UNIVERSITY OF
KWAZULU-NATAL

The Effectiveness of Public Health Spending in Sub-Saharan Africa

by

Wa Ntita Serge Kabongo

Submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy (Ph.D.)

School of Accounting, Economics & Finance

College of Law and Management Studies

Supervisor: Prof. Josue Mbonigaba

November 2023

PLAGIARISM DECLARATION

I, Wa ntita serge Kabongo, declare that,

(i) Unless otherwise specified, the studies reported in this thesis are original.

(ii) This PhD thesis has not been submitted to any other university for a degree or examination.

(iii) This thesis does not include data, images, diagrams, or information from other individuals unless the source is explicitly acknowledged.

(iv). This PhD thesis does not include the work of others unless it is expressly acknowledged as the work of other scholars. Wherever other written sources have been cited, their words have been rewritten, but all the information attributed to them has been quoted. Where the precise phrases used have been mentioned, their writings are enclosed in quotation marks and cited.

(v). This PhD thesis does not contain text, images, or tables that have been copied from the Web unless explicitly acknowledged, with the source cited in the PhD thesis and the reference section.

Signature [redacted] Date: 26 November 2023

DEDICATION

To the Almighty God, then

To my wife Kalonga Daddy Ndaya and

To my family.

ACKNOWLEDGEMENTS

I would like to express my gratitude to Professor Josue Mbonigaba for his support and guidance while writing my PhD thesis. I acknowledge the priceless time he spent reading and (re)reading my PhD thesis on several occasions to make valuable comments and suggestions, which have improved the quality of my PhD thesis. Thank you very much, Professor.

I would like to extend my gratitude to Professor Gerry Bokana, a former classmate from the University of Kinshasa, for his invaluable support in motivating me to embark on pursuing my doctoral and master's studies.

ABSTRACT

This research conducted a thorough analysis of the effectiveness of public health spending (PHS) in enhancing population health outcomes (PHO) across sub-Saharan African (SSA) countries. Implementing PHS interventions in these countries faces challenges due to the disregard of critical intermediate factors that are specific to them. These factors include high prevalence of infectious diseases, inadequate immunisation coverage, inefficiencies in the health system, governance issues, low levels of education, and underlying processes. Consequently, although the diligent allocation of financial resources towards enhancing health, PHO in the region persistently lag behind those of other global regions. This research aims to investigate the role of the above-mentioned intermediaries as transmission mechanisms of PHS and understand how these intermediaries interact with PHS to shape the effectiveness of PHS intervention. Moreover, the research assesses the benefits of using disaggregated data for measuring PHS.

To achieve its objectives, the research employed panel data from selected SSA countries and applied several quantitative methodologies, such as longitudinal growth curve mediation modelling, partial least squares structural equation modelling, and system generalised method of moments. These approaches were chosen owing to the characteristics of the different processes investigated.

The findings show that malaria incidence and female education, as indicators of infectious disease burdens and education, work sequentially as the transmission mechanism of PHS, while no indication of immunisation as a mediator was found. The findings also show that health system efficiency (HSE) and country governance are moderating factors in the PHS-PHO relationship, with weaker HSE or governance adversely affecting PHS effectiveness. Additionally, disaggregated data measuring PHS is shown to offer better evidence of PHS effectiveness.

In conclusion, the research highlights the significant role of structural factors specific to SSA in shaping the effectiveness of PHS in improving PHO in the region. Its findings underscore the imperative of integrating these factors into the development of

PHS interventions in SSA. The research provides invaluable insights into the complex nature of PHS effectiveness in SSA and proposes avenues for more targeted and impactful PHS interventions.

Key word: Public health spending, Effectiveness, Moderating effects, Disaggregated data, Transmission mechanisms

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

PUBLICATION DECLARATION

The following four articles were developed from this thesis and submitted to journals for review.

The first article is entitled *Public Health Spending in sub-Saharan Africa: Exploring Transmission Mechanisms using the Latent Growth Curve Mediation Model*. This is currently under review for publication in *The Health Economics Review.*

The second article is titled *Effectiveness of public health spending in sub-Saharan Africa: The moderating role of health system efficiency,* which is under review for publication in the journal *Development Southern Africa.*

The third article is titled *Effectiveness of public health spending: Investigating the moderating role of governance using partial least squares-structural equation modelling (PLS-SEM)*, which is currently being completed for submission to an academic journal.

The fourth article is titled Effectiveness of *public health spending* in sub-Saharan Africa: An evaluation based on disaggregated *public health spending* data, which is currently being completed for submission to an academic journal.

ACRONYMS AND ABBREVIATIONS

AR (2)	Arellano–Bond test for serial correlation
CHE	current health expenditure
DALY	disability-adjusted life year
DGGHE	domestic general government health expenditure
FE	fixed effects model
GDP	Gross domestic product
GMM	generalised method of moments
HALE	healthy life expectancy
HOC	higher-order construct
HTMT	heterotrait-monotrait ratio of correlations
LGCM	latent growth curve model
LGCMM	longitudinal growth curve mediation modelling
LI	low-income
LMI	lower-middle-income
LOC	lower-order construct
MDG	Millennium Development Goal
ME	model excluding the interaction term
MI	model, including the interaction term
OLS	ordinary least squares
PLS-SEM	partial least squares structural equation modelling
PHS	public health spending

PPP	purchasing power parity
QALY	quality-adjusted life year
SD	standard deviation
SDG	Sustainable Development Goal
SEM	structural equation modelling
SMPH	summary measure of population health
SSA	sub-Saharan Africa
UBR	urbanisation rate
UHC	universal health coverage
UMI	upper-middle-income
WHO	World Health Organisation
YHL	years of healthy lif

Chapter 1.
Introduction

1.1 Introduction

Chapter 1 provides an introduction to the study, which focused on assessing the role of intermediaries in shaping the effectiveness of public health spending (PHS) in sub-Saharan Africa (SSA) where, despite efforts to improve health through health financing, the region continues to face challenges in achieving desirable health outcomes.

This chapter provides a background to the topic, discusses the policy agenda for PHS, states the problem that the study aimed to address, outlines the research objectives, describes the scope of the research, presents an overview of the methodology employed, highlights the contribution of the study to the field of health economics, and presents an outline of the subsequent chapters.

1.2 Background

Following the end of the Cold War, numerous sessions of United Nations-led meetings in the 1990s on human rights, children, women, nutrition, and health resulted in commitments to coordinated global action on these grave issues. After diverse initiatives such as the Copenhagen Declaration on Social Development in 1995 (United Nations, 1995) and Shaping the Twenty-first Century in 1996 (OECD, 1996), the Millennium Development Goals (MDGs) were established in September 2000 by the United Nations to be achieved by 2015. The goals covered various aspects of development, including poverty reduction, education, gender equality, maternal and child health, HIV/AIDS and other diseases, environmental sustainability, and global partnership for development.

Each of the eight MDGs had specific targets and indicators to measure progress over the 15 years. The aim was to address some of the world's most pressing challenges and improve people's lives in developing countries. While significant progress was made towards achieving some of the goals, there were varying degrees of success across different regions and countries.

In particular, the MDGs aimed to address the challenges faced by the world's poorest countries, but their achievements were uneven. In other words, the progress and success in accomplishing the MDGs varied among different countries and regions. While some countries made significant strides and achieved notable improvements in the targeted areas, others struggled to meet the goals or experienced slower progress.

In 2015, the MDGs were replaced by the Sustainable Development Goals (SDGs), which built upon the progress made under the MDGs and set a new global development agenda from 2016 to 2030. The SDGs are broader in scope, encompassing 17 goals and 169 targets, aiming to address more comprehensively sustainable development's social, economic, and environmental dimensions. For instance, SDG3 for health aims to enable everyone to live excellently and promote well-being at all ages.

The current study aligned with SDG 3, which aims to enable everyone to enjoy improved health and well-being. Improved health is an important policy variable and a pillar of human capital development. Healthy individuals live healthier and longer lives and can accumulate skills through training and education, leading to higher labour income and long-term savings and well-being (Dhrifi et al., 2021). Human capital development due to improved health contributes to life enjoyment and productivity (Grossman, 1972; Sen, 1999), boosting economic growth and alleviating poverty worldwide (Adeleye et al., 2022; Tatoglu, 2011).

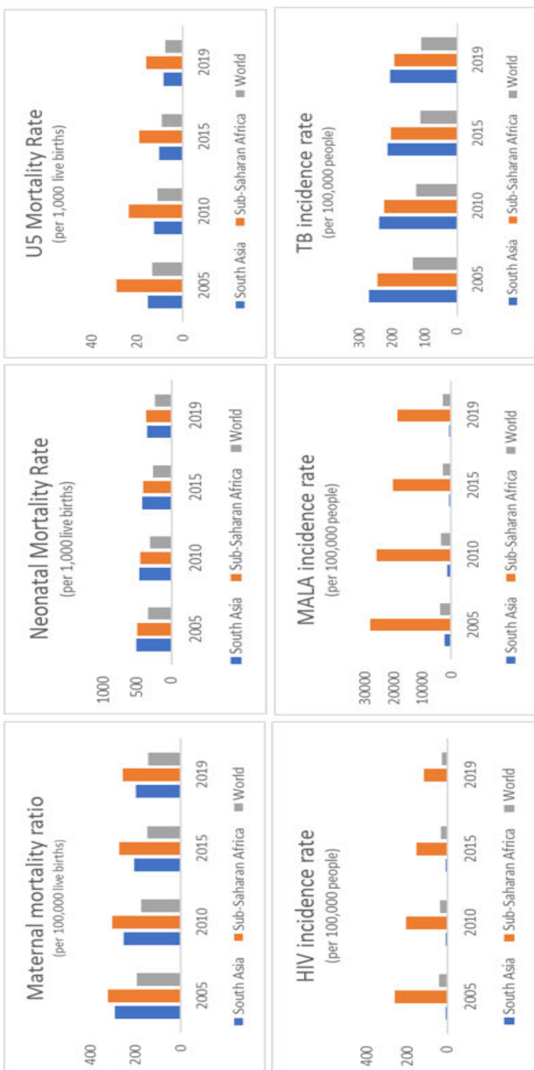
Increased human capital improves labour productivity, increases individual income, and contributes to economic growth (Bloom & Canning, 2008; Nafziger & Yoder, 2021). The benefits of human capital have been widely recognised, as a well-educated and healthy workforce is a remedy for economic stagnation and underdevelopment (Nafziger & Yoder, 2021). However, despite the significant role of health in development, the population health outcomes in SSA have remained persistently low, and addressing these challenges should be a top priority for policymakers and stakeholders in the region.

Good health status can be monitored using health outcome data. As part of the MDGs and SDGs on health-related goals, the World Health Organisation (WHO) conducts periodic assessments of health outcomes in all world regions, including sub-

Saharan Africa (SSA). From this perspective, SSA has not fared well in these assessments, as indicated in Figure 1.1 below presents the average health outcomes for SSA, South Asia, and the world in 2005, 2010, 2015, and 2019.

Figure 1.1

Selected health outcomes of SSA, South Asia, and World 2005 – 2019



Note. The graphs in the figure show the trends of the maternal mortality ratio, neonatal mortality, U5 mortality, HIV incidence, Malaria incidence and TB incidence rates in SSA, South Asia and Worldwide from 2005 to 2019. Global Health Data Exchange database. Copyright 2022 by Institute for Health Metrics and Evaluation: University of Washington.

Figure 1.1 above illustrates the trends in health outcomes for both the MDGs and the SDGs from 2005 to 2019 across all world regions. The data presented indicates a marginal improvement in health outcomes for the MDGs and SDGs targets during the specified period. However, several of the SDG targets were not achieved worldwide. These included targets for neonatal mortality (aiming for below 12 deaths per 1,000 live births), maternal mortality (targeting less than 70 deaths per 100,000 live births), and the control of HIV, tuberculosis (TB), and malaria (aiming for the end of these diseases).

One of the few successes, however, was the achievement of the under-5 mortality target, with figures falling below 25 deaths per 1,000 live births. Despite this progress, SSA consistently experienced the worst health outcomes, as indicated in Figure 1.1 above. This highlighted the urgent need for intervention in the region to address the persistently low health indicators.

In SSA, numerous studies have used various mortality indicators to measure population health outcomes. These classic indicators include cause-specific mortality rates, life expectancy, self-rated health status, and the incidence and prevalence of specific diseases. Each of these indicators offers valuable insights into different aspects of health, such as mortality, morbidity, or the impact of diseases on patients' quality of life (Wolf, 2016). However, with advancements in preventive and curative healthcare, individuals are living longer with chronic diseases and disabilities, which has shifted the focus towards considering morbidity as a crucial indicator of population health (Jagger et al., 2020). The term “morbidity” describes the prevalence or incidence of sickness and disease within a population or a specific group. Unlike mortality, which focuses on death rates, morbidity focuses on the occurrence and impact of diseases, injuries, and health conditions on individuals or communities. Consequently, combining mortality-based indicators with measures of morbidity has become essential to obtain a comprehensive and accurate view of the overall health status of populations in SSA.

Since the 1960s, efforts have been made to develop population health measures that combine mortality and morbidity, culminating in summary measures of population health (SMPH), such as the disability-adjusted life year (DALY), the quality-adjusted life year (QALY), healthy life expectance (HALE), and years of healthy life (YHL). These measures use a single numerical indicator that combines mortality and morbidity to characterise the health of a specific population (Gold & Field, 1998; Gold et al., 2002).

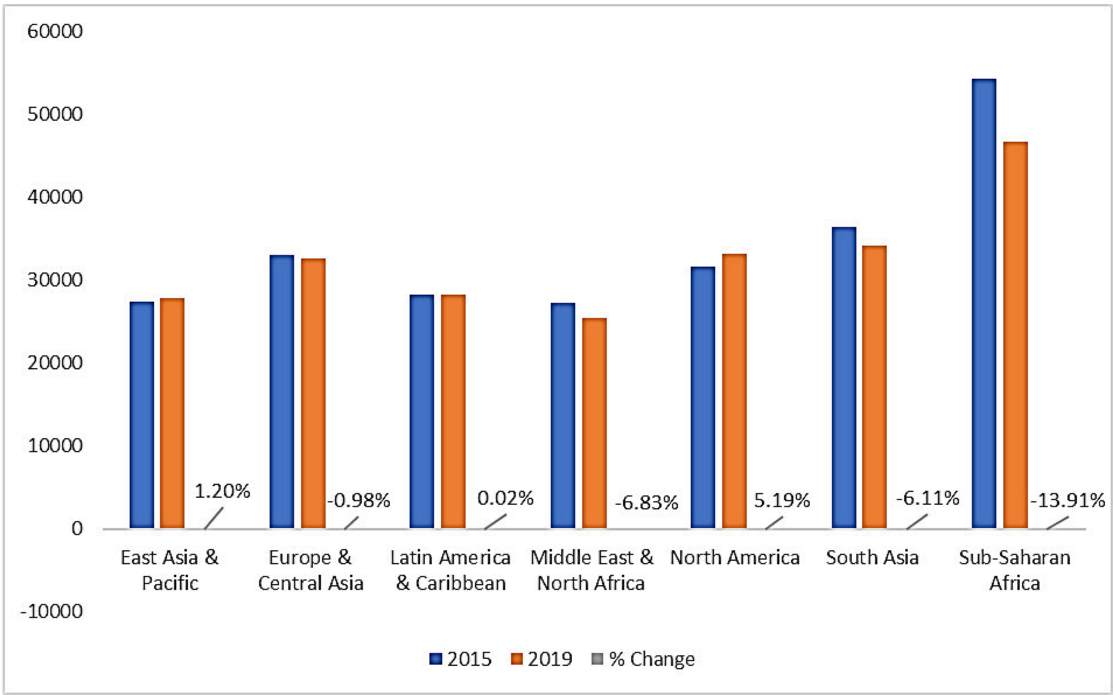
The DALY, a measure of interest in the study, was developed by Lopez and Murray in 1993 (López et al., 1994), whilst the HALE measure, also used in the study, was developed by Sullivan in 1971 (Sauerberg et al., 2020; Sullivan, 1971). These developments have triggered interest among macroeconomic researchers. Although HALE is the average number of years an individual is expected to live in excellent health, considering age-specific mortality and morbidity for a given population in a given year (Martinez et al., 2021; Wang et al., 2020), the DALY is a statistic that quantifies and combines premature death and disability caused by a disease to estimate its effect on the population (Jo et al., 2020). Since its release by the World Bank in 1993, the DALY has been the most widely used SMPH.

The DALY allows for evaluating disease burdens and health intervention effects, such as mass immunisation or the fight against malaria (Gebeyehu et al., 2022; Longfield et al., 2013; Lopez et al., 2006). With the use of the DALY, which considers both mortality and functional health loss caused by various health disorders, it is now possible to compare estimates for each disease and rank their impact on the health of the population under study (Steensma, 2012).

SSA has the poorest population health outcomes, as measured by the DALY, compared to other World Bank regions. Figure 1.2 below illustrates the DALYs of World Bank regions in 2015, when the SDGs were launched, and the progress made by 2019. In 2019, SSA had the highest all-cause DALY rate of any World Bank region, at 46,760 DALYs per 100,000 people. Conversely, in 2015, it had 54,315 DALYs per 100,000 people, a decrease of 13.91%, the most significant drop among all World Bank regions.

Figure 1.2

All-cause DALYs in World Bank regions 2015 and 2019



Note. The graph shows DALYs related to all causes from World Bank regions for 2015 and 2019. Disability-adjusted life years in DALYs per 100,000 people. Global Health Data Exchange database. Copyright 2022 by Institute for Health Metrics and Evaluation: University of Washington.

Despite achieving the highest decrease in DALYs among all World Bank regions, SSA still faced the highest burden of DALYs in 2019 (IHME, 2022). This indicates that countries in SSA needed to make significant efforts to reduce mortality and morbidity. The average DALY rate of 46,760 DALYs per 100,000 people in 2019 was the highest among all regions. In comparison, South Asia recorded the second-highest DALY rate during the same period, with 34,176 DALYs per 100,000 people. Therefore, the governments in SSA faced the challenge of improving health outcomes and reducing mortality and morbidity rates in their populations.

The low levels of population health outcomes in SSA have prevailed despite notable efforts to invest in health in the region for many years. Moreover, efforts to improve population health outcomes have increased since the 2000s, with sub-Saharan countries and development partners implementing health policies and initiatives to address the problem. These regional health policies included the MDGs implemented in September 2000, Global Fund initiatives (Global Fund, n.d.), the 2001 Abuja Declaration (OAU, 2011; Oladosu et al., 2022), global immunisation campaigns (Wolfson et al., 2008), health system strengthening initiatives (Rendell & Sheel, 2022), and the SDGs implemented on 25 September 2015 (WHO, 2016a). As a result of these initiatives, health outcomes in SSA have improved, but more must be achieved because morbidity and mortality in SSA remain high compared with other regions (Ayadi & Lawanson, 2020; WHO, 2018b).

In SSA, the main governmental policy for improving population health outcomes is increasing PHS (Olayiwola et al., 2020; WHO, 2016b; Xu et al., 2022). Moreover, the relevance of this policy has been supported by the literature (Chireshe & Ocran, 2020; Mustapha et al., 2021), especially Grossman's (1972), which model posits that individuals possess an initial stock of health that depreciates over time but can be increased through funding, including public and private health spending (Grossman, 1972). In other words, in theory, financial investment in health plays a role in determining population health outcomes. PHS represents the costs incurred by governments for providing healthcare to their populations (WHO, 2016).

