0
H88	1.00	1.00	1.00	CRS	10

H89	0.89	1.00	0.89	IRS	2
H90	0.82	1.00	0.82	DRS	3
H91	0.37	0.42	0.88	DRS	6

Appendix C.3: Actual and target values of inefficient hospitals to render efficient, in addition to the amount of change in each hospital.

Name	Beds Value	Beds Target	Beds Gain(%)	Phesician Value	Phesician Target	Phesician Gain(%)	Nurse Value	Nurse Target	Nurse Gain(%)	Allied Health Value	Allied Health Target	Allied Health Gain(%)
H01	330	216.41	-34.42	222	125.39	-43.52	349	298.45	-14.49	241	206.09	-14.49
H02	320	239.38	-25.19	373	271.62	-27.18	951	601.37	-36.76	351	326.47	-6.99
H03	575	575	0	577	577	0	1436	1436	0	527	527	0
H04	250	164.28	-34.29	120	94.13	-21.56	187	166.81	-10.8	157	130.66	-16.78
H05	200	100	-50	102	51	-50	244	110.04	-54.9	150	66.42	-55.72
H06	300	172.85	-42.38	251	98.72	-60.67	548	315.73	-42.38	236	135.97	-42.38
H07	300	149.38	-50.21	204	110.6	-45.78	777	325.51	-58.11	220	145.71	-33.77
H08	200	200	0	91	91	0	396	396	0	128	128	0
H09	240	240	0	200	200	0	565	565	0	258	258	0
H10	450	411.75	-8.5	457	405.14	-11.35	1002	938.26	-6.36	667	624.57	-6.36
H11	170	170	0	126	126	0	303	303	0	155	155	0
H12	150	150	0	155	155	0	251	251	0	221	221	0
H13	110	100	-9.09	63	40.62	-35.52	99	90	-9.09	75	53.26	-28.98
H14	100	100	0	38	38	0	85	85	0	50	50	0
H15	100	100	0	49	49	0	154	107.4	-30.26	82	66.15	-19.33
H16	100	100	0	46	46	0	100	100	0	64	64	0
H17	100	100	0	77	77	0	127	127	0	108	108	0
H18	360	171.31	-52.41	245	135.67	-44.62	581	344.39	-40.73	295	174.86	-40.73
H19	110	110	0	52	52	0	78	78	0	40	40	0
H20	491	491	0	694	694	0	1930	1930	0	831	831	0
H21	335	291.17	-13.08	417	255.09	-38.83	810	721.36	-10.94	457	307.54	-32.7
H22	200	110.28	-44.86	192	105.87	-44.86	353	173.2	-50.94	228	125.72	-44.86
H23	523	523	0	676	676	0	1337	1337	0	931	931	0
H24	300	300	0	157	157	0	447	447	0	185	185	0
H25	261	211.26	-19.06	388	227.1	-41.47	681	489.04	-28.19	420	339.96	-19.06
H26	128	102.71	-19.76	96	77.03	-19.76	281	171.46	-38.98	206	121.74	-40.9
H27	100	100	0	133	133	0	268	268	0	170	170	0
H28	100	100	0	57	57	0	166	126.94	-23.53	95	73.91	-22.2
H29	310	310	0	322	322	0	800	800	0	469	469	0
H30	245	203.17	-17.08	118	117.66	-0.29	380	357.83	-5.83	204	189.19	-7.26
H31	300	300	0	235	235	0	562	562	0	283	283	0
H32	200	200	0	97	97	0	377	377	0	176	176	0
H33	450	184.21	-59.07	462	189.12	-59.07	1125	456.33	-59.44	689	273.69	-60.28
H34	200	130.7	-34.65	136	107.82	-20.72	307	243.39	-20.72	257	163.48	-36.39

H35	150	101.33	-32.44	119	82.59	-30.6	252	168.77	-33.03	178	105.02	-41
H36	150	150	0	118	118	0	291	291	0	211	211	0
H37	150	150	0	100	100	0	228	228	0	175	175	0
H38	130	130	0	113	113	0	204	204	0	196	196	0
H39	100	100	0	77	77	0	194	194	0	136	136	0
H40	711	456.27	-35.83	894	563.96	-36.92	1852	1514.79	-18.21	1149	669.19	-41.76
H41	436	314.9	-27.78	529	327.44	-38.1	1123	811.08	-27.78	605	436.96	-27.78
H42	300	185.88	-38.04	375	181.91	-51.49	716	443.63	-38.04	507	218.86	-56.83
H43	120	113.98	-5.01	75	61.34	-18.22	151	142.11	-5.89	85	80.74	-5.01
H44	100	100	0	156	156	0	380	380	0	325	325	0
H45	100	100	0	48	48	0	74	74	0	49	49	0
H46	500	500	0	587	587	0	1156	1156	0	593	593	0
H47	300	227.08	-24.31	306	229.34	-25.05	971	617.35	-36.42	532	331.79	-37.63
H48	300	181.48	-39.51	269	162.73	-39.51	741	382.31	-48.41	390	235.92	-39.51
H49	279	180.62	-35.26	337	223.75	-33.61	631	516.59	-18.13	336	283.67	-15.58
H50	330	330	0	308	308	0	1006	1006	0	567	567	0
H51	200	100	-50	129	64.5	-50	326	138.61	-57.48	390	83.43	-78.61
H52	100	100	0	102	102	0	230	230	0	174	174	0
H53	350	196.18	-43.95	208	117.21	-43.65	588	395.59	-32.72	242	162.81	-32.72
H54	200	143.99	-28	84	82.34	-1.98	384	253.09	-34.09	105	102.93	-1.98
H55	110	110	0	97	97	0	237	237	0	97	97	0
H56	100	100	0	103	103	0	125	125	0	106	106	0
H57	430	430	0	469	469	0	1002	1002	0	830	830	0
H58	300	300	0	278	278	0	738	738	0	445	445	0
H59	294	294	0	259	259	0	737	737	0	309	309	0
H60	250	250	0	155	155	0	348	348	0	302	302	0
H61	135	131.42	-2.65	70	68.14	-2.65	172	167.44	-2.65	163	106.47	-34.68
H62	130	130	0	60	60	0	112	112	0	100	100	0
H63	120	120	0	54	54	0	131	131	0	120	120	0
H64	150	100	-33.33	209	111.43	-46.68	314	201.44	-35.85	202	134.67	-33.33
H65	100	100	0	99	99	0	192	192	0	145	133.16	-8.16
H66	500	247.66	-50.47	395	195.65	-50.47	1291	520.34	-59.69	604	299.18	-50.47
H67	350	226.02	-35.42	287	231.5	-19.34	633	604.85	-4.45	335	320.1	-4.45
H68	300	152.53	-49.16	296	150.5	-49.16	653	332.02	-49.16	427	217.11	-49.16
H69	244	214.34	-12.16	403	236.71	-41.26	783	557.52	-28.8	523	333.53	-36.23
H70	207	190.54	-7.95	280	205.37	-26.65	517	475.9	-7.95	331	285.4	-13.78
H71	204	159.37	-21.88	141	110.15	-21.88	380	245.61	-35.37	237	178.44	-24.71
H72	200	157.04	-21.48	135	106	-21.48	399	264.83	-33.63	243	145.49	-40.13
H73	200	130.55	-34.72	138	87.62	-36.5	316	206.28	-34.72	153	99.87	-34.72
H74	200	158.9	-20.55	211	141.31	-33.03	375	297.94	-20.55	222	176.38	-20.55
H75	170	170	0	107	107	0	163	163	0	108	108	0

H76	150	150	0	94	94	0	184	184	0	116	116	0
H77	150	116.35	-22.43	81	63.01	-22.21	190	138.16	-27.28	94	73.13	-22.21
H78	130	107.58	-17.25	118	91.33	-22.6	198	163.61	-17.37	96	79.44	-17.25
H79	100	100	0	67	46.96	-29.91	89	89	0	74	54.26	-26.68
H80	120	120	0	71	71	0	110	110	0	47	47	0
H81	100	100	0	79	79	0	177	177	0	120	120	0
H82	100	100	0	77	77	0	93	93	0	37	37	0
H83	500	145.1	-70.98	316	94.73	-70.02	983	216.05	-78.02	401	120.21	-70.02
H84	270	155.3	-42.48	319	163.7	-48.68	760	376.41	-50.47	379	218	-42.48
H85	200	107.74	-46.13	111	63.18	-43.08	299	122.36	-59.08	120	68.3	-43.08
H86	100	100	0	121	91.9	-24.05	224	194.38	-13.22	118	118	0
H87	100	100	0	76	76	0	111	107.2	-3.43	51	51	0
H88	100	100	0	101	101	0	242	242	0	129	129	0
H89	100	100	0	104	104	0	136	136	0	90	90	0
H90	500	500	0	392	392	0	1086	1086	0	538	538	0
H91	500	164.19	-67.16	388	164.29	-57.66	1006	361.22	-64.09	510	215.95	-57.66

Name	Outpatient Value	Outpatient Target	Outpatient Gain(%)	Inpatients Value	Inpatients Target	Inpatients Gain(%)	Total surgery Value	Total surgery Target	Total surgery Gain(%)
H01	50804	66582.67	31.06	49748	49748	0	2395	2395	0
H02	112038	112038	0	9714	28760.17	196.07	6061	6061	0
H03	94826	94826	0	2426	2426	0	5813	5813	0
H04	48851	70256.98	43.82	7722	11553.77	49.62	1438	1851.59	28.76
H05	15892	21140.85	33.03	3511	4953.36	41.08	1468	1572.98	7.15
H06	3376	51463.12	1424.38	499	22429.4	4394.87	2370	2370	0
H07	44209	53504.03	21.03	23039	25765.24	11.83	4535	4535	0
H08	51276	51276	0	32308	32308	0	1674	1674	0
H09	4239	4239	0	12518	12518	0	1350	1350	0
H10	169685	169685	0	97673	97673	0	4694	4694	0
H11	79036	79036	0	36000	36000	0	2559	2559	0
H12	66885	66885	0	13920	13920	0	2216	2216	0
H13	10927	16457.42	50.61	884	3027.7	242.5	260	797.15	206.6
H14	15268	15268	0	2550	2550	0	604	604	0
H15	10335	19518.19	88.86	308	4157.44	1249.82	712	1274.73	79.03
H16	31538	31538	0	12725	12725	0	543	543	0
H17	20849	20849	0	1892	1892	0	1264	1264	0
H18	59825	72013.09	20.37	40596	40596	0	3475	3475	0
H19	1785	1785	0	7671	7671	0	361	361	0

