Determinants of Technical Efficiency of Public Hospitals in Kiambu County

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DEDICATION

I dedicate this work to Ethan and Etta. For giving me a reason to be a better version of myself.

DECLARATION

This research report is my original work and has not been presented for award of a degree in any other University.

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Abbreviations and Acronyms

AE	Allocative Efficiency
CHE	Current Health Expenditure
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DHIS	District Health Information System
DMU	Decision Making Unit
DRS	Decreasing Returns to Scale
GDP	Gross Domestic Product
GP	General Practitioner
IRS	Increasing Returns to Scale
KEPH	Kenya Essential Package for Health
LIC	Low Income Countries
NHIF	National Health Insurance Fund
OECD	Organization of Economic Cooperation and Development
OLS	Ordinary Least Squares
SDG	Sustainable Development Goals
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
USD	United States Dollar
VRS	Varying Returns to Scale
WHO	World Health Organization

Abstract

The accessibility to highest achievable standards of health is identified as a basic human right (WHO, 1978). Over the years there has been global, regional and local focus to improve accessibility to health care. The sustainable development goal (SDG) 3 aims to safeguard the lives of individuals of all ages and ensure their wellbeing.(United Nations, 2022). Locally, President Uhuru Kenyatta declared in 2017 the commitment of the government to improve the lives of Kenyans through the Big Four action plan. Amongst the plan was to attain universal health coverage through scale up of NHIF uptake.

As various policies are formulated to increase demand for health care and subsequently improvement health status then it becomes necessary to have a critical look at the health system arises. Amongst Kenya's counties is Kiambu county which manages 108 health facilities. In the year 2018/2019, Kiambu county approved budget for the health department was over Ksh. 5.92 billion against a total county budget of Ksh. 17.89 billion which translates 33.4% of the total budget of Kiambu county. Despite this high allocation, the county grapples with inadequate health resources resulting in a challenge in health service provision (County Government of Kiambu, 2018).

The main purpose of this research was to evaluate technical efficiency of county managed level 4 and level 5 hospitals in Kiambu County for the year 2019. The specific objectives were to determine the relative technical efficiency of the county government managed hospitals in Kiambu County. Additionally, the factors that have an effect on the technical efficiency of the county government hospitals in Kiambu County were to be determined. The findings of these objectives were to be used provide policy options. The study used a two-part model of output-

oriented Data Envelopment Analysis and subsequently Ordinary Least Squares regression analysis which was employed to establish the factors influencing technical efficiency of these hospitals.

The study revealed that only 2 (15%) hospitals of the assessed facilities showed a CRS technical efficiency score of 1 and 6 (46.2%) had VRS technical efficiency score of 1. Of the assessed hospitals, 8 (61.5%) exhibited decreasing returns to scale and 23.1% of the assessed hospitals exhibited increasing returns to scale. Moreover, the research study showed no zero correlation between technical efficiency and size of hospital, catchment population, type of hospital and location of hospital.

The research proposes improvement of technical efficiency of Kiambu county public hospitals through by emulating best practices of the technically efficient hospitals. Additionally, the redistribution of excess resources is also proposed. An investigation into the health care services utilization of the population is recommended.

CHAPTER 1 INTRODUCTION

1.1 Background

The enjoyment of highest attainable standard of health has been recognized as a fundamental human right (WHO, 1978). It is this need to make sure all persons obtain quality health care that brought nations together to set out a strategy to protect and promote the health for each and every person worldwide. Through the declaration of Alma Ata, primary health care was set up to ensure that all people receive adequate health care. It was also declared that attainment of health can only be achieved through availability of adequate resources and efficient use of these resources.

Over the years there has been global focus to improve accessibility to health care. The sustainable development goal (SDG) 3 aims to safeguard the lives of individuals of all ages and ensure their wellbeing. (United Nations, 2022). SDG 3 targets, amongst other goals, to attain universal health coverage by mitigating financial hardship while accessing quality essential medical services and safe, cost-effective vaccines and medicines of acceptable quality. In December 2017, President Uhuru Kenyatta declared the Kenyan government commitment to improve the lives of Kenyans through the Big Four action plan. Amongst the plan was to attain universal health coverage through scale up of NHIF uptake. By attaining 100% subsidy on essential health services, the big 4 agenda envision to reduce out-of-pocket (OOP) spending on health care by 54% of expenditure of households (The Big 4, 2021). While there is an increased focus on availability and accessibility health services there is need to investigate factors that will hinder use of this services thus impeding these efforts translating to improvement of health of the people.

1.1.1. Health Care Utilization

In the quest to better health of the populations, factors such as health utilization come into play. Health utilization is defined as "the use of healthcare services to diagnose, cure or ameliorate disease or injury; improve or maintain function or obtain information on their health status and prognosis" (NASEM, 2018). A variety of factors influence utilization of health services such as the need for care. Genetic characteristics of an individual which predisposes them to illness or inheriting diseases will make them more likely to seek health care. The physical environment can also be an attributing factor as pollution and other environmental hazards can predispose one to illnesses hence increase the likelihood of seeking medical services. Secondly, having knowledge on the necessity of care can affect level and rate at which health services are utilized as well as inclination to obtain health care services. Accessibility, which is defined as the means by which a patient gains entry into the health system, also dictates use of health services. Levesque et al (2013) recognized the various facets of accessibility as appropriateness, affordability, approachability, availability and accommodation as well as acceptability. An understanding of determinants of health care utilization is important to be able to address barriers that prevent individuals and populations from seeking care.

The determinants of utilization of health care vary amongst geographical locations, populations and cultures. A study assessing the factors influencing health care utilization in Canada indicated that people with lower incomes and those with low educational levels were more likely to use services of a physician (Yip, Kephart, & Paul, 2002). Furthermore, those people living in poverty-stricken neighbourhoods were also more likely to use healthcare

services. This was possibly because of their unhealthy lifestyle choices such as smoking, poor dietary practices and lack of physical activity seen in those of lower socioeconomic status.

A study in Europe by Fjær et al on the factors influencing the utilization of the various types of services of health care i.e., general practitioner (GP) services and specialist services indicated varying trends amongst different groups (Fjær, et al., 2017). The study showed that those of lower socioeconomic status sought services of a GP while those of higher socioeconomic status preferred services of specialists. Furthermore, the findings of the research indicate that gender and educational status determined the type of services sought. They were differences in health utilization patterns across countries. For example, in six out of the nine countries studied the more educated used the services of a GP unlike in the other three countries.

In Senegal, health utilization is determined by relationship with the head of the household, employment status, gender and age (Lépine & Le Nestour, 2012). Parents of the head of the household were less probable to utilize health services. Age also was a determinant whereby as age increases probability of utilizing health services decreases until the age of 40 years where upon the likelihood increases. It was found that females were had higher probability of seeking health services than males. Other factors likely to increase probability of utilization of health services were higher socioeconomic status, perceived quality and level of schooling of the household heads. On the other hand, increased transport costs and cost of services adversely affected utilization.

In Kenya, a study by showed the need for health services increases with increase in income (Kimani, Mugo, & Kioko, 2016). People residing in the urban areas had greater likelihood of

seeking medical services in comparison to those individuals residing in the rural areas. The study also showed that existence of chronic illnesses and that larger households had higher probability to seek and use health care services. Farther distances to health facilities increased the possibility of utilization. This was possibly because there was the perception that the distant facility provided quality care. This differs with a research study of a Nairobi slum which indicated that longer distances reduced the likelihood of utilization of health care services (Muriithi, 2013). This was attributed to the increase in travel costs which hindered access to health care. This study also indicated that quality of health care did result increased need for health care particularly for the private facilities. Thus, the better the quality of service of private facilities the higher the probability of visits to these facilities. The study by Muriithi (2013) also showed that trust, waiting time and information on service also affected the demand of health services. This study had similar results to a study carried out in Ethiopia by et. al. in which farther distances and increase in user fees decreased likelihood of demand of services for health while demand for health services with the perception of higher quality services.