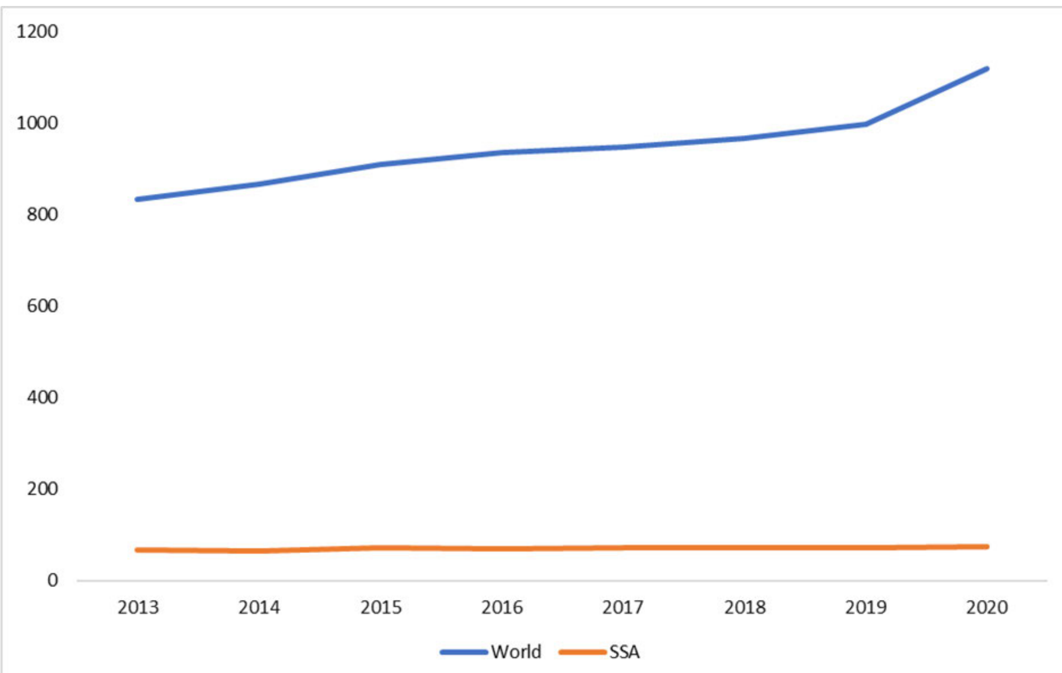
Development economists contend that PHS is a crucial policy instrument because it contributes to (1) addressing healthcare consumption concerns, (2) ensuring the optimal delivery and utilisation of health services, (3) reducing healthcare costs, the burden of disease, and catastrophic health expenditures, and 4) accelerating progress towards UHC (Boachie et al., 2018; Rad et al., 2013). For these reasons, using PHS to improve population health outcomes has been strongly advocated in sub-Saharan African countries, where most people experience multiple barriers to accessing healthcare, including high healthcare costs (Bain et al., 2022; Eze et al., 2022).

In 2019, the sub-Saharan African region recorded an average per capita PHS of US$70.13 (purchasing power parities [PPP], constant 2017 and international), which is significantly less than the global average of US$997.62 and 74 times less than the world’s highest average of US$5209.32 from North America (World Bank, 2021; World Health

Organization, 2020). This is shown in Figure 1.3 below, which depicts the per capita PHS trend between 2013 and 2020 in SSA and globally. In addition, Figure 1.3 below illustrates that the average PHS per capita exhibited an upward trend from 2013 to 2020 in SSA and worldwide. The global average hovered around US$922.17 between 2013 and 2019 before it climbed by 12% between 2019 and 2020. SSA's average per capita PHS remained around US$72 between 2013 and 2019. Although it increased between 2019 and 2020, the increase remained low at 4% (IHME, 2022; WHO, 2021).

Figure 1.3

Trends of per capita DGGHE 2013 - 2020



Note. The graph shows the trends of per capita DGGHE in SSA and Worldwide from 2013 to 2020. World Development Indicators database. Copyright 2021 by World Bank.

Figure 1.3 above shows that the average per capita current health expenditure in SSA (US$72) exceeded the minimum amount of US$60 recommended as a landmark by the high-level Taskforce on Innovative International Financing for Health Systems. This landmark was set up in 2008 to provide a set of important health interventions essential to increasing health coverage in low-income countries (Jowett et al., 2016; Stenberg et al., 2017). In 2019, current public health expenditures in sub-Saharan countries represented 4.66% of the gross domestic product (GDP), whereas private, public, and external expenditures represented 2.16, 1.66, and 1.18% of the GDP, respectively (WHO, 2020). These figures suggest that private healthcare spending accounted for the largest share of healthcare expenditure per capita, at 43% and that PHS should have been more than it was. Moreover, Low public health spending in Sub-Saharan Africa is cause for concern, given the serious effects for both individuals and society. These effects include low salaries or non-payment of health workers, a shortage of health workers, insufficient drugs and medical supplies, poor quality healthcare, and an unequal distribution of health services (WHO, 2018b). They also include the recurrence of preventable diseases and the prevalence of infectious diseases, barriers to timely and high-quality healthcare for those living in marginalised places, and an exacerbation of health inequality (Frimpong et al., 2022; Traoré, 2021).

1.3 Policy agenda for PHS

PHS is an economic policy instrument for funding and delivering health services to facilitate access, especially for the most impoverished, and ultimately, enhancing health capital (Bein et al., 2017; Xu et al., 2022). Moreover, health capital, which represents the health status of a population, is a form of human capital that determines individual productivity and overall economic and social well-being.

Global and regional policies for PHS have resulted from the MDGs, SDGs, and the Abuja Declaration (WHO, 2016; OAU, 2001). The SDGs encourage sub-Saharan countries to finance the health sector from domestic resources to ensure sustainability. The Abuja Declaration is a commitment made in 2001 by the member states of the African Union to allocate 15% of their government budgets to health to address urgent health concerns. However, few sub-Saharan countries have met this goal yearly, as many have limited budgetary flexibility (Piabuo & Tieguhong, 2017; WHO, 2014). Ineffective budget execution and wasteful spending reduce available resources for health, resulting in high costs and a deficient health system.

In SSA, ministries of health advocate for reducing spending on ineffective public programmes and for adequate funding of health services. However, achieving a balance between cost-effectiveness and meeting the population's healthcare needs remains a constant challenge. Nevertheless, some researchers suggested that implementing a significant increase in health expenditure would make achieving UHC feasible (Cashin et al., 2017; Chireshe & Ocran, 2020).

Notably, several countries in the region have successfully improved their spending on health by expanding their fiscal space through enhanced tax collection, providing exemplary practices that can serve as valuable lessons. These examples offer potential pathways for other countries in SSA to enhance their health expenditure and work towards achieving UHC. For instance, Tanzania and Uganda have instituted reforms to improve the flow of resources to health facilities and the utilisation of those resources. Gabon, Ghana, and Nigeria have allocated a substantial portion of their public revenue to the health sector (Olalere & Munyua-Gatome, 2020).

1.4 Statement of the problem

Although sub-Saharan countries have stepped up health intervention initiatives to address low health outcomes in the region (Jha et al., 2016; Scheirer & Dearing, 2011), which has led to a decline in morbidity and mortality, population health outcomes have not improved as anticipated. Moreover, SSA morbidity and mortality remain higher than in other regions (Ayadi & Lawanson, 2020; WHO, 2018b).

Despite the impact of international and regional health initiatives, including the MDGs and SDGs (Bongaarts, 2016), Global Fund initiatives (Global Fund, n.d.), the 2001 Abuja Declaration (OAU, 2011; Oladosu et al., 2022), global immunisation campaigns (Wolfson et al., 2008), and health system strengthening initiatives (Rendell & Sheel, 2022), the failure to meet health outcome targets despite increased PHS is a significant concern for sub-Saharan governments. Moreover, this raises the question of the effectiveness of PHS in improving a population's health outcomes.

The effectiveness of PHS in enhancing population health outcomes in developed countries has been the subject of extensive research (Berger & Messer, 2002; Budhdeo et al., 2015; Hsu, 2013; Lera-Lopez et al., 2016; Onofrei et al., 2021). However, the topic has received little attention in the context of sub-Saharan countries, where the existing empirical literature on PHS in SSA has produced inconsistent results (Chansa et al., 2020; Filmer & Pritchett, 1999; Grekou & Perez, 2014; Makuta & O'Hare, 2015; Mustapha et al., 2021; Osakede, 2021). Most of these studies used different mortality-based indicators to measure population health outcomes, relied on aggregated data to measure PHS, and investigated the direct relationship between PHS and population health outcomes by concentrating on the ultimate effect of PHS on population health outcomes. These measurement approaches may have had implications for the results.

It is worth noting that several structural factors, such as economic and environmental settings, country governance, persistent disease burden, and the health system, have been identified as affecting the effectiveness of health spending in SSA (Gold & John, 2013; Ibrahim et al., 2019; Ranabhat et al., 2020). These factors have the potential to either serve as transmission channels or interfere with the association between PHS and population health outcomes. Most studies examining the effectiveness of PHS have neglected to account for the potential influence of these contextual factors unique to sub-Saharan nations. However, a few studies have attempted to address these challenges when assessing the association between PHS and health outcomes within these regions (Nuhu et al., 2018; Osakede, 2021; Ssozi & Amlani, 2015). Hence, the primary objective of the present study was to investigate the influence of these factors on the relationship between PHS and health outcomes at the population level within the setting of SSA.

Within the present context of rising health issues that necessitate responses from policymakers, there continues to be a dearth of significant empirical support for the influence of structural factors specific to SSA on the effects of PHS on population health outcomes. In addition, it is imperative to provide decision-makers with considerable evidence that illustrates the influence of these factors on the effectiveness of PHS to facilitate the prioritisation and enhancement of population health outcomes. This research aligns with the ideas above yet distinguishes itself from previous research by employing multiple innovative approaches concurrently.

Firstly, the study incorporated process analysis, which enables the investigation of the channels through which PHS influences population health outcomes, as well as the moderating factors that may impact the strength and direction of this relationship (Igartua & Hayes, 2021; Memon et al., 2019). Identifying these factors that affect the PHS-population health outcomes relationship, along with their magnitudes and directions, can offer valuable insights for policymakers when designing PHS-based interventions.

Secondly, recognising that preventive and curative healthcare has significantly extended individuals' lives despite chronic diseases and disabilities, the study adopted a comprehensive approach to measure population health outcomes. By combining morbidity and mortality-based indicators, the study provided a holistic view of the overall health status of a population (Jagger et al., 2020).

Thirdly, the study utilised disaggregated data to measure PHS to avoid potential variations in PHS for specific health outcomes and programmes (Bernet et al., 2018). This approach allowed for a nuanced understanding of how different components of PHS impact population health outcomes. Moreover, disaggregated data, broken down into specific categories rather than being presented as a single aggregate or combined value, provides more detailed information about a particular phenomenon. This information helps identify disparities and patterns that may not be apparent when only looking at aggregated data.

By integrating these multifaceted methods, the study aimed to shed new light on the complex dynamics of PHS and its effect on population health outcomes, yielding valuable evidence for policymakers and enhancing the design of targeted and effective interventions.

1.5 Research objectives

To effectively address the research problems previously discussed, the subsequent research objectives were formulated.

1.5.1 Main objective

The study's main objective was to examine the effectiveness of PHS in improving population health outcomes in sub-Saharan countries.

1.5.2 Specific objectives

The specific objectives of the study were:

- To determine whether structural factors serve as channels through which PHS impacts population health outcomes in SSA (addressed in Chapter 3)
- To determine whether the efficiency of the health system influences the extent to which PHS impacts population health outcomes in SSA (addressed in Chapter 4)
- To determine whether the effectiveness of PHS in SSA depends on a country's governance (addressed in Chapter 5)
- To determine whether disaggregated data are preferable to aggregate data for measuring PHS when investigating the effectiveness of PHS (addressed in Chapter 6)

1.6 Research questions

Based on the aforementioned research objectives, the subsequent research questions were formulated:

1. Do structural factors serve as channels through which PHS influences population health outcomes in SSA? (Addressed in Chapter 3)
2. To what extent does the health system's efficiency affect PHS's impact on population health outcomes in SSA? (Addressed in Chapter 4)
3. To what extent does the effectiveness of PHS in SSA rely on the quality of a country's governance? (Addressed in Chapter 5)
4. When investigating the effectiveness of PHS, is it more advantageous to use disaggregated data instead of aggregate data to measure PHS? (Addressed in Chapter 6)

1.7 Scope of the research

The scope of the current study is focused on SSA countries. This geographic delimitation allows for a more detailed analysis of the effectiveness of PHS in one of the most deprived regions in the world. The analysis of this study covered the period from 2013 to 2019. The increased efficiency of econometric analysis when applied to panel data, the exclusion of the COVID-19 pandemic period and the availability of data were the primary factors influencing the selection of this specific period. This study concentrated solely on domestic sources of government health spending while excluding funding from international aid.

Additionally, it solely considered direct healthcare expenditures while excluding any allocation towards health infrastructure. The effectiveness of PHS was determined in this study by analysing a measure of health outcomes, including morbidity and mortality. This provides a more comprehensive understanding of population health, particularly in light of individuals experiencing an extended period of disease. This study employed quantitative data and statistical analysis to evaluate the relationship between PHS and population health outcomes.

1.8 Overview of the research methodology

1.8.1 Quantitative methods

Chapters 3 to 5 of this thesis used quantitative methodologies to investigate the subjects under discussion concerning the factors that may impact the relationship between PHS and PHO in the SSA region. The analyses used secondary data from specific sub-Saharan African nations obtained from publicly accessible databases. Various econometric software tools were employed to conduct various analyses, comprehensively examining the data and enabling a rigorous assessment of the relationship between PHS and PHO in SSA countries.

Chapter 3 focused mainly on implementing the longitudinal growth curve mediation modelling (LCGMM), an important statistical method that offers useful insights into the dynamics of variables and their interplay over time. This methodological framework facilitates the examination of mediating mechanisms that underlie these temporal changes. The use of LCGMM is highly appropriate for addressing the research question in this chapter. LCGMM allows for examining trajectories and variable changes across multiple measurement points, offering a structured approach to explore potential mediators or intermediate variables that elucidate the association between the PHS and PHO over time. This enables assessing whether changes in the mediator occur before changes in the outcome variable, a crucial factor in establishing mediation. The analysis of temporal changes in variables is essential for making informed decisions. The analysis helps to understand the factors that influence variables, allowing for predictions and understanding of cause-and-effect relationships. Comprehending this concept is crucial for policymakers when formulating economic policies, healthcare plans, and environmental regulations. This approach accounts for variations in change trajectories, exploring how mediating processes may differ across individuals or groups. Ultimately, the findings derived from LCGMM possess the potential to provide significant contributions to the development of policies or interventions that aim to promote positive changes in outcomes over a specific duration of time or mitigate negative changes.

Chapter 4 utilised regression analysis to carry out moderation analysis, which facilitates the comprehension of how the association between PHS and PHO varies across distinct situations or degrees of a moderating variable. This chapter has chosen to utilise this methodology because it can effectively capture and analyse the interactions between PHS and PHO. By employing this method, this chapter could ascertain whether the strength or direction of the relationship between PHS and PHO varied across different levels of the moderator. Additionally, this method offered a structured framework for testing study assumptions and evaluating the extent to which the moderator moderated the relationship. Furthermore, it provides quantitative estimates of the moderation effect, thereby aiding in comprehending the degree to which the moderator influences the relationship between PHS and PHO. The practical implications of the findings obtained by regression-based moderation analysis are significant, as they facilitate the identification of circumstances in which the moderator variable exerts a stronger or weaker influence on the outcome variable, PHO. This information possesses the potential to enhance decision-making processes and facilitate the implementation of actions.

Chapter 5 applied the two-stage approach for moderation in Partial Least Squares Structural Equation Modelling (PLS-SEM). A two-stage technique is particularly advantageous in this chapter since it is a statistical methodology that entails the independent evaluation of the moderating impact of an extra variable on the associations between latent components. Several factors contributed to the selection of this method. The inclusion of several mediators in the model and the fact that the model was highly complex made the use of PLS-SEM desirable. As a flexible methodology, PLS-SEM can effectively handle complex models that involve latent structures and data that do not adhere to a normal distribution. The two-stage methodology streamlines the analysis process and mitigates the computational load, particularly in scenarios including nonlinear interactions. Using the two-stage approach within PLS-SEM offers a more user-friendly method, which avoids the algorithm instability that may arise when dealing with excessively complex models by sequentially assessing the associations between latent components and the subsequent incorporation of moderation in a distinct analysis. Moreover, this method facilitates the replication of the study. It enables the comparison of findings across many studies due to its adherence to established statistical procedures often employed in moderation analysis.

In Chapter 6, the Generalised Method of Moments (GMM) estimator developed by Ahn and Schmidt (1995) was employed to estimate the parameters of the research models. This method holds significant value within econometrics due to the subsequent rationales. GMM estimators, including the Ahn and Schmidt GMM estimator, exhibit robustness against certain forms of model misspecification. They do not necessitate strong distributional assumptions and effectively address the endogeneity issues. Moreover, they incorporate the time-series dimension in panel data, a prevalent feature in economic and financial research. These estimators yield consistent and efficient estimates under diverse assumptions, accommodating heteroscedasticity and autocorrelation.

Additionally, they enable researchers to establish causal relationships by employing instruments correlated with the endogenous explanatory variables but uncorrelated with the error term. The versatility of GMM estimators allows their application in various econometric models, including those involving limited dependent variables, count data, and duration models. Furthermore, they facilitate the consideration of unobserved heterogeneity at the individual level, a common occurrence in longitudinal data analysis.

1.8.2 Health production function approach

The health production approach is a conceptual framework used in health economics and health services research to understand how inputs, such as healthcare resources and services, are transformed into health outcomes for a population. Similar to other production functions, it is dependent on the utilisation of inputs as a way to achieve desired outcomes. Therefore, this study employs this approach as a means to control the effect of the study covariates (health inputs) on the outcome (population health outcomes). This research adopted the SSA health production function developed by Fayissa and Gutena (2008) based on Grossman's (1972) model. This model considers social, economic, and environmental inputs in the production structure and contends that production function factors could be aggregated into macro-level indicators and represented as per capita variables organised by subsectors (Fayissa & Gutema, 2008). This approach is commonly employed when analysing the effectiveness of PHS and involves modelling health outcome indicators as outputs of the health production function (Adeagbo, 2022; Akinlo & Sulola, 2019; Fayissa & Gutema, 2008; Filmer & Pritchett, 1999; Kiross et al., 2020).

1.8.3 Measurement of PHS and population health outcomes

To assess PHS and population health outcomes, the research utilised two indicators—domestic general government health expenditure (DGGHE) and disability-adjusted life year (DALY).

DGGHE serves as a metric for assessing the domestic resources that the government controls for healthcare. It represents the sum of PHS by the government, encompassing various health-related policies and initiatives. DGGHE is considered a policy instrument in advancing UHC and achieving health-related SDGs. Unlike PHS indicators used in many studies, which combine multiple aspects of public health funding to evaluate their overall impact on the health of the population, the DGGHE indicator disregards the count of external funds, as their mobilisation is unpredictable and depends on the donors' will (Piatti-Fünfkirchen & Schneider, 2018). This indicator reveals the extent to which the government is dedicated to improving the country's health outcomes and investing in public health.

The DALY is a summary measure of population health considering mortality and morbidity. It serves as a single numerical indicator to assess the health status of a population. The DALY is widely recognised and employed as a population health outcome indicator to evaluate disease burden. By integrating information on years of life lost because of premature death and years living with a disability, the DALY offers a holistic perspective on the impact of various diseases and health conditions.

1.9 Significance of the study

The research investigates a pressing concern in a geographical region with high disease burdens and significant public health challenges. By assessing the effectiveness of public health spending, this research offers significant insights for enhancing the population's health outcomes, reducing disease prevalence, and increasing life expectancy in the Sub-Saharan African region.

This study's results can provide valuable insights for policymakers and governments regarding the optimal allocation of limited healthcare resources. Specifically, the research identified region-specific factors that can influence PHS's impact on population health outcomes. These factors can affect the strength and magnitude of the relationship between public health spending and health outcomes.

The results of this research also guide the prioritisation of public health efforts and allocation of funds, ultimately resulting in improved efficiency and targeted interventions. The allocation of public health resources in an efficient manner has the potential to positively impact the well-being and productivity of the workforce, thereby mitigating the economic costs associated with disease and promoting overall economic growth and stability within the region.