H20	466608	466608	0	80250	80250	0	9464	9464	0
H21	74618	144752.5	93.99	5134	42746.46	732.62	1017	2276.07	123.8
H22	34002	43055.94	26.63	576	6062.68	952.55	1300	1592.9	22.53
H23	129928	129928	0	503216	503216	0	4369	4369	0
H24	5853	5853	0	73193	73193	0	277	277	0
H25	135446	135446	0	54607	54607	0	4370	5195.27	18.88
H26	21185	50455.84	138.17	19868	19868	0	1071	1076.6	0.52
H27	58185	58185	0	20113	20113	0	7685	7685	0
H28	15830	23674.34	49.55	2019	4054.2	100.8	568	1361.61	139.72
H29	128836	128836	0	61778	61778	0	3253	3253	0
H30	39243	71545.52	82.31	47905	47905	0	2635	2635	0
H31	83496	83496	0	19992	19992	0	3647	3647	0
H32	30278	30278	0	7742	7742	0	1108	1108	0
H33	111130	111130	0	7655	36850.55	381.39	6098	6098	0
H34	41335	47906.02	15.9	4099	12441.5	203.53	3902	3902	0
H35	39988	39988	0	5540	10186.86	83.88	3730	3730	0
H36	83185	83185	0	34516	34516	0	3164	3164	0
H37	205357	205357	0	5482	5482	0	2448	2448	0
H38	47055	47055	0	2375	2375	0	3092	3092	0
H39	27226	27226	0	3002	3002	0	1389	1389	0
H40	135234	308361.6	128.02	57317	60597.18	5.72	7330	7330	0
H41	146845	146845	0	6417	42951.7	569.34	5760	5760	0
H42	6996	93001.77	1229.36	1405	25777.02	1734.66	2795	3711.62	32.8
H43	37785	37785	0	16828	16828	0	670	860.35	28.41
H44	28393	28393	0	553	553	0	1064	1064	0
H45	25345	25345	0	4565	4565	0	411	411	0
H46	311847	311847	0	14329	14329	0	5260	5260	0
H47	77887	102883.5	32.09	1403	29646.22	2013.06	1945	1945	0
H48	36922	64916.24	75.82	44510	44510	0	1570	1807.03	15.1
H49	104167	104167	0	55086	55086	0	7104	7104	0
H50	83204	83204	0	57739	57739	0	7522	7522	0
H51	8137	27154.76	233.72	4292	6487.04	51.14	172	2263.73	1216.12
H52	68734	68734	0	22989	22989	0	1581	1581	0
H53	93733	93733	0	17918	26239.17	46.44	2341	2341	0
H54	66652	66652	0	18038	18038	0	921	1559.68	69.35
H55	95102	95102	0	14326	14326	0	2105	2105	0
H56	42445	42445	0	4456	4456	0	1704	1704	0
H57	237038	237038	0	6264	6264	0	5621	5621	0
H58	210892	210892	0	68412	68412	0	6399	6399	0
H59	146599	146599	0	42274	42274	0	2246	2246	0
H60	119584	119584	0	69442	69442	0	3721	3721	0

H61	51686	51686	0	2345	12667.99	440.21	1463	1463	0
H62	51876	51876	0	2152	2152	0	1483	1483	0
H63	62697	62697	0	766	766	0	549	549	0
H64	20889	47720.68	128.45	11560	12507.27	8.19	366	4758.18	1200.05
H65	16246	38300.77	135.76	3457	8055.79	133.03	521	3106.14	496.19
H66	113210	113210	0	47994	48159.91	0.35	2748	2760.16	0.44
H67	261766	261766	0	4889	22121.94	352.48	3444	3979.99	15.56
H68	76773	76773	0	55884	55884	0	4270	4270	0
H69	93555	96178.08	2.8	45050	45050	0	3430	5276.43	53.83
H70	35418	96862.16	173.48	8955	30363.89	239.07	5748	5748	0
H71	67840	67840	0	29909	29909	0	2272	3439.06	51.37
H72	60305	60305	0	3685	9677.75	162.63	1773	1773	0
H73	58393	58393	0	21558	21558	0	807	1459.24	80.82
H74	78122	78122	0	31671	31671	0	2392	2392	0
H75	72332	72332	0	3036	3036	0	1635	1635	0
H76	84784	84784	0	21769	21769	0	3496	3496	0
H77	22374	23381.79	4.5	16330	16330	0	1087	1087	0
H78	59214	59214	0	1804	7649.11	324.01	1461	1461	0
H79	21808	21808	0	4031	4031	0	642	642	0
H80	15863	15863	0	10635	10635	0	618	618	0
H81	41117	41117	0	9961	9961	0	993	993	0
H82	39010	39010	0	507	507	0	496	496	0
H83	50258	50258	0	33730	33730	0	2205	2205	0
H84	27294	71583.82	162.27	28045	28045	0	3736	5267.8	41
H85	35686	35686	0	15404	15404	0	705	705	0
H86	3908	39436.29	909.12	19	10433.85	54815.03	544	3939.26	624.13
H87	37443	37443	0	743	2619.81	252.6	351	1081.72	208.18
H88	42548	42548	0	804	804	0	908	908	0
H89	4548	4548	0	1099	1099	0	517	517	0
H90	156019	156019	0	100719	100719	0	7587	7587	0
H91	124825	124825	0	5654	18368.47	224.88	5230	5230	0

Name	Laboratory Value	Laboratory Target	Laboratory Gain(%)	Radiology Value	Radiology Target	Radiology Gain(%)	MR Value	MR Target	MR Gain(%)
H01	1730895	1730895	0	32678	49877.59	52.63	1.09	1.09	0
H02	1148750	1414687.63	23.15	102090	102090	0	0.36	0.36	0
H03	4118277	4118277	0	188862	188862	0	0.37	0.37	0
H04	808813	808813	0	41424	41424	0	0.41	1.06	157.66
H05	12346	461542.8	3638.4	1959	19797.88	910.61	0.46	0.93	101.19
H06	162205	246532.14	51.99	73384	73384	0	0.2	1.07	437.37
H07	175717	452977.2	157.79	51626	51626	0	0.46	0.73	57.89
H08	117428	117428	0	94086	94086	0	1.2	1.2	0
H09	3204932	3204932	0	19270	19270	0	0.85	0.85	0
H10	3981389	3981389	0	17236	60494.3	250.98	0.17	0.38	120.69
H11	355470	355470	0	71930	71930	0	0.5	0.5	0
H12	1273118	1273118	0	5381	5381	0	0.36	0.36	0
H13	15584	417106.42	2576.5	3979	21017.9	428.22	1.05	1.05	0
H14	406389	406389	0	21326	21326	0	1.05	1.05	0
H15	71839	444057.07	518.13	20869	20869	0	0.37	0.95	157.77
H16	111225	111225	0	14763	14763	0	0.98	0.98	0
H17	229529	229529	0	30870	30870	0	10	10	0
H18	265467	470235.1	77.14	68303	68303	0	0.32	0.55	72.07
H19	200466	200466	0	6514	6514	0	3.7	3.7	0
H20	2412553	2412553	0	170429	170429	0	0.39	0.39	0
H21	3219922	3219922	0	103169	103169	0	0.78	0.78	0
H22	562104	562104	0	35995	35995	0	0.53	0.53	0
H23	2007360	2007360	0	96527	96527	0	0.53	0.53	0
H24	2757526	2757526	0	52994	52994	0	0.47	0.47	0
H25	1712868	1712868	0	35369	39402.27	11.4	0.69	0.69	0
H26	131721	259170.31	96.76	23123	23123	0	1.33	1.33	0
H27	809436	809436	0	10159	10159	0	0.14	0.14	0
H28	224422	457402.04	103.81	12686	19935.29	57.14	4.55	4.55	0
H29	1756992	1756992	0	221980	221980	0	0.28	0.28	0
H30	771652	771652	0	73069	73069	0	0.7	1.05	49.5
H31	1600772	1600772	0	117700	117700	0	0.3	0.3	0
H32	531940	531940	0	49811	49811	0	20	20	0
H33	716521	1066403.89	48.83	71441	71441	0	0.08	0.29	263.11
H34	256180	404416.87	57.86	48482	48482	0	0.32	0.66	106.64
H35	31405	569342.55	1712.9	11916	17085.36	43.38	1.96	1.96	0
H36	203517	203517	0	52777	52777	0	0.98	0.98	0
H37	502164	502164	0	51223	51223	0	0.41	0.41	0

