PUBLIC HEALTH EXPENDITURE AND HEALTH OUTCOMES IN SUB-SAHARAN AFRICA

By

JACOB NOVIGNON

B.A. (Hons) Economics (Cape Coast, Ghana), M.A. Economics (UNIMA, Malawi)

A Thesis in the Department of Economics,
Submitted to the Faculty of the Social Sciences
in partial fulfillment of the requirements for the Degree of

DOCTOR OF PHILOSOPHY

of the

UNIVERSITY OF IBADAN

July 2015

ABSTRACT

There is a theoretical link between health expenditure and health outcomes (life expectancy at birth, infant and under-five mortality rates). Public health expenditure is low in Sub-Saharan Africa (SSA), with an average per capita expenditure of US$154.60 compared to a world average of US$1026.50 in 2011. In the same year, life expectancy in SSA was 55 years relative to the world average of 77 years. Previous empirical studies focused mostly on the effects of health expenditure on health outcomes in developed countries, with little attention on SSA. The efficiency of health expenditure in SSA has also been barely examined. This study, therefore, investigated the effects of health expenditure on health outcomes and the determinants of its efficiency.

A Cobb-Douglas macro health production model, derived from the Grossman health production theory, was used to estimate the effects of health expenditure on health outcomes. Annual panel data were obtained from the World Bank's *World Development Indicators*, covering the period 2005 to 2011 for 45 SSA countries. Random and Fixed Effects panel data regression techniques were employed for the estimations, while the Breuch-Pagan Lagrange Multiplier test was carried out to ascertain country-specific effects. The Huber robust standard errors were estimated to correct for the problem of heteroskedasticity. The Data Envelopment Analysis model was used to determine the efficiency of health expenditure. A Tobit model was estimated to identify the factors (including institutional quality, corruption and access to health care) that influence efficiency of health expenditure. Statistical significance was determined at the 5% level.

Health expenditure had a statistically significant effect on health outcomes, with coefficients of 0.23, -1.60 and -4.30 for life expectancy, infant and under-five mortality, respectively. This implied that a 1.0% increase in health expenditure improved life expectancy by 0.23 years (approximately two months and 24 days), reduced infant mortality by 1.60 per 1,000 live births and under-five mortality by 4.30 per 1,000 live births. A 1.0% increase in one-period lag of health expenditure improved life expectancy by 0.16 years (approximately one month and 28 days), reduced infant mortality by 1.00 per 1,000 live births and under-five mortality by 3.10 per 1,000 live births. This suggested that the effect of health expenditure on health outcomes was long lasting. The average efficiency score of health expenditure was

0.45, indicating an inefficiency score of 0.55. Efficiency of health expenditure was significantly influenced by quality of public health institutions (76.0%), corruption (27.0%) and access to health care (2.0%).

The public health expenditure component of total health expenditure significantly determined life expectancy, infant mortality and under-five mortality. Health expenditure was substantially inefficient due to corruption and poor quality of public health institutions. The impact of health expenditure on health outcomes can be increased if governments emphasize its efficiency through reduced corruption and establishment of quality public health institutions.

Keywords: Health expenditure and outcomes, Grossman health production model, Data envelopment analysis model, Sub-Saharan Africa, Life Expectancy at birth.

Word count: 453

ACKNOWLEDGEMENT

Travelling this roller coaster road has been mind-numbing but not lonely. It is with great pleasure that I acknowledge individuals who contributed towards my studies in diverse ways. Firs I would like to thank the almighty God for guiding me through every step of my studies and granting me success.

Secondly, I salute my supervisor, Dr. A.O Lawanson and the two other members of my thesis committee, Dr. O. Olaniyan and Dr. O. Aregbeyan, for their unflinching support and tutoring. I would also like to appreciate my lecturers during the course work component of the programme both at the University of Ibadan and the Joint Facility for Electives (JFE) in Nairobi, Kenya. These lecturers include, among others, Prof. Festus Egwaikhide, Prof. S. A. Ilori, Prof. A. Adenikinju, Prof. N. Wawire, Prof. N. Osoro, Dr. O. T. Ekanem, Dr. A. O. Lawanson, Dr. S, Afees and Dr. M. Oyinlola. My pursuit of a doctoral degree would not have been possible without financial support from the African Economic Research Consortium (AERC). I'm eternally grateful to them for granting me full scholarship to complete both my maters and PhD programmes.

I'm also deeply grateful to my colleagues who showed me much love and concern throughout the programme. Notable among them are Eric Arthur, Solomon Olakojo, Dayo Olanikpekun, Rifkatu, Sahid, Yemisi, Nado, Uche Abamba and many more. I pray we keep looking out for each other even after here. To James Sandy I say words will not be enough to thank you for standing by me through the difficult times in Ibadan.

I also acknowledge my wife, Augustina Quansah for enduring the times I was away and continuously praying for my success on the programme. Her words of encouragement have been crucial over the years. To Dr. Justice Nonvignon I say thank you for monitoring my academic progress and making me believe this was possible. Eugene, Robert, Rojaine, Nick, Mat, Cathy, Philip, Leah, Emilia, Eric and my entire family, I say THANK YOU!

CERTIFICATION

I certify that this thesis was carried out by Mr. Jacob Novignon in the Department of Economics, University of Ibadan.

…………………………………………………………………………..

Supervisor and chairman, thesis committee
Dr. Akanni O. Lawanson,
B. Ed (Educ. Mgt. & Econs.), M.Sc. (Econs), Ph.D (Ibadan)
Senior Lecturer, Department of Economics,
University of Ibadan, Nigeria.

…………………………………………………………………………..

Member, thesis committee
Dr. Olanrewaju Olaniyan,
B. Ed (Educ. Mgt. & Econs.), M.Sc. (Econs), Ph.D (Ibadan)
Senior Lecturer, Department of Economics,
University of Ibadan, Nigeria.

…………………………………………………………………………..

Member, thesis committee
Dr. Omoaregba O. Aregbeyen,
B. Ed (Educ. Mgt. & Econs.), M.Sc. (Econs), Ph.D (Ibadan)
Senior Lecturer, Department of Economics,
University of Ibadan, Nigeria.

DEDICATION

To my parents Stephen (late) and Sefora

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.0 Introduction

Human capital is considered as a major factor in the development of any economy (Wilson and Briscoe, 2004). The justification for human capital development has been well documented in the literature (Anyanwu and Erhijakpor, 2007). In most developed regions, investment in human capital is believed to be a fundamental engine for progress. The World Bank posits that the burden of human capital development is daunting in sub-Sahara Africa (SSA) with most countries in the region off-track on most of the Millennium Development Goals (MDGs) (World Bank, 2011). The World Bank's report on building human capital in Africa identified some critical areas in terms of human capital development. These include education and health development, social protection and early childhood development (World Bank, 2011).

An important step to improve health status in Africa and other developing regions is to strengthen health systems[1] and increase equitable access to effective health care. This can be achieved by ensuring adequate and efficient expenditure in the health sector. Improving health status and other aspects of human capital does not only improve the welfare of the population but also raise productivity levels in any region. Empirical evidence on the relationship has been unanimous in the sense that higher health care spending improves productivity and economic growth (Bukenya, 2009, Heshmati, 2001, Bloom et al. , 2004). For developing regions like SSA, such investments are inevitable considering the persistent high levels of poverty and inequality (World Bank, 2010).

[1] Health systems are defined as comprising all the organizations, institutions and resources that are devoted to producing health actions

Improving the health status of any population can be seen as a shared responsibility of both the individual and government. On the part of individuals, engagement in physical exercises and diet improves the depreciating health stock over time. The government on the other hand is responsible for providing various health related goods and services, through health expenditure, to achieve the objective of improving population health status.

The relationship between health care spending and health outcomes is critical for the purposes of effective policy but as noted by Gupta and Verhoeven (2001), the efficiency with which these spending are made is equally important for the debate on the size of the government, the possible role of the private sector and macroeconomic stabilization and economic growth through improved population health.

Most SSA countries face a precarious issue of determining whether or not their expenditure on health translate into improvements in health status of the population. While it is generally believed that SSA contributes relatively little, in terms of health care expenditures, to their population (Poullier et al. , 2002), it is imperative for the effect on health to be established through empirical research. In a more comprehensive sense, the efficiency in the use of such resources should also be of priority. Unfortunately empirical research in this regard, in SSA, has been lacking. Thus this study seeks to investigate the causal nexus that exist between health care spending and health outcomes in SSA with further analysis of the efficiency of health systems[2] in the region.

1.2 Problem statement

Economic theory has over the years identified human capital as a catalyst to economic growth and development at the macro and micro levels (Wilson and Briscoe, 2004, Becker, 1964). Specifically, health capital development contributes to growth through increase in healthy time for both market and non-market activities (Grossman, 1972, Muurinen, 1982). Health capital therefore remains principal on the development agenda of several governments over the world.

[2] Efficiency of health system is operationalized in this study as the effectiveness of health production within a particular country which is defined as the efficiency with which resources of the health sector are used to generate health for the population.

In spite of this, adequate and sustained levels of health resources needed to develop health capital in SSA are largely limited (Tandon and Cashin, 2010). The Abuja declaration of 2001 was intended to improve public expenditure on health in SSA with the aim of improving population health. However very few countries in the region are close to the target of 15% of government budget (Tandon and Cashin, 2010). In 2011, exactly ten years after the declaration, only six countries had achieved this target. These countries include Rwanda (23%), Liberia (18.9%), Malawi (18.5%), Madagascar (15.5%), Togo (15.4%) and Zambia (16.0%) (World Bank, 2012).

Further, per capita expenditure on health is lowest in the SSA region, relative to all other regions of the world. Per capita expenditure on health in the region increased from US$ 79.4 in 2000 to US$ 154.6 in 2011. This was significantly less than the world average of US$ 1026.5 in 2011. Also, health financing in the SSA region are mostly from private sources and largely made up of out of pocket (OOP) expenditure. The World Health Organization (WHO) estimates that up to 10% of the population in these countries suffer this type of financial catastrophe each year, with up to 4% pushed down the poverty line (WHO, 2012). Similarly, other health related inputs in the SSA region have continually performed poorly over the years relative to other regions of the world. For instance, physician, nurse/midwife and dentistry density per 10,000 population was estimated to be 2.2, 9.0 and 0.4, respectively in 2010, relative to the world average of 14.2, 28.1 and 2.2, respectively (WHO, 2012).

Population health status in SSA also require substantial improvements to meet set targets such as the MDGs. Countries in the region continue to face high disease burdens and poor performance in terms of health status. It is reported that the Africa region lags behind in achieving the health-related MDG targets with most countries in the region unlikely to achieve these targets. The WHO in 2011 also showed that only eight countries were on track to achieve the health related MDGs. Majority of the countries in the region were achieving less than 50% of what is expected to reach the target in 2015, with progress on MDG 5 (maternal mortality) being particularly slow. Human Immunodeficiency Virus (HIV)/Acquired Immune Deficiency Syndrome (AIDS), malaria and tuberculosis (TB) remain the major causes of mortality and morbidity in the region.

The ramifications of this poor health performance on household welfare, productivity and economic growth cannot be over emphasised. The SSA region is estimated to have the smallest Gross Domestic Product (GDP) per capita, relative to all other regions of the world. GDP per capita in purchasing power parity terms was about US$2362.90 in 2011 which was an increase from about US$1389.70 in 2000. The region also remains one of the poorest regions in the world with high rates of poverty and relatively more impoverished households. For instance the percentage of population in SSA living below US$1.25 and US$2.00 a day in 2010 was estimated to be 48.5% and 69.9%, respectively, higher than any other region of the world (World Bank, 2010).

Some researchers have noted that increasing public expenditure on health may not mitigate the health challenges in SSA (Gupta et al. , 2002). For instance the WHO (2012) noted that high or low levels of health funding might not translate into improved health outcomes but rather efficiency and equity in the use of these resources. Significant inefficiencies in public expenditure on health have been recorded not only in advanced economies but also emerging and developing ones (Gupta et al. , 2002, Herrera and Pang, 2005, Jayasuriya and Wodon, 2003). Grigoli and Levy (2012) argued that reducing the considerable waste that emerge from the inefficiencies will be crucial in improving health indicators. This is even more important in resource poor regions such as SSA.

The purpose of this study, therefore, is to examine the relationship between health expenditure and health outcomes and evaluate the efficiency of public expenditure on health in SSA.

1.3 Research questions

The following research questions were answered;

i. Does public and private health care expenditure influence health outcomes differently?
ii. Are health systems efficient in the use of health care resources?
iii. What factors influence efficiency levels of health systems?

1.4 Objectives of the study

In general, the study examined the relationship between health outcomes and health care expenditure in SSA and to estimate the efficiency of health systems in the region. The specific objectives of the study were to:

i. investigate the differential effects of private and public health care expenditure on health outcomes;
ii. compare health systems efficiency in the use of health care resources across countries in SSA; and
iii. identify factors that influence health systems efficiency.

1.5 Significance of the study

In general, the study contributes to the global call to improve the performance of health systems in the use of resources devoted to the health sector. The study identifies inefficiencies (wastages) that exist across health systems in SSA and possible factors that may be responsible for these inefficiencies. Such information is critical to policy makers who seek to boost the much-needed improvement in health outcomes across the region.

Specifically, the study contributes to existing literature in three different ways namely; theory, methodology and empirical evidence. In terms of theory, the study deviates from the usual application of the Grossman (1972) model as a demand for health model to a health production model. The study explored the investment components of the Grossman (1972) model at an aggregate level. The study also contributes to the theoretical framework of health production function at the national level by disaggregating the components of health expenditure into public and private.

In terms of methodology, a significant contribution of the current study lies in the estimation of national health system efficiency. Contrary to the common practice of only using non-parametric methods such as the Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) in efficiency estimation (Hollingsworth and Parkin, 1995, Gupta et al. , 2002, Alexander et al. , 2003), the current study used stochastic frontier methods which allows for the control of diverse set of factors that influence health outcomes. The study also goes further to control for unobserved heterogeneity, which may otherwise bias the efficiency estimates, using the 'true' random effect frontier model. Several time varying frontier models were also estimated and compared to allow for rigorous robustness check. Other studies like Hernandez de Cos and Moral-Benito (2011) also used the stochastic frontier technique but did not control for unobserved heterogeneity.

In terms of empirical contribution, the current study deviates from existing literature in several ways. First, the current study estimates the effectiveness with which health sector resources are used to generate health for the population, with particular focus on the health care system as a whole. This approach is distinct from the common practice of estimating efficiency of specific components of the health care system such as efficiency of the hospital sector (Hollingsworth and Parkin, 1995, Parkin and Hollingsworth, 1997, Grosskopf and Valdmanis, 1987)[3].

Secondly, the efficiency in the current study used both monetary and physical inputs of the health care system. This improves upon existing studies that have exclusively either used monetary inputs (Alexander et al. , 2003, Evans et al. , 2001) or physical inputs (Bhat, 2005, Parkin, 1991). The use of both inputs in the current study allows for further robustness check of the efficiency estimates.

The third and final empirical contribution of the current study emerges from the introduction of lag effects in the estimation of the relationship between health care spending and health outcomes. Previous studies have ignored the possibility of lag effects in estimating this relationship (Akinkugbe and Mohanoe, 2009, Anyanwu and Erhijakpor, 2009, Gupta and Verhoeven, 2001). For instance, Gupta and Verhoeven (2001) acknowledged that there could be lags between spending and its effects on outcomes, however, they fail to address this problem.

[3] Studies on hospital efficiency in SSA include Kirigia et al. (2010); Kirigia and Asbu (2013) and Tlotlego et al. (2010)

1.6 Scope of the study

The scope of the current study is focused on 45 SSA countries over a period of 15 years, from 1995 to 2010. The choice of this scope is largely due to the availability of data and to enhance the performance of the panel data econometric analysis. A sub-sample of countries in SSA was also selected to allow for a detailed comparison and analysis of the performance of health systems. A minimum of two countries from each sub-region (western, eastern and southern Africa) were selected. The selected countries include Ghana, Nigeria, South Africa, Tanzania, Benin, Malawi and Kenya. Nigeria and South Africa were selected for their size and economic influence in the region. Ghana, Tanzania, Benin, Malawi, and Kenya all recorded per capita public expenditure on health below the regional average.

1.7 Organization of the study

This study is organized into six main chapters. Chapter two contextualizes the study by providing a detailed background analysis of the situation of health spending and outcomes in SSA. Trends and patterns of key indicators of the health systems in the region are also presented and discussed. Chapter three reviews the theoretical, methodological and empirical literature related to the study. The theoretical framework and methodology are presented in Chapter four. Chapter five presents the results and a discussion of the results. Chapter six contains a summary of major finding, conclusion and recommendations.

CHAPTER TWO

BACKGROUND

2.0 Introduction

This section presents background information on health care expenditure and health outcomes in SSA. The section compares the performance of these indicators to other regions of the world and the world average. Individual country comparisons within the SSA region are also presented in the section.

2.1 Overview of health systems in SSA

Before the global economic meltdown in 2007/2008, efforts towards the improvement of health in SSA received much attention from the international community with funding to combat health problems which kept rising steadily. Evidence of improved health was recorded in Uganda and Tanzania (Bryan et al. , 2010).

In spite of these progress, many other countries in the region have struggled to show improvement in health status with diseases such as Malaria, HIV/AIDS and Tuberculosis still having devastating effects on a vast majority of the population in SSA. This has led to a call to improve the health systems in SSA countries by ensuring efficiency in the operations of the systems and addressing the challenges faced by the health systems.

Health systems are generally considered as a means to achieve the goals of improved health through organizing, financing and ensuring the quality of health services. The health system of any country therefore plays a critical role in ensuring the success of health interventions, both curative and preventive. For instance, while several local efforts and interventions are being made to reduce the burden of malaria, HIV/AIDS etc. in SSA, the outcome of these interventions largely hinge on the performance of health systems in the region.

The world economic outlook report (Neelam, 2007) argues that majority of the health problems facing SSA could be avoided with a well functioning, efficient and effective health care system. Indeed, questions about who pays for health, how much do they pay, where is money spent, who delivers health services and how good are services delivered, characterize the performance of the health system in SSA.

Health systems in the region are typically structured in a pyramid with highly skilled, specialized facilities at the top of the pyramid and forming a small proportion of service delivery. Ideally, these facilities serve as the highest level of referral with capacity to treat complicated health problems. They are also usually owned by the government due to the high cost involved in their operations. Aside national health facilities found at the top of the pyramidal structure of the health system, there are also specialized referral or teaching hospitals that provide complex health care requiring advanced technology and highly skilled personnel. It is also worth noting that some of these facilities are owned by faith based organizations in some countries such as Tanzania (Kwesigabo et al. , 2012).

Immediately following the tertiary facilities are the secondary facilities which include regional and district health facilities. The secondary facilities are expected to serve as referral centres for facilities in the bottom part of the pyramid. The range of services provided at the regional level are similar to those at the district level in many ways except that the regional facilities are usually larger and offer more specialized care. The primary health facilities which form the largest number of facilities in most countries in SSA provide the very basic health services at affordable cost. These facilities are usually found in rural and deprived communities to improve health care service access and utilization. In most countries, improving primary health care is considered to be a critical step in reducing mortality and morbidity.

Sub-Saharan Africa remains one of the most burdened regions in terms of communicable and non-communicable diseases and health in general. This explains the significantly high maternal and child mortality rates as well as crude death rates in the region, relative to all other regions in the world. It is reported that communicable diseases alone accounted for about 798 age-standardized deaths per 100,000 population in 2008. Similarly, non-communicable diseases accounted for 779 deaths per 100,000 population. These statistics are above the global average 230 and 573 deaths per 100, 000 population caused by communicable and non-communicable diseases respectively (WHO, 2013).

Mortality among children in the region are mainly caused by Diarrhoea (11% in 2010), Malaria (15% in 2010) and Pneumonia (17% in 2010). In the case of adults, the highest ranked causes of death in the SSA region include HIV/AIDS (139 deaths per 100,000 population 2011), malaria (72 deaths per 100,000 population in 2010) and tuberculosis (26 deaths per 100,000 population in 2011). These statistics are higher than the world average and any other region of the world (WHO, 2013).

In addition to the high disease burden in the SSA region, the region also lacks health workforce and infrastructure necessary to improve the health status of the population. The region is faced with the problem of "brain drain", where trained health workforce leave for greener countries in other developed regions of the world. Between 2005 and 2012, an average of 2.5 physicians and 9.1 nurses/midwifery personnel per 10,000 population were recorded in the SSA region. These statistics significantly fall short of the world average of 13.9 physicians and 29.0 nurses/midwifery personnel per 10,000 population.

While the above provide a picture of the health system in SSA, similar situations prevail in most of the countries in the region. The following section provides brief description of the health system in selected countries across sub- regions in SSA.

Benin

With a population growth rate of about 3.25%, Benin is considered to have very decentralised health system. There is a relatively good coverage as far as health care facilities are concerned with about 77% of the population living within 5km of health facility, even though only 45.4% utilize health facilities. The main reason advanced for the low utilization include the high cost of health care. National health insurance is highly underdeveloped in Benin with most people having to pay for health care services directly out of pocket. The African Development Fund (ADF) health system development project identifies some cultural factors as limiting the utilization of health facilities in Benin. These include the high rate of self-medication and preference for traditional medicines. About 32% of health sector funds in Benin are also reported to come from the community.

The country experiences a high disease burden with communicable diseases accounting for over 70% of deaths. The main diseases considered to be public health problems include malaria, respiratory infections and HIV/AIDS.

Benin's health system mainly comprise health districts, numbering about 34, even though about half are functional. These facilities are however greatly challenged by the lack of qualified health staff and their uneven distribution across districts. Present reforms aimed at improving the performance of the health system is directed towards decentralization and downsizing directorates from the central level through to the district level. Efforts to improve health service delivery and utilization include the introduction of the universal health insurance system and free child and maternal health care in the treatment of malaria.

Ghana

The organization of health care delivery in Ghana can be categorised into four systems. These are the public, private-for-profit, private-not-for-profit and traditional systems. The traditional system is still not recognized in the country even though stringent efforts are being made to factor it into the main stream delivery system (Abor et al. , 2009). The public health care delivery systems are owned and financed by government and include regional, district and primary health posts. The private not-for-profit facilities include missionary delivery facilities whose main objective is not to make profit but to deliver health care.

The governance structure of the health system in Ghana is in three levels: the National, Regional and District. These are further divided into five functional levels of National, Regional, District, sub-District and Community levels. The structure comprises 10 regional health administrations, 8 regional hospitals, 110 district health administrations and 95 district hospitals (Ghana Health Service, 2010). The headquarters of health system administration in Ghana is the Ghana Health Service (GHS) and is in charge of transport, equipment, infrastructure etc. The activities of the various organs under the GHS are co-ordinated and administered by the GHS council supervised by the Ministry of Health

(MOH). The MOH is responsible for policy planning process and information management, particularly concerning the areas of finance, human resources and infrastructure.

In the bid to achieve universal health coverage and improve population health status, Ghana started a national health insurance scheme in 2004 through which the public health care system is operated. As at 2010, the scheme recorded about 66.4% of the population having registered with about 59.5% being card bearing members. The total active membership was reported to be 53.6% of the population. It must be mentioned that Ghana remains one of the very few countries with a fully operational national health insurance scheme in SSA.

While the public health care system permits the operations of insurance schemes such as district-wide mutual health insurance schemes, private mutual and private commercial insurance schemes, only the district-wide mutual insurance schemes are financed by the national health insurance scheme.

In terms of disease burden in Ghana, like in several other African countries, include Malaria, HIV/AIDS, diarrheal diseases, lower respiratory infections and perinatal conditions. For instance, the Ghana health service annual report shows an upward trend in malaria fatalities from 1.22% in 2009 to 1.44% in 2010. About 2.9% of pregnant women who were tested were also found to HIV positive.

The health system in Ghana faces major challenges that are considered as hindrances to the achievement of the health related MDGs. These challenges include the inefficient use of health resources, lack of infrastructure and human resources. Other important factors that limit the performance of the health system in Ghana include nepotism, favouritism and corruption.

Kenya

The Kenyan health system, like many other health systems in the SSA region operates a top-down system with the ministry of health being the top most institution. There is a regional distribution of health facilities with the most sophisticated available only at the national level (Wamai, 2009). At the top of the health service delivery spectrum is the national, referral and teaching hospitals such as the Kenyatta national hospital in Nairobi. This is followed by the provincial hospitals, sub-district hospitals, health centres and dispensaries and at the bottom are the community health organizations (Turin, 2010).

The health sector comprises of the public system with the Ministry of health and other parastatal organizations being the major players. The private sector comprises non-governmental organizations (NGOs) and faith based organizations (FBOs) operating a combined 15% (13% FBOs and 2% NGOs) and private-for-profit health institutions which operates 34% of all facilities. The NGO facilities have the best balance of care and cost. There are also efforts towards a sector-wide approach in health care delivery where public, private-not-for-profit (NGO/FBO) and private-for-profit health facilities are unified.

Like other countries, Kenya's Ministry of Health is at the top of the health system governance structure with responsibility of supervision, policy formulation, mobilization of resources etc. There are eight other provinces divided into lower levels of administration called districts. The districts deliver health services and implement health programmes. Management of health care at the district level is headed by a District Medical Officer of Health (DMOH) appointed by a District Health Management Board (DHMB) comprising officials appointed by the MOH and from local areas, and a professional unit, the District Health Management Team (DHMT). The DHMT prepares technical advisories and the District Health Plan in consultation with local health actors and the DHMB (Wamai, 2009).

The challenges of the health system in Kenya are similar to those of other countries in the region. The country's health system is faced with high burden of communicable and non-communicable diseases. Health service utilization remain low with varying degree of inequalities. The system is also faced with inadequate health infrastructure, human resources and other health inputs (WHO, 2009).

Malawi

The health care system in Malawi comprises the provision of health care services by three main organizations: The ministry of health, the Christian Health Association of Malawi (CHAM) and the ministry of local government. Other private institutions also play part in the health service delivery system. Health care delivery is generally done at three (3) levels.

The primary level, which is the lowest in the hierarchy, is mostly delivered through rural hospitals, health centers, health posts, outreach clinics etc. The secondary health facilities mainly comprise district hospitals and CHAM facilities and they serve as referral facilities for the primary level facilities. The tertiary level provide services similar to those of the secondary level but with some range of specialist interventions (Chirwa, 2010).

The Ministry of Health in Malawi sets the agenda for health in collaboration with stakeholders. It is responsible for developing, revising and enforcing health policy, spearheading sector reforms, developing and revising standards and communicating with lower levels, planning and mobilization of health resources, providing technical support for supervision, coordinating research and monitoring and evaluation. The MOH has established five zonal offices, whose role is to provide technical support to District Health Management Teams (DHMT) in the planning, delivery and monitoring of health service delivery at the district level and to facilitate central hospitals' supervision of districts (Government of Malawi, 2011).

The private health sector in Malawi plays an instrumental role in the delivery of health services. The biggest and most recognised private not-for-profit health service provider in Malawi is the CHAM. The organization owns 11 out of the 166 health training facilities, mostly located in rural areas. There also exists a partnership between the private non-profit providers and the government to improve health care delivery at the lowest possible cost. Supports from the government include subsidies by financing some essential medicines and all local staffing cost in CHAM facilities.

Traditional medicines, even though very prominent in Malawi, is not fully recognized by the government. There exists a weak relationship between the Ministry of health and the traditional healers. However, there has been efforts to engage traditional birth attendants (TBAs) with an intention to make maternal and child health care services available at the community level.

HIV/AIDS and TB remain major public health concerns in Malawi. Malaria also pose huge challenge to efforts at improving the population health status. With national health insurance systems largely unavailable in Malawi, health care cost poses major constraints to health care utilization in the country.

Nigeria

Health care delivery system in Nigeria is pluralistic with both orthodox and traditional providers operating alongside each other. Indeed this situation also prevails in many other countries in SSA. Orthodox health care delivery is provided by both the private and public sectors. Statistics from the Federal Ministry of Health (FMOH) suggest that the private sector own 38% of the health facilities in Nigeria and provide about 60% of health services in the country (FMOH, 2010).

Health care delivery in the country is performed in three tiers with each associated administrative level of government. Starting from the lowest to the highest tier of health care delivery, the primary care services, mainly located in local government areas, are largely responsible for primary health care services with support from the state ministry of health and the federal government (National Agency for Control of HIV/AIDS, 2011). The secondary care level is the second in the bottom-up hierarchy and is largely responsible for providing care to patients referred from the primary care level. The state governments are responsible for secondary care services. The highest level of health service delivery is the tertiary level which provides highly specialized services to patients referred from the primary and secondary facilities. Operating these tertiary level facilities lies on the shoulders of both the state and federal governments (Ademiluyi and Aluko-Arowolo, 2009).

In a similar fashion, the health system governing structure in Nigeria is also decentralized into three tiers with responsibility at the federal, state and local government levels. All three tiers to some extent, are involved in functions of the health system, stewardship, financing as well as service delivery. The FMOH is charged with the responsibility of policy and technical support to the overall health system, international relations on health matters, the national health management information system and the provision of health services through the tertiary and technical hospitals and national laboratories. The State Ministry of Health (SMOH) is responsible for secondary hospitals and for the regulation and technical support for primary health care services. The local government level of health administration in

Nigeria is equivalent to the district level in other countries and is mainly responsible for primary health care.

It is reported that out of the 23,640 health facilities in Nigeria, 85.8% are primary health care facilities, 14% are secondary and 0.2% are tertiary. About 60% of the primary health care facilities are located in the Northern zone of the country (FMOH, 2010). Traditional health care delivery, like in many other countries in SSA is not given much attention in Nigeria. This type of health service is, however, profound in Nigeria and dates as far back as pre-colonial era before the introduction of orthodox systems. It is predominant among the poor and mostly in rural countries (Ademiluyi and Aluko-Arowolo, 2009).

The Nigerian health system continues to face the challenge of large population pressure making the system over stretched. Inadequate and decay of health facilities and equipments also pose challenges to the system. The emigration of trained health professionals to seek greener pastures coupled with unequal distribution of health facilities and personnel across the country has retarded progress in the health system over the years (FMOH, 2010).

National health insurance in Nigeria is largely under developed, as is the case in many other countries in the region. A national health insurance scheme (NHIS) was established in 1999. While the scheme was mandated to offer universal health coverage by 2015, it has very low coverage with about 98% and 97% of women and men without coverage, respectively (National Population Commission, 2008).The main diseases that pose threat to public health include malaria and HIV/AIDS. Malaria is estimated to contribute up to 11% of maternal mortality, 25% of infant mortality and 30% under-five mortality in Nigeria. HIV prevalence increased from 1.8% in 1991 to 4.6% in 2008 (National Population Commission, 2008).

South Africa

The health delivery system in South Africa comprises both public and private health care facilities. Services delivered varies from basic primary health care provided by the state without any charge to specialized health services available in both public and private health facilities. The public sector is usually stretched and underfunded in most places across the country. The public sector has a daunting task of providing health care services to about

80% of the population. The private sector on the other hand operates largely on commercial lines and only attract middle and high income earners due to the high cost involved. The private sector also attracts most of the countries health professionals.

The health system governing structure, even though complex in South Africa can be categorised into Central or Federal, Provincial and Local levels (the first second and third tiers of government, respectively). The organization structure is more decentralized and participatory at the lowest levels. The department of health at the Federal level tops the governing structure and is responsible for policy formulation, service coordination etc. The second tier of government (Provincial Departments of Health) comprise departments of hospitals and services, one for each of the provincial administrations. They are largely responsible for operational decision making in health care delivery and finance. They also provide hospital and primary health care. The third tier of government comprises a complex array of local authorities, management committees, boards and regional service councils. They are responsible for preventive, promotive and rehabilitative services with particular emphasis on communicable disease control and environmental health services.

Before the first democratic elections, the South African health care system faced huge fragmentation and inequality with the white communities having the best of health care facilities. Hospitals were assigned to particular racial groups and most were concentrated in white communities. While several efforts have been made to change the situation over the years, the burden of care provision lies on the state due to the high levels of poverty and the absence of a well functioning national health insurance system.

There are approximately 4200 public health facilities in South Africa with an estimated 13, 718 people per clinic. Health care utilization has remained low in the country with an estimated average of 2.5 visits per year to public health facilities which serve the majority of the population. Health insurance in South Africa is mainly available in the private sector with various forms of managed care. Plans are well advanced to operationalize national health insurance scheme to cover all South Africans.

The major challenge of the South African Health system is the prevalence of HIV/AIDS, tuberculosis and other poverty related diseases such as cholera. Unlike other countries in the

SSA region, malaria is not endemic in South Africa with over 90% of the population living in malaria free areas. The system also faces a challenge of erasing inequality in the access and utilization of health care with physicians, hospitals and pharmacists concentrated in the wealthier provinces.

Traditional medicine plays an important role in the South African health care delivery system. It is estimated that about 80% of South Africans consult with traditional healers alongside general medicine practitioners. In this regard, several efforts have been made to improve services of traditional healers including the funding of the traditional medicines research unit.

Tanzania

The health system in Tanzania is organized into three broad categories. Primary health care services are found at the lowest level and are usually made up of public and private health care providers. The regional health services are in the middle with the national services being the highest level of health service delivery (Kwesigabo et al. , 2012).

There exist a total of 4679 dispensaries, 418 health centres, 18 regional facilities, 55 district facilities and 8 consultancy and specialized facilities (Musau et al. , 2011). Access to health care facilities has improved over the years with about 90% of the population living within 5kms of primary health care facilities. This is attributed to efforts by the government to build enough facilities for easy access of health services.

In Tanzania, the key responsibility of health system administration lies in the hands of the Ministry of Health and Social Welfare. The Ministry oversees aspects of the health system such as policy formulation, resource mobilization, management support to national, referral and specialist hospitals, public health interventions, research, supervision and training of health professions. However for effective service delivery, the Ministry relies on Local Government Authorities to implement new policies, allocate resources, deliver health services and provide health data. The delineation of responsibilities between the Ministry and Local Government Authorities in Tanzania increase complexities for the Ministry in overseeing effective service delivery and consistent policy implementation. New Local

Government Reform Programmes are aimed at eliminating bottlenecks and improve co-ordination.

Health service utilization and access in Tanzania is characterised by user fees and exemptions. Public health facilities charge user fees that contribute towards the cost of care but several groups are exempted from paying fees including children under five, pregnant women, people below some income levels, the elderly and those covered under vertical programmes like TB, HIV/AIDS and diabetic patients.

There exists a national health insurance fund in Tanzania with clients and their employees contributing through their payroll taxes. These clients are not required to pay for health services with cost of services reimbursed by the National Health Insurance Fund (NHIF). The fund however faces challenges such as over use (moral hazard) and late reimbursement.

Traditional health care seems to be profound in Tanzania mostly in rural areas. It is reported that about 60% of all those seeking health services depend on some traditional health services and that about 53% of deliveries take place at home, mostly with traditional birth attendants (Kwesigabo et al. , 2012).

Summary of health system indicators

Table 2.1 below shows a summary of selected health system indicators for the countries above. Statistics on health system supply side indicators such as availability of health facilities and health workforce are shown in the table. Also demand side health indicators such as Malaria, TB and HIV prevalence are also reported. As mentioned earlier, these three diseases have been identified to pose significant challenge to health systems in SSA. The statistics on health facilities confirm the pyramid hypothesis where primary health care facilities compose the largest, followed by secondary and then tertiary facilities. Nigeria has the largest number of facilities at all levels followed by South Africa at the secondary and tertiary levels. Ghana has the lowest secondary and tertiary health care facilities.

In terms of health workforce, South Africa dominates with significantly higher Physician (7.8) and Nurses/Midwives (49.0) population. All the other countries fall short of this with Nigeria recording physician population of about 4.3 per 10,000 population and about 16.0

Nurses/Midwives per 10,000 population. A striking observation is that Benin, Tanzania and Malawi have relatively very low physician population. In particular, Tanzania and Malawi also have significantly low Nurses/Midwives population. The statistics generally show enormous limitation in terms of health workforce across these countries. This is also reflective of the situation in most countries in the SSA region.

Table 2.1. Summary of health system indicators for selected countries

Country	Public health facilities			Health workforce		Major disease prevalence		
	Primary	**Secondary**	**Tertiary**	**Nurses/Midwives**	**Physicians**	**HIV**	**Malaria**	**TB**
Benin	491	39	5	7.7	0.6	1.1	1 151 038	3 966
Ghana	1213	12	3	9.3	1	1.4	8 774 516	14 753
Kenya	1976	132	7	7.9	1.8	6.1	5 788 381	92 987
Malawi	259	23	5	3.4	0.2	10.8	3 659 565	20 335
Nigeria	21832	1569	73	16.1	4.3	3.1	2 087 068	92 818
South Africa	3493	315	10	49	7.8	17.9	6 846	323 664
Tanzania	3924	95	9	2.2	0.1	5.1	2 441 750	62 178

Source: Various country health statistics reports

Note: 1. Density of health workforce is measured per 10,000 population (2006-2013)
2. Malaria and TB prevalence are measured in number of reported cases, 2012
3. Prevalence of HIV is measured in percent of population ages 15-49 (2012)

In terms of disease prevalence, Table 2.1 shows that while the three diseases are common across different countries, the prevalence of specific diseases are peculiar to countries. As expected South Africa recorded significantly low cases of Malaria since the country is considered to have unfavourable climatic conditions for the spread of the disease. The country however recorded significantly high HIV and TB prevalence. Relatively high malaria cases were recorded in Ghana followed by Kenya and Malawi. Malawi also recorded relatively high (10.8%) HIV prevalence rate while Benin recorded the lowest (1.1%) HIV prevalence rate among these countries.

2.2 Health care expenditure

Table 2.2 presents the pattern and trend in the performance of health care expenditure across regions of the world and the world average. The statistics show that, relative to all other regions of the world, with the exception of Middle East and North Africa (MENA), SSA spends the lowest on health as percentage of Gross Domestic Product. Total health expenditure as percent of GDP increased in SSA from 5.9 in 2000 to 6.4 in 2011, relative to the world average of 9.2 to 10.1, North America (from 13.1 to 17.1), Organization for Economic Co-operation and Development (OECD) (from 10.0 to 12.3), MENA (from 4.6 to 4.8) and East Asia and Pacific (EAP) (from 6.6 to 6.8).

Further, public health expenditure as percent of GDP in 2011 was 2.9% for SSA relative to the world average (6.0%), North America (8.2%), East Asia and Pacific (4.6%). Similarly, private health expenditure as percentage of GDP was 3.6% for SSA, which suggests poor performance against the world average (4.1%), East Asia and Pacific (2.2%) and North America (9.0%) in 2011. This suggests that health related expenditures still remain major concerns in developing regions like SSA (Table 2.2). It is worth noting that, relative to other regions of the world, only SSA and North America has private health expenditure as percentage of GDP higher than public health expenditure. All other regions have greater share of their public health expenditure sources relative to private sources.

Table 2.2. Health care expenditure trend across regions of the world

	Total health expenditure(% of GDP)			**Public health expenditure (% of GDP)**			**Private health expenditure (% of GDP)**		
	2000	**2005**	**2011**	**2000**	**2005**	**2011**	**2000**	**2005**	**2011**
East Asia & Pacific	6.6	6.7	6.8	4.7	4.6	4.6	1.8	2.1	2.2
Middle East & North Africa	4.6	4.3	4.8	2.6	2.5	2.8	1.9	1.9	1.9
North America	13.1	15.3	17.1	5.8	7.0	8.2	7.3	8.3	9.0
OECD	10.0	11.3	12.3	5.9	6.8	7.6	4.1	4.5	4.8
Sub-Saharan Africa	5.9	6.7	6.4	2.4	2.7	2.9	3.5	4.1	3.6
World	9.2	10.1	10.1	5.3	5.9	6.0	3.9	4.2	4.1

Source: Authors compilation from World Development Indicators (WDI) dataset (2012)

Table 2.3 presents a summary of per capita and out-of-pocket health care expenditure across various regions in the world. The statistics show that sub-Sahara Africa spends the lowest on health care expenditure per capita. While health care expenditure per capita in the Middle East and North Africa was US$602.8 in 2011, health care expenditure per capita was US$154.6 in SSA. This marks an increase from US$79.4 in 2000 but significantly falls short of the world's average of US$1026.5 in 2011 (Table 2.3). Health expenditure per capita is highest in the North American region with an increase from US$4,488.7 in 2000 to US$8,200.5 in 2011. The differences in the level of spending may be explained by the fact that most countries in the SSA region face limited government budget. Several countries depend mainly on external aid which is burdened by demands from many other sectors of the economy.

Table 2.3. Out-of-pocket and per capita health care expenditure across regions of the world

	Out-of-pocket health expenditure (% of total expenditure on health)			Per capita health expenditure (PPP)		
	2000	**2005**	**2011**	**2000**	**2005**	**2011**
East Asia & Pacific	22.8	25.2	25.3	260.0	374.3	448.8
Middle East & North Africa	38.8	36.0	33.7	295.5	392.8	602.8
North America	14.6	13.3	11.5	4488.7	6404.4	8200.5
OECD members	15.6	14.9	13.9	2387.6	3302.3	4419.4
Sub-Saharan Africa	30.5	34.1	29.8	79.4	115.7	154.6
World	18.3	17.8	18.0	570.7	785.1	1026.5

Source: Authors compilation from WDI dataset (2012)
Note: PPP is purchasing power parity in constant 2005 international dollars

Out of Pocket health care expenditure as percentage of total health care expenditure decreased in SSA from 30.5% in 2000 to 29.8% in 2011, relative to the world average with a decrease from 18.3% in 2000 to 18.0% in 2011. This value is higher than North America (11.5%), OECD (13.9%) and East Asia and Pacific (25.3%). SSA however performs better than the MENA (33.7%). Out of pocket health care expenditure becomes a source of worry in regions where poverty levels are very high with significantly impoverished population and relatively harsh economic conditions. Increasing direct health care spending will only worsen population welfare and increase poverty.

While health care expenditure was relatively low in SSA compared to other regions of the world and the world average, health care expenditure differs across individual countries in the region. Figure 2.1 and Appendix B1 shows the pattern and trend in per capita health care expenditure.

Figure 2.1 suggests that per capita health care expenditure differs less across majority of the countries in the SSA region. In 2011, most countries in the region recorded less than US$200 per capita health care expenditure. Equatorial Guinea had the highest per capita health care spending of about US$1642.7 in 2011. Seychelles recorded the second highest per capita health care expenditure of about US$989.4 followed by the Republic of South Africa with per capita health care expenditure of about US$942.5 in 2011. Mauritius and Botswana also recorded relatively better performance with per capita health care expenditure of about US$842.0 and US$734.1, respectively.

Countries that recorded significant low per capita health care expenditure include Eritrea, Ethiopia, Democratic Republic of Congo, Central African Republic etc. (Figure 2.1). Eritrea recorded the lowest per capita health care expenditure in SSA in 2011 with about US$17.0 followed by the Central African Republic (US$30.9) and Democratic Republic of Congo (US$32.1).

In terms of the trend in per capita health care expenditure, Figure 2.2 show that majority of the countries in SSA increased per capita health care expenditure between 2000 and 2011 while a few countries recorded reduction over the same period. Equatorial Guinea recorded the highest improvement in per capita expenditure from US$148.3 in 2000 to US$1642.7 in

2011, representing about 1007.6% increment. This is followed by Liberia with about 523.2% increase and Rwanda with about 444.0% increase over the same period. Sudan, Tanzania, Lesotho and Angola also performed relatively well with a 200% increase in per capita health care expenditure between 2000 and 2011.

Eritrea, Guinea Bissau and Sao Tome and Principe all recorded a fall in per capita health care expenditure between 2000 and 2011. For instance, per capita health care expenditure decreased from US$23.1 in 2000 to US$17.0 in 2011 in Eritrea, representing about 26.0% change. Similarly, Guinea Bissau recorded per capita health care expenditure of US$73.9 in 2011 which marks a reduction from US$97.3% in 2000. This shows a percent change of about 24.1. Sao Tome and Principe saw a reduction in per capita health care expenditure of about 43% between 200 and 2011. Per capita health care expenditure in Sao Tome and Principe reduced from US$287.8 in 2000 to US$164.1 in 2011.

In comparing the public-private mix in health care expenditure, Figure 2.3 indicate that the public-private combination differ across countries in the region. While some countries show significant dependence on public health care expenditure, others show dependence on private sources of financing health care expenditure. Sierra Leone show the highest variation in public-private health care expenditure with private making up over 15% of the country's GDP while the public sector contributes about 5% of GDP to health care expenditure.

This is followed by Liberia where the private sector contributes about 13% of GDP in terms of health care expenditure while public health care expenditure makes up about 6% of GDP in 2011. Other countries that shows dominance of the private sector in terms of health care expenditure as percent of GDP include Democratic Republic of Congo, Cote d'Ivoire, Nigeria, South Africa, Sudan, Uganda, Burundi, Chad etc (Figure 2.3 and Appendix B2).

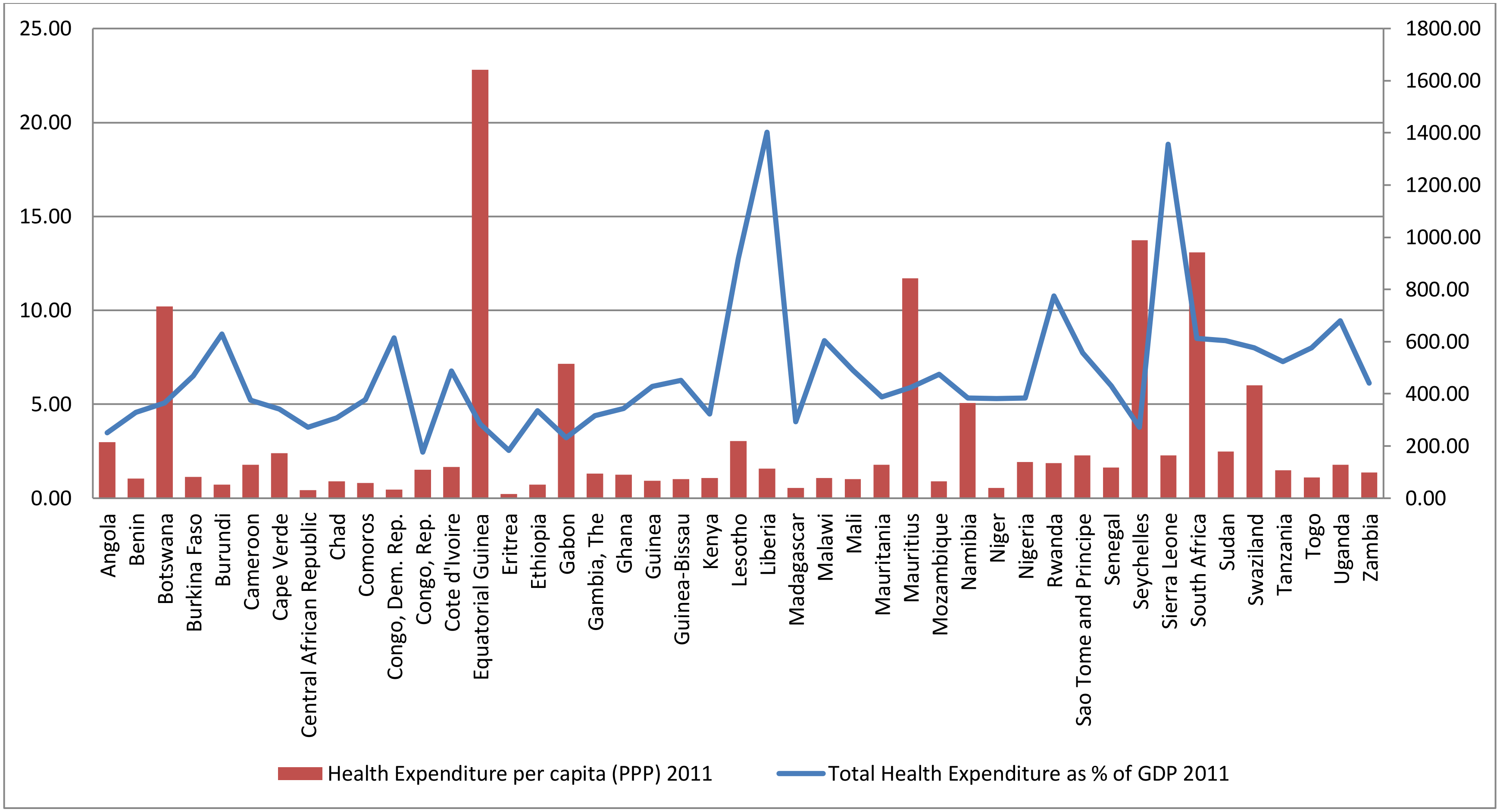

Figure 2.1. Health care expenditure per capita (PPP) and as percentage of GDP
Source: Authors compilation from WDI dataset (2012)
Note: PPP is purchasing power parity in constant 2005 international dollars

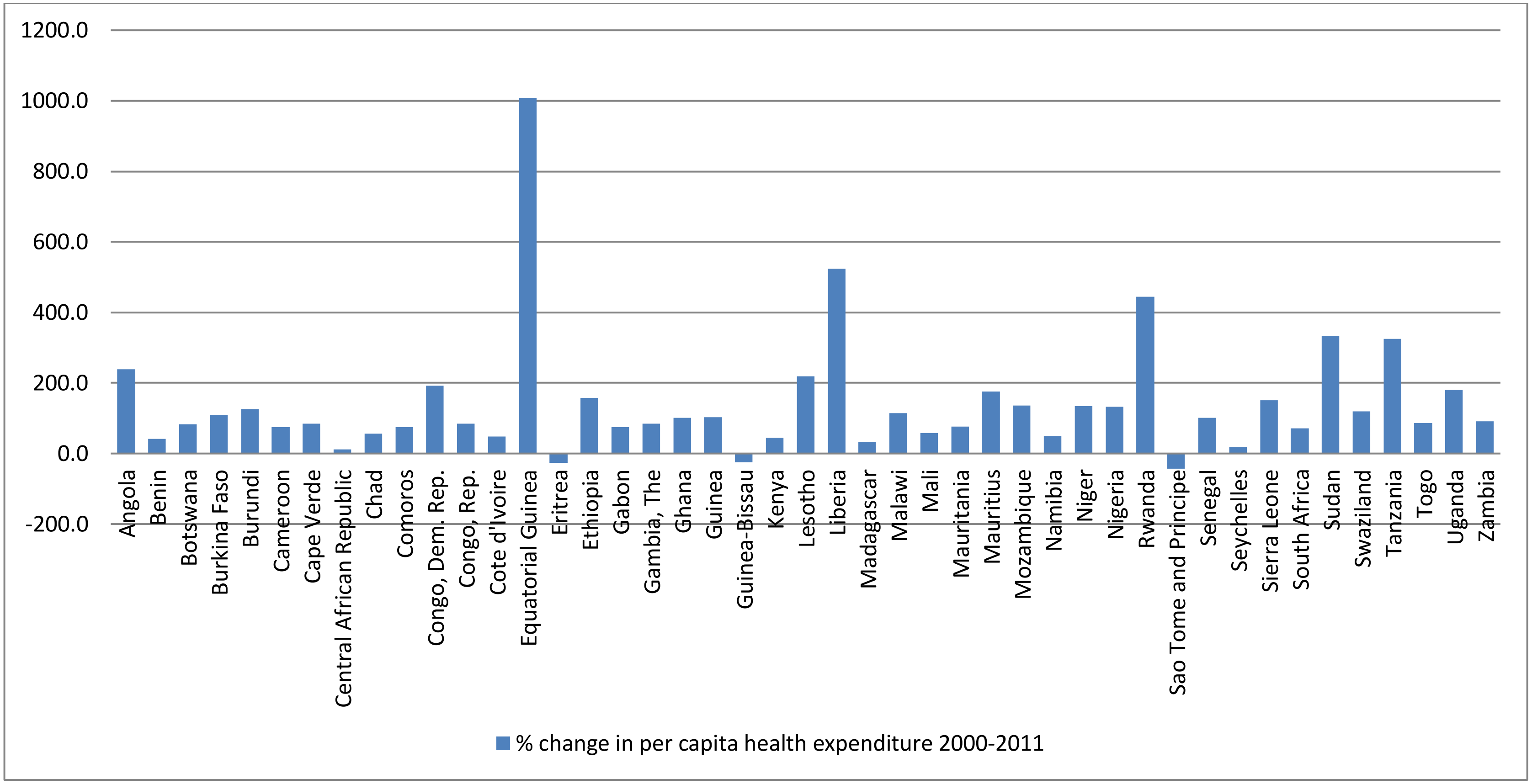

Figure 2.2. Percentage change in per capita health care expenditure (2000-2011)
Source: Author's computation from WDI dataset (2012)

On the other hand, Figure 2.3 shows that Lesotho had the most significant contribution of the public sector relative to the private sector. The public sector in Lesotho contributes about 9% of GDP to health care expenditure while the private sector contributes about 5% of GDP. This is followed by Malawi with a little over 6% of GDP from the public sector relative to about 2% from the private sector. Similar observations can be made in the case of Angola, Benin, Botswana, Equatorial Guinea, Gabon, The Gambia, Ghana, Namibia, Niger, Togo, Zambia etc. Burkina Faso recorded almost equal contributions from the private and public sectors with both sectors contributing about 3% of GDP apiece in terms of health care expenditure (See Appendix B2).

While there is no clear cut consensus about the optimal mix of public and private sources of health care expenditure, there seem to exist some level of bias towards increased involvement of the public sector in financing health care across countries. Indeed the popular theory of market failure suggests that the involvement of the public sector in the provision is inevitable due to the distinct characteristics of health care relative to other commodities on the market.

However, with recent calls on health systems to move towards attaining universal health coverage, the role of the public sector becomes even more important. This may be justified by the fact that the largely profit-oriented private sector may only increase health care cost and discourage universal health coverage. This may however not be the case in situations where not-for-profit organizations dominate the private sector of the health system, even though this is hardly the case in most health systems in SSA.

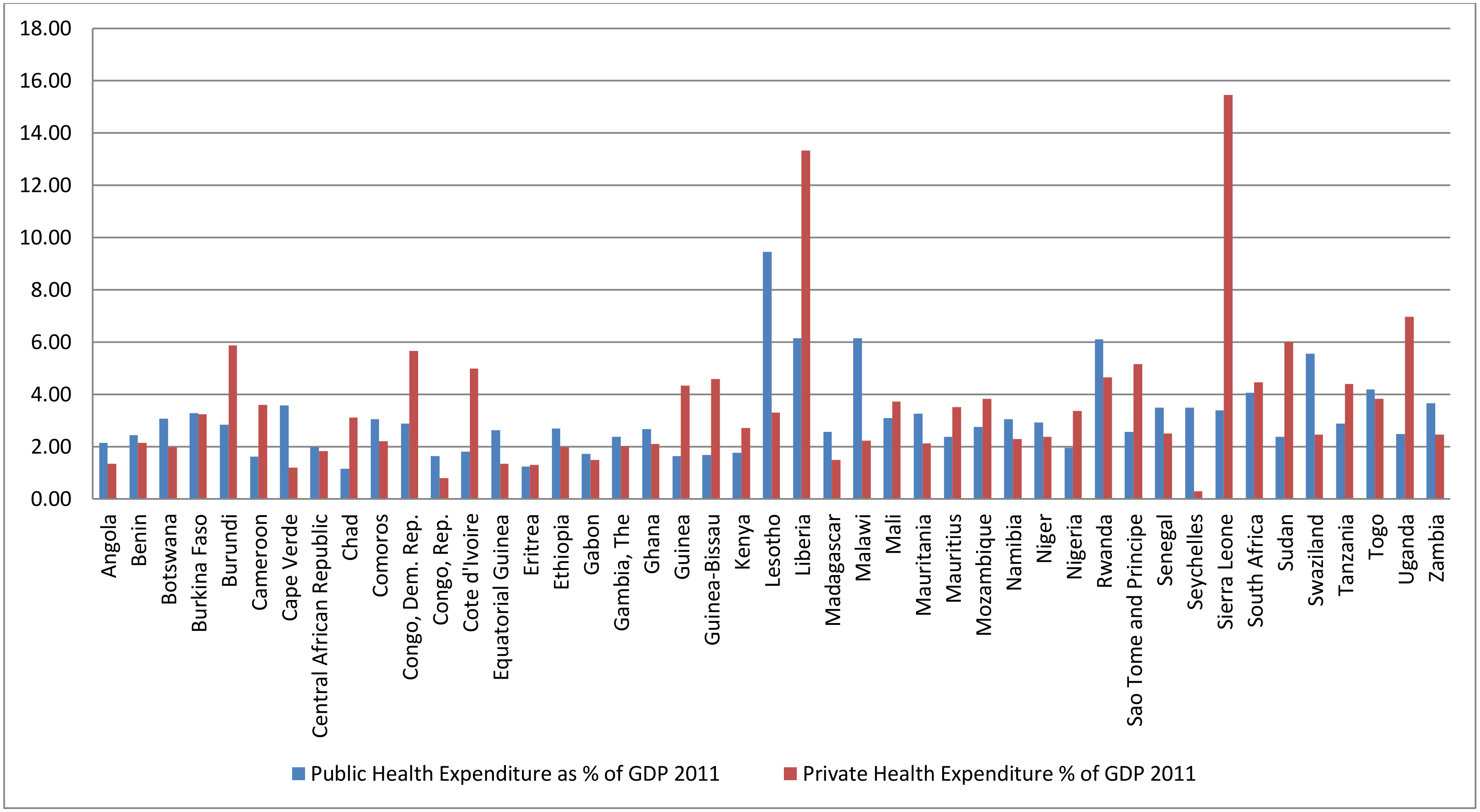

Figure 2.3. Public and Private health care expenditure as percent of GDP (2011)
Source: Author's compilation from WDI dataset (2012)

Figure 2.4 shows that out-of-pocket health care expenditure remains high in majority of countries in the SSA region as at the year 2011. This suggests that a large percentage of health spending is made directly from the pocket of individuals who seek health care, hence placing financial burden on these individuals. The high levels of OOP health expenditure in some of these countries suggests that there is still a long way to ensuring that individuals access the needed, quality health care without fear of financial ruins as a consequence. Health care financial protection, especially in favour of the poor, may not be guaranteed in such situations.

It can be observed from Figure 2.4 that some countries recorded significantly low OOP health care expenditure as percent of total expenditure on health in 2011. These countries include Botswana (4.97%), Madagascar (9.01%), Namibia (7.0%), Seychelles (5.4%) and South Africa (7.21%). This suggests that a very small proportion of health care expenditure is made out of pocket in demanding health care services (see Appendix B3).