The various policies are formulated in to increase utilization of health care services and subsequent improvement of status of health of the population necessitates a critical look at the health system. An increase in utilization will require well-functioning health care system in order to attain objectives put forth in the various policies aforementioned. A health care system is described as “organizations, the institutions, resources and people involved whose primary purpose is to improve health” (WHO, 2010). The components of a health system have been established as human resource for health, service delivery, health care financing, information and communication and technology, health products and technologies, and leadership & governance. Establishment of universal health coverage will require increased

resources. Therefore, the adequacy of the financing for health care requires to be investigated so as to ensure a well-functioning system.

1.1.2 Health Financing

Between 2000 to 2016, government expenditure on health care has been observed to increase. On average for low-income countries (LIC) expenditure has increased from USD 7 per person in 2000 to USD 9 per person in 2016 and USD 30 per person to USD 58 per person for low middle income countries (Shæferhoff, Sebastian, Obuoji O, & G., 2019). However, it is noted that for LIC the proportion of total government spending on health decreased from 7.9% in 2000 to 6.8% in 2016. This is due to dependency on development aid which has led to aid fungibility. However, for low middle-income countries the has been an increase in proportion from 7.6% in 2000 to 8.3% in 2016.

While it has been observed rise in the proportion of government spending on health, it is notable that no country spends more than 20% of its GDP in health (Ortiz-Ospina & Roser, 2017). It was also noted that while healthcare spending in developing countries had increased over time, most countries spent 5-12% of their GDP. It was also observed that states with greater GDP per capita had higher spending towards health care. Conversely, as GDP per capita increases the out-of-pocket expenditure and donor funding decreases. For low-income countries OOP expenditure attributes to a higher fraction of the total spending on health.

In Africa, average health care expenditure per capita was USD 80 in 2016 which in comparison was way below the that of Organization of Economic Cooperation and Development (OECD) countries which was around USD 4003. Furthermore, government spending on health as proportion of the GDP in 2017 was 1.9% which is still below the global average of 3.3%. The proportion of health care spending by government was 7.2% of the total

government expenditure. With reference to the Alma Ata declaration, it means that countries are not able to keep the pledge of 15% of government expenditure towards health care.

In Kenya, total health expenditure in financial year (FY) 2015/2016 was Ksh. 346 billion which represents a 27.7% increase in expenditure compared to FY 2012/2013 (Ministry of Health, 2019). Additionally, this accounted for 5.2% of the GDP. The average health expenditure per capita was USD 78.2 in financial year (FY) 2015/2016 this was an increase from USD 77.4 in FY 2012/2013. The three main sources of revenue for health in Kenya are government, households and donor funding. Government health expenditure accounted 33% of the current health expenditure (CHE) for FY 2015/2016. The out-of-pocket expenditure was high representing 32.8% of the CHE while donor funding accounted for 22% of CHE.

In 2013, Kenya adopted the devolved system of government i.e. national and county government. An analysis of county budgets indicate that the county governments allocated 30% of their total budgets for health in FY2017/2018 (Njuguna, Pepela, & Wanjala). This indicates the prioritization of health by the county governments. However, a study of five counties by Kairu et. al revealed health financing at counties faces various challenges with issues such as delayed and erratic disbursement of funds (Kairu, Orangi, Ondera, Ravishankar, & Barasa, 2021). Furthermore, health facilities lack financial autonomy whereby funds collected by facilities are remitted to the county revenue funds account and later being reimbursed to the facilities.

1.1.3 Efficiency

Since resources are limited, it is only prudent that the existing resources are utilized efficiently. The WHO report, 2010 estimates that 20-40% of health resources are utilized inefficiently. The areas of inefficiency can broadly be classified as human resources for

health, inefficient use of health products and technologies, leakages due to corruption and waste and inappropriate intervention mix (WHO, 2010). Improving efficiency of the health systems will therefore mean that these resources can be ploughed back to better the system of health along with accessibility to health care.

Amidst the global and local focus on increasing access to quality health care there comes a need to avail or increase resources. As resources are limited and needs unlimited, it becomes imperative to investigate production of health and determine whether the resources in utilization are being put in best use. Efficiency is a measure of input against output and can be classified as allocative efficiency and technical efficiency.

1.2 Statement of Problem

In 2010, the governance system in Kenya changed to two levels of government that is, centralized government and semi-autonomous county governments. Management of health was split between the two tiers of government. The functions are stipulated in the 4th schedule of the constitution of Kenyan; those of the county governments and those of the national government whereby the management of health facilities put under the county government (Republic of Kenya, 2010).

Amongst the counties in Kenya is Kiambu county which manages 108 health facilities; these include three Level 5 hospitals, nine Level 4 Hospitals, twenty-four Level 3 health facilities and seventy Level 2 facilities. In the year 2018/2019, Kiambu county approved budget for the health department was over Ksh. 5.92 billion against a total county budget of Ksh. 17.89 billion. The health budget allocation represented 33.4% of the total budget of Kiambu county which is way above the mean of the country county health budget of 27.8% for the year 2018/2019 (County Government of Kiambu, 2021). Moreover, this is way above the 15% of

the budget that leaders of African Union pledged to be allocating towards the betterment of the health sector in the Abuja declaration (Organization of African Union, 2001).

The county health budget is utilized for, among other things, wages of human resources for health and procurement of health commodities. Despite this high allocation, Kiambu county health strategic plan 2018-2022 identifies inadequate health resources posing a challenge in health service provision (County Government of Kiambu, 2018). Specifically, the strategic plan points out that the county faces the challenges of inadequate human resource for health, deficient infrastructure and financing, and erratic supply of health commodities. There is also no clear strategy for resource allocation between the health facilities. Resource allocation remains ad hoc and is based on level of facility which does not necessarily reflect on the priorities. Additionally, distribution of health care workers remains skewed without any basis. Given this evidenced scenario there is need to establish the level of efficiency that is tied to utilization of resources within the health facilities. Without this understanding pumping in more resources to meet the healthcare demand and to improve health system is likely to be a daunting task. Hence, establishing the level and determinants of technical efficiency of the hospitals in Kiambu county will provide insight on the best way that the scarce health system resources can be utilized.

1.3 Research Questions

This research paper seeks to answer the questions:

1. What is the level of technical efficiency in public hospitals in Kiambu county?
2. What are the determinants of technical efficiency of public hospitals in Kiambu?
3. What are the policy options tied with the findings?

1.4 Objectives

1.4.1 Broad Objective

The aim of this paper is to assess the technical efficiency of public hospitals in Kiambu County for the year 2019

1.4.2 Specific Objectives

a. To assess the relative technical efficiency of the public hospitals in Kiambu County
b. To determine the factors influencing the efficiency of public hospitals in Kiambu County
c. To provide policy options for the finding of objectives (a) and (b)

1.5 Justification of the study

Kiambu County department of health faces a challenge of limited resources as pointed out in the County Health Strategic Plan 2014-2019. Inadequate health financing and shortage of staff were factors identified that affect the health service delivery within the county (County Government of Kiambu, 2018). In order to overcome these challenges, the county seeks to increase resource mobilization and recruitment of additional human resources for health yet it is not clear whether the existing resources are utilized efficiently. An increase in resources without efficient utilization may therefore not translate to improved health service delivery.