H38	262866	262866	0	60540	60540	0	0.7	0.7	0
H39	352299	352299	0	33186	33186	0	0.71	0.71	0
H40	2546786	2546786	0	177909	177909	0	0.17	0.37	115.33
H41	2102890	2102890	0	129340	129340	0	0.13	0.29	125.1
H42	1804651	1804651	0	57819	57819	0	0.44	0.44	0
H43	116486	145833.21	25.19	26482	26482	0	0.56	0.93	66.86
H44	404112	404112	0	54168	54168	0	0.43	0.43	0
H45	124436	124436	0	262	262	0	4.35	4.35	0
H46	1845619	1845619	0	200843	200843	0	0.17	0.17	0
H47	2106035	2106035	0	99057	99057	0	0.15	0.43	186.36
H48	905097	905097	0	86251	86251	0	0.12	0.71	494.77
H49	1274730	1274730	0	107	36655.65	34157.61	0.54	0.54	0
H50	1551686	1551686	0	105923	105923	0	0.18	0.18	0
H51	15765	504639.92	3101.01	5772	18614.68	222.5	2.56	2.56	0
H52	398810	398810	0	29652	29652	0	0.65	0.65	0
H53	564991	564991	0	82211	82211	0	0.33	0.88	168.18
H54	383294	383294	0	48434	48434	0	0.76	1.01	33.06
H55	377025	377025	0	25709	25709	0	0.96	0.96	0
H56	402092	402092	0	32714	32714	0	0.19	0.19	0
H57	5512774	5512774	0	36075	36075	0	0.18	0.18	0
H58	1583040	1583040	0	112329	112329	0	0.39	0.39	0
H59	3295076	3295076	0	103949	103949	0	0.46	0.46	0
H60	2039637	2039637	0	69488	69488	0	1.04	1.04	0
H61	558987	558987	0	38671	38671	0	1.06	1.06	0
H62	730021	730021	0	22454	22454	0	1.08	1.08	0
H63	533038	533038	0	14206	14206	0	0.96	0.96	0
H64	572330	624117.98	9.05	18780	18780	0	1.18	1.18	0
H65	215893	534592.24	147.62	23623	23623	0	2.44	2.44	0
H66	1401519	1401519	0	125984	125984	0	0.28	0.72	156.43
H67	950075	950075	0	65021	77659.26	19.44	0.43	0.43	0
H68	612481	612481	0	37353	37353	0	1.59	1.59	0
H69	1320105	1320105	0	123515	123515	0	0.32	0.32	0
H70	1692312	1692312	0	62285	62285	0	0.79	0.79	0
H71	1190061	1190061	0	31781	36091.64	13.56	0.7	0.8	13.79
H72	1290889	1290889	0	32649	32649	0	0.67	0.84	26.01
H73	136131	223203.06	63.96	39015	39015	0	0.71	5.51	676.74
H74	537340	537340	0	68511	68511	0	0.42	0.42	0
H75	518705	518705	0	50266	50266	0	1.04	1.04	0
H76	306845	306845	0	18803	18803	0	0.84	0.84	0
H77	98935	210311.77	112.58	18861	18861	0	0.37	2.08	462.43
H78	203207	254130.51	25.06	26992	26992	0	0.75	12.6	1580.3

H79	202426	313516.33	54.88	16403	18741.66	14.26	3.7	3.7	0
H80	195191	195191	0	27748	27748	0	2.38	2.38	0
H81	87992	87992	0	30280	30280	0	1.75	1.75	0
H82	40815	40815	0	16955	16955	0	33.33	33.33	0
H83	248467	298950.78	20.32	28210	28210	0	0.7	1.39	98.68
H84	1127981	1127981	0	58052	58052	0	0.37	0.37	0
H85	47352	154011.18	225.25	17554	18693.88	6.49	0.74	4.97	571.68
H86	794	604408.26	76021.95	1648	15863.1	862.57	4.35	4.35	0
H87	49670	158078.58	218.26	12436	17234.59	38.59	8.33	25.64	207.82
H88	476309	476309	0	19540	19540	0	25	25	0
H89	103599	103599	0	35224	35224	0	1.23	1.23	0
H90	3527179	3527179	0	50414	50414	0	0.44	0.44	0
H91	345769	791324.64	128.86	54506	54506	0	0.33	0.33	0

Appendix C.4 VRS scores of the public hospitals **(DEA sensitivity analysis)**

Name	All variables (Original model)	Outpatient Removed	Inpatient Removed	Surgery Removed	LAB Removed	RAD Removed	MR Removed
H01	85.51	85.51	84.09	83.84	68.02	85.51	83.45
H02	93.01	90.49	93.01	65.96	93.01	61.16	91.61
H03	100	100	100	100	100	100	100
H04	89.2	89.2	89.2	89.2	79	69.23	84.2
H05	50	50	50	50	50	50	50
H06	57.62	57.62	57.62	53.83	57.62	33.33	57.62
H07	66.23	66.23	66.23	48.04	66.23	58.02	66.23
H08	100	100	100	100	100	91.87	100
H09	100	100	100	100	41.67	100	100
H10	93.64	92.72	80.24	90.89	53.16	93.64	90.37
H11	100	100	100	100	100	84.9	100
H12	100	98.57	100	100	70.4	100	100
H13	90.91	90.91	90.91	90.91	90.91	90.91	89.91
H14	100	100	100	100	100	100	100
H15	100	100	100	100	100	100	100
H16	100	100	100	100	100	100	100
H17	100	100	100	100	100	100	100
H18	59.27	59.27	55.5	52.03	59.27	48.83	56.27
H19	100	100	100	100	100	100	100
H20	100	100	100	100	100	100	100
H21	89.06	89.06	89.06	89.06	53.19	76.93	86.63
H22	55.14	55.14	55.14	55.14	51.55	50	54.12
H23	100	100	44.88	100	100	100	100
H24	100	100	100	100	92.41	100	100
H25	80.94	71.1	71.06	80.94	61.42	80.94	74.7
H26	80.24	80.24	78.13	80.24	80.24	79.75	78.96
H27	100	100	100	100	100	100	100
H28	100	100	100	100	100	100	100
H29	100	100	100	100	100	69.3	100
H30	99.71	99.71	91.49	94.67	99.6	95.41	94.71
H31	100	100	100	92.8	90.7	66.73	100
H32	100	100	100	100	90.3	85.97	92.3
H33	40.93	38.81	40.93	33.77	40.93	28.79	37.93
H34	79.28	79.28	79.28	62.22	79.28	61.41	79.28
H35	69.4	68.56	69.4	66.67	69.4	69.4	68.19
H36	100	100	89.73	97.69	100	92.57	100
H37	100	93.04	100	100	100	100	100
H38	100	100	100	100	100	77.83	100
H39	100	100	100	100	100	100	100
H40	81.79	81.79	81.79	46.9	79.02	43.34	78.79
H41	72.22	70.48	72.22	59.92	64.2	55.19	72.22
H42	61.96	61.96	61.96	61.96	41.36	53.3	61.94
H43	94.99	94.74	86.4	94.99	94.99	86.89	94.99
H44	100	100	100	100	100	100	100
H45	100	100	100	100	100	100	100
H46	100	97.83	100	100	100	85.92	100
H47	75.69	75.69	75.69	75.69	56.88	63.01	75.69
H48	60.49	60.49	55.63	60.49	59.62	47.41	60.49
H49	84.42	74.37	73.62	65.51	79.6	84.42	84.07

H50	100	100	100	69.03	100	70.8	89.72
H51	50	50	50	50	50	50	50
H52	100	100	100	100	100	100	100
H53	67.28	63.23	67.28	63.69	63.98	47.43	67.28
H54	98.02	79.94	94.77	98.02	95.03	90.49	95.02
H55	100	99.92	76.38	100	100	100	100
H56	100	100	100	100	100	100	100
H57	100	100	100	100	68.54	100	100
H58	100	100	100	100	100	100	100
H59	100	100	100	100	83.77	100	100
H60	100	100	100	100	100	100	100
H61	97.35	96.34	97.35	94.62	92.74	85.43	97.21
H62	100	100	100	100	100	100	100
H63	100	88.09	100	100	99.14	100	98.64
H64	66.67	66.67	66.67	66.67	66.67	66.67	66.67
H65	100	100	100	100	100	100	100
H66	49.53	49.18	49.53	49.53	47.4	38.21	46.53
H67	95.55	52.98	95.55	95.55	94.58	95.55	95.49
H68	50.84	50.21	40.13	47.98	50.69	49.09	50.6
H69	87.84	87.84	86.05	87.84	85.16	66.37	87.81
H70	92.05	92.05	92.05	87.77	71.1	74.79	91.32
H71	78.12	76.71	74.55	78.12	65.69	78.12	72.12
H72	78.52	76.5	78.52	78.18	55.17	77.57	78.52
H73	65.28	64.34	60.78	65.28	65.28	59.05	63.27
H74	79.45	78.75	75.77	79.33	79.21	63.69	73.45
H75	100	100	100	100	100	89.39	100
H76	100	100	100	97.09	100	100	100
H77	77.79	77.79	66.67	72.28	77.79	76.43	77.79
H78	82.75	80.55	82.75	81.66	82.75	79.2	82.75
H79	100	100	100	100	100	100	100
H80	100	100	100	100	100	100	100
H81	100	100	100	100	100	100	100
H82	100	100	100	100	100	100	100
H83	29.98	29.96	22.76	27.4	29.98	29.47	27.84
H84	57.52	57.52	56.39	57.52	52.54	47.89	51.52
H85	56.92	54.6	50.4	56.68	56.92	56.92	52.92
H86	100	100	100	100	100	100	100
H87	100	100	100	100	100	100	100
H88	100	100	100	100	100	100	100
H89	100	100	100	100	100	100	100
H90	100	100	100	91.61	85.53	100	100
H91	42.34	34.58	42.34	28.86	42.34	33.49	40.13
Efft. No	47	42	44	42	38	37	44
average	86.98	85.50	84.72	84.26	82.15	80.75	85.95
min	29.98	29.96	22.76	27.4	29.98	28.79	27.84
median	100	97.83	95.55	95.55	92.41	86.89	97.21

Sensitivity analysis of DEA results. In each model, deleted the selected output variable on the first row.

The number of efficient hospitals and efficiency scores have changed significantly in each model.

Appendix C.5 Completion of DEA and SFA courses

ASTON
BUSINESS SCHOOL

This is to certify that
Ahmed Alatawi
attended
the following course

Performance Measurement using Data Envelopment Analysis

Organised at Aston Business School
Aston University
16th – 17th January 2018

Professor Emmanuel Thanassoulis, Aston Business School, Aston University, Birmingham, B4 7ET, UK

ASTON
BUSINESS SCHOOL

This is to certify that
Ahmed Alatawi
attended
the following course

Performance Measurement using Stochastic Frontier Analysis

Organised at Aston Business School
Aston University
18th - 19th January 2018

Professor Emmanuel Thanassoulis, Aston Business School, Aston University, Birmingham, B4 7ET, UK

BMJ Open

Efficiency evaluation of public hospitals in Saudi Arabia: an application of data envelopment analysis

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ABSTRACT

Objective In this study, we assess the performance of public hospitals in Saudi Arabia. We detect the sources of inefficiency and estimate the optimal levels of the resources that provide the current level of health services. We enrich our analysis by employing locations and capacities of the hospitals.

