TECHNICAL EFFICIENCY IN PUBLIC HOSPITALS IN KENYA

RITHAA KOOME GILBERT (BSc)

Q140/CTY/PT/26322/2013

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF HEALTH MANAGEMENT IN THE SCHOOL OF PUBLIC HEALTH OF KENYATTA UNIVERSITY

NOVEMBER, 2015

DECLARATION

This thesis is my original work and has not, to the best of my knowledge, been presented to any other college, university, and institution or examination body.

Signature ………………………………………………… Date 04 / 12 / 2015

Rithaa Koome Gilbert (Q140/CTY/PT/26322/2013)

Department of Health Management & Informatics

SUPERVISORS

We confirm that the work reported in thesis was carried out by the candidate under our supervision as university supervisors.

Signature ………………………………………………… Date: 07 / 12 / 2015

Dr. George Kosmbei

Department of Applied Economics

Signature ………………………………………………… Date 04 / 12 / 2015

Dr. Andrew Yitambe

Department of Health Management and Informatics

DEDICATION

I dedicate this work to my God for giving me strength, health, and sound mind throughout this course. I also dedicate this work to my family for giving me the necessary moral and financial support to undertake this thesis.

ACKNOWLEDGEMENT

The finalization of this study is a culmination of invaluable contributions by various persons. I wish to extend special thanks to my able and knowledgeable supervisors Dr. George Kosmbei and Dr. Andrew Yitambe who gave me unlimited audience and guidance. Their support and continual encouragement was fundamental in completion of this research proposal

I am also thankful to my humble, knowledgeable and able mentor, Peter Kithuka, for his support and guidance in this course to this point. I will always be grateful to you for the support and guidance you have provided; indeed, this gesture is a constant inspiration in my life.

Thanks to all my workmates and friends who gave me their moral and material support that enabled the successful completion of this work. I sincerely thank God for his spiritual support without which this work would not have been possible.

Last but not least, I wish to express my gratitude to members of my family, my parents, my spouse and my siblings for their unwavering material, moral and spiritual support all through my period of scholarship.

God bless you all.

TABLE OF CONTENTS

DECLARATION .... *ii*

DEDICATION .... *iii*

ACKNOWLEDGEMENT .... *iv*

TABLE OF CONTENTS .... *v*

LIST OF TABLES .... *viii*

LIST OF FIGURES .... *ix*

DEFINITION OF TERMS .... *x*

ACRONYMS AND ABBREVIATIONS .... *xii*

ABSTRACT .... *xv*

CHAPTER ONE:INTRODUCTION *1*

1.1 Background of the study 1

1.2 Statement of the Problem 5

1.3 Rationale for the study 6

1.4 Significance and anticipated output 7

1.5 Research questions 8

1.6 Objectives 8

1.7 Limitation and delimitation of the study 9

1.8 Conceptual model and framework of the study 10

CHAPTER TWO:LITERATURE REVIEW *13*

2.1 Introduction 13

2.2 Theoretical literature on Efficiency 13

2.3 Empirical Literature review 18

2.3.1 Technical efficiency levels 18

2.3.2 Determinants of inefficiency 20

2.4 Emerging issues, gaps and challenges in literature review 25

CHAPTER THREE:METHODOLOGY *28*

3.1 Introduction 28
3.2 Location of the study 28
3.3 Study design 28
3.4 The theoretical model 29
3.5 Estimating Model/Model specification 30
3.6 Study variables 36
3.7 Study population 36
3.8 Sampling Technique and sample size 37
3.9 Validity and Reliability 37
3.10 Data Collection Procedure 38
3.11 Data Analysis and management 41
3.12 Ethical Considerations 41

CHAPTER FOUR:FINDINGS *42*

4.1 Introduction 42
4.2 Descriptive statistics for the hospitals 42
4.3 Scores of Technical efficiency 44
4.4 Production (slacks) changes for inefficient hospitals 46
4.5 Production targets for inefficient hospitals 49
4.6 Benchmarks (peers) and lambda weights for inefficient hospitals 52
4.7 Institutional Factors influencing technical efficiency 54

CHAPTER FIVE:DISCUSSION *58*

CHAPTER SIX:SUMMARY, CONCLUSIONS AND RECOMMENDATIONS *65*

6.1 Summary of Findings 65
6.2 Conclusions 66
6.3 Recommendations 67

REFERENCES 72

APPENDICES 81

Appendix 1: Code and Identity of Sampled Level 4 Hospitals in Kenya 81

Appendix 2: Research approval letter from graduate school 82
Appendix 3: Research approval letter from NACOSTI 83
Appendix 4: Map of Kenya 84
Appendix 5: Key indicators for Kenya 85
Appendix 6: Data collection checklist 1 86
Appendix 7: Data collection checklist 2 87

LIST OF TABLES

Table 4.1: Descriptive statistics for the hospitals 42

Table 4.2 Scores of Technical efficiency 44

Table 4.3 Magnitude of inefficiencies 47

Table 4.4 Production slacks required to make inefficient hospitals efficient 48

Table 4.5: Production targets required to make inefficient hospitals efficient 50

Table 4.6: Hospital benchmarks and lambda weights 53

Table 4.7: Determinants of technical inefficiency 55

LIST OF FIGURES

Figure 1.1: Conceptual model of the study 11

Figure 1.2: Conceptual framework of the study 12

DEFINITION OF TERMS

Efficiency	Refers to use of available economic resources in a manner that result in maximum possible output.
Technical Efficiency	Refers to use of a given amount of economic resources in the manner that produces maximum possible output.
Input-oriented Model	Refers to the optimal combination of inputs to achieve a given level of outputs-How much additional output could a hospital produce while employing same inputs.
Output Oriented model	Refers to optimal outputs that could be produced by a given set of inputs. Refers to how much fewer resources could a hospital employ to produce same level of output.
Constant Returns to scale	Refers to a technical efficiency model which assumes no deviations from the optimal scale. It assumes DMUs have same operational sizes
Variable returns to scale	Refers to technical efficiency model which assumes variability in production sizes of the DMUs
Scale efficiency	Refers to technical efficiency model which assumes economics of scale in production. It takes into account the

production sizes of DMUs. It is equal to CRS technical score divided by VRS technical score.

Benchmarks Refers to the group of hospitals against which DEA located the relatively inefficient hospitals and the magnitudes of inefficiency.

ACRONYMS AND ABBREVIATIONS

ADC	Average Daily Census
BOR	Bed Occupancy Ratio
BPS	Board of Post graduate Studies
BTR	Bed Turnover Rate
CO	Clinical Officers
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DH	District Hospital
DHIS	District Health Information System
DMUs	Decision-Making Units
DRS	Decreasing Returns to Scale
GDP	Gross Domestic Product
GDR	Gross Death Rate
GP	General Practitioners

HRIO	Health Records and Information Officer
HSWG	Health Sector Working Group
IDTDR	Inpatient Discharges to Deaths Ratio
INEFF	Inefficiency score
IRS	Increasing Returns to Scale
KNBS	Kenya National Bureau of Statistics
ML	Maximum Likelihood
MOH	Ministry of Health
MTEF	Medium Term Expenditure Framework
NACOSTI	National Commission for Science, Technology and Innovation
NHA	National Health Accounts
NHIF	National Health Insurance Fund
NTNNBDR	NHIF to non-NHIF Bed Day's Ratio
OLS	Ordinary Least Squares
OTIVR	Outpatient to Inpatient Visits Ratio
PHC	Public Health Care

SDGs	Strategic Development Goals
SE	Scale Efficiency
SSA	Sub-Saharan Africa
TE	Technical Efficiency
UN	United Nations
USA	United State of America
VRS	Variable Returns to Scale
WHO	World Health Organization

ABSTRACT

The World Health Organization called attention to the importance of efficiency in all functions of a health system for the ultimate achievement of the goals of health improvement, stewardship, responsiveness and fairness in financing. Although, efficiency improvement should be seen as a strategy for mobilizing domestic resources and utilizing the available resources without waste to achieve the desired health sector goals, it is not usually the case especially in low income countries like Kenya despite health facilities receiving over 75% of the total recurrent budget from Government allocation. Over the past years, there has been little health outcome improvement despite significant increase in budgetary allocation to the health sector especially the health facilities. Therefore, quantifying the current level of efficiency in the hospitals is an accepted strategy in dealing with inefficiencies and enhancing the scarce resource optimization. The general objective of this study was to assess the technical efficiency in public hospitals in Kenya. The study used an analytical and descriptive study design employing econometric techniques for data analysis. Simple random sampling was used to select a study sample of 30 level 4 hospitals in Kenya. A cross sectional model was used to analyze secondary data collected from District Health Information System using Data Envelopment Analysis to determine efficiency levels while interval regression was used to establish determinants of inefficiency. Results indicated that 50% of the hospitals were Constant Returns to Scale technically efficient with a mean efficiency score of 80.6% while 66.6% of the hospitals were Variable Returns to Scale technically efficient with a mean efficiency score of 92.7%. In terms of Scale Efficiency, 50% of the hospitals were scale efficient with a mean efficiency score of 86.8% score. There was a constant return to scale in 50% of the hospitals, increasing returns to scale in 40% of the hospitals and decreasing returns to scale in 10% of the hospitals. The mean level of technical inefficiency was 21.9%. The total inputs slacks in the inefficient hospitals were 122 beds and 454 staff which represented an input slack of 7.3% for the beds and 22.1% for the staff. All the inefficient hospitals required a 27.6% increase in total outpatient visits which translated to an additional 217, 547 outpatient visits. A total of 5,006 discharges were required which was a 9.2% increase in total discharges. Further, all the inefficient hospitals required to augment their operations capacity with a sum of 1,596 operations which represented a 31.3% increase in total operations for them to be technically efficient. Interval regression analysis results showed that outpatient to inpatients visits ratio, bed occupancy ratio, inpatient discharges to death ratio, National Health Insurance Fund bed days to bed days of those not enrolled in National Health Insurance Fund, gross death rate influence technical inefficiency levels. In conclusion, a substantial proportion of public hospitals were technically inefficient due to inappropriate production sizes occasioned by use of excess production inputs to produce sub-optimal outputs. Therefore, there is need for effective policy and managerial interventions for dealing with the existing production slacks and factors influencing inefficiency in the hospitals.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Tightening budget and increasing pressures on the efficiency of public spending represent currently major challenges for the Kenyan Government. Health care provision is not an exception as entrenched in the constitution promulgated in 2010. The World Health Organization (2000) called attention to the importance of efficiency in all functions of a health system and in ultimately achieving the goals of health improvement, responsiveness and fairness in financing. According to World Health Organization (2005), in 2015, Member States of the United Nations (UN) reaffirmed their commitment to eradicate world poverty and improve the health and welfare of the world's poorest by 2030. According to UN (2015), health is at the centre of the SDGs; especially goal 3 (improvement of health lives and well being for all) and 4 (eradication of inequality in access among populations).

The achievement of the health-related SDGs and related initiatives, among other things, requires the availability of adequate resources for the health sector to improve access and quality of care. However, given the poor macro-economic performance of most countries in the Africa region, the resources required to meet the costs of achieving the development goals are far beyond the reach of many (Cooper, Seiford, Zhu, 2011). In sub-Saharan Africa, hospitals absorb the greatest proportion of the total health expenditure, which is estimated at 45% to 69% of government health sector expenditure (Kirigia, Sambo, and Lambo (2002). Despite this, the Kenya health system remains under intense pressure to deliver improved health services using proportionately fewer resources.

Many factors contribute to such pressures including the health demands of an ageing population, the development of new and more expensive medical technologies, greater community expectations for access to health services, and limits on the availability of health workers and government funding to support these higher expected levels of service (Hollingsworth, 2008). Debates about inefficiency of the Kenyan health care system have resulted in a number of reforms aimed at eliminating inefficiencies in healthcare production and operation functions. The major ones include increasing private involvement on health care funding, introduction of user fees in government health facilities and introduction of compulsory National Health Insurance Fund.

Other health sector reforms included harmonization and decentralization of health care interventions, expansion of preventive health services including family planning services, use of health insurance schemes and use of performance contracts (Kirigia, Emrouznejad, Sambo, Munguti and Liambila (2004). According to UNICEF (2007), Kenyan government allocates less than 2% of her Gross Domestic Product (GDP) to the health sector, most of which is expended to curative health interventions instead of spearheading preventive health interventions which is one of the major policy goal.

As at 2010, Kenya total expenditure on health was 5.4% percent of the GDP, below the SSA average of 6.5%. Currently, health expenditure as a share of the total government spending was 7.8% in 2013. About 56% of Kenya total public health expenditure is provided by development partners which has significantly increased over time (GOK, 2013). In 2010, records indicate wide variations in per capita government spending as well as health personnel variations between counties. For instance, Isiolo County spent KES 1000 per person on health while Mandera spent less than 200 (GOK, 2013). This is an indicator of wide disparities in the ability of public agencies at the local level to provide adequate health care. This indicates need for better accountability in the usage of the available resources fueled by increased partner and stakeholder interest in the use of the scarce resources. Inadequate spending on health care results in long waits, lack of essential medicines and high cost of services which affects performance and productivity of the health facility and the health status of the population. As a result, efficiency studies provide important tool in tracking and informing proper use of the scarce resources.

According to World Health Organization global health expenditure data base, in the 2013/2014, the public per capita health spending in Kenya was $44.51. This amount compares favorably with the WHO recommendation of an average of $44 per capita on health care (WHO, 2012). Inadequate funding of health care has significant effect on provision of health care. For instance, provision of health services in Kenya remains generally sub-optimal because majority of the health facilities have staffing imbalances of qualified personnel resulting from weak deployment and resource mobilization structures. Additionally, insufficient skilled human resources (medical officers, dentists, nurses, midwives and other specialists) are also a major constraint to improving efficiency of service delivery. For example, according to GOK (2011), the doctor-patient ratio is about 17:100,000 against the recommended 1:600 by the World Health Organization (WHO) while the nurse-patient ratio is 121:100,000 against the recommended 200:100,000 by WHO.