It is with this backdrop that this research study endeavours to evaluate the degree of technical efficiency as well as establish the determining factors of technical efficiency of the county managed hospitals within Kiambu County. Findings of the study would therefore inform policy makers and county managers on the utilization of the existing resources and form a basis of their decisions on resource allocation which will improve delivery of health care services within the Kiambu county. Findings of the study will also help identify hospitals within the county with the best practice. These hospitals will therefore serve as centres of excellence and best practices from these facilities can be identified and replicated by the less efficient hospitals. This study aims to also add to the knowledge base.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter evaluates and summarizes the body of knowledge available on technical efficiency and particularly with regards to technical efficiency of health facilities. This section looks into the theoretical review of literature and the empirical review of literature on technical efficiency.

2.2 Theoretical Review of Literature

2.2.1 Technical Efficiency

Technical efficiency examines the relation between output and inputs (Follan, Goodman, & Stano, 2013). A DMU is regarded as technically efficient when it produces maximum output for a particular set of inputs. Conversely, it is can also be regarded as technically efficient in similar output is produced using the least possible inputs. Allocative efficiency not only looks at technical efficiency but also distribution of resources amongst the different inputs (capital, labour, equipment) and for the different outputs/outcomes in order to achieve the greatest benefit to the society (Palmer & Torgerson, 1999). Allocative efficiency is when a firm's mix of inputs minimizes the cost at the specific input prices or mix of outputs that maximizes the revenue at the specific output prices. Overall efficiency is a derivative of technical efficiency and allocative efficiency (Hollingsworth & Dawson, 1999).

Efficiency can be illustrated using the following example whereby a firm produces output *y* using two outputs X_1 and X_2. Thus:

$$y = f(X_1, X_2)$$

The production frontier is established when maximum output y=1 is produced using various combinations of X_1 and X_2 as shown by the isoquant below

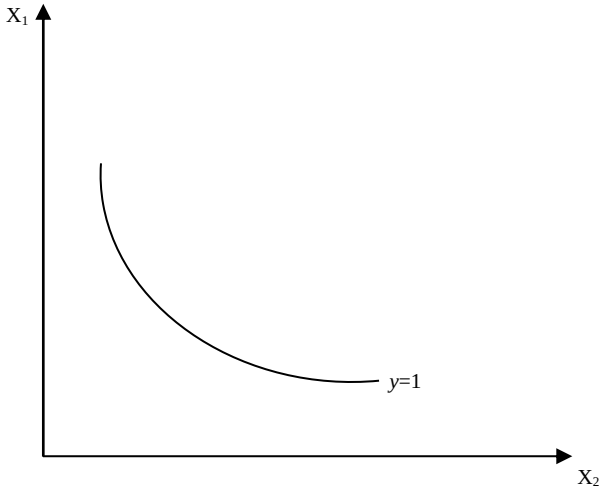

Figure 1 Production Function

Figure 2 below illustrates production at points V, Q and T. Production at point V and T is considered technically inefficient as with similar outputs maximum output could be achieved at production point Q

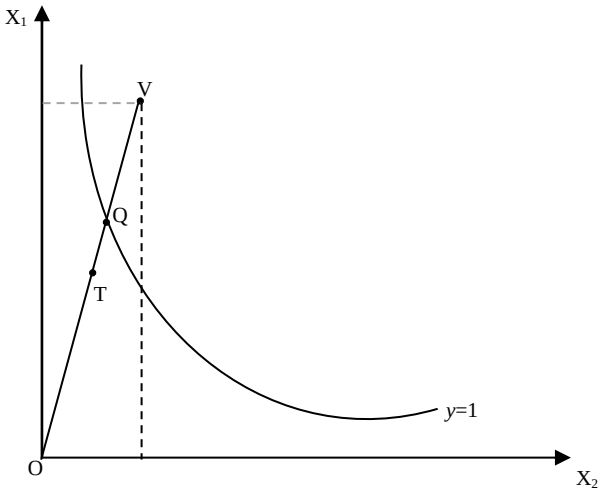

Figure 2 Technical Efficiency at Points Q, T and V

Farell (1957) established measurement of technical efficiency as the distance from the production frontier. Such that technical efficiency (TE) at point V can be calculated as:

$$TE = \frac{OQ}{OV}$$

Where technical efficiency is a value not less than zero neither not greater than one, $0 > TE \leq 1$

In order to assess the allocative efficiency, then isocosts are introduced as shown in Figure 3 below:

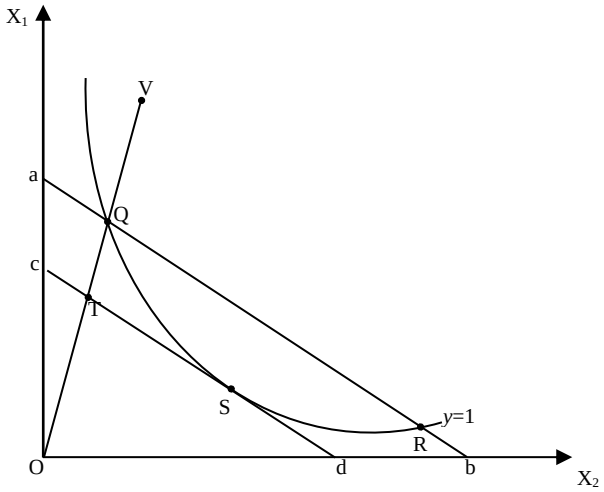

Figure 3 Radial Efficiency Measurement

An isocost indicates the different mix of inputs of production at a given cost. In figure 3 above isocost *ab* is higher than *cd* implies that cost of production at *ab* is higher than *cd*. Therefore it means that in as much as production at point Q and S is technically efficient, production at point S is cheaper therefore allocative efficient. Allocative efficiency (AE) will therefore be calculated as:

$$AE = \frac{OT}{OQ}$$

Overall efficiency is computed as a product of allocative efficiency and technical efficiency as expressed as follows:

$$Overall\ Efficiency\ (OE) = Allocative\ Efficiency\ (AE) \times Technical\ Efficiency\ (TE)$$

2.3 Empirical Review of Literature

Gruca and Nath (2001) used Data Envelopment Analysis (DEA) for evaluation of technical efficiency of 168 community hospitals in Ontario, Canada. This study revealed that small hospitals, this is those with less than 100 beds, had the greatest mean technical efficiency score of 0.79. Medium sized hospitals, that is those with a bed capacity of 100-350 beds, had a technical efficiency of 0.71 while large hospitals with more than 350 beds had a technical efficiency of 0.69. This study also showed that location influenced technical efficiency whereby hospitals in rural areas displayed the highest technical efficiency of 0.77. Hospitals located in urban areas exhibited mixed results, however, hospitals that serve a population of more than 500,000 had the lowest technical efficiency of 0.58.

Gannon (2005) examined the technical efficiency of 43 hospitals in Ireland comprising of 22 county hospitals and 13 regional hospitals using two methods: DEA and stochastic frontier analysis (SFA) for the period 1995-2000. The study compared the technical scores of the hospitals using the two methods. For 5-year period, DEA showed technical efficiency ranging 0.94-0.97 for county hospitals and 0.96-0.97 for the regional hospitals. Stochastic Frontier Analysis revealed higher inefficiencies that DEA with the average technical efficiency of 0.63 for county hospital and 0.60 for regional/general hospitals. This was attributed to the fact that SFA can distinguish between random errors and inefficiency. The study showed that type of hospital influenced efficiency whereby the regional/general hospitals exhibited higher technical efficiency levels compared to county hospitals.

Kakeman et. al. (2015) assessed the level of technical efficiency of 52 hospitals in Tehran, Iran utilizing DEA. The study showed that about 31.5% were technically efficient. About 29.6% had a technical efficiency score less than 70%. It The study revealed that ownership

had an effect of technical efficiency where social security hospitals and private hospitals showed higher technical efficiency of 84.32% and 84.29% respectively, compared to government hospitals which had a technical efficiency of 79.64%. Speciality hospitals also exhibited higher technical efficiency than government hospitals. The bed capacity also affected technical efficiency whereby hospitals with higher bed capacity had increased technical efficiency (P=0.008). There was no significant relationship between hospital type i.e. whether teaching or non-teaching.