Design We employ data envelopment analysis (DEA) to measure the technical efficiency of 91 public hospitals. We apply the input-oriented Charnes, Cooper and Rhodes, and Banker, Charne, Cooper models under Constant and Variable Returns-to-Scale. The assessment includes four inputs, and six output variables taken from the Ministry of Health databases for 2017. We conducted the assessment via PIM-DEA V.3.2 software.

Setting Ministry of health-affiliated hospitals in the Kingdom of Saudi Arabia.

Results Findings identified 75.8% (69 of 91) of public hospitals as technically inefficient. The average efficiency score was 0.76, indicating that hospitals could have reduced their inputs by 24% without reduction in health service provision. Small hospitals (efficiency score 0.79) were more efficient than medium-sized and large hospitals. Hospitals in the central region were more efficient (efficiency score 0.83), than those located in other geographical locations. More than half of the hospitals (62.6%) were operating suboptimally in terms of the scale efficiency, implying that to improve efficiency, they need to alter their production capacity. Performance analysis identified overuse of physician's numbers and shortage of health services production, as major causes of inefficiency.

Conclusion Most hospitals were technically inefficient and operating at suboptimal scale size and indicate that many hospitals may improve their performance through efficient utilisation of health resources to provide the current level of health services. Changes in the production capacity are required, to facilitate optimal use of medical capacity. The inefficient hospitals could benefit from these findings to benchmarking their system and performance in light of the efficient hospital within their capacity and geographical location.

Strengths and limitations of this study

- The study challenged to find data on economic values, the severity of cases and the quality of services. We expanded the selection of the variables to cover a broad range of health services and resources in the hospitals.
- The hospital mortality rate was included in output variables as a proxy of the service quality in the studied hospitals.
- We did not apply output-oriented data envelopment analysis models, alternatively, we adopted input orientation, since we aimed to estimate the optimum levels of the resources without deteriorating the health services.
- Further estimation of the optimal levels of resources is required, to examine the allocation of these resources among the hospitals.
- This is the first performance assessment of public hospitals in Saudi Arabia that uses real data obtained directly from official databases of the Ministry of Health.

INTRODUCTION

Increasing demand for healthcare and the expenditure required to provide efficient, equitable and effective healthcare systems, are the global concerns. The Kingdom of Saudi Arabia (KSA) has experienced these recently, alongside substantial population growth, increased life expectancy and the proliferation of lifestyle-related disease. These have increased the demand for health services at a time of the scant resource.[1–3]

During 2015, KSA government spending on health was 71.3% of the country's total health expenditure, which corresponds to 4.1% of GDP for that year.[4] Healthcare expenditure in KSA increased by 24.7% between 2013 and 2017 (table 1).[1 2 5] While public spending on health in KSA is remarkably high in comparison to many high-income countries (71.3% for KSA vs 61.2% for high-income countries), the number of hospital beds is considerably lower.[3 4] In other words, the cost of each hospital bed in the KSA is remarkably higher than those in other high-income countries.

Although much has been done to promote the efficient use of resources, this has proven insufficient to meet the rising health expenditure and demand for healthcare in KSA.[6 7] Providers seem to find it very challenging to

Appendix D

Appendix related to Determinants of efficiency

Appendix D.1 Variables of demographic and socioeconomic characteristics

Population statistics
Nationality
Saudi
Non-Saudi
Gender
Male
Female
AGE Groups
0-5
5-15
15-45
45-65
>=65
Disease Groups
Infectious & Parasitic Diseases
Neoplasm
Diseases of Blood
Disorders of Thyroid Gland
Diabetes mellitus
(Endocrine, Nutritional and Metabolic Diseases (Excluding D.M & Thyriod Gland)
Mental and Behavioral Diseases
Nervous System Diseases
Opthalmology Diseases
ENT Diseases
Diseases Rheumatic Heart
Hypertensive Diseases
Ischemic heart Diseases
Other Heart & Circulatory Diseases
Upper Respiratory system Diseases
Lower Respiratory System Diseases
Diseases of Oral Cavity , Salivary Glands and Jaws
Diseases of Digestive System
Diseases of the Skin and Subcutaneous Tissue
Diseases of the Musculoskeletal System
Diseases of the Genitourinary System
Pregnancy, Child Birth & Puerperium
Conditions Origination in the Perinatal Period

Congenital Malformation, Deformations And Chromosomal Abnormalities
Symptoms, Signs& Abnormal Clinical and Laboratory Findings
Injury, Poisoning and Certain other Consequences of External Causes
Others
Pharmacutical prescription
Antiarrhythmis
Fibrinolytics
Antithrombotics
Antihypertensives
Diuretics
Anti hypersensitivity
Bronchodilators
Antibiotics
Antihelminthics
Antifungals
Antivirals
liver Diseases Drugs
Ulcers & Bleeding Drugs
Anti-Diabetic Drugs-diabetic Tabs
Anti-Diabetic Drugs-Insulins
Hormonal Therapy
Antiepileptic Drugs
Hypnotics
Controlled Anti-Psychotics
Uncontrolled Anti-Psychotics
Opioid Analgesics
Non-opioid Analgesics
Antipyretics
Others
Low Socioeconomics data
statistics of Long Staying Patients (3+ month) (Non ICU Patients) Financial Hardship
Social Investigation Support. (Financial causes)

Appendix D.2: Heteroskedasticity test

Source	SS	df		MS Number of obs =		91
				F(15, 75)	=	1.43
Model	248.111		15	16.5407333 Prob > F	=	0.1568
Residual	868.9367		75	11.585822 R-squared	=	0.2221
				Adj R-squared	=	0.0665
Total	1117.048		90	12.4116406 Root MSE	=	3.4038

e2	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
Ln_PubulationN	-0.87127	0.567132	-1.54	0.129	-2.00106	0.258513
PF	0.072887	0.059852	1.22	0.227	-0.04634	0.192118
PNS	0.08206	0.064168	1.28	0.205	-0.04577	0.209889
PCH	-0.03688	0.078995	-0.47	0.642	-0.19425	0.120483
PA	0.048995	0.036941	1.33	0.189	-0.0246	0.122584
PA3	0.075545	0.054528	1.39	0.17	-0.03308	0.184171
pc_infectious	0.005009	0.0337	0.15	0.882	-0.06212	0.072144
Ln_anitmicropialagents	0.267251	0.248457	1.08	0.286	-0.2277	0.762202
Ln_Chronicmedications	-0.58055	0.317174	-1.83	0.071	-1.2124	0.05129
Ln_FinancialHardshipduringthetr	-0.79615	0.632185	-1.26	0.212	-2.05553	0.463224
Ln_SocialInvestigationSupportF	0.631721	0.622031	1.02	0.313	-0.60743	1.87087
region_cat						
Middle	0.32195	1.623288	0.2	0.843	-2.91181	3.555707
North	-0.29925	1.741729	-0.17	0.864	-3.76896	3.170449
South	1.872478	1.59707	1.17	0.245	-1.30905	5.054004
West	-0.41228	1.660362	-0.25	0.805	-3.71989	2.89533
_cons	6.418577	6.498619	0.99	0.326	-6.52734	19.36449

Appendix D.3: Correlation Matrix of independent variables

	Population (n)	**Female (%)**	**Non-Saudi (%)**	**Children (0-5 years) (%)**	**Adults (15-45 years) (%)**	**Elderly (>65 years) (%)**	**Infectious disease (%)**	**Anti-microbial pres. (n)**	**Chronic dis. pres. (n)**	**Financial hardship (n)**	**Social support (n)**
Population (n)	1										
P value											
Female (%)	-0.2382*	1									
P value	0.023										
Non-Saudi (%)	0.2223*	-0.2037	1								
P value	0.0342	0.0528									
Children (0-5 years) (%)	-0.0177	0.4879*	0.0207	1							
P value	0.8681	0	0.8452								
Adults (15-45 years) (%)	0.2794*	0.0288	0.0054	0.0123	1						
P value	0.0073	0.7861	0.9592	0.9082							
Elderly (>65 years) (%)	-0.0492	-0.1003	-0.0007	-0.0619	-0.6743*	1					
P value	0.6433	0.3444	0.9951	0.5598	0						
Infectious disease (%)	0.0323	0.3832*	-0.0742	0.5861*	0.0081	0.011	1				
P value	0.7609	0.0002	0.4845	0	0.9394	0.9173					
Anti-microbial pres. (n)	0.2557*	-0.0722	0.1086	-0.0385	0.1109	-0.0657	-0.0911	1			

P value	0.0144	0.4962	0.3056	0.7173	0.2952	0.5363	0.3906				
Chronic dis. pres. (n)	0.2343*	0.0205	0.1403	0.0053	0.2191*	-0.2106*	-0.1065	0.6812*	1		
P value	0.0254	0.8474	0.1846	0.9601	0.0369	0.0451	0.3151	0.003			
Financial hardship (n)	0.2596*	0.0864	0.1291	0.4216*	-0.0591	0.0443	0.3133*	0.2873*	0.4410*	1	
P value	0.0129	0.4152	0.2227	0	0.578	0.6767	0.0025	0.0058	0		
Social support (n)	0.3548*	-0.0168	0.0583	0.1197	-0.0812	0.1173	0.1057	0.15	0.2729*	0.6473*	1
P value	0.0006	0.8743	0.5828	0.2584	0.4444	0.268	0.3186	0.1558	0.0089	0	

This correlation matrix identified absence of multicolleaniarity between the independent variables.