On the other hand, countries like Sierra Leone, Sudan, Guinea, Cote d'Ivoire, Chad and Cameroon recorded significantly high OOP health expenditure as percent of total health care expenditure. For instance, in Sierra Leone, about 75% of total health care expenditure in the country was financed through OOP (see Appendix B3).

A widely accepted mitigating strategy for OOP health care expenditure and hence achieving universal health coverage has been the introduction of health insurance schemes. However, private health insurances schemes, in their bid to maximize profits, increase co-payments which in turn increases the financial burden on individuals. On the other hand, while cost containment efforts in public health insurance schemes may lead to some level of financial burden on individuals, it is considered as the most appropriate step in achieving universal health coverage.

It is however worth noting that public health insurance schemes are mostly poorly developed in SSA countries with few notable ones like the national health insurance scheme in Ghana. These suggest that there remain significant effort to be made in reducing OOP health spending and achieving universal health coverage.

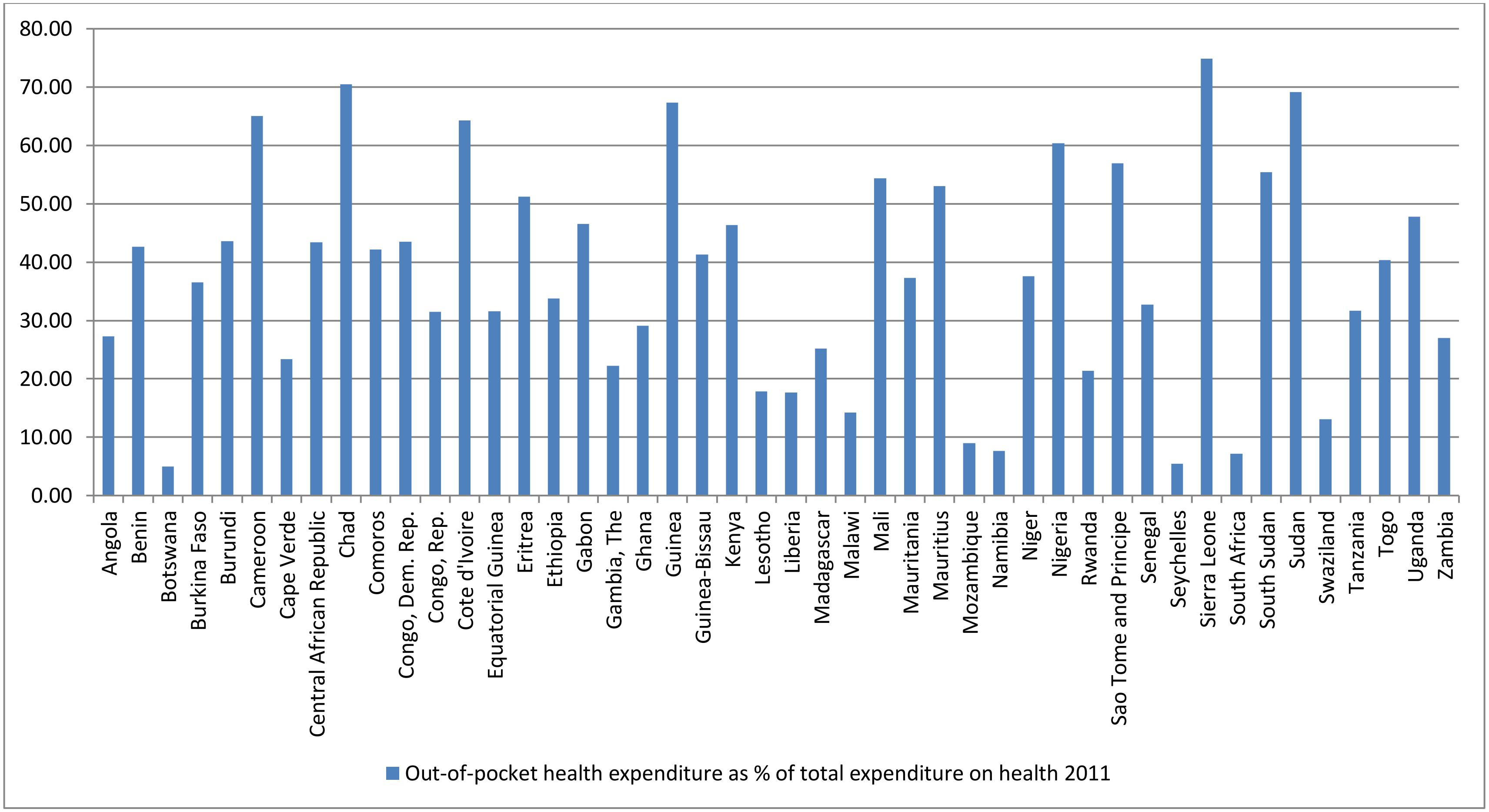

Figure 2.4. Out-of-pocket health care expenditure as percent of total expenditure on health (2011)
Source: Authors compilation from WDI dataset (2012)

2.2.1 Health care expenditure Performance on the Abuja Declaration

The Abuja Declaration highlights the outcome of a meeting of African heads of states held in Abuja, Nigeria in 2001, a year after the adoption of the MDGs. In this declaration, African heads of states pledged to commit at least 15% of their annual budgets to improve health expenditure. The primary objective of the meeting was to address the growing burden of HIV/AIDS, Tuberculosis and other related diseases through improved health systems across countries in the SSA region.

The level of public health care expenditure as percent of total government expenditure was used to show the commitment of SSA governments to the Abuja Declaration[4]. Figure 2.5 shows that in 2011, exactly 10 years after the declaration, only six (6) countries have attained the target of committing 15% of government expenditure to the health sector. These countries are Rwanda (23.8%), Liberia (18.9%), Malawi (18.5%), Madagascar (15.3%), Togo (15.4%) and Zambia (16.0%).

Other countries, even though have not reached the target, can be considered as being close to achieving the target with public health care expenditure as percent of total government spending above 10%. These countries include Benin (10.5%) Burkina Faso (12.8%), Central African Republic (12.4%), Ethiopia (14.6%), Lesotho (14.6%), Swaziland (14.9%) (see Table 2.6). The level of public health care expenditure as percent of total government in 2011 in some countries raises concern about the commitment of these countries to the Abuja declaration. These countries include Eritrea (3.6%), Chad (3.3%), Kenya (5.9%) etc (see Table 2.4).

Table 2.4 also shows some interesting trends in the performance of countries in achieving the target of the Abuja Declaration, Some countries that were meeting the target as at 2005 had reduced their health spending below the target by 2011. For instance, Botswana and Burkina Faso reduced their spending on health from 16.8% and 18.7%, respectively in 2005 to 8.7% and 12.8%, respectively in 2011. Ghana and Mozambique also had similar situations of meeting the target by 2005 but dropped out of the list of countries meeting the

[4] It's worth noting that while the Abuja declaration makes references to government budget, total government expenditure is considered more appropriate here

target in 2011. Special mention must be made of Mozambique whose public spending on health as percent of total government spending significantly reduced from 18.2% in 2005 to 7.8% in 2011. This may partially be explained by the economic crisis in 2008 which had significant impact on government budgets. The country has however initiated a number of reforms to improve expenditure in the health sector. This include a new Health Sector Strategic Plan (2014-2019) which focuses on seven strategic objectives and is based on principles of primary health care, equity and better quality of services.

Furthermore, even though some countries achieved the target in 2011, there was a reduction in public health care spending as percent of total government expenditure from their values in 2005 (see Table 2.4). For instance, while public health spending as percent of government spending in Malawi was about 18.5 in 2011, it marks a reduction from their 2005 value of about 20%.

Such situation raises some concern as the target of the Abuja Declaration is not a sufficient condition for countries to solve their health challenges but rather a complementary measure in this respect. Indeed countries should not only strive towards committing 15% of government spending but as high as possible amounts to the health sector considering the enormous health challenges in the SSA region. Thus attaining the 15% target is not enough justification for countries to relent on their commitment to the health sector.

Moreover, committing these resources to the health sector may only be considered as necessary condition. A sufficient condition involves the efficient and effective use of these resources. It must be emphasised that committing high percentage of government spending to the health sector does not guarantee automatic improvement in population health status. However, it is pertinent to ensure that the resources are used in the most efficient and effective way. In this case, the corresponding improvement in population health may be achieved. This suggests that it may not be completely appropriate to argue that countries that commit high percentage of government resources to health are well on the path to achieving the health related MDGs.

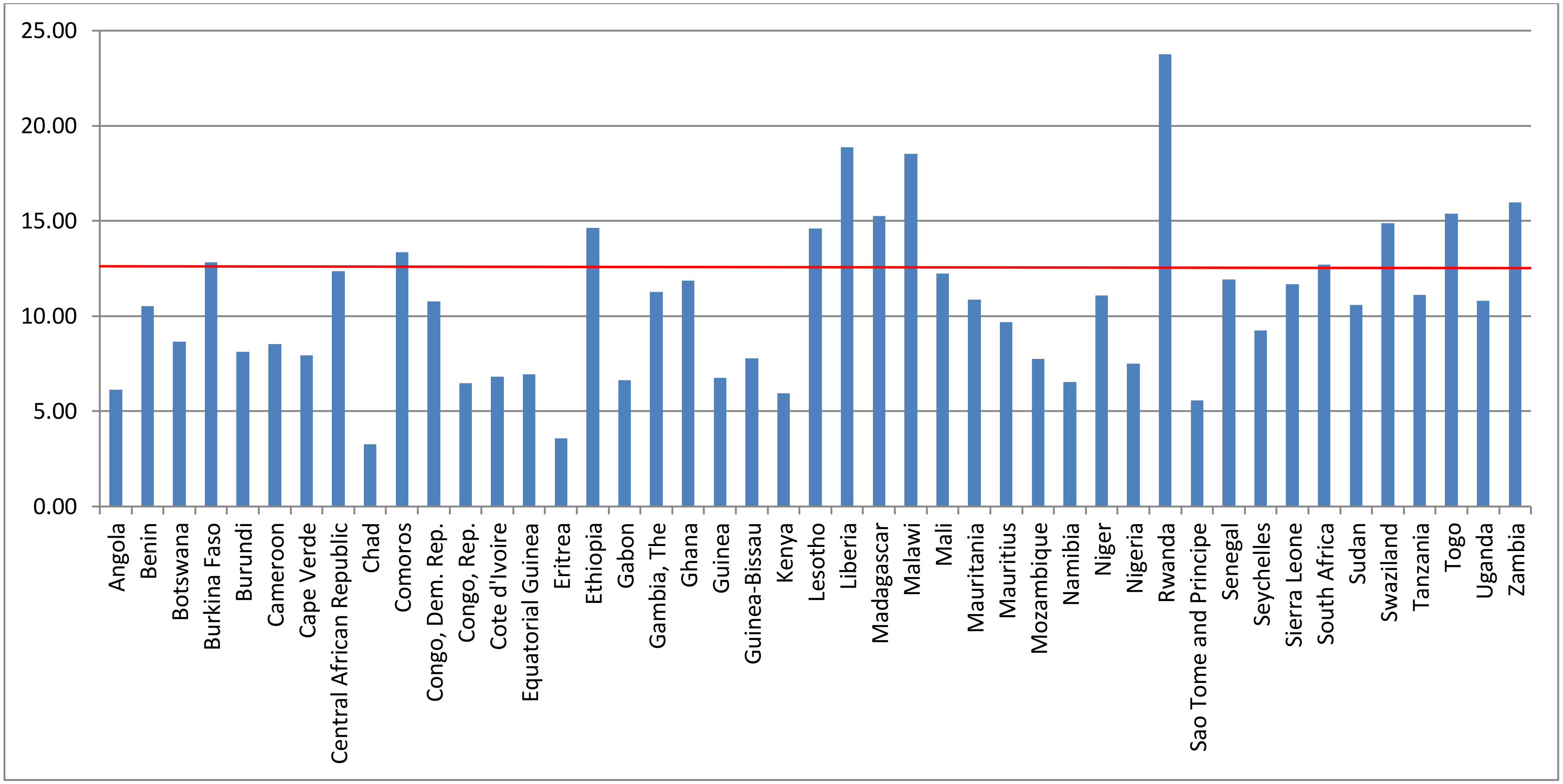

Figure 2.5. Public health care expenditure as percent of government expenditure (2011)
Source: Author's computation from WDI dataset (2012)

Table 2.4. Public health care expenditure as percent of government expenditure

Country	2000	2005	2011
Angola	2.86	5.75	6.14
Benin	9.99	11.05	10.52
Botswana	7.30	16.80	8.67
Burkina Faso	8.76	18.66	12.84
Burundi	7.45	11.56	8.14
Cameroon	6.09	7.67	8.53
Cape Verde	9.89	10.35	7.93
Central African Rep.	12.93	12.88	12.35
Chad	13.13	13.42	3.27
Comoros	9.32	11.25	13.37
Congo, Dem. Rep.	1.78	6.18	10.79
Congo, Rep.	4.79	6.18	6.46
Cote d'Ivoire	7.25	4.50	6.81
Equatorial Guinea	7.83	6.96	6.96
Eritrea	2.61	1.83	3.60
Ethiopia	8.93	10.85	14.64
Gabon	4.81	4.73	6.63
Gambia, The	10.37	11.28	11.28
Ghana	8.33	15.25	11.87
Guinea	6.42	5.96	6.77
Guinea-Bissau	2.25	5.02	7.79
Kenya	10.54	7.60	5.94
Lesotho	6.29	6.71	14.61
Liberia	6.65	13.28	18.88
Madagascar	15.55	11.59	15.27
Malawi	8.98	19.99	18.52
Mali	8.89	12.36	12.25
Mauritania	12.86	9.04	10.86
Mauritius	8.71	9.38	9.67
Mozambique	16.99	18.24	7.75
Namibia	6.90	6.82	6.54
Niger	8.43	14.78	11.08
Nigeria	4.22	6.41	7.51
Rwanda	8.17	15.57	23.75
Sao Tome and Principe	8.99	13.21	5.58
Senegal	8.53	12.41	11.92
Seychelles	7.29	8.95	9.26
Sierra Leone	14.20	14.33	11.69
South Africa	10.92	10.41	12.71
Sudan	8.29	5.74	10.57
Swaziland	10.55	13.07	14.87
Tanzania	10.18	8.74	11.13
Togo	8.48	9.84	15.38
Uganda	7.26	11.21	10.82
Zambia	9.38	14.74	15.98
Average	**8.45**	**10.50**	**10.62**

Source: Author's Compilation from WDI dataset (2012)

Note: The Abuja declaration expects governments to devote at least 15% of their budget to health. Colour red shows countries that have met the target of the declaration while blue indicate countries close to the target.

2.3 Health outcome indicators

The performance of health outcomes in developing regions like SSA have been poor relative to developed regions of the world. This is expected as these regions face economic and social challenges that limit their commitment to improving population health outcomes. Like in many developing regions, SSA compares poorly relative to other regions of the world in terms of population health-related indicators (Table 2.5). Relative to the world's average of about 70 years, life expectancy at birth in SSA was about 55 years in 2011, an increase from 50 years in 2000. In 2011, OECD member countries had the highest life expectancy at birth (80 years) followed by North America (79 years), East Asia and Pacific (74 years) and Middle East and North Africa (73 years).

In terms of gender specific life expectancy at birth, females are expected to live longer than males in all regions of the world. Females and males in SSA had life expectancy at birth of about 56 and 54 years, respectively in 2011. This falls short of the world average of about 72 and 68 years, respectively. Relative to other regions of the world, females in OECD member countries are expected to live up to approximately 82 years while their male counterparts have life expectancy at birth of about 77 years in 2011.

Other well performing regions of the world include North America, East Asia and Pacific and Middle East and North Africa where female life expectancy at birth was estimated in 2011 to be about 81, 76 and 75 years, respectively, with male life expectancy at birth is about 77, 71 and 70 years, respectively. It is worth noting that all the regions of the world showed improvement in life expectancy at birth from the year 2000 to 2011.

The trend in maternal mortality ratio indicates a reduction in SSA from 740 maternal deaths per 100,000 live births in 2000 to 500 in 2010. This however falls significantly short of the world average which fell from 320 in 2000 to 210 in 2010. OECD member states had the lowest maternal mortality ratio estimated to be 18.7 in 2010. Other regions like North America, East Asia and Pacific and MENA had maternal mortality ratio of about 20, 78 and 74, respectively in 2010 (Table 2.6).

Table 2.5. Trend in Life expectancy at birth across regions of the world

	Life expectancy at birth (total)			Life expectancy at birth (male)			Life expectancy at birth (female)		
	2000	**2005**	**2011**	**2000**	**2005**	**2011**	**2000**	**2005**	**2011**
SSA	49.7	51.6	54.6	48.6	50.6	53.6	50.9	52.7	55.8
East Asia & Pacific	71.0	72.1	73.5	69.1	70.1	71.4	73.0	74.1	75.5
Middle East & North Africa	69.8	71.2	72.7	68.3	69.6	71.0	71.4	73.0	74.6
North America	76.9	77.6	78.9	74.4	75.2	76.5	79.6	80.2	81.3
OECD	77.0	78.2	79.6	74.2	75.4	77.0	80.1	81.1	82.4
World	67.2	68.3	69.9	65.2	66.3	67.9	69.3	70.4	72.0

Note: Life expectancy at birth is measured in years

Source: Author's compilation from WDI dataset

Table 2.6. Trend in health outcome indicator across regions of the world

	Maternal mortality ratio			Adult mortality rate (male)			Adult mortality rate (female)			Infant mortality rate			Under-5 mortality rate		
	2000	**2005**	**2010**	**2000**	**2005**	**2011**	**2000**	**2005**	**2011**	**2000**	**2005**	**2011**	**2000**	**2005**	**2011**
SSA	740	630	500	428.2	410.1	374.4	381.1	372.6	342.7	93.4	82.3	69.3	153.4	132.8	108.3
East Asia & Pacific	120	95.3	78.3	174.4	163.6	152.2	117.8	108.9	100.7	29.7	22.7	16.2	37.8	28.1	19.7
Middle East & North Africa	120	90.2	73.7	170.5	158.6	151.2	122.3	106.3	92.2	35.6	29.7	24.1	44.7	36.6	29.5
North America	13.5	17.3	20.0	139.4	137.0	134.9*	81.0	78.9	79.0*	7.0	6.7	6.3	8.3	7.8	7.3
OECD	24.6	19.4	18.7	135.9	125.2	119.2*	71.3	65.9	63.6*	10.6	8.4	6.5	12.8	10.1	7.8
World	320	260	210	224.734	215.087	207.33	155.129	147.268	147.395	50.9	44.3	36.9	72.7	62.7	51.4

Note:

1. Maternal mortality ratio is measured as a modeled estimate per 100,000 live births
2. Adult mortality rate is measured as male/female adult deaths per 1,000 male/female
3. Infant mortality rate is measured as infant deaths per 1,000 live births
4. Under-5 mortality rate is measured as under-5 deaths per 1,000 live births
5. * are figures of 2009 in the absence of new figures

Source: Author's compilation from WDI dataset

Also, female adult mortality rate was relatively lower in all regions of the world than male adult mortality rate. However, SSA experienced the highest male/female deaths per every 1000 male/female. In 2011, male adult mortality rate was about 374 while female adult mortality rate was about 343. This was relatively higher than the world average of about 207 and 147 mortality rates for males and females, respectively (Table 2.6).

Other interesting population health outcomes are the infant and under-five mortality rates as these remain important policy concerns all over the world as reflected in the MDGs. SSA performs poorly in this regard relative to all other regions of the world and the world average. For instance, even though SSA's infant mortality rate reduced from about 93 infant deaths per 1000 live births in 2000 to 69 in 2011, it still remains higher than that of the world average (about 37), OECD (about 7), North America (about 6), East Asia and Pacific (above 16) and MENA (above 24) in 2011 (Table 2.6).

Similarly, under-five mortality rate reduced from about 153 under-five deaths per 1000 live births in 2000 to about 108 in 2011. This again remains significantly higher than that of the world average (51.4), North America (7.3), OECD (7.8), East Asia and Pacific (19.7) and MENA (29.5). These statistics indicate that SSA remains burdened in terms of population health outcomes. The region shows poor performance across all the population health indicators reported in Table 2.5 and 2.6.

In terms of the performance of individual countries in the SSA region, life expectancy at birth has been almost uniform across countries with few countries having significant relatively high life expectancy at birth. About 39 out of the 48 countries in the region have life expectancy at birth above 50 years (Figure 2.6). Majority of the countries had life expectancy at birth ranging between 50 and 60 years. In 2011, Cape Verde emerged the highest performer in terms of life expectancy at birth with approximately 74 years.

Seven countries had life expectancy at birth lower than 50 years. Sierra Leone had the lowest (47.8 years) life expectancy at birth in SSA region (see Figure 2.6 and Appendix A1). Female life expectancy at birth was higher than male life expectancy across all countries (Appendix A1).

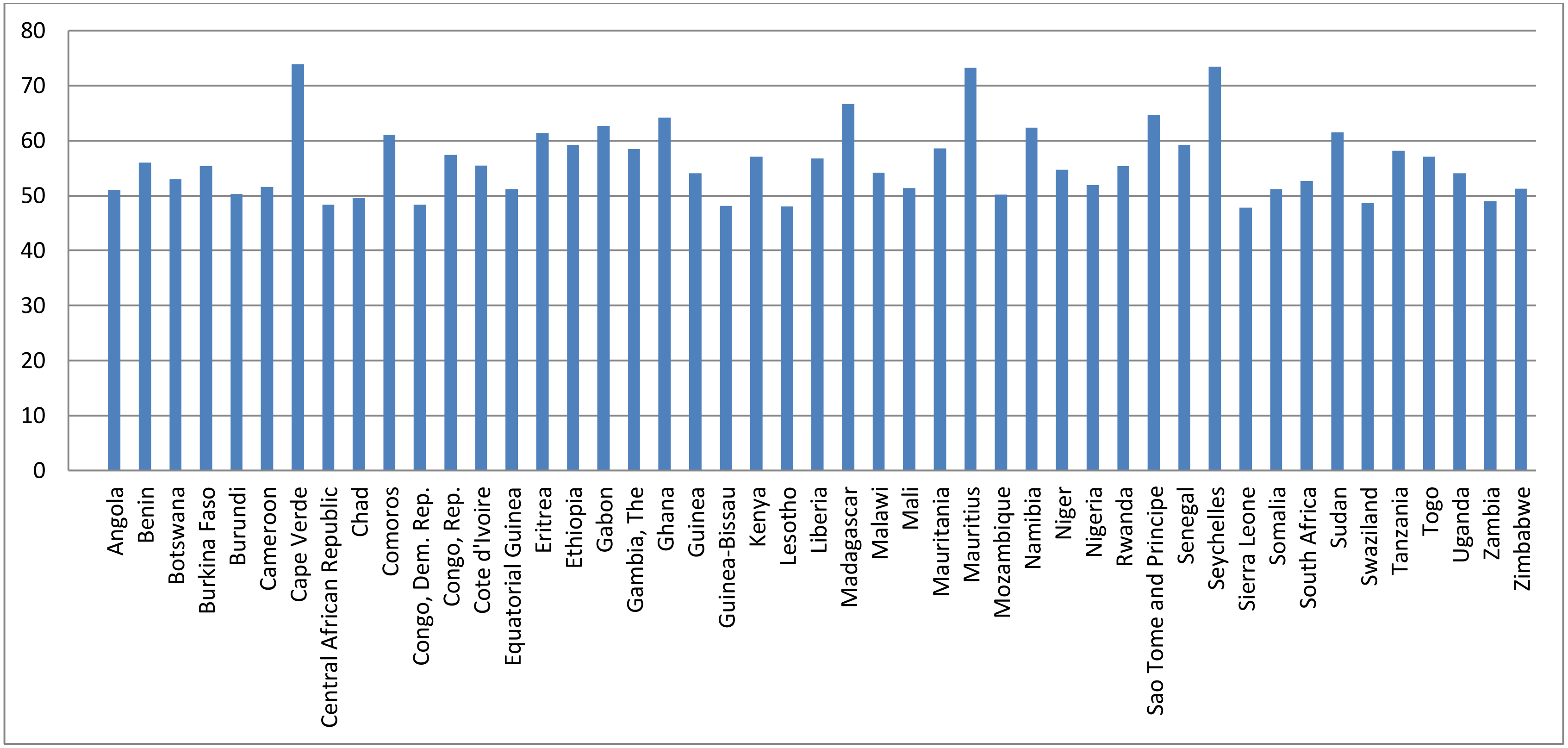

Figure 2.6. Total life expectancy at birth in 2011
Source: Authors compilation from WDI dataset (2012)

With regards to the pattern of maternal mortality ratio (per 100,000 live births) across countries, Figure 2.7 shows that the best performing countries in the SSA region in 2011 include Cape Verde (79), Mauritius (60) and Sao Tome and Principe (70). On the other extreme, some countries had relatively high maternal mortality ratios in 2011. For instance, Chad had the highest maternal mortality ratio of over 1000 maternal deaths per 100,000 live births followed by Somalia also with about 1000, Sierra Leone with about 890 maternal deaths and Central African Republic with about 890 maternal deaths as well.

In terms of the trend in the performance of maternal mortality ratio across countries, the statistics indicate that majority of countries in the SSA region experience a reduction in maternal mortality ratio over the period 1990 to 2010[5]. Figure 2.8 shows negative values for countries with reduction in maternal mortality (measured in percentage) and positive values for countries with increase over the period under review. Equatorial Guinea had the highest percentage reduction in maternal mortality of about 80% over the period. Other countries like Eritrea also performed well with over 70% reduction in maternal mortality over the same period. Aside these two countries, the following countries also achieve over 50% reduction in maternal mortality between 1990 and 2010. These include Angola (62.5%), Botswana (54.5%), Burkina Faso (57.1%), Cape Verde (60.5%), Ethiopia (63.2%), Madagascar (62.5%), Malawi (58.2%), Mali (50%), Niger (50.8%), Rwanda (62.6%), Sao Tome and Principe (53.3%) and Togo (51.6%).

On the other hand, a few countries showed increases in maternal mortality between 1990 and 2010 (Figure 2.8). For instance, maternal mortality in the Republic of Congo worsened by about 33% over the period under review. Similarly, Zimbabwe, South Africa, Lesotho and Botswana all saw poor performance in maternal mortality ratio of approximately 26.7%, 20%, 19.2% and 14.3%, respectively. It is also interesting to note that majority of these countries with worsened maternal mortality over the period under review are located in the Southern African sub-region where HIV and AIDS have had the most devastating effects on maternal and child health in the SSA region.

[5] See Appendix A2 for detailed statistics on maternal mortality across countries in SSA

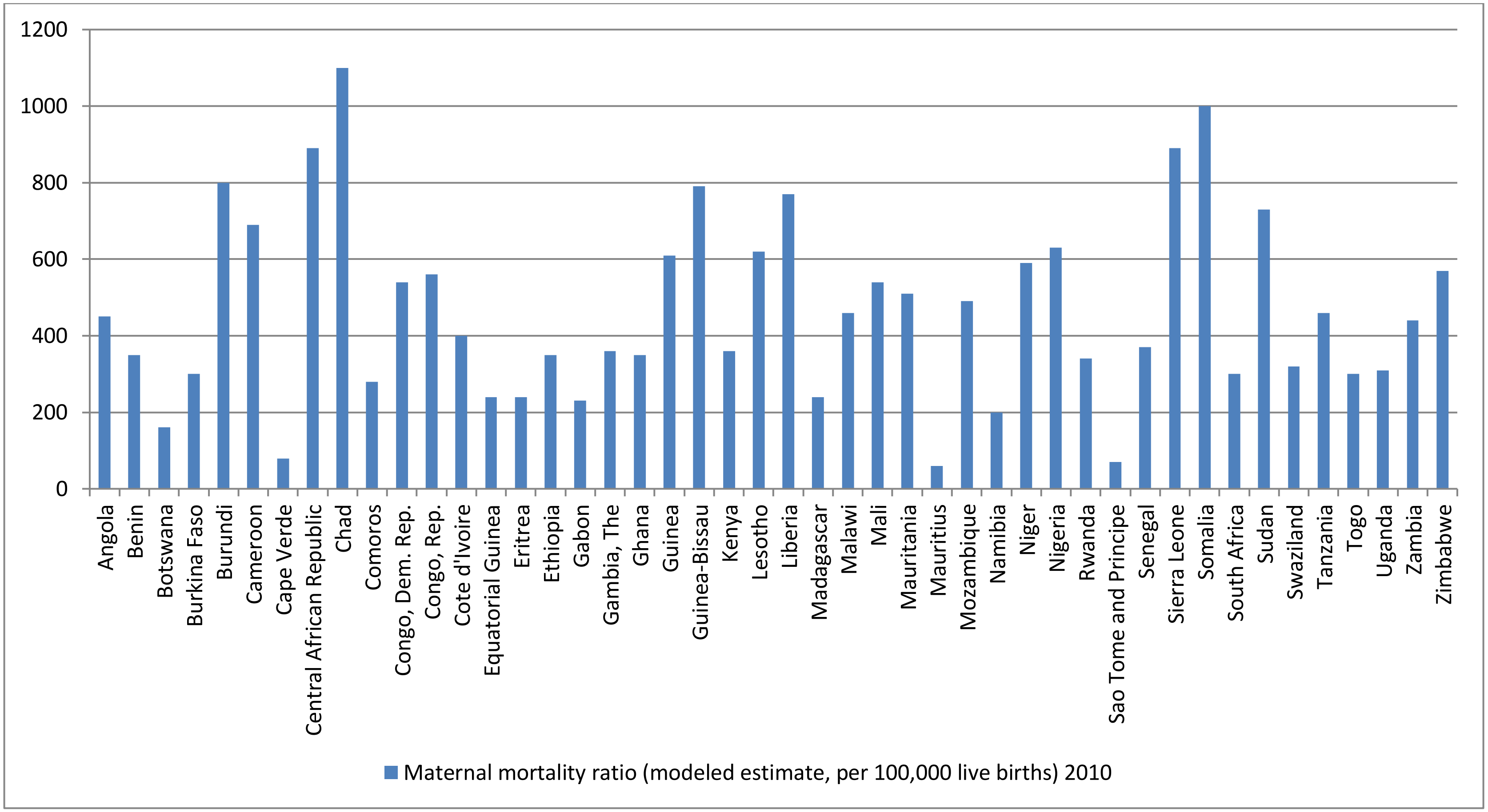

Figure 2.7. Pattern in maternal mortality ratio across SSA countries in 2010
Source: Authors compilation from WDI dataset (2012)

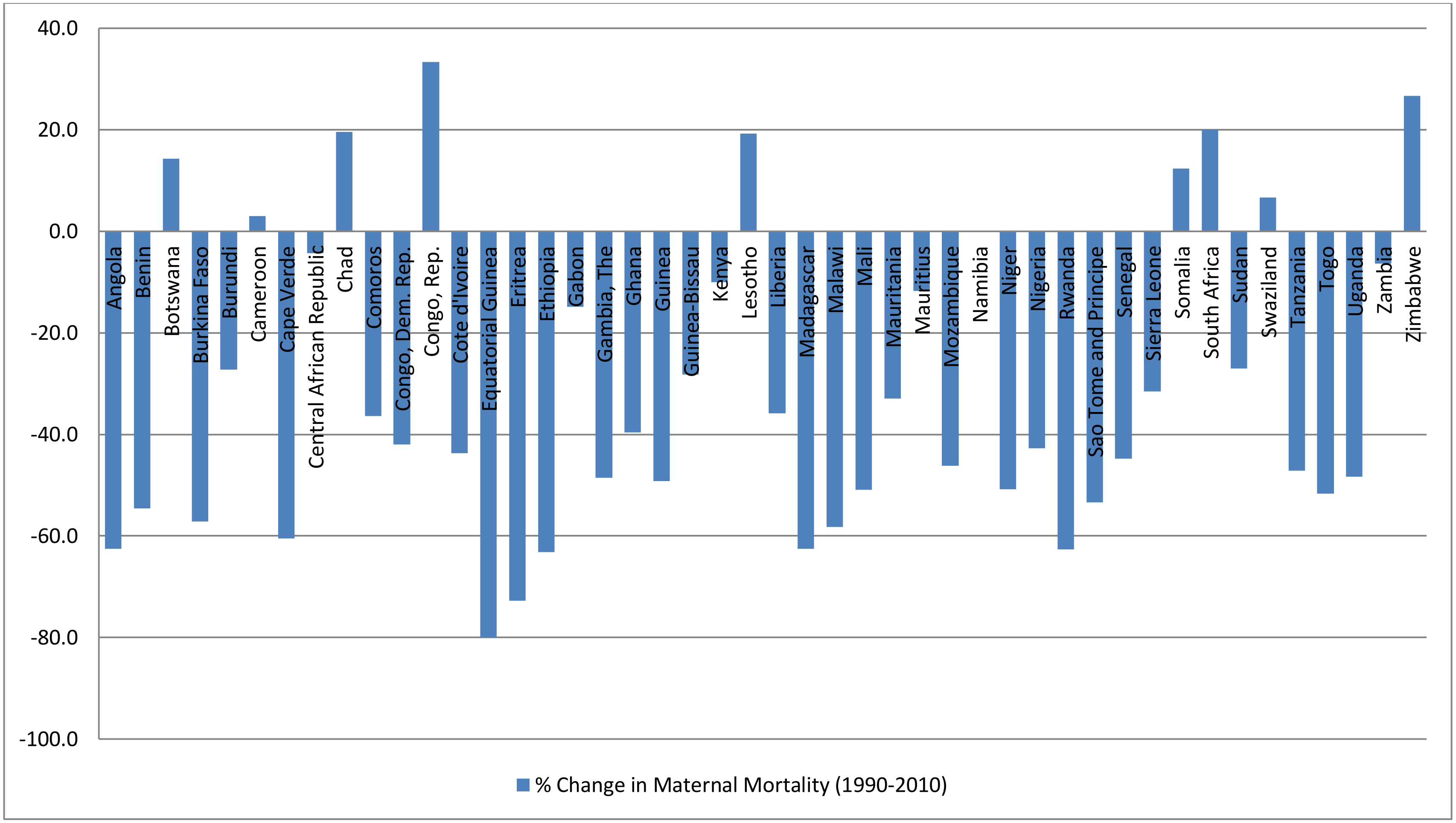

Figure 2.8. Percentage change in maternal mortality ratio (1990-2010)
Source: Authors compilation from WDI dataset (2012)

The performance of SSA countries in improving maternal health is clear in their MDG target achievements. The MDG target on maternal health was to reduce maternal mortality by three quarters between 1990 and 2015. Figure 2.9 indicates that with the exception of Eritrea, no other country was on track to achieving the MDG target on maternal mortality as at the year 2011. While Eritrea was expected to reduce maternal mortality from 880 per 100,000 live births in 1990 to a target of about 220 maternal deaths per 100,000 live births in 2015, the country recorded maternal mortality ratio of 240 in 2011 indicating only 8.3% deviation from achieving the target (see Figure 2.10 and Appendix A2).

An interesting observation can be made in Equatorial Guinea which has already out-performed the MDG target on maternal mortality as at the year 2011. The target for Equatorial Guinea was to reduce maternal mortality from 1200 maternal deaths per 100,000 live births in 1990 to 300 by the year 2015. However available statistics for 2011 shows that Equatorial Guinea recorded 240 maternal deaths per 100,000 live births. This represents 25 percent deviation beyond the target (see Figure 2.10 and Appendix A2).

This suggests that while Eritrea might need a little more effort in achieving this target by 2015, Equatorial Guinea only needs to sustain its current performance to achieve the target by 2015. Other countries like Zimbabwe, Congo Republic, South Africa, Lesotho, Chad etc. may require extra effort to achieve this target considering their high percentage deviation from the target (See Figure 2.10 and Appendix A2).

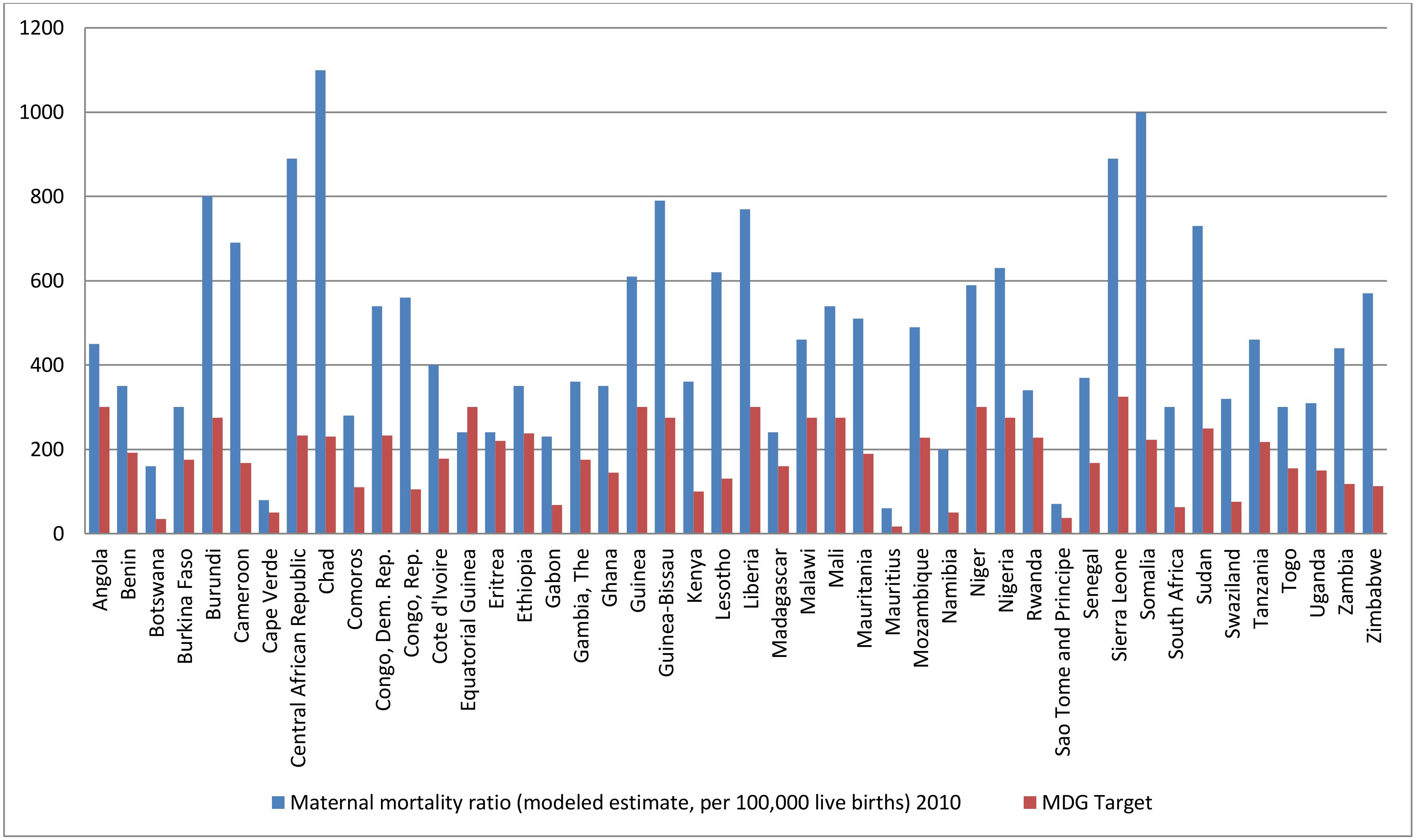

Figure 2.9. Maternal mortality ratio performance (2011) and MDG target
Source: Author's computation from WDI dataset (2012)

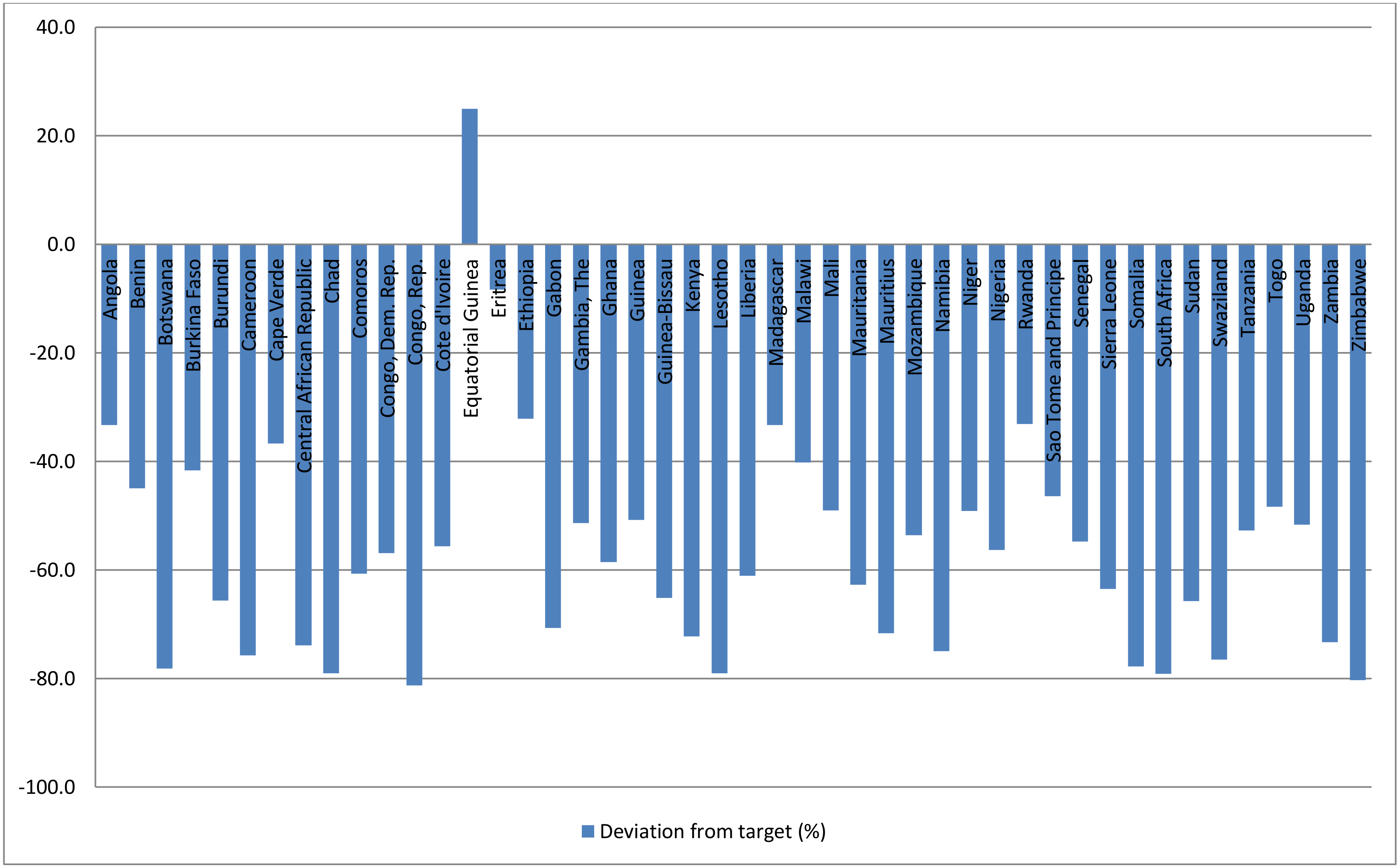

Figure 2.10. Deviation in maternal mortality ratio from MDG target (2011)
Source: Author's computation from WDI dataset (2012)

Figure 2.11 shows the pattern in under five mortality rates across countries in the SSA region. Among others, Botswana, Cape Verde, Mauritius and Seychelles recorded significantly low under five mortality per 1000 live births in 2011. Countries with poor performance in terms of under five mortality rate include Sierra Leone, Somalia, Mali, Chad and Democratic Republic of Congo (see Appendix A3). Figure 2.4 also suggests some level of variation in the rate of under five mortality. For instance while the relatively well performing countries such as Seychelles, Mauritius and Chad had under five mortality rate of about 20 under five deaths per 1000 live births, the rate was significantly high in countries like Sierra Leone, Somalia and Mali with rates of about 180 under five deaths per 1000 live births. These variations may be attributed to the differences in the health systems and the use of health inputs in generating population health outcomes.

Furthermore the trend in under five mortality rate, as shown in Figure 2.12, suggests that there has been a reduction in the rate of under five deaths in all SSA countries over the period from 2000 to 2011. Rwanda and Botswana showed the most outstanding reduction in under five mortality over the period under review with percentage reduction of about 70.4 and 68.1, respectively. On the other extreme, Sao Tome and Principe, Mauritania, Congo Republic and the Democratic Republic of Congo showed the least percentage reduction in under five mortality. For instance, under five mortality rate only reduced by 4.0% in Sao Tome and Principe between 2000 and 2011. Mauritania and the Democratic Republic of Conge saw under five mortality reducing by 4.9% and 7.6%, respectively over the same period. Other countries that had less than 10% reduction in under five mortality rate include Swaziland with a rate of about 9.3%, Congo Republic with a rate of about 9.2% and Cameroon with rate of about 8.8%.

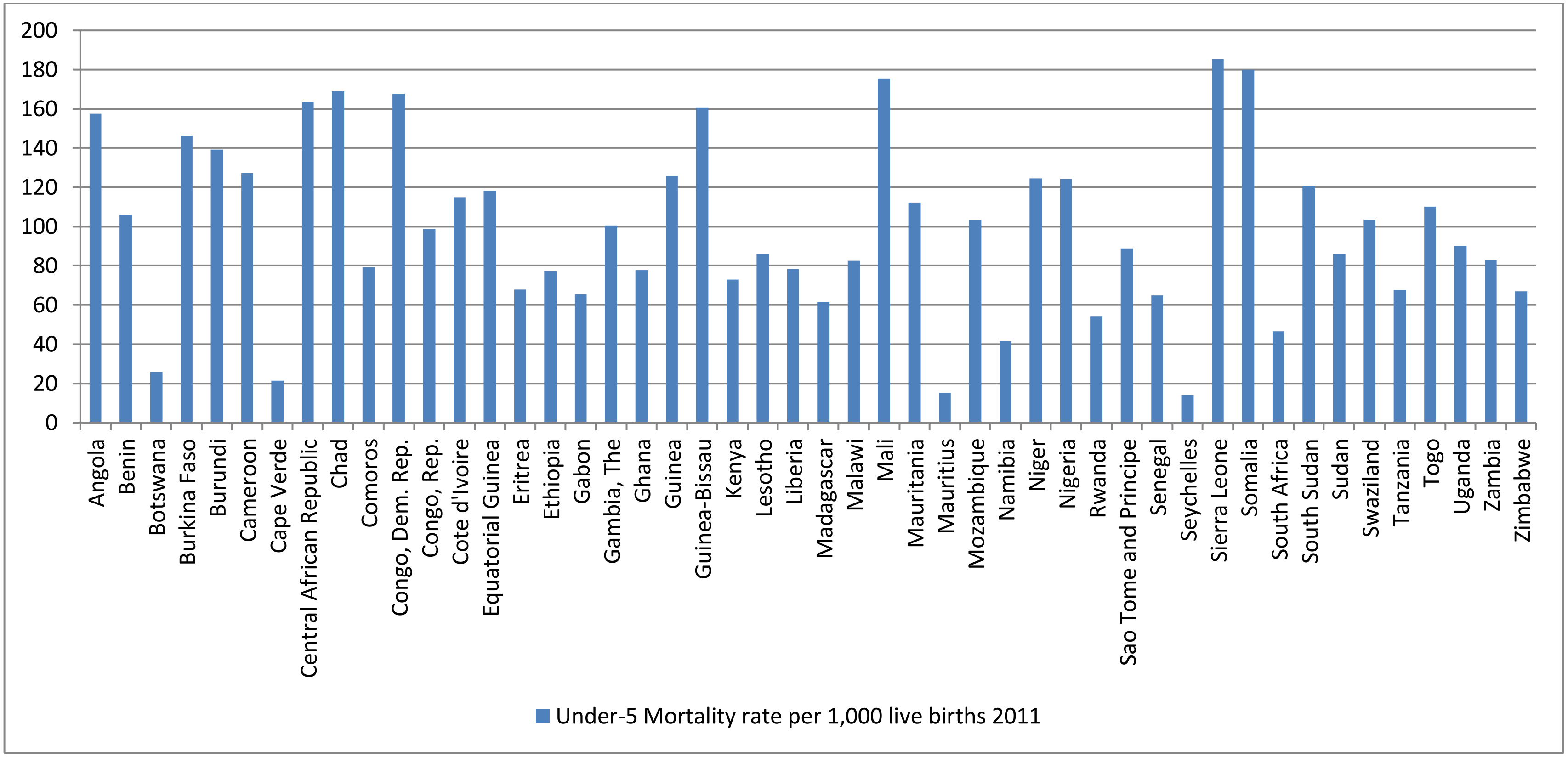

Figure 2.11. Under five mortality rate per 1000 live births (2011)
Source: Author's compilation from WDI dataset (2012)

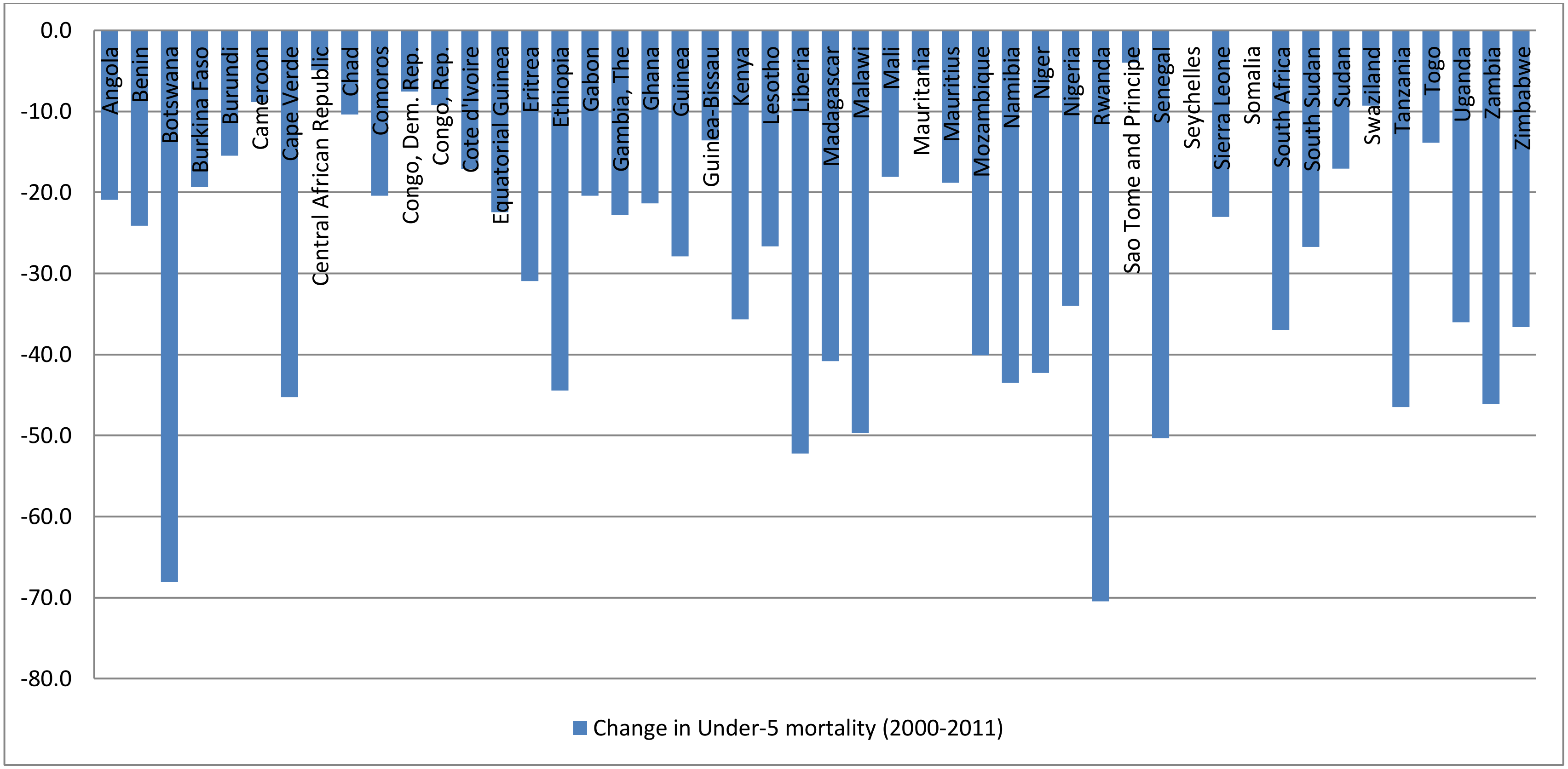

Figure 2.12. Percent change in Under-5 mortality rate (2000-2011)
Source: Author's compilation from WDI dataset (2012)

The MDG target, with regards to under five mortality, was to reduce under five mortality by two thirds between the years 1990 and 2015. In comparison with values of 2011, Figure 2.13 suggests that only Liberia had out-performed the target with about 2.7 percent deviation away from the target (Figure 2.14). The MDG target expects under five mortality in Liberia to reduce from 241.2 in 1990 to 80.4 under five deaths per 1000 live births in 2015. However, available statistics in 2011 show under five mortality in Liberia to be 78.3 under five deaths per 1000 live births (Appendix A3).

Aside Liberia, countries that could be on the path to achieving the MDG target on under five mortality include Malawi, Rwanda and Cape Verde all with less than 10% deviation from the target. For instance, the MDG target for Malawi was to reduce under five mortality per 1000 live births from 227 in 1990 to 75.7 in 2015. The country, however, recorded under five mortality rate of 82.6 in 2011. This represents about 8.4% deviation from the target (Appendix A3).

Similarly, Rwanda had a target of reducing under five mortality rate from 156.3 in 1990 to 52.1 under five deaths per 1000 live births by 2015. Rwanda recorded under five mortality of about 54.1 deaths per 1000 live births in 2011. This represents about 3.7% deviation from the set target for 2015. In the case of Cape Verde, under five mortality was 21.3 per 1000 live births in 2011 representing a reduction from 58 in 1990. This indicates a 9.2% deviation from the target of 19.3 under five mortality rate for the year 2015. These suggests that if these countries are able to reduce their under five mortality rates by less than 10% between 2011 and 2015, then they will be able to achieve the MDG target.

Countries that are significantly distant from achieving this target include Swaziland, Zimbabwe, Somalia, Sao Tome and Principe, Mauritius, Lesotho, Democratic Republic of Congo, Central African Republic and Cameroon all with over 60% deviation from the target as at 2011. These countries will require extra effort to achieve the set target for the year 2015 (see Appendix A3).