Roh et al. (2013) evaluated the technical efficiency of 114 community hospitals in Tennessee utilizing DEA. These hospitals were categorized according to size dependent based on the bed capacity. This study showed that highest average technical efficiency of 95.6% was observed in the large hospitals, followed by medium sized hospitals 95.5% and small hospitals had a technical efficiency of 82.2%. This study also showed that rural hospitals had a higher overall technical efficiency of 88.8% compared to urban hospitals which had average overall technical efficiency of 78.7%.

In Madhya Pradesh, India, Ram Jat (2013) conducted an assessment technical efficiency of 40 public sector hospitals. This research established 0.90 as the mean technical efficiency score of these hospitals. Of the assessed hospitals 50% operated at a technically efficiency of 100%. The technically inefficient hospitals, which constituted the other half, had a mean technical efficiency score of 79%. This indicates the possibility of these hospitals producing similar amount of output with 21% less inputs.

Ichoku et. al. (2011) utilized Data Envelopment Analysis to establish technical efficiency of 200 hospitals in southern Nigeria. This study showed technical inefficiency in these hospitals.

As per the constant returns to scale (CRS) method, the mean technical efficiency score was established as 59% while as per varying returns to scale method the mean technical efficiency score was established as 72%.

Atalawi et al (2020) assessed for determinants of hospital efficiency in Saudi Arabia. Hospitals whose technical efficiency had been determined by DEA were assessed using spearman's rank correlation, multivariate tobit regression and two-part model to establish determinants of technical efficiency. The study showed the association between population density and technical efficiency i.e. hospitals who had a larger catchment population density had increased technical efficiency. Furthermore, it revealed the effect of variance in demographics on the technical efficiency. Hospitals which served a catchment population with higher proportion of children under five years had also higher technical efficiency. This was attributed to the higher morbidity in children and greater need for services by children such as immunization. Additionally, the study also showed that hospitals that served populations with higher proportion of infectious diseases and those that served higher numbers of patients with chronic illness exhibited greater technical efficiency.

Jehu-Appiah et. al (2014) conducted a study of 128 hospitals in Ghana using DEA followed by a tobit regression. The study revealed technical inefficiency with only 24% of the assessed hospitals exhibiting technical efficiency of 100%. Of the assessed hospitals, 71 of them, representing 56.2%, had a technical efficiency of less than 50%. The study also revealed an association between ownership and technical efficiency. The mean technical efficiency score per ownership category was shown as 83.9%, 70.4%, 68.6%, 68.6% and 55.8% for quasi-government hospitals, public hospitals, mission hospitals and private hospitals respectively.

Hospitals of quasi-government ownership showed a positive association with technical efficiency while private ownership had negative association.

Ali et. al (2017) used DEA, malmquist index and tobit regression to evaluate 12 hospitals in eastern Ethiopia for technical efficiency over a six-year period 2007/08 to 2012/13. The study showed revealed different levels of technical inefficiency across time. Using variable returns to scale, the study indicated that 6, 5, 3, 3, 4 and 3 of the assessed 12 hospitals were demonstrated to be efficient during the period of study. Additionally, the study showed that non-teaching hospitals exhibited greater efficiency than teaching hospitals. Furthermore, the study indicated that higher proportion of inpatients treated to medical doctors, high proportion of medical doctors to staff ratio as well as higher outpatient visits to inpatient days ratio were associated with less technical inefficiency.

Kirigia et. al (2002) conducted a study of 54 hospitals in Kenya whereby DEA was utilized to measure the technical efficiency. The findings of the study indicated that 74% of the assessed hospitals had technically efficiency of 100%. Furthermore, the mean technical efficiency score for the inefficient hospitals was shown as 84% indicating that these hospitals could produce similar output with 16% less inputs.

A similar study was carried out in Kenya in 2004 by Kirigia et. al (2004) which evaluated 32 health centres to establish technical efficiency employing DEA. This study revealed substantial technical inefficiency with only 44% of the assessed health centres exhibiting technical efficiency. The inefficient health centres were found to have an average technical score of 65%, of which 2 health centres scored of less than 50%. These findings implies that

35% of the resources were wasted as health centre could produce similar output with 35% less inputs.

Oyieke et. al (2021) conducted a study in Lake Region Economic Bloc in Kenya to establish the determinants of technical efficiency. This study assessed 14 county referral hospitals over five-year period 2012-2016 and DEA was employed in assessment of technical efficiency. Findings established a mean technical efficiency score of these hospitals as 0.80 and 0.90 aps per constant returns to scale method and as per variable returns to scale method respectively. Additionally, the study also assessed association between technical efficiency and its determinants using panel regression model. It revealed there was no correlation between technical efficiency and teaching status of hospitals, bed occupancy rates, and size of hospitals. It also showed no correlation between size of catchment population and technically efficiency which is contrary to the findings by Ali et. al. (2017) However, the study revealed an inverse correlation between technical efficiency and average length of stay (ALOS).

2.4 Overview of the Literature Review

An examination of the studies reveals that DEA is a more commonly used method for assessment of technical efficiency of health facilities. However, DEA has its limitations including difficulty in identifying deviation due to statistical noise. The study by Gannon (2005) reveals variation in results based on method used for assessment of technical efficiency hereby DEA portrays greater efficiency compared to SFA.

Additionally, these studies shows that a myriad of factors affect technical efficiency. A study by Kakeman et. al (2015) showed that bed capacity, representative for size of hospital, had a positive correlation with technical efficiency. This contrasts with studies by which showed

that an inverse correlation between hospital size and technical efficiency. The study by Oyieke et. al (2021) showed zero correlation between technical efficiency and hospital size.

Catchment population was shown to be positively associated as shown in a study by Atalawi et al (2015). This study showed that hospitals with higher catchment population exhibited higher technical efficiency. In addition, studies have also shown that location of a hospital has an effect on technical efficiency whereby hospitals in rural area were shown to have higher technical efficiency than urban hospitals as was shown in the studies by Roh et al (2013) and Gruca and Nath (2001).

The type of hospital has also been shown to have an effect on technical efficiency. A study by Gannon (2005) showed that regional hospitals exhibited higher technical efficiency than county hospitals. This study also showed that teaching hospitals exhibited lower technical efficiency than non-teaching hospitals. However research by Kakeman et.al (2015) and Oyieke et. al (2021) showed no significant corelation between technical efficiency and type of hospital.

With the array of factors likely to affect technical efficiency, a good understanding will be critical to inform decisions such as resource allocation. Knowledge of these factors will enable the identification of areas for potential improvement or wastage.

CHAPTER 3: METHODOLOGY

3.0 Introduction

This section discusses the methods of research that will be adopted in this study. Research methodology details the approach to be used to identify, select, process, and analyse data about a subject. Development of a good research strategy will enable answer the research questions. Furthermore, a well formulated research methodology will allow replicability. This chapter will specifically present the conceptual framework, models and estimations, sources of data, sampling and area of study.

3.1 Conceptual Framework

Health care facilities utilize various inputs like staff (medical and non-medical), hospital beds and supplies (pharmaceutical or non-pharmaceutical) to generate outputs like inpatient admissions, outpatient attendance and maternal deliveries (Bundi 2018). The interconnection between the inputs, processes and outputs is illustrated in Figure 4 below.