According to Health Sector Working Group (2012), the Kenyan health budget has been growing over time but there has not been a corresponding significant change in key health indicators. Although, efficiency improvement should be seen as a strategy for mobilizing domestic resources and utilizing the available resources without waste to achieve the desired health sector goals; it is not usually the case especially in low income countries like Kenya. Practically, there is not much consideration to efficiency by health care administrators in contrast to it being mentioned in health policies (Hollingsworth, 2008). Consequently, quantifying and improving efficiency has become an accepted strategy for controlling an organization's overall expenditures (Zere, Mbeeli, Shangula, Mandlhate, Mutirua, Tjivambi and Kapenambili, 2006). This study intended to generate reliable information which will inform strategies for optimal resource utilization and expedite the move towards achieving health and development goals through efficiency gains.

1.2 Statement of the Problem

According to Ministry of Health (2011), the Kenyan government over time has undertaken major reforms to eliminate inefficiencies and inequities such as harmonization and decentralization of health care interventions, expansion of preventive health services and introduction of user fees. However, Kenya continues to faces a number of problems in the health care delivery system; there is shortage of health care personnel, and there are glaring access disparities across the country. This can make it difficult to achieve the SDGs for transforming our world especially goal 3 (ensuring healthy lives and well being for all at all ages) and goal 10 (reducing inequality within and among populations). However, these problems and underperformance of the sector cannot be blamed on low levels of health spending alone. This is so because the per capita spending on health for Kenya is above those of some fellow Sub-Saharan countries which have the same conditions but are doing better (Nancy, 2010). This is underpinned by the findings that an estimated 30% of public facilities in Kenya are said to be technically inefficient (Kirigia, 2004).

Additionally, according to Health Sector Working Group report (2012), despite of increase in health care allocations and spending, with hospitals accounting for 75% of the health sector recurrent budget and employing 80% of the key professional health staff (Sealy and Rosbach, 2010), there are little improvements in health indicators which implies that the available resources may not have been utilized efficiently. In addition, although efficiency improvement should be seen as a strategy for mobilizing domestic resources and utilizing the available resources without waste to achieve the desired health sector goals; in Kenya, there is not much consideration given to efficiency by health care managers in contrast to it being mentioned in health policies (Hollingsworth, 2008). Further, there was no study done on technical efficiency in public hospitals in Kenya. Therefore, the purpose of this study was to assess the technical efficiency of public hospitals in Kenya so as to bridge the information gap by providing evidence-based policy and managerial intervention for facilitating optimal resource utilization.

1.3 Rationale for the study

The rationale for this study stemmed from the following observations:

- There was limited literature on technical efficiency and its determinants in public hospitals in Kenya especially at the county level. Kenyan studies (Kirigia *et al.*, 2002; Kirigia *et al.*, 2004) on technical efficiency of public hospitals looked only at the efficiency levels and the magnitudes of the performance targets without determining the causes of inefficiency and productivity changes.
- In Kenya, hospitals account for 75% of the health sector recurrent budget and employs 80% of the key professional health staff (Sealy and Rosbach, 2010). This makes public hospitals to be resource intensive hence requiring close scrutiny to ensure maximum outputs are derived from the limited resources

- There exist information gap on technical efficiency to facilitate realistic and productive policy actions and managerial interventions in the context of Kenyan Hospitals and its translation into policy. Therefore, the study aimed at generating information key in formulating policy actions and managerial interventions to facilitate utilization of the available scarce resources optimally and expediting the move towards achieving health and development goals. This was achieved by assessing and quantifying the possible efficiency gains which could be ploughed back into the system and bridging the resource gaps in the health facilities.

- Since devolution of the health care delivery in Kenya, no efficiency studies had been undertaken to inform the policy makers including county governments on efficiency levels. This has limited formulation of key interventions aimed at improving efficiency in the health care production process. This study findings helps provide practical suggestions for government intervention in curbing resource wastages occasioned by inefficiencies

1.4 Significance and anticipated output

The information generated by this study constituted a good baseline data against which to evaluate the impact of various health sector reforms especially in hospitals such as introduction of user fees, harmonization and decentralization of health care interventions, expansion of preventive health services, use of health insurance schemes and use of performance contracts among others. The study findings and recommendations are meant to facilitate policy-makers, county and health facility managers in their effort of designing appropriate policy and managerial interventions for ensuring efficient use of health care resources so as to improve health indicators and reverse the declining health indicators. The study also contributed to the general and available research and knowledge on health services research for documentation, further research and reference.

1.5 Research questions

1. What is the level of technical efficiency in public hospitals in Kenya?
2. What production slacks are required for inefficient public hospitals in Kenya to be efficient?
3. What are the institutional factors influencing technical efficiency in public hospitals in Kenya?

1.6 Objectives

1.6.1 Main Objective

The main objective of the study was to analyze the technical efficiency in public hospitals in Kenya.

1.6.2 Specific objectives

The specific objectives of the study were:

1. To determine the level of technical efficiency levels in public hospitals in Kenya;

2. To estimate the production slacks required to achieve technical efficient levels among inefficient public hospitals in Kenya;
3. To establish institutional factors influencing technical efficiency in public hospitals in Kenya;

1.7 Limitation and delimitation of the study

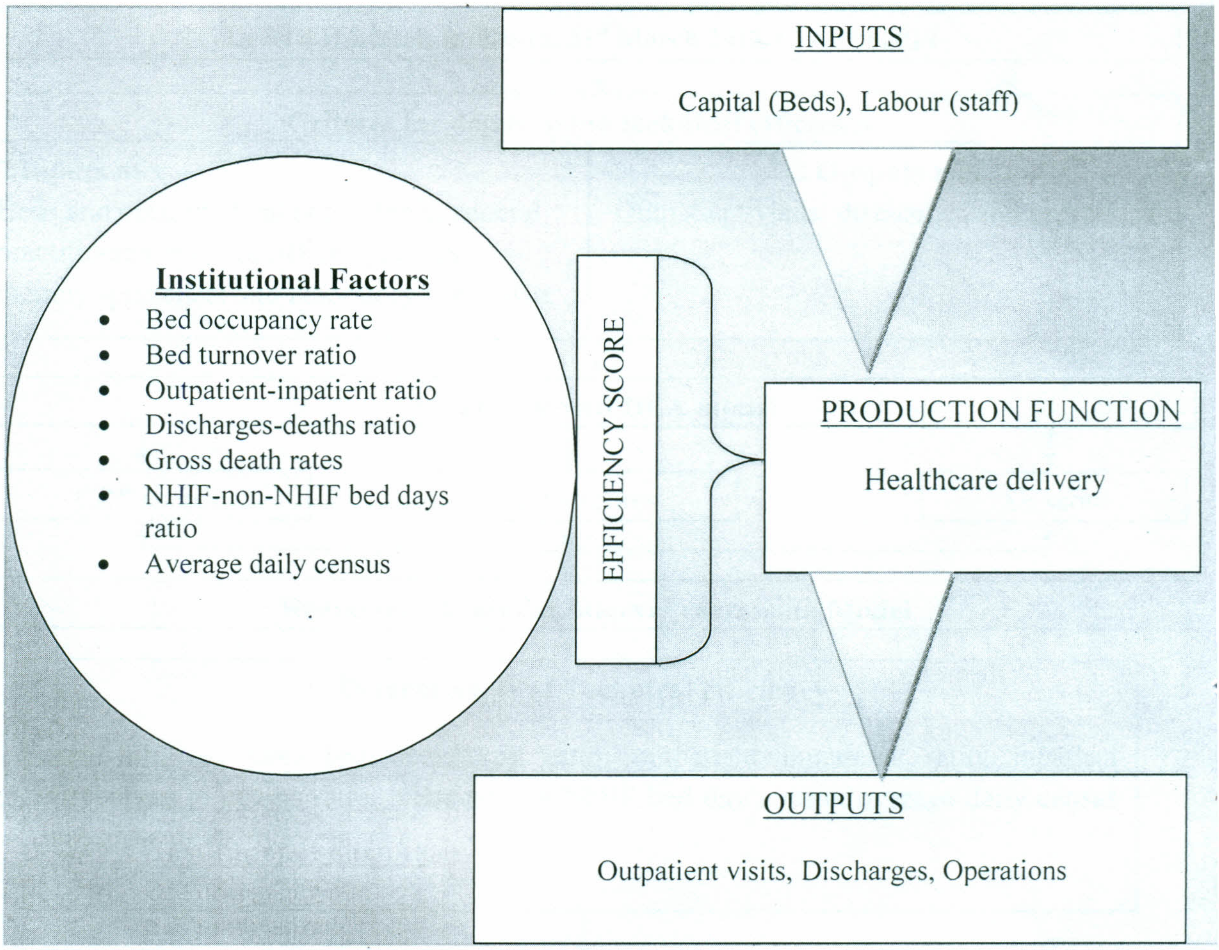
Since DEA is a deterministic technique, any deviation from the production possibilities frontier is attributed to inefficiency although some of the deviations from the frontier may due to external variables beyond control of the facility such as epidemics and strikes common in the Kenyan health system. Secondly, due to difficulty in measuring health service outcomes, the study measured intermediate outputs of health care delivery which included facility visits and discharges.

Thirdly, quality of health service outputs and severity of cases varies across hospitals. Severity of cases handled and quality of products and services can affect production functions in terms of quantity of outputs. The study didn't take into account quality of services and severity of cases which can have significant effect on efficiency of the hospitals. Finally, due to difficulty of performing statistical testing using DEA (Ramalho, Ramalho and Henriques (2010), Tobit regression analysis was used to test the statistical hypothesis for the hypothesized determinants of efficiency.

1.8 Conceptual model and framework of the study

1.8.1 Conceptual model

This illustrated the relationship between the independent variables (institutional factors) and dependent variables (efficiency scores) of the study. It explains the hospital production function in which the inputs (labour and staff) are combined to produce outputs (discharges, OPD visits and surgical operations through a production function known as health care delivery. The model indicates that institutional factors such as bed occupancy ratio affect the efficiency of the health care delivery (Figure 2.1).

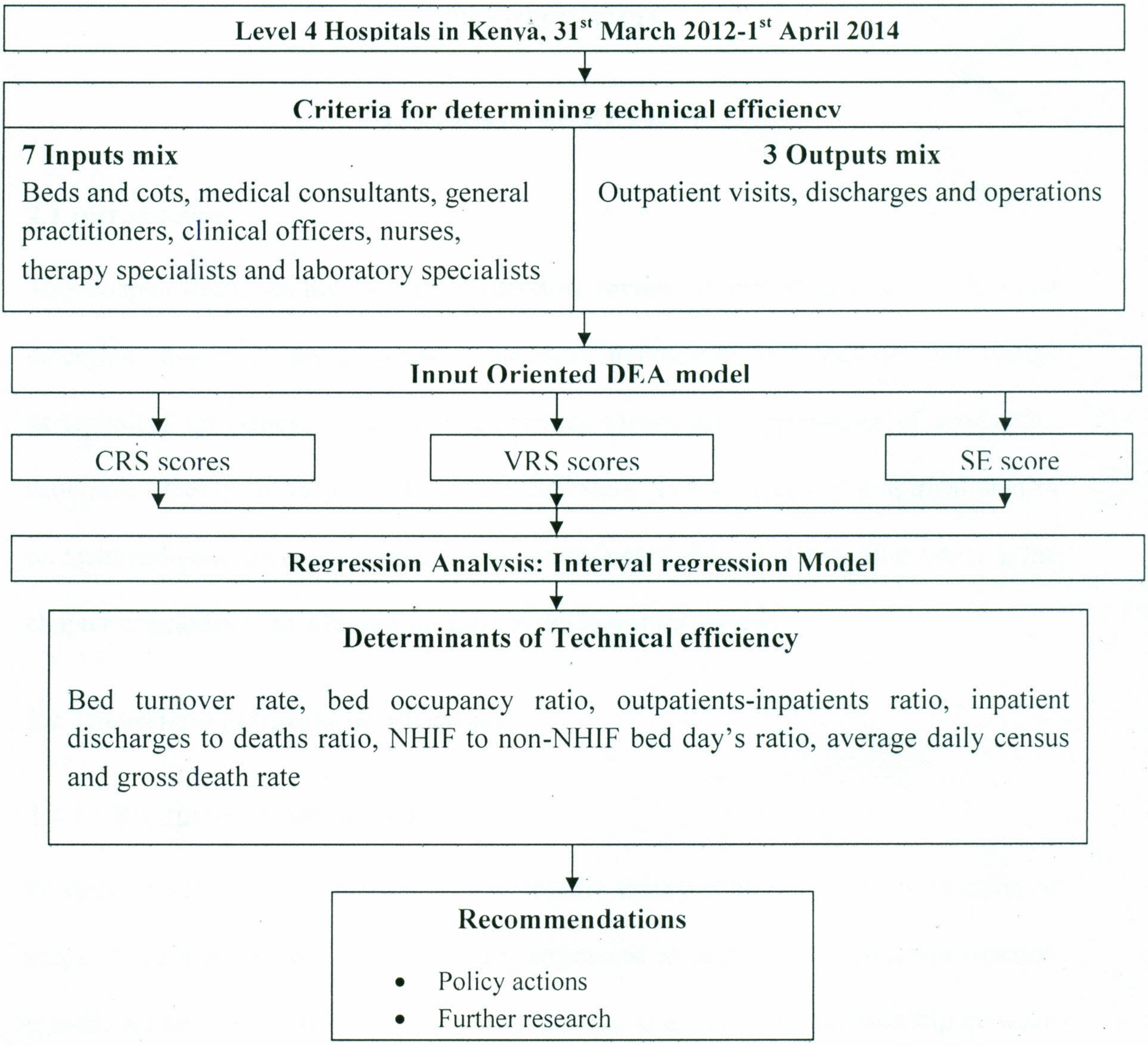


Source: Adapted from Literature Review, 2015

Figure 1.1: Conceptual model of the study

1.8.2 Conceptual Framework

The conceptual framework (Figure 1.2) illustrates the design, process, methods and activities involved in each stage of the study.



Source: Adapted from Literature Review, 2015

Figure 1.2: Conceptual framework of the study

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the theoretical literature review, empirical literature review and emerging gaps in literature review. Theoretical literature review discusses the concept of technical efficiency, production economics theory and application of production economics theory to hospitals. Empirical literature review discusses empirical studies on technical efficiencies of hospitals and determinants of inefficiency after which it the chapter concludes with a review on gaps in the literature review.