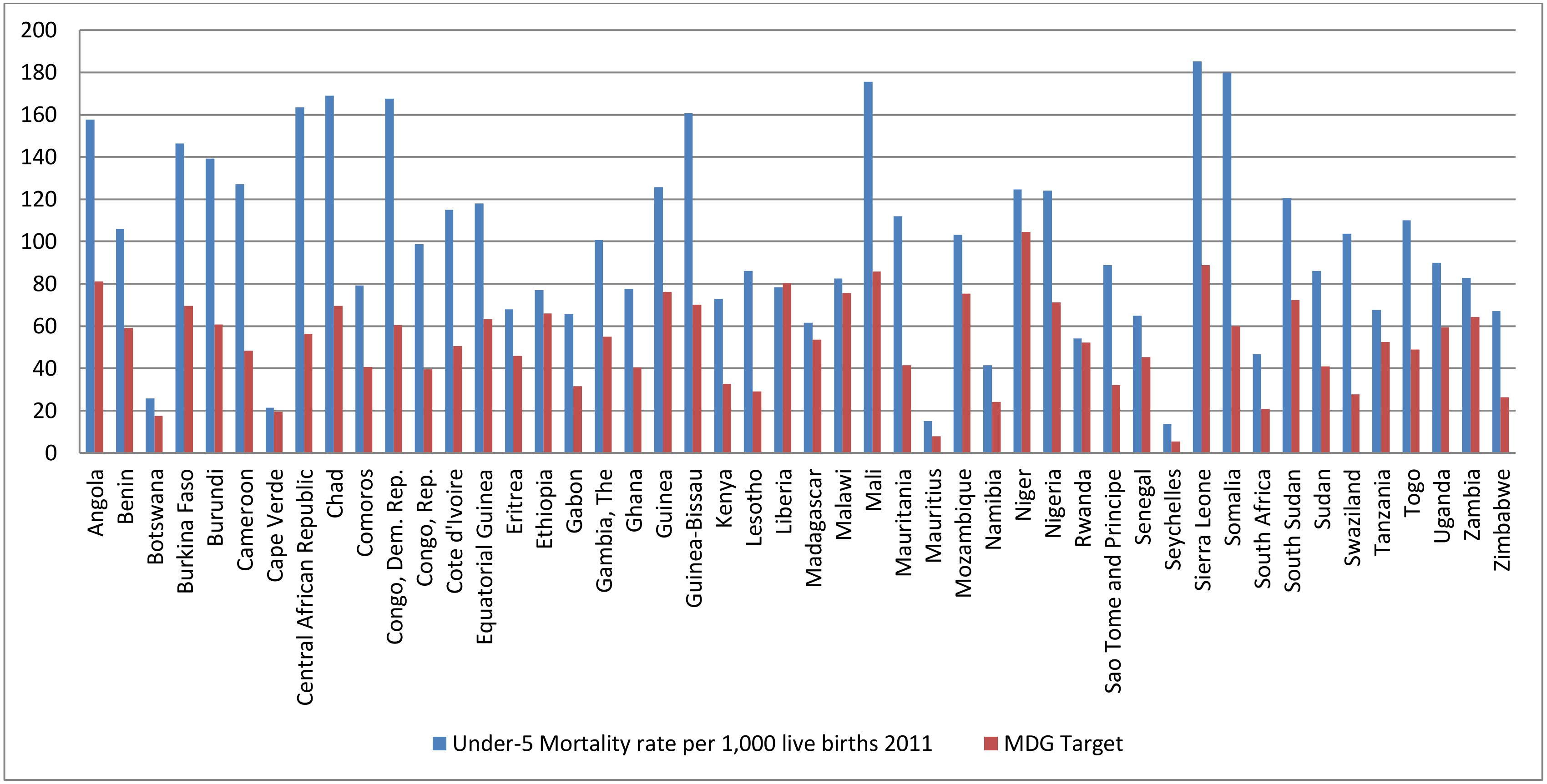

Figure 2.13. Under-5 mortality rate performance (2011) and MDG target
Source: Author's computation from WDI dataset (2012)

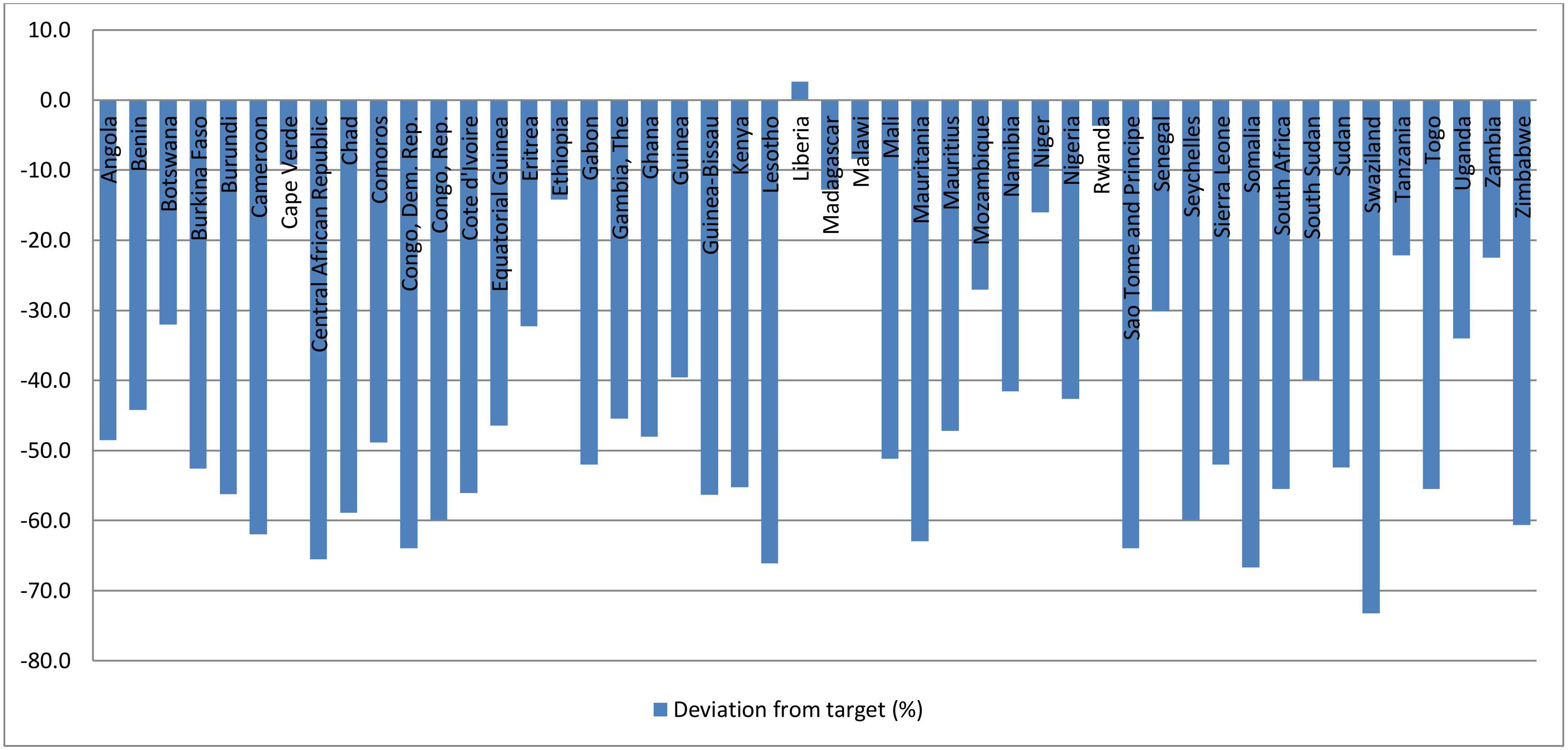

Figure 2.14. Deviation of under-5 mortality rate from MDG target (2011)
Source: Author's computation from WDI dataset (2012)

The pattern of infant mortality rate (Figure 2.15) also show significant variation across countries in 2011 with a wide gap between the best performing and worse performing countries. While some countries experienced high infant deaths per 1000 live births (such as Sierra Leone, Somalia, Democratic Republic of Congo, Central African Republic etc.), other countries showed low levels of infant mortality rate (such as Seychelles, Mauritius, Cape Verde and Botswana).

Sierra Leone recorded about 119.2 infant deaths per 1000 live births in 2011 which was relatively higher than Somalia which recorded about 108.3 infant deaths per 1000 live births. Similarly, the Democratic Republic of Congo recorded an infant mortality rate of 110.6 deaths per 1000 live births while the Central African Republic had 112.3 infant deaths per 1000 live births in 2011. Contrary to these performance, Seychelles and Mauritius recorded low infant mortality rates of about 11.9 and 12.8 infant deaths per 1000 live births in 2011, respectively (see Appendix A4).

It is also interesting to note that the trend in infant mortality rate, as shown in Figure 2.16, indicates that while Seychelles had the lowest infant mortality rate in 2011, it represents a marginal increase from 11.6 infant deaths per 1000 live births in 2000. This indicates a 2.9% increase over the period.

With the exception of Seychelles, all other countries in the region experienced some reduction in infant mortality rate between 2000 and 2011. Countries with notable performances include Rwanda with about 65% reduction in infant deaths per 1000 live births and Botswana with approximately 60% reduction over the same period. Aside Rwanda and Botswana, all other countries in the region had less than 50% reduction in infant mortality rate over the period under review (Figure 2.16 and Appendix A4)

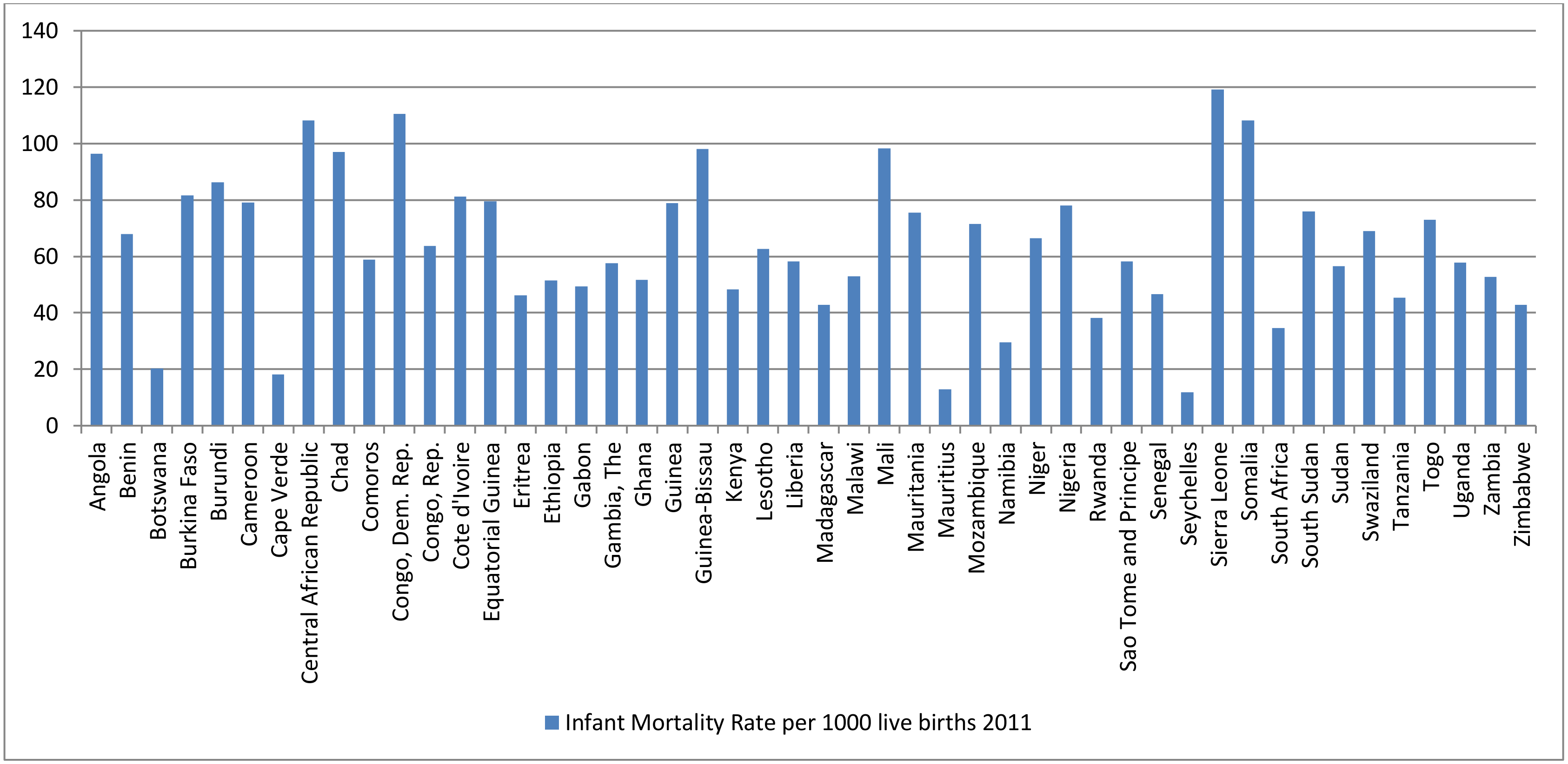

Figure 2.15. Pattern of infant mortality rate across SSA countries in 2011
Source: Author's compilation from WDI dataset (2012)

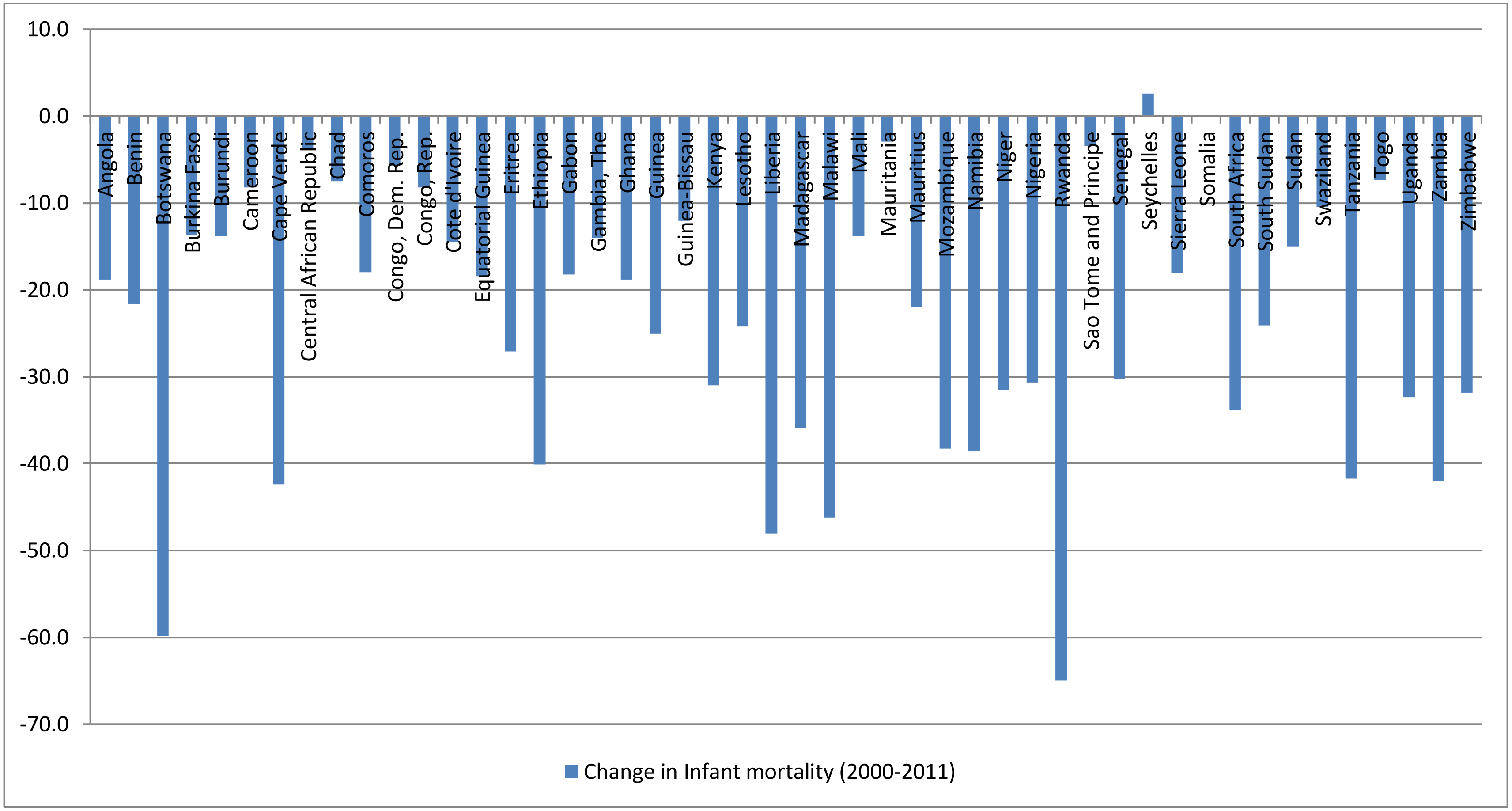

Figure 2.16. Percent change in Infant mortality rate (2000-2011)
Source: Author's compilation from WDI dataset (2012)

Figures 2.17 and 2.18 show the performance of countries in the SSA region towards the achievement of MDG target on infant mortality. The MDG target proposed to reduce infant mortality by two thirds between 1990 and 2015. Figure 2.17 shows that no country has yet out-performed this MDG target as at the year 2011. However, some countries may be considered to be on good footing toward achieving the target. Notable among these countries include Liberia with less than 10% deviation from the target. Rwanda, Malawi and Cape Verde all with less than 20% deviation from the target as at 2011.

Infant mortality rate reduced in Liberia from 160.8 in 1990 to 58.2 in 2011 which represents a 7.9% deviation from the target of 53.6 infant deaths per 1000 live births. Similarly, Rwanda had a target of reducing infant mortality from 95 in 1990 to 31.7 in 2015. However, the country recorded an infant mortality rate of 38.1 in 2011, representing a 16.9% deviation from the target for 2015. In the case of Malawi, the infant mortality target was to reduce the number of infant deaths from 133.6 deaths per 1000 live births in 1990 to 44.5 by the year 2015. Available statistics in 2011 suggests that infant mortality had reduced to 52.9 deaths per 1000 live births. This suggests that Malawi is about 15.8% short of achieving this target for 2015.

Majority of the countries in the region had over 30% deviation from achieving the MDG target on infant mortality and will require extra effort to achieve this target for the year 2015. Swaziland recorded that highest deviation of over 70% from target at 2011. The country's infant mortality in 1990 was 61.3 per 1000 live births with a target of 20.4 infant deaths per 1000 live birth by the year 2015. However, the country recorded an infant mortality rate of 69 in 2011 which falls short of the target by about 70.4% (see Appendix A4).

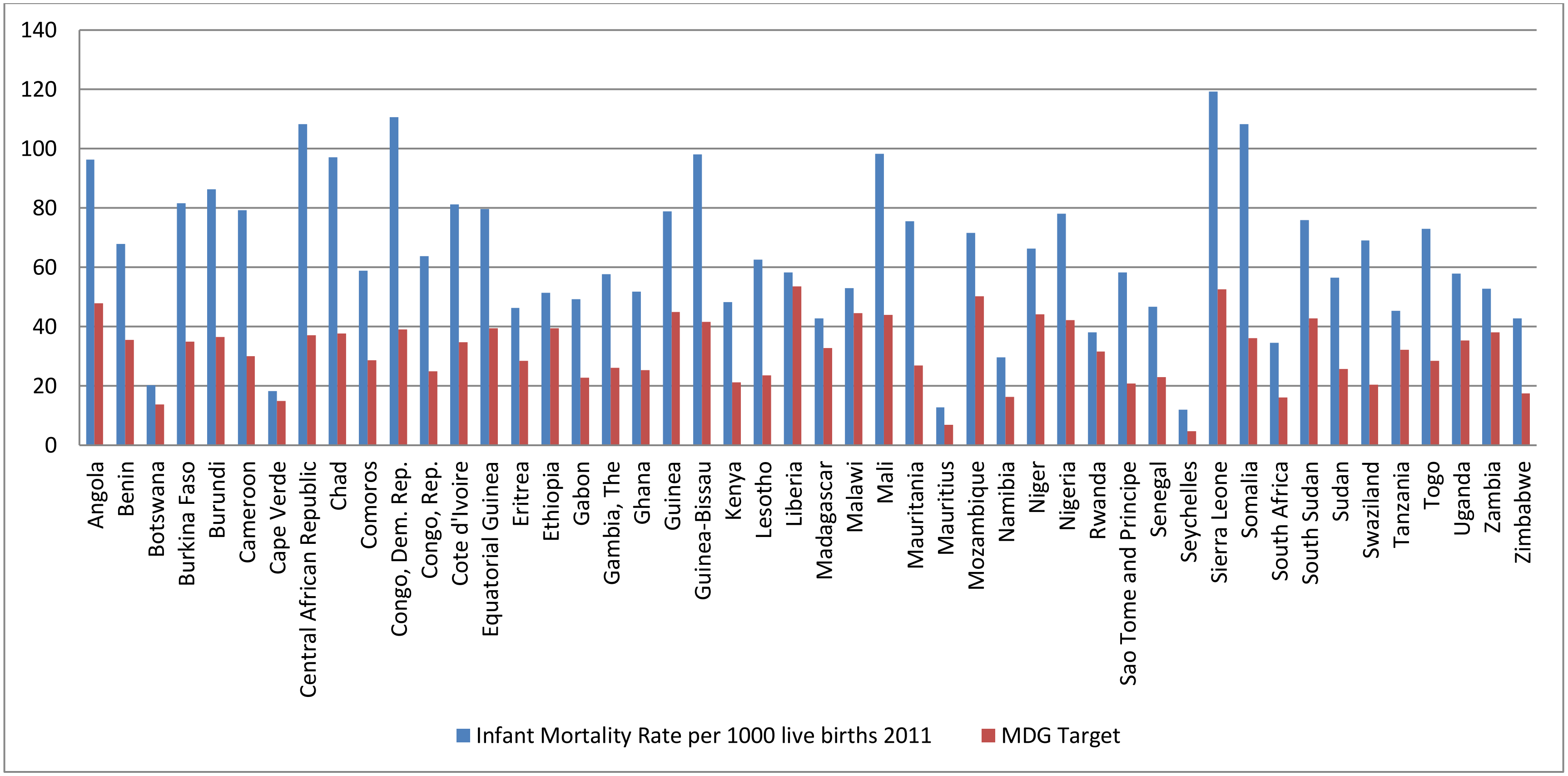

Figure 2.17. Infant mortality rate performance (2011) and MDG target
Source: Author's computation from WDI dataset (2012)

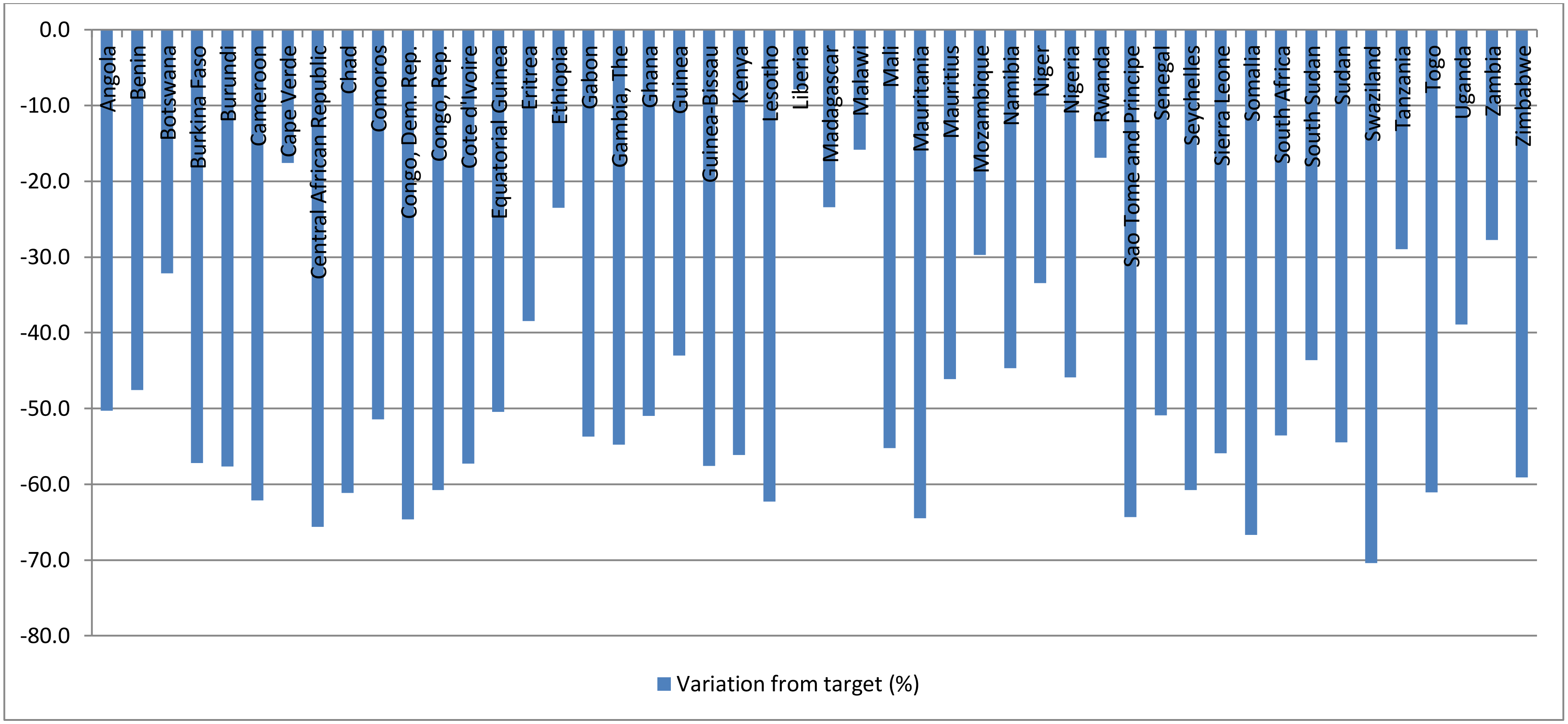

Figure 2.18. Gap between actual infant mortality rate and MDG target (2011)
Source: Authors computation from WDI dataset (2012)

CHAPTER THREE

LITERATURE REVIEW

3.0 Introduction

The chapter presents both theoretical, methodological and empirical literature relevant to this study. The chapter begins with theoretical literature that seeks to explain the link between health care expenditure, health outcomes and health system performance. This is followed by a review of relevant methods and the empirical literature which summarises empirical evidences in this regard.

3.1 Theoretical Literature

3.1.1 Health Production Function

The first attempt to conceptualize health capital and investment is credited to Grossman (1972). The theoretical formulation of Grossman provides a micro-level insight into the investment made by individuals to improve their stock of health as it depreciates over time. It is worth noting that earlier studies provided theoretical insight into investment in human capital in general. For instance Becker (1967) and Ben-Porath (1967) developed models that determine the optimal quantity of investment in human capital. Other studies have considered health as any other form of human capital and argued that the model on investment in human capital could also be applied to health capital (Mushkin, 1962, Becker, 1964, Fuchs, 1966).

Grossman (1972) provided a contrary argument that health capital is unique and should be distinguished from any other form of human capital. The main point of departure from previous theoretical attempts on human capital is that while other forms of human capital directly affects market and non-market productivity, health capital influences the total amount of time available to engage in these market and non-market activities.

For instance, one's knowledge[6] of an economic activity will influence how much of output from that activity can be produced. However, the individual's health status determines how much time the individual can spend producing. This implies that even though the individual has the knowledge to produce more, this may be limited by the poor health of the individual.

The relevance of the Grossman model in the current study lies in the proposition that individuals inherit an initial stock of health that depreciates over time but can be increased by investments in health. Gross investments in health capital are produced by production functions whose direct inputs include the time of the individual and other market goods such as medical care, diet, exercise, recreation and housing. The amount spent on these market goods directed to improve the stock of health may be considered as the consumer's direct and indirect health care expenditure. Aside the consumer's time and market goods, other environmental factors may influence the production function. The education (both formal and informal) of the producer is considered to be the most important environmental variable and also relevant to the efficiency of the production process.

If the production of health is considered as a shared responsibility between individuals and government, then the model by Grossman can be extended to the macro level by considering the entire health system as a production process where inputs are converted into outputs. In this case the outputs are the population health status which represents the end result of an efficient use of health inputs. Like the micro level, health inputs at the macro level include the use of various market goods such as provision of hospitals and equipments needed in the hospital, improved sanitation and water supply, improved working conditions, mass media communications on health and various forms of preventive and curative interventions. While these market goods may be difficult to identify the level of expenditure can be used to capture health inputs into the health system at any point in time.

The basic Grossman (1972) model assumes a typical consumer's intertemporal utility function given as

$$U = U(\phi_0 H_0, ..., \phi_n H_n, Z_0, ..., Z_n), \quad (3.1)$$

[6] The stock of knowledge is considered as an example of the forms of human capital

where H_0 is the inherited health stock, H_i is the stock of health in the *ith* time period, ϕ_i is the service flow per unit stock, $h_i = \phi_i H_i$ is total consumption of health services and Z_i is total consumption of other commodities in the *ith* period.

Individuals invest in health and non-health goods through the production of the gross health investment (I) and the investment in other non-health commodities (Z) in the utility function, respectively. The production of I and Z also depend on other factors, hence, the household production functions for these variables are given as:

$$I_i = I_i(M_i, TH_i; E_i),$$

$$Z_i = Z_i(X_i, T_i; E_i). \tag{3.2}$$

Where M_i is medical care, X_i is the goods input in the production of the commodity, Z_i, TH_i is time used on medical care or health production, T_i is time used in non-health production[7] and E_i is the stock of human capital.

The net investments in the stock of health is defined as gross investment less depreciation, such that

$$H_{i+1} - H_i = I_i - \delta_i H_i, \tag{3.3}$$

gross investment and depreciation rate are represented by I_i and δ_i, respectively. The depreciation rate is assumed to be exogenous but varies with age.

On the other hand, the consumption of non-health goods and services (Z) depends on the amount of goods (X) and available time to the individual to consume these goods (T). The individual has the choice to allocate time to each activity. However, the time constraint requires that the total amount of time available, Ω, be exhausted by all possible uses:

$$TW_i + TL_i + TH_i + T_i = \Omega, \tag{3.4}$$

[7] Z_i may represent consumption of an aggregate commodity in period i. TH_i represents time input in gross investment function. T_i represents time input in the production of Z_i.

where TL_i is time lost to market and non-market activities due to illness or injury (sick time) and TW represents working time.

Aside the constraints specified in (3.2) and (3.3), individuals also face another constraint called the goods budget constraint. The goods budget constraint equates the present value of outlays on goods to the present value of earnings income over the life cycle plus initial assets and is given as;

$$\sum \frac{P_i M_i + V_i X_i}{(1+r)^i} = \sum \frac{W_i TW_i}{(1+r)^i} + A_0. \qquad (3.5)$$

Where P_i and V_i are the prices of M_i and X_i, W_i is the wage rate, TW_i is hours of work, A_o is discounted property income and r is interest rate.

By substituting for TW_i from (3.4) into equation (3.5), a single "full wealth" constraint can be obtained and presented as follows;

$$\sum \frac{P_i M_i + V_i X_i + W_i (TL_i + TH_i + T_i)}{(1+r)^i} = \sum \frac{W_i \Omega}{(1+r)^i} + A_0 = R. \qquad (3.6)$$

Equation (3.6) indicates that "full wealth" equals initial assets plus the present value of the earnings an individual would obtain if he spent all of his time at work. At the macro level, the full wealth may represent the total amount of resources available for providing public services (for example health, education etc.).

Given the above constraints in equations (3.2), (3.3) and (3.6), the optimal values of H_i and Z_i can be obtained by maximizing the objective function in equation (3.1). The optimal quantities of gross investment in health determine the optimal quantities of health capital.

The first-order optimality condition for gross investment in period *i-1* is written as follows:

$$\frac{\pi_{i-1}}{(1+r)^{i-1}} = \frac{W_i G_i}{(1+r)^i} + \frac{(1+\delta_i) W_{i+1} G_{i+1}}{(1+r)^{i+1}} + \ldots + \frac{(1-\delta_i)\ldots(1-\delta_{n-1}) W_n G_n}{(1+r)^n} + \frac{Uh_i}{\lambda} G_i + \ldots$$
$$+ (1-\delta_i)\ldots(1-\delta_{n-1}) \frac{Uh_n}{\lambda} G_n; \qquad (3.7)$$

Where $Uh_i = \frac{\partial U}{\partial h_i}$ is the marginal utility of healthy days; λ is the marginal utility of wealth; $G_i = \partial h_i / \partial H_i = -\left(\partial TL_i / \partial H_i \right)$ is the marginal product of the stock of health in the production of healthy days (the increase in the number of healthy days caused by a one-unit increase in the stock of health).; and π_{i-1} is the marginal cost of gross investment in health in period *i-1*.

Equation (3.7) states that the present value of the marginal cost of gross investment in period i-1 must equal the present value of marginal benefits. While equation (3.7) determines the optimal amount of gross investment in period i-1. Total cost is minimized when the increase in gross investment from spending as additional dollar on medical care equals the increase in gross investment from spending an additional dollar on time. Since the gross investment production function is homogeneous of degree 1 and since the price of medical care and time are independent of the level of these inputs, the average cost of gross investment is constant and equal to the marginal cost.

Converting equation (3.7) gives an opportunity to examine the factors that affect the demand for health and gross investment. If gross investment in period *i* is positive, then

$$\frac{\pi_i}{(1+r)^i} i = \frac{W_{i+1}G_{i+1}}{(1+r)^{i+1}} + \frac{(1+\delta_{i+1})W_{i+2}G_{i+2}}{(1+r)^{i+2}} + \ldots + \frac{(1-\delta_{i+1})\ldots(1-\delta_{n-1})W_n G_n}{(1+r)^n} + \frac{Uh_{i+1}}{\lambda} G_{i+1} + \ldots$$
$$+ (1-\delta_{i+1})\ldots(1-\delta_{n-1}) \frac{Uh_n}{\lambda} G_n. \qquad (3.8)$$

From equations (3.7) and (3.8),

$$\frac{\pi_{i-1}}{(1+r)^{i-1}} = \frac{W_i G_i}{(1+r)^i} + \frac{Uh_i G_i}{\lambda} + \frac{(1-\delta_i)\pi_i}{(1+r)^i}. \qquad (3.9)$$

Therefore,

$$G_i \left[W_i + \left(\frac{Uh_i}{\lambda} \right) (1+r)^i \right] = \pi_{i-1}(r - \tilde{\pi}_{i-1} + \delta_i) \,, \qquad (3.10)$$

Where W_i is the wage rate which measures the monetary value of a one-unit increase in the total amount of time available for market and nonmarket activities, Uh_i/λ measures the discounted monetary value of the increase in utility due to a one-unit increase in healthy time, $\tilde{\pi}_{i-1}$ is the percentage rate of change in marginal cost between period *i-1* and period *i*. Equation (3.10) implies that undiscounted value of the marginal product of the optimal stock of health capital (the right hand side of the equation) at any moment in time must equal the supply price of capital (the left hand side of the equation).

The condition in equation (3.10) fully determines the demand for capital goods that can be bought and sold in a perfect market. However since health capital cannot be traded like other capital goods, gross investment must be positive. This implies that suppose an individual desires to increase the stock of health by one unit in period *i*, then there is need to increase gross investment in period *i-1* by one unit. This emphasises the importance of previous investments in health on current health status. This implies that improving the health of any population requires not just investment (health care spending) in the current period but also investment over a period of time.

In a similar theoretical presentation Wagstaff (1986) used the concept of health production function to express the notion that individuals can control their health through their influence on health affecting consumption patterns, their health care utilization and their environment. At the macro level, this can be conceptualized as the government influencing the health of the population through investments in these variables.

Wagstaff (1986) argues that just like the case in any firm where production functions are seen as a process where outputs are produced by combining factor inputs, individuals also produce health by combining health inputs. Similarly at the macro level, population health can be improved by effective and efficient combination of health inputs. The production process therefore simply links health inputs to the output, health. To better understand the concept of health production function, the following graphical illustration can be employed. The output health is measured along the vertical axis while health inputs are on the horizontal axis.

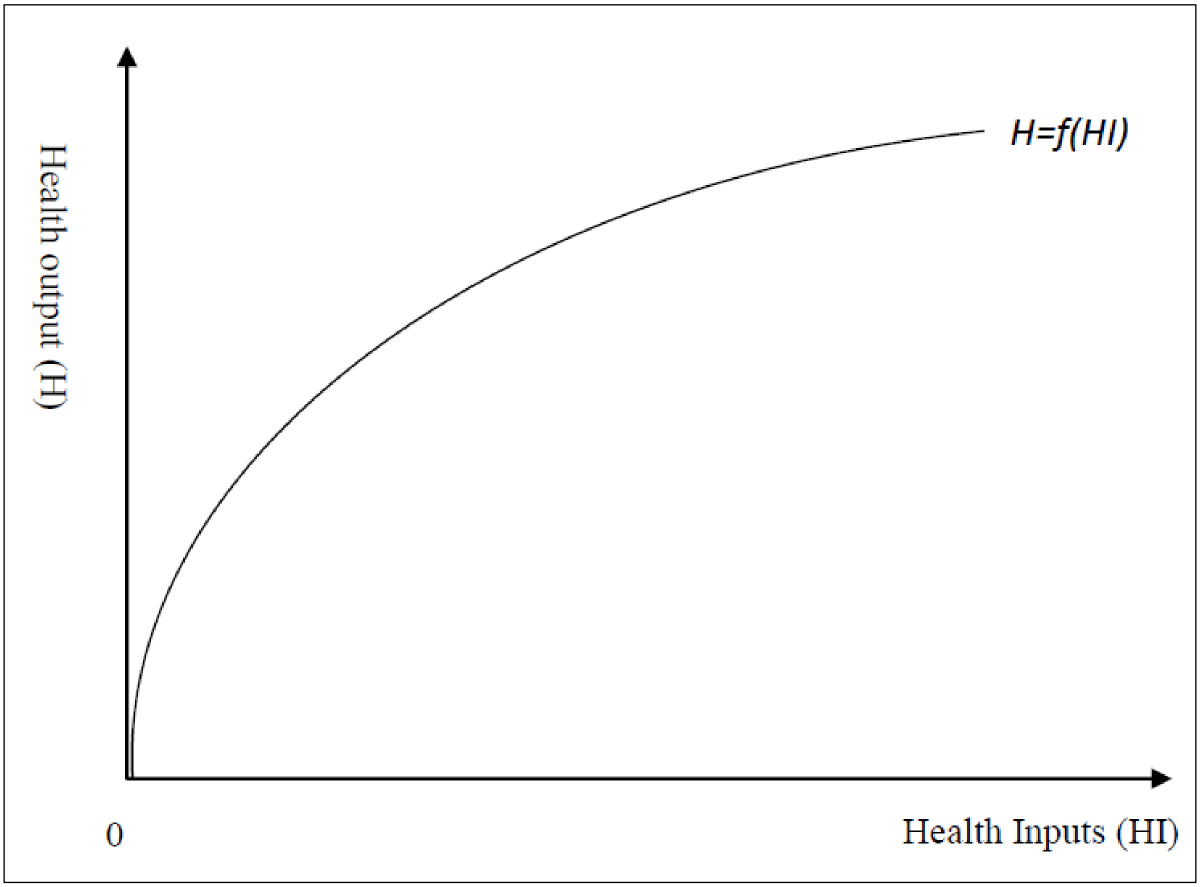

Figure 3.1. Health production function

Source: Adopted from Wagstaff (1986)

The production function exhibits two characteristics as is the case in many other production functions. First is the positive relationship between health inputs and outputs. That is as more inputs of health are employed, more health is produced. Secondly, the production function exhibits the law of diminishing marginal product. This means that successive additions to the quantity of health inputs results in successively smaller increment in health status. The theory also posits that factors that are likely to influence the efficient production of health include increase in knowledge[8] and level of educational attainments. It is predicted that a population with high levels of education attainments and developed medical and other health services is likely to have improved health outcomes (Grossman, 1972, Muurinen, 1982).

Based on the theoretical formulations of Grossman (1972) and Wagstaff (1986), Koc (2004) derived necessary and sufficient conditions under which increased health care productivity must lead to decreased (increased) demand for health care as long as the demand for health care is inelastic (elastic).

The contribution of Koc (2004) lies in the derivation of a class of production functions based on the assumption about the elasticity of health care demand with respect to shadow price and its relationship with technology effects. To demonstrate this, Koc (2004) adopts a simplified version of Grossman's pure consumption model which was provided by Wagstaff (1986) and used by Dardanoni and Wagstaff (1990) who defined a health production function *H(m,s)* over quantity of medical care, *m*, and the productivity of health care, *s*. It is assumed that $\frac{\partial H}{\partial m} = H_1 > 0$, $\frac{\partial H}{\partial s} = H_2 > 0$, $\frac{\partial^2 H}{\partial m^2} = H_{11} \leq 0$ and $\frac{\partial^2 H}{\partial m \partial s} = H_{12} \geq 0$.

Where $H_{12} > 0$ implies that increased health care productivity shifts the production function upward and also causes larger contribution to health. If $H_{12} = 0$, then marginal product of health care is constant.

Let the health production function be twice continuously differentiable with $H_1 > 0$, $H_2 > 0$ and $H_{11} \leq 0$. Two cases are feasible under this proposition: in the first case, it is assumed

[8] Including medical science breakthrough and good understanding of the role of environmental factors

that $H_{12} > 0$ and the production function takes the form of a product of a function of m and s only. Thus

$$H(m,s) = \alpha(m)\beta(s). \tag{3.11}$$

This implies that

$$\frac{mH_{11}}{H_1} = \frac{mH_{12}}{H_2} - 1, \tag{3.12}$$

iff

$$H(m,s) = am^{-c}\exp\left(\int \frac{-c}{\exp\left[\Theta(s)\right]}ds\right) \tag{3.13}$$

where $a > 0$ and $-1 \leq c < 0$ are constants and Θ(s) is an arbitrary function of the productivity of health care.

The second case assumed $H_{12} = 0$. This implies that $mH_{11}/H_1 = -1$ iff

$$H(m,s) = \exp(-d)\ln m + \xi(s) + b \tag{3.14}$$

where d and b are some constants and $\xi(s) = \ln(s)$ is an arbitrary function of the productivity of health care with $\xi^{'}(s) > 0$.

Now suppose, in the first case, that a = 1 and c = -1 and Θ(s) = ln(s). This implies that $H(m,s) = ms$ which gives a particular form of health production function[9]. Similarly, if a =1 and c = -α (with 0 < α < 1) and Θ(s) = ln(sα/(1-α)), then the health production function becomes a Cobb-Douglas type specified as $H(m,s) = m^{\alpha} s^{1-\alpha}$. In the second case, if b = d = 0 and $\xi(s) = \ln(s)$, then one gets H(m,s) = ln(m) + ln(s), which is a health production function in which inputs are expressed in logarithms in an additive fashion[10].

---

[9] An example of this form of health production function was used by Dardanoni and Wagstaff (1990)

[10] See Koc (2004) for detailed description of the model. Only relevant functional forms are presented here.

In extending the Grossman health production model, Fayissa and Gutena (2008) developed a macro level health production function suitable for cross-country analysis. The model proposes similar argument as Grossman (1972) and Wagstaff (1986), by establishing a relationship between health inputs and outputs as follows;

$$H = F(x) \qquad (3.15)$$

Where H is individual health output and x is a vector of inputs to the health production function, F. Based on Grossman's assumption that an individual's health status is influenced by a set of social, economic and environmental factors (represented by x in equation 3.20 above), Fayissa and Gutena (2008) argued that these elements of the health production function can be aggregated to the macro level by representing these by per capita variables re-grouped into sub-sectors. The following aggregate health production function can therefore be specified;

$$h = F(Y, S, V) \qquad (3.16)$$

where Y is a vector of per capita economic variables, S is a vector of per capita social variables and V is a vector of per capita environmental factors.

It is worth noting that, an appropriate transformation of the Cobb-Douglas health production function gives a linear function presented in a logarithmic form. The transformed Cobb-Douglas function has the additional advantage that it provides elasticities of the relationship between heath inputs and outputs in the production process. In this regard, the current study adopts the transformed Cobb-Douglas health production function specification.

3.1.2 Concept of efficiency

The concept of efficiency of a production process is generally related to productive efficiency which refers to how well inputs are converted into final products. The production process of an organization varies across various activity levels including the entire industry, a firm, a production line or a work procedure. Subject to the scope of production activities, productive efficiency may be measured by actual and optimal amounts of inputs and products. These optimum amounts are defined in terms of production possibilities. The distance from the frontier measures relative technical efficiency since the frontier reflects both technology and operating environment. Peacock et al. (2001) highlighted the possibility of defining the optimum in terms of behavioural goals of the production process. In this case the level of efficiency can be measure by comparing actual and optimal attainments of the objectives of the production process within the constraints on production possibilities. A typical example of the goals of any production process includes cost minimisation, income maximization or social wellbeing maximization.

3.1.2.1 Productivity and Efficiency

The concepts of efficiency and productivity have been used interchangeably in the literature, even though these concepts are perceived to be similar but not identical. For instance, Sengupta (1995) and Cooper, Seiford and Tone (2000) have defined both efficiency and productivity as the ratio between output and input. Lovell (1993) defined productivity of a production unit exclusively as the ratio of its outputs to its inputs. According to a classic definition, productivity is the ratio between an output and the factors that made it possible (Vincent 1968). Two basic types of productivity can be distinguished; Partial productivity concerns only a single factor of production while total factor productivity concerns all factors of production.

Efficiency on the other hand is distinctively described as the distance between the quality of inputs and output and the quantity of input and output that defines the best possible frontier for a firm in its cluster. In the definition of Lovell (Lovell, 1993), efficiency is the comparison between observed and optimal values of output and input. Such comparison can be done either in terms of the ratio of observed to maximum potential output that can be obtained from the available inputs or the ratio of minimum potential input required to produce the given level of output. The optimum in both cases is defined in terms of the production possibilities and efficiency is technical. In sum, efficiency can be equated to productivity after the impact of environmental factors on performance has been adjusted for (Lovell, 1993). According to Koopmans (1951) technical efficiency exists if, and only if, increasing any output or decreasing any input requires decreasing some other output or increasing some other input.

The concept of efficiency and the appropriate evaluation technique adopted depends on the scope of activities defined and the objectives assumed for a production process. The application of the concept of efficiency in the health economics literature has been conducted at different activity levels. These include efficiency comparisons of health sectors across countries, individual service providers and alternative health programmes or care procedures (Peacock et al. , 2001). The objective of production is generally perceived to be either providing services or achieving outcomes. This contextual difference leads to considerable variation in the efficiency term used and therefore there is the need to provide a consistent definition of health care efficiency. They proposed that if health services are considered as interventions provided to improve health for people in different health states, then health care efficiency refers to how well health care resources are used to obtain health improvements and comprises two components; (1) Technical efficiency which considers whether health care interventions for particular health states are each performed with the least amount of inputs. (2) Allocative efficiency which considers whether a set of technically efficient interventions is chosen to yield the greatest possible amount of health improvements.

This definition of efficiency is specific to health services and differs in several ways from one that is commonly used in such sectors as manufacturing and agriculture. First, the final product of health care interventions is conceptualised to be the health consequences of service provision rather than the amount of goods as measured for other production activities. Second, the definition of technical efficiency in health care is based on two types of comparisons: (1) comparison of alternative diagnostic or treatment procedures applied to particular health states and (2) comparison of service providers who choose and implement these care procedures. In the non-health sectors, technical efficiency is defined mostly in terms of the latter type of comparison only. An important component of health system efficiency measurement is the health production frontier which serves as the benchmark for comparison of decision making units. The frontier of health production can be determined using either the 'bottom-up' approach of the 'top-down' approach.

According to Peacock et al. (2001), the 'bottom-up' approach measures technical efficiency for individual service providers in the benchmarking analysis and alternative care procedures in the economic evaluation. In the benchmarking analysis, the level of technical efficiency is compared for various service providers against certain benchmark units. A limitation of the benchmark technique is the possibility of omitting inefficiency arising from the use of non-cost-effective care procedure since it does not determine whether the benchmark units would use cost-effective procedures. In this regard service providers not fully adopting cost-effective procedures may still be assessed as relatively efficient and chosen to be the benchmark. Economic evaluation, on the other hand, focuses on what differences exist in the various diagnostic and treatment methods available for specific health states or diseases. In effect the assessment seeks to find out the possible improvements in health states if the available technology and resources were used to full advantage. The limitation of the economic evaluation is its inability to assess the level of operational inefficiency of service providers.

In contrast, the 'top-down' approach to estimating frontier of overall efficiency is based on comparisons of aggregated health care inputs and health improvements achieved from the entire health sector across countries. Similar to the 'bottom-up' approach, the top-down approach measures relative efficiency with an observed benchmark. There is therefore the likelihood that the estimated frontier may understate inefficiency. An illustration of the bottom-up and top-down approaches is presented in Figure 3.2 below.

The various frontiers in the Figure 3.2 shows the maximum level of health improvements that can be achieved given the level of inputs and the component of efficiency that is taken into consideration. For any data point, the vertical distance from any one of the frontiers measures the level of inefficiency. In the 'bottom-up' approach, technical efficiency is measured for a sample of service providers in four countries (A to D). Line AB represents the average results for countries A and B and are considered to be relatively efficient. Counties C and D are on average assumed to be inefficient since they lie below the frontier. If cost-effective treatment procedures are discovered in countries A and B then adjusting for the potential health gains will adjust the frontiers for these countries to A'B'. On the other hand, if the health improvements occur from resource reallocation within the country, then the efficiency frontier can be adjusted further to A*B* which represents the level of overall efficiency across the countries.

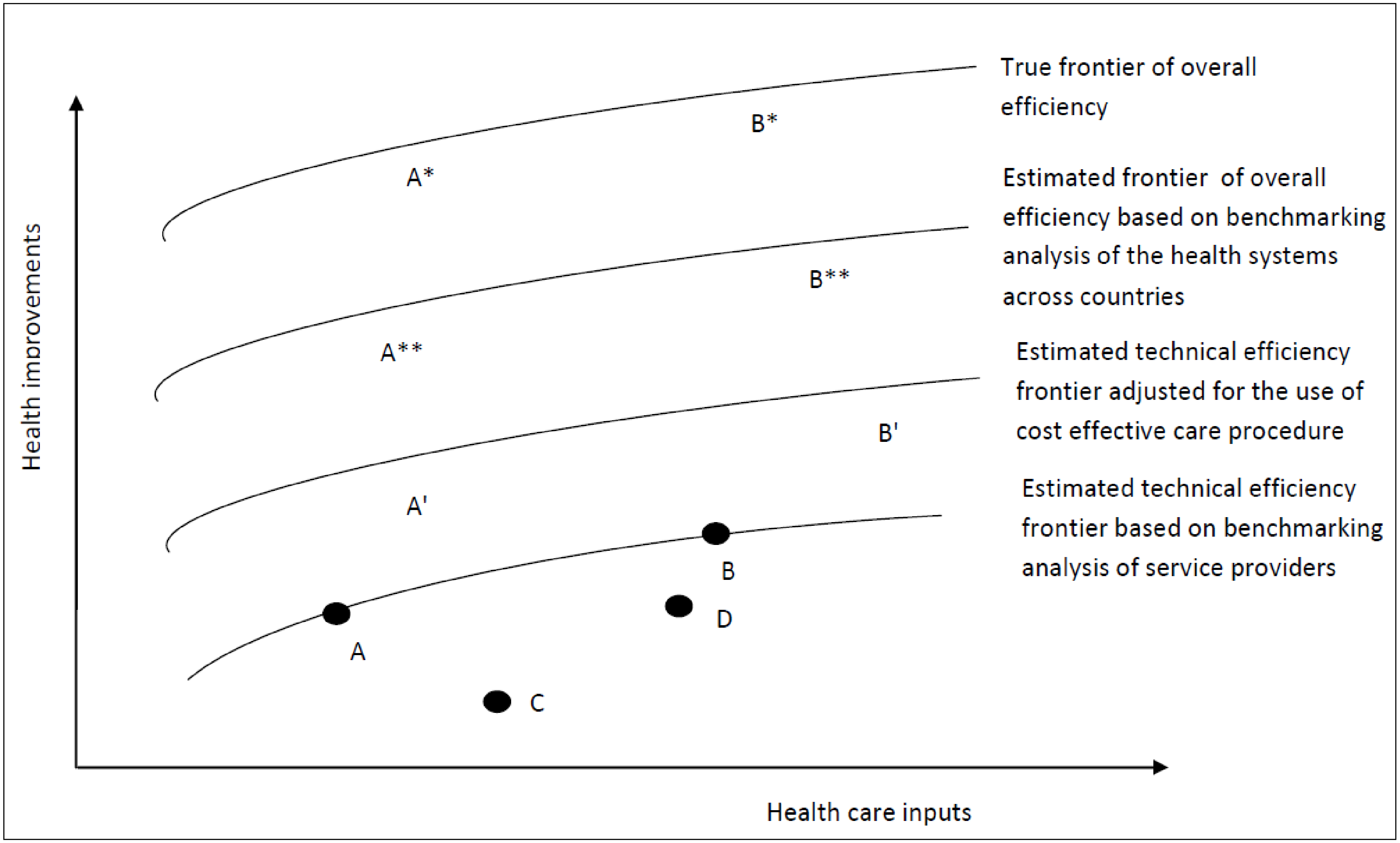

Figure 3.2. An illustration of bottom-up and top-down approaches
Source: Adopted from Peacock et al. (2001)

The 'top-down' approach uses aggregated country data to estimate the frontier of overall efficiency. The estimated frontier is line A**B** which lies above line AB because of its partial inclusion of allocative efficiency. However, Line A**B** may understate the true level of overall efficiency as even the best performing countries may have scope for improving efficiency. Like in the case of the 'bottom-up' approach, adjusting for economic evaluation can adjust line A**B** upward to A*B*.

In sum, while the economic evaluation and benchmarking technique to measuring efficiency may be widely popular in the literature, they may not separately provide comprehensive estimates of inefficiency in a particular health system. These techniques can however complement each other in revealing the diverse sources of inefficiency.

Daraio and Simar (2007) argues that the concept of efficiency simply involves the formulation of a production set and the distance between observed points and the boundary of the production set. They posit that the primary motive of producers is to maximize their output levels subject to the available inputs. However, this objective is not always achieved and in most cases, producers operate below their optimal capacity, given the technology at their disposal. In this regard the use of tradition production functions in solving the optimization problem may be less desirable to the frontier approach. While the production function approach seeks to intersect data of decision making units (DMUs), the frontier based approach seeks envelop data of DMUs. The basic idea of the frontier approach is to provide a numerical evaluation of the performance of a certain number of DMUs from the perspective of technical efficiency; which is their ability to operate close to or on the boundary of their production set (Daraio and Simar, 2007).

3.1.2.2 Defining Efficiency Measurement

Farrell (1957) is credited with the earliest attempt to provide a generally acceptable measure of efficiency. Efficiency of any decision making unit, as noted by Farrell basically means the success of the unit to produce the largest possible output from the inputs available. The overall efficiency of a DMU can be defined as the product of two distinctive measures of efficiency namely; technical and price efficiency. A DMU is considered to be technically efficient when it uses fewer inputs to achieve a given level of output or more outputs with a given amount of inputs. The price efficiency on the other hand measures the extent to which a DMU uses the various factors of production in the best proportions, in view of their prices (Farrell, 1957). The resulting inefficiency arising after controlling for input prices are also known as allocative inefficiency (Herrera and Pang, 2005).

An illustration of technical and allocative efficiency is presented in the Figure 3.3 below, following Farrell (1951) and Herrera and Pang (2005). The starting point is to define an isoquant curve YY' that depicts the set of minimum inputs required for a unit of output. Point *P* defines an input-output combination which uses input quantities X_1 and X_2 to produce a unit of output. However at point *R*, it is possible to produce one unit of output using less of both inputs. The level of inefficiency in the use of resources can therefore be described by the segment *RP*. This type of Technical efficiency (TE) can be defined as $TE=OR/OP$.

There is also a possibility for the DMU to reduce cost by choosing another input combination. Point *T* provides such cost reduction option where one unit of output can be produced at the least cost combination of inputs. This is depicted by the equality of the marginal rate of technical substitution (MRTS) and the input price ratio. To achieve this cost level implicit in the optimal combination of inputs, there is the need to contract the input use to point *S*. The input allocative efficiency (AE) can therefore be defined as $AE=OS/OR$.

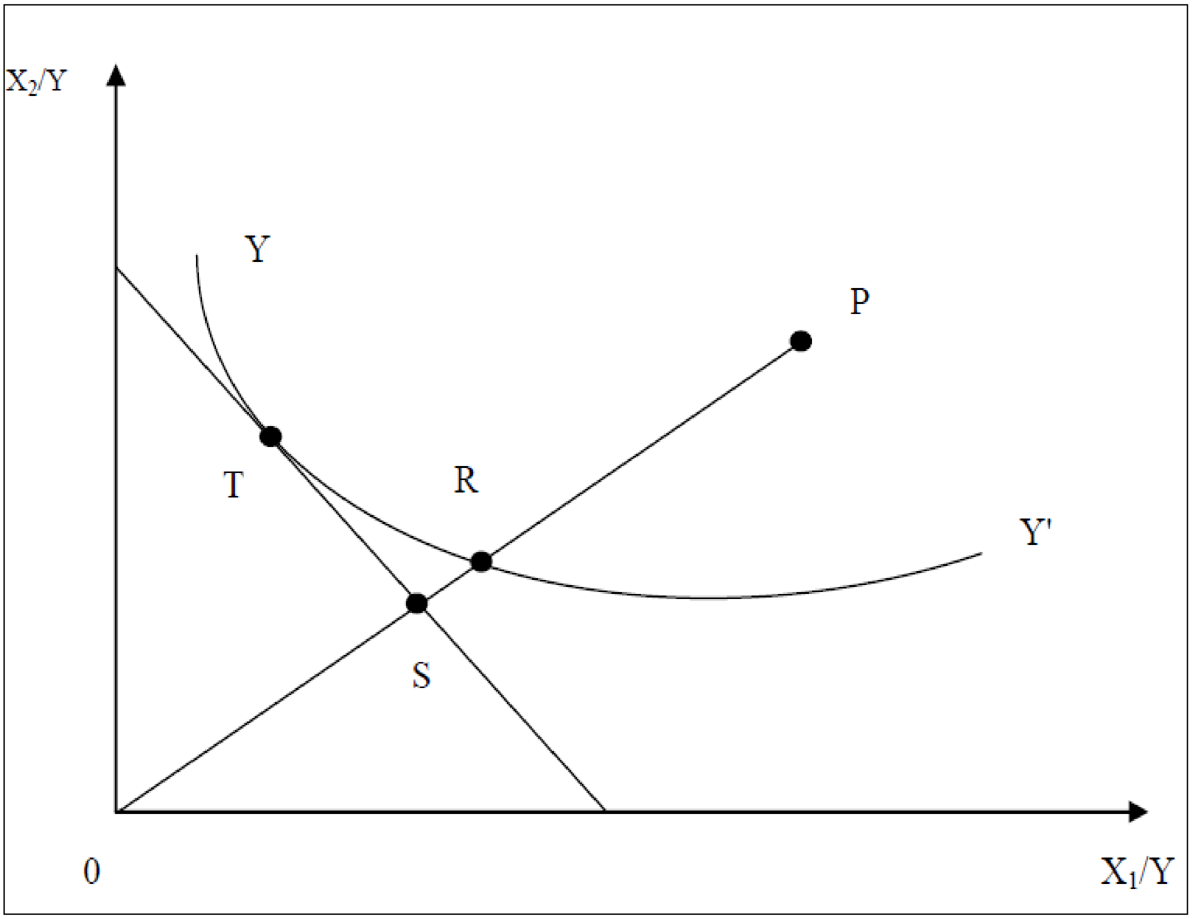

Figure 3.3. Illustration of technical and allocative efficiency
Source: Adopted from Jacobs et al. (2006)

3.1.2.3 Approaches in Measuring Efficiency

3.1.2.3.1 Performance ratio analysis

This approach to efficiency measurement is less complicated as in the two approaches discussed below. The approach simply seeks to compare input-output ratios across DMUs. The decision about whether or not a DMU is efficient is based on some rule of thumb. DMUs with ratios below some threshold are considered to be less efficient (Mortimer and Peacock, 2002). Performance ratio analyses are based on such relations as cost per patient days, cost per patient, personnel fulltime equivalent per patient, etc. The ratio analysis is restricted in the sense that different facilities produce different outputs and use different inputs, this therefore makes comparison difficult. However, in situations where the entire health system is evaluated, similar inputs and outputs could be identified. This method of efficiency analysis also neglects scale and scope effects as well as the distinction between chance and efficiency or inefficiency.

Ratio analysis indicators can be broadly categorised into productivity indicators, hospital specific cost indicators, output characteristics and other hospital characteristics. The productivity indicators are grouped into two, namely the partial productivity indicators (PPI) and the total factor productivity (TFP) indices. The PPI measures efficiency as the ratio of final output produced to a single input used in the production process. On the other hand, the TFP indices is a ratio of total output quantity measure to an index of total input quantity (i.e. TFP = output index/input index). The hospital-specific cost indicator simply takes a ratio of the hospital's total cost to an output index[11] (Jacobs and Dawson, 2003b, Jacobs and Dawson, 2003a). Efficiency measure based on output characteristics encompasses the quality of the hospital's output and the actual activities of the hospital. Finally, the other characteristics of the hospital may include whether or not the hospital is public, subsidized, private for-profit, private not-for-profit etc.

---

[11] The output index in this case is a weighted sum of the hospital's output

3.1.2.3.2 Data Envelopment Analysis

Data envelopment analysis is a widely used approach in the estimation of efficiency across DMUs. This approach is data driven unlike the parametric approach which is largely guided by economic theory. The basic ideology of the DEA approach is the possibility that DMUs with fewer inputs are likely to be more efficient than those that use more inputs but produce the same output levels. This implies that the higher the output-input ratio, the more efficient the DMU. The DMUs with the highest ratios are then joined up in an input-output space to construct the frontier. This frontier is based on best observed practice, hence is considered an approximation of the true frontier which is unobservable (Jacobs et al. , 2006). Efficiency measurement under the DEA methodology can be done either using the input-oriented or output-oriented efficiency measures (Jacobs et al. , 2006).