Appendix D.4 Tobit Model

CRS	Coef.	Std.Err.	t	P>t	[95% Conf.	
Ln_PubulationN	-0.548	0.179	-3.07	0.003	-0.904	-0.192
PF	0.030	0.020	1.52	0.132	-0.009	0.069
PNS	0.029	0.021	1.41	0.161	-0.012	0.071
PCH	-0.058	0.029	-2.01	0.047	-0.115	-0.001
PA	0.034	0.013	2.68	0.009	0.009	0.058
PA3	0.040	0.018	2.28	0.025	0.005	0.075
pc_infectious	-0.041	0.015	-2.76	0.007	-0.071	-0.011
Ln_anitmicropialagents	0.109	0.075	1.45	0.151	-0.041	0.258
Ln_Chronicmedications	-0.222	0.100	-2.23	0.029	-0.421	-0.023
Ln_FinancialHardshipdur~r	-0.506	0.197	-2.57	0.012	-0.898	-0.113
Ln_SocialInvestigationS~F	0.489	0.193	2.54	0.013	0.105	0.872
region_cat						
Middle	0.183	0.506	0.36	0.718	-0.824	1.190
North	0.137	0.545	0.25	0.802	-0.949	1.224
South	0.370	0.496	0.75	0.457	-0.617	1.358
West	-0.007	0.508	-0.01	0.989	-1.019	1.005
_cons	4.165	2.040	2.04	0.045	0.101	8.229
var(e.CRSnew)	0.970	0.166			0.690	1.363
LR	chi2(15)	=	63.89			
Prob>	chi2	=	0			
Pseudo	R2	=	0.238			
Log	likelihood	=	-102.285			

Appendix D.5: Two-part model

Two-part model			
Log pseudolikelihood = -102.13645	Number of obs	=	91
Part 1: logit			
	Number of obs	=	91
	LR chi2(14)	=	85.22
	Prob > chi2	=	0.00
Log likelihood = -7.719727	Pseudo R2	=	0.8466
Part 2: regress			
	Number of obs	=	69
	F(14, 54)	=	2.17
	Prob > F	=	0.0217
	R-squared	=	0.3597
	Adj R-squared	=	0.1937
Log likelihood = -94.416721	Root MSE	=	1.0746

CRS	**Coef.**	**Std. Err.**	**z**	**P>z**	**[95% Conf. Interval]**	
LOGIT						
Ln_PubulationN	-12.5685	7.199776	-1.75	0.081	-26.6798	1.542792
PCH	-0.10064	0.264251	-0.38	0.703	-0.61856	0.417283
PA3	0.212827	0.210321	1.01	0.312	-0.19939	0.625048
PF	-0.29654	0.270735	-1.1	0.273	-0.82717	0.234094
PA	0.14538	0.146362	0.99	0.321	-0.14148	0.432244
PNS	0.255957	0.29505	0.87	0.386	-0.32233	0.834244
Ln_FinancialHardshipduringthetr	-19.0546	11.47267	-1.66	0.097	-41.5406	3.43142
Ln_SocialInvestigationSupportF	10.44367	6.305541	1.66	0.098	-1.91497	22.8023
Ln_Chronicdiseases	12.37887	7.002781	1.77	0.077	-1.34632	26.10407

Ln_anitmicropialagents	0.472276	0.528479	0.89	0.372	-0.56352	1.508075
region_cat						
Middle	16.49501	2621.051	0.01	0.995	-5120.67	5153.661
North	9.222643	2621.032	0	0.997	-5127.91	5146.35
South	11.97256	2621.037	0	0.996	-5125.17	5149.11
West	4.765353	2621.019	0	0.999	-5132.34	5141.868
_cons	40.71037	2621.116	0.02	0.988	-5096.58	5178.003
REGRESS						
Ln_PubulationN	-0.3431	0.25991	-1.32	0.187	-0.85251	0.166315
PCH	0.041249	0.04164	0.99	0.322	-0.04036	0.122862
PA3	0.069413	0.021694	3.2	0.001	0.026894	0.111933
PF	0.01629	0.024539	0.66	0.507	-0.03181	0.064385
PA	0.039832	0.0149	2.67	0.008	0.010629	0.069035
PNS	0.029419	0.023697	1.24	0.214	-0.01703	0.075864
Ln_FinancialHardshipduringthetr	-0.48756	0.235846	-2.07	0.039	-0.94981	-0.02531
Ln_SocialInvestigationSupportF	0.495769	0.231673	2.14	0.032	0.041699	0.949839
Ln_Chronicdiseases	-0.4828	0.277588	-1.74	0.082	-1.02687	0.061259
Ln_anitmicropialagents	0.020209	0.062603	0.32	0.747	-0.10249	0.142909
region_cat						
Middle	0.240436	0.567702	0.42	0.672	-0.87224	1.353111
North	0.566193	0.615546	0.92	0.358	-0.64026	1.772641
South	0.236946	0.564131	0.42	0.674	-0.86873	1.342622
West	-0.02294	0.574051	-0.04	0.968	-1.14806	1.102183
_cons	4.325655	2.603006	1.66	0.097	-0.77614	9.427454

Alatawi *et al. Health Economics Review* (2020) 10:25
https://doi.org/10.1186/s13561-020-00282-z

Health Economics Review

RESEARCH Open Access

Determinants of Technical Efficiency in Public Hospitals: The Case of Saudi Arabia

Ahmed D. Alatawi[1,2*], Louis W. Niessen[3,4] and Jahangir A. M. Khan[3,5]

Abstract

Objective: In this study, we investigate the effect of the external environmental and institutional factors on the efficiency and the performance of the public hospitals affiliated to the Ministry of Health (MOH) in the Kingdom of Saudi Arabia (KSA). We estimate the demographic and socioeconomic characteristics of catchment populations that explain the demand for health services.

Methods: We apply descriptive analysis to explore what external factors (demographic and socioeconomic factors) can explain the observed differences in technical efficiency scores. We use Spearman's rank correlation, multivariate Tobit regression and Two-part model to measure the impact of the explanatory variables (i.e. population density, nationality, gender, age groups, economic status, health status, medical interventions and geographic location) on the efficiency scores.

Results: The analysis shows that the external factors had a significant influence on efficiency scores. We find significant associations between hospitals efficiency scores and number of populations in the catchment area, percentage of children (0–5 years old), the prevalence of infectious diseases, and the number of prescriptions dispensed from hospital's departments. Also, the scores significantly associate with the number of populations who faced financial hardships during medical treatments, and those received financial support from social administration. That indicates the hospitals that serve more patients in previous characteristics are relatively more technically efficient.

Conclusions: The environmental and institutional factors have a crucial effect on efficiency and performance in public hospitals. In these regards, we suggested improvement of health policies and planning in respect to hospital efficiency and resource allocation, which consider the different demographic, socioeconomic and health status of the catchment populations (e.g., population density, poverty, health indicators and services utilization). The MOH should pay more attention to ensure appropriate allocation mechanisms of health resources and improve utilization of health services among the target populations, for securing efficient and equitable health services.

Keywords: Technical efficiency, Public hospitals, Healthcare utilization, Environmental factors, Population characteristics, Saudi Arabia

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Full list of author information is available at the end of the article

Appendix E

Appendix related to Chapter 5

Appendix E.1 Approval of hospital affairs in the Ministry of Health for the data collection in Saudi Arabia

المملكة العربية السعودية
وزارة الصحة
الوكالة المساعدة للتخطيط والتميز المؤسسي
الإدارة العامة للبحوث والدراسات

وزارة الصحة
Ministry of Health

وزارة الصحة
01-07-2019 28-10-1440
1440-2109103

الموضوع: بحث الطالب/ أحمد العطوي.

سعادة/ الوكيل المساعد لشؤون المستشفيات بوزارة الصحة المحترم

السلام عليكم ورحمة الله وبركاته،،،،

إشارة إلى موضوع الطالب / أحمد ضيف الله العطوي، المبتعث من جامعة الجوف لدراسة درجة الدكتوراه في تخصص "إقتصاديات الصحة" بكلية ليفربول للطب المداري بجامعة ليفربول بالمملكة المتحدة، رقم الهوية الوطنية (١٠٤٢٣٤٤٧٠٣) وعنوان الرسالة:

" تقييم كفاءة الخدمات الصحية بالمستشفيات العامة بالمملكة العربية السعودية"

نحيطكم علماً بأن الطالب قد إستوفى كافة المستندات المطلوبة وتمت مراجعتها من قبل اللجان المعنية بالإدارة العامة للبحوث والدراسات ولجنة الأخلاقيات بمدينة الملك فهد الطبية بوزارة الصحة، وتمت الموافقة على تسهيل مهمة إجراء هذا البحث، وحيث أن الطالب سينفذ جزء من دراسته في الوكالة المساعدة لشؤون المستشفيات بوزارة الصحة.

وعليه، نأمل من سعادتكم التفضل بالإطلاع والإيعاز لمن يلزم بتسهيل مهمته بعد موافقة الجهات المختصة لديكم، لجمع البيانات اللازمة بما يضمن أن لا يكون هناك أي تأثير على خدمة المراجعين خلال قيامه بمهام بحثه، مع العلم بأن وزارة الصحة تضمن حقوقها في نتائج هذا البحث من خلال إتفاقية المشاركة في البيانات والتي تم توقيعها بين الطالب والإدارة العامة للبحوث والدراسات.

وتفضلوا بقبول خالص تحياتي ،،،

مرفق مستندات وملخص المقترح البحثي،،،،

مدير عام الإدارة العامة للبحوث والدراسات

ص. عذاري فيصل العتيبي

e-mail: research@moh.gov.sa

Appendix E.2 Approval of human resources administration in the Ministry of Health for the data collection in Saudi Arabia

المملكة العربية السعودية
وزارة الصحة
الوكالة المساعدة للتخطيط والتميز المؤسسي
الإدارة العامة للبحوث والدراسات

وزارة الصحة
Ministry of Health

وزارة الصحة
01-07-2019 28-10-1440
1440-2109185

الموضوع: بحث الطالب/ أحمد العطوي.

سعادة/ مدير عام الإدارة العامة لتخطيط الموارد البشرية
والتنمية التنظيمية بوزارة الصحة المحترم

السلام عليكم ورحمة الله وبركاته،،،،

إشارة إلى موضوع الطالب / أحمد ضيف الله العطوي، المبتعث من جامعة الجوف لدراسة درجة الدكتوراه في تخصص "إقتصاديات الصحة" بكلية ليفربول للطب المداري بجامعة ليفربول بالمملكة المتحدة، رقم الهوية الوطنية (١٠٤٢٣٤٤٧٠٣) وعنوان الرسالة:

" تقييم كفاءة الخدمات الصحية بالمستشفيات العامة بالمملكة العربية السعودية"

نحيطكم علماً بأن الطالب قد إستوفى كافة المستندات المطلوبة وتمت مراجعتها من قبل اللجان المعنية بالإدارة العامة للبحوث والدراسات ولجنة الأخلاقيات بمدينة الملك فهد الطبية بوزارة الصحة، وتمت الموافقة على تسهيل مهمة إجراء هذا البحث، وحيث أن الطالب سينفذ جزء من دراسته في الإدارة العامة لتخطيط الموارد البشرية والتنمية التنظيمية بوزارة الصحة.