In addition, the implications of the research's findings are of great importance for epidemic preparedness, as allocating public health resources plays a critical role in effectively addressing disease outbreaks, including the emergence of infectious illnesses such as pandemics. The findings of this research contribute to an improved understanding of the broader health implications of PHS.

This was achieved by utilising novel methodology and the disability-adjusted life year, a measure of population health outcomes which provides a more comprehensive assessment of a population's health by considering both mortality and morbidity. Additionally, the study employed the domestic general government health expenditure, a measure of public health spending that allows focusing on public domestic resources while enhancing population health outcomes.

1.10 Outline of the thesis

Chapter 1: This chapter provides the introduction to the study by presenting a background to the topic, a discussion of the policy agenda for PHS, the problem statement, the research question and objectives, an overview of the methodology employed, the contribution of the study to the field of health economics, and an outline of the subsequent chapters.

Chapter 2: This chapter provides the background and contextual information on health and PHS in the sub-Saharan region to set up the contextual and conceptual overview from which subsequent results and discussion will be understood.

Chapter 3 provides empirical evidence of the transmission mechanism of PHS. It is the form of an essay explaining the channels through which PHS, as measured by DGGHE, affects population health outcomes, as measured by DALY, in the sub-Saharan region. This essay examines both simple and serial mediation analyses, with growth rates and initial levels of malaria prevalence, female education, and immunisation coverage as mediators in the relationship between the DGGHE and DALY growth factors. This essay explains how the study used panel data for 42 sub-Saharan countries from 2015–2018 collected from the Global Health Data Exchange, World Development Indicators, and Global Health Expenditures databases (IHME, 2022; World Bank, 2021; WHO, 2021) and applied the latent growth curve mediation modelling approach within the structural equation modelling framework.

The results explained in Chapter 3 suggested that malaria and female education form a channel through which DGGHE impacts the DALY in sub-Saharan countries. This impact was achieved via the specific paths from the DGGHE slope to the DALY slope via malaria and female education slopes. However, the study did not find the mediating effects of immunisation coverage in the relationship between DGGHE and the DALY in sub-Saharan countries. This implied that the government should emphasise malaria control and promote female education. This would result in improved population health outcomes because of PHS intervention. The main contribution of the essay presented in Chapter 3 is its investigation of the mediational process in the relationship between DGGHE and DALY. Other contributions included the implementation of parallel mediation and latent growth curve mediation modelling techniques and studying PHS effectiveness. Further details are provided in Chapter 3.

The second essay (Chapter 4) provides empirical evidence of the moderating effects of health system efficiency on the relationship between PHS and population health outcomes, as measured by DGGHE and the DALY, respectively. This essay explains how the study evaluated the impact of health system efficiency on the relationship between DGGHE and the DALY in sub-Saharan countries and the moderating effects of health system efficiency on this relationship. The study used the GMM estimator based on linear and nonlinear moment conditions to analyse panel data from the Global Health Data Exchange, World Development Indicators, and Global Health Expenditure databases for 42 sub-Saharan countries from 2008 to 2018 (IHME, 2022; World Bank, 2021; WHO, 2021).

The results indicated that an increase in DGGHE was significantly associated with a reduction in the DALY, with the smallest reduction occurring in the countries with the lowest health system efficiency scores. Furthermore, the results suggested that the moderating effect of health system efficiency is significant only for countries with health system efficiency levels at or above the average health system efficiency score. The most important contribution of this part of the study was the investigation of the factors that determined the strength and/or size of the relationship between DGGHE and the DALY.

The use of health system efficiency scored as a moderating factor in the relationship between PHS and population health outcomes, which was another contribution of the study, as it allowed the researcher to capture the broad potential of the health system in the model. The policy implication of the study's results is that when designing PHS-based interventions, governments in sub-Saharan countries should consider strengthening factors with the potential to improve health system efficiency. Further details are provided in Chapter 4.

The third essay (Chapter 5) presents empirical evidence of the moderating effects of country governance on the relationship between DGGHE and the DALY because it evaluates the extent to which country governance affects the magnitude and/or size of this relationship between DGGHE and the DALY. The study described in this essay applied the two-stage approach for moderation using PLS-SEM to analyse panel data from the World Governance Indicators, Global Health Data Exchange, World Development Indicators, and Global Health Expenditure databases for 43 sub-Saharan countries from 2013 to 2019 (IHME, 2022; World Bank, 2021; World Bank, 2022; WHO, 2021).

The results suggested a disordinal or crossover interaction effect of country governance on the negative association between DGGHE and the DALY. This interaction indicated the moderating effect of country governance, which faded as governance improved. These results highlighted the importance of good governance for the effectiveness of PHS in sub-Saharan countries. They suggested strategies to improve the quality of country governance when planning health-spending-based interventions. The study contributed two ways to the literature on health spending in the SSA. It investigated country governance as a moderator of the relationship between DGGHE and the DALY. It used PLS-SEM to evaluate the model used to investigate the effectiveness of DGGHE. Further details are provided in Chapter 5.

The fourth essay (Chapter 6) provides empirical evidence on the use of disaggregated data to measure PHS when evaluating the effectiveness of PHS in SSA. The study examined whether disaggregated data for measuring DGGHE provided better estimates of PHS effectiveness than aggregated data. This investigation contributed to the growing literature on PHS by addressing the challenge of selecting aggregated or disaggregated data types to measure PHS. The study uses a GMM estimator, based on the linear and nonlinear moment conditions developed by Ahn and Schmidt (1995), to examine panel data from the Global Health Data Exchange, World Development Indicators, and Global Health Expenditure databases for 31 sub-Saharan countries between 2013 and 2019 (IHME, 2022; World Bank, 2021; WHO, 2021).

The results revealed that when compared to the aggregate DGGHE, DGGHE spent on HIV/AIDS and DGGHE spent on TB provided superior evidence of PHS effectiveness in the sub-Saharan region. These results underscored the policy implications and need for governments in SSA to use disaggregated data to evaluate the effectiveness of their PHS-based interventions. Further details are provided in Chapter 6.

Chapter 2.
Health and Public Health Spending in the Sub-Saharan Context

2.1 Introduction

This chapter provides the background and contextual information on health and PHS in the sub-Saharan region to set up the contextual and conceptual overview from which subsequent results and discussion will be understood. This chapter describes the health conditions in the sub-Saharan region in the context of the SDGs. It addresses PHS as a strategy for achieving UHC and the health SDG agenda. It also examines countries' progress in the sub-Saharan region as they have adopted various measures to move their populations towards the health goals of the 2030 Agenda for Sustainable Development. This chapter is divided into two main sections. The first analyses sub-Saharan health statistics to know where sub-Saharan states stand and why, and the second discusses PHS as an essential tool that sub-Saharan countries should use to achieve their health objectives. The chapter starts by defining concepts.

2.2 Definition of concepts

2.2.1 Public health spending

2.2.1.1 Defining public health spending

Healthcare spending is defined as spending on "all activities with the primary purpose of improving, maintaining, and preventing the deterioration of individuals' health status and mitigating the consequences of ill health through the application of qualified health knowledge" (OECD et al., 2011). System health accounting (SHA 2011) developed three analytical approaches to healthcare expenditure analysis: function or consumption, supply, and financing. The classification of health expenditures into healthcare functions, providers, and financing systems allows countries to focus on specific areas of health policy. It allows for a more thorough analysis of health expenditures (OECD et al., 2011). The healthcare function or consumption classification allows for functional dimension analysis by examining the breakdown of healthcare expenditure by beneficiary characteristics such as disease, age, gender, region, and socioeconomic status. The healthcare provider classification investigates the cost structures of healthcare provision and capital formation, removing any doubt about the relationship between healthcare and capital expenditure. The classification related to healthcare financing systems examines how funds are raised, managed, and used, including financing schemes, financing agents, and revenue collection mechanisms (OECD et al., 2011). This study considered classifications of health expenditure into health care functions and health care financing systems. PHS, which results from the health care financing systems classification, was disaggregated in this study according to the investigated health outcomes.

2.2.1.2 Measuring public health spending

Public health expenditures and DGGHE are the indicators used to measure PHS. Their encompassing components consist of transfers originating from national public revenues, social insurance contributions, and mandatory prepayments designated for healthcare, as well as intragovernmental transfers from national public revenues, which include budget allocations, transfers made by the government on behalf of particular groups, subsidies, and other forms of transfers (WHO, 2017). Unlike PHS indicators, DGGHE indicators exclude external support, such as direct foreign transfers and transfers distributed by the government from a foreign origin (Piatti-Fünfkirchen & Schneider, 2018), which are typically driven by donor interests, can conflict with the health objectives of assisted countries, and are included in public health expenditures (Khan et al., 2018; WHO, 2017).

2.2.2 Population health outcomes

2.2.2.1 Understanding population health outcomes

Researchers frequently employ the concept of population health, but there is no consensus regarding its definition. The concept originates from Evans et al.'s (1994) article titled *Why Are Some People Healthy and Others Not? The Determinants of Population Health*. Grasping the factors that influence health has led to a field of study or research concentrating on the determinants themselves (Evans, 1994). According to

Health Canada's Health Promotion and Programs Branch, the overarching objective of a population health approach is to maintain and improve the health of the entire population and reduce health disparities between population groups (Health Canada, 1998). In other words, population health refers to the health of a population as measured by health status indicators and influenced by social, economic, and physical environments, personal health practises, individual capacity and adaptability, human biology, early childhood development, and health services. It focuses on the interrelated conditions and factors that influence the health of populations across the lifespan, identifies systematic variations in their occurrence patterns, and applies the resulting insights to the development and implementation of policies and actions aimed at improving the health and well-being of these populations.

The term has recently become more prevalent in developed nations, but its meaning and definition remain unclear. Consequently, the term may be more confusing than useful, similar to the confusion surrounding "community health" or "quality of medical care". A more precise definition is provided to promote active criticism and discussion, which may lead to elucidation and standardisation of usage (Kreuter & Lezin, 2001). The greatest source of confusion in population health is the difference between viewing population health as a field of study of the factors influencing health and as a concept of health. According to some observers, population health is a new term that emphasises the impact of social and economic forces and biological and environmental factors on the health of entire populations.

Others view population health as the objective of measurably enhancing the health of a specified population (Kreuter & Lezin, 2001). Three options have emerged for defining population health. The first considers population health as being determined by multiple determinants, the second by health outcomes, and the last by defining and measuring health outcomes and the role of determinants. The latter approach is preferable as it concentrates attention and research efforts on the impact of each factor and their interactions on the desired outcome (Culyer & Maynard, 1997). In addition, it permits consideration of health disparities and inequalities, the distribution of health among subpopulations, and the ethical and value considerations underlying these issues.

Given these considerations, Kindig and Stoddart (2003) propose that population health be defined as "the health outcomes of a group of individuals, including the distribution of these outcomes within the group" (Kindig & Stoddart, 2003).

These populations interest policymakers and are frequently geographical regions, such as nations or communities. They can also be other groups, such as employees, ethnic groups, people with disabilities, or prisoners. This definition of population health necessitates the measurement of population health outcomes, including their distribution. The term "health outcomes" is chosen over "health status" because the latter refers to health at a particular moment rather than over a prolonged period (Kindig & Stoddart, 2003). Since there is no definitive measure, this definition implies the need for summary measures that can act as the dependent variable for all determinants and other sub-measures for different policy and research purposes.

The study lent credence to the notion that the field of population health is also characterised by a focus on the multiple determinants of health outcomes, regardless of how they are measured. These factors encompass public health measures, medical care, physical environment components (clean air, urban planning, and water), social environment factors (social support, income, education, culture, employment), individual genetics, and behaviour. Therefore, to be able to examine systematic differences in outcomes within populations, the complexity of interactions between determinants, the socio-economic pathways linking determinants to population health outcomes, and the influence of different determinants over time and across the life cycle, population health researchers must employ a variety of methods and approaches capable of handling these issues.

2.2.2.2 Measuring population health outcomes

Health indicators are used to assess population health outcomes. The WHO defines health indicators as "a public health surveillance construct that defines a measure of health (i.e., the prevalence of a sickness or other health-related event) or a factor associated with health among a specified population" (WHO, 2001). While health indicators may give valuable information on many health qualities and dimensions, as well as the functioning of the health system, this analysis focuses on quantitative indicators that provide assessments of health status.

Existing population health outcomes indicators are divided into three metrics: mortality, morbidity, and SMPH, which incorporate mortality and morbidity data (Etches et al., 2006). The SMPH are the subject of the study because it integrates information on mortality and non-fatal health outcomes in a single numerical index to describe the health of a given population (Gold et al., 2002; Robine et al., 2003). The SMPH are better for quantifying population health outcomes since individuals live longer with chronic illnesses and impairment (Jagger et al., 2020). SMPH indicators are divided into two categories: health expectations and health gaps, from which various particular types of indicators have been compiled (Gold et al., 2002; Robine et al., 2003).

Health expectancies extend beyond simply mortality-based life expectancy calculations to determine how long individuals may expect to live without certain diseases or limitations on their usual activities. Health gaps measure the difference between a population's health and its norm or aim (for example, the average age at death of 80). Historically, mortality-based indicators have been used to measure population health. However, as preventive and curative healthcare became increasingly effective in changing disease patterns by allowing individuals to live longer with chronic diseases and disabilities, morbidity has emerged as a crucial indicator of population health (Jagger et al., 2020).

Since the 1960s, efforts have been made to develop population health measures that combine mortality and morbidity dimensions of health, culminating in SMPH, such as the DALY, QALY, HALE, and YHL. The DALY has been the most often used health gap indicator since its first publication in the World Bank's World Development Report in 1993 (Investing in Health) (Murray et al., 2000). The DALY, a measure of interest in the study, was developed by Lopez and Murray in 1993 (López & Murray, 1994), whilst HALE measures, also used in the study, were developed by Sullivan in 1971 (Sauerberg et al., 2020; Sullivan, 1971). These developments have triggered interest among macroeconomic researchers. Although HALE is the average number of years an individual is expected to live in excellent health, considering age-specific mortality and morbidity for a given population in a given year (Martinez et al., 2021; Wang et al., 2020).

The DALY is a statistic that quantifies and combines premature death and disability caused by disease to estimate its effect on the population (Jo et al., 2020). Since its release by the World Bank in 1993, the DALY has been the most widely used summary measure of population health. The DALY allows for evaluating disease burden and health intervention effects, such as mass immunisation or the fight against malaria (Gebeyehu et al., 2022; Longfield et al., 2013; Lopez et al., 2006). With the use of the DALY, which considers both mortality and functional health loss caused by various health disorders, it is now possible to compare estimates for each disease and rank their impact on the health of the population under study (Steensma, 2012).

For a specific disease or health condition, the DALY is calculated as the sum of the years lost due to specific premature mortality and the years lost due to disability for incident cases of a specific disease or health condition. Whereas it has a broad range of applications, the DALY is a key component in the WHO's ranking of global healthcare systems based on the burden of disease (Gebeyehu et al., 2022; Lopez et al., 2006). Information on the disease burden in the population is critical for health officials because it assists in identifying health areas to prioritise when implementing PHS interventions.

2.3 Health Statistics in SSA

Health statistics suggest that SSA's population's health status is poor (Arthur & Oaikhenan, 2017; Chireshe & Ocran, 2020). Therefore, the study focused on health outcomes, health system performance and health system investment to describe the health situation in SSA. These components provided relevant insights to understand better the state of health in SSA (WHO, 2018).

2.3.1 Health and health outcomes

From the viewpoint of the SDGs, health is viewed in a wider setting, with less focus on diagnosing and managing particular illnesses. To track the progress of health concerning the SDGs, the study examined healthy and productive times of life and focused on the conditions that influence the population's health.

2.3.1.1 Healthy life expectancy.

Healthy life expectancy is the average number of years an individual is expected to live in excellent health, considering age-specific mortality and morbidity for a given population in a year (Martinez et al., 2021; Wang et al., 2020). It is the total number of years someone can live in good health. Sub-Saharans are now enjoying longer life expectancies than ever before. This region's life expectancy at birth was approximately 64 years in 2018. This is a remarkable rise of 11 years from 2000 when the life expectancy at birth in SSA was only 53 years. Life expectancy at birth is the expected total of years a newborn will live based on the assumption that present mortality rates remain unchanged. Variations in life expectancy can be used to monitor the effects of health issues that affect entire populations, such as the HIV/AIDS epidemic in the sub-Saharan African region. Keeping track of life expectancy can also give essential data needed to allocate resources and implement successful interventions in the field.

Research indicates that life expectancy in SSA differs between women and men, in sub-regions, and across countries (Dicker et al., 2018; Martinez et al., 2021). For example, men's life expectancy in SSA is 62 years, while women's is 66 years (Dicker et al., 2018). In central Africa, men have an average life expectancy of 60 years, while those in eastern Africa can expect to live to 63 years. In the Central African Republic, women have an average life expectancy of 64 years, while in southern Africa, it is 68 years. Men in the Central African Republic have the lowest life expectancy compared to southern Africa, at 49 years. The highest life expectancy, 73 years, is observed in the Republic of Cabo Verde. Women in those countries have a life expectancy ranging from 55 to 79 years (Dicker et al., 2018).

In the setting of the SDGs, life expectancy assessment is not beneficial compared to HALE, which differentiates between merely living and living without illness or ill health. Table 2.1 below presents the trends in HALE from 2015 to 2019 in SSA.

Table 2.1

Trends in healthy life expectancy in SSA, 2015–2019

Measure of healthy life expectancy (at birth)	2015	2016	2017	2018	2019
Healthy life expectancy at birth, Average	54.30	54.77	55.18	55.63	56.06
Healthy life expectancy at birth, Median value,	54.25	54.78	55.32	55.97	56.34
Healthy life expectancy at birth, Regional range	22.87	21.92	21.31	19.57	19.38
Healthy life expectancy at birth, Country Income Level (2019)					
LI countries	53.25	53.75	54.15	54.65	55.11
LMI countries	55.35	55.83	56.27	56.66	57.06
UMI countries	55.10	55.40	55.77	56.25	56.61
Healthy life expectancy at birth, Country special categories					
Large population (highest 10)	55.04	55.47	55.95	56.47	56.93
Small population (lowest 10)	55.40	55.79	56.21	56.47	56.36
High population density (highest 10)	53.44	57.75	58.17	58.46	58.83
Low population density (lowest 10)	53.58	53.98	54.25	54.69	55.13
In-/post- Conflict states, 2010 - 2016	51.76	52.21	52.56	53.08	53.60
Healthy life expectancy at birth, Country level of health Investment					
High total Health spending (highest 10)	53.37	56.68	55.25	55.60	56.21
Low total health spending (lowest 10)	54.19	54.54	54.52	52.42	55.44

Note. Reprinted from *The State of Health in the WHO African Region: An analysis of the status of health, health services and health systems in the context of the Sustainable Development Goals,* by WHO, 2018, Brazzaville: WHO Regional Office for Africa. Licence: CC BY-NC-SA 3.0 IGO.

Between 2010 and 2019, the average life expectancy of people in good health in SSA increased from 52 to 56 years. The median HALE also increased from 52 to 56 years over the same period. This suggests an improvement in the overall health of people in the region. Five countries, Cabo Verde, Sao Tome, Mauritania, Comoros, and Senegal, have an average HALE of over 55 years, much higher than other nations. Thirteen additional countries have an average HALE of fewer than 50 years, representing a substantial decline. In the last five years, the span of HALE across countries in the region has dropped from 24 to 19 years (Byaro et al., 2022; WHO, 2021b). This HALE decrease implies narrowing disparities between countries in sub-Saharan Africa, although disparities remain substantial.

The HALE enhancement is above average in LMI countries. UMI countries and, finally, LI countries follow this. The magnitude of the improvement in HALE is at its maximum once countries achieve the status of a lower-middle-income country. The health of countries with large populations is improving rapidly. This might be due to the lower average HALE of countries with large populations, which is 55.0 years compared to 55.4 years for small-population countries.