2.2 Theoretical literature on Efficiency

2.2.1 Production Economics Theory

Production economics is part of microeconomic theory concerned with production of output from a given set of inputs usually expressed in terms of a production function (Maddala and Ellen, 1989). A production function is a functional relationship between outputs and inputs showing the maximum output to be obtained from a given set of inputs. It defines a production relationship between inputs and output of a product. It is usually specified as: $Q = f(x_1, x_2 \ldots\ldots x_n)$ **Where:**

Q=maximum amount of output

$x_1, x_2 \ldots x_n$ = are amounts of various inputs;

A firm is technically efficient if it obtains maximum level of output from any given set of inputs (Maddala and Ellen, 1989). A production function therefore defines a technically efficient method of production such that a producer cannot decrease one input and maintain the same output level at the same time without increasing one or more inputs. A production plan is therefore efficient if more output cannot be produced with the same inputs or the same output cannot be obtained with less input.

In the context of hospitals, hospitals combine multiple inputs (human, financial, informational resources) to produce multiple outputs (services or interventions) intended to ultimately improve health or quality of life outcomes. However, hospitals are faced with challenge of scarce resources and competing uses for them. One major function of health system is to obtain the best set of scarce resources available; resource allocation (WHO, 2000). A health system aims at improving the health of the population with a fixed health care budget. Technical efficiency considers the production of health and health care in hospital set up. This involves determining the relationship between various resource inputs and outputs (Maddala and Ellen, 1989). Therefore, production economics theory principles has been used in hospitals to determine best ways of combining various resource inputs in hospitals (information, staff, and materials e.t.c) to produce outputs (treatments, surgeries e.t.c) in both efficient and effective manner (Schmacker, 2008).

2.2.2 Concepts of Technical Efficiency

Efficiency can be defined as the use of a given amount of economic resources in the manner that produces maximum possible output. The measuring efficiency in the health care is made difficult by the nature of the production process. Measurement of output, which is improved health status of individuals and society is difficult both theoretically and empirically (O'Neilla, Raunerb, Heidenbergerb, and Kraus (2008). The problem can be explained by the fact that health status is also a function of many exogenous variables to the health sector such as income, individual and household decisions and education (Ruggiero, 2004).

In the health facilities, efficiency focuses on the relation between resource inputs such as labor, capital or equipment and either intermediate outputs (such as number of patient treated, waiting time) or final health outcome (life saved, life years gained etc). Ideally, health care evaluations should focus on final health outcomes rather than on outputs or intermediate outputs (McKay, 2008). Measuring efficiency using intermediate outputs or by examining the intensity of capacity utilization is not appropriate because it focuses on process rather than outcomes (Hollingsworth, 2008).

In general, for a firm to be economically efficient, it must first be technically efficient. Profit maximization requires a firm to produce the maximum output given the level of inputs employed (technical efficiency), use the right mix of inputs in light of the relative price of each input (input allocative efficiency) and produce the right mix of outputs given the set of prices (output allocative efficiency) (Nancy, 2010). Measurement of technical efficiency is founded on microeconomic theory which has its basis on the theory of the firm.

2.2.3 Measurement of Technical efficiency

Efficiency refers to the use of available economic resources in a manner that result in maximum possible output. In health care set up, measuring efficiency is difficult due the nature of production process in hospital (Coelli, Rao, O'Donnell and Battese, 2005). Many factors affect the health service delivery process such as the population health status, their socio-economic status, resource envelop and political stability. For a hospital to be efficient, it has to respond appropriately to its environmental changes/demands. Further, for a hospital to be economically efficient, it has to be also technically efficient. This requires the firm to use the right mix of inputs in light of the relative price of each input (input allocative efficiency) and produce the right mix of outputs given the set of prices (output allocative efficiency) which results into economic efficiency (WHO, 2013; UNICEF, 2014; Kirigia et al., 2002). Therefore, economic efficiency refers to the process of obtaining the maximum benefits from a given cost or minimizing the cost of obtaining a given benefit (Skaggs and Carlson, 1999).

Technical efficiency of a hospital can be categorized into pure technical efficiency and scale efficient. Pure technical efficiency refers to technical efficiency score which cannot be attributed to changes in economics of scale in the production process of the DMU. It assumes no deviations from the optimal scale. It is depicted by regions in which there exist constant return to scale in the relationship between the outputs and inputs (Coelli *et al.*, 2005; Fried, Lovell & Schmidt, 1993). On the other hand, scale efficiency refers to extent to which health care outputs changes due to changes in health care inputs. In other words, according to Salvatore (Salvatore, 2008), scale efficiency assumes economics of scale in the production process of the DMUs mainly depicted in regions with variable returns to scale regions. Scale efficiency is equal to constant returns to scale technical score divided by variable returns to scale technical score (Coelli, 1996).

Technical efficiency is evaluated relative to other Decision Making Units (DMUs). A DMU is said to be fully efficient (100%) when the performance of other DMUs indicate that altering the mix of its inputs and outputs could worsen the production mix (Cooper et al., 2011). In a health care set up, technical efficiency refers to production by a health facility also called DMU, of optimal health care outputs from the available health care inputs (Salvatore, 2008; Fried *et al.*, 1993; Coelli et al., 2005)]. This requires use of the least amount of health care inputs such as beds, drugs, health workforce and equipments among others.

Therefore, technical efficiency can be measured in terms of the optimal combination of inputs to achieve a given level of outputs (an input oriented model) or the optimal outputs that could be produced by given a set of inputs (an output orientation model).

The output-oriented model measures how much additional output a hospital could produce while still employing its current inputs. In this sense, efficiency can be interpreted as a hospital's productivity relative to best practice. However, this model orientation is appropriate for hospitals that have the flexibility to change their level of output which is more likely to be the case for private hospitals mainly due to their greater ability of increasing a facility revenue base.

On the other hand, input-oriented model of technical efficiency measures how many fewer resources a hospital could employ and still produce the same level of output. In this context, efficiency is interpreted as a hospital's resource intensity relative to best practice. This is the best approach for estimating technical efficiency in public hospitals which have less flexibility to change their output, but can change their use of inputs since they operate using a capped/fixed budget. In this analysis, hospital efficiency is assessed using an input-oriented model. In this study, a two stage Data Envelopment Analysis (DEA) was used in estimating technical efficiency scores of the public hospitals in Kenya and its determinants.

2.3 Empirical Literature review

2.3.1 Technical efficiency levels

Studies done in Africa using DEA have indicated varying magnitude and causes of inefficiency in hospitals. In a study done by Kirigia and Asbu (2013) in Eritrea using DEA, the study found that the average constant returns to scale technical efficiency score was 90.3%; the average variable returns to scale technical efficiency score was 96.9%; and the average scale efficiency score was 93.3%. The findings revealed that inefficient hospitals could have become more efficient by either increasing their outputs by 20,611 outpatient visits and 1,806 hospital discharges or by transferring the excess 2.478 doctors (2.85%), 9.914 nurses and midwives (0.98%), 9.774 laboratory technicians (9.68%), and 195 beds (10.42%) to primary care facilities such as health centers, health stations, and maternal and child health clinics.

In South Africa, Zere et al. (2006) found that 58 percent of all the hospitals were inefficient with inefficiency scores ranging between 35 to 47 percent. Further analysis showed that 58 percent of the facilities were operating at a sub-optimal scale. A similar study in Namibia found that technical efficiency ranged between 15 percent and 37.3 percent (Government of Namibia, 2004). Osei, George, Almeida, Kirigia, Mensah and Kainyu (2005) found that 47 percent of the public hospitals in Ghana were technically inefficient and 10 percent were scale 20 inefficient.

In another study done by Kirigia et al. (2004), DEA findings indicated that out of the 32 health centers included in the analysis, 14 (44%) were technically efficient, whereas the remaining 18 (56%) were technically inefficient. Among the inefficient health centers, 2 (13%) had a technical efficiency (TE) score of less than 50%, 9 centers (28%) had TE of between 51 and 74% and 6 centers and 19% of the facilities had TE of between 75 and 99%. The inefficient health centers had an average TE score of 65% and a standard deviation of 22%. This implies that on average, they could reduce their utilization of all inputs by about 35% without reducing output. On the other hand, out of the 32 health centers analyzed, 19 (59%) were scale efficient, while the remaining 13 (41%) were scale inefficient.

According to a study done in Kenya by Kibe (2010), data envelopment analysis revealed an average technical efficiency score of 95.75% for level 5 hospitals and 97.72% for level 4 hospitals. Stochastic frontier analysis revealed an average cost efficiency score of 77.49% for level 5 hospitals and 66.78% for level 4 hospitals. A negative technological change for level 4 and 5 public hospitals was found to impact negatively on the total factor productivity for the two levels of public hospitals. An increase in recurrent expenditure was also found to reduce cost efficiency in both level 4 and level 5 public hospitals. Increases in number of nurses was found to increase cost efficiency in level 5 public general hospitals while increases of doctors increased cost efficiency in level 4 public hospitals. All the results cited above point to the fact that substantial inefficiency exits in the hospitals of many Sub-Saharan countries.

2.3.2 Determinants of inefficiency

Studies have shown that individual efficiency scores of hospitals are dependent on the characteristic features of each unit examined. When not accounted for, lower efficiency scores are taken as inefficiency even though caused by the environmental factors. Therefore, determinants of inefficiency are examined in most of the studies as well, however exceptions appear.

A few studies have also investigated factors contributing to efficiency of health facilities. These determinants include ownership type, size and capacity, output quality and degree of specialization, market structure and funding issues and geographic location. A study by Zere *et al.* (2006) is among the studies that explored these factors in a two-stage procedure involving DEA and regression analysis. Zere, basing his assumption that low income patients who have more complicated case mix, are often admitted into the hospital through the emergency rooms and require greater lengths of stay, inferred that they are a source of higher costs for urban hospitals in the United States of America. As such it would be expected that in regions with relatively more poverty like the south of Malawi, hospital costs would be higher which also translates into higher inefficiency.

A study by Zere et al. (2006) found that the bed occupancy rate affects technical efficiency positively at all levels of health facilities but found that average length of stay has a negative impact on technical efficiency. Specifically, Zere et al. (2006) found that in South Africa, occupancy rate and the number of outpatient days as a proportion of inpatient days positively affects technical efficiency while the average length of stay had some adverse effect. They also found that there was a presence of economies of scope.

The effect of ownership status on inefficiency has been empirically widely examined. Besides Zuckerman, Hadley and Iezzoni (1994), Rosko and Chilingerian (1999) and Rosko (2001) investigated the role of ownership on efficiency. They consistently found out that government regulatory pressures are inversely associated with inefficiency. On the other hand Vitaliano & Toren (1996) found the effect of both for-profit status and government ownership on inefficiency not to influence inefficiency of facilities. The effect of competition and inefficiency has been found to be inverse-related, however, insignificant by some studies, such as Zuckerman *et al.* (1994) and Cellini, Pignataro & Rizzo (2000), the latter of which analyzed the effect of competition on efficiency of hospitals in Italy.

As far as hospital size is concerned, the evidence is rather mixed. It has been found that larger hospitals are different from smaller ones. Zuckerman *et al.* (1994) found out that size, measured with the number of beds, is significantly and negatively related to inefficiency when regressing scores obtained from inefficiency results on a set of determinants. The same conclusion was reached by Vitaliano & Toren (1996), specifically, when including size variable into the Tobit regression model; they found that having up to 120 beds is positively related to inefficiency, but when there are more than 300 beds, the effect on inefficiency is negative.

Similarly, Wang, Ozcan, Wan and Harrison (1999) who measured a different sample of United States hospitals found out that large hospitals generally demonstrate higher inefficiency when the size effect is not accounted for. On the other hand, using log of available beds to account for size, Yong & Harris (1999) found out that size is positively related to inefficiency. On the other side, demand factors such as income levels, population density and purchasing power of the public sector will influence technical efficiency e.g. in levels of utilization, standards of care and duplication in the system. Similarly, supply factors influence the input mix through levels of economic development, management of human resources, institutional structures, and the strength of the public sector capacity. Lack of resources and decision-making ability are poor motivators for efficiency and constrain overall ability of providers to choose an efficient input/output mix.

Poor infrastructure and human resources result in a loss of the confidence in the health system. Uniform policies reduce opportunities to increase efficiency and may propagate inefficiencies. Payment mechanisms can act as strong incentives for providers to act efficiently in the production and delivery of outputs. At the provider level, efficiency incentives are generally stronger under prospective than retrospective reimbursement. At the personnel level, incentives depend on the extent to which enumerations are linked to performance. A study in Ghana found that those receiving incentives from the

Ghanaian County Health Management Team were nine times more likely to be technically efficient (Akazili & Fernandes, 2008). However, healthcare production is complex with many interrelationships. In this interaction, incentives may lead to perverse effects such as over-using inputs or skimping on quality. These factors cut across all levels of the system and types of ownership.

A study by Lee, Yang, & Choi (2009) also investigated factors contributing to efficiency of health hospitals in different countries. The study found determinants of inefficiency to include hospital ownership type, size and capacity, output quality and degree of specialization, market structure and financing mechanism and geographic location (Lee et al., 2009). A similar study found that low income patients have more complicated case mix. The study found that these patients are often admitted into the hospital through the emergency rooms and require greater lengths of stay. This means that they are a source of higher costs for urban hospitals (Freisner, Roseman & McPherson, 2008). As such it would be expected that in regions with relatively more poverty, hospital costs would be higher which also translates into higher inefficiency. On the other hand, bed occupancy rate affects technical efficiency positively at all levels of health facilities but average length of stay has been shown to have negative impact on technical efficiency (Kimsey, 2009). The high number of empirical studies dealing with hospital efficiency and its determinants abroad supports the necessity to deal with the subject matter. Unfortunately, a similar analysis of hospital efficiency is scarce or even missing in developing countries creating a gap which this study aimed at bridging.