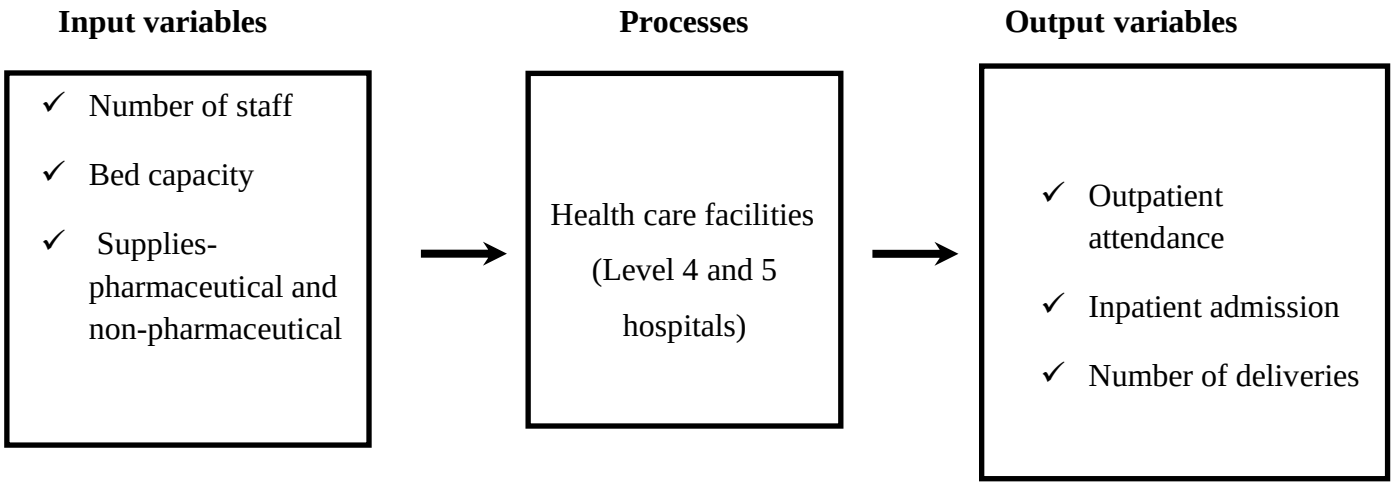

Figure 4 Technical Efficiency Conceptual Framework

In order to assess performance of a firm or decision-making unit, attention is often on the level or quantity of outputs. Whereby firms that have the most output are viewed as

productive. However, it is important to note that output does not always correlate with resource utilization and proportion of output may not correspond to input. In an effort to look at productivity of firms, Debreu (1951) looked into the concept of resource utilization so as to evaluate "dead loss" brought about by inefficient use of resources. Farrell (1957) improved on this concept further and developed methods of measuring technical efficiency. He defined technical efficiency as "producing maximum output from a given set of resources". Technical efficiency investigates best use of limited resources. Resources are scarce thus the desire is for firms to use minimum inputs/resources to achieve a set output or use of the given resources to achieve maximum outputs.

Health facilities utilize multiple inputs and similarly have multiple outputs as shown in figure 4 above. Assessment of technical efficiency will allow to determine the use of these resources in a health facility relative to its peers. In the assessment of technical efficiency of the sampled health facilities, Data Envelopment Analysis (DEA) shall be employed based on its capability to permit use of several input variables and output variables. Technical efficiency will be between 0 to 1 based on distance from the production frontier, with 1 being the firm at the production frontier.

3.2 *Economic models and Estimation*

The methods used to measure technical efficiency can be classified as parametric or non-parametric. They can be further classified as stochastic or deterministic. Parametric methods assume a specific relationship between the dependent variables and explanatory variables in that an assumption is made of the functional form for the production frontier as opposed to non-parametric approaches. The deterministic approaches to measurement of efficiency make the assumption that inefficiency presents as distance from the production frontier while

stochastic methods make the assumption that the distance that is due to some random error. Table 1 below shows the different methods of measuring efficiency.

Table 1 Methods of measuring technical efficiency

	Non-parametric	*Parametric*
Deterministic	Data envelopment analysis	Parametric mathematical programming Deterministic frontier analysis
Stochastic	Stochastic data envelopment analysis	Stochastic frontier analysis

Source: (Hollingsworth, Dawson, & Maniadakis, 1999)

Technical efficiency can also over be compared over different period of time using methods such as the Malmquist index. Malmquist index is defined as 'two input, one output, two time period' and is formulated on the data envelopment analysis (Hollingworth, 2014).

In a review of literature on efficiency, Hollingworth (2003) showed that DEA was a popular approach to measuring technical efficiency in health. Though he also noted the increasing popularity of two stage analysis using DEA and different forms of regression to establish the determinants of efficiency in health. It was also noted that a large proportion of the papers reviewed focused on efficiency of health care as opposed to production of health at individual level.

The study will employ DEA in the determination of technical efficiency. This is due to the nature of production in hospitals where numerous input resources are employed in the production of various health outputs. Subsequently, OLS regression analysis will be done to establish determinants of technical efficiency in these hospitals.

3.2.1 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a non-parametric linear programming model used to establish relative performance of an organization also known as decision making unit (DMU). Farell (1957) described the approach which was later advanced by Charnes, Cooper and Rhodes (1978) as a benchmarking approach to evaluate non-profit and public sector organizations. DEA measures performance of each DMU against the DMU that exhibits the best practice within the assessed sample. Based on observed data, DEA determines which of the set of producers form the envelopment surface or otherwise known as the empirical production function.

Unlike other optimization methods, in DEA the weight assigned to input and outputs is computed by the model rather than assigned by the user. This makes it suitable for firms whose production function cannot be easily determined DEA and is a suitable choice for assessment of the technical efficiency of the public hospitals in Kiambu county. If an organization uses solitary input to produce a solitary output, the technical efficiency is basically defined as:

$$Technical\ Efficiency = \frac{Output}{Input}$$

However, hospitals have numerous inputs such human resources, drugs and non-medical supplies, capital inputs as well as numerous outputs such as admissions, deliveries, outpatient services thus the equation is adapted. Therefore, "technical efficiency (TE) of a health facility is expressed as a ratio of total sum of weighted outputs to total sum of weighted inputs" (Charnes, Cooper, & Rhodes, 1978).

$$Efficiency\ = \frac{weighted\ sum\ of\ hospital\ outputs}{weighted\ sum\ of\ hospital\ inputs}$$

According to Charnes et. al (1978), the technical efficiency of a specific decision making unit is computed as the maximum ratio of weighted outputs to weighted inputs limited to

comparable ratios for individual DMUs (health facilities) not be greater than one. The fractional programming model below is used to obtain the efficiency.

$$Efficiency_o = Max \frac{\sum_{r=1}^{s} U_r Y_{rj}}{\sum_{i=1}^{m} V_i \ X_{ij}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

subject to: $$\frac{\sum_{r=1}^{S} U_r Y_{rj}}{\sum_{i=1}^{m} V_i \ X_{ij}} \leq 1 \quad j = 1 \ldots\ldots\ldots\ldots n$$

$$U_i \geq 0; 1 \ldots\ldots\ldots s$$

$$V_i \geq 0; 1 \ldots\ldots\ldots m$$

where:

Y_{rj} is the quantity of health output r (r = 1,…, s) from hospital j ;

X_{ij} = the quantity of health input i (i = 1,…, m) in j_{th} hospital;

U_r = the weight given to health output r;

V_i = the weight given to health input i; and n is the number of sampled hospitals

Charnes et. al (1978) converted model (1) into the following constant returns to scale (CRS) linear programming model:

$$Efficiency_o = Max_{u_r v_i} \sum_r^s U_r \, Y_{rj} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Subject to: $\sum V_i \ X_{ij} = 1$