The input-oriented efficiency measure considers the possible proportional reduction in inputs given that output is fixed. This can be demonstrated by assuming a DMU uses two inputs (x_1 and x_2) which produce an output (y). By assuming diminishing factor productivity, a downward sloping convex isoquant can be constructed tangent to the budget line or isocost line. This is shown in Figure 3.4. Any point on the frontier represents efficiency and a reduction in x_1 necessitates a corresponding increase in x_2 to produce the same level of output. On the other hand, points that lie above the frontier are considered to be inefficient. The input oriented efficiency measure suggests that DMUs that lie above the frontier can reduce both x_1 and x_2 to produce the same level of output.

The straight line SS^1 is the budget line and represents the ratio of input prices. Figure 3.4 shows that $B^'$ is the cost-efficient point of production since the marginal rate of substitution between the two inputs is equal to the price ratio. It can however be noted that point A lies above this point of efficiency which shows a clear case of inefficiency[12]. The concept of inefficiency under DEA emerges from the notion of radial measure of inefficiency which compares the position of the DMU in relation to the production frontier (distance BA) with its location in relation to the origin (distance OA).

---

[12] The amount of both inputs needed to produce this output level are more than what is needed at points B and $B^'$

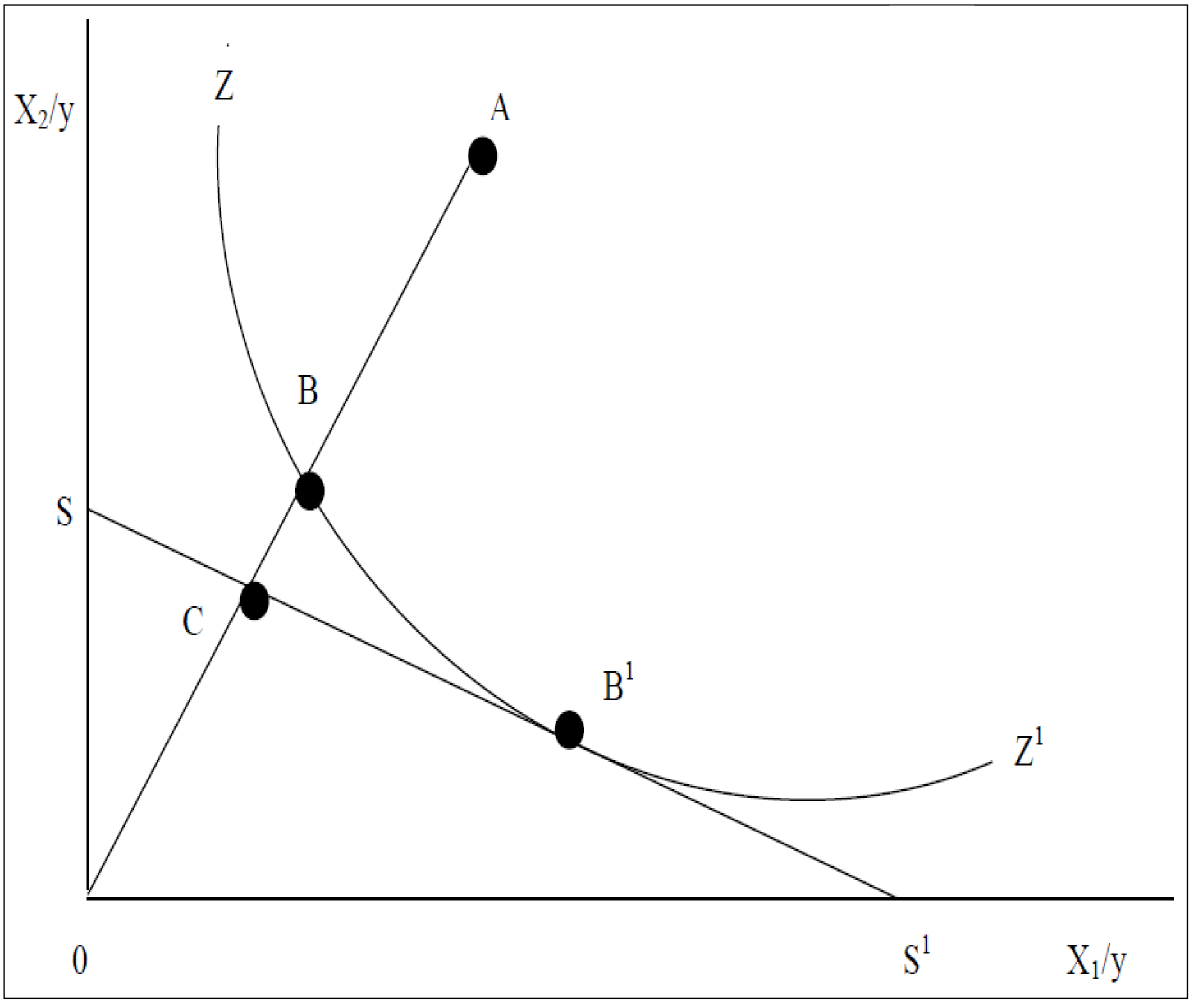

Figure 3.4. Technical and allocative efficiency under an input orientation
Source: Adopted from Jacobs et al. (2006)

The distance BA indicates the amount by which all inputs could be proportionally reduced without a reduction in output. This is then expressed in percentage terms by the ratio BA/OA. The technical efficiency of DMU A under the input orientation can be expressed as follows

$$TE_{IN} = \frac{OB}{OA} \qquad (3.17)$$

Which is equal to 1- BA/OA and where *TE* is technical efficiency and the *IN* subscript represents the input orientation (Jacobs et al, 2006). The value 1 represents full technical efficiency. This efficiency measure shows the deviation from the production frontier and also indicates that the DMU A can obtain the same output by reducing its inputs by the ratio 1- BA/OA (Ji and Lee, 2010). This value lies between 0 and 1 with a value of 1 indicating full technical efficiency.

In a situation where the prices of inputs are known and the isocost can be specified, the allocative efficiency of A can be calculated as follows:

$$AE_{IN} = \frac{OC}{OB} \qquad (3.18)$$

Where the distance CB is the reduction in production costs that would occur if production were to take place at the allocatively (and technically) efficient point B' instead of at the technically efficient (but allocatively inefficient) point B. It thus represents the deviation from the price-efficient point (Jacobs et al. , 2006).

The economic efficiency of a DMU comprises a combination of both the technical[13] efficiency and the allocative[14] efficiency such that:

$$EE_{IN} = TE_{IN} \times AE_{IN}$$

$$EE_{IN} = \frac{OB}{OA} \times \frac{OC}{OB} = \frac{OC}{OA} \qquad (3.19)$$

---

[13] Reflects that ability of a DMU to produce the maximum amount of output given a set of inputs

[14] Reflects the ability of a DMU to use inputs in optimal proportions given their respective prices

The output oriented DEA efficiency measure presents an alternative to the input oriented measure and basically suggests how possible proportional expansions in output can be explored, holding inputs constant. This is a direct opposite of the input-oriented model and is demonstrated with Figure 3.5 below, assuming two outputs (y_1 and y_2) and a single input (x).

In Figure 3.5, the production possibility frontier (ZZ^1) shows the highest possible production possibilities and DMUs that lie on it are considered to be efficient while those below the frontier are inefficient. In this regard, the output-oriented model posits that DMUs such as point A could proportionally expand their outputs while still holding their inputs constant. This expansion can be done up to point B which is located on the production boundary. The line SS^1 represents the iso-revenue line and reflects the market value of the two outputs. This then implies that given the production frontier, the efficient point of production will be B^1, the point of tangency. The technical efficiency under the output orientation (TE_{OUT}) of DMU A can be expressed as

$$TE_{OUT} = \frac{OA}{OB} \tag{3.20}$$

The allocative efficiency under the output orientation (AE_{OUT}) can be expressed as

$$AE_{OUT} = \frac{OB}{OC} \tag{3.21}$$

The economic[15] efficiency can therefore be given by the expression below

$$EE_{OUT} = TE_{OUT} \times AE_{OUT}$$

$$EE_{OUT} = \frac{OA}{OB} \times \frac{OB}{OC} = \frac{OA}{OC} \tag{3.22}$$

[15] In health care, output prices are hard to find and hence most efficiency analysis are restricted to technical efficiency and not total economic efficiency

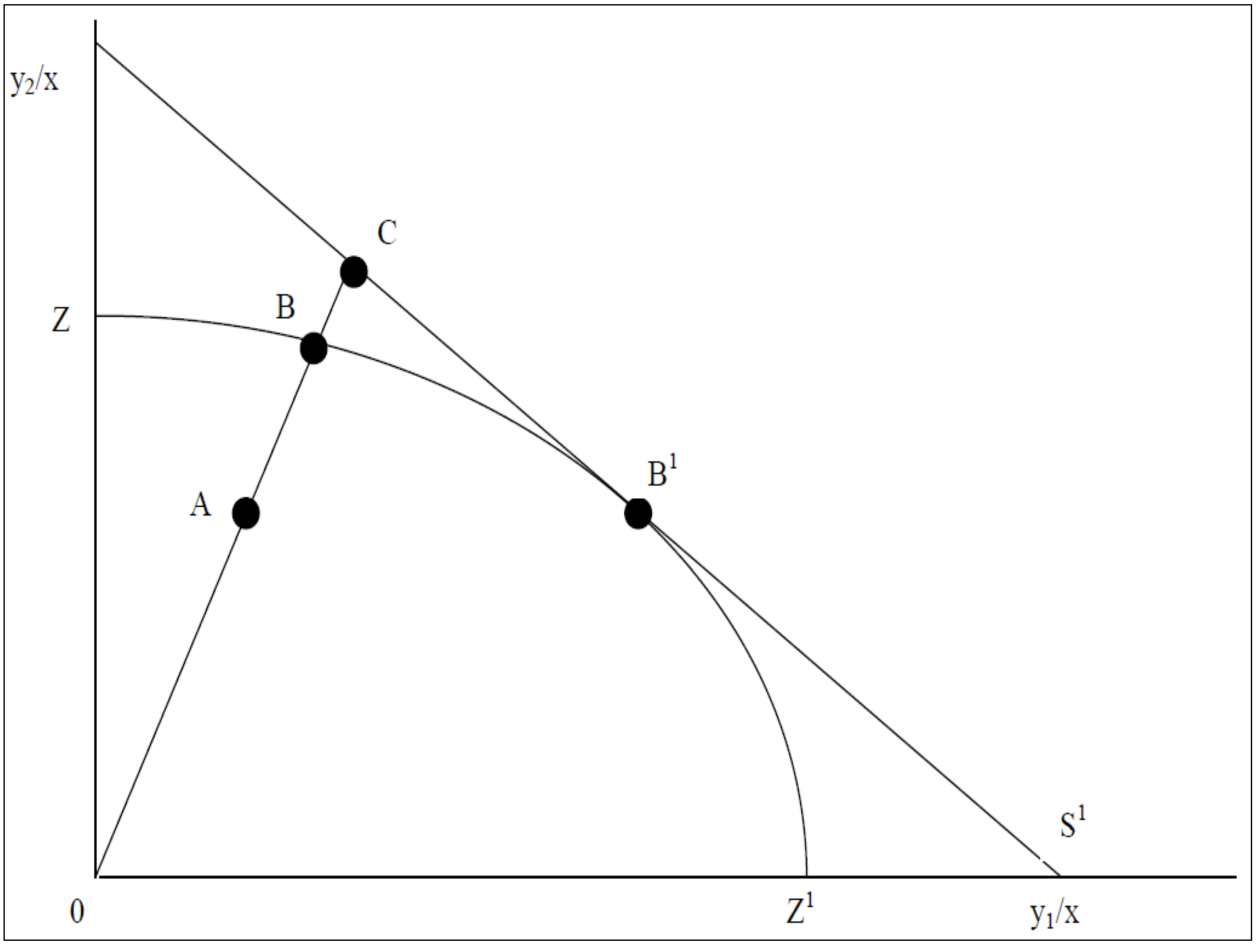

Figure 3.5: Technical and allocative efficiency under an output orientation
Source: Adopted from Jacobs et al. (2006)

According to Daraio and Simar (2007), the choice of orientation, whether input or output, depends on the direction in which distance to the technology is measured. Both the input or output distance functions can be used in measuring technical efficiency. However, an important point to note is the fact that the choice of orientation should correspond with the variable under the control of the decision makers. Daraio and Simar (2007) noted that most public services, such as health and education, only have input variables under their control and hence input efficiency will be of interest. It must be noted that, while the input orientation may be preferred in this situation, both measures are available and could be used in the measurement of efficiency.

3.1.2.3.3 Stochastic Frontier Analysis

The SFA is an alternative method of estimating efficiency and basically generates stochastic errors and inefficiency terms based on the residuals obtained from an estimated production frontier. Khaki et al. (2012) presents a theoretical specification of the production frontier model ignoring random components as:

$$y_i = f(x_i; \beta).TE_i \qquad (3.23)$$

Where y_i is the observed scalar output of the *ith* DMU, $i = 1,...,I$ is a vector of N inputs used by the *ith* DMU, $f(x_i;\beta)$ is the production frontier and β is an unknown vector of technology parameters which has to be estimated. The ratio of observed output to what is considered as maximum feasible output gives the technical efficiency (TE_i) measure. If $TE_i = 1$, then the DMU is efficient and produces highest feasible output. On the other hand, if $TE_i < 1$ then the DMU is, relatively, less efficient and shows the deviation from the maximum feasible output.

A stochastic formulation of the equation can be presented by adding a random term denoted by $exp(u_i)$ and is assumed to be identically independent.

$$y_i = f(x_i; \beta).TE_i.\exp\{u_i\} \qquad (3.24)$$

The TE_i is also assumed to be a stochastic variable with a common distribution function to all DMUs which can be written as

$$TE_i = \exp\{-u_i\} \tag{3.25}$$

It is assumed that $u_i \geq 0$ since $TE_i \leq 1$. This therefore implies that equation (3.23) becomes

$$y_i = f(x_i;\beta).\exp\{-u_i\}.\exp\{u_i\} \tag{3.24}$$

The specification of the underlying production function can be assumed to be log-linear, Cobb-Douglas or a translog function (Khaki et al. , 2012, Coelli and Perelman, 1999).

3.2 Methodological Review

On the methodological front, various approaches have been used by different researchers in examining the relationship between health spending and outcomes as well as estimating the efficiency of health resources. In this regard, the current section provides a review of the various methodologies, their strength and weaknesses.

3.2.1 Health expenditure and health outcomes

The relationship between health expenditure and outcomes has been estimated using various approaches in the literature. Both time series and panel data models have been used in estimating this relationship. Studies that employed time series analysis for individual countries mostly sought to estimate the short and long run relationships between health care spending and health outcomes. For instance Akinkugbe and Mahonoe (2009) used an error correction model (ECM) to investigate the relationship between public health expenditure and health status in Lesotho. This approach requires long enough time series data on country health expenditure and health outcomes. Such data are mostly not available for countries especially in the SSA region.

To circumvent this challenge, some researchers have used panel data models for cross country analysis. A key advantage of the panel data models over time series is that it grants the researcher extra leverage on degrees of freedom. Most of the studies conducted in SSA employed panel data techniques such as Ordinary Least Squares (OLS), fixed and random effects estimators. For instance Anyanwu and Erhijakpor (2009) used robust OLS, robust two stage least squares and fixed effect estimators to investigate this relationship using infant and under five mortality as health outputs while total and public health expenditure per capita were used as inputs. Lawanson (2012) in a similar study employed two-stage least squares and fixed effect estimators using four measures of health outcomes (infant, under five mortality, crude death rate and life expectancy) while public health care expenditure was used as a measure of inputs. In their time series analysis, Akinkugbe and Jerome (2006) used a one-way error component random effects model after a fixed effect model was rejected by the Hausman specification test. The authors also used life expectancy at birth, Infant mortality and under-five mortality rates were used as health outcomes while ratio of public health expenditure as percentage of GDP, population per physician, immunization against measles and hospital beds were used as inputs.

In similar studies from other regions, Nixon and Ulmann (2006) used fixed effect estimators with infant mortality rate and gender specific life expectancy at birth as outputs. They used total health expenditure and number of physicians as inputs. Cremieux et al. (2005) employed Generalised Least Squares (GLS) for panel data and corrected for AR(1) autocorrelation. They also used gender specific infant mortality rates, gender specific life expectancy at birth and at age 65 as health outputs while public and private drug spending and non-drug care spending were used as inputs. Babazono and Hillman (1994) adopted a multiple linear regression with stepwise regression approach. They also used total and public per capita health care spending in PPP terms as inputs and perinatal mortality, infant mortality, gender specific life expectancy at birth and at 80 years.

The random and fixed effects panel data models are generally considered to have efficient estimates, relative to the conventional OLS estimates. This strength of the random and fixed effects models lies in their ability to control for potential differences in cross sectional observations. The current study adopts the random and fixed effects panel data models and deviates from existing literature by using disaggregated national heath expenditure data as inputs. The lagged effect of health care expenditure was also captured.

3.2.2 Health system efficiency

With regards to estimating health system efficiency, two key methodologies have been used in the literature. These are the non-parametric and parametric approaches. The non-parametric approach includes the data envelopment analysis and the free disposable hull. The parametric approach includes the stochastic frontier analysis (SFA). It must be noted that the DEA approach have been relatively dominant in the health system efficiency literature.

Examples of studies that have used the nonparametric methods include Afonso and Aubyn (2005) who used both the DEA and FDH approaches to estimate efficiency using infant survival and life expectancy at birth as outputs while availability of doctors, availability of nurses and hospital beds were used as inputs. Other studies that used the DEA approach include Alexander et al. (2003) who also used gender specific disability adjusted life expectancy (DALE) and infant mortality rate as outputs while per capita expenditure adjusted for price differences across countries was used as inputs. Herrera and Pang (2005) employed both the DEA and FDH methods using life expectancy at birth, immunization and DALE as outputs while aggregate public spending on health was used as input. In terms of the parametric methods, Hernandez de Cos and Moral-Benito (2011) used the SFA approach with life expectancy at birth as output and per capita health expenditure, measured as a weighted average of the per capita expenditure for each age group using population age groups as weights, as inputs. Grigoli and Kapsoli (2013) also employed the SFA in analysing the efficiency of health expenditure in emerging and developing economies.

While the DEA and FDH are the most used in the estimation of health system efficiency, they are weak in the sense that they are extremely sensitive to the presence of outliers, which define the frontier. Their nonparametric nature also implies that they are unable to address random variations in the data which are then captured as inefficiency. While the SFA addresses these weaknesses, it is also limited in the imposition of some functional form on the production function which, in some cases, become difficult to estimate. A critical advantage of the SFA over nonparametric methods lies in its ability to control for large number of variables that can influence health outcomes. Efficiency scores from the nonparametric methods become biased when large number of inputs are used with small sample size, making it difficult to rank countries in terms of efficiency. While the second stage regression analysis have been employed to resolve this problem, it does not allow one to derive efficiency scores in a way that incorporates the influence of these factors (Burgess, 2006).

Comparative studies on these methods have been inconclusive as to which is most preferred (Chirikos and Sear, 2000, Hollingsworth and Wildman, 2003). However econometric studies favour the SFA due to its ability to control for randomness in the data and a wide range of variables that influence health outcomes. In the current study, both the DEA and SFA methods were employed to allow for comparison and robustness check. The study also deviates from studies that have used the SFA method by controlling for unobserved heterogeneity that may bias the inefficiency estimates (Greene, 2004). This aspect of the parametric methods, even though critical, has been missing in empirical studies that used the SFA.

Aside the estimation methods, there seems to be consensus in the literature about using per capita health care expenditure as the main monetary input of the health system while output measures have varied across researchers. Other researchers have employed physical inputs such as physician population, nurses and midwifery population as well as hospital beds. Bhat (2005) argued that the use of per capita health expenditure was less appropriate relative to specific health system inputs such as physicians, nurses and hospital beds. However, Hernandez de Cos and Moral-Benito (2011) argued that these health system specific inputs were acquired using health system expenditure and therefore the use of total health system expenditure is more encompassing. The current study employed both physical and monetary inputs in the analysis to allow for robustness.

3.3 Empirical Evidence[16]

3.3.1 Health expenditure and outcomes

Empirical analyses around macro level health expenditure have focused on three broad themes over the years. Some studies analysed the effects of per capita income on health expenditure (Baltagi and Mascone, 2010, Martin et al. , 2011, Jack and Lewis, 2009, Murthy and Okunade, 2009, Jaunky and Khadaroo, 2008, Husain, 2010, Farag et al. , 2012). Another

[16] See Appendix E for a tabulated summary of the empirical literature review

group of studies have focused on estimating the relationship between health care expenditure and aggregate population health (Babazono and Hillman, 1994, Berger and Messer, 2002, Bokhari et al. , 2007, Lawanson, 2012). A final set of studies in recent years have concentrated on the relationship between health aid and health outcomes at the macro level (Mallaye and Yogo, 2012, Mukherjee and Kizhakethalackal, 2012, Williamson, 2008, Wilson et al. , 2009).

With regards to the focus of the current study, the last two sets of empirical studies are reviewed. Consequently, the review suggests that there exists a plethora of studies that estimate the relationship between health care expenditure and health outcomes at the macro level in developed regions with little attention on developing regions. Studies that have focused on developing regions with emphasis on SSA include Lawanson (2012), Anyanwu and Erhijakpor (2009), Akinkugbe and Mohanoe (2009) and Kamiya (2010) with all of these studies focusing only on public health care expenditure to the neglect of private health spending.

In general, there seem to be some level of inconsistency in the exact relationship that exist between health care expenditure and health outcomes. Some studies have shown that public health expenditure has no impact on health outcomes. For instance, Musgrove (1996) concluded that health care expenditure has no significant influence on child mortality. Also, Filmer and Pritchett (1999) found that the most important determinant of child mortality was not public spending on health. And much recently, Kamiya (2010) found that government spending on health do not lead to reduction in mortality in developing countries. In terms of health aid and health outcomes, Mukherjee and Kizhakethalackal (2012), Williamson (2008) and Wilson et al (2009) all showed in their empirical studies that the relationship between health aid and reducing infant mortality rate was not significant.

In contrast, studies such as Cremieux et al. (1999), Gupta et al. (2002) and Bokhari et al. (2007) found strong positive relationships between health care spending and childhood mortality. Other studies like Murthy and Okunade (2009), Lawanson (2012), Anyanwu and Erhijakpor (2009) have all established that public health expenditure significantly improves life expectancy, reduces under five mortality and infant mortality rates. Other studies that found positive relationship between health aid and health outcomes include Mishra and Newhouse (2009) and Mallaye and Yogo (2012) for the case of SSA.

For instance, in the case of SSA, Lawanson (2012) estimated the effects of public health expenditure on health outcomes, measured by infant mortality, under-five mortality, crude death rate and life expectancy. Using panel data between 2003 and 2007 across 45 SSA countries with two-stage least squares and fixed effects estimates, the results showed that the relationship between public health expenditures and health outcomes was negative for mortality rates but positive for life expectancy.

In an earlier study, Anyanwu and Erhijakpor (2007) examined the effectiveness of total (both public and private) and public health expenditure on two health outcome measures, namely under-five mortality and infant mortality rates across African countries. Their study employed panel data and two-stage ordinary least squares estimation and found that both total health expenditure and per capita public health expenditure significantly influenced under-five and infant mortality rates in Africa. Their results showed that increasing per capita total health expenditure by 10% reduced under-five mortality by 21% and infant mortality by 22% while a 10% increase in per capita public health expenditure reduced under-five and infant mortality by 25% and 21%, respectively. Using time series data from Lesotho, Akinkugbe and Mohanoe (2009) employed an error correction model (ECM) and found that in addition to public health care expenditure, the availability of physicians, female literacy and child immunization significantly influenced health outcomes.

Farag et al (2013) provided a more recent empirical investigation into the relationship between country health spending and selected health outcomes, measured by infant and child mortality. using data from 133 low and middle income countries for the years 1995,2000,2005 and 2006, the study showed a significant impact of health spending on reducing infant and under five mortality rates with elasticities from 0.13 to 0.33 for infant mortality and 0.15 to 0.38 for under five mortality rates. The study also found that the level of good governance determined the magnitude of the impact of government health spending on infant and under five mortality rates for each country. Countries with higher levels of good governance showed higher impact of government health spending on health outcomes.

Rhee (2012) performed a single country analysis of the effects of health care expenditure on infant mortality rate and life expectancy at birth in Korea. The study used time series data from 1985 to 2010. The results of the study indicate that there exists a significant and positive relationship between health care expenditure and the two measures of health outcomes with elasticities ranging from 0.01 to 0.02. Using the number of physicians and number of hospital beds as health inputs, the results showed significant relationship with elasticities ranging from 0.04 to 0.13. Rhee (2012) concluded that health care expenditure tends to be effective in the long run while the number of physicians and hospital beds are effective in the short run due to the magnitude of variation in the elasticities of the two sets of inputs.

Bokhari et al. (2007) estimated the relationship between health care expenditure, per capita income and health outcomes nexus using under five mortality and maternal mortality as health outcome measures. The study found elasticities for under five mortality ranging from -0.25 to -0.42 and maternal mortality ranging from -0.42 to -0.52, with respect to health care expenditure. An interesting implication of the results however suggests that economic growth is a more important contributor to health outcomes relative to government health expenditure for developing countries.

In a similar study for 15 European Union countries over the period 1980-1995, Nixon and Ulmann (2006) applied fixed effects model to panel data to estimate the relationship between health care expenditure and two measures of health outcomes (infant mortality and life expectancy). The results showed that increase in health care expenditure significantly influence infant mortality but only marginally in relation to life expectancy. Using mortality rates per 1000 population with data from 20 OECD countries from 1960 to 1992, Berger and Messer (2002) showed that health care expenditure have a significant negative relationship with mortality rates.

Cremieux et al (2005) used gender specific infant mortality and gender specific life expectancy at birth and at age 65 as measures of health outcomes. Panel data analysis from Canadian provinces showed that both public and private drug spending were significant for all the health outcome measures. Cremieux (1999) also investigated the impact of total health care spending (including both public and private sources) on gender specific infant mortality and life expectancy at birth using panel data from Canadian provinces over the period of 1978-1992, the study showed that health expenditure was significant for all outcomes with elasticity of -0.4 and -0.6 for male and female infant mortality respectively, 0.05 and 0.024 for male and female life expectancy, respectively.

Babazono and Hillman (1994) estimated the relationship between health care spending and health outputs measured by perinatal mortality, infant mortality, life expectancy at birth for both males and females and life expectancy at 80 years. Using data from 21 OECD countries for 1988 and multiple linear regression with stepwise analysis, they found that only female life expectancy at birth was significantly affected by health care expenditure with elasticity of 0.38. Hiltiris and Possnett (1992) also employed panel data from 20 OECD countries between 1960 and 1987. The results show that health expenditure had a negative impact on mortality with elasticity of -0.08.

With regards to health aid and health outcomes, Mukherjee and Kizhakethalackel (2012) investigated the impact of health aid on infant mortality rate and examine the role of education in understanding this nexus. The authors also investigated this nexus by disaggregating health aid into infectious disease control and nutrition health aids. Using data from poor developing countries, the results showed that education always lowers infant mortality rate but the overall effect of health aid remains insignificant. In terms of disaggregated health aid, the study also found that total health aid and nutrition aid may lower infant mortality rate only after education exceeds a threshold level.

In a related study conducted for 28 sub-Saharan African countries from the year 2000 to 2010, Mallaye and Yogo (2012) found that additional units of health aid increases life expectancy at birth, decreases HIV prevalence and decreases infant mortality with elasticities of 0.14, -0.05 and -0.17, respectively. Female primary school completion rate was identified to be the main channel through which these effects operate. The study also showed that differences in health aid received did not explain the differences in health outcomes between conflict and stable countries. However, level of good governance and female primary school completion rate were found to be relevant variables in explaining these differences.

3.3.2 Efficiency of health systems

Empirical evidence on efficiency in the health economics literature have, over the years, concentrated on various components of the health system. These studies are micro based and mostly answer the question of how health inputs are used to generate the highest possible outcomes within specific components of the health system. In SSA, most of these micro-based studies have been at the hospital level (Kirigia et al. , 2010, Tlotlego et al. , 2010). In a typical setting, such studies that estimate efficiency at the hospital level use hospital workforce (including physicians and nurses population) and hospital beds as inputs and inpatient and outpatient days as health outcomes.

Another set of studies have analysed efficiency at the disease level. The import of such studies is basically to estimate the efficiency in the use of health resources in the prevention and treatment of diseases. Such empirical analysis have been done within and across countries (Baily et al. , 1997, Garber and Skinner, 2008). Inputs used in such studies include among others labour (physicians, nurses and technicians), supplies (medications, surgical instruments and X-ray films) and capital (diagnostic equipments and hospital facilities). Survival rates or quality of life with respect to each disease treatment may be used as outcome variables.

In much more recent years, the attentions of empirical studies on efficiency in the health economics literature have been on the health system as a whole. This type of macro level analysis of how health resources are used to generate population health outcomes is fast gaining grounds. Unlike the micro based studies on efficiency, health care expenditure per capita has been widely used as the input variable at the macro level analysis of health system efficiency (WHO, 2000, Afonso and Aubyn, 2005). A few studies have, however, exclusively used physical inputs (including population of physicians, nurses and hospital beds) at the macro level (Bhat, 2005). Life expectancy, infant, under five and maternal mortality rates as well as child survival rates and disability adjusted life years (DALY) have been widely used as measures of health system output.

The pioneering attempt to estimate cross country health system efficiency is credited to the World Health Report published in the year 2000. The report provided estimates of health system performance for 191 member states of the WHO. Following this, several other studies have emerged using various methods and data to estimate the efficiency of health systems across countries. A review of a cross section of these studies is presented below.

First, Hernandez de Cos and Moral-Benito (2011) Used panel data for 29 OECD countries with annual observation from 1997 to 2009. The authors employed a stochastic frontier analysis (SFA) which showed that Japan was the most efficient country in terms of health system performance. The authors also showed that both health system efficiency and health care expenditure positively influenced life expectancy with elasticity of 0.71 and 0.06, respectively.

Defining health system efficiency as a process of turning financial inputs into additional health outputs rather than the level of health status reached, Kotzian (2009) employed data on OECD members to estimate the differences in efficiency in the use of health resources. By estimating country specific health care expenditure interaction effect, the results showed that Czech Republic and Finland had the most productive health care system while Greece and Spain had the least productive. The study also concluded that health care system efficiency and potential for improving the system are generally overstated. Kotzian (2009) attributed differences in life expectancy across countries to factors outside of the health care system and argued that tackling these might be more effective than changing the health care system.

Mirzosaid (2011) computed relative efficiency for the commonwealth of Independent States. The study employed per capita expenditure on health, physicians, nurses and midwifes density and hospital beds as inputs and life expectancy at birth and infant survival rate as outputs. Using DEA approach, the study found Tajikistan and Uzbekistan to be the most efficient in the single and multiple input/output case while Moldova and Russia were effective only in the multiple input/output case.

Deviating from the regular use of per capita health care expenditure as health inputs, Bhat (2005) used DEA to compute the efficiency of health care delivery systems using only physical health care inputs such as number of physicians, nurses, inpatient beds and pharmaceuticals. Using data from the OECD health data set, efficiency estimates under the constant return to scale assumption showed that 8 out of the 24 OECD countries fell on the frontier and had efficiency score of 1. These include Denmark, Japan, The Netherlands, Norway, Portugal, Sweden, Turkey and the United Kingdom. Belgium, Iceland and Australia had the lowest efficiency score. The study also showed that institutional arrangements have significant impact on the level of efficiency. For instance, countries in which physicians are paid in wages and salaries and countries with capitation have higher efficiency than free-for-service countries.

Jafarov and Gunnarsson (2008) estimated relative efficiency of government spending on health care and education using the DEA analysis in a cross country comparison. The study employed the density of physicians, pharmacist, health care workforce, number of hospital beds and number of immunization vaccines as inputs while infant, child and maternal mortality as well as standardized death rates, incidence of tuberculosis and healthy average life expectancy were used as health output variables. The findings showed evidence of significant inefficiencies in Croatia's spending on health care. Among the 37 countries used in the relative analysis, Croatia ranks in the 63rd percentile in terms of public spending and 48th percentile in terms of total spending on health. The following factors were found to be associated with inefficiency in Croatia: inadequate cost recovery, weaknesses in the financing mechanism and institutional arrangements weak competition in the provision of these services and weaknesses in targeting public subsidies on health care.

Another attempt made to estimate the efficiency of health systems was done by Evans et al. (2001) provided empirical evidence on health system efficiency for 191 WHO countries (both developed and developing) by estimating the relation between levels of population health and the inputs used to produce health with data from 1993 to 1997. While population health output was measured by healthy life expectancy, health system input was measured by per capita health expenditure. The results showed Oman to be the most efficient with a score of 0.992 and Zimbabwe the least efficient with a score of 0.080. They argued that health system performance was likely to be influenced by civil unrest and the prevalence of HIV and AIDS.

In a related study, Afonso and Aubyn (2005) estimated efficiency in education and health sectors for a sample of OECD countries by applying two alternative non-parametric methodologies, namely: the free disposable hull and data envelopment analysis. Using number of doctors, nurses and hospital beds as inputs and infant survival and life expectancy as outputs, the results for health efficiency scores using the FDH indicate that eleven among the 24 countries were efficient[17]. The DEA efficiency score indicates that eight countries were estimated to be efficient[18] relative to the eleven under the FDH analysis.

Alexander et al. (2003) presented a DEA analysis of health system performance across 51 developing countries using panel data between 1998 and 1999. The study used male disability adjusted life expectancy, female disability adjusted life expectancy and infant mortality rate as outputs and per capita health expenditure adjusted for price differences across countries as inputs. The results showed that a total of nine health systems were estimated to be efficient[19]. Results from the Tobit model showed that health expenditure, nutrition and female education were significant determinants of health system efficiency.

Gupta and Verhoeven (2001) assessed the efficiency of government expenditure on education and health for 37 countries in Africa in 1984-1995 and compared with countries in Asia and Western Hemisphere. Using the FDH efficiency analysis, the results showed that on average, countries in Africa are less efficient than countries in Asia and Western Hemisphere. Further, education and health related spending reduced the level of inefficiency.

Herrera and Pang (2005) analysed efficiency of public spending in developing countries. The study used both the FDH and DEA techniques to efficiency measurement with data from 140 countries from 1996 to 2002. From the single input and output analysis, nine[20]

---

[17] Efficient countries under the FDH analysis are Canada, Denmark, France, Japan, Korea, Norway, Portugal, Spain, Sweden, the United Kingdom and United States.
[18] Efficient countries under the DEA analysis are Canada, Japan, Korea, Portugal, Spain, Sweden, the United States and the United Kingdom.
[19] Efficient countries are Bangladesh, Bhutan, Lao (PDR), Madagascar, Tanzania, China, Indonesia, Jamaica and Sri Lanka
[20] Input efficient countries are Korea, Malaysia, Thailand, Trinidad & Tobago, Oman, United Arab Emirates, Mauritius, Kuwait, Chile

countries were found to be input efficient while six[21] countries were found to be output efficient. Evidence from the multiple input and output indicate that eight[22]countries were input and output efficient, respectively. Results from a Tobit model showed that higher expenditure levels, higher wage bill as share of government budget, higher public to private financing, higher HIV/AIDS prevalence and higher aid-dependency ratio were associated with lower efficiency scores.

Retzlaff-Roberts et al. (2004) analysed technical efficiency in the production of aggregate health outcomes of reduced infant mortality and increased life expectancy. The study employed OECD health dataset of 2000 for 27 countries. The result revealed Japan, Sweden, Norway and Canada as the relatively efficient countries with good health outcomes while Turkey and Mexico were efficient with modest health outcomes.

3.4 Overview of literature

The literature presented above suggests that the relationship between health care expenditure and health outcomes is not consistent. Some researchers have found positive relationship while others have found no significant relationship with varying methodologies being used (Nixon and Ulmann, 2006). One interesting observation, however, is that majority of these studies have focused on developed regions (largely OECD) with very little done on developing regions. The studies on SSA did not consider the differential effects of public and private health expenditure sources on health outcomes. Again the potential lag effect that exist between health expenditure and health outcomes was absent in the literature. This is important, considering that health expenditure may not have immediate but delayed impact on population health. The review also found very little studies that exclusively estimates the efficiency of health expenditure for SSA countries. The current study filled these research gaps.

---

[21] Output efficient countries are Korea, Dominica, Oman, United Arab Emirates, Anigua and Barbuda

[22] Input and output efficient countries are Bangladesh, Malaysia, Costa Rica, Kuwait, Morocco, Oman, Mauritius and Niger

CHAPTER FOUR

METHODOLOGY

4.0 Introduction

The chapter focuses on the approaches proposed to achieve the stated objectives of the study. The data to be used in the study, variables and econometric models are presented in this chapter. Also, the chapter presents a theoretical framework from where the empirical specification of the models is derived.

4.1 Theoretical Framework

The theoretical framework adopted in this study follows Fayissa and Gutena (2008) who developed a macro level health production function based on the Grossman (1972) model. Like Grossman (1972), Fayissa and Gutena (2008) treated social, economic and environmental factors as inputs in the health production system. At the micro level the theoretical formulation can be simply expressed as follows

$$H = F(x) \tag{4.1}$$

where H is individual health output and x is a vector of individual inputs to the health production function, F. The elements of the vector of inputs include nutrient intake, income, consumption of public goods, education, time devoted to health related procedures, initial health stock and the environment. While the above model analyses health production at the individual level, the current study seeks to analyse health production at the level of the health sector as a whole. Without loss of theoretical ground, Fayissa and Gutena (2008) presented a macro level specification of equation (4.1) by representing the elements of the vector x by per capita variables and regrouped into sub-sectors of economic, social and environmental factors.

This specification is shown in the expression in equation (4.2)

$$h = F(Y, S, V) \tag{4.2}$$

where Y is a vector of per capita economic variables, S is a vector of per capita social variables and V is a vector of per capita environmental factors.

Equation (4.2) can be re-written in its scalar form as follows

$$h = f(y_1, y_2, ..., y_n; s_1, s_2, ..., s_m; v_1, v_2, ..., v_l) \tag{4.3}$$

where h is population health status, $(y_1, y_2,...,y_n) = Y$; $(s_1, s_2,...,s_m) = S$; $(v_1, v_2,..., v_l) = V$ and n, m and l are number of variables in each sub-group, respectively.

Assuming a Cobb-Douglas production technology relating the inputs and outputs, then equation (4.3) can be transformed as

$$h = \Omega \Pi_{yi}^{\alpha i} \Pi_{sj}^{\beta j} \Pi_{vl}^{\gamma k} \tag{4.4}$$

where α_i, β_j and γ_k are elasticities

The term Ω in equation (4.4) estimates the initial health stock and measures the health status that would have been observed if there was no depreciation in health or health improvement due to changes in social, economic and environmental factors used in the production process. In a similar way, $(\Pi_{yi}^{\alpha i} \Pi_{sj}^{\beta j} \Pi_{vl}^{\gamma k} - 1)x100\%$ estimates the percentage change in health status due to socioeconomic and environmental factors.

Taking the logarithmic transformation of equation (4.4) and rearranging yields equation (4.5) below

$$\ln h = \ln \Omega + \sum \alpha_i (\ln y_i) + \sum \beta_j (\ln s_j) + \sum \gamma_k (\ln v_k) \tag{4.5}$$

where $i = 1,...,n$; $j = 1,....,m$ and $k = 1,....,l$

Equation (4.5) also corresponds to the additive logarithm health production function derived by Koc (2004)[23]. According to Fayissa and Gutena (2008), the economic inputs in the health production function may include the total health care expenditure per capita in a particular country. This can further be disaggregated into private and public components of health expenditure.

4.2 Empirical Model

4.2.1 Health care expenditure and health outcomes

Following Baltagi (2008), the starting point for the estimation of the relationship between health care expenditure and health outcomes in a panel regression model is specified as follow;

$$y_{it} = \alpha + X_{it}^{'}\beta + u_{it}; \quad i = 1,...,N; \quad t = 1,...,T \tag{4.6}$$

Where *i* and *t* denote countries (cross section units) and time (time series dimension) respectively. α is a scalar, β is $Kx1$ vector and X_{it} is the *it*th observation on K^{th} explanatory variables.

For the purposes of estimation, the following reduced form health production model was considered to achieve the first objective.

$$HS_{it}^{j} = \alpha_i + \beta_1 THE_{it} + \beta_2 Y_{it} + \beta_3 \operatorname{Im} m_{it} + \beta_4 Educ_{it} + \beta_5 THE_{it-l} + \beta_6 S_{it} + \beta_7 HIV_{it} + \beta_8 U_{it} + \sum_n \gamma_n Pop_{nit} + \varepsilon_{it} \tag{4.7}$$

$$HS_{it}^{j} = \alpha_i + \beta_1 PuHE_{it} + \beta_2 Y_{it} + \beta_3 \operatorname{Im} m_{it} + \beta_4 Educ_{it} + \beta_5 PuHE_{it-l} + \beta_6 S_{it} + \beta_7 HIV_{it} + \beta_8 U_{it} + \sum_n \gamma_n Pop_{nit} + \varepsilon_{it} \tag{4.8}$$

$$HS_{it}^{j} = \alpha_i + \beta_1 \Pr HE_{it} + \beta_2 Y_{it} + \beta_3 \operatorname{Im} m_{it} + \beta_4 Educ_{it} + \beta_5 \Pr HE_{it-l} + \beta_6 S_{it} + \beta_7 HIV_{it} + \beta_8 U_{it} + \sum_n \gamma_n Pop_{nit} + \varepsilon_{it} \tag{4.9}$$

Where *j* in each equation represents different health status measure as dependent variable and *n* represents different population brackets in terms of the explanatory variables. All

[23] See presentation of class of health production functions in Chapter three

variables were used in logarithms. Equation (4.7), (4.8) and (4.9) estimates the effect of total, public and private health expenditure on health outcomes, respectively. This allows for an understanding of the separate effect of each of these variables on the health outcomes of a population. The variables in the equations are further described in Table 4.1 below:

Table 4.1. Variable description

Variables	**Description**
Health status (HS)	Represents health outcome measures including Life expectancy at birth, neonatal mortality, crude death rate, Infant mortality and under-5 mortality
Life expectancy at birth (LE)	Average number of years that a new born could expect to live given prevailing death rates at the time of birth, for a specific year in a given country.
Neonatal mortality rate (NMR)	Number of deaths during the first 28 completed days of life per1000 live births in a given year
Under-five mortality rate (U5M)	The probability of a child born in a specific year or period dying before reaching the age of five
Infant mortality rate (IMR)	The probability of a child born in a specific year or period dying before reaching the age of one
Crude death rate (CDR)	Number of deaths per 1000 population
Per capita health care expenditure (THEpc)	Per capita total expenditure on health expressed in ppp international dollar
Total health care expenditure (THE)	Total health expenditure expressed as a percentage of gross domestic product (GDP). Covers spending on preventive and curative health services, family planning activities etc.
Public health care expenditure (PuHE)	Level of public spending on health expressed as percent of GDP. Includes spending from government budgets, external borrowing, grants and social health insurance funds
Private health care expenditure (PrHE)	Level of private expenditure on health expressed as a percentage of GDP. Includes direct household (out-of-pocket) spending, private insurance, charitable donations and direct service payments by private corporations.
Real GDP per capita (RGDPpc) (Y)	Real GDP per capita measured in constant 2005 international dollars
DPT Immunization (Imm)	Percentage of children ages 12-23 months who received DPT immunization before 12 months
Education (Educ)	Secondary school enrolment as percentage of gross school enrolment
Sanitation (S)	Percentage of population using an improved sanitation facility
HIV prevalence rate (HIV)	Estimated number of adults aged 15-49 years with HIV infection expressed as percent of total population in that age group
Urbanization (Urban) (U)	Percentage of population living in areas classified as urban according to the criteria used by each country.

Population aged 14 years and below (Pop1)	Population age group below or equal to 14 years expressed as percentage of total population
Population 15-64 years (Pop2)	Population age group between 15 and 64 years expressed as percentage of total population
Population 65 years and above (Pop3)	Population age group above 65 years expressed as percentage of total population
Governance	Country policy and institutional Assessment (CPIA) of transparency, accountability and corruption in the public sector rating (1-low to 6=high)
ERMR	CPIA efficiency of revenue mobilization rating (1=low to 6=high)
PSMI	CPIA public sector management and institutions cluster average (1=low to 6=high)
MEMR	CPIA macroeconomic management rating (1=low to 6=high)
ERR	CPIA equity of public resource use rating (1=low to 6=high)

Source: Author’s compilation

4.2.2 Health system efficiency

The sub-section presents methods employed to achieve the second and third objectives. The DEA and SFA models, used to estimate health system efficiency, are presented in details while the Tobit model used to determine the factors influencing health system efficiency (as stated in the third objective) is also presented.

4.2.2.1 Formulation of the DEA model

The study employs the DEA technique to examine the effectiveness with which health care resources are used to generate population health outcomes across SSA countries. Essentially, the extent to which a country could achieve better health for its population if all health resources were used efficiently is estimated and compared across countries in the SSA region. The empirical methods employed in this study follow Fare et al. (1994) and Alexander et al. (2003) using non-parametric linear programming techniques.

The empirical analysis starts by finding out the achievable population health outcome of a particular country, given its expenditure on health resources or physical health inputs and performance of other health systems elsewhere. This optimization problem is solved by constructing a 'best practice' frontier, which is a piece-wise linear envelopment of the health expenditure-health outcome data for the sample countries. The estimated frontier describes the most efficient performance conditions within the countries and therefore forms a benchmark for comparison.

Efficiency in the production of population health is measured relative to such a frontier for each country. The health systems of countries that are operating on (and determine) the frontier are termed efficient while countries with health systems operating off the frontier are considered to be relatively inefficient. Inefficiency in this case should be understood to mean that better population health outcomes could have been attained from the observed health expenditure or health inputs, were performance similar to that of 'best-practice' countries (Alexander et al. , 2003).

To better understand the procedures described above, let S^t be the technology that transforms health sector resources into population health outcomes. This technology can be modelled by the output possibility set

$$P^t(x^t) = \left\{ y^t : (x^t, y^t) \in S^t \right\} t = 1, ..., T \qquad (4.10)$$

where $P^t(x^t)$ denotes the collection of population health output vectors that consume no more that the bundle of resources indicated by the resource vector x^t, during period t.

The best practice frontier can be empirically estimated as the upper bound of the output possibility set, $P^t(x^t)$. The output possibility set, $P^t(x^t)$, can be estimated empirically by assuming that the sample set is made up of observations on $j=1,...J$ countries' health systems, each using $n=1,...N$ resources, x^t_{jn}, during period t, to generate $m=1,...,M$ population health outcomes, y^t_{jm}, in period t. Accordingly, $P^t(x^t)$ is estimated from the observed set of health expenditures, physical health sector inputs and population health outcomes for all the countries of the sample.

The empirical construction of the piece-wise linear envelopment of the input possibility set is given by

$$\begin{aligned} P^t(x^t) = \{ y^t : x^t_n \le \sum_{j=1}^{J} z_j x^t_{jn}, n = 1, ..., N \\ \sum_{j=1}^{J} z_j y^t_{jm} \ge y^t_m, m = 1, ..., M \\ \sum_{j=1}^{J} z_j = 1 \\ z_j \ge 0, j = 1, ..., J \} \end{aligned} \qquad (4.11)$$

where z_j is a variable indicating the weighting of each of the health systems.

The output-based efficiency score for each country's health system for period t can be derived as

$$F^t_o(x^t_j, y^t_i) = \max\{\theta \text{ such that } \theta y^t \in P^t(x^t)\} \text{ where } F^t_o(x^t_j, y^t_i) \ge 1. \qquad (4.12)$$

This suggests that a county's health outcomes vector, y^t, will be located on the efficiency frontier when equation (4.12) has a value of one. However, if equation (4.12) produces a value less than one, the health system must be classified as inefficient relative to best-observed practice. This measure can be computed for country j as the solution to the linear programming problem

$$F_o^t(x_j^t, y_i^t) = \max\theta \qquad (4.13)$$

with θ, z such that

$$\begin{aligned}
&\sum_{j=1}^{J} z_j y_{jm}^t \geq \theta y_{jm}^t, m = 1,\dots,M,\\
&\sum_{j=1}^{J} z_j x_{jn}^t \leq x_{jn}^t, n = 1,\dots,N,\\
&\sum_{j=1}^{J} z_j = 1,\\
&z_j \geq 0, j =,\dots,J,
\end{aligned} \qquad (4.14)$$

where the restrictions on the weighting variables, z_j, imply a variable returns to scale assumption in regard to the underlying technology of health production.

Jacobs (2000) noted that DEA measurement can be done under two critical assumptions. These are the constant or variable returns to scale assumptions. Further explanation of the two assumptions is presented in the sub-section that follows.

4.2.2.1.1 Constant versus Variable returns to scale

The estimates of technical efficiency depend on the scale assumptions imposed on the model. The variable returns to scale (VRS) and constant returns to scale (CRS) are generally imposed. The VRS assumption includes both increasing and decreasing returns to scale. The thrust of the CRS assumption is that it reflects the fact that output changes by the same proportion as inputs are changed. For instance a doubling of all inputs will double outputs. This assumption was first imposed in the efficiency analysis work by Farrell (1957). This assumption was considered to be strongly restrictive hence an extension of the assumption was proposed by Farrell and Fieldhouse (1962) to allow for non-decreasing returns to scale.

The VRS model was originally proposed by Afriat (1972) but popularized in the literature by Banker et al. (1984). Banker et al. (1984) showed that the addition of a convexity constraint to the CRS model results in a DEA model that allows for increasing, constant and decreasing returns to scale. This also allows for the decomposition of the efficiency estimates into scale and technical parts. The figure below is used to demonstrate the distinction between the CRS and VRS assumptions

Given an input (x) and output (q), a DMU's (say, P) efficiency under the CRS assumption is measured by the ratio AP_c/AP. However, under the VRS assumption, the DMU's efficiency is measured by the ratio AP_v/AP. The difference between the CRS and VRS is the scale of operation of the DMUs. The CRS is only appropriate when the DMUs are operating at an optimal scale. In a situation where they are all not operating at an optimal scale, the technical efficiency estimates will be confounded by scale efficiencies if CRS is specified. To calculate technical efficiencies devoid of scale effects, the VRS specification is used. It therefore follows that, the difference between the estimated CRS and VRS models give the scale efficiency. The VRS model is essentially the CRS model with an additional constraint on the linear programming problem.

The input and output approaches are not different under the CRS assumption. This is demonstrated in the Figure 4.1. It can be seen from the figure that under the CRS assumption, the distance from the frontier of the input-output combination does not change regardless of whether it is being measured horizontally or vertically. On the other hand, the figure again shows, in the case of the VRS assumption, that the distance from the frontier is greater if measured vertically (output approach) than horizontally (input-approach).

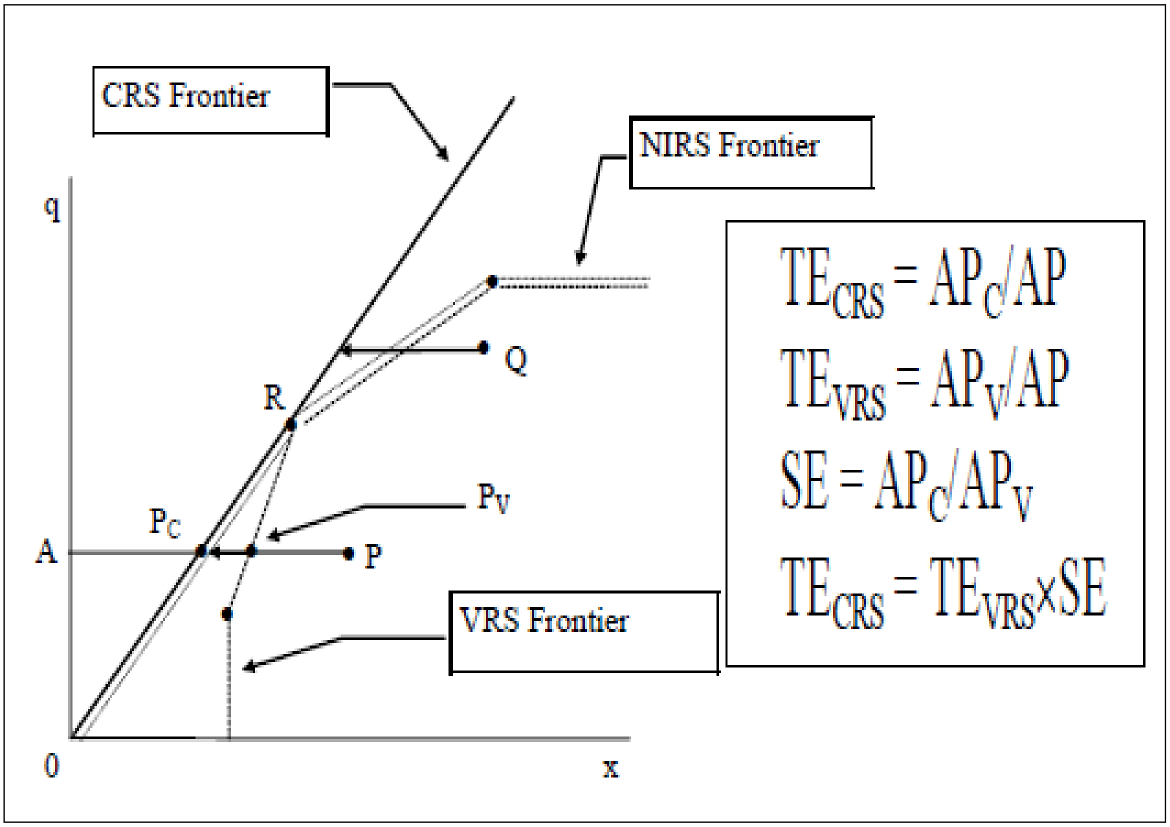

Figure 4.1. Constant and Variable returns to scale assumptions
Source: Adopted from Rao (2012)

4.2.2.1.2 The Malmquist productivity index

To measure the evolution in health system productivity, the Malmquist productivity index was used to compute total factor productivity (TFP) change for each health system or decision making unit (DMU) over time. The index was proposed by Caves et al. (1982) from the notion of "proportional scaling" introduced by Malmquist (1953). A short fall of the proposition by Caves et al. (1982) was that they did not account for inefficiency. Fare and Grosskopf (1992) addressed this limitation my combining ideas on measurement of efficiency from Farrell (1957) and on measurement of productivity from Caves et al. (1982) to develop a Malmquist index of productivity change.

The Malmquist index measures changes between two data points in terms of ratios of distance functions and has been used for microeconomic (Bjurek, 1992) and also macroeconomic (Färe et al. , 1994) studies. However, Bjurek (1996) showed that the TFP index has the advantage of non-restriction of the input or output based index in the case of variable returns to scale (VRS). The Malmquist index approach does not also require neither aproiri behavioural assumption about the production technology nor input and output price data. Zere (2000) noted that these characteristics of the Malmquist index approach makes it appealing for measuring productivity in the public sector. An estimated index of one (1) suggests that a DMU has been stagnant in terms of health system productivity over time while an index greater than (less than) one (1) indicates growth (decline) in productivity.

In line with Fare et al. (1994) a Malmquist TFP change between periods t and t+1, given the level of output (y) and input (x) can be defined as;

$$M_0^{t,t+1}(y^t, x^t, y^{t+1}, x^{t+1}) = \left[\frac{D_0^t(y^{t+1}, x^{t+1})}{D_0^t(y^t, x^t)} \times \frac{D_0^t(y^{t+1}, x^{t+1})}{D_0^{t+1}(y^t, x^t)} \right]^{1/2} \quad (4.15)$$

The Malmquist productivity index can further be decomposed into efficiency change and technologic change as follows;

$$M_0^t(y^t, x^t, y^{t+1}, x^{t+1}) = \left[\frac{D^{t+1}(y^{t+1}, x^{t+1})}{D_0^t(y^t, x^t)} \right] \times \left[\frac{D_0^t(y^{t+1}, x^{t+1})}{D_0^{t+1}(y^{t+1}, x^{t+1})} \times \frac{D_0^t(y^t, x^t)}{D_0^{t+1}(y^t, x^t)} \right]^{1/2} \quad (4.16)$$

Change in technical efficiency is captured by the first term on the right hand side of equation (4.16) while the second term captures change in technology. Coelli et al. (1998) showed that the technical efficiency change can further be decomposed into pure efficiency change and scale change components under the assumption of variable returns to scale. As indicated by Fare et al. (1994), the productivity index can be computed through various methods. However, the most preferred of these methods involves the use of DEA-like linear programming techniques.

4.2.2.2 The Stochastic Frontier model

The SFA model employed in the empirical estimation is based on the 'True' fixed effect (TFE) and 'True' random effect (TRE) models proposed by Greene (2004). This is considered an improvement on the traditional fixed and random effect specifications which do not account for unobserved heterogeneity in cross-section units.

The first empirical model using longitudinal data efficiency under the SFA is attributed to Pitt and Lee (1981). Their work was based on Maximum Likelihood (ML) estimation of the following Normal-half Normal stochastic frontier model

$$y_{it} = \alpha + x_{it}^{'}\beta + \varepsilon_{it}, \quad i = 1,....,N \quad t = 2,...T$$

$$\begin{aligned} \varepsilon_{it} &= v_{it} - u_i \\ v_{it} &\sim N(0, \delta_v^2) \\ u_i &\sim N^{+}(0, \delta_u^2) \end{aligned} \tag{4.17}$$

where *y* is the output variable and *x* represents a vector of inputs. ε_{it} is the composite error term which comprises the normal error term (v_{it}) and the inefficiency term (u_i).

In generalizing the above specification, Battese and Coelli (1988) proposed a Normal-Truncated Normal model. In a similar way, Schmidt and Sickles (1984) proposed that fixed effect estimation techniques can be employed to SFA models with time invariant inefficiency. This approach enables one to avoid distributional assumptions about u_i. A major limitation of the time invariant models is that the efficiency estimates may be biased in the case of long panel data sets. In this regard, Kumbhakar (1990) and Battese and Coelli (1992) proposed a ML estimation of a time-varying stochastic frontier model.

A common feature of the time-varying models is that the intercept (α) is the same across DMUs, thus generating a misspecification bias in the case where time-invariant unobservable factors (which may be unrelated with the production process but affecting the output) are available. Such unobservable factors may be captured by the inefficiency term and may lead to biased estimates.