2.4 Emerging issues, gaps and challenges in literature review

In terms of hospital performance, there are few known studies on technical efficiency in hospitals settings and its determinants in developing countries especially in Kenya and Africa in general. Apparently, studies on factors that contribute to productivity of the hospitals in developing countries are not easily available as well. However, the trend in the analysis of technical efficiency is that Data Envelopment Analysis has become the most popular tool in the past decade in many industries such as banks. This has also been applied in health care as a tool of appraising efficiency levels. This is the case despite DEA being criticized for its inability to accommodate random variation in the data (George, 2006).

Studies reviewed indicated existence of varying magnitude of inefficiencies in public hospitals indicating potentials to reduce inputs or alternatively increase outputs in-order to improve efficiency. However, most of the studies done in Africa especially those done in Kenya have failed to establish key determinants of inefficiencies in the public facilities with none of the studies undertaking in-depth exploration of the factors correlated with inefficiencies. This has created a knowledge gap that can help understand how each of the significant factors influences the efficiency in hospital settings.

In addition, most of the studies are not current; were done in 1990s and early 2000. Given the changes and dynamics of the health care industry and its operating environment, their findings may be rendered less useful over time. For instance, Kenya has introduced devolved system of governance and devolved health care in the process to the counties. This could have significant effect on the operations and service delivery of the individual facilities compared to the previous system of leadership and governance. There is no baseline data on efficiency that can be used to analyze trend and compare it over time both longitudinally and cross-sectionally. Therefore, there is need for a robust monitoring and evaluation frameworks for measuring and tracking efficiency in production mix function.

Additionally, many reforms and restructuring has been implemented overtime as a result of continued research and renewed interest for responsible, accessible, affordable and quality care. This could have significant effect to the production functions and create new challenges as well. Therefore this study aimed at bridging this gap by providing generating contextualized knowledge and in-depth understanding of the technical efficiency of public hospitals and its key influencing factors using more robust measures of efficiency measurement in order to be able to utilize the available resources optimally in light of efforts to achieve millennium development goals and health sector strategic plans in place.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter gives a description of the methodology applied in the study. It highlights the study area, study design, study population, sampling design and sample size determination, reliability and validity approaches, methods of data collection and data analysis.

3.2 Location of the study

The study was conducted in all counties of Kenya. Kenya is divided into 47 Counties (See map of Kenya in Appendix 4). The population of Kenya is highly heterogeneous (diverse) with different ethnic groups. Kenya has a population of about 39 million with an annual growth rate of about 3%. According to KNBS (2012), Kenya per capital GDP is Ksh 38,970 with an average GDP growth of 4.60 (See Kenya Health indicators in Appendix 5).

3.3 Study design

The study used an analytical and descriptive study design employing both linear programming econometric techniques for its analysis. In the first stage, DEA was used to compute efficiency score after which interval regression was used to identify determinants of inefficiency in public hospitals.

3.4 The theoretical model

This study used DEA (Charnes, Cooper & Rhodes, 1978) to estimate technical efficiency and magnitude of inefficiency in public hospitals. Coelli *et al.* (2005) defined Data Envelopment Analysis (DEA) as a non-parametric mathematical programming approach to frontier estimation which uses linear programming to sketch a boundary function (efficient frontier) to observed data for relatively homogenous firms. The hospitals on the frontier which have an efficiency score of one (1) are considered to be technically efficient relative to their peers. Those with an efficiency score of less than one are considered to be inefficient. The efficiencies of the hospitals below the efficiency frontier are measured by their distance to the frontier. The closer a hospitals is to the efficiency frontier, the better the efficiency levels; hospitals which are far from the frontier are considered to be more inefficient than those near the frontier. DEA as an approach to measure efficiency was first proposed by Farrell (1957) when seeking for better ways of productivity evaluations.

DEA has numerous advantages, particularly for public sector applications. The major one is that it can accommodate multiple units of input and output without the need for any kind of aggregation. This makes it highly appropriate to be applied in sectors where price information is not available or unreliable such as health care (Coelli., Prasada, O'Donnell, & Battese, 1998). DEA models have been applied in hospitals to measure magnitude of inefficiencies and generate new alternatives to improve performance and efficiency to a great extent due to its ability to identify the optimal ways of performance (Simar, 2007). It is also used in benchmarking by identifying optimal performance leading to benchmarking in a normative way. Using DEA, health care managers can not only identify top performers, but also discover the alternative ways to stir their health care organizations into becoming one of the best performers.

3.5 Estimating Model/Model specification

3.5.1 DEA Analytical Framework

Data Envelopment Analysis (DEA) is defined as a non-parametric mathematical programming approach to frontier estimation which uses linear programming to sketch a boundary function (efficient frontier) to observed data for relatively homogenous firms (Coelli et al., 2005). DEA and econometric methods have been greatly used in analyzing technical efficiency of health care sector in both developed and developing countries. In this study, DEA is used to estimate the hospital-efficiency scores and magnitude of technical inefficiencies in public hospitals. Past studies (Kirigia, Mensah, Mwikisa, Asbu, Emrouznejad, Makoudode & Hounnankan, 2010; Ruggiero, 2004; Tlotlego, Nonvignon, Sambo, Asbu & Kirigia, 2010, Osei et al., 2005) indicated that DEA is a preferred efficiency analytic tool because it has capacity to: (1) deal with DMUs that employ multiple inputs to produce multiple outputs or services, as is the case in hospitals; (2) identify inefficient decision-making units; (3) permit analysis of sources of inefficiency and quantification of magnitudes of inefficiencies in the use of hospital inputs and production of outputs; (4) estimate production targets to be attained by inefficicient hospitals for them to achieve efficient frontiers and (5) identify suitable benchmarks/peers for the less performing hospitals.

DEA evaluates the efficiency of an individual hospital by using efficient frontiers in comparison to peer hospitals. The efficiencies of the hospitals below the efficiency frontier are measured by their distance to the frontier. Hospitals with an efficiency score of one are said to be technically efficient relative to others while those with efficiency score of less than one are termed as inefficient. According to Charnes *et al.* (1978) assuming a constant return to scale (CRS), efficiency score of an individual hospital can be obtained by solving the linear programming model illustrated below:

$$\max E_0 = \sum_{r=1}^{s} u_r y_{rjo}$$

$$\text{subject to: } \sum_{i=1}^{m} v_i x_{ijo} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, j = 1, \ldots, n$$

$$u_r, v_i \geq 0$$

(

1)

Where:

y_{rj}=amount of output r from hospital j

x_{ij}=amount of input i from hospital j

u_r=weight given to output r

v_i=weight given to input i

n=number of hospitals

s=number of outputs

m=number of inputs

The first constraint above means that the weighted sum of inputs for an individual hospital equals to one while the second constraint means that all hospitals are on or below the frontier, that is, efficiencies of all hospitals have an upper bound of one. The weights u_r and v_i are unknowns obtained by solving the linear programming problem. An inefficient hospital (hospital operating below the frontier) can reach the efficient frontier by either increasing output with the same input combination or producing the same output with less input. CRS is suitable when all hospitals operate at an optimal scale. However, this is not the case in the public health sector. i.e. CRS assumes no deviations from the optimal scale. Therefore, to capture the effects of scale efficiency, Banker, Charnes, Cooper (1984) proposed an extension of the original CRS DEA model to account for the variations in returns to scale (VRS) which assumes economics of scale in the production frontiers of the DMUs i.e. Scale efficiency. Variable returns to scale efficiency can be determined by solving the following linear programming model:

$$\max E_0 = \sum_{r=1}^{s} u_r y_{rjo} + U_0$$

$$subject\ to: \sum_{i=1}^{m} v_i x_{ijo} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + U_0 \leq 0, j = 1, \dots, n$$

$$u_r, v_i \geq 0$$

$$U_0 \text{ is either } >, <, or = 0 \quad (2)$$

Notations in the equation 2 above are the same as those in equation 1. However, u_o is an unconstrained in sign intercept that determines the returns to scale. If $U_o<0$, it indicates increasing returns to scale5, if $U_o>o$ it indicates decreasing returns to scale and if $U_o=0$, it indicate constant returns to scale. Scale efficiency is equal to constant returns to scale technical score divided by variable returns to scale technical score (Masiye, 2007; Celli, 1996) as shown below:

$$SE_j = \frac{TE_j(y_j, x_j CRS)}{TE_j(y_j, x_j VRS)} \quad (3)$$

3.5.2 Interval regression Model

In the second stage, the efficiency scores computed using DEA were regressed against the institutional variables hypothesized to influence inefficiency scores of the hospitals. These factors are bed turnover rate, bed occupancy ratio, outpatients-inpatients ratio, inpatient discharges to deaths ratio, NHIF to non-NHIF bed day's ratio, average daily census and gross death rate. Data for these factors were obtained from District Health Information System (DHIS) housed in the ministry of health.

Various techniques have been proposed and applied in past similar studies in determining contextual factors on efficiency such as the Maximum Likelihood (ML) based probit, Ordinary Least Squares (OLS), Tobit and logit techniques. However, there seems no consensus on the techniques appropriate for second stage DEA estimator with some scholars against the two stage DEA Estimator (Simar & Wilson, 2007) while others supports use of econometric models such as probit, logit, and truncated regression (Tobit) in estimating impact of contextual factors on efficiency (McDonald , 2009; Ramalho et al., 2010). Maddala & Ellen (1989) showed that cross-sectional studies using the Tobit regression suffer mostly from problems associated with heteroscedasticity, auto-correlated errors and non normality of the random error and lagging of variables. To overcome this limitation, interval regression (a robust standard errors regression of the Tobit model) which takes care of heteroscedasticity and non-normality of the random error was used (Mc Donald & Moffitt, 1980).

Following a study by Asbu, Mc Intyre & Addison (2001), the DEA efficiency scores were transformed into inefficiency scores, left-censored at zero using the formula:

$$\textbf{Inefficiency score} = \left[\frac{1}{DEA\ TE\ score-1}\right] - 1$$

This Interval regression model is formulated as follows (McDonald, 1980, 34):

$y*=\beta ixi+\varepsilon iyi=y*iify*i>0yi=0ify*i\leq 0i=1, 2\ldots N$

Where: N is the number of observations; y_i is the observed inefficiency score, i.e. dependent variable; y^* is the latent dependent variable; βi is the $kx1$ vector of unknown parameters; x_I is the $kx1$ vector of explanatory/independent variables; and ε_i is an independently distributed error term assumed to be normal with zero mean and constant variance σ^2. Therefore, the estimated empirical model for the study was:

$Ineff=\alpha+\beta 1OTIVR+\beta 2BTR+B3BOR+\beta 4IDTDR+B5NTNBDR+\beta 6ADC+ \beta 7GDR +\varepsilon i$ (6)

Where: INEFF is the inefficiency score; OTIVR is outpatient to inpatient visits ratio; BTR is the bed turnover rate; BOR is the bed occupancy ratio, IDTDR is the inpatient discharges to deaths ratio, NTNNBDR is the NHIF to non-NHIF bed days ratio, ADC is the average daily census and GDR is the gross death rate; α is the intercept term; β_I is the vector of unknown parameters or coefficients; and ε_I is the stochastic/random error term.

In this study, we expected a negative relationship between hospital inefficiency (*Ineff*) and OTIVR, BTR, BOR, NTNNBDR, IDTDR and ADC. Thus, regression coefficients β_1, β_2, β_3, β_4 and β_6 were expected to assume a negative coefficient. On the other hand, we expected a positive relationship between the *Ineff* and *GDR*, and thus, β_7 was expected to assume a positive coefficient. Interval regression coefficients indicated how a one unit change in an independent variable x_i alters the latent dependent variable y^*. Therefore, the study tested two hypotheses using the interval regression model:

(1) The null hypothesis which tests the overall significance of the equation;

$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0,$

Therefore the null hypothesis was, $H_0: \beta_n = 0$;

(2) The alternative hypothesis:

$H_A: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 \neq 0,$

Therefore, the alternative hypothesis was, $H_A: \beta_n \neq 0$

3.6 Study variables

3.6.1 Dependent variable

The dependent variable of the study was technical efficiency. This was measured by efficiency score derived from the hospital production function (conversion of selected inputs to outputs) using the DEA model.

3.6.2 Independent variables

These were factors hypothesized to influence the efficiency of hospitals. Factors included: bed turnover rate, bed occupancy ratio, outpatients-inpatients ratio, inpatient discharges to deaths ratio, NHIF to non-NHIF bed days ratio, average daily census and gross death rate.

3.7 Study population

The study targeted all the level 4 hospitals in Kenya. Two major level 4 hospitals were selected from each county using the number of bed and cots as a measure of operational size for the hospitals. The study population constituted a total of 80 hospitals within

Kenya which formed the sampling frame for the study. However, private hospitals and public hospitals offering specialized services were excluded from the sampling frame.

3.8 Sampling Technique and sample size

Simple random sampling was used to obtain a study sample of 30 level 4 hospitals (Appendix 1) from a sample frame of 80 hospitals in Kenya. Simple random sampling was used to eliminate bias in selection of hospital since some counties had more than one level 4 hospitals. This sampling design was also useful in ensuring representativeness of hospitals from different places such as urban and rural set up. First, all the hospitals were entered into excel sheet. According to past researchers (Boussfofiane & Dyson, 1991), to achieve good discrimination in a DEA model, the number of DMUs should be at least three times the summed number of outputs and inputs used in the study. Therefore, in the second stage, simple random sampling was used to select 30 hospitals to form the study population from all over Kenya. This sampling technique was justified by its ability to ensure representation and control for selection bias.

3.9 Validity and Reliability

To ensure that relevant data was mined from the DHIS, standard checklists (appendix 6 and appendix 7) were used to ensure the data collected was both accurate and reliable. The researcher ensured rigorous methodological coherence such as use of standard formulae in calculating rates and ratios for the study variables and application of valid and appropriate data analysis methods including linear programming and use of interval regression modeling.