Concentrating on these high-population countries may result in greater regional HALE improvements. HALE improves slightly quicker among states with high population densities than those with lower populations. This may be because countries with higher-density populations are in urban areas, where improvements in health conditions are significant, and access to healthcare is easier than in rural areas with low population density (Ameye & De Weerdt, 2020; Atake, 2021).

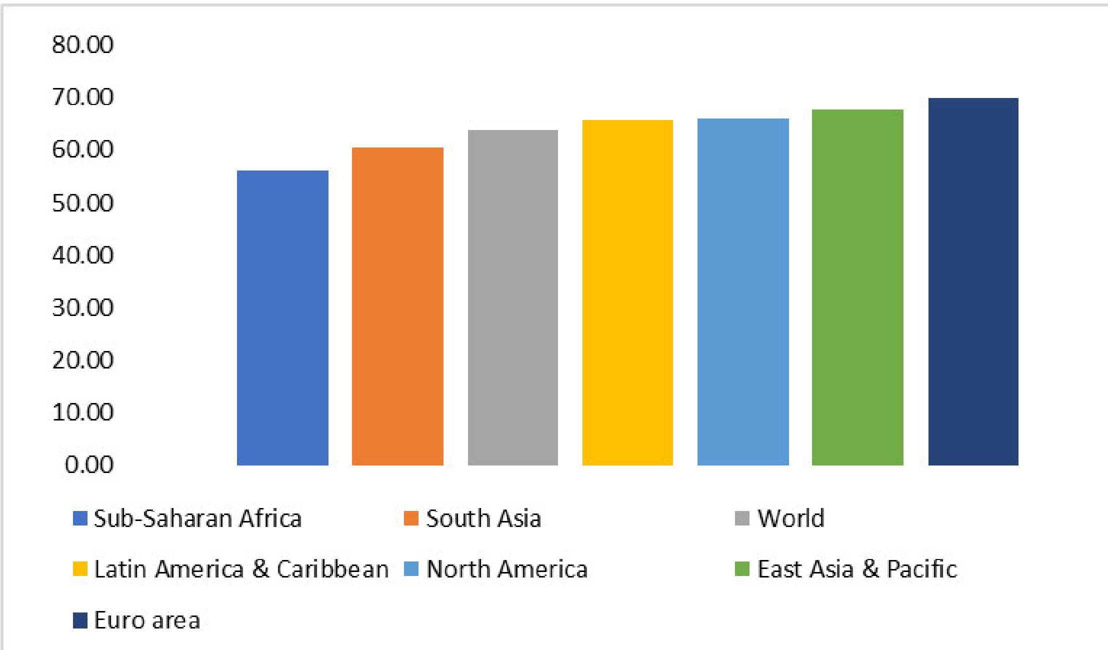
Focusing on countries with high population density shows a relative improvement in HALE. In contrast, countries classified as post-conflict or recent post-conflict in the 2010-2016 period did not show significant improvements in the health of their populations. Concentrating on these countries will not result in a significant increase in the region's healthy living dividends.

Based on countries' health expenditure levels, there is no major difference in improving HALE. Table 2.1 shows that high-spending countries have, on average, a higher HALE (55.42 years) than low-spending countries (54.22 years), even though the average rate of improvement in HALE in high-spending countries (1.35%) is twice that in low-spending countries (0.63%) (WHO, 2018).

A comparative analysis of HALE across the world's regions underscores that countries in SSA need to enhance their health outcomes. Figure 2.1 below illustrates the average HALE across the WHO Region in 2019.

Figure 2.1

Average healthy life expectancy by WHO region 2019



Note. The graph shows the trend of the average healthy life expectancy in the WHO regions in 2019. Global Health Data Exchange database. Copyright 2022 by Institute for Health Metrics and Evaluation: University of Washington.

Figure 2.1 above confirms that the levels of HALE in the sub-Saharan region are still much reduced than in other parts of the world. This region is the only one in the World Health Organization recording a HALE of less than 60 years (56.2 years, contrasted to the next lowest, South Asia, at 60.4 years). SSA presents a deficit of 14 years in HALE compared to the European region, which is the highest-achieving region in the world (WHO, 2021).

2.3.1.2 Morbidity and mortality in SSA

The direct sources of ill-health and mortality in SSA are diverse, with three conditions ranking among the highest five. This section analyses mortality and morbidity benefits from the comprehensive information derived from the 2000-2015 MDGs evaluation (WHO, 2018). Despite progress made, there is evidence that morbidity remains a significant health issue in SSA, with socioeconomic and environmental factors playing a significant role; therefore, calls to action have been made to address the issue (Adedokun & Yaya, 2020; Alebel et al., 2021; BeLue, 2017). Table 2.2 below shows the patterns in the top five sources of morbidity between 2000 and 2015.

Table 2.2

Causes of morbidity in SSA, 2000 and 2015

2015 Rank	Condition	Cause of Morbidity (DALYs per 100 000 people)		
		2015	**2000**	**% variation**
1	Lower respiratory infections	6,546	11,360	-42.4
2	HIV/AIDS	4,637	11,016	-57.9
3	Diarrhoeal diseases	4,497	10,336	-56.5
4	Malaria	3,600	10,665	-66.2
5	Preterm birth complications	3,215	4,890	-34.3
	Total	**22,495**	**48,267**	**25,772**

Note. Global health expenditure database. Copyright 2021 by World Health Organisation.

HIV/AIDS, Lower respiratory contagions, and diarrhoeal infections are the leading three causes of ill health in SSA. They account for over 65% of the total DALY associated with the top five conditions. From 2000 to 2015, this proportion decreased from 69.7 to 67.7%, while the DALY per 100,000 people linked to the highest five diseases has decreased significantly by more than half since 2000, proving the significance of the efforts made by sub-Saharan countries. The largest decreases were related to infectious diseases, with the incidence of malaria (66%), HIV/AIDS incidence (57.9%), and diarrhoeal ailments

(56.5%) exhibiting the greatest decreases in ill health. Conversely, the condition with the least amount of reduction was non-communicable with preterm birth complications (34.3%). It is crucial to note that morbidity has had a substantial impact on children, and the likelihood of suffering from morbidity increases for children aged 12 to 23 months, children born in higher order, children of small size at birth and children from households without improved toilets (Ameye & De Weerdt, 2020).

HIV/AIDS, Lower respiratory contagions, diarrhoeal sicknesses, stroke, and ischaemic heart disease are the five leading causes of death in SSA, which has the highest mortality rate worldwide. Table 2.3 below presents the trends in the highest five causes of death between 2000 and 2015.

Table 2.3

Causes of mortality in SSA, 2000 and 2015

2015 Rank	Condition	Cause of Mortality (per 100 000 people)		
		2015	**2000**	**% variation**
1	Lower respiratory infections	101.8	157.7	-35
2	HIV/AIDS	76.8	179	-57
3	Diarrhoeal diseases	65	136.3	-52
4	Stroke	45.6	47.2	-3
5	Ischaemic heart disease	44.5	45.5	-2
	Average	**66.74**	**113.14**	**-46.4**

Note. Global health expenditure database. Copyright 2021 by World Health Organisation.

Table 2.3 above shows that mortality rates of the top five disease killers decreased significantly in sub-Saharan countries from 113.14% in 2000 to 66.74% in 2015. The most significant decrease was in diarrhoeal diseases, with 52%, while a small decrease was recorded in ischaemic heart disease. The comparison of the crude deaths worldwide best indicates the extent of the mortality decrease in the sub-Saharan region.

Table 2.4 below presents the crude death rates and overall fatalities across global regions in SSA during the period under study. The mortality decreased, with the mean crude death rate being due to the highest five sources of death dropping from 113.14 to 66.74 per 100,000 people. The most remarkable decreases in crude mortality rates were seen for HIV/AIDS (57%), malaria disease (66%), and diarrhoeal illnesses (52%). Noncommunicable diseases had the lowest amount of mortality reduction, with ischaemic heart illness (2%) and stroke (3%) being the most affected. This makes it more important for sub-Saharan countries to reduce mortality and morbidity by focusing on infectious diseases. Table 2.4 below contrasts crude mortality rates and overall deaths among WHO regions between 2000 and 2015.

Table 2.4

Overall deaths and crude death rates in world regions, 2000 – 2015

WHO regions	Crude death rates *(all causes)/100 000 people*			Total deaths *(all sources) thousands*		
	2015	2000	% change	2015	2000	change
SS African	950	1,449	-34	7906	8713	-807
Americas	666	670	0	6575	5592	983
South-East Asia	718	829	-13	13836	13041	795
European	1,020	1,089	-6	9279	9439	-160
Eastern Mediterranean	625	727	-14	4023	3400	623
Western Paci c	718	635	13	13309	10699	2610
Global	769	852	-10	56441	52135	4306

Note. Global health expenditure database. Copyright 2021 by World Health Organisation.

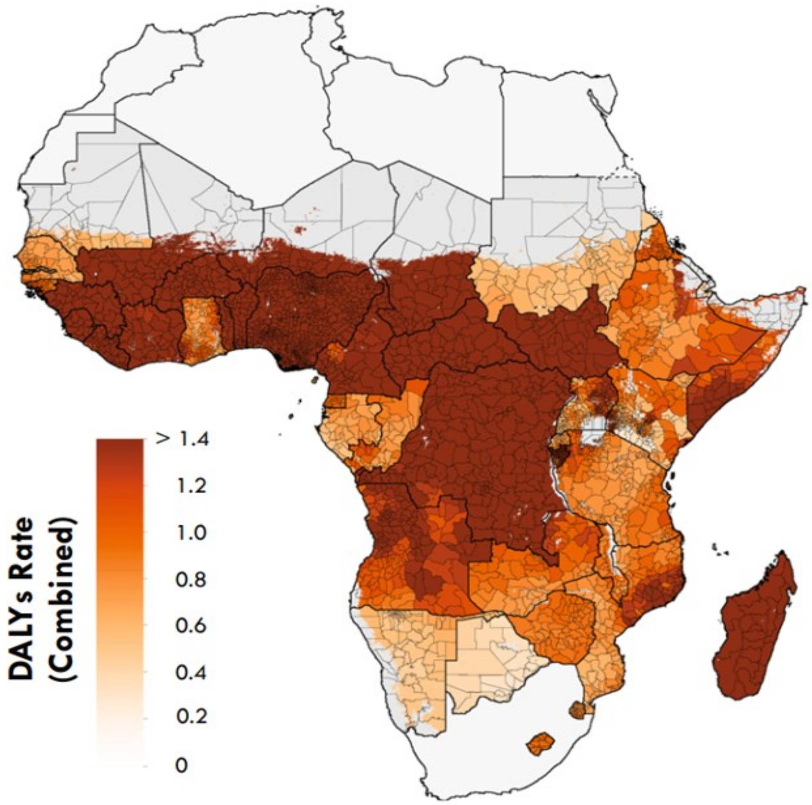
Between 2000 and 2015, the all-cause fatality rate in the sub-Saharan African region decreased by 34%, as shown in Table 2.4 above. Compared to the global reduction of 10%, the mortality rate recorded in SSA is extremely high, placing SSA among the two regions to have experienced a significant reduction in the mortality rate (from all causes) during the period. Furthermore, regarding the number of deaths, SSA recorded the best result, with the greatest decrease in deaths from all causes during the period. These figures demonstrate the efforts made by sub-Saharan countries to reduce preventable deaths in their respective countries.

2.3.1.3 The state of child disease burden in SSA

Most childhood illnesses and deaths in the sub-Saharan region are caused by three of the most common diseases: lower respiratory infections, diarrhoea, and incidence of malaria. In 2017, the average all-source DALY rate among children in all the countries in SSA was 2 DALYs per child annually, resulting in a total of 248.8 million all-cause DALYs (Kyu et al., 2018). Although this burden may be broken down into non-communicable and infectious diseases and injuries, more than half of it (54.7%; 136.0 million DALYs) was caused by infectious diseases (Kyu et al., 2018). Despite the existence of proven and effective interventions, In SSA, lower respiratory contagions, malaria, and diarrhoeal illnesses accounted for around two-thirds of the infectious disease burden in 2017 (94.1 million; 69.2%) and accounted for more than one-third of the total disease burden among all causes (37.8% of all DALYs) (Bhutta et al., 2013). In 2017, the D.R. Congo, Ethiopia, and Nigeria had a combined total of over five million DALYs attributed to kids owing to these three causes, with Nigeria contributing over 31.4 million DALYs alone. The combined DALYs for low respiratory infections, diarrhoea, and malaria vary greatly between countries (Reiner Jr & Hay, 2022). Figure 2.2 below presents the joint DALY distribution in 2017.

Figure 2.2

Distribution of combined DALY in SSA 2017



Note. Adapted from "The overlapping burden of the three leading causes of disability and death in sub-Saharan African children" by R. C. Reiner Jr and S. I. Hay, 2022, Nature Communications, 13(1), p.7457. Copyright 2022 by Nature Communications.

Figure 2.2 above shows that the combined DALY rate in Sierra Leone, Niger, Chad, and Central African Republic was greater than one DALY per infant annually. These nations have the highest rate of DALYs for children under five of any country in the world, as the worldwide average DALY rate for lower respiratory infections, malaria, and diarrhoea was around 0.2 per child year (Kyu et al., 2018). The mean combined DALY rates in sixteen sub-Saharan countries exceeded 0.5 per child-year. A DALY per child of more than 0.5 signifies a substantial combined burden, while a value above 1 indicates an extremely high combined burden. Kyu et al. (2018) observed that countries with a greater overall all-cause burden had a larger proportion attributed to low respiratory infections, malaria, and diarrhoea combined (Kyu et al., 2018).

At the national level, there is a clear indication that overall interventions that would simultaneously decrease the burden of lower respiratory conditions, malaria, and diarrhoea would have a tremendous effect in countries with the largest total infantile illness burden. The combined disease burden varied significantly between countries from 2000 to 2017 (Reiner Jr & Hay, 2022). In summary, the burden of combined low respiratory infections, malaria, and diarrhoea decreased in almost every country from 2000 to 2017. Countries with the highest combined burden, like Sierra Leone and Niger, have achieved considerable decreases through different paths. Niger experienced a significant decrease in their LRI (56.4%) and diarrhoea burden (64.0%), while their malaria burden only saw a minor increase (31.2%) over the period. The introduction of Hib, pneumococcal, and rotavirus childhood vaccines for lower respiratory infections in Niger has not decreased the disease burden (Troeger et al., 2020).

Despite the inconsistent patterns, the existing combined burden through most of Niger is generally evenly distributed among the three causes (33.3% incidence of malaria, 36.6% diarrhoea, and 30.2% low respiratory infections) (Reiner Jr & Hay, 2022). In contrast, Sierra Leone experienced a steadier decrease in burden among all three sources (27.0% incidence of malaria decrease, 63.1% diarrhoea decrease, and 56.1% low respiratory infections reduction), likely due to the significant reduction in micronutrients (zinc and vitamin A) deficiencies (Troeger et al., 2020). In addition, Sierra Leone initiated a government programme (the Free Health Care Initiative) in 2010, intending to expand access to healthcare, thereby improving access to and equity for maternal and child health services (Bognini et al., 2022).

2.3.2 Health systems performance

Health systems are viewed as instruments for achieving health improvement objectives through the organisation, financing, and quality assurance of health services. Consequently, a nation's health system is crucial to the effectiveness of curative or preventative health interventions. An efficient health system ensures that the public receives essential health and health-related services when and where they are required. The study applied the framework proposed by the WHO African Region to evaluate the health system performance (WHO, 2018). This framework focuses on the health system investments impact in four domains. Table 2.5 below shows the performance characteristics of the health system in the four domains considered. These characteristics were used as evaluation criteria because they represent each category's expected outcomes of health system investments. Improving the features of these four domains will ensure the delivery of important health services.

Table 2.5

Characteristics of health system performance

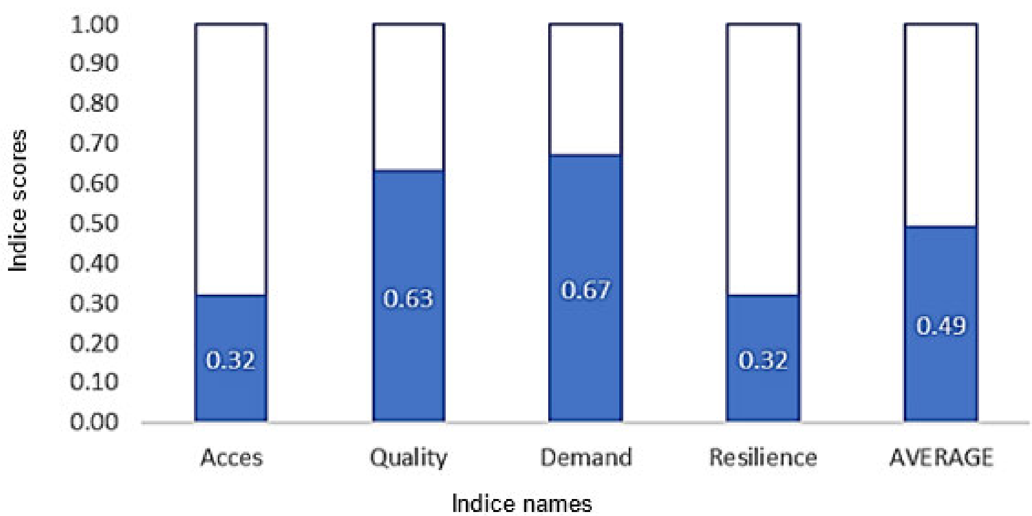
Attribute	Description	Achievement Measurements
Access to medical and health related-services	The elimination of physical barriers that impede the population's access to services. Primarily, this is accomplished by locating the health workforce, infrastructure, and equipment, as well as medicines and products, as near as possible to the population.	Health and health-associated services are accessible to families and communities, enabling them to be used whenever necessary.
Quality of Care Service when providing essential health and health-related services	How well the Services provided are aligned with the legitimate requirements of the customers. This includes experiences throughout the use of basic amenities, safety factors, and the efficacy of supplied interventions.	Health and health-connected services are structured in a way that maximizes potential benefits for families and communities.
Effective demand for health and health related services	Attitudes, knowledge, and behaviours of families and communities that influence their utilisation of available needed health and health-related services.	Families and communities are making use of available health and health-associated services in a way that optimizes their health and wellbeing.
Resilience in supplying needed medical and health-related services	The inherent ability of the health system to continue providing vital healthcare and related services despite outbreaks, natural disasters, or other stresses.	Families and communities continue to have access to medical and health-related services despite system disruptions.

Note. Reprinted from The State of Health in the WHO African Region: An analysis of the status of health, health services and health systems in the context of the Sustainable Development Goals, by WHO, 2018, Brazzaville: WHO Regional Office for Africa.

The performance of these areas was measured using indices of the four characteristics presented in Table 2.5 above: access, quality of care, demand, and resilience indices. Figure 2.3 below shows the performance indices of the four domains of health system investment in sub-Saharan countries as well as the global medical system performance indicator. The health system performance index comprises the four aforementioned indices.