$\sum_r^s U_{r=1} \ Y_{rj} - \sum_{i=1}^{m} V_i \ X_{ij} \leq 0$; j=1……n

The CRS model makes the assumption that the DMUs, that is the hospitals, are operating at optimal scale efficiency whereby an increase in health system outputs leads to a proportionate increase in output such that a twofold increase inputs results in twofold increase of outputs. This notwithstanding the model is subject to all DMUs being below or on the production frontier. Despite this assumption, in actual fact, a health facility could exhibit different returns to scale that is, increasing returns to scale (IRS), constant returns to scale (CRS), or

decreasing (diminishing) returns to scale (DRS). Wherein a hospital displays increasing returns to scale indicates that a rise in the health input resources brings about a greater proportionate rise in health outputs when compared to inputs for example a twofold increase of all input resources will generate a more than twofold increase of outputs. Contrastingly, if a health facility is exhibits DRS, scale up of input resources will brings about a less than proportionate rise in outputs. Thus, in instance where there is an assumed variable returns to scale then the BCC model is used. This model was brought forth by Banker et. al (1984) and is determined as follows:

$$Max\ Efficiency_o = Max_{u_r v_i} \sum_r^s U_r\, Y_{rj} + U_o$$

Subject to: $\sum V_i\, X_{ip} = 1$

$$\sum_r^s U_{r=1}\, Y_{rj} - \sum_{i=1}^m V_i\, X_{ij} + U_o \leq 0;\ \text{j=1}\ldots\ldots\text{n}$$

In both models, score of technical efficiency should have values larger than 0 and below or equal to 1 whereby 0 implies the firm is totally inefficient, and 1 which implies firm is totally technically efficient.

Table 2 Study Variables and Definitions

Variable	***Definition***	***Source of Data***
Input		
Beds	Number of beds available in the hospital for the year 2019	Hospital Management Records
Medical staff	Number of medical staff -Consultants, Medical Officers, Pharmacists, Nurses and Other medical staff	Hospital Management Records
Supplies- Pharmaceutical and Non-pharmaceutical	Total costs of pharmaceutical and non-pharmaceutical supplies procured in 2019	Hospital Management Records
Output		
Outpatient attendance	Total number of outpatient visits recorded in 2019	DHIS
Inpatient admissions	Total number of inpatient admissions for 2019	DHIS

Maternal deliveries	Total number of maternal deliveries, both caesarian and vaginal, in 2019	DHIS

3.2.2 Regression Analysis

Regression analysis will be conducted so as to establish the association of the various factors and the technical efficiency of the hospitals. The factors included in the assessment will include type of hospital whether level 4 or level 5, catchment population, hospital size and location of hospital (rural vs urban). These variables will be the independent variables and their effect on technical efficiency (dependent variable) will be assessed in an ordinary least square (OLS) regression analysis. The study estimates a multiple regression function in a cross-sectional analysis The technical efficiency score will be the dependent variable which will be compared to the composite value of the factors influencing technical efficiency. Ordinary Least Squares regression (OLS) is a commonly used method to describe the relationship between one or more independent quantitative variables and a dependent variable (multiple linear regression). This makes OLS the best model for this study. It will take the form of:

$Y= \beta_0+\beta_1X_{pop}+\beta_2X_{size}+\beta_3X_{hosptype}+\beta_4X_{loc}+\varepsilon$

where;

Y is the aggregate value of outputs

β_0 represents a constant

β_1- β_4 are the regression coefficients of independent variables

X_{pop} is catchment population

X_{size} is hospital size

$X_{hosptype}$ is type of hospital

X_{loc} is location of hospital

ε is the error tem representing other variables

3.3 Data sources, sampling, collection and coding

This research will utilize annual cross-sectional data from the public hospitals in Kiambu county. It will focus on level 4 and 5 hospitals will be involved, as they utilize bulk of the resources. The data will be collected on the determinants affecting efficiency of the hospitals as well as input variables data along with output variables data of the health facilities. The data on the input variables and the determinants will be obtained from the hospital management records whilst output variable data will be obtained from District Health Information System (DHIS). DHIS is an online platform that allows collection, validation, analysis and presentation of health data (DHIS2, 2021). The unit(s) of analysis are the public hospitals.

In 2005, the second national health strategic plan was developed whose main objective to reverse the decline in the health trends in Kenya. The strategic plan lay ground for the establishment of the Kenya Essential Package for Health (KEPH) in which health programmes were consolidated into a single package to focus interventions for the various defined stages of the human development cycles for the betterment of health. Six levels of care were introduced that is Level 1-6 and health services to be offered at the different levels was defined (Ministry of Health, 2005). This study will involve all the level 4 and level 5 public hospitals in Kiambu County as they handle a diverse set of patients and have a wider geographical coverage. Input variables to be measured will include number of medical staff, hospital size determined by the total beds in the health facility and supplies that is pharmaceutical commodities and non-pharmaceutical commodities. These input variables are significant in the health services production hence influence in the efficiency of the hospitals. The study will use output variables including total inpatient admissions, total outpatient attendance and number of

maternal deliveries within the hospitals for 2019. These outputs will be considered as they are important for the outcomes of hospitals. The data collected will be cleaned, coded and entered STATA 14 for analysis.

3.4 Study Area

The research study will be carried out in Kiambu county geographically situated in the central part of Kenya. To the south, Kiambu county borders Nairobi and Kajiado and to the east it borders Machakos county. Murang'a county located to the North and Northeast of the county while Nakuru county to the west and Nyandarua county to the Northwest. The county has 505 health facilities majority being private health facilities that is 333 while 64 of the health facilities are managed by faith-based organization. The government of Kiambu manages 108 public health facilities classified as per KEPH level in table 3 below. (County Government of Kiambu, 2018).

Table 3 Number of Public Health Facilities per KEPH level

KEPH Level	Number of Facilities
Level 2	70
Level 3	24
Level 4	11
Level 5	3

The private health facilities Mission Hospitals 17, nursing homes 5, dispensaries 36 and 169 private clinics. These facilities are easily accessible due to a good network and the average distance to a health facility is 7 kilometres. These facilities have a health workforce of 2652 workers with the doctor/population ratio of 1:6667 and the nurse/population ratio stands at 1:

1,110 (County Government of Kiambu, 2018). The study will involve the eleven Level 4 hospitals and the three Level 5 hospitals.

Communicable diseases form the bulk of the illness experienced in Kiambu county with a notable rise in non-communicable diseases. In 2016, the leading causes of morbidity were respiratory diseases, diseases of the skin, diarrhoea, urinary tract infections and hypertension. During the same year, the county maternal mortality ratio was 78/100,000 live births which is lower than national mortality rate of 362/ 100,000 live births. This was attributable to the high percentage of deliveries conducted by skilled attendants comprising of 88.5% of the deliveries. The immunization coverage for Kiambu county was 89% of which the population not immunized is because of various reasons such as religious beliefs.

CHAPTER 4 ANALYSIS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter discusses analysis of study data as well as elucidation of findings of the study.

4.2 Descriptive Statistics

The study involved 14 facilities across the twelve sub counties in Kiambu county. There were 3 level 5 hospital assessed and 11 level 4 hospitals assessed in this study. Of the fourteen facilities assessed, 5 were in located in the urban locality and 9 were in the rural locality. The hospital with the highest catchment population had a population of 77,647. Whilst the hospital with the lowest catchment population had a population of 9,177. Table 4 below summarizes the facility information.