Greene (2004) showed that these restrictions can be relaxed by placing country specific constant terms in the stochastic frontier model. This approach is called the 'True' fixed effect model. The specification is given as follows;

$$y_{it} = \alpha_i + x_{it}^{'}\beta + v_{it} - u_{it} \qquad (4.18)$$

The model is estimated using ML and simply involves the inclusion of a full set of country dummy variables in the stochastic frontier model. The model also treats country specific time-invariant fixed effects (α_i) and time varying inefficiency (u_{it}) separately and is therefore able to distinguish between the unobserved heterogeneity and inefficiency (Danqua et al. , 2013). The shortcomings of the TFE model include the possibility of incidental parameters problem and over specification of the model with the inclusion of the country specific dummies.

An alternative to resolving the unobserved heterogeneity problem is to estimate a time invariant random term meant to capture country specific heterogeneity. This process is termed the 'true' random effect. The TRE model can be specified as follows;

$$y_{it} = \alpha + \beta^{'} x_{it} + \omega_i + v_{it} - u_{it} \qquad (4.19)$$

Where ω_i is a time-invariant and country specific random term meant to capture unobserved country specific heterogeneity. The model is estimated using the simulated maximum likelihood (SML). As noted by Greene (2004), this form of the model overcomes both of the drawbacks in the TFE specification. In this regard, while both the TFE and TRE were estimated in the current study, the TRE was preferred.

The kernel density estimates were used to compare the results from the different outcome variables used in the estimation of efficiency. The kernel density plots from the estimates show the distribution of the efficiency scores from the different health outcome variables. The kernel density plots are considered a more effective ways to illustrate the distribution of a variable. The kernel distributions are similar to the histogram in the sense that they both build a function to represent the probability distribution using the sample data. They however differ in the sense that, unlike the histogram the kernel distribution sums the component smoothing function for each data value to produce a smooth, continuous probability curve.

4.2.2.3 Choice of inputs and outputs

The choice of inputs in estimating the health production function is not straight forward as there exist several factors that influence population health status both directly and indirectly. With regards to the health system, inputs have been categorised into physical (e.g. personnel, equipments etc) and monetary (expenses on the health system). As noted by Afonso and Aubyn (2005), efficiency results may be sensitive to the type of input used. The current study used both physical and monetary inputs to allow for robustness in analysis. The physical inputs included in the analysis were physicians, nurses and midwives and hospital beds per 1000 people. Health care expenditure per capita expressed in purchasing power parity terms was used as monetary input.

An important aspect of choosing health system inputs, that has generated some controversy in the literature, is the choice of indirect inputs that influence health status but are not directly controlled by the health system (Tandon et al. , 2003). This is intuitively appealing since two countries that spend the same amounts on health may not necessarily have the same health outcomes if they operate in different environments. Within the DEA framework, three different approaches have been suggested to resolve this problem (Jacobs et al. , 2006). First is to perform separate efficiency analysis for sub-samples with similar environment. The effects of the indirect factors on efficiency are then determined by comparing the efficiency scores from each sub-sample with those of the total sample. However, the un-categorical nature of environmental variables complicates this approach.

The second approach involves including an environmental variable as an input in the efficiency estimation process (Banker and Morey, 1986, Coelli et al. , 1998). The third approach involves a two stage DEA analysis where efficiency scores from the first stage are used in the second stage to explore the effect of environmental variables on efficiency, using econometric models.

The current study follows the second and third approaches. Following the practice in many empirical studies, the current study employed education (measured by average years of schooling) as an environmental variable which, even though, not directly controlled by the health system, is highly likely to influence health status (Caldwell and Caldwell, 1985).

In terms of health system outputs used in the efficiency analysis the current study employed health system indicators such as life expectancy at birth, infant and under five mortality rates and crude death rates. However, as noted by Afonso and Aubyn (2005), efficiency measurement techniques suggest that outputs are measured in such a way that "more is better". Therefore consistent with practice in the literature, various transformations were performed on the mortality variables so that they are measured in survival rates. For instance, infant mortality rate (IMR) is measured as

[(number of children who died before 12 months)/(number of children born)] X 1000

This implies that an infant survival rate (ISR) can be computed as follows;

$$ISR = \frac{1000 - IMR}{IMR} \tag{4.20}$$

This shows the ratio of children that survived the first year to the number of children that died and this increases with better health status. Similar transformations were performed for the other mortality variables. This suggests that, in effect, the output variables used in the analysis are life expectancy at birth, infant survival, under-five survival and crude survival rates. Several model specifications were estimated using various combinations of the output and input variables.

4.2.2.4 Choice of orientation for efficiency measurement

In estimating health system efficiency, the choice of orientation is usually neglected. It is however important to note that the choice of orientation can have direct implications for police recommendations based on the estimated efficiency scores. The output orientation estimates the potential for changing outputs without changing the inputs of the production system. The input orientation on the other hand estimates the potential for changing inputs without changing the output quantities produced.

The choice between input or output orientation is usually straight forward when decision units such as firms are considered. This is because the primary objective of these DMUs is to minimize inputs or maximize outputs as much as possible. In the case of health systems, the output orientation is more intuitively appealing. For instance, Alexander et al. (2003) argues that the output orientation is preferred because it helps to understand the potential for improvement in health outcomes rather than the potential for saving in health expenditure or reducing health related resources in general. Moreover, it may be impractical to recommend a reduction in health resources in a country while maintaining a fixed population health status. Following this argument, the current study reports efficiency estimates from both input and output orientations, however, more emphasis is placed on the output orientation. This implies that in this context, the potential of improving health status using the same levels of health resources is explored.

4.2.2.5 Determinants of health system efficiency

Analysing efficiency is usually done in two stages, in the first stage a non-parametric method (DEA) is used to estimate the level of efficiency of DMUs. The second stage employs regression analysis to determine the factors likely to influence efficiency. The efficiency scores from the first stage usually lie between 0 and 1. In most cases the efficiency scores are close to 1 but none at or close to zero. To achieve the third objective, a Tobit model is used to estimate the relationship between dependent variable y_i (efficiency scores) and a vector of explanatory variables x_i (McDonald, 2009). For the *ith* DMU, the Tobit model can be defined as follows:

$$y_i^* = x_i\beta + \varepsilon_i \qquad (4.21)$$

If $Y_i^* \leq 0$, $Y_i=0$; If $Y_i^* \geq 1$, $Y_i=1$ and if $0<Y_i^*<1$, $Y_i=Y_i^*$

Where y_i^* is an unobservable latent variable, ε_i is normally, identically and independently distributed with zero mean and variance, σ^2. x_i is a vector of explanatory variables and β, a vector of unknown coefficients.

The specific variables employed in estimating the determinants of health system efficiency are presented in Table 4.2 below:

Table 4.2. Variable description for Tobit model

Variable category	Variable specification
Policy variables	Public sector accountability and transparency, quality of public sector management, health system financing structure
Economic variables	Per capita gross domestic product
Socio-sanitary variables	Population with access to improved sanitation and improved water source
Education variables	Percentage of population with secondary education
Demographic variables	Rate of urbanization and population age groups under 14, 15-64 and above 65 years.

Source: Author's compilation

4.3 Estimation Issues

This section highlights some of the tests that were performed to ensure efficient and unbiased estimates from the panel regression analysis. First, as is the case in most panel data analysis there was the need to test for random effects or panel effects in the model. As suggested by Baltagi (2008), the Breuch-Pagan Lagrange Multiplier (BPLM) test was used to make a decision between a random effects regression and simple OLS regression. Secondly, the Hausman's specification test was employed to compare estimates from the random effects and the fixed effects models. Panel data analysis also raises the issue of heteroskedasticity when the regression disturbances are not with the same variances across time and cross sectional units. Robust standard errors were therefore computed to correct for the presence of heteroskedasticity as suggested by Baltagi (2008).

4.4 Source of data

Data for the study was obtained from the World Bank world development indicators. The data covered the period 1995 to 2011 across 45 countries in SSA[24].

[24] The following countries were included in the study: Angola, Benin, Burkina Faso, Botswana, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo Demographic Republic, Congo, Cote d'Ivoire, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Ghana, Guinea, Guinea Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, South Africa, Sao Tome, Senegal, Seychelles, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, The Gambia, Togo, Uganda and Zambia.

CHAPTER FIVE

EMPIRICAL RESULTS AND DISCUSSION

5.0 Introduction

The chapter presents the empirical findings and discussions of the study based on the objectives and research questions of the study. The chapter is divided into various sections and sub-sections including the descriptive statistics of the variables used in the study, empirical results on the effects of health care expenditure on health outcomes, the efficiency of health expenditure.

5.1 Descriptive statistics of study variables

Table 5.1 shows descriptive statistics of the variables included in the study. The table includes variables directly related to the health system as well as other macroeconomic policy and institutional variables that may have direct or indirect influence on the health system. The number of observations, mean, standard deviation, minimum (Min) and maximum (Max) values are reported. The descriptive statistics cover the period from 1995 to 2011 and 2005 to 2011 for the macroeconomic policy and institutions variables.

The statistics show that real health care expenditure per capita (THEpc), measured in constant 2005 international dollar, recorded a mean of about \$145.4 with a standard deviation of about 211.5. The minimum value of THEpc was \$9.5 and a maximum of about \$1806.5. Total health expenditure as percentage of GDP (THE) recorded a mean of approximately 5.6%, standard deviation of 2.4%, with 1.7% and 22.2% as minimum and maximum values, respectively. Mean private spending on health as percentage of GDP (PrHE) was higher (3.1%) than public spending on health (PuHE) with an average of about 2.5%. The minimum and maximum values of these two variables also showed significant variation in favour of PrHE.

Mean external sources of health expenditure as percentage of total health expenditure (Health Aid) was about 17.7% with standard deviation of 16.2, minimum and maximum values of approximately 0.03% and 97.4%, respectively. This significant variation between the minimum and maximum values suggests that while some countries depend less on external sources to support their health system, others are self sufficient. The mean value, however, shows general dependence on external funding.

With regards to the population health variables, the statistics show that mean life expectancy at birth (LE) over the period was about 53.2 years with a minimum and maximum of about 30.5 and 73.9, respectively. An average of about 77.2 infant deaths per 1000 live births (IMR) was also recorded with a minimum of 11.5 and maximum of 155.7. Neonatal mortality rate per 100 live births (NMR) had a mean of about 35.3 while under five mortality rate per 1000 live births (U5M) and crude death rate per 1000 people (CDR) recorded averages of approximately 124.1 and 13.9, respectively. While the mean values of the health indicators suggest significant health problems in the region, the minimum and maximum values show significant variations across countries.

About 42.8% of the total sample were 14 years old or less while about 3.3% were 65 years or older and about 53.9% were between the ages of 15 and 64 years. The demographic structure suggests more people living in the active group in SSA. Population ages below 14 years and above 65 years are usually expect to be vulnerable to poor health situations. HIV remains endemic in the region with mean prevalence rate of about 5.3%, minimum of 0.1 and maximum of 27.0.

Average GDP per capita (GDPpc), measured in constant 2005 international dollar, was $2944.2 with minimum and maximum values of about $101.6 and $27346.3. Also, on average, urban population in SSA grows by 3.8% annually. Approximately 32.4% of the population, on average, had access to improved sanitation facilities while an average of 69.8% of children between the ages of 12 to 23 months were immunized against DPT. Average secondary school enrolment (Education) as percent of gross school enrolment was 34.4%.

The macroeconomic policy and institutions variables were based on rating on performance (from 1=Low to 6=high). The statistics show that mean public sector management and institutions (PSMI) was about 3.0 while mean macroeconomic management rating (MEMR) was about 3.6. Average public sector transparency, accountability and corruption rating (corruption) was 2.8 with minimum and maximum values of about 1.5 and 4.5, respectively.

Table 5.1. Descriptive statistics of the study variables

Variable	Description	Mean	Standard deviation	Min	Max
THEpc	Per capita health care expenditure	145.39	211.54	9.51	1806.48
THE	Total health care expenditure (% of GDP)	5.58	2.44	1.70	22.19
PuHE	Public health care expenditure (% of GDP)	2.49	1.23	0.11	9.45
PrHE	Private health care expenditure (% of GDP)	3.09	2.11	0.22	19.33
Health Aid	External aid on health (%)	17.66	16.23	0.03	97.39
OOP	Out-of-pocket health spending (% of private health expenditure)	41.62	20.02	2.98	85.47
LE	Life expectancy at birth (years)	53.22	7.24	30.47	73.92
IMR	Infant mortality per 1000 live births	77.18	28.45	11.50	155.70
NMR	Neonatal mortality per 1000 live births	35.33	10.62	8.50	57.70
U5M	Under five mortality per 1000 live births	124.05	51.51	13.60	275.10
CDR	Crude death per 1000 people	13.94	3.99	5.24	32.81
Population 14<	Population under age 14 years (% of total)	42.81	5.10	20.64	49.92
Population15-64	Population between ages 15-64 years (% of total)	53.85	4.28	47.49	71.32
Population 65>	Population above age 65 (% of total)	3.34	1.09	1.66	8.07
Fertility	Fertility rate measured as births per woman	5.10	1.22	1.45	7.71
HIV	Adults living with HIV expressed as percent of population ages 15-49 years	5.25	6.30	0.10	27.00
Educ	Secondary school enrolment (% of gross)	34.42	20.75	5.16	95.70

Urban	Urban population (% of total)	3.81	1.75	-1.90	20.20
RGDPpc	Real Gross domestic product per capita	2944.19	4506.65	101.60	27346.40
ImmDPT	DPT Immunized (% of children ages 12-23 months)	69.77	21.21	16.00	99.00
Sanitation	Population with access to improved sanitation facilities (% of population)	32.44	22.50	2.80	97.10
Macroeconomic policy and institution variables					
PSMI	public sector management and institutions cluster average (1=low to 6=high)	3.00	0.48	2.20	4.00
MEMR	macroeconomic management rating (1=low to 6=high)	3.62	0.69	2.00	5.00
ERR	equity of public resource use rating (1=low to 6=high)	3.28	0.67	1.50	4.50
ERMR	efficiency of revenue mobilization rating (1=low to 6=high)	3.37	0.53	2.50	4.50
Corruption	transparency, accountability and corruption in the public sector rating (1-low to 6=high)	2.80	0.62	1.50	4.50

Source: Author's computation

5.2. Effects of health care expenditure on health outcomes

As explained in the previous chapter, this sub-section provides econometric results of the effects of health care expenditure on various measures of population health outcomes in SSA. Total health care expenditure is disaggregated into public and private health care expenditure so as to allow the estimation of the differential effects of these components on health outcomes. In this regard models one, two and three in the tables in this sub-section indicate separate models for total, private and public health care expenditure, respectively. Five different measures of health outcomes were used as dependent variables in the regression analysis. These were life expectancy at birth, infant mortality rate, under-five mortality rate, neonatal mortality rate and crude death rate. This was to allow for robustness in the regression analysis.

5.2.1 Health care expenditure and life expectancy at birth

Table 5.2 below shows the estimation results for the effects of health care expenditure on life expectancy at birth in SSA. The statistics from the regression output suggest that the models have fits that can be trusted with highly significant F-test for the fixed effects models and Wald chi-square tests for the random effects models. The within, between and overall R-square values were also acceptable for the panel data models.

Other tests conducted to improve the performance of the models include the modified Wald test for group-wise heteroskedasticity, the Breusch and Pagan Lagrangian Multiplier (BPLM) test for random effects and the Hausman specification test for fixed or random effects. The outcomes of these tests are reported in Table 5.3. The Hausman specification tests were conducted based on the null hypothesis that differences in coefficients are not significant. Accepting this hypothesis implies that the random effects models are preferred. The test results however suggest that the null hypothesis should be rejected hence making the fixed effects models preferable. However, both fixed and random effects models are reported to allow for robustness. Furthermore, the Wald test for heteroskedasticity in the fixed effects regression models was conducted on the null hypothesis of homoskedasticity. The probability values for the chi-square tests suggest high statistical significance which implies the presence of heteroskedasticity. To remedy this situation, robust standard errors were estimated and reported in all the models. The results are therefore more likely to be consistent in standard errors and unbiased in parameter estimates.

The Breusch-Pagan Lagrange Multiplier (BPLM) test was conducted to decide between a random effects regression and simple ordinary least squares (OLS) regression. The null hypothesis in this test states that variances across countries are zero. That is, there is no significant difference across cross section units (i.e. no panel effect). However, the test statistics suggests the presence of panel effects and hence supporting the random effects models against OLS.

The regression results suggest that all the control variables had the expected signs. A strong relationship was also established between disaggregated health care expenditure and life expectancy at birth. To capture the time effects of health care expenditure in the model, the lag of the variables were included in each of the models appropriately. Total health care expenditure (THE) showed positive and significant relationship in both the fixed and random effects models. The relationship was significant at 5% level in the fixed effects model and 10% level in the random effect model.

The estimated elasticities of approximately 0.03 in both models suggest that a 10% increase in THE as percentage of GDP is likely to raise life expectancy by approximately 0.30%. The one-period lag of THE showed a positive relationship with life expectancy at birth in both fixed and random effects models but only statistically significant (at 10% level) in the fixed effects model. This implies that not only does the present values of THE improve life expectancy at birth but also the level of such investments in the previous years. The estimated elasticity of about 0.02 implies that a 10% increase in previous THE is likely to raise life expectancy at birth by about 0.20%. The second and third models in both the fixed and random effects models show the disaggregated regression results for private and public health care expenditure, respectively. Model 2 shows a positive relationship between private health care expenditure (PrHE) and life expectancy at birth, even though the relationship was not statistically significant at all levels in both fixed and random effects models. Similarly, the lagged value of this variable was not also statistically significant even though it showed the expected signs.

Table 5.2. Results of Health Care Expenditure and Life Expectancy at Birth

	Fixed Effect Models			Random Effect Models		
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
LnTHE	0.03157**			0.02547*		
	(0.01299)			(0.01366)		
LnRGDPpc	0.01665	0.02346	0.0188	0.02956	0.02793	0.027
	(0.03158)	(0.03196)	(0.03084)	(0.01997)	(0.01929)	(0.02062)
LnUrban	0.01606*	0.01585	0.01465	0.01335	0.01192	0.01275
	(0.00883)	(0.01114)	(0.01043)	(0.01066)	(0.01330)	(0.01140)
LnImmDPT	0.03827**	0.04453***	0.03551**	0.04420***	0.04950***	0.03966***
	(0.01425)	(0.01608)	(0.01428)	(0.01431)	(0.01617)	(0.01382)
LnSanitation	0.08471**	0.09071**	0.07973**	0.03614**	0.03459**	0.03843**
	(0.03464)	(0.03570)	(0.03476)	(0.01756)	(0.01757)	(0.01871)
LnPop<14	0.13475	0.09318	0.1418	0.11857	0.08876	0.13012
	(0.14960)	(0.12445)	(0.14212)	(0.13072)	(0.11203)	(0.13014)
LnPop65>	-0.07419	-0.07831	-0.07388	0.0115	0.00852	-0.00043
	(0.05720)	(0.06685)	(0.06168)	(0.05762)	(0.06459)	(0.05961)
LnHIV	-0.04474***	-0.04579**	-0.0471***	-0.0549***	-0.0551***	-0.05484***
	(0.01609)	(0.01760)	(0.01555)	(0.01038)	(0.01063)	(0.01039)
LnTHE(-1)	0.02164*			0.0146		
	(0.01273)			(0.01231)		
LnEduc	0.02957*	0.03117*	0.03333**	0.04685***	0.05300***	0.04736***
	(0.01493)	(0.01571)	(0.01304)	(0.01399)	(0.01427)	(0.01200)
LnPrHE		0.01421			0.00516	
		(0.01372)			(0.01220)	
LnPrHE(-1)		0.01007			0.00255	
		(0.01173)			(0.01189)	
LnPuHE			0.02042**			0.02036**
			(0.00822)			(0.00849)
LnPuHE(-1)			0.00909			0.00766
			(0.00805)			(0.00795)
Constant	2.83453***	2.96116***	2.87590***	2.80443***	2.95449***	2.84824***
	(0.66664)	(0.60776)	(0.62015)	(0.57909)	(0.51848)	(0.56353)
Within R^2	0.61299	0.58257	0.60703	0.59351	0.55988	0.59463
Between R^2	0.10334	0.15084	0.18781	0.36254	0.43292	0.40036
Overall R^2	0.18835	0.22179	0.26648	0.49179	0.53479	0.51115
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
No. of Obs.	409	409	409	409	409	409

Source: Author's computation

Note: ***significant at 1%; ** at 5%; * at 10%. Standard errors are reported in parenthesis. (1) is model with total health expenditure as percent of GDP. (2) is model with private health expenditure as percent of GDP. (3) is model with public health expenditure as percent of GDP.

Table 5.3. Diagnostic Tests

	Fixed Effects			Random Effects		
Test	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Wald test (χ^2)	79751.58***	0.000022***	69925.99***			
BPLM test (χ^2)				845.64***	741.03***	916.87***
Hausman (χ^2)	30.20***	64.35	39.70***	30.20***	64.35	39.70***

Source: Author's computation
Note: *** shows significance at 1%.

On the other hand, the regression results for public health care expenditure (PuHE), presented in model 3, satisfied a-priori expectations. The variable showed a positive and statistically significant (at 5% level) relationship with life expectancy at birth. This suggests that an increase in the level of public expenditure on health leads to a corresponding increase in life expectancy at birth. The estimated elasticity of, approximately, 0.02 implies that a 10% increase in public heath care spending triggers a marginal response of 0.20% increase in life expectancy at birth. The one-period lag of PuHE was, however, not significant.

Other variables that showed significant effect on population health, measured by life expectancy at birth, include education, immunization and sanitation. As expected, the results suggest that an increase in the level of education is likely to improve the health status of the population. Similarly, increased DPT immunization (ImmDPT) was found to be more likely to improve population health status. Improved sanitation condition was also found to be an important determinant of population health status.

5.2.2 Health care expenditure and infant mortality rate

Table 5.4 shows regression results for the effects of disaggregated health care expenditure on infant mortality rate. The overall performance of the various regression models suggests that the models are well behaved. This can be observed from the probability values of the Wald chi square test and F-test for the fixed and random effects models, respectively. The various R-square statistics are also generally acceptable. The hausman specification test generally seems to confirm the fixed effects model over the random effects model (Table 5.5). Both models were, however, reported to allow for robustness. Moreover, a close observation of the models suggests not much difference. The Wald chi-square test strongly confirms the presence of heteroskedasticity in the fixed effects models. Robust standard errors were, therefore, estimated and reported in all the models to ensure consistent standard errors and unbiased estimates. The Breusch-Pagan lagrangian multiplier test also showed support for the random effects model over OLS estimations (Table 5.5).

The estimation results presented in Table 5.4 suggests that health care expenditure is an important determinant of infant mortality in SSA. Total health care expenditure (THE) showed negative and significant (at 1% level) relationship with infant mortality rate. This implies that an increase in aggregate spending on health is likely to reduce the death of infants in the region. The estimated elasticity for this relationship suggests that infant mortality will be reduced by approximately 1.00% when THE increases by 1%. Similar results were reported in both the fixed and random effects models.

The one and two-period lags of THE included in the regressions also showed negative and statistically significant relationship with infant mortality rate. The relationship was significant at 10% for the one-period lag and 1% for the two-period lag. This suggests that THE does not only have immediate impact on infant mortality but also delayed impacts. This relationship was observed for both fixed and random effects models. The estimated elasticities suggest that a 10% increase in THE one year back reduces current year infant mortality by 0.80% in the fixed effects model and 0.70% in the random effects model. Similarly, a 10% increase in THE two years back reduces infant mortality by about 1.00% in both fixed and random effects models.

The effect of disaggregated health care expenditure on infant mortality shows public health care expenditure (PuHE) to be more significant, relative to private health care expenditure (PrHE). This is observed from the high statistical significance of PuHE and its two-period lag, even though both variables showed the expected negative sign. A 10% increase in public health spending reduces infant mortality rate by approximately 0.60 in both the fixed and random effects models with statistical significance of 1% level. The one-period lag of public health spending showed negative but insignificant relationship with infant mortality. A much significant relationship was portrayed by the two-period lag of public health spending (at 1% level of significance). The negative relationship indicates that previous years' public health spending impacts on present period infant mortality inversely. The relationship was consistent in both the fixed and random effects models. Education, real GDP per capita, sanitation, HIV prevalence were also found to be important factors influencing infant mortality. Improved education, real GDP per capita and sanitation are likely to reduce infant mortality while increased HIV prevalence in likely to increase infant mortality. The relationships were consistent in both models.

Table 5.4. Results of Health Care Expenditure and Infant Mortality

	Fixed Effect Models			Random Effect Models		
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
LnTHE	-0.1146***			-0.10680***		
	(0.03726)			(0.03908)		
LnRGDPpc	-0.22299**	-0.26012**	-0.21273*	-0.15924**	-0.12831**	-0.13882*
	(0.10434)	(0.11075)	(0.10953)	(0.07163)	(0.06264)	(0.07294)
LnUrban	0.06385	0.0658	0.06941	0.07269	0.07795	0.07664
	(0.04919)	(0.06627)	(0.05912)	(0.05518)	(0.07359)	(0.06249)
LnImmDPT	0.02911	-0.02763	0.05246	-0.02008	-0.07879	0.01396
	(0.04301)	(0.05023)	(0.05226)	(0.04422)	(0.05277)	(0.04968)
LnSanitation	-0.27696**	-0.24528*	-0.24710*	-0.10867	-0.07492	-0.10901
	(0.12655)	(0.14349)	(0.12892)	(0.07135)	(0.06698)	(0.07430)
LnPop<14	0.44825	0.71240**	0.43672	0.61535*	0.88317***	0.58914*
	(0.37260)	(0.33213)	(0.35930)	(0.35868)	(0.32457)	(0.35679)
LnPop65>	-0.13502	-0.14743	-0.1058	-0.17505	-0.11949	-0.12669
	(0.22038)	(0.29527)	(0.25297)	(0.18606)	(0.24062)	(0.21844)
LnHIV	0.03241	0.06883	0.03283	0.08280**	0.09042***	0.07358**
	(0.05912)	(0.07280)	(0.05644)	(0.03718)	(0.03463)	(0.03650)
LnTHE(-1)	-0.08114*			-0.06873*		
	(0.04028)			(0.04171)		
LnTHE(-2)	-0.1435***			-0.12532***		
	(0.04598)			(0.04697)		
LnEduc	-0.11382**	-0.1395***	-0.1493***	-0.15996***	-0.2042***	-0.187***
	(0.05379)	(0.05073)	(0.04870)	(0.04426)	(0.03885)	(0.04302)
LnPrHCE		-0.04764			-0.04181	
		(0.04155)			(0.03879)	
LnPrHE(-1)		-0.0309			-0.01431	
		(0.02767)			(0.02827)	
LnPrHE(-2)		-0.04654			-0.00741	
		(0.03508)			(0.03526)	
LnPuHE			-0.0606***			-0.059***
			(0.02089)			(0.02181)
LnPuHE(-1)			-0.03145			-0.02485
			(0.02310)			(0.02377)
LnPuHE(-2)			-0.0976***			-0.100***
			(0.03131)			(0.03316)
Constant	5.95365***	4.98367***	5.39489***	4.62679***	3.16627**	4.12143**
	(1.91868)	(1.66924)	(1.87888)	(1.72541)	(1.43973)	(1.69969)
Within R^2	0.73458	0.63901	0.71519	0.72297	0.61854	0.70599
Between R^2	0.30386	0.38234	0.39545	0.42053	0.52819	0.51714
Overall R^2	0.40701	0.47153	0.48092	0.54333	0.60749	0.60344
Prob.	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
No. of Obs.	391	391	391	391	391	391
Groups	42	42	42	42	42	42

Source: Author's computation

Note: ***significant at 1%; ** at 5%; * at 10%. Standard errors are reported in parenthesis. (1) is model with total health expenditure as percent of GDP. (2) is model with private health expenditure as percent of GDP. (3) is model with public health expenditure as percent of GDP.

Table 5.5. Diagnostic tests for Infant mortality regression

	Fixed Effects			Random Effects		
Test	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Wald test (χ^2)	1.4e+30***	1.2e+28***	6.7e+24***			
BPLM test (χ^2)				1068.30***	885.83***	1279.60***
Hausman (χ^2)	5.09	1209.22***	21.82**	5.09	1209.22***	21.82**

Source: Author's computation
Note: *** shows significance at 1%, ** shows significance at 5%

5.2.3 Health care expenditure and under-five mortality

Table 5.6 presents regression results for the effects of disaggregated health care expenditure on population health status measured as under-five mortality. The joint significance of the model is confirmed by the probability values of the Wald chi-square test and F-test statistics for the fixed and random effects models. The within, between and overall R-squared values for both models also suggests the models have fits that can be trusted. Again, as in the previous analysis, the Hausman chi-square specification tests presented in Table 5.7 show that results from models 1 and 2 are better with the fixed effects model while model 3 is better specified in the random effects model. Results from both fixed and random effects specifications were, however, reported for all models. The BPLM test for random effects also confirmed that, relative to the OLS analysis, there were panel effects and hence the random effect specification should be used.

The estimated results show that all the explanatory variables had expected signs. Also, a general observation suggests that there exist a strong relationship between health care expenditure and under-five mortality in SSA. The relationship between THE and under-five mortality was estimated to be negative and statistically significant at the 5% level. The results indicate that a rise in the level of THE is likely to reduce under-five mortality with estimated elasticities of approximate -0.1 for the fixed and random effects models. The one-period lag of THE was negative and statistically significant at 5% level in both models. This indicate that THE in the previous year impacts on under-five mortality negatively. This result presupposes that THE does not only have implications for under-five mortality in the current year but also in future periods. Public health care spending showed strongly significant (at 1% level) influence on under-five mortality in both models. The negative sign suggests that an increase in the level of PuHE is likely to reduce under-five mortality with an estimated elasticity of about -0.09. That is, a 10% increase in PuHE leads to a reduction in under-five mortality by 0.90. The one-period lag of PuHE showed a negative and significant relationship with under-five mortality with estimated elasticity of approximately -0.1. Unlike public health care spending, private health care spending did not show statistical significance, even though the expected sign was observed.

Table 5.6. Results of Health Care Expenditure and Under-five Mortality

	Fixed Effect Models			Random Effect Models		
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
LnTHE	-0.14784**			-0.13512**		
	(0.05619)			(0.05576)		
LnRGDPpc	-0.20118	-0.23463*	-0.20838	-0.13700*	-0.0908	-0.12553
	(0.12237)	(0.13097)	(0.13001)	(0.07602)	(0.06825)	(0.08045)
LnUrban	0.04517	0.05174	0.05415	0.05979	0.07238	0.06561
	(0.05422)	(0.07478)	(0.06502)	(0.06161)	(0.08419)	(0.06910)
LnImmDPT	-0.02031	-0.05875	0.00285	-0.06198	-0.10747	-0.02877
	(0.05538)	(0.06976)	(0.06450)	(0.05536)	(0.06792)	(0.05972)
LnSanitation	-0.22641*	-0.25374*	-0.19599	-0.10739*	-0.10311*	-0.10182
	(0.13301)	(0.13683)	(0.13604)	(0.06085)	(0.05662)	(0.06813)
LnPop<14	0.28884	0.52001	0.24936	0.52228	0.79088**	0.45569
	(0.54142)	(0.45493)	(0.52308)	(0.46906)	(0.40114)	(0.47079)
LnPop65>	-0.12165	-0.10597	-0.10929	-0.22864	-0.17044	-0.18234
	(0.26141)	(0.34658)	(0.29451)	(0.21742)	(0.27502)	(0.24611)
LnHIV	0.04612	0.05889	0.05851	0.08879*	0.08697**	0.08824*
	(0.07481)	(0.08526)	(0.07253)	(0.04540)	(0.04232)	(0.04530)
LnTHE(-1)	-0.19452**			-0.16359**		
	(0.08116)			(0.08276)		
LnEduc	-0.19352***	-0.2205***	-0.2170***	-0.2392***	-0.2897***	-0.2555***
	(0.05747)	(0.06023)	(0.05432)	(0.04573)	(0.04854)	(0.04408)
LnPrHE		-0.03965			-0.02348	
		(0.06584)			(0.05554)	
LnPrHE(-1)		-0.05424			-0.00641	
		(0.04820)			(0.04973)	
LnPuHE			-0.0868***			-0.0874***
			(0.03171)			(0.03209)
LnPuHE(-1)			-0.11387**			-0.11067**
			(0.04979)			(0.05063)
Constant	7.16082***	6.35539***	6.80035***	5.77046***	4.22271**	5.43562**
	(2.50719)	(2.22083)	(2.49219)	(2.14772)	(1.83146)	(2.16239)
Within R^2	0.68097	0.5984	0.67274	0.67161	0.57975	0.66629
Between R^2	0.38777	0.45113	0.48355	0.5119	0.61889	0.59263
Overall R^2	0.49441	0.53432	0.57111	0.61628	0.67853	0.66907
Prob.	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
No. of Obs.	409	409	409	409	409	409
Groups	42	42	42	42	42	42

Source: Author's computation

Note: ***significant at 1%; ** at 5%; * at 10%. Standard errors are reported in parenthesis. (1) is model with total health expenditure as percent of GDP. (2) is model with private health expenditure as percent of GDP. (3) is model with public health expenditure as percent of GDP.

Table 5.7. Diagnostic Tests for Under-five Mortality Regression

	Fixed Effects			Random Effects		
Test	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Wald test (χ^2)	16731.51***	26764.17***	59928.29***			
BPLM test (χ^2)				1008.46***	802.90***	1264.48***
Hausman (χ^2)	22.36***	96.98***	32.19	22.36***	96.98***	32.19

Source: Author's computation

Note: *** shows significance at 1%, ** shows significance at 5%

Other variables that showed statistical significance in influencing under-five mortality include education, HIV prevalence and sanitation. Education showed negative relationship with under-five mortality at 1% significance level. HIV prevalence was negatively associated with under-five mortality, even though the relationship was only significant in the random effects model. Access to improved sanitation facilities showed negative relationship with under-five mortality at 10% significance level.

5.2.4 Health care expenditure and neonatal mortality

Table 5.8 shows regression results of the relationship between health care spending and neonatal mortality in SSA. Judging from the R-square values, the models exhibit acceptable goodness of fit. The joint significance of the model was also confirmed with a probability value less than 0.01.

Diagnostic tests performed on the regression models suggest that the random effects model is preferable, relative to the fixed effects models. This is evident from the insignificant Hausman chi-square tests reported in Table 5.9. The Breusch-Pagan lagrangian multiplier test for random effects also provides highly significant evidence in support of the random effects model, relative to the OLS. The Wald test also, strongly, confirmed the presence heteroskedasticity. To remedy the problem of heteroskedasticity, robust standard errors were estimated and reported.

Similar to the findings presented earlier, health care spending was generally significant in influencing population health status measured by neonatal mortality. Total health spending was showed negative and significant (at 1% level) impact on neonatal mortality with estimated elasticities of approximately -0.08 in both the fixed and random effects models. The one-period lag of total health spending also exhibited a significant (at 5% level) impact on neonatal mortality. The negative sign of this variable suggests that previous year's investments on health care have significant impact on current period health status. The relationship showed estimated elasticities of -0.07 in the fixed effects model and -0.08 in the random effects model.

Table 5.8. Results of Health Care Expenditure and Neonatal Mortality

	Fixed Effect Models			Random Effect Models		
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
LnTHCE	-0.08257***			-0.08061***		
	(0.02532)			(0.02534)		
LnRGDPpc	-0.11076	-0.13031*	-0.11628	-0.09368*	-0.09475*	-0.09227
	(0.06754)	(0.06775)	(0.07404)	(0.05656)	(0.05430)	(0.06005)
LnUrban	0.05716*	0.0569	0.06148	0.05976*	0.06163	0.06371*
	(0.03182)	(0.03837)	(0.03803)	(0.03294)	(0.04047)	(0.03846)
LnImmDPT	-0.00921	-0.02825	-0.0006	-0.02075	-0.0417	-0.01057
	(0.02951)	(0.03327)	(0.03438)	(0.02928)	(0.03345)	(0.03329)
LnSanitation	-0.12758*	-0.14809**	-0.11404	-0.08937**	-0.09544**	-0.08065*
	(0.06737)	(0.06949)	(0.06779)	(0.04326)	(0.04163)	(0.04456)
LnPop<14	0.27295	0.40045	0.26096	0.34236	0.47567	0.32673
	(0.37859)	(0.31651)	(0.36570)	(0.35390)	(0.29210)	(0.34750)
LnPop65>	-0.1185	-0.10763	-0.11306	-0.12916	-0.10727	-0.11535
	(0.14560)	(0.16445)	(0.16354)	(0.12591)	(0.14619)	(0.14534)
LnHIV	-0.01044	-0.00765	-0.00447	0.0063	0.01046	0.00881
	(0.04417)	(0.04738)	(0.04453)	(0.03454)	(0.03497)	(0.03486)
LnTHCE(-1)	-0.07563**			-0.06871**		
	(0.03328)			(0.03294)		
LnEduc	-0.11247***	-0.11511***	-0.12384***	-0.12467***	-0.13544***	-0.134***
	(0.03407)	(0.03553)	(0.03340)	(0.02939)	(0.03065)	(0.02917)
LnPrHCE		-0.04933			-0.04343	
		(0.02969)			(0.02837)	
LnPrHCE(-1)		-0.03317			-0.02004	
		(0.03000)			(0.03042)	
LnPuHCE			-0.04277**			-0.0437**
			(0.01787)			(0.01775)
LnPuHCE(-1)			-0.04341*			-0.04301*
			(0.02388)			(0.02364)
Constant	4.45136**	4.07218***	4.28369**	4.02890**	3.46481***	3.83794**
	(1.68413)	(1.45834)	(1.66958)	(1.58396)	(1.32135)	(1.56758)
Within R^2	0.69656	0.65154	0.68281	0.69388	0.64599	0.68048
Between R^2	0.37277	0.37643	0.43272	0.41868	0.43928	0.477
Overall R^2	0.43927	0.44361	0.4914	0.48221	0.49906	0.52811
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
No. of Obs.	409	409	409	409	409	409
No. of Groups	42	42	42	42	42	42

Source: Author's computation

Note: ***significant at 1%; ** at 5%; * at 10%. Standard errors are reported in parenthesis. (1) is model with total health expenditure as percent of GDP. (2) is model with private health expenditure as percent of GDP. (3) is model with public health expenditure as percent of GDP.

Table 5.9. Diagnostic Tests for Neonatal Mortality Regression

	Fixed Effects			Random Effects		
Test	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Wald test (χ^2)	87176.15***	18486.37***	2.2e+05***			
BPLM test (χ^2)				1643.07***	1491.98***	1862.80***
Hausman (χ^2)	47.04	52.46	120.21	47.04	52.46	120.21

Source: Author's computation
Note: *** shows significance at 1%, ** shows significance at 5%

The results also showed an expected negative relationship between private health care spending and neonatal mortality. This relationship was, however, not significant at all the statistically acceptable levels in both the fixed and random effect models. The one-period lag of the variable was also not significant even though it showed the expected negative sign. Contrary to this, public spending on health showed the expected negative sign and also significant at the 5% level. The negative relationship with estimated elasticities of approximately -0.04 in both the fixed and random effects models suggest that a 1% increase in PuHE is likely to reduce neonatal mortality by about 0.04. The one-period lag of the variable showed significant negative relationship with neonatal mortality with estimated elasticities of about -0.04 in both models. The results also suggest that while increment in both private and public health care spending is likely to reduce neonatal mortality, the later is more important in this process.

Other independent variables that showed statistical significance in influencing neonatal mortality include education and sanitation. Education showed negative and significant (at 1% level) relationship across all the models. Access to sanitation facilities also showed similar inverse relationship with the dependent variable even though the level of significance was inconsistent across the models.

5.2.5 Health expenditure and crude death rate

Table 5.10 presents the estimation results for the effects of health care spending on crude death rate. The estimated R-squared statistics and probability values for the F-test and Wald test for the fixed effects and random effects respectively, suggests that the models have good fit. The diagnostic tests for the regression models suggest that the fixed effects model specifications were preferable (Table 5.11). This is evident from the highly significant chi-square statistics from the Hausman specification tests. The presence of heteroskedasticity was also highly confirmed in the fixed effects model specifications. In this regard, robust standard errors were estimated and reported in all the models. The Breusch-Pagan test for random effects also provided evidence to reject the null hypothesis of no significant differences across cross section units.

The performance of the main variables of interest showed that health care spending play an important role in reducing crude death rate in SSA. The results show that a 10% increase in total health spending would reduce crude death rate by approximately 0.70 and 0.60 in the fixed and random effects models, respectively. This negative relationship met apriori expectations and was statistically significant at the 5% level. The effects of previous year's spending on health as captured by the one-period lag of the THE variable showed negative relationship with crude death rate. The relationship was, however, not statistically significant.

The differential effects of disaggregated health care spending on crude death rate also showed that there exist an inverse relationship between both private and public health spending and crude death rate. The relationship was however only significant for public health care spending, relative to private health care spending. The significant negative relationship of PuHE and the estimated elasticities suggest that a 1% increase in PuHE would likely reduce crude death rate by approximately 0.50% in both fixed and random effects models. Similarly, the one-period lagged effects of both public and private health care spending on crude death rate showed negative but statistically insignificant relationship.

Education, HIV prevalence, access to sanitation facilities, immunization and urbanization were also found to be significant determinants of crude death rate. Education was negative and significant with estimated elasticities of approximately -0.1 across both and random effects models. HIV prevalence rate, as expected, showed positive and significant relationship with crude death rate with elasticities of about 0.1 in both fixed and random effects models. Access to sanitation facilities, immunization and urbanization all showed negative and significant relationship with crude death rate at varying levels of statistical significance and estimated elasticities.

Table 5.10. Results of Health Care Expenditure and Crude Death Rate

	Fixed Effect Models			Random Effect Models		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
LnTHE	-0.06997**			-0.06050**		
	(0.02749)			(0.02817)		
LnRGDPpc	-0.01621	-0.0286	-0.02089	-0.02781	-0.02398	-0.02599
	(0.07501)	(0.07608)	(0.07240)	(0.05152)	(0.04927)	(0.05163)
LnUrban	-0.04348***	-0.04177**	-0.04121**	-0.03647**	-0.03176	-0.03578**
	(0.01562)	(0.01818)	(0.01579)	(0.01685)	(0.02058)	(0.01686)
LnImmDPT	-0.09539***	-0.10572***	-0.08879**	-0.1094***	-0.11910***	-0.0992***
	(0.03374)	(0.03675)	(0.03343)	(0.03315)	(0.03662)	(0.03199)
LnSanitation	-0.26400***	-0.27093***	-0.25267***	-0.1545***	-0.14155***	-0.1576***
	(0.07803)	(0.08057)	(0.07737)	(0.03958)	(0.04127)	(0.04153)
LnPop<14	-0.35368	-0.2853	-0.37922	-0.30932	-0.25629	-0.3455
	(0.34397)	(0.28783)	(0.33547)	(0.30788)	(0.25805)	(0.31137)
LnPop65>	0.16059	0.17004	0.1569	0.00576	0.00658	0.02229
	(0.16675)	(0.17911)	(0.17258)	(0.15637)	(0.16361)	(0.15972)
LnHIV	0.08482**	0.08731*	0.08929**	0.11385***	0.11639***	0.11349***
	(0.04154)	(0.04410)	(0.03911)	(0.02942)	(0.02922)	(0.02870)
LnTHE(-1)	-0.02461			-0.01213		
	(0.03208)			(0.03029)		
LnEduc	-0.09362**	-0.09978**	-0.09905***	-0.1319***	-0.14944***	-0.1308***
	(0.03840)	(0.03923)	(0.03397)	(0.03523)	(0.03512)	(0.03060)
LnPrHE		-0.01698			0.00054	
		(0.03009)			(0.02760)	
LnPrHE(-1)		-0.01043			0.00554	
		(0.02558)			(0.02624)	
LnPuHE			-0.05037***			-0.0513***
			(0.01824)			(0.01846)
LnPuHE(-1)			-0.00993			-0.00777
			(0.02104)			(0.02004)
Constant	5.49194***	5.26434***	5.46464***	5.36262***	5.05660***	5.35552***
	(1.56561)	(1.41015)	(1.47874)	(1.39040)	(1.21364)	(1.35764)
Within R^2	0.68876	0.66815	0.69199	0.67498	0.64989	0.68249
Between R^2	0.10956	0.14752	0.16346	0.31409	0.39938	0.34226
Overall R^2	0.17639	0.20897	0.23003	0.41955	0.49019	0.44018
Prob.	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
No. of Obs.	409	409	409	409	409	409
No. of Groups	42	42	42	42	42	42

Source: Author's computation

Note: ***significant at 1%; ** at 5%; * at 10%. Standard errors are reported in parenthesis. (1) is model with total health expenditure as percent of GDP. (2) is model with private health expenditure as percent of GDP. (3) is model with public health expenditure as percent of GDP.

Table 5.11. Diagnostic Tests for Crude Death Rate Regression

	Fixed Effects			Random Effects		
Test	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Wald test (χ^2)	1.3e+05***	24018.99***	3.6e+05***			
BPLM test (χ^2)				1045.90***	900.93***	1109.36***
Hausman (χ^2)	58.30***	25.64***	43.15***	47.04	52.46	120.21

Source: Author's computation
Note: *** shows significance at 1%, ** shows significance at 5%

The findings from the various models give a general indication that health expenditure is a significant contributor to improving population health (irrespective of the measure used). This findings conform with previous studies that found similar relationship from other regions of the world (Cremieux, 2005; Bokhari et al. 2007; Farag et al. 2013) as well as SSA (Erhijakpor, 2007; Lawanson, 2012). It was also clear from the findings that, while both public and private expenditure on health positively affect health outcomes, health expenditure from the public purse were more significant. This provides emphasis for increased government commitment to the improved health agenda in SSA.

The Abuja Declaration was, therefore, a crucial step in getting governments to increase budgetary allocations to the health sector. However, there is need for more effort to ensure that these targets are actually realised. As noted in the background section of the study, very few countries have achieved this declaration while health spending in other countries have rather fallen over the years. Effective government fiscal policies have been identified as an important tool to create additional fiscal space for the health sector. This is to say that, increasing revenue from tax collection could be a good source of increased allocations to the health sector.

Other studies have recommended external aid as another source of improved health expenditure in developing regions such as SSA (Mallaye and Yogo, 2012). While this may be a viable option, it is worth noting that the economies of several SSA countries already depend largely on external aid. It is however pertinent for the international community to continue investing in the health sector of countries in SSA with particular focus on poor countries that already rely heavily on foreign aid.

The positive and statistically significant lag effect in the relationship between health expenditure and health outcomes suggest that investments in health may not only have immediate impact on health status but also but also the impact may be delayed with some time dimensions. This also implies that investment in the health sector should not be one-off but continuous if the general objective of improved population health is to be achieved.

5.3 Health system efficiency

Table 5.12 presents summary statistics for the variables used in the estimation of health system efficiency. It should be recalled that all mortality variables were transformed into their survival equivalent, consistent with efficiency measurement. The mean, standard deviation, minimum and maximum values were reported. The total of 315 observations consisting of 45 cross section units and 7 time periods (2005-2011) were used in the analysis.

The statistics suggest that average life expectancy at birth over the period was about 55 years with minimum and maximum values of approximately 44 and 74 years, respectively. While mean infant mortality rate was about 68 per 1000 live births, average infant survival rate was about 18 per 1000 live births with minimum and maximum values of about 7 and 84, respectively. Similarly, average under five mortality rate was reported to be approximately 107 per 1000 live births while mean under five survival rate was about 12 with minimum and maximum values of about 4 and 71 survival per 1000 live births, respectively. Average crude death rate over the period was about 12 per 1000 people relative to computed average crude survival rate of about 87 per 1000 people.

In terms of the inputs used in the analysis, average health expenditure per capita over the period was $186 with minimum and maximum values of about $15 and $1806, respectively. Average years of schooling was about 4 over the period with minimum and maximum years of about 1 and 9 years, respectively. The statistics also show that, on average, there exist less than one physician per 1000 people while approximately 1 nurses and midwives was reported on average. Average hospital beds per 1000 people was reported to be approximately 2 over the period of study.

Table 5.12. Descriptive statistics of health outputs and inputs

Variable	Description	Mean	Std dev.	Min	Max
	Outputs				
LE	Life expectancy at birth	55.05	7.02	44.17	73.92
IMR	Infant mortality per 1000 live births	68.30	25.60	11.70	133.20
ISR	Infant survival rate per 1000 live births	18.09	15.28	6.51	84.47
U5MR	Under five mortality per 1000 live births	107.31	44.48	13.80	214.40
U5SR	Under five survival per 1000 live births	12.40	13.52	3.66	71.46
CDR	Crude death rate per 1000 People	12.34	3.30	5.24	18.79
CSR	Crude survival rate per 1000 people	87.23	28.49	52.22	189.77
	Inputs				
HCEpc	Per capita health care expenditure ($)	186.38	257.87	14.59	1806.48
Educ	Average years of schooling	4.40	2.10	1.10	9.40
Phy	Physicians per 1000 people	0.20	0.30	0.01	1.51
Nur	Nurses and midwives per 1000 people	1.20	1.56	0.14	7.93
Hospbed	Hospital beds per 1000 people	1.51	1.32	0.10	6.30

Source: Author's computation

5.3.1 Health system efficiency results from DEA model

Table 5.13 presents a summary of DEA results using various combination of inputs and outputs under output orientation[25]. The table reports specifications from various combination of multiple outputs against both single and multiple inputs. Under-five survival rate (U), infant survival rate (I) and crude survival rate (C) were used as output measures while per capita health care expenditure was used as the main input variable and years of schooling being the measure of uncontrollable health system input. The table also reports the mean efficiency score, standard deviation and minimum values of efficiency estimates across SSA countries. The countries that were estimated to be relatively efficient with efficiency score of one and those with least performance in terms of health system efficiency were also reported in the summary table.

It can also be observed that, mean efficiency score increased when two inputs were used in the analysis, relative to just one input. Also, the number of countries that were estimated to be efficient increased in the multi input analysis, relative to the single input analysis. However, the minimum level of efficiency did not change much between the two sets of specifications. Similar observations were made across other results presented in subsequent tables. The mono-input specifications used health system inputs that are directly controlled by the health system. On the other hand, the multi-input specifications allowed the use of inputs that are not directly controlled by the health system but are likely to influence health outcomes.

The summary of results on efficiency estimates reported in Table 5.13 show that mean efficiency varied between 0.45 and 0.65 depending on the model specification used in the estimation. This suggests that there is the potential for health outcomes to improve between 0.55 and 0.35. The minimum level of efficiency varied between 0.14 and 0.34. This suggests that some countries in the region have the potential to improve health outcomes between 0.86 and 0.66.

---

[25] In line with explanation provided in Chapter four, analysis under the VRS assumption were reported in this section. The analysis were also performed under the CRS assumption and the findings are reported in Appendix C.

Table 5.13. Summary of multi-output DEA results (2011) - Output orientation

Model	**M(UC;1in)**	**M(UI;1in)**	**M(UIC;1in)**	**M(UC;2in)**	**M(UI;2in)**	**M(UIC;2in)**
Mean	0.56	0.45	0.57	0.64	0.50	0.65
Standard deviation	0.19	0.23	0.19	0.22	0.26	0.22
Min	0.34	0.14	0.34	0.34	0.15	0.34
No. efficient	4	3	4	8	6	8
Efficient[a] countries	Cape Verde, Eritrea, Seychelles, Madagascar	Cape Verde, Eritrea, Seychelles	Cape Verde, Eritrea, Seychelles, Madagascar	Burkina Faso, Cape Verde, Eritrea, Madagascar, Mauritius, Mozambique, Niger, Seychelles	Cape Verde, Eritrea, Mauritius, Mozambique, Niger, Seychelles	Burkina Faso, Cape Verde, Eritrea, Madagascar, Mauritius, Mozambique, Niger, Seychelles
Inefficient[b] countries	Swaziland, Equatorial Guinea, Guinea-Bissau, Sierra Leone, Lesotho	Nigeria, Swaziland, Angola, Sierra Leone, Equatorial Guinea	Swaziland, Equatorial Guinea, Guinea-Bissau, Sierra Leone, Lesotho	Angola, Swaziland, Equatorial Guinea, Sierra Leone, Lesotho	Nigeria, Swaziland, Equatorial Guinea, Angola, Sierra Leone	Angola, Swaziland, Equatorial Guinea, Sierra Leone, Lesotho

Source: Author's computation

Notes:

[a] Countries located on the estimated frontier (score =1).

[b] Countries in bottom five of efficiency ranking

M(UC;1in): Two output - under five survival and crude survival rate; 1 input - health expenditure per capita (ppp). **M(UI;1in):** Two output - under five survival and infant survival; 1 input - health expenditure per capita (ppp). **M(UIC;1in):** Three output - under-five, infant and crude survival rate; 1 input - health expenditure per capita (ppp). **M(UC;2in):** Two output - under five and crude survival rate; 2 inputs - health expenditure per capita (ppp), average years of schooling. **M(UI;2in):** Two output - under five and infant survival; 2 inputs - health expenditure per capita (ppp), average years of schooling. **M(UIC;2in):** Three output - under-five, infant survival and crude survival rate; 2 inputs - health care expenditure per capita (ppp), years of schooling

Countries that were relatively efficient irrespective of the model specification used include Cape Verde, Eritrea and Seychelles. These countries were consistently located on the estimated production frontier, irrespective of the model specification. Burkina Faso, Mauritius, Mozambique and Niger only became efficient after the introduction of a second input variable. Madagascar was also efficient in all the specifications except for one. These countries were estimated to be relatively efficient in transforming health resources into health outcomes. The relatively inefficient countries were mostly similar across all the model specification reported in Table 5.13. These include Angola, Equatorial Guinea, Lesotho, Sierra Leone and Swaziland.

Table 5.14 presents summary results from the multi-output DEA analysis. The mean efficiency varied between 0.28 and 0.58 depending on the model specification employed. The mean efficiency scores suggest that on average, SSA countries have the potential to improve population health outcomes between 0.72 and 0.42. That is, given the current levels of health care expenditure, health outcomes could improve between 0.72 and 0.42. It must be noted that mean efficiency was similar for the group of model specifications with multiple inputs. Similar observation can also be made for the group of models with single input. The minimum efficiency score was estimated to be between 0.01 for the single input specifications and 0.17 for the multi input model specifications.

The countries that were estimated to be relatively efficient include Cape Verde, Eritrea, Madagascar, Seychelles, Burkina Faso, Mozambique, Mauritius and Niger were the additional countries after the inclusion of a second input variable. The results suggest that these countries used their health system resources in a more productive way, relative to other health systems in SSA region. Similar to the earlier results, the countries that showed relatively poor performance in terms of health system efficiency were almost similar across various model specifications. These countries include Angola, Lesotho, Equatorial Guinea, Sudan, Gabon, South Africa and Swaziland. This implies that, these countries have relatively higher potential to improve upon the use of health system resources in generating population health outcomes.

Table 5.14. Summary of Multi-output DEA results (2011) - Input orientation

Model	**M(UC;1in)**	**M(UI;1in)**	**M(UIC;1in)**	**M(UC;2in)**	**M(UI;2in)**	**M(UIC;2in)**
Mean	0.28	0.28	0.29	0.58	0.55	0.58
Standard deviation	0.28	0.26	0.28	0.27	0.26	0.27
Minimum	0.01	0.01	0.01	0.17	0.17	0.17
No. efficient	4	3	4	8	6	8
Efficient[a] countries	Cape Verde, Eritrea, Madagascar, Seychelles	Cape Verde, Eritrea, Seychelles	Cape Verde, Eritrea, Madagascar, Seychelles	Burkina Faso, Cape Verde, Eritrea, Madagascar, Mauritius, Mozambique, Niger, Seychelles	Cape Verde, Eritrea, Mauritius, Mozambique, Niger, Seychelles	Burkina Faso, Cape Verde, Eritrea, Madagascar, Mauritius, Mozambique, Niger, Seychelles
Inefficient[b] countries	Lesotho, South Africa, Sudan, Swaziland, Gabon, Equatorial Guinea	Lesotho, South Africa, Sudan, Swaziland, Gabon, Equatorial Guinea	Lesotho, South Africa, Sudan, Swaziland, Gabon, Equatorial Guinea	Angola, Lesotho, South Africa, Equatorial Guinea, Gabon, Swaziland	Angola, South Africa, Equatorial Guinea, Gabon, Swaziland	Angola, South Africa, Equatorial Guinea, Gabon, Swaziland

Source: Author's computation

Notes: [a] Countries located on the estimated frontier (score =1). [b] Countries in bottom five of efficiency ranking

M(UC;1in): Two output - under five survival and crude survival rate; 1 input - health care expenditure per capita (ppp). **M(UI;1in):** Two output - under five survival and infant survival; 1 input - health care expenditure per capita (ppp). **M(UIC;1in):** Three output - under-five, infant survival and crude survival rate; 1 input - health care expenditure per capita (ppp). **M(UC;2in):** Two output - under five and crude survival rate; 2 inputs - health expenditure per capita (ppp), average years of schooling. **M(UI;2in):** Two output - under five and infant survival; 2 inputs - health care expenditure per capita (ppp), average years of schooling. **M(UIC;2in):** Three output - under-five, infant survival and crude survival rate; 2 inputs - health care expenditure per capita (ppp), average years of schooling

Table 5.15 presents results from mono-output DEA efficiency analysis using an output orientation. The table presents summary results on mean efficiency scores across DMUs (health systems) in SSA. The standard deviation of estimated efficiency scores and minimum efficiency values were presented in the table. A summary of the best performers and worst performing countries were also presented in the table. The table also reports various model specifications including single and multi input models.

The results show that mean-efficiency varies between 0.38 and 0.62 depending on the model specification used. This suggests that on average, given the current level of health expenditure, health systems have the potential to improve population health outcomes between 0.62 and 0.38. Again it can be observed that mean efficiency scores were lower for the single input models relative to the multi input models. The minimum efficiency scores were however, relatively, similar across all the models reported in Table 5.15. The minimum scores varied between 0.10 and 0.34.

Similar to the previous results, the number of countries located on the frontier increased in the multiple input models, relative to the single input models. The results show that Cape Verde, Eritrea and Seychelles were consistently efficient, irrespective of the model specification employed. Mauritius, Mozambique and Niger were only efficient in the multiple input models. The countries that were estimated to consistently have relatively less efficient health systems include Nigeria, Equatorial Guinea, Swaziland and Sierra Leone. There was not much variation established between the single and multiple input models.