وعليه، نأمل من سعادتكم التفضل بالإطلاع والإيعاز لمن يلزم بتسهيل مهمته بعد موافقة الجهات المختصة لديكم، لجمع البيانات اللازمة بما يضمن أن لا يكون هناك أي تأثير على خدمة المراجعين خلال قيامه بمهام بحثه، مع العلم بأن وزارة الصحة تضمن حقوقها في نتائج هذا البحث من خلال إتفاقية المشاركة في البيانات والتي تم توقيعها بين الطالب والإدارة العامة للبحوث والدراسات.

وتفضلوا بقبول خالص تحياتـي ،،،

مرفق مستندات وملخص المقترح البحثي،،،،

مدير عام الإدارة العامة للبحوث والدراسات

ص. عذاري فيصل العتيبي

e-mail: research@moh.gov.sa

Appendix E.3 Approval of 2030 Administration in the Ministry of Health for the data collection in Saudi Arabia

المملكة العربية السعودية
وزارة الصحة
الوكالة المساعدة للتخطيط والتميز المؤسسي
الإدارة العامة للبحوث والدراسات

وزارة الصحة
Ministry of Health

وزارة الصحة
25-06-2019 22-10-1440
1440-2071577

الموضوع: بحث الطالب/ أحمد العطوي.

سعادة/ مدير مكتب تحقيق الرؤية بوزارة الصحة المحترم

السلام عليكم ورحمة الله وبركاته،،،،

إشارة إلى موضوع الطالب / **أحمد ضيف الله العطوي**، المبتعث من جامعة الجوف لدراسة درجة الدكتوراه في تخصص "**إقتصاديات الصحة**" بكلية ليفربول للطب المداري بجامعة ليفربول بالمملكة المتحدة، رقم الهوية الوطنية (١٠٤٢٣٤٤٧٠٣) وعنوان الرسالة:

" تقييم كفاءة الخدمات الصحية بالمستشفيات العامة بالمملكة العربية السعودية"

نحيطكم علماً بأن الطالب قد إستوفى كافة المستندات المطلوبة وتمت مراجعتها من قبل اللجان المعنية بالإدارة العامة للبحوث والدراسات ولجنة الأخلاقيات بمدينة الملك فهد الطبية بوزارة الصحة، وتمت الموافقة على تسهيل مهمة إجراء هذا البحث، وحيث أن الطالب سينفذ جزء من دراسته في مكتب تحقيق الرؤية بوزارة الصحة.

وعليه، نأمل من سعادتكم التفضل بالإطلاع والإيعاز لمن يلزم بتسهيل مهمته بعد موافقة الجهات المختصة لديكم، لجمع البيانات اللازمة بما يضمن أن لا يكون هناك أي تأثير على خدمة المراجعين خلال قيامه بمهام بحثه، مع العلم بأن وزارة الصحة تضمن حقوقها في نتائج هذا البحث من خلال إتفاقية المشاركة في البيانات والتي تم توقيعها بين الطالب والإدارة العامة للبحوث والدراسات.

وتفضلوا بقبول خالص تحياتـي ،،،

مرفق مستندات وملخص المقترح البحثي،،،،

مدير عام الإدارة العامة للبحوث والدراسات

ص. عذاري فيصل العتيبي

e-mail: research@moh.gov.sa

Appendix E.4 Approval of health districts administration in the Ministry of Health for the data collection in Saudi Arabia

المملكة العربية السعودية
وزارة الصحة
الوكالة المساعدة للتخطيط والتميز المؤسسي
الإدارة العامة للبحوث والدراسات

وزارة الصحة
Ministry of Health

وزارة الصحة
25-06-2019 22-10-1440
1440-2071178

الموضوع: بحث الطالب/ أحمد العطوي.

سعادة/ الرئيس العام التنفيذي للتجمع الصحي الأول بالرياض المحترم
سعادة/ الرئيس العام التنفيذي للتجمع الصحي الثاني بالرياض المحترم
سعادة/ مدير عام الشؤون الصحية بمنطقة الرياض المحترم
سعادة/ مدير عام الشؤون الصحية بمنطقة تبوك المحترم
سعادة/ مدير عام الشؤون الصحية بمنطقة المدينة المنورة المحترم
سعادة/ مدير عام الشؤون الصحية بمنطقة الجوف المحترم

السلام عليكم ورحمة الله وبركاته،،،،

إشارة إلى موضوع الطالب / أحمد ضيف الله العطوي، المبتعث من جامعة الجوف لدراسة درجة الدكتوراه في تخصص "إقتصاديات الصحة" بكلية ليفربول للطب المداري بجامعة ليفربول بالمملكة المتحدة، رقم الهوية الوطنية (١٠٤٢٣٤٤٧٠٣) وعنوان الرسالة:

" تقييم كفاءة الخدمات الصحية بالمستشفيات العامة بالمملكة العربية السعودية"

نحيطكم علماً بأن الطالب قد إستوفى كافة المستندات المطلوبة وتمت مراجعتها من قبل اللجان المعنية بالإدارة العامة للبحوث والدراسات ولجنة الأخلاقيات بمدينة الملك فهد الطبية بوزارة الصحة، وتمت الموافقة على تسهيل مهمة إجراء هذا البحث، وحيث أن الطالب سينفذ جزء من دراسته في مديرية الشؤون الصحية بمنطقة الرياض، المدينة المنورة، تبوك، والجوف، وبعض المستشفيات الحكومية التابعة للتجمع الصحي الأول والثاني بمنطقة الرياض و بعض المستشفيات الحكومية التابعة لمنطقة تبوك والمدينة المنورة والجوف.

وعليه، نأمل من سعادتكم التفضل بالإطلاع والإيعاز لمن يلزم بتسهيل مهمته بعد موافقة الجهات المختصة لديكم، لجمع البيانات اللازمة بما يضمن أن لا يكون هناك

e-mail: research@moh.gov.sa

المملكة العربية السعودية
وزارة الصحة
الوكالة المساعدة للتخطيط والتميز المؤسسي
الإدارة العامة للبحوث والدراسات

وزارة الصحة
Ministry of Health

أي تأثير على خدمة المراجعين خلال قيامه بمهام بحثه، مع العلم بأن وزارة الصحة تضمن حقوقها في نتائج هذا البحث من خلال إتفاقية المشاركة في البيانات والتي تم توقيعها بين الطالب والإدارة العامة للبحوث والدراسات.

وتفضلوا بقبول خالص تحياتـي ،،،

مرفق مستندات وملخص المقترح البحثي،،،،

مدير عام الإدارة العامة للبحوث والدراسات

ص. عذاري فيصل العتيبي

e-mail: research@moh.gov.sa

Appendix E.5

FOR OFFICE USE ONLY	Application Number	Date considered

GOVERNANCE & ETHICS APPLICATION FORM

Please refer closely to the Guidance Notes when completing this form.
Please ensure that this form is completed fully and the relevant enclosures are received, so that the study can be properly reviewed by the Research Ethics Committee. If any documentation is missing, proposals will not be submitted for review.

Please confirm that this application is for:	YES	NO	
LSTM Sponsorship Approval		X	N.B. LSTM Sponsorship is required when LSTM is the recipient of grant funding
LSTM REC Approval	X		

*If the Sponsor is not LSTM, provide documents which confirm Sponsorship

Project Title:	Evaluation of Health Services Efficiency of Public Hospitals in Saudi Arabia
Applicant Full Name: (including title)	Ahmed Alatawi, PhD student- Health Economics. Department of clinical sciences, LSTM.
Email address:	ahmed.alatawi@lstmed.ac.uk
Postal Address (if not LSTM):	
Telephone number:	+44(0)7491496786
Administrative Contact Name: (if applicable)	
Administrative Contact Email:	

Budget & Administration Charges **Awards ≥£10,000: £250 Awards <£10,000: £50 PhD studies; £50 UoL Studies: £500 External studies: £750**			
Is the proposed work already funded?		**Yes**	
Total budget of proposal	£8,400	**Name of Funder**	Saudi Arabian Cultural Bureau in London

Main Applicant and Research Team				
List LSTM research team and all collaborators. (Please include all overseas collaborators and give their affiliations, qualifications and role in the study).				
Name	**Organisation**	**Qualifications**	**Role in Study**	**Geographic Location**
Ahmed Alatawi	LSTM	MSc, Health Economics	Principal Investigator PI	United Kingdom
Dr Jahangir Khan	LSTM	PhD, Health Economics	Co-Investigator	United Kingdom
Prof. Louis Niessen	LSTM	MD, PhD, Health Economics	Co-Investigator	United Kingdom

Project Details							
Proposed start date	01/06/2019	**Proposed end date**	01/12/2019	**Total number of participants (refer to A.5)**	16	**Is the study multi-centre?**	Yes / **No**

Appendix E.6

Consent Form

CONFIDENTIAL

Study Title: Evaluation of Health Services Efficiency of Public Hospitals in Saudi Arabia	
Principal Investigator: Ahmed Alatawi	**Study Site: Saudi Arabia**

If you agree with each statement, please INITIAL the box provided	
1. I confirm I have read and understood the information sheet dated..... (Version.....) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2. I understand that participation in this study is voluntary and I am free to withdraw consent at any time, without giving a reason, without any penalties.	
3. I understand that data collected during the study may be looked at by individuals from LSTM and from regulatory authorities. I give permission for these individuals to have access to my records.	
4. I agree to my GP being informed of my participation in the study, and to their sharing my prescription and vaccination history with the study team. **(UK only)**	
5. I hereby declare that I have not been subjected to any form of coercion in giving this consent.	
6. I agree to the data about me collected in this study being stored for further use in the future. **(delete if not applicable)**	
7. I will gift these samples so that they may be used for future ethically approved research. **(delete if not applicable)**	
8. I agree to take part in this study.	

Signing this declaration does not affect your right to decline to take part in any future study.