Table 4 Facility information

	Facility Descriptives				
No	Facility Name	Sub County	KEPH Level	Locality	Catchment Population
1	Kiambu Level 5 Hospital	Kiambu Town	5	Urban	77,647
2	Gatundu Level 5 Hospital	Gatundu South	5	Urban	54,048
3	Thika Level 5 Hospital	Thika	5	Urban	41,161
4	Igegania Level 4 Hospital	Gatundu North	4	Rural	31,307
5	Wangige Level 4 Hospital	Kabete	4	Rural	27,958
6	Lari Level 4 Hospital	Lari	4	Rural	9,177
7	Karatu Level 4 Hospital	Gatundu South	4	Rural	17,180
8	Kigumo Level 4 Hospital	Githunguri	4	Rural	10,366
9	Nyathuna Level 4 Hospital	Kabete	4	Rural	10,799
10	Karuri Level 4 Hospital	Kiambaa	4	Urban	23,159
11	Kihara Level 4 Hospital	Kiambaa	4	Rural	29,957
12	Lusigetti L4 Hospital	Kikuyu	4	Rural	23,711
13	Ruiru Level 4 Hospital	Ruiru	4	Urban	70,765
14	Tigoni Level 4 Hospital	Limuru	4	Rural	23,850

The study assessed 3 input variables namely: total number of staff, cost of supplies along with number of hospital beds. The hospitals had an average number of 114 staff with the highest number of staff was 362 while the facilities with the lowest number of staff had 16 staff members. The mean cost of supplies for the hospitals was Kshs. 20,295,520 with the hospital with the highest expenditure on cost supplies spending Kshs. 84, 774,471 in 2019. The hospital with the lowest expenditure on supplies spent Kshs. 1,201,062. The assessed hospitals had mean number of 120 beds. The health facility with the greatest total number of beds had 467 beds while that with the lowest total number of beds had 8 beds.

Data on output variables was also collected. The output variables assessed were outpatient attendance, inpatient admissions and maternal deliveries. The mean outpatient attendance of the hospitals in 2019 was 70,695. The highest number of outpatient attendance in 2019 reported was 249,406 while the lowest outpatient attendance in 2019 was 9,616. The mean inpatient admission in 2019 was 5,309 of which the highest reported admission was 24,216 while the lowest reported was 27. The mean maternal deliveries in 2019 was 3,157 with the highest number of reported maternal deliveries was 9,855 and the lowest reported was 71. Table 5 below summarizes descriptive statistics of input parameters and output parameters.

Table 5 Descriptive statistics

Variable	***Mean***	***Standard Deviation***	***Minimun Value***	***Maximum Value***
Input Variable				
Number of staff	114.15	123.73	16	362
Cost of Supplies (Kshs.)	20,295,520	29,036,425	1,201,062	84,774,471
Number of Beds	120	153.13	8	467
Output Variable				
Outpatient Attendance	70,695.08	78,127.13	9,616	249,406
Inpatient Admissions	5,309.23	7,019.76	27	24,216
Maternal Deliveries	3,157.23	3,407.9	71	9,855

4.3 Technical Efficiency Scores

Data envelopment analysis (DEA) was employed in determination of the technical efficiency of sampled health facilities. The technical efficiency was determined as per constant return to scale (CRS) and under varying returns to scale (VRS). The range of technical efficiency score should lie between 0 to 1; where 0 is the least efficient and 1 for the highest efficiency. The study assessed 14 facilities however only 13 hospitals had complete data and therefore only these were used for the data analysis. Table 6 below summarizes the technical efficiency scores per facility.

Table 6 Technical Efficiency Scores per Facility

Health facility	***DMU***	***CRS_TE***	***VRS_TE***	***SCALE***	***RTS***
Kiambu Level 5 Hospital	dmu:1	0.7366490	1.0000000	0.7366490	-1
Gatundu Level 5 Hospital	dmu:2	0.5375340	0.8325320	0.6456610	-1
Thika Level 5 Hospital	dmu:3	0.8421980	0.9944750	0.8468770	-1
Igegania Level 4 Hospital	dmu:4	0.4953000	0.5078680	0.9752550	-1
Lari Level 4 Hospital	dmu:5	0.3626310	0.5241330	0.6918680	1
Karatu Level 4 Hospital	dmu:6	0.5540770	1.0000000	0.5540770	1
Kigumo Level 4 Hospital	dmu:7	1.0000000	1.0000000	1.0000000	0
Nyathuna Level 4 Hospital	dmu:8	0.7670630	1.0000000	0.7670630	1
Karuri Level 4 Hospital	dmu:9	1.0000000	1.0000000	1.0000000	0
Kihara Level 4 Hospital	dmu:10	0.8599910	0.9889490	0.8696010	-1
Lusigetti L4 Hospital	dmu:11	0.8900780	0.8908150	0.9991720	-1
Ruiru Level 4 Hospital	dmu:12	0.5758590	1.0000000	0.5758590	-1
Tigoni Level 4 Hospital	dmu:13	0.5259230	0.6278000	0.8377250	-1

4.3.1 CRS TE Score

Only 2 (15%) of the assessed health facilities attained a technical efficiency score of 1. A mean technical efficiency score of 0.65 was obtained from the technically inefficient health facilities. This implies that these hospitals can produce the same output with 35% less input. Conversely,

these hospitals can produce 35% more output with the same resources. Two facilities attained a CRS technical efficiency score of below 0.5.

4.3.2 VRS TE score

Of the assessed facilities, 6 (46.2%) had an efficiency score of 1 under VRS. Furthermore, technically inefficient hospitals obtained an average score of 0.77 under VRS. This suggests that these hospitals can produce the same output with 23% less input. Conversely, these hospitals can produce 23% more output with the same resources.

4.3.3 Returns to scale

Of the assessed facilities, 8 (61.5%) exhibited decreasing returns to scale. This suggests that increased input in these health facilities will result in a less proportional rise in output. Three hospitals which represents 23.1% exhibited increasing returns to scale suggestive that an increased input results in a far much greater proportionate rise in output. Two hospitals exhibited constant returns to scale which indicates that an increased input results in equal proportionate rise in output.

4.4 Regression Analysis

Ordinary Least Squares (OLS) was utilized to establish correlation between technical efficiency scores and hospital size, catchment population, type of hospital and location of hospital. The findings indicate no significant correlation between catchment population and technical efficiency. Additionally, there was neither a correlation between hospital size and technical efficiency nor to the type of hospital. There was also correlation between technical efficiency and location of hospital.

Table 7 Regression Analysis Data

Variable	Coefficient	Std Error
Catchment Population	0.000000305	0.00000455
Size of Hospital	0.000254	0.0009159
Type of Hospital (Level 4/Level 5)	-0.2267394	0.327793
Location of Hospital (Urban/Rural)	0.1639264	0.2181065

4.5 Discussion

The VRS efficiency scores were higher than CRS efficiency score. This is consistent with findings by Ichoku et. al. (2011). Higher VRS technical efficiency scores are due to the efficiency of individual health facility being compared to those facilities operating at the same scale while CRS compares efficiency of individual health facilities to all the efficient health facilities in the assessed sample.

The study also revealed technical inefficiency of the hospitals where only 2 hospitals were efficient under CRS and only 6 were technical efficient under VRS. These findings are like those by Kirigia et. al (2002) and Oyieke et. al. (2021) which showed technical inefficiency of hospitals in Kenya.

There was no correlation between hospital size and technical efficiency. Similarly, the study by Oyieke et. al (2021) found no correlation between hospital size and technical efficiency. Moreover, there was no correlation between the catchment population and technical efficiency which corresponds to the findings by Ali et. al (2017) and Oyieke (2021).

CHAPTER 5 SUMMARY, RECOMMENDATIONS AND STUDY LIMITATION

5.1 Summary

With global and local focus to improve health of the people it becomes imperative to strengthen the health care system. Kenya UHC policy seeks "to ensure access Kenyans have access to quality health services without suffering financial hardship" (Republic of Kenya, 2020). County governments have a role in delivery of health care services via health facilities managed by the county amongst other functions. Additionally, Kenya UHC policy stipulates improvement of efficiency and use of health system resources as a strategy to achieving its objectives.