Figure 2.3

Performance Indices of Health Systems in SSA, 2017

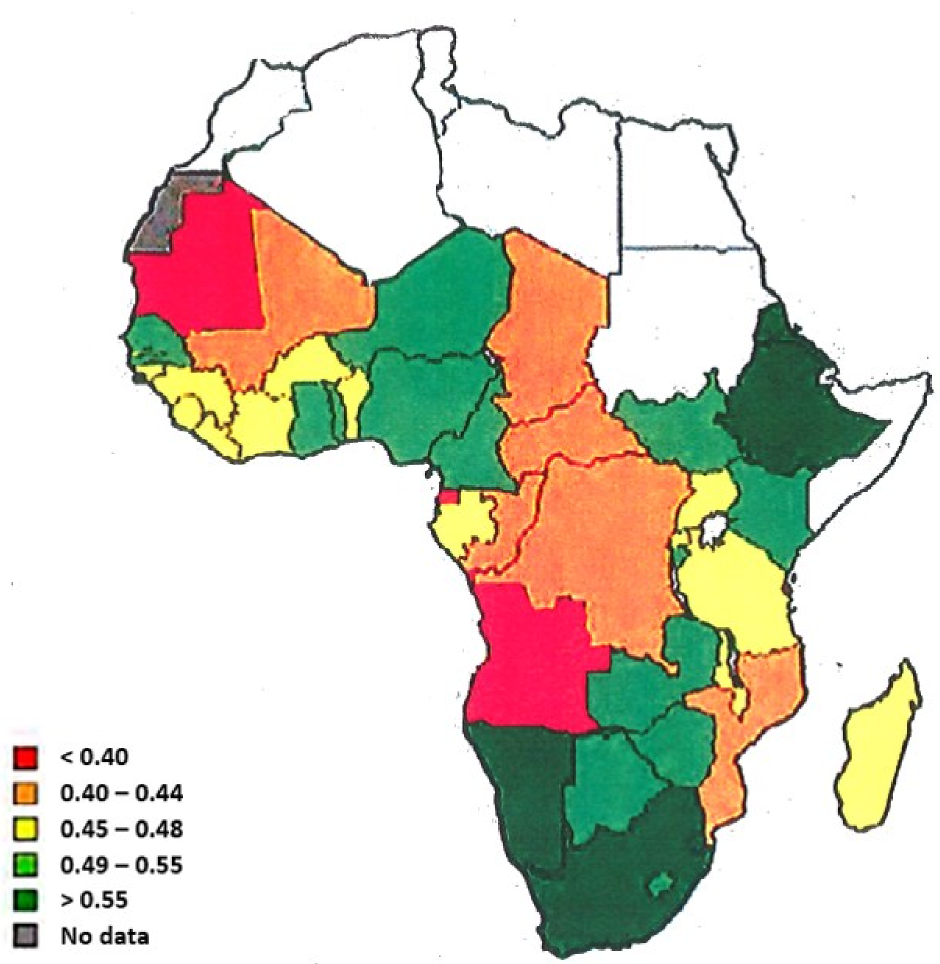


Note. The graph shows the performance indices of health systems in SSA in 2017. Adapted from *The State of Health in the WHO African Region: An analysis of the status of health, health services and health systems in the context of the Sustainable Development Goals,* by WHO, 2018, Brazzaville: WHO Regional Office for Africa. Licence: CC BY-NC-SA 3.0 IGO.

As shown in Figure 2.3 above, all indices that make up this global performance rank are below 1, indicating an underperformance. Access to essential services and system resilience is the lowest of all the attributes. According to these indices, the combined health system performance index for SSA was 0.49 in 2017, indicating that health systems only operated at 49% of their potential performance level. Substantial enhancements in system performance are necessary for successful progress towards health and well-being. Figure 2.4 illustrates the distribution of the overall index of health system performance across sub-Saharan countries.

Figure 2.4

Health System Performance Level in SSA, 2018



Note. The figure shows the health system performance level distribution in the SSA countries in 2018. Adapted from The State of Health in the WHO African Region: An analysis of the status of health, health services and health systems in the context of the Sustainable Development Goals, by WHO, 2018, Brazzaville: WHO Regional Office for Africa. Licence: CC BY-NC-SA 3.0 IGO.

As shown in Figure 2.4 above, a wide variation in the health system performance index is observed across regional countries. The best-performing health systems – South Africa, Namibia, and Ethiopia – only perform at approximately 70% of the feasible. Nevertheless, most of the country's performance lies between 0.4 and 0.6, a limited performance range. However, the performance of a few countries requires further investigation. Angola has an extremely poor performance (0.26), explained by long-lasting violence in this country, impeding efforts to construct a comprehensive health system. Following the war, the health system construction emphasised certain features such as specialised staff. Countries such as Burundi, South Sudan, and Zimbabwe have recently faced political challenges that significantly impact their health systems' functionality. However, these countries appear to have performed better than expected. This is most likely due to hurdles in obtaining credible data from these countries because of the breakdown of their information systems. The data indicators used to produce these nations' health status indices are either missing or do not adequately reflect their situations (WHO, 2018).

2.3.3 Health system investments

The performance level required to advance towards UHC necessitates the health sector to invest in certain domains. The framework of actions of the WHO African Region defines seven health system investment areas, which fall into two categories (WHO, 2018): 1) tangible inputs that are necessary to provide essential services, such as the health staff, medical goods and technologies, and health infrastructure; and 2) intangible procedures that are necessary to facilitate the use of tangible inputs, including the design of service delivery schemes, health information, health governance, and health funding. The health system's performance depends on the amount, allocation, and effectiveness of health investment.

An analysis of the government funding in 18 countries in SSA for these investment areas reveals that, on average, 60% of the funds are allocated to tangible input fields and 40% to intangible process fields (WHO, 2018). This pattern has been sustained for several decades. Regarding tangible sectors, the government spent the most on medical supplies (39%) and health personnel (14%). Infrastructure, including transport, equipment, and information and communication technology, receives only 7% of government expenditure (WHO, 2018). Further analysis is required to understand better whether this investment apportionment is efficient. This is especially true given that a different pattern of public spending is observed in South Africa, one of the nations with a well-functioning medical scheme, where spending on medicines, intangibles, health staff, and infrastructure represents 13%, 14%, 40%, and 33%, respectively (WHO, 2018). In this best-performing country, the focus is put on the health personnel (40% against 14% in the most spending country among the 18 countries) and infrastructure (33% against 7% in the most spending country among the 18 countries), which has a better-performing health system than other states with less performing schemes. If this pattern is seen in other states with successful health systems, there will be a need to primarily raise public spending on health personnel and investments in infrastructure.

In SSA, medical funds are sourced from the government, private sector, or foreign sources. These funds can be classified as project or program funds, out-of-pocket funds, pre-payment resources, or tax incomes (WHO, 2018). These funding sources are used differently across the region's countries since they possess distinct qualities: private sources are the most enduring, government-related sources are the fairest, and external sources are the easiest to access. Nevertheless, external sources are not sustainable, government sources are hard to increase, and private sources are unfair, especially when the income gap is wide. In 2015, government funding for health in SSA ranged from 7.4% to 97.0% of current health expenditure (CHE). External funding accounted for between 0.5% and 71% of CHE, while private spending ranged from 2.5% to 77% (WHO, 2018).

SSA utilises three distinct buying modalities: input-based, output-based, and outcome- or result-based. Every modality has its benefits and drawbacks. Most government funds employ an input-based purchasing system, using resources to acquire inputs such as hiring medical workers, constructing infrastructure, and purchasing goods. This is the most administratively practical way of buying services, but it is inefficient since it does not link funds to outcomes. This issue can be resolved by enhancing variables which promote the efficiency of the region's health system and governance. Numerous sub-Saharan nations use this technique to acquire services.

Output-based purchasing is becoming a more popular way of financing health services and has yielded positive results in Kenya and other pilot countries (Ekirapa-Kiracho et al., 2022). It is based on outcomes related to the funding, such as the delivery of services by institutions and the immunisation of children. Connecting outputs with financing can enhance resource utilization efficiency, yet it has been challenging to expand this approach due to the institutional barriers that impede financing.

Certain nations have adopted outcome-based purchasing, especially for out-of-pocket or insurance payment plans (Gatome-Munyua et al., 2022). Funding is based on specific outcomes or results typically identified by diagnoses. This enables a focus on spending based on the outcomes achieved due to the healthcare process. Diverse experiences are present in the region; while it is easier to monitor, outcome-based purchasing requires significant investments in audit capability to limit diagnosis creep, which leads to practitioners selecting diagnoses with better financial returns (WHO, 2018). Although there are various sources of financing for health in SSA, research has demonstrated that government funding is a more effective approach for UHC and achieving the health agenda in the sub-Saharan region, as it offers people financial protection against catastrophic health expenditures in this region, where people are impoverished (Meheus & McIntyre, 2017; United Nations, 2019a).

Good health system governance is essential to ensure effective global health investment, as it creates the conditions in which public and private sector health investment can occur (West et al., 2017). The quality of healthcare governance in 18 LMI countries from SSA and Asia was evaluated, with a particular emphasis on management capacity, regulatory systems, medical infrastructure, and policy conditions. The study examined 25 facets of health governance based on the research literature summarising the metrics related to investment choices, focusing particularly on metrics that mirror essential aspects of health management, regulations, policies, infrastructure, financing, and medical systems. The LMI countries evaluated in the study include selected sub-Saharan countries such as the D.R. Congo, Ethiopia, Ghana, Kenya, Liberia, Mozambique, Nigeria, Sierra Leone, South Africa, Tanzania, and Uganda. The selection of these countries was guided by their geographical diversity, potential to improve health outcomes and population size.

The analysis yielded the following noteworthy results: 1. LMI countries can draw more private investment in medical care Research and Development by increasing transparency, enhancing management capabilities, reducing tariffs on medical products to the financially feasible extent, accelerating governing reviews of new drugs, constructing effective medical infrastructure, and increasing well-targeted and efficient public spending on health. 2. South Africa and Ghana are among the countries that scored the highest in overall health governance in the study, which are the most likely to draw private sector investment in medical Research and Development. 3. Several countries have elements of excellent governance that appear conducive to fostering an investment-friendly environment. South Africa and Uganda, for instance, have instituted effective health regulations in SSA, where South Africa has made substantial investments in health infrastructure, and Kenya has endeavoured to construct its health system. 4. Ghana and Liberia have effective health leadership and administration. In contrast, Tanzania has implemented several effective health policies. 5. Nigeria and the D.R. Congo have lower key health governance metrics scores.

On a larger scale, countries need supportive policy, regulatory, and administrative frameworks to promote beneficial health outcomes and stimulate investments in global health research and development. Governments, corporations, and non-governmental organisations will be more capable of taking advantage of new investments related to global health objectives if the capacity to utilise resources effectively is enhanced. It will be more probable for private investors to invest in global health. Research and Development if it is clear that the resultant vaccines, drugs, and diagnostics will comply with regulatory, policy, and legal requirements and produce positive health outcomes (West et al., 2017).

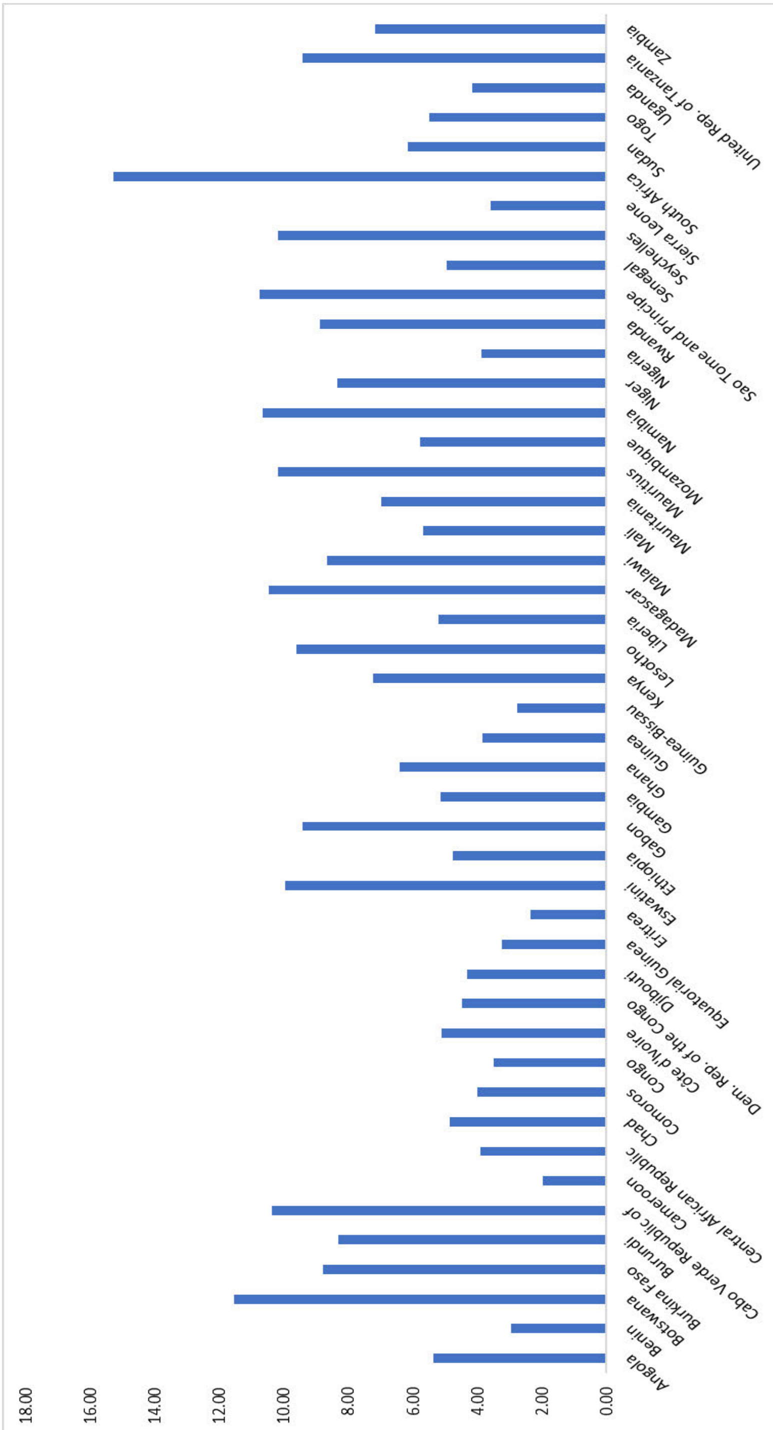
2.4 Public health spending: A better strategy to fund health

2.4.1 The Abuja Declaration on Health Spending

In 2001, a year after the adoption of the Millennium Development Goals, African heads of state held a meeting in Abuja (Nigeria) with the primary objective of addressing the growing burden of TB, malaria, HIV/AIDS, and other related sicknesses through enhanced health systems in the African region. African state leaders pledged to allocate 15% of their yearly budget to health expenditures at this meeting. This allocation reflected the acknowledgement of the critical role of public financing in providing sustainable and equitable healthcare, as well as the sub-Saharan government's commitment to the Abuja Declaration (WHO, 2011). Figure 2.5 below shows PHS as a portion of the overall government spending in SSA in 2018.

Figure 2.5

DGGHE as a share of overall government expenditure in SSA 2018



Note. The graph shows the DGGHE as a share of overall government expenditure in SSA in 2018. Global health expenditure database. Copyright 2021 by World Health Organisation.

As shown in Figure 2.5 above, South Africa was the only country that met the Abuja commitment in 2018, with PHS representing 15.29% of the overall government expenditure. Only 7 other countries had health spending above 10% of the government budget but less than 15% of the required spending. These countries include Botswana (11.5%), Madagascar (10.5%), Mauritius (10.2%), Namibia (10.7%), the Republic of Cabo Verde (10.4%), Sao Tome (10.8%), and Seychelles (10.2%). The failure to achieve the Abuja objective might be ascribed to a lack of devotion and inconsistencies in the implementation of the Abuja Declaration, as several countries have either abandoned the Abuja objective or are not implementing it in its entirety (Tandon & Cashin, 2010; World Bank, 2013).

Note that while the share of PHS in overall government expenditure in SSA has exhibited sustainable attainment of the Abuja goal since 2015, some countries, such as Chad, Guinea-Bissau, Madagascar, Namibia, Sao Tome, Sudan, and Zimbabwe, have achieved this target at least once since the implementation of the Abuja Declaration. The trend from 2001, when the Abuja Declaration was launched, to 2018 demonstrates that sub-Saharan countries have made significant advances towards this goal (Dzingirai, 2023; Sadr-Azodi, 2019). After seventeen years, twenty out of the forty-eight African governments had raised the percentage of public expenditure devoted to health. Appendix 2 shows the trend in PHS as a share of overall public spending from 2001 to 2018.

Appendix 2 reveals some interesting trends in the country's performance towards achieving the targets set by the 2001 Abuja Declaration, which called for governments to allocate 15% of their budgets to healthcare. Several countries that met or were close to achieving the target in 2005 significantly decreased their health expenditures by 2011, when no country met it. For instance, Guinea-Bissau, Namibia, Niger, and Tanzania reduced their spending on health from 12.56%, 15.75%, 13.54%, and 13.51% in 2005 to 2.52%, 10.64%, 8.30%, and 6.76%, respectively, in 2011. Particular attention should be paid to Guinea-Bissau, whose PHS, as a proportion of total government expenditure, dropped drastically from 12.56% in 2005 to 2.52% in 2011.

This can be partially attributed to the 2008 economic crisis, which considerably affected this nation's government budgets, unlike other countries. Furthermore, the country has experienced political unrest and an exceptionally high HIV/AIDS rate compared to other countries in West Africa (Galjour et al., 2021). While no country met the target in 2011, some countries, such as Eswatini, Ghana, Madagascar, Namibia, and South Africa, moved closer to the goal by spending more than 10% of their overall government expenditure on health.

In 2016, only two countries achieved the Abuja target: Madagascar and South Africa, with 17.51% and 15.29%, respectively. Botswana, Burkina Faso, Burundi, Mauritius, Namibia, Cabo Verde, and Sudan recorded 11.22%, 11.03%, 10.39%, 10.39%, 10.20%, 10.47%, and 12.94% target achievements, respectively. The trend in the share of PHS spending to total government spending in most sub-Saharan nations is cause for concern regarding the commitment of sub-Saharan governments to the Abuja Declaration. While the average level of PHS per capita in the sub-Saharan region increased from US$57.94 in 2000 to US$91.37 in 2018 (a 58% increase), this increase didn't culminate in the increase in PHS anticipated under the Abuja commitment (WHO, 2019).

The preceding evidence shows that simply committing to the Abuja Declaration target is insufficient for achieving better health outcomes. The collection must be supported by true political will on the side of the governments to change the health status on the ground by adopting the best approach to enhance the population's health. Given the severe medical issues confronting sub-Saharan countries, efforts to collect health funding must not be limited to achieving 15% of public spending. It should be emphasised that meeting the 15% objective should not be considered adequate grounds for limiting increases in health funding, as some countries may have health requirements that require much higher funding.

The experience of various countries in reforming their public finance systems to support progress towards universal health shows that success depends not only on raised public budgets but also on well-targeted budget distributions. This is true in the sub-Saharan region, where public health resources fail to target priority areas because of their inefficient distribution (WHO, 2016b). Moreover, deficiencies in public financial management prevent the systematic and total disbursement of the annual health budget (WHO, 2016), resulting in missed opportunities to improve health outcomes.

There needs to be approved efficiency in how public health resources are used since it is sometimes possible to move towards better service coverage and financial protection without significantly changing how public funds are used. While it can be argued that the provision of public funds for health contributes to the achievement of universal health, there is evidence that for every US$100 that enters government coffers in Africa, an average of US$16 is allocated to health. Still, only US$10 and less than US$4 are spent on adequate health services (WHO, 2016).

Consequently, it is not evident that countries that spend a high proportion of their public health resources are on track to meet health-related goals. This was recognised by the adoption of the Addis Ababa Action Agenda on Financing for Development (Agenda, 2015) and the SDGs in the second half of 2015, which considered and supported the need to investigate the nature of available resources and how they are used, rather than focusing solely on the volume of resources that must be mobilised to make progress towards UHC.

According to WHO, the development of the medical sector in sub-Saharan countries remains a source of concern because of the following four characteristics (WHO, 2018): a) The deprioritisation of health seen through their non-increase following an increase in income; b) inconsistent health finance and c) underspending in health care. Concerning deprioritisation, the increase in GDP did not increase proportional health spending, suggesting deprioritisation, which jeopardised the government's ability to continue improvements in the health sector sustainably. For example, when government revenue in the region increased by an average of 18% of GDP in 2014 because of the region's significant economic expansion over the previous decade, this increase did not match that of the spending in the health sector.

Regarding inconsistent health finance, the latter stems from the inconsistency and unpredictability of local and external resource levels and flows, impeding the health sector's ability to plan and implement strategies properly. Uncertainty in available resources affects sector performance, efficiency, accountability, transparency, and governance. The unpredictability of resources impedes budget implementation and adds to historical planning and potential misallocations. Concerning the underspending in the healthcare budget, it appears that even when governments seek to boost healthcare spending, the budget execution is poor. Inadequate health and public finance management links are a leading cause of underspending in the medical sector. For example, unrealised spending in SSA is approximated to be between $10 and $100 million (WHO, 2016).