Name of participant	Date	Signature
Name of person taking Consent	Date	Signature

When complete: 1 copy for participant; 1 copy (original) for research

Appendix E.7 LSTM REC Approval for data collection

Ahmed Alatawi
Liverpool School of Tropical Medicine
Pembroke Place
Liverpool
L3 5QA

LSTM
LIVERPOOL SCHOOL OF TROPICAL MEDICINE
Pembroke Place,
Liverpool, L3 5QA, UK
Tel: +44(0)151 705 3100
Fax: +44(0)151 705 3370
www.lstmed.ac.uk

Tuesday, 18 June 2019

Dear Mr.Alatawi,

Re. Research Protocol (19-036) ***Evaluation of Health Services Efficiency of public Hospitals in Saudi Arabia***

Thank you for your letter of 18th June 2019 providing the necessary in-country approvals for this project. I can confirm that the protocol now has formal ethical approval from the LSTM Research Ethics Committee.

The approval is for a fixed period of three years and will therefore expire on 17th June 2022. The Committee may suspend or withdraw ethical approval at any time if appropriate.

Approval is conditional upon:

- Continued adherence to all in-country ethical requirements.
- Notification of all amendments to the protocol for approval before implementation.
- Notification of when the project actually starts.
- Provision of an annual update to the Committee.
  Failure to do so could result in suspension of the study without further notice.
- Reporting of new information relevant to patient safety to the Committee
- Provision of Data Monitoring Committee reports (if applicable) to the Committee

Failure to comply with these requirements is a breach of the LSTM Research Code of Conduct and will result in withdrawal of approval and may lead to disciplinary action. The Committee would also like to receive copies of the final report once the study is completed. Please quote your Ethics Reference number with all correspondence.

Yours sincerely

Dr Jamie Rylance
Acting Chair
LSTM Research Ethics Committee

Appendix E.8 LSTM REC sponsorship approval

LSTM
LIVERPOOL SCHOOL OF TROPICAL MEDICINE
Pembroke Place,
Liverpool, L3 5QA, UK
Tel: +44(0)151 705 3100
Fax: +44(0)151 705 3370
www.lstmed.ac.uk

Ahmed Alatawi
Liverpool School of Tropical Medicine
Pembroke Place
Liverpool
L3 5QA

Thursday, 20 June 2019

Dear Mr.Alatawi,

Re. Research Protocol (19-036) Evaluation of Health Services Efficiency of public Hospitals in Saudi Arabia

I am pleased to confirm that LSTM has agreed to act as Sponsor for the above mentioned clinical research study.

Please note that LSTM approval to allow your study to proceed is conditional upon compliance with the relevant regulatory requirements.

All study staff should be given the appropriate training in Protocol, GCP, Consent and Data Protection, relevant to their responsibilities as defined within the study protocol.

LSTM Research Governance and Ethics Office should receive annual study progress and final close out reports via lstmgov@lstmed.ac.uk

Yours Sincerely,

Carl Henry
Research Governance Manager
Research Governance and Ethics Office

Appendix E.9

Participant Information Sheet

Taking part in an interview - Evaluation of Health Services Efficiency of Public Hospitals in Saudi Arabia

Greetings

We are Ahmed Alatawi, Jahangir Khan and Louis Niessen, researchers from Liverpool School of Tropical Medicine in the United Kingdom. We are kindly asking you to take part in this research. Before you decide whether you want to take part or not, we want to tell you why this research is being done and what you expect if you do take part. We would like to ask you to read carefully what we have to say. Ask us if you have any other questions. Please feel free to talk to others about the study if you like and take as much time as you want to decide.

Thanks for reading this sheet.

- **What is the purpose of the study?**

The aim of this research is to describe the factors that affect the hospital efficiency and overall performance through identifying, exploring your point of view based on your experience, regarding the health resources and health services and outcomes of the public hospitals, in addition, to recommend feasible steps to improve effective use of the health resources. Specifically, through this interview, we are aiming to:

- Identify the factors that affect hospital efficiency from a stakeholder perspective.
- Understand the causative element in public hospitals, external environment, and socio-economic characteristics (Population in the catchment area) on performance and efficiency.
- Explain the desired mix of health resources and health services of public hospitals to meet health outcomes.
- Create feasible recommendations based on daily-operations to reform the health policies and enhance the efficiency and quality of public hospitals.

- **What is the importance of the study? /Why are we doing this research?**

In an earlier study, we conducted an empirical quantitative analysis using a technique called 'Data Envelopment Analysis' to evaluate the technical efficiency of public hospitals of the Ministry of Health in Saudi Arabia. The study found a high level of technical and scale inefficiencies among the hospitals. Also, we found excess use of health resources and a shortage of health services. This demands to eliminate the overuse of health resources, which can be used in another public sector, and improve health services provision and their

quality. These findings raised the need to investigate the process and performance of public hospitals, also the related health policies and regulations. Literature has found that the efficiency of the hospital sector is crucial for the efficiency of the overall health system, as the main consumer of health resources. Thus, they provide additional importance to explore and understand the performance and efficiency of the hospitals. To improve the efficiency of public hospitals, it requires further cooperation on administrative, policy-planning and daily operation management levels in the public sector. Additional knowledge based on real-life operations of expert stakeholders would be more useful to understand the mechanisms behind inefficiency in hospitals and how to improve the production process towards higher efficiency. Implementation of this research will extract valuable information from real life situation regarding the factors that influence the efficient use of public resources in the hospitals and the processes that should be in place, to develop feasible recommendations in this aim.

- **Why have I been asked to take part in this interview?**

You have been contacted because we want to interview key informants who have professional experience and administrative knowledge of health resources (inputs), services (outputs) and transformation process (from inputs to outputs) that have been undertaken in the public hospitals. We will be interviewing a range of participants who have such valuable experiences.

- **Do I have to take part?**

No. It is fully up to you to decide if you want to take part or not. If you choose to take part, we will give you this information sheet to keep, and we will ask you to sign a consent form. If you select to take part, you are still free to stop at any time you want without giving a reason. No questions will be asked if you stop at all, and no consequences will happen.

- **What will happen if I take part?**

If you agree to participate, we will contact you to arrange an interview at a convenient time and place that suits you. We will answer any questions you may have about the interview or the research.

- **How is the interview will be?**

We will ask you if you are willing to have the interview recorded. You will be given the ‘consent form'. You only sign this form if you accept to take part in the interview. You will be provided with a copy of the consent form to keep. The interview will be like a conversation, in which we will help you talk about your professional experience of public hospital

outcomes, performance and management. We will ask questions about what health resources used in hospitals, health services produced to meet the health outcomes and what the main challenges are that should be considered to improve the effective use of resources to deliver health services. You can also suggest possible recommendations to reform health policies to improve the efficiency and quality of public hospitals.

- **How long would the interview take?**

The interview time varies depending on how much you have to say. But most interviews last for an hour. If you would prefer, we can have a break or two during the interview. Please remember, if you wish to stop the interview at any time, you can do so without giving any reason.

- **What happens if I decide to withdraw after the interview has done?**

If you decide to withdraw your statements after an interview has taken place, all recordings, transcripts and typing of your interview will be destroyed.

- **What will happen after the interview has taken place?**

We will label the interview recording with a code of series number and will type out everything you said in the interview. Your name or identification will not be collected. For your job position information, the anonymisation technique will be used. That will be transformed into letters and numbers to decrease the chance for identification. This information will be kept in a private file and saved under lock and strong password, separated from the transcript files. The digital recording and the written record (transcript) will be identified only by the code number that I assigned. All data will be stored in files under lock, and a strong password (using a combination of capital and lower-case letters, numbers and symbols) with accessibility only by the Principal Investigator Ahmed Alatawi. The data encryption techniques will be used to code data to prevent the risk of using data by others. The data will be used in current degree research (PhD study) of Mr Alatawi and related paper publications. After completion of the degree and publications, all data will be erased from files and destroyed to ensure that it will not be used in future.

If you wish, we will send a copy of the interview transcript to you. This will help you decide if you want your interview to be made available to use for our research and only by this research team or not. A copy of the interview's recording can also be provided if you request it. You would be asked to read the interview and consider if there were anything you would change or delete to keep anything secret, or if you would delete or change some parts of your interview. We can delete any sections that you do not want us to use. You can

take as long as you want to do it before we start the data analysis. You can also decide how your interview will appear in any work we produce in future.

- **How would the researcher use the interview's transcript?**

Before the interview, we will ask you to sign a 'consent form' for the interview. If you decide that you are happy and comfortable with your interview to contribute to this research, you will again be asked (after the interview) to sign a form called 'Further use of my interview'. If you sign this form, you give the copyright of the interview to Liverpool School of Tropical Medicine. It is important that you have time to think about and discuss the copyright form before you sign it. You will be given a copy of this form to keep. If you do decide to allow your interview to be used in the research, it would be used along with interviews from other participants who have professional experiences of hospital performance. A summary of these interviews would be used for the degree research. The research team would be able to see the summaries of the interviews. All data from the interview will be used strictly within the terms of the Data Protection Act (DPA 1998).

- **Can I choose how my interview will be used?**

If you give your permission for parts of/ all the interview to be used in this research, you will have a choice about whether it will be included. Anonymous techniques will be used for all participants' identification including you. We thus keep out any part of the interview which might identify you, which make identifying you really challenging. If you have any concerns about how you want the interview to be included, talk to us, or we could find an independent adviser for you to talk to if you like.

- **Who has reviewed the study?**

This study was given an ethical opinion and approval by the Institutional Review Ethics Board (IRB) of King Fahad Medical City affiliated to the Administration of Research and Studies in the Ministry of Health in Saudi Arabia. If you wish to make any complaint about any aspect of the study, please contact Ahmed Alatawi on 0117 491496786.

- **Who is organising and funding the research?**

The Saudi Arabian Cultural Bureau in London, which is affiliated to the Ministry of Education in Saudi Arabia has sponsored this research in collaboration with Liverpool School of Tropical Medicine in the U.K.

- **What if there is a problem?**

Given the nature of this study, it is unlikely that you will suffer harm by taking part in this research. However, if you wish to complain about any aspect of the way in which you have been approached or treated during the interview of this study, you should contact the research ethics committee team in LSTM at lstmrec@lstmed.ac.uk.

Contact for further information

We hope that this information sheet has described what you need to know before deciding if you take part or not. If you have any queries at all about the project, please telephone Ahmed Alatawi on 0117 491496786.