Table 5.15. Summary of mono-output DEA results (2011) - Output orientation

Model	M(IS;1in)	M(CS;1in)	M(U;1in)	M(IS;2in)	M(CS;2in)	M(U;2in)
Mean	0.45	0.55	0.38	0.5	0.62	0.44
Standard deviation	0.23	0.17	0.24	0.26	0.21	0.27
Minimum	0.14	0.34	0.10	0.15	0.34	0.10
No. efficient	3	3	3	7	6	6
Efficient[a] countries	Cape Verde, Eritrea, Seychelles	Cape Verde, Eritrea, Madagascar	Cape Verde, Eritrea, Seychelles	Cape Verde, Eritrea, Ethiopia, Mauritius, Mozambique, Niger, Seychelles	Burkina Faso, Cape Verde, Eritrea, Madagascar, Mozambique, Niger	Cape Verde, Eritrea, Mauritius, Mozambique, Niger, Seychelles
Inefficient[b] countries	Cameroon, Nigeria, Equatorial Guinea, Angola, Swaziland, Sierra Leone	Guinea-Bissau, Equatorial Guinea, South Africa, Swaziland, Lesotho, Sierra Leone	Nigeria, Swaziland, Angola, Equatorial Guinea, Sierra Leone	Cameroon, Nigeria, Swaziland, Angola, Sierra Leone, Equatorial Guinea	South Africa, Lesotho, Swaziland, Angola, Sierra Leone, Equatorial Guinea	Nigeria, Swaziland, Equatorial Guinea, Angola, Sierra Leone

Source: Author's computation

Notes:

[a] Countries located on the estimated frontier (score =1).

[b] Countries in bottom five of efficiency ranking

M(IS;1in): One output - Infant survival rate; One input - health care expenditure per capita (ppp)

M(CS;1in): One output - Crude survival rate; One input - health care expenditure per capita (ppp)

M(U;1in): One output - under-five survival rate; One input - health care expenditure per capita (ppp)

M(IS;2in): One output - Infant survival rate; Two inputs - health care expenditure per capita (ppp), average years of schooling

M(CS;2in): One output - Crude survival rate; Two inputs - health care expenditure per capita (ppp), average years of schooling

M(U;2in): One output - under-five survival rate; Two inputs - health care expenditure per capita (ppp), average years of schooling

A summary of results from the single output DEA model is reported in Table 5.16. The results are based on the input orientation and include specifications for both single and multiple inputs. The table presents summary findings on the mean efficiency scores from the various model specifications as well as the standard deviation and minimum values. The best performing countries alongside the worst performing countries were also reported in the table.

The results show that mean-efficiency varied between 0.23 and 0.54, depending on the type of model specified for the efficiency analysis. Again the results show that the mean efficiency scores were lower for the single input specifications, relative to the multiple input specifications. The results suggest that, on average, SSA countries could improve health outcomes between 77% and 45% while maintaining the same level of health expenditure.

The results also show minimum estimated efficiency score of 0.01 consistent for the single input models and 0.17 for the multiple input model specifications. The number of efficient countries located on the production frontier also doubled with the multiple input model specifications. The results show that again Cape Verde, Eritrea and Seychelles were the consistently efficient health systems, irrespective of the model specification. Other countries including Mauritius, Madagascar and Niger were only efficient in the multiple input specifications.

The countries estimated to have the least relative efficiency scores were also consistent across the various model specifications. That is, there was not many variations in the list of countries that fall in this category. The countries that fall into this category include Angola, Lesotho, Equatorial Guinea, Gabon and South Africa.

Table 5.16. Summary of mono-output DEA results (2011) - Input orientation

Model	**M(IS;1in)**	**M(CS;1in)**	**M(U;1in)**	**M(IS;2in)**	**M(CS;2in)**	**M(U;2in)**
Mean	0.28	0.23	0.28	0.54	0.53	0.54
Standard deviation	0.26	0.24	0.26	0.26	0.28	0.26
Minimum	0.01	0.01	0.01	0.17	0.14	0.17
No. efficient	3	3	3	6	6	6
Efficient[a] countries	Cape Verde, Eritrea, Seychelles	Cape Verde, Eritrea, Madagascar	Cape Verde, Eritrea, Seychelles	Cape Verde, Eritrea, Mauritius, Mozambique, Niger, Seychelles	Burkina Faso, Cape Verde, Eritrea, Madagascar, Mozambique, Niger	Cape Verde, Eritrea, Mauritius, Mozambique, Niger, Seychelles
Inefficient[b] countries	Angola, Lesotho, South Africa, Swaziland, Gabon, Equatorial Guinea	Gabon, Mauritius, Botswana, Seychelles, South Africa, Equatorial Guinea	Lesotho, South Africa, Sudan, Swaziland, Gabon, Equatorial Guinea	Angola, South Africa, Lesotho, Equatorial Guinea, Gabon, Swaziland	Seychelles, Lesotho, Equatorial Guinea, Swaziland, South Africa, Botswana	Angola, Lesotho, South Africa, Equatorial Guinea, Gabon, Swaziland

Source: Author's computation

Notes:

[a] Countries located on the estimated frontier (score =1).

[b] Countries in bottom five of efficiency ranking

M(IS;1in): One output - Infant survival rate; One input - health care expenditure per capita (ppp)

M(CS;1in): One output - Crude survival rate; One input - health care expenditure per capita (ppp)

M(U;1in): One output - under-five survival rate; One input - health care expenditure per capita (ppp)

M(IS;2in): One output - Infant survival rate; Two inputs - health care expenditure per capita (ppp), average years of schooling

M(CS;2in): One output - Crude survival rate; Two inputs - health care expenditure per capita (ppp), average years of schooling

M(U;2in): One output - under-five survival rate; Two inputs - health care expenditure per capita (ppp), average years of schooling

5.3.1.1 Efficiency analysis using physical inputs

The sub-section presents DEA results using physical inputs including physicians, nurses and midwifes and hospital beds per 1000 people. Population health outcomes such as under-five, infant and crude survival rates were used as measures of output. The analyses were performed to check for robustness against the DEA results from monetary inputs reported earlier[26].

Table 5.17 presents both single and multiple output DEA results under the output orientation. The table also presents the mean efficiency scores for health systems in SSA, including the standard deviation and minimum values. Countries with relatively efficient and worst performing health systems were also reported in Table 5.17. The mean efficiency score for SSA countries ranges between 0.47 and 0.70. The mean efficiency score was, generally, higher for the single output models relative to the multiple output models. The mean estimates suggest a potential for improvement in health outcomes between 53% and 30%, if health care resources are effectively used. The minimum values of efficiency were also reported to be between 0.11 and 0.36, depending on the model specified.

The countries located on the estimated production frontier recorded an efficiency score of unity and are considered to be relatively more effective in the use of health care resources. These countries varied marginally across the various specifications even though some were consistently efficient. The results show that Cape Verde, Guinea, Madagascar, Niger and Tanzania were the most consistently best performers in terms of health system efficiency. Other countries such as Mali, Mauritius, Seychelles, Eritrea and Ethiopia were efficient in at least one of the model specifications. The poor performing countries were mostly similar across the various model specifications and these include South Africa, Congo DR, Equatorial Guinea, Sao Tome and Principe, Swaziland and Nigeria. These countries showed inefficiency in more than one specifications. This suggests a relatively higher room for improvement in the use of health care resources.

---

[26] Similar to the previous sub-section, estimates from the CRS assumption are reported in Appendix C.

Table 5.17. Summary of DEA results using physical inputs (2010) - Output orientation

Model	**M(IS;3in)**	**M(CS;3in)**	**M(U;3in)**	**M(UI;3in)**	**M(UC;3in)**
Mean	0.64	0.70	0.59	0.64	0.74
Standard deviation	0.25	0.21	0.26	0.27	0.27
Minimum	0.21	0.36	0.16	0.21	0.37
No. efficient	8	8	8	8	10
Efficient[a] countries	Cape Verde, Guinea, Madagascar, Mali, Mauritius, Niger, Seychelles, Tanzania	Cape Verde, Eritrea, Ethiopia, Guinea, Madagascar, Mali, Niger, Tanzania	Cape Verde, Guinea, Madagascar, Mali, Mauritius, Niger, Seychelles, Tanzania	Cape Verde, Guinea, Madagascar, Mali, Mauritius, Niger, Seychelles, Tanzania	Cape Verde, Eritrea, Ethiopia, Guinea, Madagascar, Mali, Mauritius, Niger, Seychelles Tanzania
Inefficient[b] countries	Guinea-Bissau, Angola, Sao Tome and Principe, Congo DR, Equatorial Guinea	Swaziland, Congo DR, Botswana, Equatorial Guinea, South Africa	Angola, Congo DR, Guinea-Bissau, Equatorial Guinea, Sao Tome and Principe	Angola, Guinea -Bissau, Congo DR, Equatorial Guinea, Sao Tome and Principe	Congo DR, South Africa, Nigeria, Equatorial Guinea, Swaziland,

Source: Author's computation

Notes:

[a] Countries located on the estimated frontier (score =1).

[b] Countries in bottom five of efficiency ranking

M(IS;3in): One output - Infant survival rate; Three input - Physicians, Nurses and Midwifes population, Hospital beds

M(CS;3in): One output - Crude survival rate; Three input - Physicians, Nurses and Midwifes population, Hospital beds

M(U;3in): One output - under-five survival rate; Three input - Physicians, Nurses and Midwifes population, Hospital beds

M(UI;3in): Two output - Under-five and Infant survival rates; Three inputs - Physicians, Nurses and Midwifes population, Hospital beds

M(UC;3in): Two output - Under-five and Crude survival rate; Three inputs - Physicians, Nurses and Midwifes population, Hospital beds

Table 5.18 presents a summary of efficiency scores for single and multiple output DEA model using the input orientation. The table shows mean efficiency score for SSA countries, including the minimum and standard deviation values. Four different models are presented using physical inputs of the health system.

The results suggest that average efficiency scores in SSA ranges between 0.56 and 0.60. The mean efficiency scores were relatively higher for the multiple input models compared to the single input models. The statistics also showed no significant variation in mean efficiency across the various models used in the analysis. The results show that there exist a potential for improvement, between 46% and 40%, in the performance of health systems if health care resources are well managed. The minimum efficiency scores did not vary much across the various model specifications. The minimum values were estimated between 0.10 and 0.17, depending on the model specified.

In terms of the best performing countries, almost all the model specifications estimated showed eight (8) countries located on the production frontier, except the model in the last column with ten (10) countries. The countries with efficient health systems include Cape Verde, Mauritius, Seychelles, Guinea, Madagascar, Mali, Niger and Tanzania. These countries were also consistently efficient across all the model specifications. Eritrea and Ethiopia were only efficient in the multiple output specification with under-five and crude survival rates as output measures.

Countries estimated to have relatively poor performing health systems include Gabon, South Africa, Swaziland, Equatorial Guinea and Sao Tome and Principe. These countries were consistent in almost all the model specifications. The results suggest that there exist a relatively higher potential for these countries to improve upon the performance of the health system in producing population health outcomes.

Table 5.18. Summary of DEA results using physical inputs (2010) - Input orientation

Model	M(IS;3in)	M(U;3in)	M(UI;3in)	M(UC;3in)
Mean	0.56	0.56	0.57	0.60
Standard deviation	0.27	0.26	0.27	0.27
Minimum	0.10	0.11	0.11	0.17
No. efficient	8	8	8	10
Efficient[a] countries	Cape Verde, Mauritius, Seychelles, Guinea, Madagascar, Mali, Niger, Tanzania	Cape Verde, Guinea, Madagascar, Mali, Mauritius, Niger, Seychelles, Tanzania	Cape Verde, Guinea, Madagascar, Mali, Mauritius, Niger, Seychelles, Tanzania	Cape Verde, Eritrea, Ethiopia, Guinea, Madagascar, Mali, Mauritius, Niger, Seychelles, Tanzania
Inefficient[b] countries	Gabon, Comoros, Equatorial Guinea, Sao Tome and Principe, Swaziland	Gabon, South Africa, Swaziland, Equatorial Guinea, Sao Tome and Principe	Gabon, South Africa, Swaziland, Equatorial Guinea, Sao Tome and Principe	Gabon, South Africa, Swaziland, Equatorial Guinea, Sao Tome and Principe

Source: Author's computation
Notes:
[a] Countries located on the estimated frontier (score =1.00).
[b] Countries in bottom five of efficiency ranking
M(IS;3in): One output - Infant survival rate; Three input - Physicians, Nurses and Midwifes population, Hospital beds
M(CS;3in): One output - Crude survival rate; Three input - Physicians, Nurses and Midwifes population, Hospital beds
M(U;3in): One output - under-five survival rate; Three input - Physicians, Nurses and Midwifes population, Hospital beds
M(UI;3in): Two output - Under-five and Infant survival rates; Three inputs - Physicians, Nurses and Midwifes population, Hospital beds
M(UC;3in): Two output - Under-five and Crude survival rate; Three inputs - Physicians, Nurses and Midwifes population, Hospital beds

5.3.1.2 Country specific analysis of health system performance using monetary inputs

This sub-section presents country specific analysis of the performance of health systems in SSA. The section examines the rank and efficiency score for countries in the region. The analysis was based on different model specifications to allow for robustness and also the output orientation is preferred to the input orientation[27]. This is because as noted by Alexander et al. (2003), the primary objective of any health system is to improve population health outcomes. In this regard it is important to understand the potential for improvement in health outcomes, rather than the potential for savings in health expenditure.

Table 5.19 shows the estimated efficiency score for 45 countries in SSA using various multiple input and output model specifications. The results suggest that most of the best performing countries were consistently located on the production frontier across all the model specifications with the exception of Burkina Faso and Madagascar who were located on the frontier in the first and last models.

In terms of poor performing countries, Lesotho was ranked 45 in two of the three models with efficiency score of 0.34. This suggests that, compared to the estimated frontier, health system efficiency in Lesotho can be improved by 66%. This is to say that, given the current level of health care expenditure, population health outcomes in Lesotho can be improved by about 66%. Other countries in the region that showed relatively poor efficiency performance include Angola with rank of 41 and efficiency score of 0.38. Sierra Leone was also relatively inefficient with a rank of 44 and estimated efficiency of 0.36. This suggests that the performance of the health system in Sierra Leone can be improved by about 64% if health resources are used efficiently.

[27] Analysis from the input orientation are reported in Appendix C

Table 5.19. Efficiency of health systems, 2011-DEA output orientation(Multi-inputs/output)

DMU	Rank	M(UC;2in)	Rank	M(UI;2in)	Rank	M(UIC;2in)
Angola	41	0.38	44	0.17	41	0.38
Benin	22	0.59	24	0.43	24	0.59
Botswana	23	0.59	10	0.65	19	0.65
Burkina Faso	1	1.00	9	0.76	1	1.00
Burundi	25	0.58	23	0.44	25	0.58
Cameroon	37	0.40	40	0.26	39	0.40
Cape Verde	2	1.00	1	1.00	2	1.00
Central African Rep.	35	0.45	31	0.35	36	0.45
Chad	15	0.69	16	0.54	15	0.69
Comoros	10	0.91	12	0.61	10	0.91
Congo, Dem. Rep.	36	0.44	34	0.34	37	0.44
Congo, Rep.	29	0.53	29	0.36	31	0.53
Cote d'Ivoire	33	0.49	39	0.27	33	0.49
Equatorial Guinea	43	0.37	43	0.18	43	0.37
Eritrea	3	1.00	2	1.00	3	1.00
Ethiopia	9	0.99	8	0.87	9	0.99
Gabon	20	0.61	36	0.29	21	0.61
Gambia, The	12	0.79	20	0.49	12	0.79
Ghana	13	0.77	19	0.50	13	0.77
Guinea	11	0.84	11	0.62	11	0.84
Guinea-Bissau	30	0.51	32	0.35	32	0.51
Kenya	24	0.59	13	0.59	22	0.61
Lesotho	45	0.34	38	0.27	45	0.34
Liberia	28	0.55	25	0.39	29	0.55
Madagascar	4	1.00	7	0.88	4	1.00
Malawi	32	0.50	17	0.53	30	0.53
Mali	19	0.64	26	0.37	20	0.64
Mauritania	21	0.60	37	0.27	23	0.60
Mauritius	5	1.00	3	1.00	5	1.00
Mozambique	6	1.00	4	1.00	6	1.00
Namibia	17	0.65	15	0.54	17	0.65
Niger	7	1.00	5	1.00	7	1.00
Nigeria	38	0.39	41	0.25	40	0.39
Rwanda	31	0.51	14	0.56	28	0.56
Sao Tome	14	0.71	35	0.31	14	0.71
Senegal	18	0.65	21	0.48	18	0.65
Seychelles	8	1.00	6	1.00	8	1.00
Sierra Leone	44	0.36	45	0.15	44	0.36
South Africa	39	0.39	33	0.35	38	0.42
Sudan	16	0.67	30	0.36	16	0.67
Swaziland	42	0.37	42	0.21	42	0.37
Tanzania	26	0.58	18	0.52	26	0.58
Togo	27	0.57	27	0.37	27	0.57
Uganda	34	0.47	28	0.37	34	0.47
Zambia	40	0.38	22	0.47	35	0.47
Mean		**0.64**		**0.50**		**0.65**

Source: Author's computation

Note: M(UC;2in): Two output - under five survival and crude death rate; 2 inputs - health care expenditure per capita (ppp), average years of schooling**. M(UI;2in):** Two output - under five survival and infant survival; 2 inputs - health care expenditure per capita (ppp), average years of schooling**. M(UIC;2in):** Three output - under-five, infant survival and crude death rate; 2 inputs - health care expenditure per capita (ppp), average years of schooling

Table 5.20 presents individual country efficiency scores using single input and multiple outputs. The results presented were generated from the output orientation with three different model specifications. A combination of under-five, infant and crude survival rates were used as the measure of output while per capita health care expenditure was used as input. The results show strong similarity between the first and the last models while estimates in the second model were relatively lower.

The results also show that all the countries located on the efficiency frontier were consistent for all the three model specifications with the exception of Madagascar that was efficient in the first and the last models. This suggests that, compared to other countries in the region, Cape Verde, Eritrea, Madagascar and Seychelles were efficient in the use of health care resources. Lesotho was the least efficient in more than one specification with a rank of 45 and efficiency score of 0.34. This suggest that compared to the estimated frontier, health system efficiency in Lesotho can be improved by about 66% if health care resources are used efficiently.

Ghana recorded efficiency score of 0.77 and is ranked 6th which suggests that, compared to the estimated frontier, there exists a potential for improvement of about 23% in the performance of the Ghanaian health system. Nigeria was relatively less efficient with estimated efficiency score of 0.39. This implies a 61% potential for improvement in the performance of the health system, compared to the estimated frontier. In the case of Sierra Leone, health system efficiency was estimated to be 0.35 with a low rank of 44.

Table 5.20. Efficiency of health systems, 2011 - DEA output orientation (Mono-input)

DMU	Rank	M(UC;1in)	Rank	M(UI;1in)	Rank	M(UIC;1in)
Angola	40	0.38	43	0.17	40	0.38
Benin	21	0.53	20	0.42	24	0.53
Botswana	16	0.59	7	0.65	13	0.65
Burkina Faso	23	0.52	30	0.33	26	0.52
Burundi	30	0.45	22	0.38	31	0.45
Cameroon	35	0.40	40	0.26	37	0.40
Cape Verde	1	1.00	1	1.00	1	1.00
Central African Rep.	33	0.42	27	0.35	34	0.42
Chad	38	0.38	33	0.30	39	0.38
Comoros	7	0.72	11	0.54	7	0.72
Congo, Dem. Rep.	34	0.41	29	0.34	36	0.41
Congo, Rep.	22	0.53	26	0.36	25	0.53
Cote d'Ivoire	26	0.49	39	0.27	27	0.49
Equatorial Guinea	42	0.37	45	0.14	42	0.37
Eritrea	2	1.00	2	1.00	2	1.00
Ethiopia	9	0.67	6	0.66	9	0.69
Gabon	13	0.61	34	0.29	14	0.61
Gambia, The	10	0.66	18	0.44	10	0.66
Ghana	6	0.77	15	0.50	6	0.77
Guinea	28	0.48	23	0.37	28	0.48
Guinea-Bissau	43	0.37	36	0.28	43	0.37
Kenya	17	0.59	8	0.59	15	0.61
Lesotho	45	0.34	38	0.27	45	0.34
Liberia	20	0.54	21	0.39	22	0.54
Madagascar	3	1.00	5	0.88	3	1.00
Malawi	25	0.49	13	0.53	23	0.53
Mali	32	0.43	35	0.28	33	0.43
Mauritania	15	0.59	37	0.27	17	0.59
Mauritius	5	0.98	4	0.99	5	0.99
Mozambique	31	0.43	19	0.42	32	0.44
Namibia	11	0.65	12	0.54	11	0.65
Niger	24	0.51	9	0.55	20	0.56
Nigeria	36	0.39	41	0.25	38	0.39
Rwanda	27	0.48	10	0.55	21	0.55
Sao Tome	8	0.71	31	0.31	8	0.71
Senegal	12	0.65	16	0.48	12	0.65
Seychelles	4	1.00	3	1.00	4	1.00
Sierra Leone	44	0.35	44	0.14	44	0.35
South Africa	37	0.39	28	0.34	35	0.42
Sudan	14	0.61	32	0.31	16	0.61
Swaziland	41	0.37	42	0.21	41	0.37
Tanzania	18	0.58	14	0.52	18	0.58
Togo	19	0.57	24	0.37	19	0.57
Uganda	29	0.47	25	0.37	29	0.47
Zambia	39	0.38	17	0.47	30	0.47
Mean		**0.56**		**0.45**		**0.57**

Source: Author's computation

Note: **M(UC;1in):** Two output - under five survival and crude death rate; One input - health care expenditure per capita (ppp). **M(UI;1in):** Two output - under five survival and infant survival; One input - health care expenditure per capita (ppp). **M(UIC;1in):** Three output - under-five, infant survival and crude death rate; One input - health care expenditure per capita (ppp)

In Table 5.21, results from single output and multiple input models were presented using the output orientation. Under-five, infant and crude survival rates were used as the output variables while per capita heath care expenditure and average years of schooling were used as input variables. Similar to previous observations, most of the countries located on the estimated frontier were consistent across the various models. Again Cape Verde, Eritrea, Mauritius, Madagascar and Seychelles were estimated to have the most efficient health systems. These countries therefore form the basis for comparison with other health systems in the region in terms of efficiency performance. This implies that a majority of countries in the SSA region have potential for improvement in the performance of the health system.

For instance, in the single output analysis, Sierra Leone emerged the least efficient country with an estimated health system efficiency score of 0.10 and 0.36 depending on the model specification. Angola recorded an efficiency score of 0.11 when under-five survival is used as the outcome variable and 0.17 when infant survival is used as the outcome variable. The efficiency score increased to 0.38 when crude survival rate was used as outcome variable. Other countries worth mentioning include South Africa and Nigeria. South Africa recorded efficiency scores between 0.30 and 0.36 while Nigeria recorded estimated efficiency score between 0.18 and 0.39.

Table 5.21. Efficiency of Health systems, 2011 - DEA output orientation (Multi-inputs)

DMU	Rank	M(U;2in)	Rank	M(IS;2in)	Rank	M(CS;2in)
Angola	44	0.11	44	0.17	40	0.38
Benin	24	0.35	24	0.43	22	0.59
Botswana	10	0.59	10	0.65	37	0.40
Burkina Faso	11	0.57	9	0.76	1	1.00
Burundi	21	0.36	23	0.44	24	0.58
Cameroon	40	0.19	40	0.26	36	0.40
Cape Verde	1	1.00	1	1.00	2	1.00
Central African Republic	26	0.31	31	0.35	34	0.45
Chad	18	0.42	16	0.54	15	0.69
Comoros	9	0.61	12	0.61	8	0.91
Congo, Dem. Rep.	29	0.29	34	0.34	35	0.44
Congo, Rep.	30	0.28	29	0.36	28	0.53
Cote d'Ivoire	38	0.22	39	0.27	32	0.49
Equatorial Guinea	43	0.13	43	0.18	42	0.37
Eritrea	2	1.00	2	1.00	3	1.00
Ethiopia	7	0.85	8	0.87	7	0.99
Gabon	35	0.25	36	0.29	20	0.61
Gambia, The	25	0.34	20	0.49	10	0.79
Ghana	20	0.41	19	0.50	11	0.77
Guinea	12	0.54	11	0.62	9	0.84
Guinea-Bissau	32	0.27	32	0.35	29	0.51
Kenya	13	0.49	13	0.59	23	0.59
Lesotho	37	0.22	38	0.27	45	0.34
Liberia	23	0.35	25	0.39	27	0.55
Madagascar	8	0.83	7	0.88	4	1.00
Malawi	16	0.42	17	0.53	31	0.50
Mali	33	0.27	26	0.37	19	0.64
Mauritania	39	0.21	37	0.27	21	0.60
Mauritius	3	1.00	3	1.00	12	0.77
Mozambique	4	1.00	4	1.00	5	1.00
Namibia	15	0.44	15	0.54	17	0.65
Niger	5	1.00	5	1.00	6	1.00
Nigeria	41	0.18	41	0.25	38	0.39
Rwanda	14	0.47	14	0.56	30	0.51
Sao Tome and Principe	36	0.23	35	0.31	14	0.71
Senegal	19	0.41	21	0.48	18	0.65
Seychelles	6	1.00	6	1.00	13	0.72
Sierra Leone	45	0.10	45	0.15	43	0.36
South Africa	28	0.30	33	0.35	44	0.36
Sudan	34	0.27	30	0.36	16	0.67
Swaziland	42	0.16	42	0.21	41	0.37
Tanzania	17	0.42	18	0.52	25	0.58
Togo	27	0.30	27	0.37	26	0.57
Uganda	31	0.28	28	0.37	33	0.47
Zambia	22	0.36	22	0.47	39	0.38
Mean		**0.44**		**0.51**		**0.63**

Source: Author's computation

Note: M(U;2in): One output - under-five survival rate; Two inputs - health care expenditure per capita (ppp), average years of schooling**. M(IS;2in):** One output - Infant survival rate; Two inputs - health care expenditure per capita (ppp), average years of schooling**. M(CS;2in):** One output - Crude survival rate; Two inputs - health care expenditure per capita (ppp), average years of schooling

5.3.1.3 Country specific analysis of health system performance using physical Inputs

The sub-section presents results from DEA analysis using physical inputs for individual countries in SSA. The analysis was conducted using physicians, nurses and midwifes and hospital beds per 1000 population as inputs of the health system while under-five, infant and crude survival rates were employed as output measures. The analysis was conducted to allow for further robustness analysis of the performance of health systems in the SSA region.

Results from the multiple input and output DEA model suggest that countries that were located on the frontier are similar to those in the monetary input results reported earlier (Table 5.22). The countries estimated to have relatively efficient health systems include Cape Verde, Guinea, Madagascar, Mauritius, Seychelles and Tanzania. These countries had efficiency scores of 1.00 in at least two out of the three models. Eritrea and Ethiopia were only relatively efficient in one out of the three models. The results suggest that, compared to other countries in the SSA region, these countries performed better in the transformation of physical health care inputs into health outcomes.

The worst performing countries include Equatorial Guinea with efficiency scores well below the estimated regional average. Angola and Congo Democratic Republic also showed consistent poor performance with estimated efficiency scores below the regional average. This suggests relatively higher potential for improvement in the efficiency in the use of health care resources. Other countries that performed relatively poor in terms of health system efficiency include South Africa, Cameroon, Nigeria and Swaziland.

Table 5.22. Efficiency of Health Systems - DEA output orientation (Multi-output/input)

DMU	Rank	M(UI;3in)	Rank	M(UC;3in)
Angola	38	0.31	35	0.45
Benin	18	0.66	21	0.75
Botswana	9	0.97	14	0.91
Burundi	23	0.57	19	0.75
Cameroon	34	0.40	34	0.53
Cape Verde	1	1.00	1	1.00
Chad	25	0.54	26	0.65
Comoros	31	0.43	18	0.75
Congo, Dem. Rep.	40	0.26	39	0.42
Congo, Rep.	30	0.47	28	0.64
Equatorial Guinea	41	0.21	41	0.37
Eritrea	14	0.80	2	1.00
Ethiopia	11	0.86	3	1.00
Gabon	35	0.37	29	0.61
Gambia, The	16	0.67	15	0.90
Ghana	17	0.66	11	0.93
Guinea	2	1.00	4	1.00
Guinea-Bissau	37	0.33	36	0.44
Kenya	28	0.51	31	0.60
Lesotho	21	0.58	32	0.58
Liberia	12	0.81	12	0.91
Madagascar	3	1.00	5	1.00
Malawi	13	0.80	17	0.77
Mali	4	1.00	6	1.00
Mauritania	27	0.52	22	0.71
Mauritius	5	1.00	7	1.00
Mozambique	20	0.59	27	0.65
Namibia	22	0.58	25	0.65
Niger	6	1.00	8	1.00
Nigeria	32	0.41	37	0.44
Rwanda	10	0.95	13	0.91
Sao Tome and Principe	39	0.27	23	0.70
Seychelles	7	1.00	9	1.00
Sierra Leone	29	0.50	20	0.75
South Africa	33	0.41	40	0.39
Sudan	26	0.53	24	0.69
Swaziland	36	0.34	38	0.44
Tanzania	8	1.00	10	1.00
Togo	24	0.55	16	0.81
Uganda	15	0.68	30	0.60
Zambia	19	0.65	33	0.55
Mean		**0.64**		**0.74**

Source: Author's computation

Note: M(UI;3in): Two outputs - Under-five and Infant survival rates; Three physical inputs**.** **M(UC;3in):** Two outputs - Under-five and Crude survival rate; Three Physical inputs. **M(UIC;3in):** Three outputs - Under-five, Infant and Crude survival rate; Three physical inputs.

Table 5.23 presents the single output results for the DEA model using physical inputs of the health system and output orientation. Two different models were analysed using under-five and infant survival rates as health outcome measures while physicians, nurses and midwives and hospital beds per 1000 people. The results again show that the most efficient countries in terms of health system performance include Cape Verde, Guinea, Madagascar, Mali, Mauritius, Niger, Seychelles and Tanzania. These countries were estimated to be consistently efficient for the two models.

The results show that a number of countries in the SSA region have significantly high potential for improvement in the performance of health system efficiency. For instance, the results show Equatorial Guinea as the least efficient health system with a score significantly below the regional average. Other countries with relatively poor efficiency performance include Congo Democratic Republic, Angola and Swaziland. The estimated efficiency scores for these countries suggest that, compared to the estimated frontier, health system performance can be improved if health care resources were used more effectively.

Table 5.23. Efficiency of Health Systems - DEA output orientation (Momo-input)

DMU	Rank	M(U:3in)	Rank	M(ISR;3in)
Angola	38	0.23	38	0.31
Benin	15	0.62	18	0.66
Botswana	10	0.91	9	0.97
Burundi	21	0.53	23	0.57
Cameroon	35	0.32	34	0.40
Cape Verde	1	1.00	1	1.00
Chad	27	0.48	25	0.54
Comoros	30	0.40	31	0.43
Congo, Dem. Rep.	39	0.21	40	0.26
Congo, Rep.	31	0.39	29	0.47
Equatorial Guinea	41	0.16	41	0.21
Eritrea	13	0.74	13	0.80
Ethiopia	11	0.84	11	0.86
Gabon	34	0.32	35	0.37
Gambia, The	22	0.52	16	0.67
Ghana	18	0.59	17	0.66
Guinea	2	1.00	2	1.00
Guinea-Bissau	37	0.26	37	0.33
Kenya	29	0.41	28	0.51
Lesotho	19	0.58	21	0.58
Liberia	12	0.81	14	0.75
Madagascar	3	1.00	3	1.00
Malawi	14	0.74	12	0.80
Mali	4	1.00	4	1.00
Mauritania	25	0.49	27	0.52
Mauritius	5	1.00	5	1.00
Mozambique	17	0.59	20	0.59
Namibia	26	0.48	22	0.58
Niger	6	1.00	6	1.00
Nigeria	33	0.33	32	0.41
Rwanda	9	0.91	10	0.95
Sao Tome and Principe	40	0.20	39	0.27
Seychelles	7	1.00	7	1.00
Sierra Leone	24	0.50	30	0.46
South Africa	32	0.35	33	0.41
Sudan	28	0.45	26	0.53
Swaziland	36	0.27	36	0.34
Tanzania	8	1.00	8	1.00
Togo	23	0.50	24	0.55
Uganda	16	0.60	15	0.68
Zambia	20	0.55	19	0.65
Mean		**0.59**		**0.64**

Source: Author's computation

Note: M(UI;3in): Two outputs - Under-five and Infant survival rates; Three physical inputs**.** **M(UC;3in):** Two outputs - Under-five and Crude survival rate; Three Physical inputs. **M(UIC;3in):** Three outputs - Under-five, Infant and Crude survival rate; Three physical inputs.

5.3.2 Efficiency of Health systems using SFA model

The sub-section presents efficiency estimates from the stochastic frontier model. Table 5.24 presents a cross section (2011) analysis using both under-five and infant survival rates as measures of health outcome. The results show mean efficiency of approximately 0.70 for the two models used in the analyses. A close observation of the results also shows strong similarity in the individual country efficiency scores and rankings.

The best performing countries from the cross-section SFA analysis include Mauritius with efficiency estimate of about 0.90. This suggests that, relative to best practice, the health system in Mauritius can be improved by about 10%. Similarly, Cape Verde recorded health system efficiency score of about 0.90 which also suggests a 10% potential for improvement. Other countries that performed relatively well include Madagascar, Kenya, Tanzania and Eritrea.

Countries that showed relatively high potential for improvement in the performance of the health system with efficiency score way below the regional average include Angola, Equatorial Guinea, South Africa, Sierra Leone, Swaziland, Mauritania and Nigeria. The estimated efficiency scores for these countries suggest that, given the current level of health care resources, it is possible to significantly improve population health status if best practices are followed in the production process.

Table 5.24. Efficiency of Health systems - SFA, 2011

DMU	Rank	Efficiency score (U5SR)	Rank	Efficiency score (ISR)
Angola	44	0.301	44	0.345
Benin	26	0.706	27	0.737
Botswana	18	0.790	18	0.808
Burkina Faso	41	0.456	36	0.563
Burundi	23	0.737	22	0.778
Cameroon	25	0.717	25	0.751
Cape Verde	2	0.893	2	0.907
Central African Republic	36	0.574	37	0.556
Chad	34	0.611	33	0.683
Comoros	13	0.812	19	0.802
Congo, Dem. Rep.	27	0.699	31	0.694
Congo, Rep.	32	0.646	34	0.665
Cote d'Ivoire	19	0.788	23	0.775
Equatorial Guinea	45	0.087	45	0.111
Eritrea	9	0.837	9	0.862
Ethiopia	14	0.812	11	0.840
Gabon	39	0.525	42	0.494
Gambia, The	29	0.675	24	0.767
Ghana	12	0.821	10	0.847
Guinea	21	0.762	20	0.799
Guinea-Bissau	30	0.669	29	0.709
Kenya	4	0.881	3	0.905
Lesotho	37	0.551	40	0.538
Liberia	6	0.867	7	0.877
Madagascar	3	0.883	4	0.903
Malawi	22	0.750	21	0.798
Mali	42	0.453	39	0.546
Mauritania	38	0.548	38	0.551
Mauritius	1	0.906	1	0.924
Mozambique	28	0.698	30	0.698
Namibia	16	0.802	15	0.832
Niger	33	0.619	26	0.751
Nigeria	31	0.662	32	0.693
Rwanda	8	0.848	8	0.876
Sao Tome and Principe	17	0.796	16	0.829
Senegal	10	0.824	13	0.837
Seychelles	11	0.824	12	0.839
Sierra Leone	35	0.593	35	0.606
South Africa	40	0.515	41	0.527
Sudan	15	0.803	14	0.835
Swaziland	43	0.315	43	0.349
Tanzania	5	0.873	5	0.899
Togo	24	0.719	28	0.736
Uganda	7	0.853	6	0.884
Zambia	20	0.782	17	0.825
Mean		**0.695**		**0.723**

Source: Author's computation**. Note:** U5SR - Under-five survival rate; ISR - Infant survival rate

A panel model specification of the stochastic frontier analysis is presented in Table 5.25. The table reports results from the 'true' random effect (TRE) specification. The preference of the TRE lies in its ability to capture unobserved heterogeneity, which may otherwise be captured by the inefficiency term. Mean efficiency scores are reported between the period 2005 and 2011. The analysis also used two different measures of health system outcomes namely, under-five and infant survival rates. This was to allow for some robustness in the results.

Average efficiency for the period was estimated to be 0.78 and 0.82 for the two models. This suggest that on average there exist the potential for SSA countries to improve the performance of health systems between 22% and 18%. The results also show that over the period under study, average efficiency scores were higher for countries such as Cape Verde, Mauritius, Madagascar, Seychelles. Eritrea, Ethiopia and Ghana also performed relatively better in terms of health system efficiency. That is compared to best practice, these countries showed lower inefficiency in the use of health care resources in the production of health outcomes. For instance Cape Verde recorded efficiency score of 0.999 which suggests that, compared to best practice, the health system in Cape Verde can be improved by about 0.001. Similar observations can be made for the other countries that showed relatively improved health system efficiency.

On the other extreme, countries that recorded significantly low health system efficiency performance include Equatorial Guinea, Angola, Gabon, Mali, Sierra Leone and South Africa. This suggests that, compared to best practice, such countries have high potential for improvement in the performance of the health system. For instance Equatorial Guinea recorded an estimated efficiency score of about 0.17 and 0.23. This lies significantly below the estimated regional average and implies about 83% and 77% potential for improvement if resources are used efficiently.

Table 5.25. Efficiency of Health systems in SSA - Panel SFA (2005- 2011)

DMU	Rank	Efficiency score (USR)	Rank	Efficiency score (ISR)
Angola	44	0.305	44	0.337
Benin	26	0.775	28	0.798
Botswana	20	0.870	15	0.977
Burkina Faso	37	0.568	31	0.721
Burundi	22	0.833	19	0.952
Cameroon	33	0.647	34	0.647
Cape Verde	1	0.999	3	0.999
Central African Republic	34	0.641	30	0.735
Chad	39	0.508	39	0.605
Comoros	8	0.996	14	0.993
Congo, Dem. Rep.	31	0.685	25	0.888
Congo, Rep.	30	0.702	33	0.658
Cote d'Ivoire	29	0.724	35	0.638
Equatorial Guinea	45	0.167	45	0.230
Eritrea	5	0.998	4	0.999
Ethiopia	11	0.994	7	0.998
Gabon	38	0.514	41	0.485
Gambia, The	25	0.805	21	0.938
Ghana	7	0.996	10	0.996
Guinea	27	0.764	27	0.816
Guinea-Bissau	36	0.577	36	0.634
Kenya	10	0.994	11	0.995
Lesotho	24	0.824	29	0.767
Liberia	6	0.998	6	0.998
Madagascar	4	0.998	5	0.999
Malawi	14	0.962	12	0.994
Mali	41	0.482	38	0.612
Mauritania	32	0.652	37	0.621
Mauritius	2	0.999	1	0.999
Mozambique	23	0.831	26	0.855
Namibia	21	0.833	24	0.895
Niger	28	0.745	13	0.993
Nigeria	35	0.585	40	0.600
Rwanda	12	0.993	8	0.997
Sao Tome and Principe	13	0.976	17	0.970
Senegal	17	0.954	16	0.976
Seychelles	3	0.999	2	0.999
Sierra Leone	42	0.448	42	0.481
South Africa	40	0.502	32	0.671
Sudan	16	0.958	22	0.937
Swaziland	43	0.383	43	0.444
Tanzania	9	0.995	9	0.997
Togo	18	0.927	20	0.941
Uganda	15	0.960	18	0.966
Zambia	19	0.880	23	0.922
Mean		**0.777**		**0.815**

Source: Author's computation**. Note:** U5SR - Under-five survival rate; ISR - Infant survival rate

5.3.2.1 Distribution of efficiency and inefficiency scores from different models

Figures 5.1 to 5.4 compare the estimated efficiency from the two different models using SFA. The figures compare the distribution of the efficiency and inefficiency estimates using the Kernel density estimates (KDE). Figure 5.1 shows the distribution of KDE for health system efficiency using panel data while Figure 5.2 presents estimates from cross section data. Both Figure 5.1 and 5.2 show strong correlation between the distributions of the efficiency estimates from the two models. This implies that the estimated efficiency scores are not completely different from each other. The Figures show very similar movement in the kernel density estimates for the two models, confirming the comparability of estimates from the two models.

Figure 5.3 and 5.4 shows the distribution of kernel density estimates of health system inefficiency from the panel and cross section models, respectively. The two figures compares the mean and variance of the inefficiency estimates from the two model specifications used in the analysis. The kernel density estimates show that both models have acceptable means and considerably small variation in the estimates of health system inefficiency. Similar relationship was established for the inefficiency estimates from the cross section data.

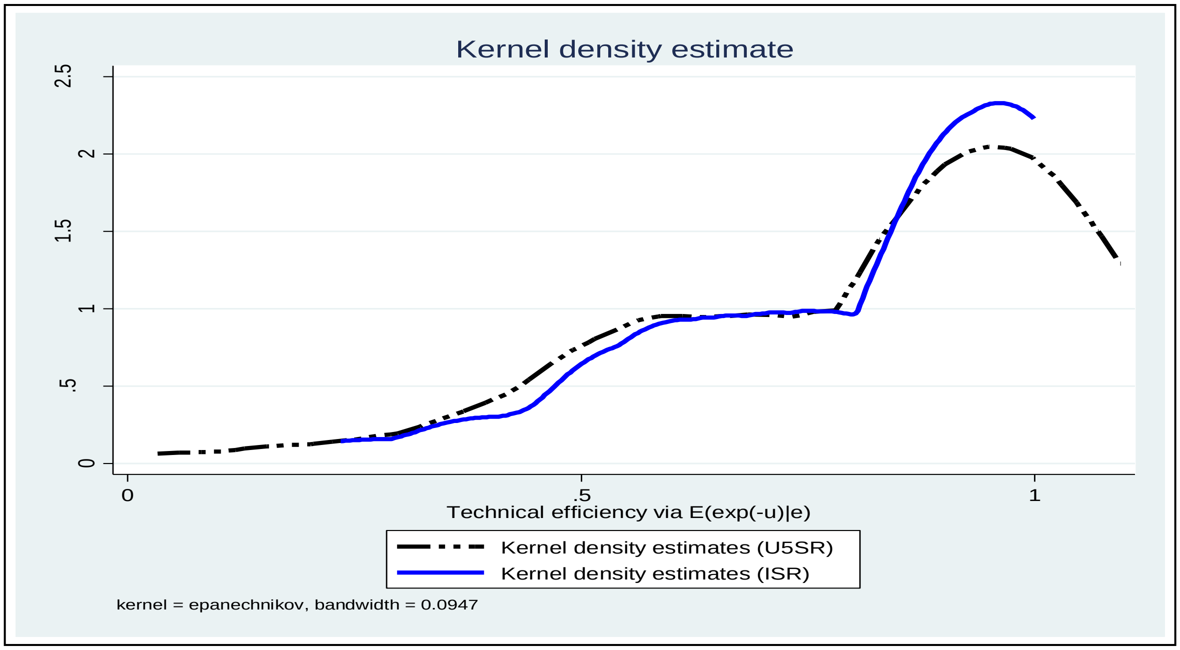

Figure 5.1. Kernel Density Estimates for efficiency scores (Panel data model)

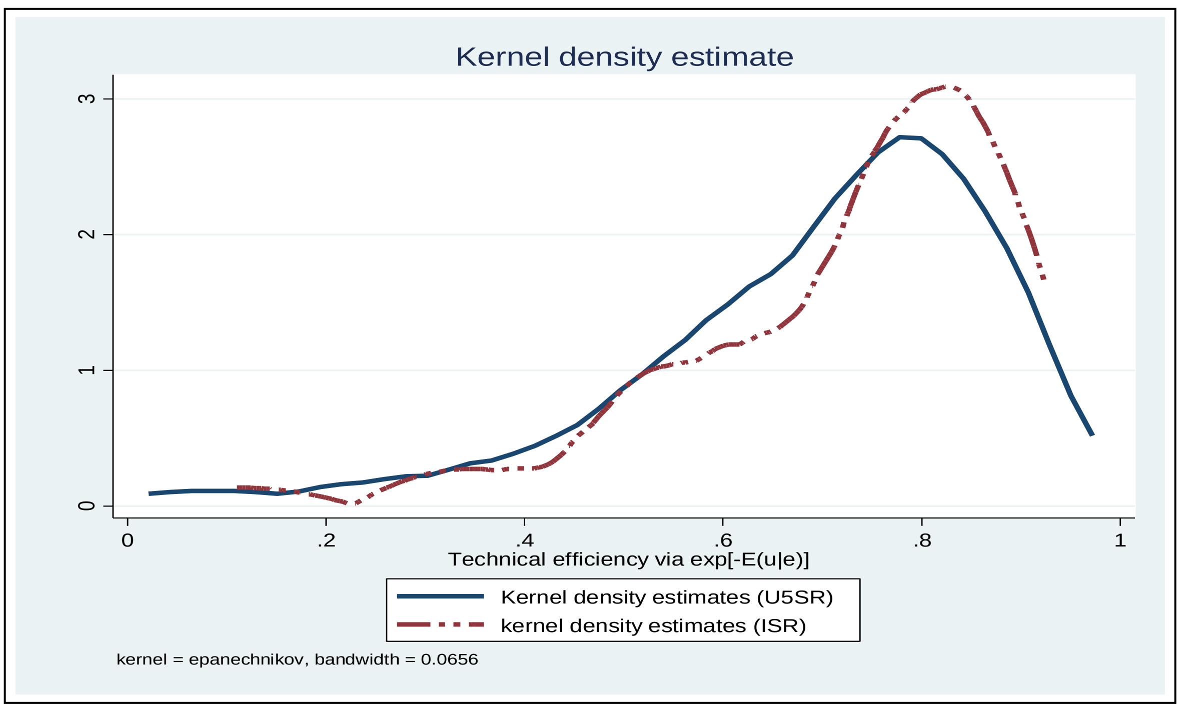

Figure 5.2. Kernel Density Estimates for efficiency scores (Cross section data model)
Source: Author's computation
Notes: U5SR = Under five survival rate. ISR = Infant survival rate

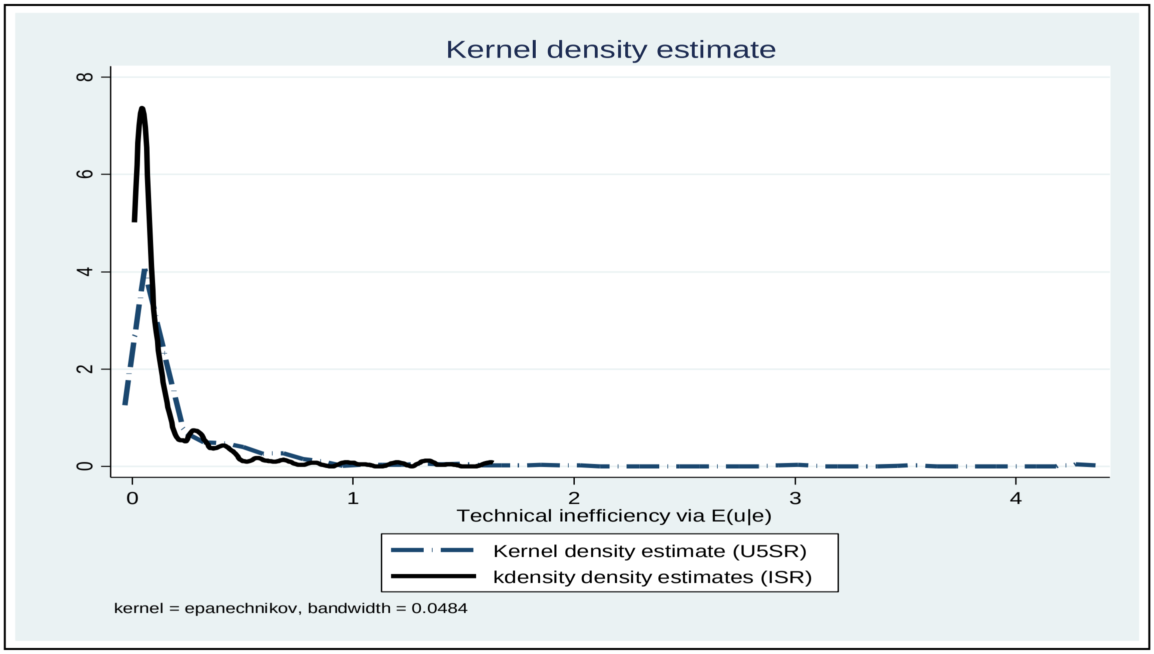

Figure 5.3. Kernel Density Estimates for inefficiency scores (Panel data model)

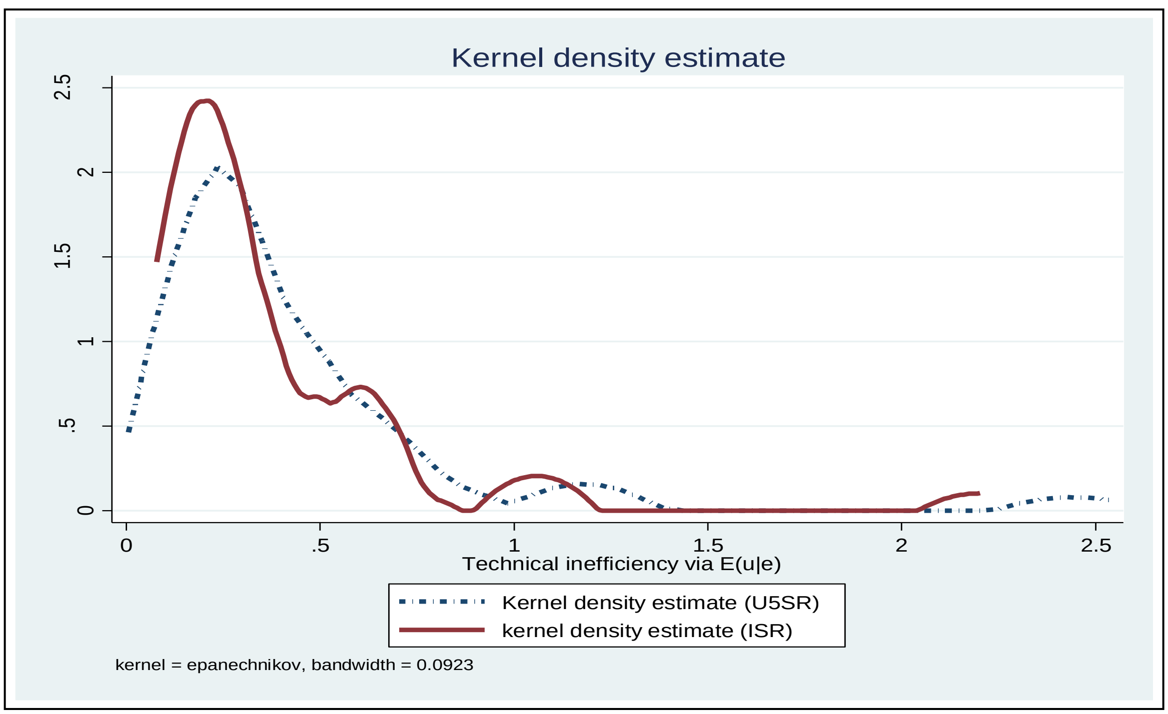

Figure 5.4. Kernel Density Estimates for inefficiency scores (Cross section data model)
Source: Author's computation
Notes: U5SR = Under five survival rate. ISR = Infant survival rate

5.3.3 Evolution of Efficiency Using Malmquist Productivity Index

Table 5.26 provides a summary of the changes in efficiency, technology and productivity for the period 2005-2011. The table shows the number of countries that experienced growth, decline or stagnation in any of the above mentioned components. In general, growth suggests that such countries recorded improvements in the performance of the health system in the respective fields over the period under consideration. On the other hand a decline suggests poor performance in these fields while stagnation, as the name suggests, shows no change at all over the period.

The summary shows that between 2005 and 2011, 11 out of the 45 countries experienced growth in the efficiency of the health system. This implies that about 32 countries recorded a decline in health system efficiency with 2 countries recording stagnation in efficiency performance.

In terms of the evolution of productivity of health systems in SSA, the summary from the Malmquist index suggests that, in general, there were declines across many countries in the region. Results from the index of productivity suggest that 26 countries declined over the period under consideration. A total of 17 countries recorded growth in factor productivity while 2 countries recorded stagnation over the period.

Technical change shows the evolution of "best practices" over the period under consideration. Improvements show countries moving towards best practices while declines suggests moving away from best practices. The summary shows generally that majority of the countries experienced growth in technical change.

Table 5.26. Summary results for changes in Productivity and Efficiency (2005-2011)

	M(ISR,CSR;2inputs)		
	Efficiency Change	**Technical Change**	**Total Factor Productivity**
Growth	11	33	17
Decline	32	12	26
Stagnation	2	0	2

Source: Author's computation
Note: M(ISR, CRS; 2inputs): Two outputs, Infant and Crude survival rates; Two inputs, HCEpc and average years of schooling

The individual country analysis of the evolution of health system performance is reported in Table 5.27. Accordingly, values above unity indicate improvement in productivity, efficiency, technical change between period t_1 and t_2. On the other hand, values below unity indicate decline while values equal to unity suggests stagnation or no changes. It is observed from the table that, on average, there was decline in all the indices except for the case of technical change. Mean total factor productivity from 2005 to 2011 was estimated to be 0.994. This implies that health systems in SSA countries on average experienced productivity decline of approximately 0.60%. This decline is evident from the corresponding decline in average efficiency. Average efficiency over the period was estimated to be 0.985 which suggests a decline of about 1.50%. There was however progress recorded in the technical change over the period under consideration. The average technical change of 1.009 suggests a marginal improvement of about 0.90% between 2005 and 2011. These statistics suggest that the decline in the productivity of the health system in SSA is driven by decline in efficiency in the use of resources than best practice.

Consequently, the results suggest that majority of the countries recorded decline in total factor productivity over the period 2005 to 2011. As shown in the summary above, seventeen (17) countries recorded improvements in productivity. This suggests that, in 2011, these countries were producing above 100% as much output per unit of input as they were producing in 2005. This shows that productivity grew in these countries from 2005 to 2011. For instance, a productivity index of about 1.04 was estimated for Cape Verde which shows that on average by 2011, the country was producing 104% as much output per unit of input as it was producing in 2005. This shows that productivity grew by about 4.0% from 2005 to 2011. It can be observed from the results that some countries showed consistent growth in all the indexes computed. These include Cape Verde, Madagascar, Rwanda and Zambia. Eritrea recorded stagnation in efficiency change while growth was recorded in the other indexes. Further observation also reveals that most of the countries that experienced improvement in the productivity of their health systems also recorded improvement in technology change. The countries that recorded decline in productivity also recorded corresponding decline in efficiency change. This suggests that the improvement in productivity can largely be attributable to improvement in technical change (best practice) rather than efficiency change (catching up).

Table 5.27. Malmquist Index, Multi input/output - Output orientation

DMU	**Efficiency Change**	**Technical Change**	**Total Factor Productivity**
Angola	0.987	0.968	0.955
Benin	0.974	1.029	1.002
Botswana	1.061	0.989	1.050
Burkina Faso	0.961	1.027	0.986
Burundi	0.974	1.027	1.001
Cameroon	0.978	1.001	0.979
Cape Verde	1.003	1.032	1.035
Central African Rep.	0.964	1.021	0.984
Chad	0.976	1.027	1.002
Comoros	0.973	1.021	0.993
Congo, Dem. Rep.	0.949	1.019	0.967
Congo, Rep.	0.959	1.024	0.982
Cote d'Ivoire	0.951	1.014	0.964
Equatorial Guinea	1.015	0.990	1.005
Eritrea	1.000	1.017	1.017
Ethiopia	0.974	1.019	0.993
Gabon	1.015	0.953	0.968
Gambia, The	0.953	1.028	0.980
Ghana	0.975	1.025	0.999
Guinea	0.968	1.031	0.998
Guinea-Bissau	0.965	1.018	0.982
Kenya	0.973	1.028	1.000
Lesotho	0.974	0.979	0.954
Liberia	0.936	1.028	0.963
Madagascar	1.002	1.011	1.013
Malawi	0.994	1.030	1.024
Mali	0.960	1.025	0.985
Mauritania	0.942	1.023	0.964
Mauritius	0.999	0.954	0.953
Mozambique	0.985	1.029	1.013
Namibia	1.093	0.970	1.060
Niger	0.991	1.020	1.011
Nigeria	1.018	0.992	1.011
Rwanda	1.018	1.015	1.033
Sao Tome	0.974	1.020	0.994
Senegal	0.976	1.027	1.003
Seychelles	1.000	0.971	0.971
Sierra Leone	0.982	0.980	0.963
South Africa	1.080	0.990	1.069
Sudan	0.927	1.017	0.943
Swaziland	1.033	0.967	1.000
Tanzania	0.950	1.029	0.978
Togo	0.948	1.028	0.975
Uganda	0.982	1.009	0.991
Zambia	1.028	1.009	1.038
Mean	**0.985**	**1.009**	**0.994**

Source: Author's computation

5.3.4 Comparative Analysis of Health System Performance

This sub-section seeks to understand the efficiency performance of health systems in terms of their health indicators and health care spending. This is because the DEA output efficiency measures distinguish countries performing better based on health outcomes given the level of health sector resources. Countries that were estimated to be consistently efficient irrespective of the model specification were included in Table 5.28 for the analysis of best performing health systems. Considering that these countries' health systems have formed the benchmark for the assessment of others, it is prudent to investigate how their health outcomes and resources compare to the regional average to understand the nature of efficiency.

The table shows that health system efficiency can be explained from two perspectives: one is the group of countries that have higher than average per capita health care expenditure but significantly lower than average health indicators. The second comprise a set of countries that have lower than average health care expenditure with corresponding better health outcomes. For instance, while health care expenditure per capita in Mauritius and Seychelles are higher than the regional average, this corresponds to significantly improved health outcome indicators, compared to the regional averages. On the other hand, Eritrea, Ethiopia and Madagascar are examples of countries with low health care expenditure per capita, but health outcomes are relatively better than might be expected despite the scarcity of health resources. This explains the nature of health system efficiency in these countries.