The extent to which medical spending is underutilised is essential for the government's running and gauging the level of success in the health sector. Given their commitment to universal healthcare, access to and optimal use of allocated resources must be the primary goal of strengthened collaboration between the financial and health authorities at all levels of public management. The last feature of the medical system in SSA is the misallocation of health resources. Significant quantities of funds are assigned to "wrong" factors. Evidence suggests that primary health care accounts for less than 40% of PHS in most sub-Saharan countries. Access to critical services is frequently supported through out-of-pocket payments, undermining people's financial security. Governments must emphasise service delivery and poor protection when raising health expenditures.

The discussion above shows that government health financing in SSA requires reform. Health financing should enhance the population's health because it is expected to support better access to and utilisation of health amenities, provide financial protection against the burden of healthcare costs, and make progress towards universal public health. This reform will require substantial adjustments at the national level to establish the explicit use of healthcare purchasing mechanisms as a policy tool.

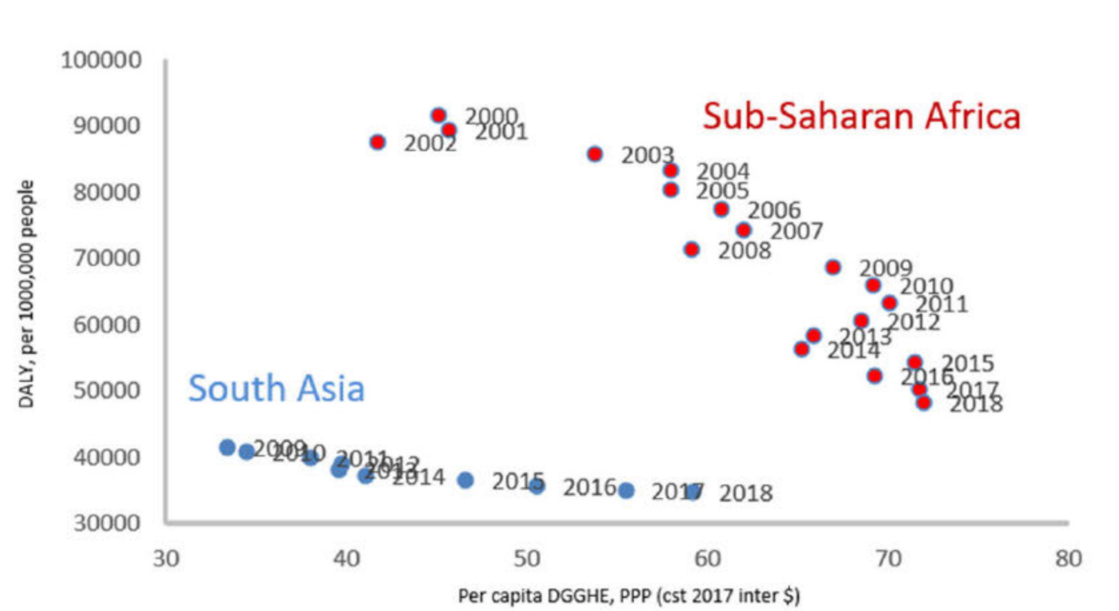
As part of the budget planning process, this tool can be used to strategically shift resources to priority services through increased collaboration between health and finance ministries. In addition, this reform will need to implement mechanisms to ensure the effective use of the health budget. It should also be noted that how health is financed in this region will primarily determine how the region will progress towards UHC and thus achieve the health-associated SDGs.

2.4.2 Linking Public Health Spending to Population Health Outcomes

This section addresses the association between PHS and population health outcomes, as measured by DGGHE and the DALY, respectively, in SSA and South Asia. To this end, a graphical analysis based on Figure 2.6 illustrates the association in both regions from 2000 to 2018.

Figure 2.6

Trends of the association between DGGHE and the DALY in SSA and South Asia

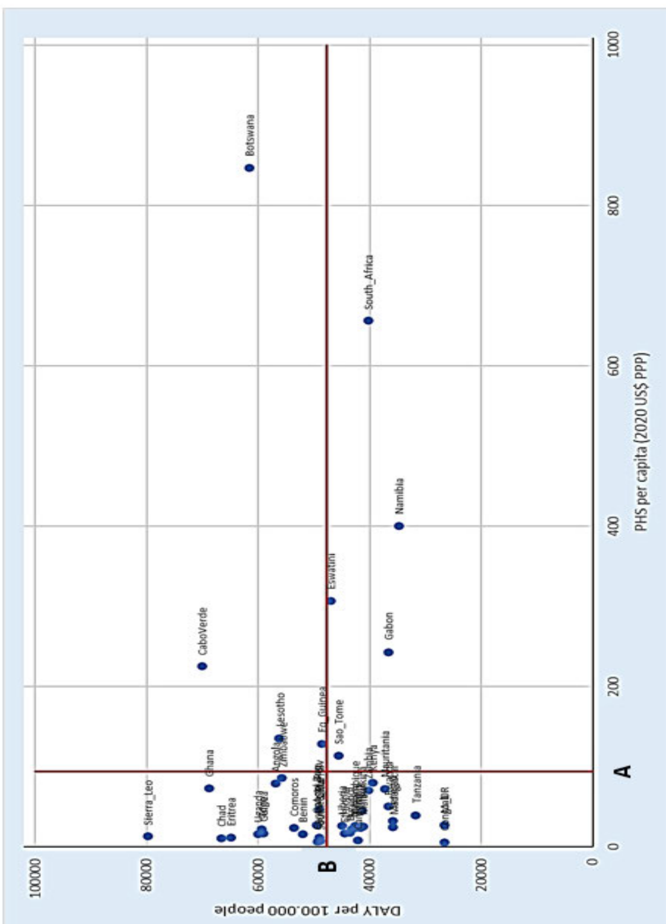


Note. The figure depicts the association trends between DGGHE and the DALY from 2000 to 2018 in South Asia (blue points) and SSA (red points). World development indicators and Global Burden of Disease databases. Copyrights by World Bank and Institute for Health Metrics Evaluation.

Figure 2.6 shows that the association of DGGHE and the DALY in both regions exhibits a negative slope, indicating that an increasing amount of DGGHE is required to attain a specific level of DALY. The slope of SSA exhibits a mild trend from 2000 to 2004, which after that becomes steeper. This implies that after 2004, there was a gradual decrease in the amount of DGGHE allocated towards attaining a specific level of DALY. In contrast, the situation in South Asia exhibited an opposite trend. Nonetheless, it remains evident that the allocation of DGGHE in these regions does not result in the lowest DALYs, which raises serious issues. Figure 2.7 below illustrates the association between DGGHE and the DALY in the SSA countries in 2018.

Figure 2.7

Association between per capita DGGHE and the DALY 2018



Note. The figure shows a correlation between DGGHE and the DALY in the SSA countries in 2018. World Development Indicators and Global Burden of Disease databases. Copyrights by World Bank and Institute for Health Metrics Evaluation.

Figure 2.7 shows how the level of DALY varied as a function of the level of DGGHE in Sub-Saharan Africa in 2018, where each country spent a different amount of DGGHE. The figure provides a complex picture of the association between DGGHE and the DALY in Sub-Saharan Africa, as no general trend can be observed. Using the DGGHE and the DALY averages, sub-Saharan countries were classified into four categories, represented by four quadrants in Figure 2.7. These four quadrants are defined by intersecting vertical and horizontal lines originating at points A and B on the PHS and DALY axes. Points A and B indicate the regional averages for the PHS (94 USD per person) and the DALY (47.742 DALYs per 100,000 persons).

Category 1 (lower left quadrant) includes countries with DGGHE and DALY below the regional averages. This category represents the most efficient countries in achieving health outcomes as they have low DALYs and low public spending on health. These nations demonstrate how to achieve high health outcomes–low DALYs–even with limited resources. Although other factors have played a role in this achievement, the study focuses on government spending. If these countries had adequate financing, holding other factors constant, they could significantly increase their health outcomes.

Category 2 (upper left quadrant) consists of countries with DGGHE values below but the DALY values above regional averages. This category includes countries with high DALYs and low public health expenditures. In these countries, increased DGGHE is required, as it is expected to reduce the DALY, for example, by enabling access to healthcare.

Category 3 (lower right quadrant) presents countries with DGGHE levels above but DALY levels below regional averages. This group of countries has the best health (lower DALY levels) but achieves this with significantly more resources. The five countries with the highest per capita PHS are LI and UMI countries (excluding Sao Tome). These countries demonstrate how to enhance health outcomes using an increased resource base. Note that two countries, South Africa and Namibia, appear as outliers because they have lower DALYs at their highest spending on health. This is an indication of the potential inefficiency in spending.

Category 4 (upper-right quadrant) includes countries with DGGHE and DALY higher than the regional average. Botswana, Cabo Verde, Equatorial Guinea, and Lesotho constitute this group. As their DALY remains higher, signifying a lower level of health, despite the increase in DGGHE, these countries are at risk of inefficiency in health spending and a possible waste of health resources.

In addition, as shown in Figure 2.7, several countries in the region fall within the combined area, ranging from 36 to 62,000 DALYs per 100,000 people and DGGHE from $5 to $94 per person. Only nine countries (all upper-middle or lower) spend more than $91.31 per capita, and most countries (27 in total) have a PHS of less than $46 per capita. This analysis also revealed that 20 of the 44 countries had DALYs above the regional average; however, these nations had an average of 57,933 DALYs per 100,000 people. These countries recorded an average of $90.2 per capita as DGGHE. The remaining 24 countries had lower DALYs than the regional average, although their average DALY was 39,250 DALYs per 100,000 people. These countries spend an average of $98.12 per individual as DGGHE. These figures demonstrate a link between increased DGGHE and a low DALY.

2.5 Chapter Summary

This chapter gave an overview of the health status of sub-Saharan populations in terms of the SDGs and a concise discussion of PHS as a strategy for achieving the SDG health objectives. The chapter also examined the medical status of populations at various levels of the SDG agenda, emphasising areas where progress towards health-related SDGs is satisfactory and drawing attention to those areas where progress must be accelerated. Despite the progress that has been made in this area, it still has a long path to go before its inhabitants can experience the same level of health as the remainder of the globe.

Notwithstanding the existing disparities in achieving health objectives, every country must improve health outcomes further. The region's health system performance scores are still below the levels required to achieve UHC, and significant health disparities exist between countries owing to disparities in health investments and their outcomes. The sources of medical financing utilised by countries in SSA differ in that government sources are the most equitable, external sources are the simplest to target, and private sources are the most sustainable. Their use differs considerably from country to country.

Still, research suggests that public health financing is the best option for UHC and health program delivery in the sub-Saharan region because it financially protects low-income people. Despite a reported increase in regional income, African nations continue to struggle to achieve and maintain the level of health financing resources outlined in the Abuja Declaration of 2001.

In light of the evidence indicating that the allocation, expenditure, and utilisation of PHS directly influence health outcomes, health coverage, and financial protection, a suggestion was put forth during the follow-up meetings of the Abuja Declaration. With the adoption of the “Addis Ababa Action Agenda on Financing for Development” in 2015, African Heads of State became aware of the need to examine the nature of available funds, how they are utilised and factors that affect their effectiveness, as opposed to focusing solely on increasing the number of resources required to achieve universal health. This rationale underpins the analyses of this thesis, as conducted in subsequent chapters.

Chapter 3.
The Effectiveness of Public Health Spending in Sub-Saharan Africa: Exploring Transmission Mechanisms using the Latent Growth Curve Mediation Model

3.1 Introduction

The PHS has become one of the most researched policy instruments over the last three decades. PHS can potentially enhance population health outcomes (Grossman, 1972). As a result, significant research has been conducted to measure its impact on population health outcomes and to justify allocating more resources to the medical sector. Notwithstanding the potential of PHS to advance population health outcomes, some studies call into question the assumption that public financial intervention in the health sector is required to improve health (Folland et al., 2016). These two views highlight the ambiguity of the relationship between PHS and population health outcomes, implying that more studies are needed to clarify the effectiveness of PHS in enhancing population health outcomes, especially in SSA, where several structural factors have been documented to affect the relationship between PHS and population health outcomes (Galadima et al., 2021; Micah et al., 2019) but have not been empirically investigated.

Most studies on the effectiveness of PHS on population health outcomes in SSA have investigated the direct effect of PHS on population health outcomes through impact analyses (Akinlo & Sulola, 2019; Arthur & Oaikhenan, 2017; Fayissa & Gutema, 2008; Filmer & Pritchett, 2000; Novignon & Lawanson, 2017; Ssozi & Amlani, 2015; Weibo & Yimer, 2019). Health is never directed by a single isolated factor but rather by a causal chain of elements derived from a complex interaction of prior events (Shrestha & Stopka, 2022). To better understand the population health outcomes resulting from PHS changes in such a complex setting and achieve reliable results, it is worthwhile to consider all potential factors located along the pathways in the association between PHS and population health outcomes. This could provide insights into the ambiguous association between PHS and population health outcomes in the sub-Saharan region. The study fitted this framework as it intended to investigate the mechanisms by which PHS impacts population health outcomes in sub-Saharan countries; that is, it evaluated the mediational process in the association between PHS and population health outcomes, focusing on changes in variables over time.

The study measured PHS and population health outcomes using the DGGHE and the DALY, respectively. DGGHE denotes the domestic resources over which the government has complete control. It provides financial protection against catastrophic medical expenses and is an important policy tool for accelerating progress towards UHC and achieving health-related SDGs (Meheus & McIntyre, 2017; United Nations, 2019). DGGHE is an important policy variable, as governments have been urged to take control of their finances in response to their development needs in the context of limited international funding. DGGHE does not include external funds. The DALY is a summary of population health, encompassing morbidity and mortality. Traditionally, mortality rates have been used as a yardstick when assessing the health of a population. However, as preventative and curative healthcare has improved, disease patterns have shifted to accommodate people living longer with chronic conditions and disabilities (Robine & Jagger, 2017). As a result, morbidity has emerged as an important indicator of population health and has been included in analyses. The DALY serves this purpose as a summary measure of population health.

Similar to Cheong et al.'s (2003) study, the current study proposes that any change in a variable over time exerts two distinct effects via two components of change: the initial level or intercept of the variable and its slope or growth rate (Cheong et al., 2003). If included in the analysis, the distribution of the components of change in the variable can provide significant information for the analysis. Consequently, the following question arose in the setting of the study, which explored the DGGHE transmission mechanism: is a change over time (variable growth rate) in DGGHE related to a change over time (variable growth rate) in the DALY via a change over time (variable growth rate) in mediators? Analysing the temporal change of variables is crucial for informed decision-making. It provides insights into underlying mechanisms affecting variables, enabling forecasting and causal linkages. This understanding is essential for policymakers in economic policies, healthcare plans, and environmental regulations, as it helps make decisions based on these variables' present and projected future states. Therefore, this study applied the longitudinal growth curve mediation modelling technique to a panel of selected sub-Saharan countries.

The study adds to the larger PHS literature by investigating sub-Saharan-specific structural factors and how they mediate the effect of DGGHE on DALYs in sub-Saharan countries. First, the study used DGGHE and DALYs indicators, which have rarely been used to analyse the effect of healthcare spending. Most studies have used public health expenditures (including external funding) and have focused on under-five and maternal mortality. Second, this study investigated the mediation processes of structural factors on the effect of DGGHE on health outcomes, considering both the initial effects and the effects over time. This study used the longitudinal growth curve mediation model technique, which considers temporal precedence while analysing the mediational process. Any change in the variable is divided into a change in the intercept and a change in the slope, as these two components may have opposite directions according to the study. Third, the study used variables such as malaria, level of immunisation, and female education as mediators, which are important factors in SSA's burden of illness and socioeconomic structure.

The remainder of this chapter is structured as follows: Section 2 reviews the literature, Section 3 outlines the methodology, Section 4 presents the study's results, Section 5 examines the results, and Section 6 concludes the study.

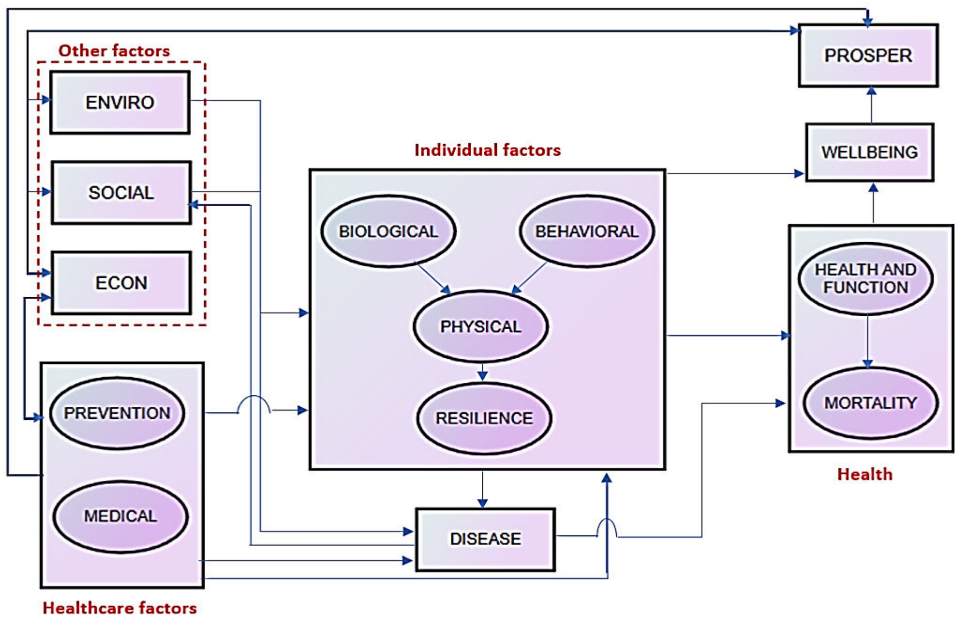
3.2 Literature Review

3.2.1 Theoretical framework and hypotheses

This study adopted Evans and Stoddart's (1990) health domain model to investigate the pathways from PHS to population health outcomes. Figure 3.1 illustrates the cyclical integration of health, economic wealth, and well-being using this model.

Figure 3.1

Study framework



Note. As the study framework, the figure shows the cyclical integration of health, economic wealth, and well-being. Adapted from "Producing health, consuming health care", by T. G. Evans and G. L. Stoddart, 1990, Social Science & Medicine, 31(12), 1347-1363. Copyright 2009 by Elsevier Ltd.

According to this model, better health outcomes translate into improved wellbeing. Without well-being, prosperity or economic growth cannot be achieved. To attain prosperity, the government must allocate resources from economic growth to social, economic, and environmental factors that contribute to prosperity (Evans & Stoddart, 1990). Economic factors such as PHS would, for example, interact with healthcare factors. Healthcare factors alter individual factors (behaviour or disease). Social and environmental factors influence individual factors simultaneously. Individual factors are expected to affect health and wellbeing. At the same time that health affects well-being, prosperity is also affected. The cycle is closed when prosperity interacts with other components. This conceptual framework outlined above outlines the potential pathways by which proximal and ultimate health determinants, including PHS, can influence health outcomes. These routes comprise several segments, some of which have been analysed.

3.2.2 Empirical review and hypothesis development

Uncertainty regarding the association between PHS and population health outcomes, as evidenced by contradictory results, necessitated the exploration of alternatives to the commonly used impact analysis to shed light on this relationship. The study entered this line of thought by applying the analysis of mediation, one of the alternative approaches considered, to analyse the association between PHS and population health outcomes. This approach allowed for a different investigation of this relationship, which considered the PHS transmission mechanism.