Many thanks for reading this information sheet.

Appendix E.10

Consent Statement

Evaluation of Health Service Efficiency of the Public Hospitals in Saudi Arabia

You are invited to participate in the research study titled "Evaluation of health service efficiency of the public hospitals in Saudi Arabia", led by Ahmed Alatawi, Dr. Jahangir Khan and Prof. Louis Niessen of the Liverpool School of Tropical Medicine in the United Kingdom. This consent statement explains the research study and its goals and objectives so that you will have the opportunity to discuss this and ask the questions you may have prior to your participation. If you agree to participate in this study, you will be requested to sign the consent statement at the end of this document.

Purpose of the Study

The aim of this study is to extract the factors that influence the hospital efficiency and the mechanisms behind the production process from the view points of the relevant stakeholders. For this purpose, we intend to explore the inputs, outputs and outcomes as well as their interactions for better understand the factors that affect the efficiency. This research will be useful for creating knowledge for a better measurement of the hospital efficiency. Subsequently, decision makers should be able to improve health policies to enhance efficiency and quality of public hospitals in Saudi Arabia.

Procedures of the Study

By signing this form, you agree to take part in-person or in a telephone interview. The interview should last approximately 45 minutes and will be scheduled at your convenience in desired time and place.

Confidentiality

All data collected during this study will be kept in secure papers in private place and electronic files that are accessible only to the principal investigator. Your name, location, contact information and all identifications will be kept separate from your interview transcript, which will be anonymous number/letter code. Your data (answers) will be analysed along with the data of several other participants. These will be described in the research reports, and some of the issues may be showed with specific quotations from the

interviews. If you are quoted in the research reports, your identity will be kept confidential so that readers cannot attribute the quote directly to you.

The Costs and Benefits of Taking Part in the Study

There are no physical risks involved in participating in this study. The only cost to you is the time you take to talk with the interviewer. To eliminate or decrease that cost, you can choose the time and location of the interview that are convenient to you. Also, you may withdraw at any time from the study without prejudice. There will be no direct benefit from participating in this research. However, we hope that the results of this study will help other researchers and policy-makers to develop tools for measuring efficiency of public hospitals in a better way. The health systems of Saudi Arabia should be benefited from this study.

Voluntarism

Your participation in this research study is completely voluntary. You are free to withdraw at any time from the study and without prejudice. If you withdraw during the interview, we will stop the interview and you will be asked whether you would like to have the data that you have provided to be used in the study or not. Also, you can specify any selected parts of the data to be destroyed, if you feel it revealed sensitive information.

Questions

If you have questions, or concerns or require more information about the study, please contact below:

Ahmed Alatawi
Principal investigator
Health Economics research group
Department of Clinical Science
Liverpool School of Tropical Medicine
Email: ahmed.alatawi@lstmed.ac.uk
Phone: 001491496786

Signature of study participant

Evaluation of Health Services Efficiency of the Public Hospitals in Saudi Arabia

I have read and understand the preceding information thoroughly for the study. I have had the opportunity to ask questions, and all of my questions have been answered to my satisfaction. I agree to voluntarily participate in this study. I understand that I will receive a signed copy of this form. I hereby, declare that I have not been subjected to any form of coercion in giving this consent.

_____

Name of the participant

_____

Participant's Signature Date :

_____

Name of Principal investigator

_____ Date:

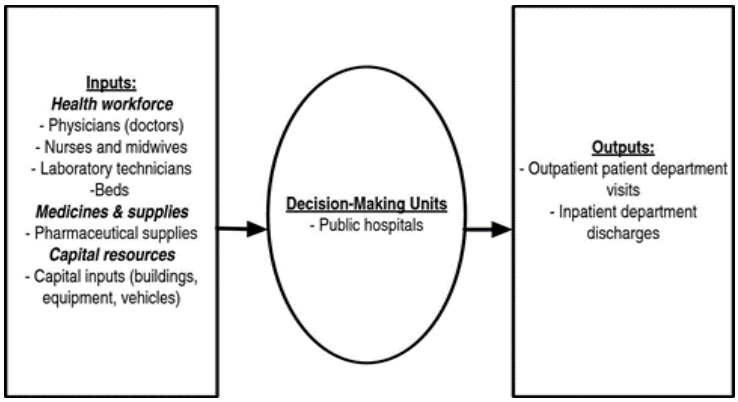
Signature

Appendix E.11

Interview Questions Guide

Evaluation of Health Services Efficiency of Public Hospitals in Saudi Arabia

The purpose of today's interview is to explain the factors that affect the hospital efficiency, through identify desired inputs to and outcomes of public hospitals, from your point of view. A hospital that produces the maximum amount of outputs from a given inputs, or provides a given output with least quantities of inputs, can be recognised a technically efficient. Hospital outputs or health services that include; outpatient services that patients receiving from a hospital, discharge or inpatient services, emergency, surgical operations, pharmaceutical prescriptions, radiology and laboratory tests. Where inputs or health resources used in a hospital are; 1- capital, e.g. hospital capacity, number of beds, medical devices, 2- labour (health professionals), e.g. physicians, nurses, etc, and 3- consumable resources e.g. medications.



Your valuable information will be used for the making recommendations to reform the public hospitals towards improve the efficiency and performance.

Outputs (part one)

1. What are the outputs (health service categories) of the public hospitals delivers to the patients, please rank it in respect to their priority (Hospital goals)?
2. Why have you prioritized them this way? with respect to the objectives and outcomes of the public hospitals?
3. What health services do patients need and demand more than other services, and why?
4. Can the demand for specific services change according to the type of patients (average income for auditors, age groups, level of education, etc.)?
5. What are the main obstacles or difficulties that are opposed to providing adequate health services in public hospitals, if we assume that all health resources (clinical capacity, human forces, consumables) are sufficiently available in the hospital, and why?
6. Depending on your answer to the previous question, how can these difficulties be overcome? What is your practical advice that can be done in the hospitals?

7. What are the efforts that made by the Ministry of Health MOH to measure and monitor the efficiency of public hospitals? What is your advice in this regard?
8. How to improve the data reporting system to capture pattern and quality of service provisions in the hospitals?

Inputs (part two)

1. What are the main health resources (inputs) that the public hospitals use to produce the health services (outputs), rank please?
2. According to your answer to the first question, are there other health resources (other than you mentioned) that are critical to achieving the goals and vision of the hospital?
3. What are the barriers that affect the public hospital ability to transform these inputs into given outputs? (If we assume that a hospital has all required inputs)
4. What is the effect of hospital-managers autonomy on the efficiency of the given hospitals, and management on the production process? E.g. more autonomy will be helpful to improve a hospital performance or not. Why? Please provide recommendations.
5. How can the results of hospitals efficiency analysis be applied within the MOH system? Especially those that recommend reallocating resources according to the hospital's efficiency in providing health services. For example: If we assume that hospital A has low efficiency despite the availability of health resources, while hospital B is more efficient but suffers from some shortage of needed health resources. Can resources be reallocated from least (A) to highest (B) efficient in this regard? What are the practical steps to be followed?
6. In your opinion, what are the elements of measurement that must be followed in measuring health resources, services and the efficiency of public hospitals within MOH?

General statement (final)

1. What are the tips and recommendations you would like to provide to develop the efficiency of public hospitals in the Kingdom of Saudi Arabia? Do you have any final comments that you would like to make now when we are coming to the end of the interview?

Appendix E.12

Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist

Developed from:

Tong A, Sainsbury P, Craig J. 2007. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. Volume 19, Number 6: pp. 349 – 357

No. Item	Guide questions/description	Reported on Page #
Domain 1: Research team and reflexivity		
Personal Characteristics		
1. Inter viewer/facilitator	Which author/s conducted the inter view or focus group?	Section 5.2.4
2. Credentials	What were the researcher's credentials? E.g. PhD, MD	Page 1
3. Occupation	What was their occupation at the time of the study?	Page 1
4. Gender	Was the researcher male or female?	Page 1
5. Experience and training	What experience or training did the researcher have?	Page 1 and 5.2.1
Relationship with participants		
6. Relationship established	Was a relationship established prior to study commencement?	Section 5.2.3 .
7. Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	Section 5.2.3
8. Interviewer characteristics	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	Section 5.1.1 and 5.2.1

Domain 2: study design		
Theoretical framework		
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Section 5.2
Participant selection		
10. Sampling	How were participants selected? e.g. purposive, convenience, consecutive, snowball	Section 5.2.2 and 5.2.3
11. Method of approach	How were participants approached? e.g. face-to-face, telephone, mail, email	Section 5.2.3
12. Sample size	How many participants were in the study?	Section 5.2.3
13. Non-participation	How many people refused to participate or dropped out? Reasons?	Section 5.2.3
Setting		
14. Setting of data collection	Where was the data collected? e.g. home, clinic, workplace	Section 5.2.4
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	No
16. Description of sample	What are the important characteristics of the sample? e.g. demographic data, date	Table 5.1
Data collection		
17. Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Additional file appendix E
18. Repeat interviews	Were repeat inter views carried out? If yes, how many?	No
19. Audio/visual recording	Did the research use audio or visual recording to collect the data?	Yes, Section 5.2.5

20. Field notes	Were field notes made during and/or after the inter view or focus group?	Section 5.2.4 and 5.2.5
21. Duration	What was the duration of the inter views or focus group?	Section 5.2.4
22. Data saturation	Was data saturation discussed?	Section 5.4
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	Section 5.2.4 and 5.2.5
Domain 3: analysis and findings		
Data analysis		
24. Number of data coders	How many data coders coded the data?	Section 5.3
25. Description of the coding tree	Did authors provide a description of the coding tree?	Section 5.2.5 and 5.3
26. Derivation of themes	Were themes identified in advance or derived from the data?	Section 5.2.5
27. Software	What software, if applicable, was used to manage the data?	Section 5.2.5
28. Participant checking	Did participants provide feedback on the findings?	No
Reporting		
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	Section 5.3
30. Data and findings consistent	Was there consistency between the data presented and the findings?	Yes, Section 5.3 and 5.4
31. Clarity of major themes	Were major themes clearly presented in the findings?	Yes. Section 5.3

32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes, Section 5.3 and 5.4