3.10 Data Collection Procedure

In Kenya Health System, the first contact with a hospital results into opening of a patient card which is kept in the medical records office, and then updated during subsequent visits. The hospital medical records officers collates daily summaries of the numbers of visits, discharges, and operations using patient records and registers. Every month, hospitals upload a summary of this data on selected output and input indicators to the District Health information system (DHIS) housed at the MOH headquarters. This data is accessible through DHIS portals. However, the staff data and capital data such as bed capacity is updated annually in the DHIS. Therefore, the input, output and other capital data used in the study were obtained from the DHIS report 2012/2013 financial year using a standard checklist (Appendix 6). Use of secondary data from DHIS was based following reasons: (1) Collecting primary data on the inputs and outputs is a difficult task since one would require to collect input and output data for all the department in the hospital for a longer period such as a year, (2) if well collected and achieved, secondary data provides an objective source of data which can be easily used to determine the efficiency frontiers of hospitals for a given period and use the findings to inform future decisions, (3) DEA is able to use secondary data in estimating technical efficiency without necessarily interrupting the functions of the hospital in the process of data collection, (4) Use of secondary data in efficiency measurement adds value to the process of achieving and managing data records (uses data to inform decision making and resource mobilization) and (5) DHIS provides a range of relevant data on health service delivery collected from all the health facilities in Kenya hence reducing duplication of efforts.

In selecting hospitals to be enlisted in the study, first, level 4 hospitals were listed in the study based on the number of beds as proxy for their operational sizes. At least two main level 4 hospitals at the county level were enlisted from each of the 47 counties in Kenya to form a sampling frame of 80 hospitals. In the second stage, random sampling was used to sample 30 hospitals enlisted in the analysis. In this study, the following hospital inputs and outputs were used in the study:

Hospital inputs:

Input 1: Number of beds (including cots)

Input 2: Number of medical consultants

Input 3: Number of general medical practitioners

Input 4: Number of clinical officers

Input 5: Number of nurses

Input 6: Number of therapy specialists

Input 7: Number of laboratory specialists

Hospital Outputs

The three intermediate outputs used were:

Output 1: Number of outpatient visits

Output 2: Number of discharges

Output 3: Number of surgical operations

Since information on capital services, measured in machine hours such as equipment, was not part of routinely collected and archived data in the DHIS, only the number of hospital beds was used as proxy for the capital goods. Further, head counts for the health workforce in the selected hospitals were used due to lack of information on work hours for the staff. In addition, regression data on variables hypothesized to influence inefficiency levels which were not included in the input and output data used in determining efficiency scores of the hospitals were also collected from the DHIS using a standard checklist (appendix 7). These data variables included: Number of NHIF and non NHIF patient days, number of deaths (both outpatient and inpatient), number of non-medical staff and daily census of patients for each hospital sampled in the study.

The choice of the inputs and outputs was based on two key considerations: (1) relevance of data in the DHIS for the 2012/2013 financial year (2) and availability of routinely collated and updated data from the sampled hospitals.

3.11 Data Analysis and management

The Analysis framework consisted of two stages: In the first stage, input and output data was entered into Excel sheet after which DEA version 2.1 was used to calculate the technical efficiency scores for the hospitals. In the second stage, interval regression analysis using censored interval regression model was used to identify determinants of technical efficiency for the sampled hospitals.

3.12 Ethical Considerations

Approval to carry out the study was granted by graduate school of Kenyatta University (Appendix 2) while a research permit was granted by National Commission of Science, Technology and Innovation (NACOSTI) (Appendix 3).

CHAPTER FOUR

FINDINGS

4.1 Introduction

This chapter presents results of the study. The chapter covers the descriptive statistics of the sampled hospitals, their technical efficiency scores, production slacks, production targets, benchmarks of inefficient hospitals and determinants of technical inefficiency.

4.2 Descriptive statistics for the hospitals

Table 4.1 below presents the descriptive statistics (sum, minimum, maximum, range, mean and standard deviation) for inputs and outputs of randomly sampled Kenyan hospitals in this study.

Table 4.1: Descriptive statistics for the hospitals

Description	Sum	Mean	Standard deviation	Minimum	Maximum	Range
Outputs						
Outpatient visits	2,424,360	242,609	60,107	2,181	242,609	240,428
Discharges	158,179	14,454	4,155	676	14,454	13,778
Total operations	20,012	2,087	495	14	2,087	2,073
Inputs						
Beds and cots	4,089	294	66	46	294	248
Medical consultants	150	17	4	1	17	16
General medical officers	208	19	5	1	19	18
Clinical officers (Cos)	574	100	18	5	100	95
Nurses	3,189	410	79	27	410	383
Therapy specialists	217	23	5	2	23	21
Laboratory Technologist	306	44	8	1	44	43

In the financial year of 1st March to 31st April 2013, the 30 hospitals (Appendix 4) received 2,424,360 outpatient visits, discharged 158,179 inpatients and performed 20,012 operations. These outputs were produced using a total of 7 inputs which were: 150 medical consultants, 208 general practitioners (medical officers), 574 clinical officers (specialized and registered clinical officers), 3,189 nurses, 217 therapy specialists, 306 laboratory technologists, and 4,089 hospital beds (including cots).

The outputs and inputs varied widely across different hospitals. The outpatient department visits varied from a minimum of 2,181 to a maximum of 242,609. Inpatient discharges ranged between 676 and 14,454 patients and operations ranged from 14 to 2,087. The means and standard deviations of hospitals outputs varied widely across the hospitals. The means of outputs were as follows: 242,609 Outpatient visits; 14,454 Discharges and 2,087 Operations.

In terms of inputs, there was considerable variation: Medical consultants varied from a minimum of 1 to a maximum of 17, general medical practitioners ranged between 1 and 19, Clinical officers ranged from 5 and 100, nursing officers, nurses and midwives varied between a minimum of 27 to 410, therapy specialists ranged between 2 and 23, laboratory technologists ranged from 1 and 44 and hospital beds varied from a minimum of 46 to a maximum of 294. On the other hand, the mean inputs were as follows: 17 Medical consultants; 19 General practitioners; 100 Clinical officers; 410 Nurses; 23 Therapy specialists and 14 Laboratory technologists.

4.3 Scores of Technical efficiency

Table 4.2 below shows the scores for constant returns to scale technical efficiency, variable returns to scale technical efficiency, scale efficiency, types of returns to scale.

Table 4.2 Scores of Technical efficiency

Name of Hospital	CRS	VRS	SE	
A	1.000	1.000	1.000	CRS
B	0.688	0.874	0.787	IRS
C	0.637	0.817	0.780	IRS
D	0.429	0.440	0.975	IRS
E	0.863	0.885	0.976	DRS
F	0.414	0.959	0.432	IRS
G	1.000	1.000	1.000	CRS
H	1.000	1.000	1.000	CRS
I	1.000	1.000	1.000	CRS
J	1.000	1.000	1.000	CRS
K	0.630	0.821	0.767	DRS
L	0.749	0.802	0.933	DRS
M	1.000	1.000	1.000	CRS
N	1.000	1.000	1.000	CRS
O	0.807	1.000	0.807	IRS
P	1.000	1.000	1.000	CRS
Q	1.000	1.000	1.000	CRS
R	1.000	1.000	1.000	CRS
S	1.000	1.000	1.000	CRS
T	1.000	1.000	1.000	CRS
U	1.000	1.000	1.000	CRS
V	0.466	0.640	0.727	IRS
W	1.000	1.000	1.000	CRS
X	0.803	0.871	0.922	IRS
Y	1.000	1.000	1.000	CRS
Z	0.684	1.000	0.684	IRS
AB	0.229	1.000	0.229	IRS
AC	0.514	0.700	0.734	IRS
AD	0.753	1.000	0.753	IRS
AE	0.522	1.000	0.522	IRS
Minimum	**0.229**	**0.440**	**0.229**	
Standard Deviation	**0.233**	**0.135**	**0.197**	
Mean	**0.806**	**0.927**	**0.868**	

4.3.1 Constant returns to scale efficiency

15 hospitals, representing 50% of the sampled hospitals, were constant return to scale technically efficient, scoring 100% while the remaining 15 hospitals, which represented 50% of the sampled hospitals, were relatively constant return to scale inefficient. The mean constant return to scale technical efficiency was 80.6% with a standard deviation of 23.3%. The average constant return to scale technical efficiency score varied from a minimum of 22.9% in AB hospital to a maximum of 100% in A, G, H, I, J, M, N, P, Q, K, S, T, U, W and Y hospitals.

4.3.2 Variable returns to scale efficiency

20 hospitals, representing 66.6% of the total hospitals studied, were variable returns to scale technically efficient while the remaining 10 hospitals, representing 33.3% of the hospitals were variable returns to scale technically inefficient. The mean variable return to scale technical efficiency score was 92.7% with a standard deviation of 19.7%. D hospital had the lowest variable returns to scale technical efficiency score of 44%.

4.3.3 Scale efficiency

50 hospitals, representing 50% of the sampled hospitals, had an optimal production function for their input–output mix i.e. they had a scale efficiency score of 100%. The mean scale efficiency score was 86.8%, with a standard deviation of 19.7%. The average scale efficiency score varied from a minimum of 22.9% in AB hospital to a maximum of 100% at A, G, H, I, J, M, N, P, Q, K, S, T, U, W and Y hospitals

The results revealed that increasing the quantity of all hospitals inputs by a given proportion would result in:

(i) Increasing returns to scale in 40% of the hospitals. This implies that their health service outputs would increase by a greater proportion. This means that B, C, D, F, O, V, X, Z, AB, AC, AD and AE hospitals were not operating at their optimal scale sizes hence the need to increase their operational sizes.

(ii) Constant returns to scale in 50% hospitals. This means that their health service outputs would increase in the same proportion. This means that A, G, H, I, J, M, N, P, Q, K, S, T, U, W and Y hospitals were operating at their most productive scale sizes hence scale efficient.

(iii) Decreasing returns to scale in 10% hospitals. This implies that the health service outputs in these hospitals would increase by a smaller proportion. This means that E, K and L hospitals were not operating at their optimal scale sizes. Therefore, these hospitals would have needed to reduce their size to achieve optimal scale efficiency.

4.4 Production (slacks) changes for inefficient hospitals

4.4.1 Magnitude of inefficiencies

The Table 4.3 shows the level of technical inefficiencies and the production slacks required under VRS technical efficiency model to make the inefficient hospitals technically efficient. DEA analysis indicated that 20 (66.6%) hospitals were variable returns to scale technically efficient while the remaining 10 (33.3%) hospitals were variable returns to scale technically inefficient.

Table 4.3 Magnitude of inefficiencies

Name of Hospital	Technical inefficiency
B	0.126
C	0.183
D	0.560
E	0.115
F	0.041
K	0.179
L	0.198
V	0.360
X	0.129
AC	0.300
Minimum	**0.041**
Maximum	**0.560**
Standard Deviation	**0.151**
Mean	**0.219**

Technical inefficiency varied from a minimum of 4.1% (in F hospital) to a maximum of 56% (in D hospital). Among the technically inefficient hospitals, the mean level of VRS inefficiencies was 21.9% with a standard deviation of 15.1%.

4.4.2 Production changes (input and output slacks)

Due to inefficiencies, 33.3% of the hospitals were variable return to scale inefficient. These hospitals exhibited existence of differing levels of production (input and output) slacks as shown in table 4.4 below.

Table 4.4 Production slacks required to make inefficient hospitals efficient

Name of hospital	Technical inefficiency	Input slacks								Output slacks		
		No. of beds and cots	Medical consultants	General practioners	Cos	Nurses	Therapy specialists	Laboratory Technologists	Total staff	Outpatient visits	Discharges	Operations
B	0.126	16	0	0	5	0	0	1	6	-	-	18
C	0.183	37	0	0	0	3	1	0	5	1,674	3,772	-
D	0.560	0	0	4	41	129	8	21	203	29,728	-	96
E	0.115	12	4	2	7	0	7	8	28	115,626	-	599
F	0.041	36	2	1	0	4	0	1	8	2,170	-	1
K	0.179	0	0	2	16	70	0	5	94	35,163	-	343
L	0.198	21	0	0	1	7	0	3	11	20,418	-	166
V	0.360	0	0	1	6	3	1	0	11	-	541	25
X	0.129	0	0	2	8	36	2	4	52	-	692	187
AC	0.300	0	8	11	0	17	0	1	37	12,768	-	160
		0	0	0	0	0	0	0	0	-	-	-
Maximum		37	8	11	41	129	8	21	203	115,626	3,772	599
Sum		122	15	23	84	268	20	44	454	217,547	5,006	1,596
Slack %		7.3	19.9	22.4	27.9	19.2	24.3	46.4	22.1	27.6	9.2	31.3
Mean		12	1	2	8	27	2	4	45	21,755	501	160
Standard Dev.		15	3	3	13	42	3	6	62	35,503	1,178	189

According to the findings, for efficiency to be achieved, the technically inefficient hospitals were required to change their input-output mix in different proportions. Since the VRS model was an input oriented model, the inefficient hospitals were required to reduce their inputs and augment any resulting gaps with their outputs in different proportions to achieve optimal efficiency scores. In all the inefficient hospitals, the following total input reductions were required: 122 beds; 15 medical specialists; 23 general practitioners; 84 clinical officers, 268 nurses, 20 therapy specialists and 44 laboratory technologists; this translated to a total of 122 beds (including cots) and 454 staff in all the inefficient hospitals; equivalent of 7.3% reduction in total beds and 22.1% reduction in total staff in all the inefficient hospitals.

Reductions in input levels were not sufficient to achieve efficient levels in the inefficient hospitals. This required inefficient hospitals to augment their input reductions (slacks) with output additions (slacks). All the inefficient hospitals required a 27.6% increase in total outpatient visits which translated to an additional 217,547 outpatient visits. Increase in outpatients' visits varied between a minimum of 0 to a maximum of 115,626 visits (in E hospital) with a mean of 21,755 outpatient visits. Additions in outpatient discharges varied from a minimum of 0 to a maximum of 3,722 (in C hospital) with a mean of 501 discharges in all the hospitals. An additional 5,006 discharges were also required which translated to 9.2% increase in total discharges. A mean of 160 operations was required for all the hospitals to reach efficient production frontier. The additional operations varied from a minimum of 0 to a maximum of 599 operations (in E hospital). All the hospitals required to augment their operations capacity with a sum of 1,596 operations which represented a 31.3% increase in total operations.