Only a few studies have applied mediation analyses to examine the association between PHS and population health outcomes in SSA. This is the case with Makuta and O'Hare (2015), who investigated whether governance mediated the relationship between PHS and health outcomes, as measured by life expectancy at birth and under-five mortality in SSA. The study applied the two-stage least squares regression method to panel data from 43 sub-Saharan countries from 1996 to 2011. The results suggest that governance mediates the impact of PHS (Makuta & O’Hare, 2015). The interaction term was used to analyse the mediational process. However, in the mediation and moderation literature, the interaction term is used to evaluate the moderating effects on the association between interventions and outcomes. The use of the interaction term in Makuta and O'Hare’s (2015) study produced results that did not suit the context, as interaction terms are typically employed to evaluate moderating effects and not mediation processes (Hayes, 2022; Urhie et al., 2020).

The study conducted by Mallaye and Yogo (2018) investigated the direct and indirect effects of health aid on child mortality from 1990 to 2011 in 95 developing countries, including sub-Saharan countries. The study utilised a seemingly unrelated regression approach to examine the mediating effects of health expenditure, female education, and governance on the relationship between health aid and child mortality. A mediation analysis was conducted, and the results showed that female education and governance mediated the link between health aid and infant mortality. Without a direct effect of health aid on infant mortality, the study identified full mediation (Mallaye & Yogo, 2018).

Another study by Okwan and Kovacs (2019) investigated a latent health construct as a mediator in the association between maternal mortality and latent socioeconomic constructs, as well as the association between maternal mortality and latent sociocultural constructs. PLS-SEM was applied to panel data from 2008 to 2015 for the 35 sub-Saharan countries. The results indicated that the health latent construct only mediated the relationship between maternal mortality and socio-cultural latent constructs (Okwan & Kovács, 2019).

The literature above indicates that scholars in SSA have devoted limited attention to the analysis of transmission mechanisms of PHS. Indeed, they have used either impact approaches or transmission mechanism evaluation methods that do not consider the temporal precedence of the components analysed. This research has mostly measured population health outcomes using mortality indicators. Furthermore, they conducted a single mediation analysis, wherein mediators were assessed individually. As a result, potential mediatory interactions were disregarded. Concerns, such as reverse causality, sampling bias, and measurement error, have also remained unaddressed as potential outcomes of endogeneity in causal research (Liu & Yuan, 2021; Soluk et al., 2021). All these drawbacks can produce inaccurate indications of the mediational process (Cheong et al., 2003; VanderWeele, 2015). The current study intended to address the limitations above by considering the theoretical framework described earlier and using a suitable approach.

Among the potential route segments presented in the study framework, the study considered the following that reflected health challenges in SSA and were the most investigated: 1) the PHS-immunisation segment, the results of which suggested that PHS is a predictive factor for vaccination coverage (Castillo-Zunino et al., 2021; De Figueiredo et al., 2016), 2) the immunisation-population health outcomes segment, which revealed that immunisation programmes have prevented one million deaths, and that increased health coverage, as measured by immunisation, is related to a decrease in child and adult mortality (Toor et al., 2021), 3) the PHS - malaria segment, the results of which suggested that PHS is making a substantial contribution to reducing malaria cases in the African region (Omoruyi, 2018; Sede & Nosakhare, 2018), 4) the malaria-female education segment, the results of which disclosed malaria's significantly negative effects on education, including female education; with adverse effects of malaria ranging from school absenteeism (Akazili et al., 2007; Baker et al., 2011; King et al., 2015) to attention deficit and cognitive dysfunction in children (Clarke et al., 2008; Nankabirwa et al., 2013; Opoku et al., 2016), 5) the female education – population health outcomes segment, the results of which suggested that female education has a beneficial impact on the health of the population, as assessed by maternal health, neonatal mortality, as well as under-five and infant mortality (Amwonya et al., 2022; Kaffenberger et al., 2018; Wang, 2021; Wu, 2022).

Based on the studies reviewed and considering the research objectives, this study developed hypotheses concerning how structural factors mediate the effect of PHS growth rates (slopes) on population health outcomes growth rates (slopes) over time. The study measured PHS and population health outcomes using DGGHE and the DALY, respectively, and investigated two mediational processes. Malaria incidence and female education mediate the first mediational process, while immunisation coverage mediates the second. The resulting hypotheses are as follows:

H1: Malaria and female education growth rates sequentially mediate the relationship between the DGGHE and DALY growth rates (mediational process 1).

H2: Immunisation growth rates mediate the relationship between the DGGHE and DALY growth rates (mediational process 2).

This study considered Hayes' (2022) parallel mediation procedure to achieve the intended objective. Therefore, as mentioned above, this study investigated two pathways: immunisation and malaria and education as sequential mediators (Hayes, 2022). The study estimated a model by applying LGCMM to a panel of countries from SSA. The LGCMM is appropriate for panel data, supports multiple mediation analysis, considers temporal precedence, and addresses endogeneity. It assesses change pathways when evaluating health interventions (Liu & Flay, 2009; Roesch et al., 2009). The use of LGCMM is another contribution to the literature on SSA. To the best of our knowledge, no study exploring the effectiveness of PHS in SSA has adopted this approach.

3.3 Methodology

3.3.1 Data description and sources

Secondary data from 40 sub-Saharan countries from 2015 to 2018 were selected due to availability. This resulted in a sample of 40 observations over four distinct periods. Data were obtained from the Global Health Data Exchange (GHDex), World Development Indicators (WDI), World Governance Indicators (WGI), and Global Health Expenditures (GHED) databases for 2013–2019 (IHME, 2022; Kaufmann & Kraay, 2022; WHO, 2021a; World Bank, 2021). Before analysis, all data were cross-checked for consistency with specific sources, such as the country's national health accounts reports. Table 3.1 overviews the study variables, including their respective descriptions, sources and expected signs.

Table 3.1

Variable descriptions and sources

Description		Indicators	Type of variable	Sources	Expected sign
DALY, total	daly	Disability-Adjusted Life Years (per 10,000 people)	Dependent	GHDex	-
DGGHE, total	dgghe	DGGHE per capita, PPP (cst 2017 intl $)	Covariate (main)	GHED	Negative
Economic prosperity	gdp	GDP per capita, PPP (cst 2017 intl $)	Covariate	WDI	Negative
Female education	femed	School enrollment, primary, female (% gross)	Mediator	WDI	Negative
HIV/AIDS	hiv	Incidence of malaria (per 1,000 population at risk)	Covariate	WDI	Positive
Immunization	imm	Immunization, DPT (% of children ages 12-23 months)	Mediator	WDI	Negative
Malaria	mala	Incidence of malaria (per 1,000 population at risk)	Mediator	WDI	Positive

Note. Variables included in the study dataset from 2015 to 2018.

According to Duncan et al. (2013), the sample size used in this study satisfies the requirement of a minimum of three time periods to investigate latent growth curves with confidence in the accuracy of the estimated parameters (Duncan et al., 2013). In addition, Hart and Clark (1999) and Shi et al. (2021) contended that a sample size of N = 40 enables the use of multivariate latent growth curve models (LGCMs), such as the LGCMM, within the structural equation modelling (SEM) framework (Hart & Clark, 1999; Shi et al., 2021). Of the data collected for this study, 3.5% were missing. A multiple-imputation approach was used to address the issue of missing data.

The key study variables were DGGHE and the DALY. The DGGHE variable included government domestic revenue transfers, social insurance contributions, and mandatory prepayments (WHO, 2017). It represented the domestic resources that governments controlled overall and used as a crucial policy instrument for accelerating progress towards UHC and achieving health-related SDGs. In contrast to the Public Health Expenditure, which is commonly employed as a metric for assessing public health spending in several studies, DGGHE disregards external funding due to its unpredictable nature and reliance on the discretion of donors (Khan et al., 2018). The DALY is a health gap summary measure of population health that accounts for both mortality and morbidity to characterise the health of a specific population (Gold & Field, 1998). It has been most commonly used to assess the disease burden. It has proven useful to researchers and health professionals because it provides information on the population's disease burden and helps identify priority health areas for implementing PHS interventions. Malaria incidence, women's education, vaccination, GDP, and HIV/AIDS are the other study variables selected as mediators based on an investigation of the pathway segments through which PHS influences population health outcomes carried out earlier in the study.

3.3.2 Empirical models and estimation technique

3.3.2.1 Theoretical model

The empirical model was developed based on the standard latent curve presented using a general structural equation modelling framework. The LGCM typically comprises two components, the first and second related to the intercept and slope, respectively. The slope can be set to show a linear change, or the slope pattern can be estimated (Shi et al., 2021). LGCM represents growth by modelling two levels: the measurement level, which analyses repeated measurements, and the structure level, which models the latent initial level and latent growth rate (Bollen & Curran, 2006; Shi et al., 2021). The latent intercept indicates the initial condition of the country, and the latent slope denotes the growth rate and direction. The two components of the latent growth curve model represent the measurement model (Equation 3.1) and the latent model (Equation 3.2).

$$\boldsymbol{y_{it}} = \boldsymbol{\eta_{0i}} + \boldsymbol{\eta_{1i}}(\boldsymbol{t}-\mathbf{1}) + \boldsymbol{\varepsilon_{ii}},\ \boldsymbol{i} = \mathbf{1},\mathbf{2},\dots,\boldsymbol{n}\ \boldsymbol{and}\ \boldsymbol{t} = \mathbf{1},\mathbf{2},\dots,\boldsymbol{T} \qquad 3.1$$

where $\boldsymbol{y_{it}}$ represents the observation of country i at time point t, $\boldsymbol{\eta_{0i}}$ is the intercept component of country i, $\boldsymbol{\eta_{1i}}$ represents the linear slope component for country i, $\boldsymbol{\varepsilon_{ii}}$ is the measurement error for country i at time point t, n represents the number of observations, and T is the number of time points.

$$\left.\begin{array}{l}\boldsymbol{\eta_{0i}} = \boldsymbol{\alpha_0} + \boldsymbol{\zeta_{0i}},\\ \boldsymbol{\eta_{1i}} = \boldsymbol{\alpha_1} + \boldsymbol{\zeta_{1i}}, i = 1,2,\dots n\end{array}\right\} \qquad 3.2$$

where $\boldsymbol{\alpha_0}$ and $\boldsymbol{\alpha_1}$ are assumed fixed values of latent growth factors $\boldsymbol{\eta_{0i}}$ and $\boldsymbol{\eta_{1i}}$, respectively; $\boldsymbol{\zeta_{0i}}$ and $\boldsymbol{\zeta_{1i}}$ are random variables that shape country growth.

This model defines linear growth over time, such as intercept ($\boldsymbol{\eta_{0i}}$), and slope ($\boldsymbol{\eta_{1i}}$) indicates the initial level and linear growth rate of the growth trajectory of a country, respectively (Curran & Muthén, 1999).

a) Standard latent growth curve model

Using a generic structural equation modelling framework, the standard latent curve can be obtained by combining the multiple distinct equations of each individual's various time points (t = 1, 2...., T) with an implicit data model (Hipp & Bauer, 2006). This example is provided by

$$\left.\begin{array}{l}\boldsymbol{y_i} = \boldsymbol{\Lambda\eta_i} + \boldsymbol{\varepsilon_i}\\ \boldsymbol{\eta_i} = \boldsymbol{\alpha} + \boldsymbol{\zeta_i}\end{array}\right\} \qquad 3.3$$

where y_i is a T x 1 vector of observed repeated measures for country i, T is the number of waves of data, $\eta_i = (\eta_{0i}, \eta_{1i})^T$ is a 2 x 1 vector of latent growth factors (or random coefficients, i.e., intercept and slope), $\boldsymbol{\Lambda}$ is a factor-loading matrix, $\boldsymbol{\zeta_i}$ represent random variables, ε_i is a T x 1 vector of measurement errors, and α is a 2 x 1 vector of estimated values of η_i.

In addition, the study assumed that E(ε_i) = 0 and = E(ζ_i) = 0, and

$$\left.\begin{aligned} \boldsymbol{COV(\varepsilon_i) = \Theta = diag(\theta_1, \theta_2, \dots \theta_T) = \Lambda\eta_i + \varepsilon_i} \\ \boldsymbol{COV(\zeta_i) = \Psi = \begin{bmatrix} \psi_{00} & \psi_{01} \\ \psi_{10} & \psi_{11} \end{bmatrix}} \end{aligned}\right\} \qquad 3.1$$

where Θ is the T x T covariance matrix of the time-specific residuals, and Ψ is the covariance matrix of the growth factors.

The mean vector and covariance matrix of η are as follows:

$$\left.\begin{aligned} \boldsymbol{E(\eta) = \mu_i = \alpha} \\ \boldsymbol{COV(\eta) = \Psi} \end{aligned}\right\} \qquad 3.2$$

The mean vector and covariance matrix of the observed variables y are as follows:

$$\left.\begin{aligned} \boldsymbol{E(y) = \mu_y = \Lambda E(\eta) = \Lambda\alpha} \\ \boldsymbol{COV(y) = \Sigma_y = \Lambda\Psi\Lambda^T + \Theta} \end{aligned}\right\} \qquad 3.3$$

where Σ_y represents the variance-covariance matrix of *y*, Θ, and Ψ denote the covariance structure of ε_i and ζ_i, respectively. The functional form of the individual trajectories is defined by fixing the coefficients in the T x 2 factor-loading matrix Λ to predetermined values, as shown above. The conventional assumption is that growth factors and time-specific residuals are multivariate and normally distributed as

$$\boldsymbol{\begin{bmatrix} \eta_i \\ \varepsilon_i \end{bmatrix} \backsim N\left(\begin{bmatrix} \alpha \\ 0 \end{bmatrix}, \begin{bmatrix} \Psi & 0 \\ 0 & \Theta \end{bmatrix}\right)} \qquad 3.7$$

Given Equation 3.5, the T x 1 vector y follows a multivariate normal distribution as follows:

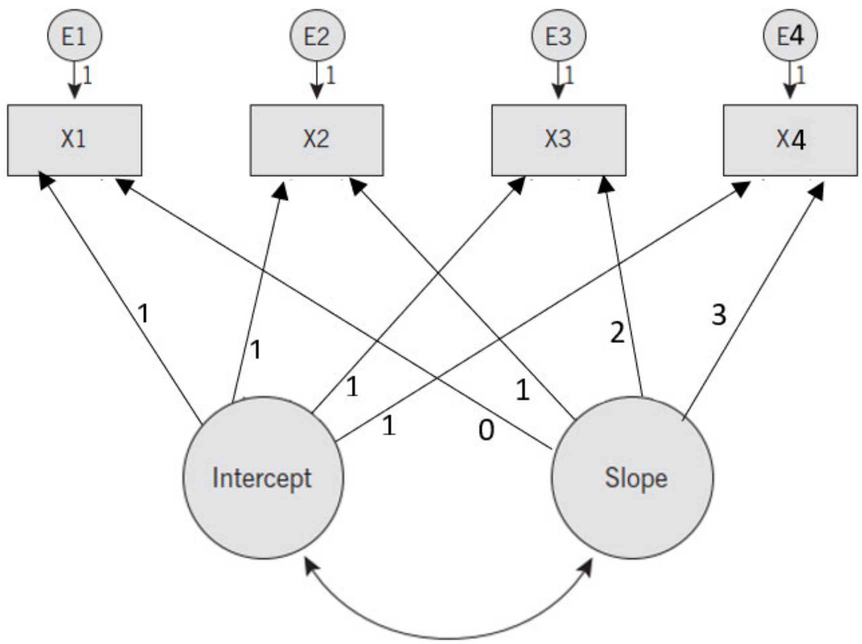
$$\boldsymbol{y_i \backsim N_T(\mu_y, \Sigma_y), i = 1, 2, \dots n} \qquad 3.8$$

where μ_y and Σ_y are given by Equation 3.6.

The above model depicts the mechanism by which each variable in the study is generated. Figure 3.2 graphically depicts the latent linear growth model as a model variable.

Figure 3.2

Latent growth model with linear growth



Note. X1 to X4 represent the observed data collected over four periods t = 1, 2, 3 and 4, E1 to E4 are time-specific errors. Simple arrows depict the link between the intercept and slope with observed variables. Double arrows depict the link between growth factors (intercept and slope). The intercept loading parameters are reported on arrows. Adapted from "Latent curve models: A structural equation perspective," by K. A. Bollen and P. J. Curran, 2006, John Wiley & Sons. Copyright 2009 by John Wiley & Sons.

The observed X-scores depend on the latent intercept factor, the latent slope factor (with factor loadings representing the predicted slope), and time-specific errors (Kenny & Milan, 2012). Because the intercept remains constant across time, the intercept factor loadings are always one. Since linear growth was expected, the slope factor loadings were 0, 1, 2, and 3. An observation at any time can be chosen as the intercept (i.e., the observation with a factor load of 0), and slope factor loadings can be modelled in various ways to reflect different patterns of change.

b) Latent growth model with covariates

In this study, a covariate was considered related to the latent growth for a single outcome variable y, which was observed for country i at time point t. Each country was presumed to have a unique growth trajectory when only one covariate was considered. An LGCM presents growth with the following predictors.

$$\left.\begin{aligned} \boldsymbol{y_i} = \boldsymbol{\Lambda}\boldsymbol{\eta_i} + \boldsymbol{\varepsilon_i} \\ \boldsymbol{\eta_i} = \boldsymbol{\Gamma}\boldsymbol{x_1} + \boldsymbol{\zeta_i} \end{aligned}\right\} \qquad 3.9$$

where y_i is a T x 1 vector of observed repeated measures for country i, T is the number of waves of data, $\boldsymbol{\Lambda}$ is a factor-loading matrix, $\eta_i = (\eta_{0i}, \eta_{1i})^T$ is a 2 x 1 vector of latent growth factors (or random coefficients, i.e., intercept and slope), ε_i is a T x 1 vector of measurement errors, $\boldsymbol{\Gamma}$ is a matrix of regression coefficients, $\boldsymbol{x_1}$ is a 2 x 1 vector of estimated values of η_i and $\boldsymbol{\zeta_i}$ represent random variables.

However, considering several variables in the model made it complex, which was not the study's focus. Moreover, detailed information on the model development has been widely discussed (Roesch et al., 2009; Shi et al., 2021).

In the study, the LGCMM required constructing the unconditional LGCM to measure the degree of connection between the study constructs. This development indicated the extent to which univariate LGCMs preliminarily evaluated for each variable fitted the data together. The unconditional LGCM was derived by connecting, using covariance, all the variables' univariate LGCMs, which had been preliminarily and separately evaluated. There should not have been any dependent variable in the unconditional LGCM because of the use of covariance to interlink the study variables. Once this condition was satisfied, the LGCM could be constructed based on the study's hypotheses by linking the latent variables through regression.

3.3.2.2 Empirical model

The LGCM is a daring and innovative implementation of the SEM, analysing the changes in repeated measures over time at both the individual and aggregate levels (Preacher, 2018). This model was suitable for the study, as it concentrates on the variations or developments over time of PHS, population health outcomes, moderators, and making deductions about the characteristics of growth paths, such as the initial levels of outcome indicators and their rate of change.