It is in the backdrop of these policies that this study has been conducted within the public hospitals; level 4 and level 5; in Kiambu County to establish the efficiency of these public hospitals and factors determining technical efficiency. The research finds will the guide policy towards improvement of the healthcare system in Kiambu county. Assessment of 13 public hospitals in Kiambu county using two stage DEA followed by OLS regression revealed inefficiencies within these hospitals. Only 15% of the assessed hospitals exhibited technical efficiency. Furthermore, the technically inefficient health facilities obtained an average CRS technical efficiency score of 0.65, which implies that 35% savings can be made with improved efficiency. This is particularly important for Kiambu County as it cites resource constraints as a major challenge in delivery of health services. Therefore, the county needs to look into ways to increase the technical efficiency of these health facilities.

5.2 Recommendations

Study findings shows an opportunity for improvement of utilization resources in the assessed public health facilities in Kiambu County. It will be necessary to determine factors affecting the efficiency of these health facilities. Additionally, technically efficient hospitals can provide insight on the approaches to improve technical efficiency. Redistribution of excess resources will be necessary to improve efficiency. Health care services utilization of the population will be a critical factor to investigate. This is important as poor health care services utilization will result in low output and subsequently affect output and efficiency of health facilities.

5.3 Area for further study

The study focuses on the only 14 public hospitals thus the dispensaries and health centres had been excluded. While individually, the resources used in each dispensary and health centre may not be as great as the hospitals, cumulatively the resources utilized are significant. A study on the technical efficiency of the level 2 and level 3 facilities would therefore be worthy and insightful.

Notably, only external factors were assessed in the determinants of technical efficiency. Studies on effect of internal factors, such as average length of stay, staff mix and magnitude of funding, on technical efficiency would give insight on how to optimize efficiency. It would also be useful to investigate other external factors not included in this study such socio-demographic factors on efficiency.

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APPENDICES

APPENDIX 1 REGRESSION ANALYSIS DATA

Variable	Mean	Std. Dev.	Min	Max
vrs_te	.8523029	.1936384	.5078675	1
Population	32548.23	22413.7	9177	77647
Size	120	153.1323	8	467
Level	4.230769	.438529	4	5
Location	1.384615	.5063697	1	2

	vrs_te	Popula~n	Size	Level	Location
vrs_te	1.0000				
Population	0.1573	1.0000			
Size	0.0605	0.6071	1.0000		
Level	-0.0162	0.6377	0.8848	1.0000	
Location	0.2370	0.7639	0.6824	0.6928	1.0000

Source	SS	df	MS		
Model	.057435144	4	.014358786	Number of obs	= 13
Residual	.392514854	8	.049064357	F(4, 8)	= 0.29
				Prob > F	= 0.8748
Total	.449949998	12	.037495833	R-squared	= 0.1276
				Adj R-squared	= -0.3085
				Root MSE	= .2215

vrs_te	Coef.	Std. Err.	t	P>|t|	Beta
Population	3.05e-07	4.55e-06	0.07	0.948	.0353448
Size	.000254	.0009159	0.28	0.789	.2008767
Level	-.2267394	.327793	-0.69	0.509	-.5134921
Location	.1639264	.2181065	0.75	0.474	.4286719
_cons	1.54419	1.25964	1.23	0.255	.

Variable	VIF	1/VIF
Level	5.05	0.197874
Size	4.81	0.207867
Location	2.98	0.335206
Population	2.54	0.393860
Mean VIF	3.85	

APPENDIX 2 NACOSTI LICENCE

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **789956**

Date of Issue: **14/October/2022**

RESEARCH LICENSE

This is to Certify that Dr.. Brenda Nyangate Onyancha of University of Nairobi, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kiambu on the topic: Determinants of Technical Efficiency of Public Hospitals in Kiambu County for the period ending : 14/October/2023.

License No: **NACOSTI/P/22/19435**

789956

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

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See overleaf for conditions

APPENDIX 3 ETHICAL APPROVAL

KIJABE HOSPITAL INSTITUTIONAL ETHICS AND RESEARCH REVIEW COMMITTEE
PO Box 20 Kijabe 00220, Kenya
Tel: 0709728200/637
Fax: 020-3246335
E-mail:researchcoord@kijabehospital.org
Website: www.kijabehospital.org

REF: KH/IERC/0024/2022
Approval no: KH/IERC/02718/0024/2022

Date: 22nd September

Dear Brenda Onyancha

RE: DETERMINANTS OF TECHNICAL EFFICIENCY OF PUBLIC HOSPITALS IN KIAMBU COUNTY

Many thanks for your submission to KH IERC.

The Institutional Ethics and Research review Committee having carefully reviewed your above title proposal grants you approval to conduct this study in **Kiambu County** as of **22nd September 2022**.
The draft of any manuscript resulting from the study should be submitted to the IERC for review before it is submitted for publication.
As exempt studies, annual reviews will not be required and no expiration date will be listed in this approval letter.
This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by KH IERC.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to KH IERC within 72 hours of notification.

iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to KH IERC within 72 hours.

v. Clearance for export of biological specimens must be obtained from relevant institutions.

vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.

vii. Submission of an executive summary report within 90 days upon completion of the study to KH IERC.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.keand also obtain other clearances needed

Please do not hesitate to contact the AIC Kijabe Hospital IERC Coordinator (researchcoord@kijabehospital.org) for any clarification or query.

Thank you,

Yours sincerely,
Peter Halestrap.

BMBCh, MRCGP, DCH, DRCOG, MA (OXON)

Chair, AIC Kijabe Hospital IERC

APPENDIX 4 COUNTY APPROVAL

COUNTY GOVERNMENT OF KIAMBU
DEPARTMENT OF HEALTH SERVICES

All correspondence should be addressed to HEAD
HRDU – HEALTH DEPARTMENT
Email address: mndiritu@gmail.com
mkwasa@live.com
Tel. Nos: 0721641516
0721974633

HEALTH RESEARCH AND DEVELOPMENT
UNIT
P. O. BOX 2344 – 00900
KIAMBU

Ref. No.: KIAMBU/HRDU/22/07/26/RA_ONYANCHA Date: 26th July 2022

TO WHOM IT MAY CONCERN

RE: CLEARANCE TO CONDUCT RESEARCH IN KIAMBU COUNTY

Kindly note that we have received a request by Dr. Brenda Onyancha of University of Nairobi to carry out research in Kiambu County, the research topic being on "Determinants Of Technical Efficiency Of Public Hospitals In Kiambu"

We have duly inspected her documents and found that she shall not, at any point, interact with patients or patient clinical data. As she has applied for a NACOSTI license, we hereby give her a provisional clearance to begin collecting her data immediately to avoid any delays in the research process. However, she is required to submit the license within 2 months of receiving this letter.

It is incumbent upon the institution where she is carrying out research to ensure that she receives adequate supervision during the process of conducting the research. This note also accords her the duty to provide a feedback on her research to the county at the conclusion of her research.

DR. MWANCHA KWASA
COUNTY CLINICAL RESEARCH OFFICER
KIAMBU COUNTY

APPENDIX 5 DATA COLLECTION FORM

DETERMINANTS OF TECHNICAL EFFICIENCY OF PUBLIC HOSPITALS IN KIAMBU COUNTY
DATA COLLECTION FORM

A. Facility Descriptive			
Facility Name			
Sub County		County	
Facility KEPH Level			
Locality *(Urban/Rural)*			
Catchment Population			
B. Input Variables			
1. Staff Establishment *(as at 2019)*			
Consultant Specialists			
Medical Officers			
Pharmacists			
Nursing Officers			
Laboratory Officers			
Pharmaceutical Technologists			
Others			
2. Number of Beds in 2019			
3. Medicines and Medical Supplies *(Cost of medicines and medical supplies procured/supplied in 2019)*			
a) Medicines			
b) Medical Supplies			
C. Output Variables			
i) Total Outpatient Attendance in 2019			
ii) Total Inpatient Admissions in 2019			
iii) Number of maternal deliveries in 2019			