4.5 Production targets for inefficient hospitals

The production targets were the results of respective input slack values added to outputs. In calculating the target values for inputs, the input values were multiplied with an optimal efficiency score (peer/lambda weights) and then slack amounts were subtracted from this amount. All inefficient hospitals needed to achieve production targets for them to attain optimal efficiency levels as shown in table 4.5.

Table 4.5: Production targets required to make inefficient hospitals efficient

Name of the Hospital	Input Targets								Output targets		
	No. of beds	Medical consultants	General practioners	Cos	Nurses	Therapy specialists	Laboratory Technologist	Total staff	Outpatient visits	Discharges	Operations
B	151	5	4	12	81	5	3	110	64,697	4,392	433
C	169	5	6	11	72	6	8	107	85,386	7,052	675
D	170	10	14	59	281	12	2	378	95,791	7,865	900
E	205	8	13	35	129	4	7	196	264,055	11,397	1,514
F	155	3	3	6	37	4	2	55	35,050	1,227	15
K	195	8	14	18	166	6	7	218	145,047	10,576	1,233
L	223	5	6	15	89	5	4	124	130,190	5,227	444
V	108	4	7	18	83	3	10	125	60,119	2,584	532
X	94	2	6	24	88	10	2	132	65,484	4,765	495
AC	74	9	8	20	103	8	6	154	59,367	4,444	459
	0	0	0	0	0	0	0	0	-	-	-
Minimum	**74**	**2**	**3**	**6**	**37**	**3**	**2**	**55**	**35,050**	**1,227**	**15**
Maximum	**223**	**10**	**14**	**59**	**281**	**12**	**10**	**378**	**264,055**	**11,397**	**1,514**
Sum	**1544**	**58**	**81**	**218**	**1130**	**62**	**51**	**1600**	**1,005,186**	**59,530**	**6,701**
Mean	**154**	**6**	**8**	**22**	**113**	**6**	**5**	**160**	**100,519**	**5,953**	**670**
Standard dev.	**49**	**3**	**4**	**15**	**68**	**3**	**3**	**89**	**66,651**	**3,269**	**436**

The target values for efficient hospitals are always equivalent to their original input and output values. Therefore, efficient hospitals were not included in the production targets since they are already technically efficient i.e. efficient hospitals don't require any input reduction or output additions because they are already efficient. There was a lot of variation in production targets among the inefficient hospitals. In terms of input mix targets, the inefficient hospitals required get a total of 1,544 beds (including cots) which varied from a minimum of 74 (AC hospital) to a maximum of 233 (in L hospital). This translated to a mean of 154 beds in all the hospitals.

In relation to medical consultants, results indicated that the inefficient hospitals required to get a total of 58 medical consultants which varied from a minimum of two (2) medical consultants (X hospital) to a maximum of 10 (in D hospital). This translated to a targeted mean of 6 medical consultants in every inefficient hospital. In terms of general practitioners, the inefficient hospitals should have targeted to have a total of 81 general practitioners (GPs) which varied from a minimum of three (3) general practitioners (in F hospital) to a maximum of 14 general practitioners (in K hospital). This translated to a targeted mean of 8 general practitioners in all the inefficient hospitals. A total of 218 Clinical Officers were required in all the inefficient hospitals. There was a variation of between 6 (in F hospital) and 59 COs (in D hospital). The hospitals should have targeted a mean of 22 COs for them to be VRS efficient.

All the inefficient hospitals would also have required a total of 1, 130 nurses for them to reach VRS efficient frontier. There was a variation of between 37 nurses (in F hospital) and 281 nurses (in D hospitals) with a mean of 113 nurses in all the inefficient hospitals. In terms of Therapy specialists, the inefficient hospitals should have targeted to have a total of 62 therapy specialists with V hospital having the least number of therapy specialists (3) to a maximum of 12 in D hospital. This translated to a mean of 6 therapy specialists in all inefficient hospitals. All the inefficient hospitals would also have required a total of 51 lab technologists for them to be technically efficient. This translated to variation of between 2 lab technologists (in D hospital) and 10 lab technologists (in V hospital) with a mean of 5 lab technologists in all the technically inefficient hospitals.

In terms of output targets, all the inefficient hospitals required a total of 1,005,186 outpatient visits for them to be technically efficient with variations of between 35,050 outpatient visits (in F hospital) and 264,055 outpatient visits (in E hospital). This translated to a mean of 100,519 outpatient visits. In addition, the hospitals required to target a total of 59,530 discharges which translated to a minimum of 1, 227 discharges (in F hospital) and a maximum of 11,397 discharges (in E Hospital). This translated to a mean of 5,953 discharges. In terms of operations, all the inefficient hospitals required to target a total of 6,701 operations for them to be technically efficient with variations of between 15 operations (in F hospital) and 1,514 operations (in E hospital). This translated to a mean of 670 operations for them to be technically efficient.

4.6 Benchmarks (peers) and lambda weights for inefficient hospitals

Efficiency reference set (benchmarks) refers to the group of hospitals against which DEA located the relatively inefficient hospitals and the magnitudes of inefficiency.

Table 4.5 indicates benchmark (s) and lambda weights assigned to the different inefficient hospitals.

Table 4.6: Hospital benchmarks and lambda weights

Name of hospital	TE	Benchmarks/Labda weights			
B	0.874	0.171(Y)	0.115(A)	0.531(AD)	0.138 (K)
C	0.817	0.505 (AD)	0.238(S)	0.257 (P)	
D	0.440	0.085(AD)	0.176 (S)	0.739 (P)	
E	0.885	0.077 (N)	0.923(S)		
F	0.959	0.855 (AD)	0.004 (S)	0.141(AE)	
K	0.821	0.207 (P)	0.422 (K)	0.371(Y)	
L	0.802	0.085 (H)	0.353 (AD)	0.34(U)	0.222 (S)
V	0.640	0.389(AD)	0.257 (N)	0.295 (Y)	0.059(P)
X	0.871	0.742 (Y)	0.242 (N)	0.016 (Q)	
AC	0.700	0.212 (K)	0.304 (N)	0.484 (Y)	

Health care managers whose hospitals are inefficient can observe the benchmark hospitals that they need to catch up with. A benchmark with the highest lambda (lambda) weight indicates a higher modeling (benchmarking) preference for the inefficient hospital compared to the other benchmarks. For instance, F hospital, which was the least inefficient hospital among all the inefficient hospitals, had the following benchmarks: AD (0.855) AE (0.141) and S (0.004). It follows that Kathiani should strive to benchmark more with AD hospital (0.855) compared to AE hospital and S hospital.

The benchmark of inefficient hospital (s) is one or many of the efficient hospitals. For example, D hospital is the most inefficient hospital among all the hospitals studied. Its technical efficiency score of 63.2% and its production (input and output) slacks were calculated based on the lambda weights assigned to its peers/benchmarks. The benchmarks for D were: S hospital whose lambda weight was 0.286 and Y hospital whose lambda weight was 0.714. This means D would like to benchmark more with Y hospital (0.714) than S hospital (0.286).

4.7 Institutional Factors influencing technical efficiency

During analysis, the DEA efficiency scores were transformed into inefficiency scores by the interval regression model, left-censored at zero. Interval regression coefficients indicate how a one unit change in an independent variable alters the latent dependent variable, the efficiency score. The regression model was significant at 5 percent level of significance ($\chi2=$ **13.257**, p=**0.000**). Table 4.6 presents the Interval regression model results for the determinants of technical inefficiency in public hospitals.

Table 4.7: Determinants of technical inefficiency

Variable	**Coefficient**	**Std. Error**	**z**	**p-value**
Bed turnover rate	-0.020	0.002180	1.3291	0.054
Bed occupancy ratio	-0.168	0.000141	2.4876	**0.011**
Outpatient visits to inpatients visits ratio	-0.093	0.001650	2.1097	**0.002**
Inpatient discharges to deaths ratio	-0.143	0.000428	3.9872	**0.030**
NHIF to non-NHIF bed days ratio	-0.318	0.001812	2.3232	**0.024**
Average daily census	-0.121	0.000347	1.9217	0.070
Gross death rate	0.124	0.001390	3.4810	**0.032**
Test statistic:				
Chi-square(2)	**13.257**			
p-value	**0.000**			

Results indicates that bed occupancy was significantly associated with technical inefficiency (**p=0.011**). According to the model, a unit increase in bed occupancy ratio would lead to a decrease in the expected inefficiency score of a hospital by 0.168 (C=-0.168). This shows that increase in the number of beds occupied helps ensure maximum use of the available resources such as beds and staff for optimal use of the available resources. This improves efficiency of the hospital by reducing unnecessary wastages and sub-optimal resource use. Outpatient to inpatient visits ratio was significantly associated with technical inefficiency (**P=0.002**). A unit increase in the Outpatient to inpatient ratio is expected to decrease expected inefficiency score of a hospital by 0.093 (C=-0.093). Increase in outpatient visits reduces the economic costs associated with inpatient support and care. Most health services are offered through outpatient departments; therefore, increase in outpatient visits enables the facility to make maximum use of it facilities and resources which improve efficiency levels.

Further, inpatient discharges to deaths ratio was statistically significantly associated with technical inefficiency (**p=0.030**). According to the model, a unit increase in inpatients discharges to deaths ratio is expected to decrease the expected inefficiency score of a hospital by 0.143 (C=-0.143). Further, gross death rate was also significantly associated with technical inefficiency (**p=0.032**) According to the model, a unit increase in gross death rate would increase technical inefficiency score of a hospital by 0.124 (C=0.124). This has significant implication on the public image and perceptions patients have towards health facility. Increase in facility-based deaths is often associated with poor service quality and negligence. High death rates in relation to facility admissions can scare away and deter clients from utilizing the services which results in declining efficiency levels of a facility. NHIF to non-NHIF bed days was significantly associated with technical inefficiency (**p=0.024).** A unit increase in the ratio of NHIF to non-NHIF bed days would result in 0.318 decrease in technical inefficiency score of a hospital (C=-0.318). Increase in insurance coverage helps reduce economic disparities in accessing health care which improves health care utilization hence optimal use of the available resources. In addition, insurance coverage helps increase revenue generation for a facility and reduces waivers and exemptions which enable a facility to raise additional income and acquire important resources for improved services delivery. This helps improve the production process, enhance efficiency of the service delivery hence reduction in inefficiency.

Among all the six determinants, NHIF to non-NHIF day's ratio was the strongest determinant for technical efficiency. Bed turnover rate and average daily census were not significantly associated with technical inefficiency (P>0.05). Therefore, they had no significant influence on the efficiency scores of the hospitals.

CHAPTER FIVE

DISCUSSION

This chapter presents discussion of the study results in relation to findings of related studies. The discussion highlights deductions from the study results as well as similarities and differences in findings from other documented studies elsewhere. The chapter presents discussion of the technical efficiency scores, production slacks for inefficient hospitals and determinants of technical inefficiency.

According to CRS model, the mean technical efficiency for the hospitals was 81.4%. This means that the hospitals can attain efficiency levels in the efficiency frontiers by reducing their input mix by an average of 19.6%. This is similar to findings of a study conducted in Kenya by Kirigia *et al.* (2002) who found that about 44% of the public health centers were inefficient with an average efficiency score of 84%. The VRS model indicated that the hospitals had a variable return to scale efficiency mean of about 93.9% which meant that they could achieve efficiency levels by reducing their input levels by 6.1%. However, this contrasts results by Kibe (2010) who found that the average technical efficiency score for level four hospitals in Kenya in the period 2008-2011 to be 97.72%. Decrease in efficiency levels may point to increase in inefficiency in public hospitals amid the many health care reforms targeting optimal resource utilization. This was further supported by the scale efficiency findings that about 13.6% of the total inefficiency scores can be attributed to scale inefficiency (i.e. hospitals not operating at their optimal sizes). This requires the inefficient hospitals to achieve optimal operational mix in their production functions by reducing the excess production inputs and augmenting them with output additions for them to achieve optimal resource utilization.

These finding supports the findings that hospitals in developing world operate at high levels of technical inefficiency. Reflecting on other studies done in this area, it emerges that the problem of inefficiency is present to varying degrees in developing countries (Kirigia *et al,* 2010; Schmacker & Mc Kay, 2008; Zere *et al.*, 2006). The results have shown that 46.6% of the hospitals have increasing return to scale production functions which means that an increase in their health service inputs would increase their outputs by a greater proportion. This means that they are not operating at their optimal scale sizes. Therefore, these hospitals need to increase their production sizes to achieve optimal scale efficiency and reduce unit costs for their production functions. This is consistent with an observation that the country can do better with the level of resources that are allocated to the sector without scaling them up (Kirigia & Asbu, 2013; Masiye, 2007).

40% of the hospitals exhibited CRS in their production function. This meant that increasing their health service inputs would result in proportional increase in their health service outputs. These hospitals are said to be scale efficient (i.e. operating at their most productive scale sizes). However, 13.4% of the hospitals had a DRS which meant that increasing their inputs in the production mix, their health service outputs would increase by a smaller proportion. As a result, they are said not to be operating at their optimal scale sizes. Therefore, these hospitals need to reduce their production sizes to achieve optimal scale efficiency. This shows existence of excess inputs in some hospitals when other hospitals are grappling with resource shortages. This gap can be bridged through policy and managerial interventions aimed at reducing resource wastages and underutilization.

Reviews have indicated that technical inefficiency can be attributed to inappropriate production function especially in public facilities (Sealy & Rosbach, 2010). A study by Hollingsworth & Parkin (1997) indicated that one cause of inefficiency is excess use of resources (such as labour and supplies) and inefficient organizational structures and processes. This agrees with the study finding that excess inputs such as overstaffing are causing inefficiencies. This has been shown by existence of inputs and output slacks which is a cause of inefficiency in public hospitals. Previous researches have recommended reallocation and rationalization of the excess inputs. so as to achieve maximum production frontiers in other facilities (Kirigia & Asbu *et al.*, 2013; Zere *et al.*, 2006).

Inefficient hospitals with slacks in their production mix should make appropriate production changes which may require reducing specific inputs so as to achieve optimal resource utilization and production. However, the input reduction may not be sufficient to make the hospitals inefficient hence the need for augmenting gaps with outputs additions. The study findings are supported by WHO (2012) guidelines on resource management which recommended proper staffing and deployment of health personnel and proper allocation of available resources for equality, equity and improved health outcomes. Additionally, managers in inefficient hospital need to benchmark their facilities with their peers/reference sets. This means that they ought to benchmark their facilities with best practices that entrench efficiency principles in the production functions and daily operations.