Table 5.28. Health indicators and expenditure for the best performers

Country name	HCEpc	U5MR	IMR	LE	CDR
Cape Verde	171.69	21.30	18.20	73.92	5.37
Eritrea	16.99	67.80	46.30	61.42	7.52
Ethiopia	51.96	77.00	51.50	59.24	9.39
Madagascar	39.55	61.60	42.80	66.70	6.41
Mauritius	841.95	15.10	12.80	73.27	7.00
Seychelles	989.37	13.80	11.90	73.46	7.40
Regional mean	**225.39**	**97.35**	**63.17**	**56.38**	**11.57**

Source: Author's computation
Note: HCEpc= health care expenditure per capita (constant 2005 international dollar) U5MR= under-five mortality rate; IMR= infant mortality rate LE= life expectancy at birth; CDR= crude death rate

Table 5.29 presents comparative analysis for the worst performing countries in terms of health system efficiency. The pattern of health outcomes and expenditure in these countries provide a clearer understanding of the nature of health system efficiency. The estimated health system efficiency scores for these countries lie way below the regional average. Again two group of countries can be deduced from the table; one group have significantly higher health care expenditure above the regional average but this does not correspond to improved health outcomes. The other group, even though have health expenditure below average, their health outcomes are poorer than might be expected.

Cameroon, Nigeria and Sierra Leone had health care expenditure slightly lower than the regional average but the deviation of the performance of health outcome indicators from the regional average is significantly large. Almost all the health outcome indicators for these countries were considerably poorer relative to the regional average. Swaziland and Equatorial Guinea with the significantly higher health care expenditure, relative to the regional average, performed poorly in all the health outcome indicators.

A clearer observation on the nature of health system efficiency can be made by comparing the best and worst performers. For instance, Cape Verde and Sierra Leone spend similar amounts on health care per capita, however, health outcomes indicators for the two countries are vastly different. With health care expenditure per capita of $172 in Cape Verde, under-five mortality and life expectancy stands at 21.3 under five deaths per 1000 live births and 74 years, respectively. A sharp contrast is observed in Sierra Leone where health care expenditure per capita of about $165 correspond to under-five mortality of 185 per 100 live births and life expectancy at birth of about 48 years. Similarly, health expenditure per capita in Equatorial Guinea is significantly higher than Mauritius and Seychelles, however, health outcome performance is significantly better in Mauritius and Seychelles than in Equatorial Guinea.

Table 5.29. Health indicators and expenditure for the worst performers

Country name	HCEpc	U5MR	IMR	LE	CDR	M(UI;2in)	M(UC;2in)
Angola	214.58	157.60	96.40	51.06	14.03	0.17	0.38
Cameroon	127.92	127.20	79.20	51.58	6.00	0.26	0.40
Equatorial Guinea	1642.71	118.10	79.60	51.14	14.37	0.18	0.37
Nigeria	137.45	124.10	78.00	51.86	14.06	0.25	0.39
Sierra Leone	165.24	185.30	119.20	47.78	15.34	0.15	0.36
Swaziland	433.51	103.60	69.00	48.66	14.25	0.21	0.37
Regional mean	**225.39**	**97.35**	**63.17**	**56.38**	**11.57**	**0.50**	**0.64**

Source: Author's computation
Note: HCEpc= health care expenditure per capita (constant 2005 international $) U5MR= under-five mortality rate; IMR= infant mortality rate LE= life expectancy at birth; CDR= crude death rate
M(UI; 2in) - Two outputs, Under-five and Infant survival rates; Two inputs, HCEpc and years of schooling
M(UC; 2in) - Two outputs, Under-five and Crude survival rates; Two inputs, HCEpc and years of schooling

Table 5.30 presents analysis for comparison across some selected countries from sub-regions in SSA. A comparison of health care expenditure and health outcomes provides some understanding of the nature of health system efficiency in these countries. A striking observation from the table is the case of South Africa. While health care expenditure per capita in South Africa lies significantly above the regional average, life expectancy in the country is below the regional average.

A more interesting picture is depicted when South Africa is compared to the best performing countries (Table 5.28). For instance, Seychelles spends similar amount on health care per capita as South Africa ($989.4 and $942.5, respectively). However, comparing the health outcomes of the two countries suggest vast difference in performance. Life expectancy at birth in Seychelles is 73.5 years compared to 52.6 years in South Africa. Also infant mortality rate in Seychelles is 11.9 per 1000 live births compared to 34.6 in South Africa. A fairly acceptable performance can be observed for Kenya, Ghana, Tanzania where less than average health care expenditure per capita relates to above average performance in health outcomes. It is worth mentioning that about 17.3% of adult population in South Africa are living with HIV/AIDS and this may account for higher financial burden on the health system. Similar situations prevail for countries like Zambia, Lesotho and Botswana.

Table 5.30. Health indicators and expenditure for selected countries

Country name	HCEpc	U5MR	IMR	LE	CDR	M(UI;2in)	M(UC;2in)
Ghana	90.01	77.60	51.80	64.22	7.69	0.50	0.77
Kenya	77.08	72.80	48.30	57.08	10.27	0.59	0.59
Malawi	76.99	82.60	53.90	54.14	12.31	0.53	0.50
South Africa	942.50	46.70	34.60	52.61	14.68	0.35	0.39
Tanzania	107.41	67.60	45.40	58.15	10.10	0.52	0.58
Zambia	99.32	82.90	52.70	48.97	15.30	0.47	0.38
Regional mean	**225.39**	**97.35**	**63.17**	**56.38**	**11.57**	**0.50**	**0.64**

Source: Author's computation
Note: HCEpc= health care expenditure per capita (constant 2005 international $) U5MR= under-five mortality rate; IMR= infant mortality rate LE= life expectancy at birth; CDR= crude death rate
M(UI; 2in): Two outputs, Under-five and Infant survival rates; Two inputs, HCEpc and average years of schooling
M(UC; 2in): Two outputs, Under-five and Crude survival rates; Two inputs, HCEpc and average years of schooling

5.4 Determinants of health system efficiency performance

This sub-section shows results from Tobit model of the determinants of health system efficiency across countries in SSA. The focus of the analysis was to examine how various policy variables influence the level of health system efficiency in the region. The variables included in the analysis were public health spending levels, corruption, public sector management, ratio of public to private participation in the health care system and health financing burden on the population. Efficiency estimates from three different DEA models were converted into inefficiency scores and used as dependent variables for all the regression analysis.

The performance of the models and their suitability are reflected in the likelihood ratio (LR) chi square test for joint significance of the independent variables. The Pseudo R^2 also give an indication of the general fitness of the models. While these statistics are generally low in the various models, they are characteristic of the second-stage Tobit models and are considered to be acceptable in such analysis. The results in Table 5.31 suggest that the independent variables together are significant determinants of the level of inefficiency of health systems in SSA. This can be seen from the highly significant chi-square test statistic at 1% significance level. The key variable of interest in Table 5.30 is the proportion of health expenditure that comes from the public sector as percentage of the total expenditure on health (HCE-pubtot). It should be recalled that, the dependent variable in the analysis was health system inefficiency rather than efficiency. A negative relationship therefore indicates a positive relationship with efficiency of health system.

The results suggest that public health expenditure as percentage of total health spending relates positively to health system efficiency. This implies that increased public health spending is likely to reduce health system inefficiency and improve efficiency performance. This underscores the importance of government commitments in improving the performance of health systems as reflected in such initiatives as the Abuja Declaration. Improving the performance of health systems in developing regions like SSA requires governments to own, scale-up and sustain their financial commitments. The results were in agreement with Evans et al. (2001) who found a significant relationship between efficiency and health expenditure.

Table 5.31. Tobit model for Health care spending and health system efficiency

Variables	M(UI;2IN)	M(UC;2IN)	M(UIC;2IN)
HCE-pubtot	-0.23302**	-0.07315*	-0.07871**
	(0.09108)	(0.03752)	(0.03693)
Immunization	-0.00761	-0.00952	-0.00952
	(0.01435)	(0.00599)	(0.00590)
GDP-pc	0.00013	-0.00002	-0.00001
	(0.00009)	(0.00004)	(0.00004)
Urbanization	-0.33141	0.00934	0.00995
	(0.30062)	(0.12825)	(0.12622)
Population < 14	-0.01851	-0.022	-0.02486
	(0.10290)	(0.04295)	(0.04232)
Population > 65	-0.96283*	-0.29248	-0.2843
	(0.47250)	(0.19753)	(0.19449)
HIV	-0.0036	0.04787***	0.04272***
	(0.03681)	(0.01569)	(0.01542)
HCE-pubtot^2	0.00231**	0.00072*	0.00078*
	(0.00097)	(0.00040)	(0.00040)
Sanitation	0.0025	0.00895*	0.00745
	(0.01254)	(0.00525)	(0.00517)
Constant	12.18032*	4.49376*	4.75313*
	(6.09150)	(2.51881)	(2.48230)
LR χ^2	15.77***	22.97***	21.41***
Pseudo R^2	0.1163	0.2791	0.2681
No. of Obs.	45	45	45

Source: Author's computation

Note: ***significant at 1%; **significant at 5%; *significant at 10%. Standard errors are reported in parenthesis.

M(UI;2IN) - Efficiency scores from two outputs, under-five and infant survival rates; two inputs, HCEpc and average years of schooling

M(UC;2IN) - Efficiency scores from two outputs, under-five and crude survival rates; two inputs, HCEpc and average years of schooling

M(UIC;2IN) - Efficiency scores from three outputs, under-five, infant and crude survival rates; two inputs, HCEpc and average years of schooling

Table 5.32 presents Tobit results on the effect of governance on health system efficiency performance. The CPIA transparency, accountability, and corruption in the public sector rating (1=low to 6=high) was employed as a measure of corruption. The higher the rating the better the level of corruption in a particular country. The performance of the models and their suitability were reflected in the likelihood ratio (LR) chi square (χ^2) test for joint significance of the independent variables. The results in Table 5.31 suggest that the independent variables together are significant determinants of the level of efficiency of health systems in SSA. This can be seen from the highly significant chi-square test statistic at 1% significance level.

The results show a negative relationship between improved corruption and health system inefficiency. The relationship was statistically significant at 1% for one of the models and 5% for the others. This implies that corruption plays a critical role in determining health system efficiency and countries with relatively improved corruption levels are likely to have better health system efficiency performance.

Like the earlier analysis in Table 5.30, the results in Table 5.32 also show HIV/AIDS to be another important determinant of health system efficiency. A positive and significant relationship was established between the variable and health system inefficiency in both analysis. This implies that countries with relatively higher HIV/AIDS burden were more likely to perform poorly in terms of health system efficiency. A similar relationship was established by Alexander et al. (2003) that the proportion of adults living with HIV/AIDS negatively associates with health system performance. This relationship may be explained by the fact that countries with high prevalence of HIV usually have higher pressure on health spending and also reduced health outcomes.

Table 5.32. Tobit model for improved corruption and health system efficiency

Variable	**M(UI;2IN)**	**M(UC;2IN)**	**M(UIC;2IN)**
Corruption	-0.81109***	-0.26867**	-0.30241**
	(0.26131)	(0.11723)	(0.11320)
Immunization	0.00019	-0.00506	-0.00521
	(0.01219)	(0.00549)	(0.00529)
GDPpc	0.00009*	0.00001	0.00001
	(0.00005)	(0.00002)	(0.00002)
Urbanization	-0.42351	-0.04132	-0.03616
	(0.26281)	(0.12017)	(0.11573)
Population <14	-0.04607	-0.02729	-0.03443
	(0.09451)	(0.04233)	(0.04081)
Population >65	-0.70815*	-0.24275	-0.24049
	(0.38910)	(0.17745)	(0.17067)
HIV	0.04434	0.06344***	0.05873***
	(0.03274)	(0.01536)	(0.01476)
Constant	9.16591*	3.61591	4.00063*
	(5.21557)	(2.33066)	(2.24721)
LR χ^2	21.88***	24.25***	24.37***
Pseudo R^2	0.1465	0.2657	0.2741
No. of Obs.	45	45	45

Source: Author's computation
Note:
***significant at 1%; **significant at 5%; *significant at 10%.
Standard errors are reported in parenthesis.
M(UI;2IN): Efficiency scores from two outputs, under-five and infant survival rates; two inputs, HCEpc and average years of schooling
M(UC;2IN): Efficiency scores from two outputs, under-five and crude survival rates; two inputs, HCEpc and average years of schooling
M(UIC;2IN): Efficiency scores from three outputs, under-five, infant and crude survival rates; two inputs, HCEpc and average years of schooling

In Table 5.33, the relationship between health system performance and public sector management was investigated using the Tobit model. Again the CPIA quality of public administration rating (1=low to 6=high) was used as a measure public administration quality. The higher the score the better the quality of public administration. The results suggest that the joint significance of all the independent variables in explaining health system efficiency is confirmed by the statistically significant (at 1% level) of the Wald chi-square statistic for both models.

The results show that improved quality in public administration relates negatively with health system inefficiency. This implies that the higher the quality of public sector administration, the better the performance of the health system in terms of efficiency. This suggests that an important step in the bid to improve health system efficiency will be to do that alongside the quality of public administration.

Again HIV/AIDS showed a highly significant and negative influence on health system efficiency as showed in the previous analysis. Immunization coverage was also found to have strong correlation with health system efficiency. The results show that countries with improved immunization coverage correspond to better health system performance. This results confirms the finding by Alexander et al. (2003) and emphasises the need for such public health programmes to be protected and improved.

Other variable that showed significant association with health system efficiency was the population distribution. The result suggests that increased population distribution above 65 years and below 14 years reduced health system inefficiency. A positive relationship was also estimated between public sector management score and health system inefficiency, even though the relationship was only marginally significant.

Table 5.33. Tobit model for Public management and Health system efficiency

Variable	M(UI;2IN)	M(UC;2IN)	M(UIC;2IN)
Public administration Quality	-2.52359***	-0.82903**	-0.88660**
	(0.89478)	(0.37955)	(0.37297)
Immunization	-0.02575*	-0.01265**	-0.01356**
	(0.01268)	(0.00541)	(0.00530)
GDPpc	0.00072***	0.00026***	0.00026***
	(0.00020)	(0.00009)	(0.00008)
Urbanization	-0.40428	-0.08808	-0.06154
	(0.27797)	(0.12072)	(0.11782)
Population <14	-0.24350**	-0.11260**	-0.11587**
	(0.10148)	(0.04575)	(0.04416)
Population >65	-2.23167***	-0.90765***	-0.85531***
	(0.61460)	(0.26088)	(0.25566)
HIV	0.04767	0.09906***	0.08587***
	(0.04183)	(0.02316)	(0.02129)
Public sector management	2.33220**	0.74094	0.76670*
	(1.03414)	(0.43564)	(0.42896)
Constant	21.45481***	9.09611***	9.15508***
	(5.93994)	(2.60369)	(2.53369)
LR χ^2	24.24***	31.44***	30.05***
Pseudo R^2	0.1989	0.4195	0.4120
No. of Obs.	45	45	45

Source: Author's computation
Note:
***significant at 1%; **significant at 5%; *significant at 10%.
Standard errors are reported in parenthesis.
M(UI;2IN): Efficiency scores from two outputs, under-five and infant survival rates; two inputs, HCEpc and average years of schooling
M(UC;2IN): Efficiency scores from two outputs, under-five and crude survival rates; two inputs, HCEpc and average years of schooling
M(UIC;2IN): Efficiency scores from three outputs, under-five, infant and crude survival rates; two inputs, HCEpc and average years of schooling

The relationship between public and private participation in the health system and out of pocket health spending was investigated and reported in Table 5.34 below. The chi-square statistic from the likelihood ratio test suggests that the independent variables were jointly significant in the models. Following Alexander et al. (2003), a ratio of private to public health spending as percent of GDP was computed to capture the structure of spending. Out of pocket expenditure as percent of private spending was also used to capture the burden of health care on the population.

The results suggest a positive relationship between private/public financing ratio and health system inefficiency. This implies that health systems with limited participation of the private sector were likely to be efficient. while this result contradicts the negative relationship established by Alexander et al. (2003), it underscores the critical role of the public sector in improving the performance of the health sector, especially in developing countries like SSA.

The results also showed that higher OOP health spending relates to poor health system efficiency performance. This relationship is intuitively appealing considering most health systems all over the world are moving towards universal health coverage with little or no OOP spending. An efficient health system should also include ensuring universal access to health care without fear of financial distress. This situation is hardly the case in SSA which suggests that greater health system efficiency in the region will require policies to reduce OOP spending (especially catastrophic health spending) to the minimum. Such policies include operational and effective national health insurance schemes.

Other significant determinants of efficiency include population distribution above 65 years, HIV prevalence and sanitation. The results suggest that higher population above 65 years relates negatively with health system inefficiency. Similarly, higher HIV prevalence increases inefficiency in the health system. Access to sanitation facilities also relates negatively with health system efficiency.

Table 5.34. Health financing structure and health system efficiency

Variables	**M(UI;2IN)**	**M(UC;2IN)**	**M(UIC;2IN)**
Ratio (private/public financing)	1.20538**	0.32780*	0.34322*
	(0.45936)	(0.18397)	(0.18127)
OOP spending (% of private)	0.02275**	0.00995**	0.00992**
	(0.00956)	(0.00400)	(0.00395)
Immunization	-0.00581	-0.00832	-0.00831
	(0.01304)	(0.00547)	(0.00539)
GDPpc	0.00011	-0.00002	-0.00002
	(0.00008)	(0.00003)	(0.00003)
Urbanization	-0.17576	0.06728	0.06573
	(0.27872)	(0.11983)	(0.11795)
Population <14	-0.0553	-0.03779	-0.04045
	(0.09597)	(0.03988)	(0.03938)
Population >65	-1.03282**	-0.33209*	-0.32275*
	(0.44004)	(0.18309)	(0.18057)
HIV	0.05335	0.07298***	0.06796***
	(0.03872)	(0.01709)	(0.01676)
HCE-pubtot^2	0.00051	0.00012	0.00013
	(0.00031)	(0.00013)	(0.00012)
Sanitation	0.0106	0.01194**	0.01047**
	(0.01154)	(0.00485)	(0.00479)
Constant	2.85556	1.63208	1.7275
	(5.36589)	(2.24159)	(2.21151)
LR χ^2	24.37***	30.46***	28.82***
Pseudo R^2	0.1796	0.3700	0.3608
No. of Obs.	45	45	45

Source: Author's computation

Note:

***significant at 1%; **significant at 5%; *significant at 10%.

Standard errors are reported in parenthesis.

M(UI;2IN): Efficiency scores from two outputs, under-five and infant survival rates; two inputs, HCEpc and average years of schooling

M(UC;2IN): Efficiency scores from two outputs, under-five and crude survival rates; two inputs, HCEpc and average years of schooling

M(UIC;2IN): Efficiency scores from three outputs, under-five, infant and crude survival rates; two inputs, HCEpc and average years of schooling

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

The chapter provides a summary of the key findings of the current study. Based on these findings, appropriate conclusions are drawn about the relationship between health care spending and health outcomes, as well as the efficiency with which these health resources are used across SSA countries. Relevant lessons for policy are recommended based on the findings. Various limitations encountered during the study are also presented with grey areas for further research explicitly proposed.

6.1 Summary of major findings

Developing countries all over the world are faced with major health system challenges including poor population health status, inequality in health service utilization and inefficiency in the use of health resources. This is in spite of various commitments made by policy makers in terms of health resources. For instance, various efforts have been made to improve population health through increased health related spending. Such efforts include the MDGs on health and Abuja Declaration of allocating 15% of government budgets on health. In SSA, where public sector resources are lacking, it is important to ensure that resources committed to the health sector are used in the most efficient way.

This situation motivated the current study to investigate the relationship between health care spending and health outcomes, with particular focus on the public-private decomposition of health care spending. The study also compared the efficiency in the use of health resources across countries in the SSA region.

To achieve these objectives, the study used panel data from the World Bank world development indicators. Both random and fixed effect panel data models were used to estimate the relationship between health expenditure and health outcomes in SSA. To compare the efficiency of health systems, both parametric and non-parametric frontier models were used to estimate the efficiency with which resources of the health system are used to generate health for the respective population. The data envelopment analysis was used under the non-parametric technique while the stochastic frontier analysis was used under the parametric technique. In trying to understand the factors that influence health system efficiency, a Tobit model was used to estimate the effects of some relevant policy variables on health system efficiency. Examples of variables employed in this analysis include corruption, public sector management and health system financing structure.

The findings of the study provides policy makers and public sector managers engaged in health service delivery some basis to compare health system performance and provide response to questions such as, which systems are most efficient given available resources, which are performing poorly and how does the performance of one health system compare to the performance of the other?

A number of interesting and important findings were derived from the empirical analysis. These include the following;

First, the results on the relationship between health care expenditure and health outcomes generally suggest that health care expenditure had significant and positive influence on health outcomes in SSA. The relationship was consistent and significant for all the various model specifications employed in the analysis. Health care spending was associated with improved life expectancy at birth, reduced infant, neonatal and under five mortality rates and crude death rates.

A disaggregation of health care expenditure suggests that public health expenditure was significant determinant of health outcomes, relative to private health expenditure. The results conform with some earlier studies on the relationship that concluded that health care spending have significant positive impact on health outcomes (Lawanson, 2012, Anyanwu and Erhijakpor, 2009).

Aside the direct effects of health spending on health outcomes in SSA, the findings also suggest that there may be lagged effects in the relationship. The one and two period lags introduced in the models were mostly significant. This suggests that investments in health may not have immediate impact on health status but the impact may be delayed with some time dimensions. This also implies that investments in the health system should not be one-off but continuous if the general objective of improved population health status is to be achieved.

In comparing efficiency in the use of health resources across health systems in SSA, the study concludes that there exist significant inefficiencies across health systems. The findings of the various model specifications and input measures show estimated health system efficiency scores between approximately 0.45 and 0.65. This implies that there exist estimated inefficiency ranging between approximately 0.55 and 0.35. The results also show significant potential for health systems in SSA to improve population health status without any further increase in health inputs.

In general, the findings reveal some countries to be relatively efficient in the use of health resources. These include Cape Verde, Eritrea, Seychelles, Madagascar and Mauritius. Other countries that were estimated to be relatively inefficient include Equatorial Guinea, Angola, Sierra Leone, Lesotho and Swaziland. In sum, the findings show that there is some potential gain in health outcomes for SSA countries if health system efficiency is improved. Enhancing the efficiency of health resource use should therefore be an important aspect of health system reforms across these countries.

To further understand the factors that explain health system efficiency, a second stage analysis was conducted using the Tobit model and the following conclusions were drawn;

The share of government expenditure on health care in total government spending was estimated to be positive and significant in explaining health system efficiency.

The findings also show that the financing structure of the health system may play an important role in improving the efficiency of the health system. A higher private/public financing ratio was estimated to be associated with poor health system performance. While this contradicts the findings of Alexander et al (2003), it underscores the importance of governments taking charge of health care delivery, especially in impoverished region like SSA. A disproportionate financing structure in favour of the private sector will only increase financial burden on the poor and lead to inequality in health care utilization.

In addition, the findings also confirm that increased out-of-pocket spending was negatively associated with health system efficiency. This supports the general call for health systems to move towards universal health coverage by reducing catastrophic health spending among the populace, especially the poor. This finding also confirm the claim by Alexander et al (2003) that while OOP expenditure or user fees for health services may generate revenue for the health system, it may impoverish poor households by depleting resources for other essential needs like food and education.

Furthermore, the findings showed that improved corruption (measured by index for transparency, accountability and corruption in the public sector) was positively associated with health system efficiency. This implies that the fight against corruption in most countries in the SSA region will also go a long way to improve the performance of the health system. High levels of corruption in the region mean that large portions of resources are not properly accounted for or used for purposes different from the original intention. This may lead to significant levels of inefficiency which may limit the performance of the health system.

The findings also indicate that improved public sector administration may be important determinant of health sector efficiency performance. The public sector administration variable had positive and significant association with health system efficiency. While this relationship may be direct, it may be justified indirectly through improved resource mobilization and general ineffectiveness in the use of scarce resources.

Finally, other factors that were identified to be significant in determining health system efficiency include improved immunization coverage, improved sanitation facilities and

HIV/AIDS prevalence. Improving these areas of the health system will likely have positive impact on health system efficiency.

6.2 Conclusions

The study explored health spending and outcomes in sub-Sahara Africa, considering that the region faces high health challenges despite the numerous efforts to increase investments into the health systems. The objectives of the study were to, first, estimate the relationship between health expenditure and health outcomes. The study then compared the efficiency in the use of health resources across countries in the region. The determinants of health system efficiency were also identified after controlling for potentially confounding variables. In line with these objectives, analyses were conducted at two stages. First, fixed and random effects panel data models were employed in the estimation of the relationship between health expenditure and health outcomes. In the second set of analysis, the DEA and SFA methods were used to estimate and compare the efficiency of health systems. Health expenditure[28], physician and nurses population and hospital beds were used as health inputs while infant and under five mortality rates, life expectancy and crude death rate were used as health system outputs[29]. Data for the analysis were sourced from the World Bank World Development Indicators.

The results on the relationship between health expenditure and health outcomes generally confirm the existence of a positive and significant relationship. The relationship also showed significant lag effects and public/private differences. In the case of health system efficiency, the results show significant variation across countries. Evidence from both the DEA and SFA models show significant potential for improvement in population health status given the current level of health resources invested into the health system. In a second stage analysis, the factors the explain the differences in the level of efficiency across countries were indentified, It can be concluded that, the commitment of governments to the health sector has significant positive impact on health system efficiency. Other public sector

[28] Various components of health expenditure (public/private, per capita health expenditure) were used depending on the nature of analysis

[29] It should be recalled that all mortality variables were transformed into survival variables for the efficiency analysis

challenges such as corruption and poor public sector administration undermine efficiency of the health system. In terms of health system financing, it can be concluded from the findings that higher OOP spending and private/public financing ratio increased health system inefficiency.

6.3 Recommendations

Following the various findings from the study and relationships established for health systems in SSA, it is prudent to provide recommendations for policy makers with the sole objective of improving population health status and the performance of health systems as a whole. The following policy implications will suffice:

A critical policy issue that comes out quite clearly from the study is the need to increase resources committed to the health sector. While some targets, such as the Abuja Declaration, have been set to fulfil this recommendation, a close assessment[30] suggests that there is still the need for strong commitments. The slow pace of progress across SSA countries in achieving the MDGs on health provides enough justification for this policy recommendation. Most countries in the region are faced with major health system challenges including poor access to health care, significant inequalities in health service utilization, lack of health care infrastructure and workforce. A sure way to ameliorate this situation is for governments to increase health sector resources.

Owing to the findings, the study also recommends the need for the public sector to partner with the private sector in providing health care services. The results however showed that the involvement of the public sector was more important. It is therefore important to ensure that the activities of the private sector is regulated. In regions like SSA where majority of the population are impoverished, a dominant private sector may lead to inequalities in favour of the rich.

The findings on health system efficiency reinforce the need for policy makers not to only improve upon resources to the health sector but to ensure that these resources are used in an

[30] This assessment is clearly made in the background section of the study

efficient way. The following recommendations will be vital in improving the efficiency performance of health systems in SSA.

First, extra efforts should be made to reduce corruption in the public sector. These efforts include adequate motivational packages for public sector workers and strengthening monitoring and evaluation systems to improve on the efficiency in the use of resources in the entire public sector including the health sector.

Secondly, in order to improve the performance of health systems, the study recommends that a careful attention should be paid to the financing structure of the health system. Particularly, there is need for direct out-of-pocket health payments to be discouraged while policy efforts should be directed towards undertaking radical shifts to universal health coverage where everyone has equal access to health care without fear of financial distress.

The study further recommends general public sector improvements by strengthening management systems and institutions whose operations, directly or indirectly, influence outcomes of the public sector.

Efforts to scale-up and sustain health preventive and treatment strategies such as immunization, improved sanitation and HIV prevention could also help improve the effective use of health resources. There is need to protect such public health programmes which may be at risk when health systems are faced with the problem of inefficiency in resource use.

6.4 Limitations and areas for future research

The study has been successful in providing much needed insight into the relationship between health spending and health outcomes as well as the efficiency in the use of these resources. However, the study was faced with some limitations that otherwise would have further enriched the study. The limitations of the study include the following.

Availability of data limited the extent to which analysis could be performed in the study. While the available data was used to achieve the objectives of explaining health spending in SSA, a more holistic analysis required that health spending be disaggregated into specific components such as spending on treatment, prevention, health system capital inputs and health workforce. Access to such data was however difficult. Also, the short time dimension of the health expenditure variables used in the study posed some limitations to the analysis.

Owing to the above limitation on the length of time series, the econometric analysis employed in the study were also limited largely due to loss of degrees of freedom. For instance the number of lags included in the models to capture the delayed effects of health spending on health outcomes was limited.

Finally, the health outcome variables used in the analysis were limited to mortality indicators of population health status. A more encompassing analysis required variables that consider both mortality and morbidity (longevity) indicators. Examples of such variables include disability adjusted life years (DALYs) and health-adjusted life expectancy (HALE). Information on these variables were hardly available for SSA countries.

Addressing these limitations will be important improvement upon the current study. It is expected that future research will extend the variables used in the study to more holistic health outcome measures. Future studies could also extend the sample of the study to include a more global sample while estimating precise efficiency gains. Another dimension for future research will be to analyse efficiency of various sub-sectors of the entire health system across selected countries.

REFERENCES

Abor, P. A., Abekah-Nkrumah, G. and Abor, J. 2009. An examination of hospital governance in Ghana. *Leadership in Health Services,* 21**,** 47-60.

Ademiluyi, A. I. and Aluko-Arowolo, O. S. 2009. Institutional distribution of health care services in Nigeria: an overview. *Journal of Geography and Regional Planning,* 2**,** 104-110.

Afonso, A. and Aubyn, M. S. 2005. Non-parametric approaches to education and health efficiency in OECD countries. *Journal of Applied Economics,* 8**,** 227-246.

Afriat, S. N. 1972. Efficiency Estimation of Production Functions. *International Economic Review,* 13**,** 568-598.

Akinkugbe, O. and Jerome, A. 2006. Public health care spending as a determinant of health status: a panel data analysis for SSA and MENA. *In:* Adenikinju, A. and Olaniyan, O. (eds.) *Applied macroeconomics and economic development.* Ibadan: Ibadan University Press.

___________ and Mohanoe, M. 2009. Public health expenditure as a determinant of health status in Lesotho. *Journal of Social Work in Public health,* 24**,** 131-147.

Alexander, C. A., Busch, G. and Stringer, K. 2003. Implementing and interpreting a data envelopment analysis model to assess the efficiency of health systems in developing countries. *IMA Journal of Management Mathematics,* 14**,** 49-63.

Anyanwu, J. C. and Erhijakpor, A. E. O. 2007. Health expenditures and health outcomes in Africa. *Economic research working paper No. 91*.

____________ and __________________ 2009. Health expenditures and health outcomes in Africa. *African Development Review,* 21**,** 400-433.

Babazono, A. and Hillman, A. L. 1994. A comparison of international health outcomes and health care spending. *International Journal of Technology Assessment in Health Care,* 10**,** 376-381.

Baily, M. N., Garber, A. M., Berndt, E. R. and Cutler, D. M. 1997. Health Care Productivity. *Brookings Papers on Economic Activity. Microeconomics,* 1997**,** 143-215.

Baltagi, B. H. 2008. *Econometric analysis of panel data,* West Sussex, John Wiley &Sons.

___________ and Mascone, F. 2010. Health care expenditure and income in the OECD reconsidered: evidence from panel data. *Economic Modelling,* 27**,** 804-811.

Banker, R. D., Charnes, A. and Cooper, W. W. 1984. SOme models for estimating technical and scale efficienccies in data envelopment analysis. *Management Science,* 30**,** 1078-1092.

___________ and Morey, R. C. 1986. Efficiency analysis for exogenously fixed inputs and outputs. *Operations research,* 34**,** 513-521.

Battese, G. and Coelli, T. 1992. Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. *Journal of Productivity Analysis,* 3**,** 153-169.

_________ and _____ 1988. Prediction of firm-level technical efficiencies with a generalised frontier production function and panel data *Journal of Econometrics,* 38**,** 387-399.

Becker, G. 1964. *Human capital,* Chicago, The University of Chicago Press.

________ 1967. Human capital and the personal distribution of income: An analytical approach. *W.S. Woytinsky Lecture no.1. Ann Arbor: Univ. Michigan.*

Ben-Porath 1967. The production of human capital and the life cycle of earnings. *Journal of Political Economy,* 75**,** 353-367.

Berger, M. C. and Messer, J. 2002. Public financing of health expenditures, insurance and health outcomes. *Journal of Applied Economics,* 34**,** 2105-2113.

Bhat, V. N. 2005. Institutional Arrangements and Efficiency of Health Care Delivery Systems. *The European Journal of Health Economics,* 6**,** 215-221.

Bjurek, H. 1992. Efficiency, productivity and determinants of inefficiency at public day care centres in Sweden. *Scandinavian Journal of Economics,* 94 (Supplement)**,** S173-S187.

________ 1996. The Malmquist Total Factor Productivity Index. *The Scandinavian Journal of Economics,* 98**,** 303-313.

Bloom, E. D., Canning, D. and Sevilla, J. 2004. The effect of health on economic growth: a production function approach. *World Development,* 32**,** 1-13.

Bokhari, F. A. S., Gai, Y. and Gottret, P. 2007. Government health expenditures and health outcomes. *Health Economics,* 16**,** 257-273.

Bryan, L., Conway, M., Keesmaat, T., McKenna, S. and Richardson, B. 2010. Strengthening sub-Saharan Africa's health systems: A practical approach. New York: McKinsey and Company.

Bukenya, J. 2009. Do fluctuations in health expenditure affect economic growth? *The Open Economic Journal,* 2**,** 31-38.

Burgess, J. F. 2006. Productivity analysis in health care. *The Eglar Companion to Health Economics.* Chaltenham: Elgar.

Caldwell, J. C. and Caldwell, P. 1985. Education and literacy as factors in health. *In:* Halstead, S. B., Walsh, J. A. and Warren, K. S. (eds.) *Goof health at low cost.* Ney York: The Rochefeller Foundation.

Caves, D., Christensen, L. R. and Diewert, W. E. 1982. The economic theory of index numbers and the measurement of input, output and productivity. *Econometrica,* 50**,** 1393-1414.

Chirikos, T. and Sear, A. 2000. Measuring hospital efficiency: acomparison of two approaches. *Health Services Research,* 34**,** 1389-1408.

Chirwa, L. M. 2010. Knowledge synthesis on Malawi health system: literature review. Blantyre: College of Medcine, University of Malawi.

Coelli, T. and Perelman, S. 1999. A comparason of parametric and non-parametric distance functions: with application to European railways. *European Journal of Operational Research,* 117**,** 326-339.

_______ , Rao, D. and Battese, G. 1998. *An introduction to efficiency and productivity analysis,* Boston, Kluwer Academic Publishers.

Cooper, W. W., Seiford, L. M. and Tone, K. 2000. *Data envelopment analysis: A comprehensive text with models, applications, references and DEA-solver software,* Boston, Kluwer Academic Publishers.

Cremieux, P.-Y., Mieilleur, M.-C., Ouellette, P., Petit, P., Zelder, P. and Potvin, K. 2005. Public and private pharmaceutical spending as determinants of health outcomes in Canada. *Journal of Health Economics,* 14**,** 107-116.

____________ , Ouellette, P. and Pilon, C. 1999. Health care spending as determinants of health outcomes. *Journal of Health Economics,* 8**,** 627-639.

Danqua, M., Barimah, A. and Williams., O. 2013. Efficiency measurment using a "true" random effects and random parameter stochastic frontier models: an application to rural and community banks in Ghana. *Modern Economy,* 4**,** 864-870.

Daraio, C. and Simar, L. 2007. *Advanced robust and nonparametric methods in efficiency analysis: methodology and applications,* Springer.

Dardanoni, V. and Wagstaff, A. 1990. Uncertainty and the demand for medical care. *Journal of Health Economics,* 9**,** 23-38.

Evans, B. D., Tandon, A., Murray, L. J. C. and Lauer, A. J. 2001. Comparative efficiency of national health systems: cross national econometric analysis. *British Medical Journal,* 323**,** 307-310.

Farag, M., NandaKumar, A. K., Wallack, S., Hodgkin, D., Gaumer, G. and Erbil, C. 2012. The income elasticity of health care spending in developing and developed countries. *International Journal of Health Care Finance and Economics,* 12, 145-162.

________ , ______________, ___________, ____________, __________ and________ 2013. Health expenditures, health outcomes and the role of good governance. *International Journal of Health Care Finance and Economics,* 13, 33-52.

Färe, R. and Grosskopf, S. 1992. Malmquist Productivity Indexes and Fisher Ideal Indexes. *The Economic Journal,* 102, 158-160.

______, _____________, Norris, M. and Zhang, Z. 1994. Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries. *The American Economic Review,* 84, 66-83.

Farrell, M. 1957. The measurement of productive efficiency. *Journal of the Royal Statistical Society. Series A (Statistics in Society),* 120, 253-290.

________ and Fieldhouse, M. 1962. Estimating production under increasing returns to scale. *Journal of the Royal Statistical Society. Series A (Statistics in Society),* 125, 252-267.

Fayissa, B. and Gutema, P. 2008. A health production function for sub-Saharan Africa. *Department of Economics and Finance Working Paper Series, August. Middle Tennessee State University*.

Filmer, D. and Pritchett, L. 1999. The impact of public spending on health: Does money matter? *Social Science and Medicine,* 49, 1309-1323.

FMOH 2010. National strategic health development plan for Nigeria, 2010-2015. Abuja: Federal Ministry of Health (FMOH).

Fuchs, V. R. 1966. The contribution of health services to the American economy. *Milbank Memorial Fund Q.,* 44, 65-102.

Garber, A. M. and Skinner, J. 2008. Is American health care uniquely inefficient? *Journal of Economic Perspectives,* 22, 27-50.

Ghana Health Service 2010. Annual report. Accra: Ghana Health Service.

Government of Malawi 2011. Malawi health sector strategic plan 2011-2016: Moving towards equity and quality. Lilongwe: Ministry of Health, Government of Malawi.

Greene, W. 2004. Distinguishing between heterogeneity and inefficiency: stochastic frontier analysis of World Health Organization's panel data on national health care systems *Health Economics,* 13, 959-980.

Grigoli, F. and Kapsoli, J. 2013. Waste not, want not: efficiency of health expenditure in emerging and developing economies *IMF Working Paper WP/13/187*.

________ and Levy, E. 2012. Quality of government and living standards: adjusting for the efficiency of public spending. *IMF Working Paper No.12/182*.

Grosskopf, S. and Valdmanis, V. 1987. Measuring hospital performance. *Journal of Health Economics,* 6**,** 89-107.

Grossman, M. 1972. On the concept of health capital and the demand for health. *The Journal of Political Economy,* 80**,** 223-255.

Gupta, S. and Verhoeven, M. 2001. The efficiency of government expenditure: experiences from Africa. *Journal of Policy Modelling,* 23**,** 433-467.

________, ________________ and Tiongson, E. R. 2002. The effectivenes of government spending on education and health care in developing and transition economies. *European Journal of Political Economy,* 18**,** 717-737.

Hernandez de Cos, P. and Moral-Benito, E. 2011. Health ecpenditure in the OECD countries: efficiency and regulation. *Bank of Spain Occasional Documents No. 1107*.

Herrera, S. and Pang, G. 2005. Efficiency of public spending in developing countries: an efficiency frontier approach. *World Bank Policy Research Working Paper 3645*.

Heshmati, A. 2001. On the causality between GDP and health care expenditure in augmented Solow growth model. *Stockholm School of Economics Working Paper Series No. 423*.

Hiltiris, T. and Possnett, J. 1992. The determinants and effects of health expenditure in developed countries. *Journal of Health Economics,* 6**,** 173-181.

Hollingsworth, B. and Parkin, D. 1995. The efficiency of Scotish acute hospitals: an application of data envelopment analysis. *IMA J. Math. Appl. Med. Biol.,* 12**,** 161-173.

______________ and Wildman, J. 2003. The efficiency of health production: re-estimating the WHO panel data using parametric and non-parametric approaches to provide additional information. *Health Economics,* 12**,** 493-504.

Husain, M. J. 2010. Contribution of health to economic development: A survey and overview. *Economics: The Open Access, Open-Assessment E-Journal,* 4**,** 2010-2014.

Jack, W. and Lewis, M. 2009. Health investments and economic growth: macroeconomic evidence and microeconomic foundations. *World Bank Policy Research Working Paper 4877*.

Jacobs, R. 2000. Alternative methods to examine hospital efficiency: data envelopment and stochastic frontier analysis. *The University of York Center for Health Economics Discussion Paper 177*.

_______ and Dawson, D. 2003a. Hospital efficiency targets. *Health Economics,* 12**,** 669-684.

_______ and _______ 2003b. Variation in unit costs of hospitals in the English NHS. *Journal of Health Services Research and Policy,* 8**,** 202-208.

______, Smith, P. C. and Street, A. 2006. *Measuring efficiency in health care: analytiques and health policy,* Cambridge, Cambridge University Press.

Jafarov, E. and Gunnarsson, V. 2008 Government spending on health care and education in croatia: Efficiency and reform operations. *International Monetary Fund Working Paper No. WP/08/136*.

Jaunky, V. C. and Khadaroo, A. J. 2008. Health care expenditure and GDP: An African perspective. *Applied Economics and International Development,* 8**,** 131-146.

Jayasuriya, R. and Wodon, Q. 2003. Efficiency in reaching the millennium development goals. *World Bank Working Paper No.9*.

Kamiya, Y. 2010. Determinants of health in developing countries: Cross-country evidence. *Osaka School of International Public Policy (OSIPP) Discussion Paper: DP-2010-E-009*.

Khaki, A. R., Sadjadi, S. J., Gharakhani, M. and Rashidi, S. 2012. Data envelopment analysis under uncertainty: a case study from public healthcare. *African Journal of Business Management,* 6**,** 7096-7105.

Kirigia, J. M., Mensah, O. A., Mwikisa, C., Asbu, E. Z., Emrouznejad, A. and Makoudode, P. 2010. Technical efficiency of zone hospitals in Benin. Brazzaville: World Health Organization Africa Region.

Koc, C. 2004. The productivity of health care and health production functions. *Health Economics,* 13**,** 739-747.

Koopmans, T. C. 1951. An analysis of production as an efficient combination of activities. *In:* Koopmans, T. C. (ed.) *Activity analysis of production and allocation.* Jhon Wiley and Sons Inc.

Kotzian, P. 2009. Productive efficiency and heterogeneity of health care systems: Results of a measurement for OECD countries. *The Open Economics Journal,* 2**,** 20-30.

Kumbhakar, S. C. 1990. Production frontiers, panel data and time varying technical inefficiency. *Journal of Econometrics,* 46**,** 201-211.

Kwesigabo, G., Mwangu, A. M., Kakoko, C. D., Warriner, I., Mkony, A. C., Killewo, J., Macfarlane, B. S., Kaaya, E. E. and Freeman, P. 2012. Tanzania's health system and workforce crisis. *Journal of Public Health Policy,* 33**,** S35-S44.

Lawanson, A. O. 2012. Public sector health care financing and health outcomes in sub-Saharan African countries. *In:* Olaniyan, O., Lawanson, A. O. and Olubajo, O. (eds.) *Economics of health sector governance and financing in Nigeria.* Ibadan: Ibadan University Press.

Lovell, C. A. K. 1993. Linear programming approaches to the measurement and analysis of productive efficiency. *College of Business Administration, Department of Economics Papers 393e*.

Mallaye, D. and Yogo, T. U. 2012. Health aid and health improvement in sub-Saharan Africa. *MPRA Paper No. 44938*.

Malmquist, S. 1953. Index numbers and indifference curves. *Trabajos de Estatistica,* 4**,** 209-242.

Martin, J. J. M., Gonzalez, M. P. L. A. and Garcia, M. D. C. 2011. Review of the literature on the determinants of healthcare expenditure. *Applied Economics,* 42**,** 19-46.

McDonald, J. 2009. Using least squares and tobit in second stage DEA efficiency analyses. *European Journal of Operational Research,* 197**,** 792-798.

Mirzosaid, S. 2011. Health expenditure efficiency in Commonwealth of Independent States: A data envelopment analysis approach. *Transition Studies Review,* 18**,** 384-404.

Mishra, P. and Newhouse, D. 2009. Does health aid matter? *Journal of Health Economics,* 28**,** 855-872.

Mortimer, D. and Peacock, S. 2002. Hospital efficiency measurement: simple ratios versus frontier methods. *The Center for Health Program Evaluation Working Paper 135: Monash University*.

Mukherjee, D. and Kizhakethalackal, E. T. 2012. Empirics of health-aid, education and infant mortality: a semiparametric study. *Applied Economics,* 45**,** 3137-3150.

Murthy, V. N. R. and Okunade, A. A. 2009. The core determinants of health expenditure in the African context: SOme econometric evidence for policy. *Health Policy,* 91**,** 57-62.

Musau, S., Chee, G., Patsika, R., Malangalila, E., Chitama, D., Van Praag, E. and Schettler, G. 2011. Tanzania health system assessment 2010. Bethesda, MD: Health Systems 20/20 Project, Abt Associates Inc.

Musgrove, P. 1996. Public and private roles in health. Washington, D.C: World Bank.

Mushkin, S. J. 1962. Health as an Investment. *Journal of Political Economy,* 70**,** 129-157.

Muurinen, J.-M. 1982. Deman for health: a generalised Grossman model. *Journal of Health Economics,* 1**,** 5-28.

National Agency for Control of HIV/AIDS 2011. National baseline survey of primary health care services and utilization in Nigeria. Abuja: National Agency for Control of HIV/AIDS (NACA).

National Population Commission 2008. Nigerian Demographic and Health Survey Report. Abuja.

Neelam, S. 2007. From funding to action: strengthening health care systems in sub-Saharan Africa. Geneva: World Economic Forum.

Nixon, J. and Ulmann, P. 2006. The Relationship between Health Care Expenditure and Health Outcomes: Evidence and Caveats for a Causal Link. *The European Journal of Health Economics,* 7**,** 7-18.

Parkin, D. 1991. Comparing health sector efficiency across countries. *In:* McGuire, A., Fenn, P. and Mayhew, A. (eds.) *Providing health care: the economics of alternative systems of finance and delivery.* New York: Oxford University Press.

________ and Hollingsworth, B. 1997. Measuring production efficiency of acute hospitals in Scotland, 1991-1994: validity issues in data envelopment analysis. *Applied Economics,* 29**,** 1425-1433.

Peacock, S., Chan, C., Mangolini, M. and Johansen, D. 2001. Techniques for measuring efficiency in health services. *Productivity Commission Staff Working Paper, July*.

Pitt, M. M. and Lee, L. F. 1981. The measurement and sources of technical inefficiency in the Indonesian weaving industry. *Journal of Development Economics,* 9**,** 43-64.

Poullier, J. P., Hernandez, P., Kawabata, K. and Savedoff, D. W. 2002. Patterns of global health expenditures: results for 191 countries. *WHO Discussion Paper No. 51.*

Retzlaff-Roberts, D., Chang, C. F. and Rubin, R. M. 2004. Technical efficiency in the use of health care resources: a comparison of OECD countries. *Health Policy,* 69**,** 55-72.

Rhee, H.-J. 2012. Effects of health care expenditure on the infant mortality rate and life expectancy at birth in Korea. *International Journal of Contents,* 8**,** 52-56.

Schmidt, P. and Sickles, R. C. 1984. Productivity frontier and panel data *Journal of Business & Economic Statistics,* 2**,** 367-374.

Sengupta, J. T. 1995. Estimating efficiency by cost frontiers: a comparison of parametric and nonparametric methods. *Applied Economics Letters,* 2**,** 86-90.

Tandon, A. and Cashin, C. 2010. Assessing public expenditure on health from a fiscal space perspective. *HND Discussion Paper.* Washington, DC: The World Bank.

_________, Lauer, A. J., Evans, B. D. and Murray, L. J. C. 2003. Health system efficiency: concepts. *In:* Murray, L. J. C. and Evans, B. D. (eds.) *Health systems performance assessment: debates, methods and empiricism.* Geneva: World Health Organization.

Tlotlego, N., Nonvignon, J., Sambo, L. G., Asbu, E. Z. and Krigia, J. M. 2010. Assessment of productivity of hospitals in Botswana: a DEA application. *International Archives of Medicine,* 3.

Turin, R. D. 2010. Health care utilization in the Kenyan health system: Challenges and opportunities *Student Pulse Journal,* 2**,** 1-3.

Wagstaff, A. 1986. The demand for health: theory and applications. *Journal of Epidemiology and Community Health,* 40**,** 1-11.

Wamai, G. R. 2009. The Kenyan health system - Analysis of the situation and enduring challenges. *Japan Medical Association Journal,* 52**,** 134-140.

WHO 2000. The world health report 2000. Health systems: improving performance. Geneva: World Health Organization.

____ 2009. Country Cooperation Strategy at A Glance. Geneva: World Health Organization.

_____ 2012. World health statistics 2012. Geneva: World Health Organization.

_____ 2013. World health statistics. Geneva: World Health Organization.

Williamson, C. R. 2008. Foreign aid and human development: The impact of foreign aid to the health sector. *Southern Economic Journal,* 75**,** 188-207.

Wilson, A. R. and Briscoe, G. 2004. The impact of human capital on economic growth: a review. *In:* Descy, P. and Tessaring, M. (eds.) *Impact of education on training.* Luxembourg: European Union.

Wilson, S. N., Gebhard, K., Kitterman, A., Mitchell, A. and Nielson, D. 2009. The ineffectiveness of health sector foreign aid on infant and child mortality, 1975-2005. *Annual Meeting of the American Political Science Association.* Boston.

World Bank 2010. World development indicators. Washington DC: The World Bank.

__________ 2011. Building human capital in Africa. Washington, D.C.: The World Bank.

__________ 2012. World development indicators dataset. Washington D.C: The World Bank.

Zere, E. 2000. Hospital efficiency in Sub-Saharan Africa: evidence from South Africa. *The United Nations University WIDER Working Paper No.187*.

APPENDICES

Appendix A. Trend and Pattern of health indicators in SSA

Table A1. Trend in Life expectancy at birth

	Total Life Expectancy at Birth (Years)			Male Life Expectancy at Birth (Years)			Female Life Expectancy at Birth (Years)		
Country Name	**2000**	**2005**	**2011**	**2000**	**2005**	**2011**	**2000**	**2005**	**2011**
Angola	45.2	48.5	51.1	43.9	47.2	49.6	46.6	49.9	52.6
Benin	52.6	53.8	56.0	50.1	51.8	54.2	55.2	55.9	57.9
Botswana	50.8	50.4	53.0	50.4	50.9	54.0	51.1	50.0	52.0
Burkina Faso	50.2	52.4	55.4	49.2	51.5	54.4	51.3	53.4	56.4
Burundi	46.0	47.8	50.3	44.8	46.6	48.9	47.2	49.0	51.8
Cameroon	50.1	49.4	51.6	49.0	48.5	50.6	51.2	50.4	52.6
Cape Verde	69.4	72.1	73.9	65.5	68.2	70.3	73.6	76.3	77.7
Central African Rep	43.7	44.3	48.3	42.2	43.1	46.7	45.2	45.7	50.0
Chad	48.5	48.1	49.5	47.1	46.7	48.1	50.0	49.5	51.0
Comoros	57.9	59.0	61.0	56.3	57.6	59.7	59.5	60.4	62.5
Congo, Dem. Rep.	45.7	47.0	48.4	44.4	45.6	46.8	47.0	48.4	50.0
Congo, Rep.	54.1	55.1	57.4	53.2	54.1	56.1	55.1	56.1	58.7
Cote d'Ivoire	50.2	51.6	55.4	49.2	50.7	54.3	51.1	52.5	56.6
Equatorial Guinea	48.7	49.4	51.1	47.3	48.1	49.9	50.2	50.8	52.5
Eritrea	56.0	58.7	61.4	53.8	56.5	59.1	58.3	61.0	63.8
Ethiopia	51.7	55.2	59.2	50.3	53.7	57.7	53.2	56.6	60.9
Gabon	59.7	60.0	62.7	58.5	59.0	61.7	60.9	61.1	63.8
Gambia, The	55.2	56.6	58.5	54.0	55.5	57.3	56.4	57.8	59.7
Ghana	58.4	61.0	64.2	57.6	60.2	63.2	59.2	61.9	65.3
Guinea	48.1	51.1	54.1	46.7	49.7	52.5	49.6	52.7	55.7
Guinea-Bissau	44.9	46.1	48.1	43.5	44.7	46.6	46.3	47.6	49.7
Kenya	52.3	53.0	57.1	51.3	52.2	56.0	53.3	53.9	58.3
Lesotho	47.6	44.2	48.0	47.2	44.7	48.7	48.0	43.7	47.2

Liberia	46.0	51.9	56.7	44.8	51.0	55.7	47.2	52.9	57.8
Madagascar	59.7	64.1	66.7	58.2	62.7	65.1	61.2	65.6	68.4
Malawi	46.0	48.9	54.1	45.7	49.0	54.1	46.4	48.9	54.2
Mali	47.2	48.9	51.4	46.2	47.9	50.3	48.3	50.0	52.5
Mauritania	57.0	57.2	58.5	55.5	55.7	56.9	58.6	58.9	60.3
Mauritius	71.7	72.4	73.3	68.2	69.1	69.7	75.3	75.9	77.0
Mozambique	47.2	48.0	50.2	45.6	46.7	49.2	49.0	49.4	51.1
Namibia	57.7	58.5	62.3	56.7	57.9	61.8	58.7	59.2	62.9
Niger	48.3	51.7	54.7	47.9	51.2	54.2	48.7	52.1	55.2
Nigeria	46.3	49.0	51.9	45.5	48.3	51.1	47.1	49.8	52.7
Rwanda	46.5	52.2	55.4	45.6	51.2	54.1	47.4	53.4	56.7
Sao Tome	62.4	63.2	64.6	61.3	62.0	63.2	63.5	64.5	66.1
Senegal	55.7	57.3	59.3	54.7	56.4	58.2	56.8	58.3	60.4
Seychelles		72.1	73.5		67.4	69.7		77.1	77.4
Sierra Leone	39.7	44.3	47.8	38.5	43.5	47.2	41.0	45.1	48.4
Somalia	48.3	49.9	51.2	46.7	48.3	49.6	49.9	51.5	52.8
South Africa	54.8	51.1	52.6	52.3	49.7	52.0	57.3	52.5	53.2
Sudan	57.0	59.5	61.4	55.5	58.0	59.7	58.5	61.1	63.3
Swaziland	48.7	45.9	48.7	48.1	46.0	49.1	49.2	45.7	48.2
Tanzania	50.4	53.3	58.2	49.6	52.7	57.2	51.2	54.1	59.1
Togo	54.8	55.3	57.0	53.3	53.9	55.5	56.4	56.8	58.6
Uganda	46.1	50.1	54.1	45.3	49.7	53.4	47.0	50.6	54.8
Zambia	41.9	44.4	49.0	41.7	44.2	48.5	42.2	44.6	49.4
Zimbabwe	44.6	43.9	51.2	44.8	44.8	52.0	44.4	42.9	50.4

Source : Author's compilation using WDI dataset (2012)

Table A2. Trend in Maternal mortality ratio and MDG target

	Maternal mortality ratio (modeled estimate, per 100,000 live births)			% Change (1990-2010)	MDG Target	Deviation from target (%)
	1990	**2000**	**2010**			
Angola	1200	890	450	-62.5	300	-33.3
Benin	770	530	350	-54.5	192.5	-45.0
Botswana	140	350	160	14.3	35	-78.1
Burkina Faso	700	450	300	-57.1	175	-41.7
Burundi	1100	1000	800	-27.3	275	-65.6
Cameroon	670	730	690	3.0	167.5	-75.7
Cape Verde	200	170	79	-60.5	50	-36.7
Central African Rep	930	1000	890	-4.3	232.5	-73.9
Chad	920	1100	1100	19.6	230	-79.1
Comoros	440	340	280	-36.4	110	-60.7
Congo, Dem. Rep.	930	770	540	-41.9	232.5	-56.9
Congo, Rep.	420	540	560	33.3	105	-81.3
Cote d'Ivoire	710	590	400	-43.7	177.5	-55.6
Equatorial Guinea	1200	450	240	-80.0	300	25.0
Eritrea	880	390	240	-72.7	220	-8.3
Ethiopia	950	700	350	-63.2	237.5	-32.1
Gabon	270	270	230	-14.8	67.5	-70.7
Gambia, The	700	520	360	-48.6	175	-51.4
Ghana	580	550	350	-39.7	145	-58.6
Guinea	1200	970	610	-49.2	300	-50.8
Guinea-Bissau	1100	970	790	-28.2	275	-65.2
Kenya	400	490	360	-10.0	100	-72.2
Lesotho	520	690	620	19.2	130	-79.0
Liberia	1200	1300	770	-35.8	300	-61.0
Madagascar	640	400	240	-62.5	160	-33.3
Malawi	1100	840	460	-58.2	275	-40.2
Mali	1100	740	540	-50.9	275	-49.1
Mauritania	760	630	510	-32.9	190	-62.7
Mauritius	68	28	60	-11.8	17	-71.7
Mozambique	910	710	490	-46.2	227.5	-53.6
Namibia	200	280	200	0.0	50	-75.0
Niger	1200	870	590	-50.8	300	-49.2
Nigeria	1100	970	630	-42.7	275	-56.3
Rwanda	910	840	340	-62.6	227.5	-33.1
Sao Tome	150	110	70	-53.3	37.5	-46.4
Senegal	670	500	370	-44.8	167.5	-54.7
Sierra Leone	1300	1300	890	-31.5	325	-63.5
Somalia	890	1000	1000	12.4	222.5	-77.8
South Africa	250	330	300	20.0	62.5	-79.2
Sudan	1000	870	730	-27.0	250	-65.8
Swaziland	300	360	320	6.7	75	-76.6
Tanzania	870	730	460	-47.1	217.5	-52.7
Togo	620	440	300	-51.6	155	-48.3
Uganda	600	530	310	-48.3	150	-51.6
Zambia	470	540	440	-6.4	117.5	-73.3
Zimbabwe	450	640	570	26.7	112.5	-80.3

Source: Author's compilation using WDI dataset (2012)