However, imbalance in input-output production function mix has been cited in past studies to be occasioned by poor policy framework, governance and leadership setbacks (MOH, 2011). Therefore, for efficiency to occur, there is need for a facilitative and conducive working conditions supported by transformative leadership and good governance which is committed to principles of efficiency in all levels of service delivery. This is consistent with World Health Organization (2000) which advocated for efficiency concerns in all functions of a health system as a strategy of effectively achieving the goals of health improvement, responsiveness and fairness.

Past studies have shown that some institutional factors, at the discretion of management, as well as those beyond the management discretion influence the efficiency levels frontiers health facilities. These factors include bed occupancy ratio and ratio of outpatient to inpatient disposition (Kirigia and Asbu, 2013; Rosko, 2001; Schmacker & McKay, 2008). This is in line with findings of this study in which outpatient to inpatients visits ratio and bed occupancy ratio were found to influence the production frontiers and hence the efficiency scores of individual hospitals. Increase in patients visits and bed occupancy ratios reduces the unit cost associated with obtaining health care benefits. This is important in ensuring that the unit cost of providing health care benefits is reduced hence facilitating optimal resource use. The study findings found inpatient discharges to death ratio, ratio of NHIF to-non-NHIF days and gross death rate to also influence the efficiency frontiers of individual hospitals. Since most of these factors are at the discretion of management, appropriate policy and managerial discretions targeting each of the determinants can be put in place to address the associated effects to overall facility performance and productivity.

According to the study, NHIF to non-NHIF day's ratio was rated as the strongest determinants influencing technical inefficiency in public hospitals. Increase in NHIF patient days as a proportion of Non-NHIF patient days has been associated with increase in efficiency levels. Past studies have reported increase in inefficiency when the poor with financial barrier are limited in their access to health care (Nancy, 2010;

Schmacker & McKay, 2008]. As a result, majority of the needy population cannot access the available health care resulting to sub-optimal outputs in these facilities. It is therefore imperative for removal of health care access disparities especially among the poor to improve access to appropriate health care and improved health outcomes.

The positive coefficient of gross death ratio and negative coefficient of inpatient deaths to deaths ratio explains the role of public image and effectiveness of a facility in efficiency levels of hospitals. Increase in deaths is perceived as an indicator of negligence, lack of competence/institutional capacity and ineffectiveness and or inefficiency by clients which has a determent effect on service utilization rate.

The study results are also consistent with other past studies (Kirigia *et al.*, 2010; Kirigia & Asbu, 2013; George, 2006) which found ratio of outpatient to inpatients deposition and bed occupancy ratio to be significantly associated with inefficiency levels. Similar to a study by (Kimsey, 2009), bed occupancy rate has been shown to affects technical efficiency positively in the hospitals. High bed occupancy ensures that the available resources in a health facility are optimally utilized. Therefore, as bed occupancy and facility visits increases, inefficiency reduces considerably which also reduces unit cost for production. This results in economic efficiency which minimizes the cost of obtaining an identified benefit of the production function such as improved quality of adjusted life years, improved health status of the population, reduction in disease burden, mortality and morbidity rate for the hospitals.

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents summary of findings, conclusions and recommendations of the study which are based on the study findings. Major conclusions are highlighted based on the study objectives and recommendations made in two key areas namely: recommendations for policy actions and recommendations for further research.

6.1 Summary of Findings

The study showed that 50% of the hospitals were Constant Returns to Scale technically efficient with a mean efficiency score of 80.6%. About 66% (66.6%) of the hospitals were Variable Returns to Scale technically efficient with a mean efficiency score of 92.7%. Half of the hospitals (50%) of the hospitals were scale efficient with a mean efficiency score of 86.8% score. Input oriented model showed that 33.3% of the hospitals were variable returns to scale inefficient with a mean level of technical inefficiency of 21.9%. Among the inefficient hospitals, results revealed a total inputs slack of 122 beds and 454 staff which represented an input slack of 7.3% for the beds and 22.1% for the staff. All the inefficient hospitals required a 27.6% increase in total outpatient visits, a 9.2% increase in total discharges and a 31.3% increase in total operations for them to be technically efficient. Interval regression model revealed that technical inefficiency in public hospitals is influenced by outpatient to inpatients visits ratio, bed occupancy ratio, inpatient discharges to death ratio, NHIF to non-NHIF day's ratio and gross death rate.

6.2 Conclusions

6.2.1 Technical efficiency

A substantial number of public hospitals are operating at unacceptable levels of technical inefficiency. Technical inefficiency in public hospitals is attributed to inefficient production frontiers in the allocation and utilization of the limited resources in public hospitals. The inefficient hospitals can attain efficiency frontiers by ensuring they attain appropriate production sizes for optimal production function and minimization of resource wastages. This will ensure maximum benefits are obtained from scarce resources available.

6.2.2 Production slacks

Many public hospitals used excess inputs to produce less output which resulted to input and output slacks. Existence of production slacks in public facilities indicated that the inefficient hospitals could produce more outputs with the same or even less inputs; hence an indicator of resource wastages. Health managers need to use hospital benchmarks and production targets as tools for dealing with input and output slacks so as to achieve maximum production frontiers in the inefficient facilities and eliminate waste in the production of health care.

6.2.3 Determinants of technical inefficiency

The study found that outpatients to inpatients visits ratio, bed occupancy ratio, inpatient discharges to death ratio, NHIF to non-NHIF day's ratio and gross death rate influence technical efficiency of public hospitals ($p<0.05$). Since these factors are institutional, health managers with support of key stakeholders, should formulate and implement effective policy and managerial interventions targeting to address these factors which impacts on efficiency of their hospitals.

6.3 Recommendations

6.3.1 Recommendation for policy actions

The following are key recommendations for addressing the technical inefficiencies in public hospitals:

For optimal resource production function to be attained, the excess staff needs to be reassigned to health facilities occasioned by staff shortages. This will require clear policy guidelines for effective, rational, equitable and evidence-based staff deployment. This can be achieved by developing demand-based model as the basis for reassigning excess staff. Further, to augment for output slacks and reduce unit cost of production, a pool of excess staff needs to be created for providing essential and demand-based health services to the population through outreach programs within and without the hospitals catchment area.

This will be key in achievement of SDGs, primary health care (PHC) goals as well as other strategic plan targets in the health sector (such as Vision 2030 and National Health Policy) which have been limited by inequality in access and utilization of health care. Further, the excess beds should be transferred to other public health facilities with bed shortages. This would helps to ensures that the extra supply of beds don't result in excess/unnecessary admissions and longer stays, an effect known as Roemer's Law (Roemer, 1961), which has been shown to cause inefficiency in hospitals. Further, health managers should institutionalize benchmarking processes for their facilities with best performing facilities to enhance continuous improvement and learning of best practices such as allocation of scarce resource, staff motivations and performance management strategies among other practices which help improve efficiency of the health service delivery.

For inefficient hospitals to achieve efficiency levels, they need to adopt optimal production sizes that suit their production capabilities. This requires increase in coverage of health services through outreach services and programs so as to increase facility visits/demand for the services. The government should develop innovative strategies for increasing coverage of prepayment mechanisms for the health services (e.g. NHIF insurance) to reduce the economic barriers to access to health care especially among the poor which is fundamental in increasing utilization, coverage and demand for the services provided. However, the hospitals should establish mechanisms for regulating against moral hazards resulting from pre-payment mechanisms such as NHIF insurance which can limit clients in need from utilizing the services.

Finally, there should be frequent service quality audits such as mortality audit to reduce unnecessary deaths within the facilities which negatively affect public image and quality perceptions of the service provided by the facilities. This can be done through service quality audits, service satisfaction surveys and other quality assurance programs. This would be an important tool for maintaining good public image key in increasing demand and service utilization rate. These strategies will require transformative leadership, effective policy framework and good governance committed to principles of efficiency in all areas and levels of service delivery/production function. This is important in creating, communicating and implementing a shared vision for a technically efficient hospital.

6.3.2 Recommendation for further research

The study recommends further studies on the following aspects of health sector service delivery:

1. Performance of Malmquist Total Factor Productivity Index analysis among hospitals in Kenya to measure the trends in efficiency and productivity of public hospitals over time. Findings on productivity growth across the years will be important in gauging the effects of health reforms such as devolution of health care that have taken place so as to provide objective basis for judging if the reforms are yielding any positive efficiency results. This would require collection of panel data for a number of years such as from 2005 to 2014 with an aim of providing baseline data to permit comparison of the current state of hospital efficiency with past periods.
2. Study on effect of managerial factors and operational factors such as absenteeism, location, specialization on efficiency of hospitals.
3. Study on impact of patient mortality (inpatient and outpatient) on efficiency of hospitals
4. Use of an applied research aimed at developing advanced Data Envelopment Analysis software that takes into accounts quality of health care delivery in analyzing efficiency levels. This will key in guiding policy discussions on development and institutionalization of efficiency processes and structures in quality health care delivery.
5. Due to the difficulty in obtaining health system inputs prices, there has been no study done in Kenya on allocative efficiency. Therefore, there is need for allocative efficiency study among the public hospitals in Kenya which will

entail collection of data on prices of various inputs. This will facilitate economic evaluations key in the health service delivery processes.

REFERENCES

Akazili, A. and Fernandes S. (2008). *Assessing Hospital Efficiency: Non-parametric Evidence for Portugal*. Portugal

Asbu E., McIntyre D., Addison T. (2001). Hospital efficiency and productivity in three provinces of South Africa. *South African Journal of Economics*, 69(2):336-358.

Banker D., Charnes A., Cooper W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science* 1984, 30(9):1078-1092.

Boussofiane A. and Dyson, R. (1995). Exploring output quality targets in the provision of perinatal-care in England using Data Envelopment Analysis. *European Journal of Operational Resources*, 80:588–607.

Cellini R., Pignataro G. and Rizzo I. (2000). Competition and Efficiency in Health Care: An Analysis of the Italian Case. *International Tax and Public Finance*, 7(4):503-519.

Charnes A., Cooper W., Rhodes E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, **2**:429-444.

Coelli T., Rao P., O'Donnell J., Battese E. (2005). *An introduction to efficiency and productivity analysis*. London: Springer.

Coelli, T. (1996). *A guide to DEAP Version 2.1: A Data Envelopment Analysis Programme.* CEPA Working Paper 96/8, Department of Econometrics, University of New England, UK

Coelli, T., Prasada D., O'Donnell J., and Battese E. (1998). *An Introduction to Efficiency and Productivity Analysis (2nd ed.).* New York: Springer.

Cooper W, Seiford M, Zhu J. (2011). Data envelopment analysis: history, models and interpretations; a Handbook on Data Envelopment Analysis. *New York: Springer*, 1:1-40.

Farrell J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society*, 120 (3): 253-290.

Freisner, D., Roseman, R., and McPherson, M. (2008). "Are hospitals seasonally inefficient? Evidence from Washington State". *Applied Economics*, 40: 699-723.

Fried H, Lovell C, Schmidt S. (1993). *The measurement of productive efficiency: techniques and applications*. New York: Oxford University Press.

George C. (2006). Technical efficiency for public hospitals in Malawi: a case of public hospitals; University of Malawi (unpublished)

GOK (2013). *Public expenditure review*. Government of Kenya, Nairobi.

GOK (2011). *Kenya National Health Accounts `20010/11*. Government of Kenya, Nairobi.

Government of Namibia (2004). Efficiency Measurement and the Operationalization of Hospital Production. *Health Service Research* 31:1: pp. 21-37.

Health Sector Working Group Report (HSWG) (2012). *Medium Term Expenditure Framework (MTEF)*, 2012/13-2014/15.

Hollingsworth B. (2008). The Measurement of Efficiency and Productivity of Health Care Delivery. *Health Economics*, 17(10): 1107-1128.

Hollingsworth B., Parkin D. (1997). The efficiency of Scottish acute hospitals-an application of data envelopment analysis. IMA. J. Math. Appl. Med. Biol, 12:161-173. http://www.unicef.org/infobycountry/kenya_statistics.html

Kibe N. (2010). *Analysis of efficiency in public hospitals in Kenya*: 2008-2011; Research paper; University of Nairobi (Unpublished)

Kimsey G. (2009). *How efficient are military hospitals? A comparison of technical efficiency using Stochastic Frontier Analysis*. University of Kentucky Doctoral Dissertations. Available at: Http://Uknowledge.Uky.Edu/Gradschool_Diss/743.

Kirigia J., A., Emrouznejad, L., Sambo, N., Munguti, W. and Liambila H. (2004). Using Data Envelopment Analysis to measure the Technical Efficiency of Public Health Centres in Kenya. *Journal of Medical Systems*, 28(2): 155-166

Kirigia J., Mensah O., Mwikisa C., Asbu Z., Emrouznejad A., Makoudode P. and Hounnankan A. (2010): Technical efficiency of zone hospitals in Benin. *The African Health Monitor;* 12:30–39.

Kirigia M., Asbu E. (2013). Technical and scale efficiency of public community hospitals in Eritrea: an exploratory study. *Health Economics Review*, 3:6

Kirigia, J., Sambo, G., and Lambo, E. (2002). Are public hospitals in Kwazulu/Natal province of South Africa technically efficient? *Africa Journal of Health Sciences,* 7(3/4):24–31.

Lee, H., Yang, B., and Choi, M. (2009). The association between hospital ownership and technical efficiency in a managed care environment. *Journal of Medical Systems*, 33: 307-315.

Maddala, G. and Ellen, M. (1989). *Microeconomics: Theory and Applications.* McGraw- Hill, Newyork.

Masiye F. (2007). Investigating health system performance: An application of data envelopment analysis to Zambian hospitals. *BMC health services research*, 7:58.

McDonald F. and Moffitt R. (1980). The uses of Tobit analysis. Rev Econ Stat 1980, 62(2):318-321.

McDonald J. (2009): Using least squares and Tobit in second stage DEA efficiency analyses. *European Journal of Operational Resources*, 197:792-798.

McKay, N. and Deily, E. (2008). "Cost Inefficiency and Hospital Health Outcomes". *Health Economics,* 17, 833-848.

MOH (2011). *Health sector budgetary allocation and spending: health sector analysis report.* Government printers, Nairobi

Nancy C. and Florian H. (2010). *Estimated Government Spending 2009/2010:* Kenyan Health Sector Budget Analysis; Mars Group.

O'Neilla, L., Raunerb, M., Heidenbergerb, K., and Kraus, M. (2008). A cross-national comparison and taxonomy of DEA-based hospital efficiency studies. *Socio-Economic Planning Sciences*, 42: 158–189.

Osei D, George M, Almeida S, Kirigia J, Mensah A, Kainyu H. (2005). Technical efficiency of public district hospitals and health centres in Ghana: a pilot study. *Cost Effectiveness and Resource Allocation* 2005, 3:9. Available at: http://www.resource-allocation.com/content/3/1/9.

Ramalho E., Ramalho S., Henriques D. (2010). Fractional regression models for second state DEA efficiency analyses. *J Product Anal*, 34:239-255.

Roemer M. (1961): Bed supply and hospital utilization: a natural experiment. *Hospitals,* 35:36–42.

Rosko M. and Chilingerian A. (1999). Estimating Hospital Inefficiency: Does Case Mix Matter? *Journal of Medical Systems* 23(1): 57-71.

Rosko M. (2001). Cost Efficiency of US Hospitals: a Stochastic Frontier Approach. *Health Economics* 10(6): 539-551.

Ruggiero J. (2004). *Performance evaluation in education: modelling educational production.* A Handbook on Data Envelopment Analysis. Edited by Cooper W., Seiford L., Zhu J. Boston: Kluwer Academic Publishers.

Salvatore D. (2008). *Managerial economics: principles and worldwide applications.* New York: Oxford University Press.

Schmacker, R. and McKay, L. (2008). "Factors affecting productive efficiency in primary care clinics". *Health Services Management Research*, 21: 60-70.

Sealy S. and Rosbach K. (2010). *Kenya Health Sector Budget Analysis.* Estimated Government Spending 2010/11. Gtz

Sherman, D. (1984). Hospital Efficiency Measurement and Evaluation; Empirical Test of a New Technique. *Medical Care*, 22: 922-938.

Skaggs N, Carlson L. (1996). *Microeconomics.* London: Blackwell Publishers.

Staat M. (2006). Efficiency of Hospitals in Germany: a DEA-Bootstrap Approach." s

StataCorp (2010). *STATA 10 data analysis and statistical software*. Texas: StataCorp.

Tlotlego N., Nonvignon J., Sambo L., Asbu Z. and Kirigia J. (2010). Assessment of productivity of hospitals in Botswana: *a DEA application. International Archives of Medicine*; 3:27.

UN (2015). *Strategic Development Goals: United Nations Resoulutions A/RES/70/1 of 25th September 2015.* United Nations

UNICEF (2007). Social Budgeting Investments in Kenya's Future. Government of Kenya/UNICEF Programme of Cooperation 2004-2008. Working Paper No.2.

UNICEF (2014). *Basic Statistics, United Nations International Children Emergency Fund.* UNICEF Kenya. Available at:

Vitaliano, D. and Toren M. (1996). Hospital Cost and efficiency in a Regime of Stringent Regulation. *Eastern Economic Journal* 22(2): 161-175.

Wang B., Ozcan A., Wan T. and Harrison J. (1999). Trends in Hospital Efficiency among Metropolitan Markets. Journal of Medical Systems 23(2): 83-97.

WHO (2000). *The World Health Organization: Health Systems-Improving Performance;* World Health Organization: Geneva

WHO (2000): *The World Health Organization: Health Systems-Improving Performance;* World Health Organization; Geneva.

WHO (2005). *In Global tuberculosis control: Surveillance, planning and financing.* World Health Organization Report; Geneva.

WHO (2011). *World Health Statistics*. Geneva: World Health Organization.

WHO (2012). Health Statistics: Global Health Observatory. World Health Organization; Kenya Office. Available at: http://www.who.int/countries/ken/en/

WHO (2015). World Health Organization Global Health Expenditure database. Available at htpp//:apps/who.int/nha/database for the most recent updates.

Worthington, A. (2004). Frontier Efficiency Measurement in Health Care: A Review of Empirical Techniques and Selected Applications. *Medical Care Research Revolution* 61(2): 135-170.

Yong K. and Harris A. (1999). *Efficiency of Hospitals in Victoria under Casemix Funding*: A Stochastic Frontier Approach. Working paper 92. Centre for Health Program Evaluation.

Zere E., Mbeeli T., Shangula K., Mandlhate C., Mutirua K., Tjivambi B. and Kapenambili W. (2006). Technical efficiency of district hospitals: evidence from Namibia using Data Envelopment Analysis. *Cost Effectiveness and Resource Allocation*, 4:5.

Zuckerman S., Hadley J. and Iezzoni L (1994). Measuring Hospital Efficiency with Frontier Cost Functions. *Journal of Health Economics*, 13: 255-280.

APPENDICES

Appendix 1: Code and Identity of Sampled Level 4 Hospitals in Kenya

Code	Name of hospital	County
A	Homa Bay District Hospital	Homa Bay
B	Iten District Hospital	Elgeyo Marakwet
C	Kangundo District Hospital	Machakos
D	Kapenguria District Hospital	West Pokot
E	Kapkatet District Hospital	Kericho
F	Kathiani District Hospital	Machakos
G	Kericho District Hospital	Kericho
H	Kerugoya District Hospital	Kirinyaga
I	Kiambu District Hospital	Kiambu
J	Kilifi District Hospital	Kilifi
K	Kisumu District Hospital	Kisumu
L	Kitui District Hospital	Kitui
M	Meru District Hospital	Meru
N	Mandera District Hospital	Mandera
O	Maralal District Hospital	Samburu
P	Moi District Hospital	Taita Taveta
Q	Msambweni District Hospital	Kwale
R	Murang'a District Hospital	Muranga
S	Naivasha District Hospital	Nakuru
T	Port Reitz District Hospital	Mombasa
U	Siaya District Hospital	Siaya
V	Taveta District Hospital	Taita Taveta
W	Mwingi District Hospital	Mwingi
X	Nandi Hills District Hospital	Nandi
Y	Makindu District Hospital	Makueni
Z	Marsabit District Hospital	Marsabit
AB	Loitokitok District Hospital	Kajiando
AC	Eldama Ravine District Hospital	Baringo
AD	Kanyakine District Hospital	Meru
AE	Lamu District Hospital	Lamu

Source: Master health facilities list in Kenya; Available at: *http://www.ehealth.or.ke/facilities/*

Appendix 2: Research approval letter from graduate school

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 810901 Ext. 57530

Internal Memo

FROM: Dean, Graduate School

DATE: 21st September, 2014

TO: Mr. Rithaa Koome Gilbert
C/o Health Management & Informatics Dept.
Kenyatta University

REF: Q140/CTY/PT/26322/13

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

This is to inform you that Graduate School Board at its meeting of 17th September, 2014 approved your Research Proposal for the M.Sc. Degree, entitled **"Analysis of Technical Efficiency in Hospital Settings in Kenya".**

You may now proceed with your Data collection, subject to clearance with the Principal Secretary, Higher Education, Science and Technology.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed supervision Tracking Forms per semester. The form has been developed to replace the progress Report Forms. The Supervision Tracking Forms are available at the University's Website under Graduate School webpage downloads.

Thank you.

JOSEPHINE KENDI
FOR: DEAN, GRADUATE SCHOOL

c.c. Chairman, Health Management & Informatics Dept.

Supervisors:

1. Dr. George Kosimbei
   C/o Economics Dept.
   KENYATTA UNIVERSITY
2. Dr. Andrew Yitambe
   C/o Health Management & Informatics Dept.
   KENYATTA UNIVERSITY

JK/cao

Committed to Creativity, Excellence & Self-Reliance

Appendix 3: Research approval letter from NACOSTI

THIS IS TO CERTIFY THAT:
MR. GILBERT KOOME RITHAA
of KENYATTA UNIVERSITY, 5306-200
Nairobi,has been permitted to conduct
research in*All Counties County*

on the topic: *ANALYSIS OF TECHNICAL EFFICIENCY IN HOSPITAL SETTINGS IN KENYA*

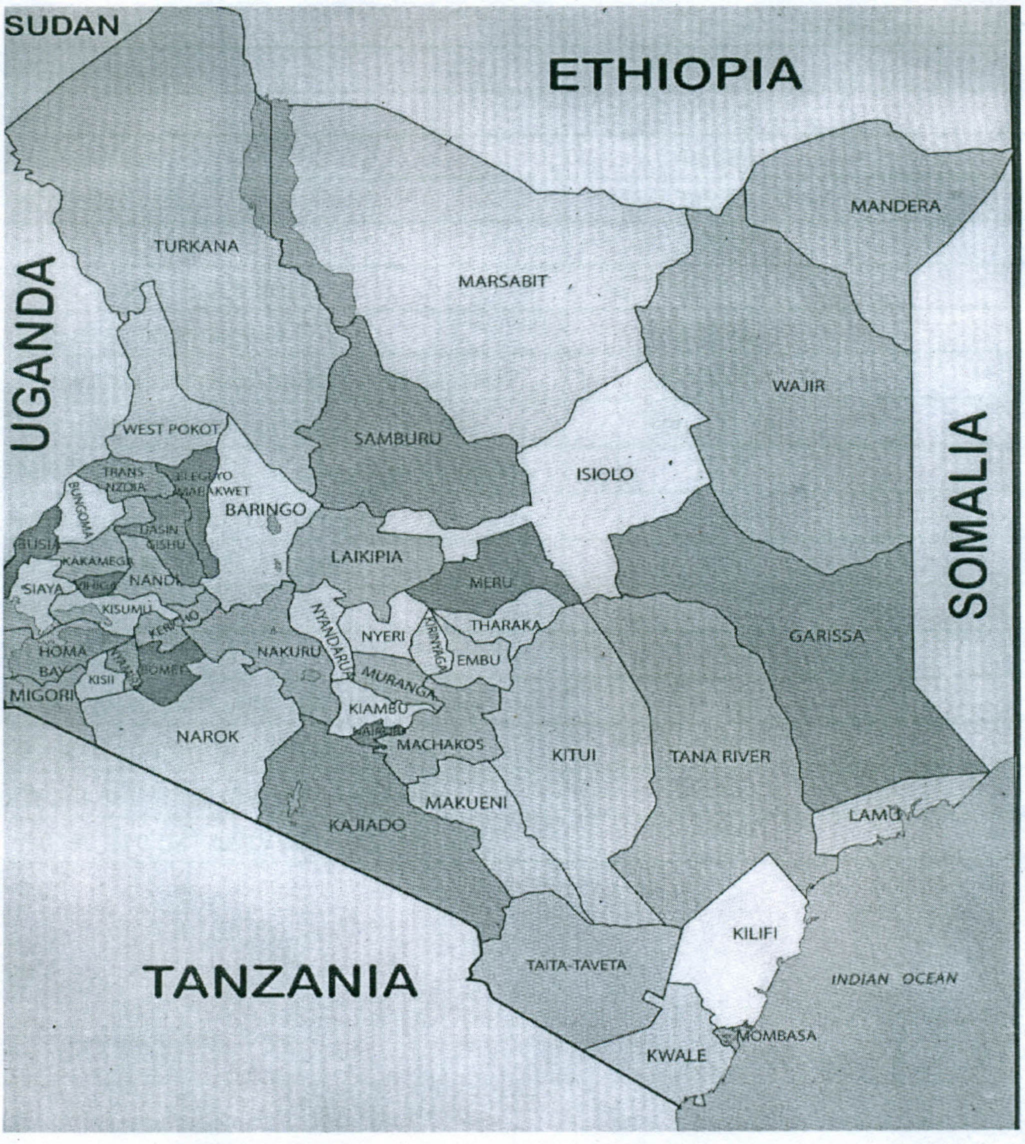
for the period ending:
31st March,2015

Permit No : NACOSTI/P/14/9613/3737
Date Of Issue : 13th January,2015
Fee Recieved :Ksh 1,000

Applicant's Signature

Secretary
National Commission for Science, Technology & Innovation

Appendix 4: Map of Kenya



Appendix 5: Key indicators for Kenya

Key indicator	Status	Recommended (WHO)	Year
Population	43.18 million		2012
GDP	$40.70 billion		2012
GDP growth	4.60%		2012
GDP per Capita	Ksh 38970		2011
Inflation	5.70%		2013
Public Health Expenditure	50.37 billion		20010/11
GHE as a percentage of GTE	6.50%	15%	2012
Preventive services budget (per capita)	Ksh 669		2012
Curative services budget (per capita)	Ksh 408		2012
NHIF coverage (% of county population)	20.8		2012
Doctors (per 100,000 people)	19	36	2011
Nurses (per 100,000 people)	153	356	2011
Dentist	2		2011
Pharmacist	8		2011
Clinical officers (per 100,000 people)	8		2012
Maternal mortlity rate (per 100,000)	488		2009
Infant mortality rate (per 100,000)	52		2009
Under five mortality rate (per 100,000)	74		2009

Appendix 6: Data collection checklist 1

Name of Hospital:	
Variables	**Number**
Hopsital Inputs	
Cots	
Medical Consultants	
General Medical Practioners	
Clinical Officers	
Nurses	
Therapists	
Lab technicians	
Hospital Outputs	
Outpatient visits	
Inpatient Discharges	
Operations	

Appendix 7: Data collection checklist 2

Name of hospital		Calculations						
Variable	Number	Bed occupancy ratio	Bed turnover rate	Ratio of outpatient to inpatient visits	Ratio of NHIF to non bed NHIF days	Ratio of inpatient discharges to deaths	Gross death rate	Average Daily census
Beds								
Beds occupied								
Length of stay								
No of NHIF bed days								
No. of non NHIF bed days								
No of patient days								
Inpatient visits								
Outpatient visits								
Outpatient deaths								
Inpatient deaths								
Inpatient discharges								