Table A3. Trend in Under-5 mortality rate and MDG target

	Under-5 Mortality rate per 1,000 live births			Change (2000-2011)	MDG Target	Deviation from target (%)
	1990	2000	2011			
Angola	243.2	199.3	157.6	-20.9	81.1	-48.6
Benin	177.3	139.7	106	-24.1	59.1	-44.2
Botswana	52.8	81.1	25.9	-68.1	17.6	-32.0
Burkina Faso	208.4	181.5	146.4	-19.3	69.5	-52.6
Burundi	182.6	164.6	139.1	-15.5	60.9	-56.2
Cameroon	145.2	139.5	127.2	-8.8	48.4	-61.9
Cape Verde	58	38.9	21.3	-45.2	19.3	-9.2
Central African Rep	169.1	172	163.5	-4.9	56.4	-65.5
Chad	208.3	188.5	169	-10.3	69.4	-58.9
Comoros	121.7	99.6	79.3	-20.4	40.6	-48.8
Congo, Dem. Rep.	181.4	181.4	167.7	-7.6	60.5	-63.9
Congo, Rep.	118.8	108.8	98.8	-9.2	39.6	-59.9
Cote d'Ivoire	151.4	138.6	114.9	-17.1	50.5	-56.1
Equatorial Guinea	189.6	152.2	118.1	-22.4	63.2	-46.5
Eritrea	137.7	98.2	67.8	-31.0	45.9	-32.3
Ethiopia	198.3	138.6	77	-44.4	66.1	-14.2
Gabon	94.4	82.4	65.6	-20.4	31.5	-52.0
Gambia, The	164.6	130.3	100.6	-22.8	54.9	-45.5
Ghana	120.9	98.7	77.6	-21.4	40.3	-48.1
Guinea	228.2	174.5	125.8	-27.9	76.1	-39.5
Guinea-Bissau	210.4	185.8	160.6	-13.6	70.1	-56.3
Kenya	97.8	113.1	72.8	-35.6	32.6	-55.2
Lesotho	87.5	117.3	86	-26.7	29.2	-66.1
Liberia	241.2	163.8	78.3	-52.2	80.4	2.7
Madagascar	161.2	104.1	61.6	-40.8	53.7	-12.8
Malawi	227	164.1	82.6	-49.7	75.7	-8.4
Mali	257.3	214.4	175.6	-18.1	85.8	-51.2
Mauritania	124.7	117.9	112.1	-4.9	41.6	-62.9
Mauritius	23.9	18.6	15.1	-18.8	8.0	-47.2
Mozambique	225.7	172.1	103.1	-40.1	75.2	-27.0
Namibia	72.8	73.5	41.5	-43.5	24.3	-41.5
Niger	313.7	215.6	124.5	-42.3	104.6	-16.0
Nigeria	213.6	187.9	124.1	-34.0	71.2	-42.6
Rwanda	156.3	183	54.1	-70.4	52.1	-3.7
Sao Tome	96	92.5	88.8	-4.0	32.0	-64.0
Senegal	135.9	130.4	64.8	-50.3	45.3	-30.1
Seychelles	16.6	13.8	13.8	0.0	5.5	-59.9
Sierra Leone	266.7	240.6	185.3	-23.0	88.9	-52.0
Somalia	180	180	180	0.0	60.0	-66.7
South Africa	62.3	74.1	46.7	-37.0	20.8	-55.5
South Sudan	217.3	164.5	120.5	-26.7	72.4	-39.9
Sudan	122.8	103.7	86	-17.1	40.9	-52.4
Swaziland	83.3	114.2	103.6	-9.3	27.8	-73.2
Tanzania	157.9	126.4	67.6	-46.5	52.6	-22.1
Togo	147	127.8	110.1	-13.8	49.0	-55.5
Uganda	178	140.5	89.9	-36.0	59.3	-34.0
Zambia	192.8	153.8	82.9	-46.1	64.3	-22.5
Zimbabwe	79.2	105.8	67.1	-36.6	26.4	-60.7

Source: Author's compilation using WDI dataset (2012)

Note: MDG target was to reduce infant mortality by two thirds between 1990 and 2015

Table A4. Trend in infant mortality rate and MDG target

	Infant Mortality Rate per 1000 live births			Change (2000-2011)	MDG Target	Deviation from target (%)
	1990	**2000**	**2011**			
Angola	143.7	118.7	96.4	-18.8	47.9	-50.3
Benin	106.8	86.6	67.9	-21.6	35.6	-47.6
Botswana	41.3	50.5	20.3	-59.8	13.8	-32.2
Burkina Faso	104.8	94.6	81.6	-13.7	34.9	-57.2
Burundi	109.7	100.1	86.3	-13.8	36.6	-57.6
Cameroon	89.9	86.3	79.2	-8.2	30.0	-62.2
Cape Verde	45	31.6	18.2	-42.4	15.0	-17.6
Central African Rep	111.5	112.3	108.2	-3.7	37.2	-65.7
Chad	113.2	105	97.1	-7.5	37.7	-61.1
Comoros	85.7	71.7	58.8	-18.0	28.6	-51.4
Congo, Dem. Rep.	117.3	117.3	110.6	-5.7	39.1	-64.6
Congo, Rep.	75.1	69.5	63.8	-8.2	25.0	-60.8
Cote d'Ivoire	104	94.9	81.2	-14.4	34.7	-57.3
Equatorial Guinea	118.3	97.6	79.6	-18.4	39.4	-50.5
Eritrea	85.5	63.5	46.3	-27.1	28.5	-38.4
Ethiopia	118.2	86	51.5	-40.1	39.4	-23.5
Gabon	68.5	60.3	49.3	-18.2	22.8	-53.7
Gambia, The	78.1	67	57.6	-14.0	26.0	-54.8
Ghana	76.2	63.8	51.8	-18.8	25.4	-51.0
Guinea	134.8	105.3	78.9	-25.1	44.9	-43.1
Guinea-Bissau	124.8	111.4	98	-12.0	41.6	-57.6
Kenya	63.5	70	48.3	-31.0	21.2	-56.2
Lesotho	70.8	82.6	62.6	-24.2	23.6	-62.3
Liberia	160.8	112	58.2	-48.0	53.6	-7.9
Madagascar	98.3	66.8	42.8	-35.9	32.8	-23.4
Malawi	133.6	98.4	52.9	-46.2	44.5	-15.8
Mali	131.9	113.9	98.2	-13.8	44.0	-55.2
Mauritania	80.5	77.9	75.6	-3.0	26.8	-64.5
Mauritius	20.7	16.4	12.8	-22.0	6.9	-46.1
Mozambique	150.9	116	71.6	-38.3	50.3	-29.7
Namibia	49.1	48.2	29.6	-38.6	16.4	-44.7
Niger	132.6	97	66.4	-31.5	44.2	-33.4
Nigeria	126.6	112.5	78	-30.7	42.2	-45.9
Rwanda	95	108.8	38.1	-65.0	31.7	-16.9
Sao Tome	62.2	60.3	58.2	-3.5	20.7	-64.4
Senegal	68.8	67	46.7	-30.3	22.9	-50.9
Seychelles	14	11.6	11.9	2.6	4.7	-60.8
Sierra Leone	157.6	145.5	119.2	-18.1	52.5	-55.9
Somalia	108.3	108.3	108.3	0.0	36.1	-66.7
South Africa	48.2	52.3	34.6	-33.8	16.1	-53.6
South Sudan	128.6	100.1	76	-24.1	42.9	-43.6
Sudan	77.3	66.6	56.6	-15.0	25.8	-54.5
Swaziland	61.3	77.1	69	-10.5	20.4	-70.4
Tanzania	96.7	77.9	45.4	-41.7	32.2	-29.0
Togo	85.2	78.7	72.9	-7.4	28.4	-61.0
Uganda	106.1	85.6	57.9	-32.4	35.4	-38.9
Zambia	114.2	91	52.7	-42.1	38.1	-27.8
Zimbabwe	52.5	62.8	42.8	-31.8	17.5	-59.1

Source: Author's compilation using WDI dataset (2012)

Appendix B. Trend and Pattern of health care expenditure in SSA

Table B1. Per capita health care expenditure (ppp in 2005 international dollars)

	2000	2005	2011
Angola	63.29	129.05	214.58
Benin	52.61	64.92	74.53
Botswana	400.60	829.59	734.06
Burkina Faso	38.85	69.67	81.15
Burundi	23.10	48.81	52.38
Cameroon	73.57	94.26	127.92
Cape Verde	93.40	133.53	171.69
Central African Republic	27.81	29.25	30.90
Chad	41.79	64.99	65.48
Comoros	33.67	46.60	58.76
Congo, Dem. Rep.	10.94	14.59	32.09
Congo, Rep.	58.82	81.88	108.64
Cote d'Ivoire	81.24	71.61	119.89
Equatorial Guinea	148.31	421.24	1642.71
Eritrea	23.14	16.85	16.99
Ethiopia	20.11	26.15	51.96
Gabon	293.32	338.06	514.53
Gambia, The	50.61	70.02	93.72
Ghana	44.86	84.79	90.01
Guinea	33.25	52.21	67.21
Guinea-Bissau	97.37	56.11	73.93
Kenya	53.31	58.75	77.08
Lesotho	68.48	83.88	218.78
Liberia	18.04	27.78	112.42
Madagascar	29.78	32.11	39.55
Malawi	35.93	52.89	76.99
Mali	46.44	58.01	73.24
Mauritania	72.80	76.16	128.92
Mauritius	304.94	466.95	841.95
Mozambique	27.37	45.98	64.67
Namibia	243.49	380.97	364.80
Niger	16.78	35.95	39.32
Nigeria	59.98	115.52	139.45
Rwanda	24.75	54.86	134.64
Sao Tome and Principe	287.83	155.38	164.06
Senegal	58.67	90.45	118.50
Seychelles	834.07	717.05	989.37
Sierra Leone	65.89	104.28	165.24
South Africa	552.44	746.71	942.50
Sudan	41.50	63.94	179.55
Swaziland	197.04	306.40	433.51
Tanzania	25.26	41.76	107.41
Togo	43.04	56.21	80.10
Uganda	45.56	83.56	127.98
Zambia	51.76	81.03	99.32

Source: Author's compilation using WDI dataset (2012)

Table B2. Public and private health care expenditure as percent of GDP

	Public Health Expenditure as % of GDP			Private Health Expenditure % of GDP		
	2000	**2005**	**2011**	**2000**	**2005**	**2011**
Angola	1.68	1.92	2.15	1.21	1.63	1.34
Benin	1.92	2.35	2.43	2.42	2.38	2.13
Botswana	2.95	5.69	3.08	1.79	1.50	1.98
Burkina Faso	2.03	4.09	3.27	3.10	2.78	3.24
Burundi	1.81	3.03	2.85	4.37	7.02	5.88
Cameroon	0.93	1.12	1.63	3.54	3.63	3.60
Cape Verde	3.52	3.65	3.57	1.29	1.21	1.19
Central African Republic	2.05	2.18	1.97	2.04	2.17	1.82
Chad	2.67	1.94	1.16	3.61	2.79	3.12
Comoros	1.52	2.23	3.04	2.09	2.19	2.22
Congo, Dem. Rep.	0.20	1.25	2.88	4.54	4.01	5.66
Congo, Rep.	1.22	1.43	1.65	0.90	0.99	0.80
Cote d'Ivoire	1.33	0.85	1.81	3.73	3.45	4.98
Equatorial Guinea	0.89	1.00	2.62	1.03	0.70	1.33
Eritrea	1.77	1.03	1.25	2.76	1.62	1.31
Ethiopia	2.30	2.50	2.69	2.00	1.61	1.97
Gabon	1.05	1.10	1.72	1.45	1.50	1.50
Gambia, The	1.23	2.46	2.37	2.38	1.92	2.02
Ghana	2.31	4.66	2.68	2.43	2.36	2.10
Guinea	1.05	0.95	1.63	4.60	4.43	4.33
Guinea-Bissau	0.52	1.11	1.69	4.42	4.41	4.60
Kenya	2.17	1.85	1.77	2.52	2.52	2.71
Lesotho	3.59	3.31	9.45	3.42	3.64	3.31
Liberia	1.45	1.55	6.15	4.46	6.48	13.33
Madagascar	2.47	2.46	2.57	1.24	1.24	1.50
Malawi	2.78	6.07	6.16	3.29	2.14	2.23
Mali	2.07	3.04	3.09	4.22	3.30	3.72
Mauritania	3.97	3.16	3.27	2.00	1.88	2.13
Mauritius	1.94	2.14	2.37	1.78	2.36	3.52
Mozambique	4.31	4.31	2.75	1.85	2.56	3.84
Namibia	4.21	3.58	3.05	1.90	3.74	2.29
Niger	1.52	2.98	2.93	1.89	2.98	2.38
Nigeria	1.53	1.93	1.95	3.04	4.68	3.37
Rwanda	1.65	3.68	6.11	2.57	2.84	4.66
Sao Tome and Principe	3.61	5.36	2.57	4.75	4.77	5.16
Senegal	1.59	2.99	3.49	2.74	2.41	2.49
Seychelles	3.98	3.74	3.48	0.83	0.27	0.30
Sierra Leone	3.96	3.46	3.39	13.55	12.66	15.45
South Africa	3.43	3.38	4.06	4.86	5.42	4.46
Sudan	0.92	1.37	2.38	2.43	2.59	6.01
Swaziland	2.96	4.58	5.56	2.30	2.21	2.45
Tanzania	1.46	1.89	2.88	1.91	2.13	4.40
Togo	1.51	1.90	4.18	3.79	4.67	3.83
Uganda	1.78	2.29	2.49	4.86	6.88	6.97
Zambia	2.91	3.84	3.66	2.76	3.16	2.46

Source: Author's compilation using WDI dataset (2012)

Table B3. Out-of-pocket health care expenditure as percent of total health care expenditure

	2000	2005	2011
Angola	26.28	33.14	27.31
Benin	55.74	47.72	42.62
Botswana	13.88	4.74	4.97
Burkina Faso	56.95	38.13	36.57
Burundi	51.62	47.99	43.62
Cameroon	74.72	72.20	65.08
Cape Verde	25.45	23.63	23.36
Central African Republic	46.20	46.21	43.37
Chad	55.32	56.88	70.47
Comoros	57.89	49.51	42.17
Congo, Dem. Rep.	74.05	56.83	43.54
Congo, Rep.	42.01	40.26	31.51
Cote d'Ivoire	72.32	78.52	64.28
Equatorial Guinea	48.81	36.03	31.60
Eritrea	60.87	61.22	51.23
Ethiopia	36.77	31.52	33.76
Gabon	58.03	57.72	46.55
Gambia, The	35.37	21.20	22.26
Ghana	33.04	21.44	29.11
Guinea	80.93	81.82	67.35
Guinea-Bissau	49.02	43.65	41.33
Kenya	43.20	44.65	46.38
Lesotho	36.08	36.15	17.89
Liberia	38.01	41.70	17.67
Madagascar	17.70	20.64	25.20
Malawi	21.95	8.82	14.20
Mali	66.50	51.75	54.34
Mauritania	31.62	35.24	37.27
Mauritius	35.78	43.98	53.04
Mozambique	12.20	10.19	9.01
Namibia	5.64	3.72	7.67
Niger	44.73	47.56	37.58
Nigeria	61.65	67.86	60.42
Rwanda	24.78	16.45	21.38
Sao Tome and Principe	43.27	34.65	56.91
Senegal	57.87	34.07	32.74
Seychelles	17.12	6.58	5.44
Sierra Leone	73.42	66.29	74.92
South Africa	13.05	18.44	7.21
South Sudan			55.43
Sudan	66.48	60.12	69.11
Swaziland	18.53	13.71	13.07
Tanzania	47.26	37.29	31.72
Togo	63.05	60.11	40.39
Uganda	41.49	48.75	47.77
Zambia	39.18	27.40	26.97

Source: Author's compilation using WDI dataset (2012)

Appendix C. Health system efficiency scores

Table C1: Summary health system efficiency - CRS - output orientation

Model	M(UC;1in)	M(UI;1in)	M(UIC;1in)	M(UC;2in)	M(UI;2in)	M(UIC;2in)
Mean	0.16	0.15	0.16	0.51	0.42	0.51
Standard deviation	0.16	0.16	0.16	0.25	0.22	0.25
Minimum	0.01	0.01	0.01	0.16	0.12	0.16
No. efficient	1	1	1	4	2	4
Efficient countries	Eritrea	Eritrea	Eritrea	Burkina Faso, Cape Verde, Eritrea, Niger	Cape Verde, Eritrea	Burkina Faso, Cape Verde, Eritrea, Niger
Inefficient countries	Angola, Gabon, South Africa, Swaziland, Equatorial Guinea	Angola, Gabon, South Africa, Swaziland, Equatorial Guinea	Angola, Gabon, South Africa, Swaziland, Equatorial Guinea	Cameroon, Equatorial Guinea, Lesotho, South Africa, Swaziland	Gabon, Equatorial Guinea, Sierra Leone, Swaziland, Angola	Cameroon, Equatorial Guinea, Lesotho, South Africa, Swaziland

Source: Author's computation

Table C2. Summary health system efficiency - multi output - CRS - input orientation

Model	M(UC;1in)	M(UI;1in)	M(UIC;1in)	M(UC;2in)	M(UI;2in)	M(UIC;2in)
Mean	0.16	0.16	0.16	0.51	0.42	0.51
Standard deviation	0.16	0.16	0.16	0.25	0.22	0.25
Minimum	0.01	0.01	0.01	0.16	0.12	0.16
No. efficient	1	1	1	4	2	4
Efficient countries	Eritrea	Eritrea	Eritrea	Burkina Faso, Cape Verde, Eritrea, Niger	Cape Verde, Eritrea	Burkina Faso, Cape Verde, Eritrea, Niger
Inefficient countries	Angola, Gabon, South Africa, Lesotho, Swaziland, Equatorial Guinea	Angola, Gabon, Lesotho South Africa, Swaziland, Equatorial Guinea	Angola, Gabon, Lesotho, South Africa, Swaziland, Equatorial Guinea	Angola, Cameroon, Equatorial Guinea, Lesotho, South Africa, Swaziland	Lesotho, Gabon, Equatorial Guinea, Sierra Leone, Swaziland, Angola	Angola, Cameroon, Equatorial Guinea, Lesotho, South Africa, Swaziland

Source: Author's computation

Table C3. Summary health system efficiency - mono output - CRS - input orientation

Model	Mc(IS;1in)	Mc(CS;1in)	M(U;1in)	Mc(IS;2in)	Mc(CS;2in)	M(U;2in)
Mean	0.15	0.14	0.15	0.42	0.67	0.35
Standard deviation	0.16	0.16	0.16	0.22	0.25	0.21
Min	0.01	0.01	0.01	0.12	0.12	0.09
No. efficient	1	1	1	2	3	2
Efficient countries	Eritrea	Eritrea	Eritrea	Cape Verde, Eritrea	Burkina Faso, Eritrea, Niger	Cape Verde, Eritrea
Inefficient countries	Sierra Leone, Angola, Gabon, Swaziland, South Africa, Equatorial Guinea	Mauritius, Swaziland, Seychelles, Botswana, South Africa, Equatorial Guinea	Lesotho, Sierra Leone, Angola, South Africa, Swaziland, Equatorial Guinea	Lesotho, Gabon, Sierra Leone, Equatorial Guinea, Angola, Swaziland	Zambia, Equatorial Guinea, Lesotho, Swaziland, Botswana, South Africa	Cameroon Gabon, Equatorial Guinea, Sierra Leone, Swaziland, Angola

Source: Author's computation

Table C4. Summary health system efficiency - mono output - CRS - output orientation

Model	**Mc(IS;1in)**	**Mc(CS;1in)**	**M(U;1in)**	**Mc(IS;2in)**	**Mc(CS;2in)**	**M(U;2in)**
Mean	0.12	0.14	0.15	0.42	0.47	0.35
Standard deviation	0.16	0.16	0.16	0.22	0.25	0.21
Min	0.01	0.01	0.01	0.12	0.12	0.09
No. efficient	1	1	1	2	3	2
Efficient countries	Eritrea	Eritrea	Eritrea	Cape Verde, Eritrea	Burkina Faso, Eritrea, Niger	Cape Verde, Eritrea
Inefficient countries	Angola, Gabon, Swaziland, South Africa, Equatorial Guinea	Swaziland, Seychelles, Botswana, South Africa, Equatorial Guinea	Sierra Leone, Angola, South Africa, Swaziland, Equatorial Guinea	Gabon, Sierra Leone, Equatorial Guinea, Angola, Swaziland	Equatorial Guinea, Lesotho, Swaziland, Botswana, South Africa	Gabon, Equatorial Guinea, Sierra Leone, Swaziland, Angola

Source: Author's computation

Table C5. Summary health system efficiency - Physical inputs - CRS - input orientation

Model	Mc(IS;3in)	Mc(CS;3in)	M(U;3in)	Mc(IS,CS;3in)	M(UI;3in)	M(UC;3in)	M(UIC;3in)
Mean	0.44	0.43	0.47	0.48	0.49	0.51	0.64
Standard deviation	0.27	0.29	0.26	0.28	0.27	0.27	0.23
Min	0.1	0.06	0.11	0.13	0.11	0.13	0.30
No. efficient	4	4	4	4	5	5	8
Efficient countries	Guinea, Madagascar, Niger, Tanzania	Guinea, Madagascar, Niger, Tanzania	Cape Verde, Guinea, Madagascar, Tanzania	Guinea, Madagascar, Niger, Tanzania	Cape Verde, Guinea, Madagascar, Niger, Tanzania	Cape Verde, Guinea, Madagascar, Niger, Tanzania	Botswana, Cape Verde, Guinea, Mauritius, Niger, Rwanda, Seychelles, Tanzania
Inefficient countries	Congo DR, Equatorial Guinea, Sao Tome and Principe, South Africa, Swaziland	Swaziland, South Africa, Seychelles, Mauritius, Botswana	Nigeria, Congo, Dem. Rep., Swaziland, Equatorial Guinea, Sao Tome and Principe	Swaziland, South Africa, Sao Tome and Principe, Gabon, Equatorial Guinea	South Africa, Congo, Dem. Rep., Equatorial Guinea, Swaziland, Sao Tome and Principe	South Africa, Nigeria, Equatorial Guinea, Swaziland, Sao Tome and Principe	Mauritania, Gabon, Nigeria, Sao Tome and Principe, Angola

Source: Author's computation

Table C6. Efficiency scores, Physical inputs - multi output - VRS - input orientation

Country Name	Rank	M(UI;3in)	Rank	M(UC;3in)	Rank	M(UIC;3in)
Angola	31	0.28	32	0.28	26	0.85
Benin	17	0.63	21	0.63	30	0.74
Botswana	9	0.96	11	0.87	1	1.00
Burundi	15	0.71	17	0.71	18	0.97
Cameroon	30	0.30	31	0.30	23	0.88
Cape Verde	1	1.00	1	1.00	2	1.00
Chad	14	0.73	16	0.73	3	1.00
Comoros	35	0.25	26	0.36	35	0.63
Congo, Dem. Rep.	32	0.27	33	0.27	17	0.99
Congo, Rep.	34	0.25	34	0.27	31	0.70
Equatorial Guinea	39	0.19	39	0.19	20	0.90
Eritrea	20	0.54	2	1.00	33	0.65
Ethiopia	10	0.87	3	1.00	22	0.88
Gabon	37	0.24	37	0.24	39	0.57
Gambia, The	24	0.40	18	0.71	32	0.68
Ghana	23	0.52	13	0.83	40	0.56
Guinea	2	1.00	4	1.00	4	1.00
Guinea-Bissau	29	0.32	30	0.32	5	1.00
Kenya	28	0.33	29	0.33	29	0.77
Lesotho	26	0.38	25	0.38	6	1.00
Liberia	13	0.78	14	0.78	19	0.95
Madagascar	3	1.00	5	1.00	34	0.65
Malawi	16	0.70	19	0.70	7	1.00
Mali	4	1.00	6	1.00	24	0.87
Mauritania	21	0.54	23	0.61	37	0.60
Mauritius	5	1.00	7	1.00	8	1.00
Mozambique	18	0.61	22	0.61	9	1.00
Namibia	25	0.40	27	0.35	38	0.60
Niger	6	1.00	8	1.00	10	1.00
Nigeria	36	0.25	36	0.25	25	0.87
Rwanda	12	0.80	15	0.73	11	1.00
Sao Tome	41	0.11	40	0.18	41	0.48
Seychelles	7	1.00	9	1.00	12	1.00
Sierra Leone	11	0.85	12	0.85	13	1.00
South Africa	38	0.22	38	0.21	16	1.00
Sudan	27	0.34	28	0.34	36	0.62
Swaziland	40	0.17	41	0.17	21	0.89
Tanzania	8	1.00	10	1.00	14	1.00
Togo	22	0.52	20	0.67	27	0.77
Uganda	19	0.58	24	0.58	28	0.77
Zambia	33	0.26	35	0.26	15	1.00
Mean		0.57		0.60		0.85

Source: Author's computation

Table C7. Efficiency scores, Physical inputs - mono output - input orientation

Country Name	Rank	M(U;3in)	Rank	M(IS;3in)	Rank	M(CS;3in)
Angola	31	0.28	31	0.28	26	0.28
Benin	17	0.63	18	0.56	19	0.59
Botswana	9	0.87	9	0.96	38	0.13
Burundi	15	0.71	15	0.71	13	0.71
Cameroon	30	0.30	30	0.30	25	0.30
Cape Verde	1	1.00	1	1.00	1	1.00
Chad	14	0.73	14	0.73	12	0.73
Comoros	35	0.25	38	0.21	21	0.36
Congo, Dem. Rep.	32	0.27	32	0.27	28	0.27
Congo, Rep.	34	0.25	36	0.21	29	0.27
Equatorial Guinea	39	0.19	39	0.18	35	0.18
Eritrea	20	0.54	20	0.53	2	1.00
Ethiopia	10	0.87	11	0.84	3	1.00
Gabon	37	0.24	37	0.21	33	0.22
Gambia, The	24	0.40	24	0.40	14	0.71
Ghana	23	0.52	21	0.49	10	0.83
Guinea	2	1.00	2	1.00	4	1.00
Guinea-Bissau	29	0.32	29	0.32	24	0.32
Kenya	28	0.33	27	0.32	30	0.25
Lesotho	25	0.38	28	0.32	23	0.32
Liberia	12	0.78	13	0.78	11	0.78
Madagascar	3	1.00	3	1.00	5	1.00
Malawi	16	0.70	16	0.69	15	0.69
Mali	4	1.00	4	1.00	6	1.00
Mauritania	21	0.54	22	0.49	18	0.61
Mauritius	5	1.00	5	1.00	39	0.12
Mozambique	18	0.61	17	0.61	17	0.61
Namibia	26	0.35	25	0.40	34	0.19
Niger	6	1.00	6	1.00	7	1.00
Nigeria	36	0.25	34	0.24	31	0.24
Rwanda	13	0.73	12	0.80	27	0.28
Sao Tome and Principe	41	0.11	41	0.10	36	0.18
Seychelles	7	1.00	7	1.00	41	0.07
Sierra Leone	11	0.85	10	0.85	9	0.85
South Africa	38	0.21	35	0.22	40	0.07
Sudan	27	0.34	26	0.32	22	0.33
Swaziland	40	0.17	40	0.14	37	0.14
Tanzania	8	1.00	8	1.00	8	1.00
Togo	22	0.52	23	0.47	16	0.67
Uganda	19	0.58	19	0.54	20	0.46
Zambia	33	0.26	33	0.26	32	0.23
Mean		0.56		0.56		0.51

Source: Author's computation

Table C8. Efficiency scores, Monetary inputs - VRS - input orientation Multi-output

Country name	Rank	M(UC;1in)	Rank	M(UI;1in)	Rank	M(UC;2in)	Rank	M(UI;2in)
Angola	40	0.08	40	0.08	40	0.27	40	0.27
Benin	18	0.23	18	0.23	23	0.52	20	0.52
Botswana	25	0.18	24	0.20	36	0.34	33	0.36
Burkina Faso	22	0.21	22	0.21	1	1.00	7	0.92
Burundi	10	0.32	10	0.32	16	0.67	14	0.67
Cameroon	33	0.13	33	0.13	38	0.28	38	0.28
Cape Verde	1	1.00	1	1.00	2	1.00	1	1.00
Cent. A. Rep.	6	0.55	6	0.55	13	0.79	11	0.79
Chad	13	0.26	14	0.26	11	0.85	9	0.85
Comoros	11	0.29	11	0.29	10	0.88	13	0.74
Congo DR.	7	0.53	7	0.53	14	0.77	12	0.77
Congo, Rep.	30	0.16	30	0.16	37	0.33	36	0.33
Cote d'Ivoire	32	0.14	32	0.14	32	0.37	34	0.35
Equat. Guinea	45	0.01	45	0.01	44	0.22	43	0.22
Eritrea	2	1.00	2	1.00	3	1.00	2	1.00
Ethiopia	9	0.33	9	0.33	9	0.98	8	0.91
Gabon	44	0.04	44	0.04	42	0.26	44	0.21
Gambia, The	24	0.18	26	0.18	15	0.75	19	0.54
Ghana	23	0.19	25	0.19	28	0.44	32	0.36
Guinea	15	0.25	15	0.25	12	0.83	10	0.80
Guinea-Bissau	17	0.23	17	0.23	19	0.59	18	0.59
Kenya	20	0.22	20	0.22	30	0.39	27	0.39
Lesotho	41	0.08	41	0.08	41	0.26	41	0.26
Liberia	31	0.15	31	0.15	26	0.46	23	0.46
Madagascar	3	1.00	5	0.64	4	1.00	16	0.65
Malawi	19	0.22	19	0.22	25	0.51	21	0.51
Mali	16	0.23	16	0.23	17	0.66	15	0.66
Mauritania	35	0.13	35	0.13	22	0.53	30	0.37
Mauritius	5	0.94	4	0.98	5	1.00	3	1.00
Mozambique	12	0.26	13	0.26	6	1.00	4	1.00
Namibia	28	0.17	23	0.20	34	0.35	28	0.37
Niger	8	0.43	8	0.43	7	1.00	5	1.00
Nigeria	36	0.12	36	0.12	39	0.28	39	0.28
Rwanda	14	0.26	12	0.29	20	0.58	17	0.60
Sao Tome	37	0.10	37	0.10	21	0.55	37	0.33
Senegal	26	0.17	28	0.17	24	0.51	22	0.47
Seychelles	4	1.00	3	1.00	8	1.00	6	1.00
Sierra Leone	38	0.10	38	0.10	31	0.37	29	0.37
South Africa	42	0.05	42	0.05	43	0.23	42	0.24
Sudan	39	0.10	39	0.10	18	0.61	24	0.45
Swaziland	43	0.04	43	0.04	45	0.17	45	0.17
Tanzania	29	0.16	27	0.18	27	0.45	25	0.45
Togo	21	0.21	21	0.21	29	0.40	26	0.40
Uganda	34	0.13	34	0.13	33	0.36	31	0.36
Zambia	27	0.17	29	0.17	35	0.34	35	0.34
Mean		0.28		0.28		0.58		0.55

Source: Author's computation

Table C9. Efficiency of Health systems, 2011-DEA output orientation (Mono-inputs)

DMU	Rank	M(U;1in)	Rank	M(IS;1in)	Rank	M(CS;1in)
Angola	43	0.11	43	0.17	39	0.38
Benin	20	0.33	20	0.42	20	0.53
Botswana	6	0.59	7	0.65	35	0.40
Burkina Faso	35	0.22	30	0.33	22	0.52
Burundi	25	0.29	22	0.38	29	0.45
Cameroon	39	0.19	40	0.26	34	0.40
Cape Verde	1	1.00	1	1.00	1	1.00
Central African Republic	21	0.31	27	0.35	32	0.42
Chad	37	0.21	33	0.30	37	0.38
Comoros	8	0.52	11	0.54	7	0.72
Congo, Dem. Rep.	24	0.29	29	0.34	33	0.41
Congo, Rep.	28	0.28	26	0.36	21	0.53
Cote d'Ivoire	34	0.22	39	0.27	25	0.49
Equatorial Guinea	44	0.10	45	0.14	41	0.37
Eritrea	2	1.00	2	1.00	2	1.00
Ethiopia	7	0.57	6	0.66	9	0.67
Gabon	30	0.25	34	0.29	13	0.61
Gambia, The	22	0.30	18	0.44	10	0.66
Ghana	15	0.41	15	0.50	4	0.77
Guinea	27	0.29	23	0.37	27	0.48
Guinea-Bissau	38	0.20	36	0.28	42	0.37
Kenya	9	0.49	8	0.59	16	0.59
Lesotho	33	0.22	38	0.27	45	0.34
Liberia	19	0.35	21	0.39	19	0.54
Madagascar	5	0.83	5	0.88	3	1.00
Malawi	12	0.42	13	0.53	24	0.49
Mali	40	0.18	35	0.28	31	0.43
Mauritania	36	0.21	37	0.27	15	0.59
Mauritius	4	0.98	4	0.99	5	0.77
Mozambique	17	0.37	19	0.42	30	0.43
Namibia	11	0.44	12	0.54	11	0.65
Niger	16	0.38	9	0.55	23	0.51
Nigeria	41	0.18	41	0.25	36	0.39
Rwanda	10	0.46	10	0.55	26	0.48
Sao Tome and Principe	31	0.23	31	0.31	8	0.71
Senegal	14	0.41	16	0.48	12	0.65
Seychelles	3	1.00	3	1.00	6	0.72
Sierra Leone	45	0.10	44	0.14	44	0.35
South Africa	26	0.29	28	0.34	43	0.36
Sudan	32	0.23	32	0.31	14	0.61
Swaziland	42	0.16	42	0.21	40	0.37
Tanzania	13	0.42	14	0.52	17	0.58
Togo	23	0.30	24	0.37	18	0.57
Uganda	29	0.28	25	0.37	28	0.47
Zambia	18	0.36	17	0.47	38	0.38
Mean		**0.38**		**0.45**		**0.55**

Source: Author's computation

Note: M(U;1in): One output - under five survival rate; One input - health care expenditure per capita (ppp)**. M(IS;1in):** One output - under five survival rate; One input - health care expenditure per capita (ppp)**. M(CS;1in):** Three output - crude survival rate; One input - health care expenditure per capita (ppp)

Table C10. Efficiency scores, Monetary inputs - VRS - Mono input - input orientation

Country name	Rank	M(U;1in)	Rank	Mv(IS,1in)	Rank	Mv(CS,1in)	Rank	M(U;2in)	Rank	Mv(IS,2in)	Rank	Mv(CS,2in)
Angola	40	0.08	40	0.08	36	0.08	40	0.27	40	0.27	38	0.27
Benin	18	0.23	18	0.23	15	0.23	19	0.52	21	0.50	20	0.52
Botswana	25	0.18	24	0.20	42	0.02	35	0.34	31	0.36	45	0.14
Burkina Faso	22	0.21	22	0.21	19	0.21	7	0.92	7	0.92	1	1.00
Burundi	10	0.32	10	0.32	8	0.32	14	0.67	13	0.67	14	0.67
Cameroon	33	0.13	33	0.13	28	0.13	38	0.28	38	0.28	36	0.28
Cape Verde	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	2	1.00
Central A Rep.	6	0.55	6	0.55	4	0.55	11	0.79	11	0.79	11	0.79
Chad	13	0.26	14	0.26	11	0.26	9	0.85	9	0.85	9	0.85
Comoros	11	0.29	11	0.29	9	0.29	13	0.74	16	0.64	8	0.88
Congo, D.R.	7	0.53	7	0.53	5	0.53	12	0.77	12	0.77	12	0.77
Congo, Rep.	30	0.16	29	0.16	24	0.16	36	0.33	37	0.32	35	0.32
Cote d'Ivoire	32	0.14	32	0.14	27	0.14	32	0.35	35	0.33	29	0.37
Equatorial Guinea	45	0.01	45	0.01	45	0.01	43	0.22	43	0.22	42	0.22
Eritrea	2	1.00	2	1.00	2	1.00	2	1.00	2	1.00	3	1.00
Ethiopia	9	0.33	9	0.33	7	0.33	8	0.91	8	0.88	7	0.98
Gabon	44	0.04	44	0.03	40	0.03	44	0.21	44	0.21	39	0.26
Gambia, The	24	0.18	26	0.18	21	0.18	20	0.52	19	0.54	13	0.75
Ghana	23	0.19	25	0.19	20	0.19	31	0.36	32	0.35	25	0.44
Guinea	15	0.25	15	0.25	12	0.25	10	0.80	10	0.80	10	0.83
Guinea-Bissau	17	0.23	17	0.23	14	0.23	17	0.59	18	0.59	17	0.59
Kenya	20	0.22	20	0.22	17	0.22	27	0.39	27	0.39	30	0.35
Lesotho	41	0.08	41	0.08	37	0.08	41	0.26	42	0.24	41	0.22
Liberia	31	0.15	30	0.15	25	0.15	23	0.46	25	0.40	22	0.45
Madagascar	5	0.61	5	0.64	3	1.00	16	0.65	15	0.65	4	1.00
Malawi	19	0.22	19	0.22	16	0.22	21	0.51	20	0.50	23	0.44

Mali	16	0.23	16	0.23	13	0.23	15	0.66	14	0.66	15	0.66
Mauritania	35	0.13	35	0.13	30	0.13	29	0.37	30	0.36	19	0.53
Mauritius	4	0.94	4	0.98	41	0.03	3	1.00	3	1.00	31	0.35
Mozambique	12	0.26	13	0.26	10	0.26	4	1.00	4	1.00	5	1.00
Namibia	28	0.17	23	0.20	38	0.05	34	0.34	28	0.37	32	0.34
Niger	8	0.43	8	0.43	6	0.43	5	1.00	5	1.00	6	1.00
Nigeria	36	0.12	36	0.12	32	0.12	39	0.28	39	0.28	37	0.28
Rwanda	14	0.26	12	0.29	31	0.13	18	0.58	17	0.60	24	0.44
Sao Tome	37	0.10	37	0.10	33	0.10	37	0.33	36	0.32	18	0.55
Senegal	26	0.17	31	0.14	26	0.14	22	0.47	24	0.45	21	0.51
Seychelles	3	1.00	3	1.00	43	0.02	6	1.00	6	1.00	40	0.25
Sierra Leone	38	0.10	38	0.10	34	0.10	28	0.37	29	0.37	28	0.37
South Africa	42	0.05	42	0.05	44	0.02	42	0.23	41	0.24	44	0.14
Sudan	39	0.10	39	0.10	35	0.10	25	0.43	22	0.45	16	0.61
Swaziland	43	0.04	43	0.04	39	0.04	45	0.17	45	0.17	43	0.17
Tanzania	29	0.16	27	0.18	23	0.16	24	0.45	23	0.45	27	0.39
Togo	21	0.21	21	0.21	18	0.21	26	0.40	26	0.40	26	0.40
Uganda	34	0.13	34	0.13	29	0.13	30	0.36	33	0.34	33	0.32
Zambia	27	0.17	28	0.17	22	0.17	33	0.34	34	0.34	34	0.32
Mean		0.28		0.28		0.23		0.54		0.54		0.53

Source: Author's computation

Appendix D. Evolution in health system performance

Table D1: Malmquist index - mono output models - output orientation

Country name	M(LE; 2inputs)			M(ISR; 2inputs)			M(CSR; 2inputs)		
	Efficiency Change	Technical Change	Total Factor Productivity	Efficiency Change	Technical Change	Total Factor Productivity	Efficiency Change	Technical Change	Total Factor Productivity
Angola	0.995	0.992	0.986	0.953	1.029	0.981	1.002	1.008	1.011
Benin	1.006	0.980	0.986	1.002	1.001	1.004	1.016	0.985	1.000
Botswana	0.999	0.996	0.995	0.994	1.052	1.045	0.971	1.025	0.995
Burkina Faso	1.013	0.996	1.009	0.964	1.052	1.014	1.000	1.022	1.022
Burundi	1.015	0.988	1.003	0.996	1.005	1.001	1.012	0.987	0.998
Cameroon	1.009	0.962	0.971	0.987	0.992	0.978	1.017	0.970	0.987
Cape Verde	1.010	0.990	0.999	1.000	1.042	1.042	0.986	1.012	0.998
Central African Rep	1.016	0.986	1.002	0.979	1.013	0.993	1.009	1.005	1.015
Chad	1.017	0.991	1.008	0.971	1.027	0.997	1.004	1.007	1.012
Comoros	1.020	0.964	0.983	1.010	0.993	1.003	1.037	0.974	1.010
Congo, DR.	0.939	0.990	0.929	0.932	1.014	0.945	0.947	1.006	0.953
Congo, Rep.	1.011	0.968	0.979	0.988	0.997	0.985	1.020	0.981	1.000
Cote d'Ivoire	0.983	0.983	0.966	0.967	1.004	0.970	1.007	0.991	0.999
Equatorial Guinea	1.010	0.996	1.006	0.970	1.052	1.021	0.991	1.025	1.016
Eritrea	1.000	1.005	1.005	1.000	1.028	1.028	1.000	1.025	1.025
Ethiopia	0.957	0.967	0.925	0.971	0.995	0.966	0.984	0.975	0.960
Gabon	0.998	0.995	0.992	0.958	1.052	1.008	0.983	1.019	1.002
Gambia, The	0.977	0.996	0.973	0.959	1.011	0.970	0.987	1.000	0.987
Ghana	1.025	0.977	1.001	1.006	1.006	1.012	1.026	0.993	1.019
Guinea	1.012	0.989	1.001	0.986	1.023	1.009	1.014	1.006	1.020
Guinea-Bissau	1.004	0.993	0.997	0.982	1.010	0.992	1.014	0.998	1.012
Kenya	1.001	0.983	0.983	1.001	1.010	1.011	1.006	1.000	1.007
Lesotho	0.970	0.972	0.943	0.963	0.996	0.960	0.990	0.985	0.975
Liberia	0.903	0.976	0.881	0.942	1.004	0.946	0.957	0.990	0.948
Madagascar	0.996	0.995	0.990	1.010	1.020	1.030	1.003	1.015	1.018
Malawi	1.001	0.965	0.966	1.028	0.995	1.023	1.014	0.976	0.990
Mali	0.988	0.991	0.978	0.963	1.023	0.985	0.992	1.006	0.997
Mauritania	0.979	0.981	0.960	0.945	1.002	0.947	0.990	0.992	0.982

Mauritius	0.997	0.996	0.992	0.951	1.052	1.001	0.967	1.025	0.991
Mozambique	1.000	0.990	0.990	0.985	1.035	1.020	0.988	1.011	0.998
Namibia	1.010	0.996	1.006	1.010	1.052	1.062	1.002	1.028	1.030
Niger	1.000	0.996	0.996	1.012	1.011	1.023	1.017	0.998	1.015
Nigeria	1.005	0.982	0.988	1.015	1.006	1.021	1.018	0.991	1.009
Rwanda	0.970	0.989	0.959	1.011	1.015	1.026	0.983	1.001	0.983
Sao Tome	0.995	0.997	0.992	0.969	1.012	0.980	0.995	1.001	0.997
Senegal	0.989	0.986	0.976	0.999	1.005	1.004	1.009	0.991	1.000
Seychelles	1.007	0.996	1.003	0.948	1.052	0.997	0.991	1.025	1.015
Sierra Leone	0.994	0.991	0.985	0.947	1.029	0.974	0.996	1.008	1.004
South Africa	1.003	0.996	0.999	1.013	1.052	1.066	0.973	1.025	0.997
Sudan	0.973	0.990	0.963	0.924	1.028	0.950	0.979	1.006	0.985
Swaziland	1.002	0.995	0.997	0.970	1.052	1.020	0.980	1.018	0.998
Tanzania	0.948	0.969	0.919	0.977	1.000	0.976	0.986	0.983	0.969
Togo	0.992	0.975	0.967	0.971	1.004	0.975	0.995	0.990	0.985
Uganda	0.994	0.980	0.974	1.000	1.002	1.002	1.019	0.989	1.008
Zambia	1.023	0.975	0.997	1.046	1.004	1.051	1.027	0.990	1.017
Mean	**0.994**	**0.986**	**0.980**	**0.981**	**1.019**	**1.000**	**0.998**	**1.001**	**0.999**

Source: Author's computation

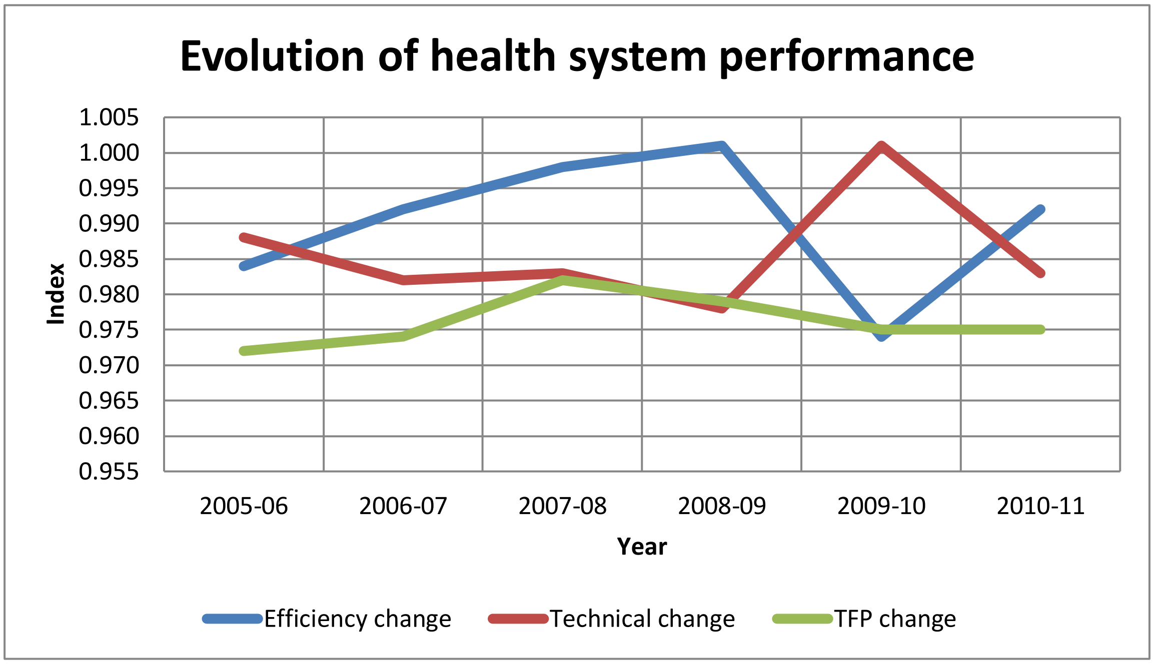

Figure D1. Trend in Malmquist indices - M(LE, ISR; 2inputs)
Note: M(LE, ISR; 2inputs) - Two outputs, life expectancy at birth and infant survival rate; Two inputs, health expenditure per capita and average years of schooling.

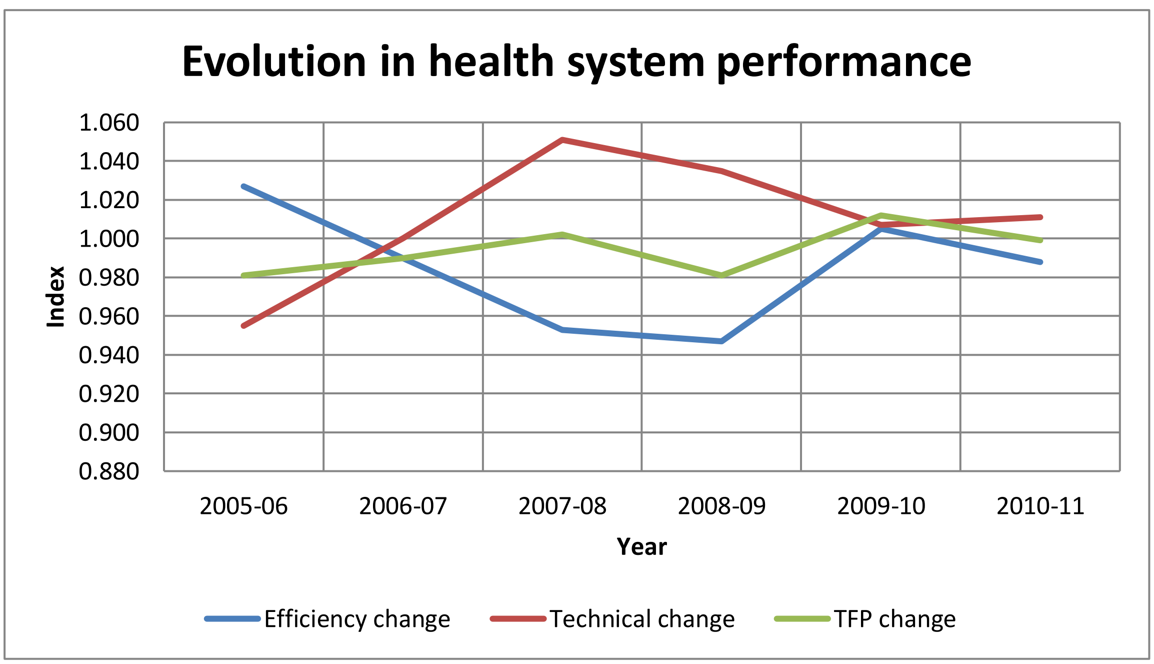

Figure D2. Trend in Malmquist indices - M(ISR, CSR; 2inputs)
Note: M(LE, ISR; 2inputs) - Two outputs, infant and crude survival rates; Two inputs, health expenditure per capita and average years of schooling.

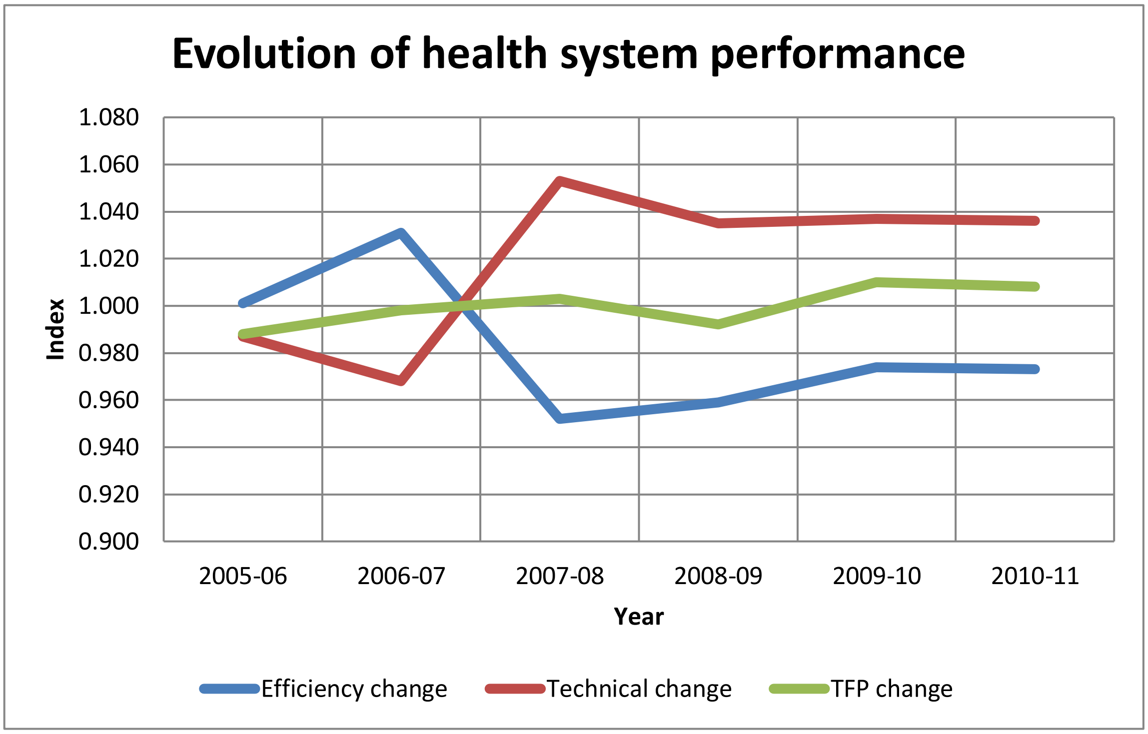

Figure D3. Trend in Malmquist indices - M(ISR; 2inputs)
Note: M(LE, ISR; 2inputs) - One outputs, infant survival rate; Two inputs, health expenditure per capita and average years of schooling.

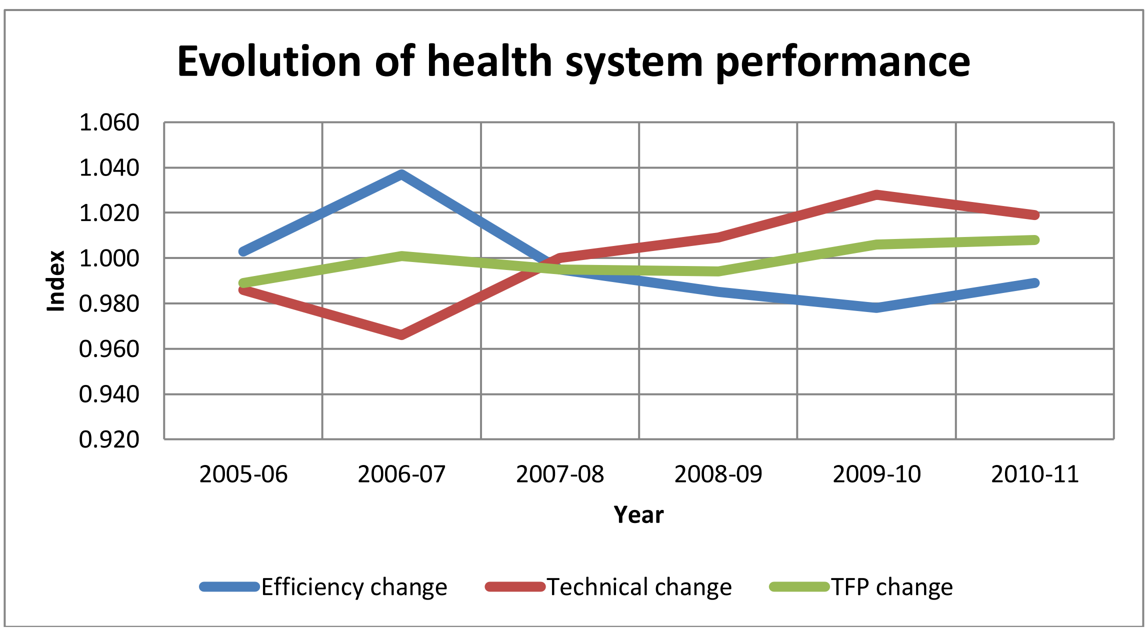

Figure D3. Trend in Malmquist indices - M(ISR; 2inputs)
Note: M(LE, ISR; 2inputs) - One outputs, infant survival rate; Two inputs, health expenditure per capita and average years of schooling.

Appendix E. Summary of Empirical Evidence

Health care expenditure and health outcomes		
Reference	**Countries studied and models**	**Principal results**
Lawanson (2012)	45 SSA countries (2003-2007). Models: Two-stage least squares; Fixed effects estimation	Public heath expenditure was significantly negative with respect to mortality variables and positive for life expectancy with elasticities as follows: infant mortality (-0.02 and -0.06); under-five mortality (-0.03 and -0.08); crude death rate (-0.08 and -0.21); life expectancy (0.01 and 0.09)
Anyanwu and Erhijakpor (2007)	47 SSA countries (1999-2004). Models: Robust OLS; robust two-stage least squares models; fixed effects estimator	Their results showed that increasing per capita total health expenditure by 10% reduces under-five mortality by 21% and infant mortality by 22% while a 10% increase in per capita public health expenditure reduces under-five and infant mortality by 25% and 21%, respectively
Nixon and Ulmann (2006)	15 European Union countries (1980-1995). Models: Fixed effects estimator	The results showed that increase in health care expenditure significantly influence infant mortality but only marginally in relation to life expectancy
Berger and Mersser (2002)	20 OECD countries (1960 - 1992). Model: panel data regression with corrected standard errors	Total health expenditure showed significant negative relationship with mortality rates (elasticity of -0.1282)
Cremieux et al., (2005)	Canadian provinces (1975-1998) Model: cross sectional time series GLS for panel data with correction for AR(1) autocorrelation within panels and heteroskedasticity across panels	Public and private drug spending were significant for all health outcomes with elasticities as: male infant mortality (-0.108); female infant mortality (-0.143); male life expectancy (0.001); female life expectancy (0.009). Total non-drug spending were significant only for male infant mortality (-0.51); male life expectancy (0.017) and male life expectancy at 65 years (-0.051)
Babazono and Hillman (1994)	21 OECD countries (1988). Model: Multiple linear regression with stepwise analysis.	They found that only female life expectancy at birth was significantly affected by health care expenditure with elasticity of 0.38
Health system efficiency		
Hernandez de Cos	29 OECD countries (1997-	The results showed that Japan was the most efficient country in terms of health system

and Moral-Benito (2011)	2009). Models: Stochastic frontier analysis (SFA).	performance. It also showed that both health system efficiency and health care expenditure positively influence life expectancy with elasticity of 0.71 and 0.06, respectively.
Mirzosaid (2011)	Commonwealth of Independent States. Model: DEA	The study found Tajikistan and Uzbekistan to be the most efficient in the single and multiple input/output case while Moldova and Russia were effective only in the multiple input/output case.
Jafarov and Gunnarsson (2008)	37 countries included. Model: DEA	Croatia ranks in the 63rd percentile in terms of public spending and 48th percentile in terms of total spending on health. The following factors were found to be associated with inefficiency in Croatia: inadequate cost recovery, weaknesses in the financing mechanism and institutional arrangements, weak competition in the provision of these services and weaknesses in targeting public subsidies on health care
Bhat (2005)	OECD member states. Model: DEA	8 out of the 24 OECD countries had efficiency score of 1.00. These include Denmark, Japan, The Netherlands, Norway, Portugal, Sweden, Turkey and the United Kingdom. Belgium, Iceland and Australia had the lowest efficiency score. The study also showed that institutional arrangements have significant impact on the level of efficiency.
Evans et al., (2001)	191 WHO countries both developed and developing (1993-1997).	The results showed Oman to be the most efficient with a score of 0.992 and Zimbabwe the least efficient with a score of 0.080. They argued that health system performance was likely to be influenced by civil unrest and the prevalence of HIV and AIDS.
Afonso and Aubyn (2005)	OECD countries. Models: free disposable hull (FDH) and data envelopment analysis (DEA)	The results for health efficiency scores using the FDH indicate that eleven among the 24 countries were efficient. The DEA efficiency score indicates that eight countries were estimated to be efficient
Alexander et al. (2003)	51 developing countries (1998-1999). Model: DEA and Tobit	The results showed that a total of nine health systems were estimated to be efficient. Results from the Tobit model showed that health expenditure, nutrition and female education were significant determinants of health system efficiency
Gupta and Verhoeven (2001)	37 African countries in comparison with countries in Asia and Western Hemisphere. Model: FDH	The results showed that on average, countries in Africa are less efficient than countries in Asia and Western Hemisphere. Further, education and health related spending reduced the level of inefficiency