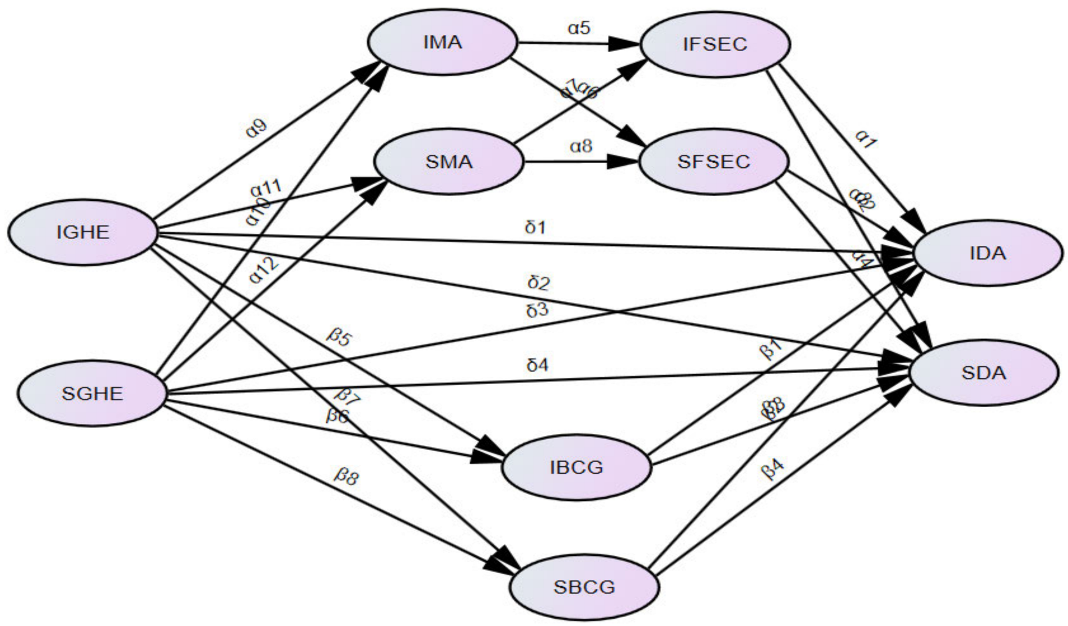
The study developed three LGCMs: two (Models 1 and 2) independently measured the mediational processes under investigation. They demonstrated the advantage of applying the parallel process, which allows simultaneous evaluation of the processes studied, and one (Model 3) conducted a mediation analysis to test the hypotheses. Model 1 assessed the mediational process that implied malaria and female education as successive mediators (Pathway 1), and Model 2 assessed the mediational process that implied immunisation as a single mediator (Pathway 2). Model 3 combines Models 1 and 2 in a parallel process. This was because the study proposed to simultaneously assess all mediators with the expectation that the combination would improve the estimates because of a potential interaction between the mediators from the two pathways.

Models 1 and 2 are not presented visually in this chapter, not only due to lack of space but also because they are included in Model 3, which is represented in Figure 3.3 below. Moreover, in the figure, Model 1 is equivalent to Model 3 without the growth factors of vaccination and Model 2 is equivalent to Model 3 without the growth factors of malaria incidence and female education. In the figure below, Model 3 includes the dependent, independent, and mediating variables, except for the control variables (the HIV/AIDS slope and intercept and the GDP slope and intercept). In the figure, IDA denotes the DALY intercept, IGHE denotes the DGGHE intercept, and IBCG denotes the immunisation intercept. In addition, IFSEC is the female education intercept, IMA is the malaria incidence intercept, SDA is the DALY slope, and SGHE is the DGGHE slope. In Figure 3.3 below, SBCG denotes the immunisation slope, SFSEC represents the female education slope, and SMA denotes the malaria incidence slope.

This model was used to test the hypotheses under investigation. Before the estimation, all models were evaluated using the guidelines developed by Hair et al. (2017).

Figure 3.3

Theoretical conditional model



Note. The figure shows the potential links between the latent constructs. IGHE and SGHE represent the intercept and slope of DGGHE; IBCG and SBCG represent the intercept and slope of immunisation; IDA and SDA represent the intercept and slope of DALY; IFSEC and SFSEC represent the intercept and slope of female education, respectively; and IMA and SMA represent the intercept and slope of malaria. Parameters αi and βi represent the segments of mediational processes 2 and 1, respectively. δ_i are parameters indicating the direct effects of DGGHE on the DALY. The observed variables, error terms, and structural paths from the control variables (IHIV, SHIV, IGDP, and SGDP) were omitted from the model presented for presentation purposes. Computed using the MPLUS 8.7 software.

3.3.2.3 Estimation technique

This study used LGCMM, a parallel process, to investigate the mediational processes in the association between PHS and population health outcomes (Cheong et al., 2003; Selig & Preacher, 2009). The LGCMM approach enabled the estimation of mediation models, including the longitudinal trajectories of mediators, covariates, and outcomes. It supports multiple mediations that prevent potentially biased estimates of indirect effects resulting from separately analysing mediators (VanderWeele, 2015) and accounts for both the initial levels and growth rates of the variables to identify variables that were systematically associated with change over time and to indicate whether the initial levels predicted growth rates (Preacher et al., 2008).

Maximum-likelihood estimation, which involves maximising the log-likelihood function, was used to estimate LGCMs (Hayes, 2022). This estimation and testing framework is extremely popular. It involves the estimation of the unknown factors underlying a presumed model using values that maximise the likelihood of observing the given data (probability density). Maximum likelihood was used to estimate parameters, assess model fit, and test hypotheses. Multivariate normality of the observed data was assumed when employing the maximum likelihood method for parameter estimation. The observed individual's distribution is determined by the product of "probabilities." This product relies on the unknown properties of the underlying distribution, such as means, variances, and covariances. The maximum likelihood estimation is as follows:

Let $\boldsymbol{\varphi} = \boldsymbol{vec}(\boldsymbol{\alpha}, \boldsymbol{\Psi}, \boldsymbol{\Theta})$ be a $\boldsymbol{k} \times \mathbf{1}$ vector, which contains all free parameters in $\boldsymbol{\alpha}, \boldsymbol{\Psi}, \boldsymbol{\Theta}$.

The parameters $\boldsymbol{\varphi}$ can be estimated by applying the maximum likelihood estimation. The maximum likelihood function describes the probability density of the observed data in terms of the model coefficients. For a set of $\boldsymbol{n}$ independent observations (specified), the likelihood function can be stated as

$$\boldsymbol{L}(\boldsymbol{\varphi}; \boldsymbol{y}) = \prod_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{n}} \boldsymbol{f}(\boldsymbol{y}; \boldsymbol{\varphi}), \qquad 3.10$$

and the log-likelihood can be stated as

$$\boldsymbol{L}(\boldsymbol{\varphi}; \boldsymbol{y}) = \boldsymbol{log}\ \boldsymbol{L}\ (\boldsymbol{\varphi}; \boldsymbol{y}) = \sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{n}} \boldsymbol{log}\ \boldsymbol{f}(\boldsymbol{y}; \boldsymbol{\varphi}) \qquad \mathit{3.11}$$

The Newton-Raphson algorithm can iteratively maximise this log-likelihood function.

The study employed a maximum likelihood mean and variance estimator for the model estimation. Maximum likelihood means and variance served as the maximum likelihood parameter estimators with robust standard errors and a test statistic robust to the non-normality of the data and non-independence of observations (Muthén & Muthén, 2017). Whereas the maximum likelihood means and variance provided the most accurate root mean square error of approximation estimates and p-values for tests of close fit, their performance declined as the number of modelled variables increased (Gao et al., 2020).

3.3.3 Data analysis

The hypotheses were empirically tested according to the protocol outlined by Cheong et al. (2003). This approach suggested three steps for modelling and testing the mediational processes within the LGCM framework, which allowed for evaluating a parallel process in mediation analysis. Initially, the form of the growth trajectory for each process was examined. The primary objectives of this step were to ascertain whether the hypothesised trajectory form was compatible with the data and whether the growth rates of the variables varied. Upon examining the growth pattern of the time points for the data, it was anticipated that the growth of the study variables would differ.

The model in Figure 3.2 above was used for this investigation. The factor loadings of the latent intercepts were set to one, as the initial factors were constant. The free factor loadings approach was used to compute the factor loadings of the latent slopes of all variables. This approach helped determine growth curves based on the data by capturing all possible individual growth curves, including growth curves with time-specific errors, and selecting the best fit for the data (Bollen & Curran, 2006). By allowing the loadings on the growth rate factor to vary, the researcher hypothesised that the effects of the initial intervention, such as increasing PHS through the implementation of health programmes, would not be as effective as the subsequent interventions.

In the second stage, the individual LGCMs analysed in the first step were combined into a single parallel process model based on the hypothesised relationships between growth factors. Before this phase, an unconditional LGCM was constructed to assess the degree of association between these latent constructs. Finally, the estimated magnitudes of the mediational effect and the standard error were computed. Standard error was used to determine the significance of the mediation effect and to construct confidence intervals for these latent constructs (Cheong et al., 2003). The comparative fit index (CFI), Tucker-Lewis index (TLI), and root mean square error of approximation

(RMSEA) were used to evaluate the goodness of fit of each model (Hu & Bentler, 1999). The maximum likelihood means and variance were used as model estimators. IBM SPSS software (version 26.0) was used for data preparation (IBM SPSS, 2019), and MPLUS software Version 8.7 was used for analysis (Muthén & Muthén, 2017).

3.4 Empirical results

3.4.1 Descriptive analysis

Table 3.1 presents descriptive statistics of the study variables. Each variable's average and standard deviation (SD) were calculated for each year. Over four years, 42 countries were observed, yielding 168 observations. Throughout the study period, the mean value of the dependent variable (DALY) decreased from 526 to 476 per 1,000 people. Many decreases were attributable to the decline in mortality observed in the region, where countries such as Cabo Verde and Lesotho reported a decline in DALY from 264 to 260 per 1,000 people and from 927 to 857 per 1,000 people, respectively.

The high SD observed in the region suggests that the DALY varied substantially between countries, owing to disparities in health. The predictor (per capita DGGHE) mean increased from $93.33 in 2015 to $95.18 in 2016 and $98.30 in 2017 before significantly decreasing to $93.86 in 2018. This fluctuation in DGGHE indicates a certain instability in public health resources, which makes forecasting the health sector challenging. Their high SDs, which ranged from 143.13 to 154.08, indicated that the DGGHE values varied significantly around their mean. This demonstrates the differences between nations. Except for the FSEC variable, the means of the mediator (BCG, FSEC, and MALA) and control (HIV and GDP) variables decreased throughout the study period.

Table 3.2

Descriptive statistics of variables, 2015 – 2018

Variables	2015		2016		2017		2018	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
DALY (per 1,000 people)	526.01	139.18	506.81	132.00	488.93	126.78	471.67	121.99
DGGHE per capita (US$ 2019 constant PPP)	93.33	143.13	95.18	142.30	98.30	157.33	92.86	154.08
Female education (% gross) [FSEC]	51.03	26.02	51.47	25.54	52.68	24.33	52.76	21.48
Gross domestic product (Per 100$ per capita) [GDP]	47.54	52.72	45.92	49.20	46.07	46.48	46.61	44.56
HIV incidence (per 1,000 uninfected population) [HIV]	1.95	2.58	1.83	2.32	1.74	2.07	1.68	1.95
Immunisation (bcg) (% of one-year-old children) [BCG]	87.55	11.09	87.98	12.49	88.07	10.28	87.38	10.85
Malaria incidence (per 1,000 uninfected population) [MAL]	196.59	140.24	203.19	152.17	197.97	145.93	185.43	140.35

Note. Computed by the author using the MPLUS 8.7 software.

3.4.2 Investigation of growth trajectory

Table 3.4 below presents the results of the univariate analysis. The table displays each study variable's univariate estimates, model fit indicators, and intercept-slope covariances.

Table 3.3

Estimates of univariate growth trajectories

Variables	Intercept		Slope		Slope Parameters	Covariance Intercept-slope	Fit indexes		
	Mean	Variance	Mean	Variance			CFI	TLI	RMSEA
DALY (per 1,000 people)	524.758***	18483.508***	-17.709***	47.614***	[0, 1, 2.027, 3]	-735.239***	1	1	0
DGGHE, per capita (US$ 2019 constant PPP)	93.325***	19998.709***	0.314	22.936**	[0, 1.2, 4.76, 6]	229.782	1	1	0
Female education (% gross)	51.444***	621.488***	0.519	10.378	[0, 1, 0.965, 3]	-54.870***	0.997	0.997	0.03
GDP (Per 100$ per capita)	46.027***	2387.666***	-0.203	13.055***	[0, 0.5, 2, 3]	-45.783***	1	1	0
HIV incidence (per 1,000 uninfected population)	1.787***	5.059***	-0.038	0.061	[0, 1, 2, 4]	-0.330*	1	1	0
Immunisation (bcg) (% of one-year-old children)	87.767***	112.652***	-0.016	0.902**	[0, 1, 3, 5]	-3.169	1	1	0
Malaria incidence (per 1,000 uninfected population)	193.478***	9.432***	21352.254***	706.939*	[0, -1, -0.218, 1]	-679.647*	1	1	0

Note. CFI, TLI, and RMSEA stand for the comparative fit index, Tucker-Lewis index, and root mean square error of approximation, respectively. Computed by author using the MPLUS 8.7 software

*p < 0.10; **p < 0.05; ***p < 0.01

The overall change in the dependent variable over time

All DALY growth factors were significant at all levels. The average of the initial levels of DALY was 525 DALYs per 1,000 people. The DALY intercept variance of 18,489 reveals that the average initial levels in SSA varied considerably across countries. The negative covariance of 735 between the initial level and the rate of change of DALY suggested that the DALY decreased over time during the study period. The RMSEA estimate was lower than the threshold of 0.08, the TLI estimate approached the norm of 1, and the CLI estimate was higher than the threshold of 0.95 (Hair et al., 2017). These results suggest that all the univariate DALY models fit the data well, and LGC fit the data.

The overall change in the independent variable of interest over time

The mean and variance of the DGGHE intercept were significant at all levels. The average initial level of DGGHE was 93.325 $ per capita, implying that sub-Saharan governments spent 93.33 USD per person during the initial period. The intercept DGGHE variance of 19,998 suggests that the initial DGGHE level varied considerably across nations. The mean of the DGGHE slope was not statistically significant; however, its variance was statistically significant at the 5% level. With CFI, TLI, and RMSEA values of 1.000, 1.000, and 0.00, respectively, the estimated univariate DGGHE model provided a good fit for the data.

The overall change in mediators and control variables over time

The intercept means, and variances of the control and mediating variables are significant at all levels. All control and mediator variables' means of the slopes were statistically insignificant, except for malaria. Only the variances of the slopes of GDP, HIV/AIDS, and immunisation were statistically significant at all levels, the 5% level and the 10% level, respectively. The model fit indices in Table 3.2 above show that the univariate models of all control variables and mediators fit the data well.

3.4.3 Model estimates

An unconditional LGCM interlinking of all covariates and outcome variables was developed to assess the degree of association between the model constructs. Given that the focus was on whether the entire model fitted the data, the model goodness-of-fit estimates are presented in Table 3.3.

Table 3.4

Goodness of fit indicators of unconditional LGCM

Goodness of fit Indicator	Value
RMSEA	0.050
CFI	0.968
TLI	0.961

Note. RMSEA represents the root mean square error of approximation, TLI is the Tucker-Lewis index, and CLI is the comparative fit index. Computed by the author using the MPLUS 8.7 software

The results in Table 3.3 above revealed that the model constructs were associated and that the model fitted the data well since the RMSEA estimate was less than its threshold of 0.08, the TLI estimate approached a norm of 1, and the CLI estimate exceeded its threshold of 0.95 (Hair Jr et al., 2017).

Following the unconditional LGCM, three conditional LGCMs were developed and evaluated. Models 1 and 2 separately examined the first and second mediational processes, and Model 3 combines Models 1 and 2 and parallelly examines both mediational processes. The estimates for the three models are presented in Table 3.4 below. The effects of the latent covariates, represented by their coefficients, on the latent outcomes differed in Models 1, 2, and 3, as shown in Table 3.4 below. For instance, the effect of the DGGHE slope on the DALY intercept is missing in Models 1 and 2 but is present in Model 3 (b= 6,688), where it is statistically significant at the 5% level.

This result suggests that when considering Model 3, higher initial DALY levels were associated with higher DGGHE change rates in sub-Saharan countries, ceteris paribus.

The effect of the DGGHE intercept on the DALY intercept was statistically significant at all levels in Models 1 and 2 but not found to be significant in Model 3. The related coefficients in Models 1 and 2 were -0.319 and 0.503, respectively, suggesting that in Model 1, a higher level of the DGGHE intercept was related to a lower level of the DALY intercept. In Model 2, a higher level of the DGGHE intercept was related to a higher level of the DALY, ceteris paribus (see Table 3.6 below).

Table 3.5

Model estimates of conditional LGCMs

Outcomes	Covariates	Model 1	Model 2	Model 3
IDA	IBCG	-3.176**		-10.376**
	SBCG	—		-20.582
	IFSEC		-5.064***	3.553**
	SFSEC		—	73.797***
	IGHE	-0.319***	0.503***	—
	SGHE	—	—	6.688*
	IHIV	30.151***	15.644***	—
	SHIV	—	—	—
	IGDP	-0.312	—	—
SDA	IBCG	0.153**		0.589**
	SBCG	-2.033 **		-3.739
	IFSEC		0.095***	-0.173
	SFSEC		-2.629***	-4.495**
	IGHE	0.026***	—	—
	SGHE	-0.008	0.331***	-0.394*
	IHIV	-1.422***	—	—
	SHIV	5.850***	—	—
	IGDP	0.011	—	—
	SGDP	-0.183	—	—
IFSEC	IMA		0.002	-0.007
	SMA			-0.113**
	IGDP		0.278***	0.239***
	IHIV		5.779***	9.771***
	SHIV		—	65.199***
SFSEC	IMA		0.001***	-0.006
	SMA		0.001	-0.296***
	SHIV		-4.600***	-0.149
	IGDP		-0.004	—
IMA	IGHE		-0.301***	-0.274***
	SGHE			2.343
	IHIV		-13.912***	-21.036***
	SHIV			-120.047***
SMA	IGHE		0.066***	0.084***
	SGHE		-0.561**	-0.392**
	IHIV		-6.099***	-6.238***
	IGDP		0.000	—
IBCG	IGHE	-0.003		-0.001
	SGHE			0.442***
	IHIV	1.265***		1.798***
	IGDP	0.018		
SBCG	IGHE	-0.001		-0.009
	SGHE	-0.003		-0.036*
	IGDP	-0.005		0.037
	SGDP	-0.186		0.725
	IHIV	0.024		0.025
	SHIV	0.289		—
CFI		0.979	0.973	0.966
TLI		0.972	0.968	0.958
RMSEA		0.05	0.05	0.05

Note. IDA denotes the DALY intercept, IGHE is the DGGHE intercept, and IBCG denotes the Immunisation intercept. IFSEC is female education, IMA represents malaria incidence intercept, SDA denotes the DALY slope, SGHE is DGGHE slope, SBCG denotes immunisation slope, SFSEC represents female education slope, SMA denotes malaria incidence slope, SHIV denotes HIV/AIDS slope, IHIV represents HIV/AIDS intercept, IGDP is GDP intercept, and SGDP denotes GDP slope. RMSEA represents the root mean square error of approximation, TLI is the Tucker-Lewis index, and CLI is the comparative fit index. It is computed by the author using the MPLUS 8.7 software.

*p < 0.10; **p < 0.05; ***p < 0.01

The effect of the DGGHE slope on the DALY slope, which was statistically insignificant in Model 1 but significant in Model 2, was significant in Model 3 but to a greater extent than in Model 2. Despite the differences in the results, these conditional models provided an excellent fit to the data, as evidenced by the CFI, TLI, and RMSEA estimates shown in Table 3.4 above.

The RMSEA estimates of each of the three conditional models were below their threshold of 0.08 (Kline, 2016), their TLI estimates approached the norm of 1, and their CLI estimates exceeded their threshold of 0.95 (Hair Jr et al., 2017).

3.4.4 Mediation assessment

The study evaluated Processes 1 and 2 of the mediation separately, and the results are presented in Table (Model 1) below and Table (Model 2) below. Then, the study simultaneously evaluated the two processes, and the results are presented in Table (Model 3) below.

Table 3.5 shows the estimates for Mediational Process 1, which includes malaria and female education as simultaneous mediators. Table 3.6 shows the estimates for Process 2, which included immunisation as the sole mediator. The DGGHE and DALY growth factors were independent and dependent variables in both models.

Table 3.5 shows that malaria and female education did not mediate the relationship between DGGHE and the DALY in SSA during the study period (Model 1). Similarly, immunisation did not mediate this relationship. This is indicated by the lack of paths in these models, which suggests a statistically significant indirect effect coefficient. However, certain pathways in these models exhibited statistically significant direct and total effects coefficients. These were the DGGHE intercept – DALY intercept and DGGHE slope – DALY slope paths in Process 1, which had coefficients of 0.505 and 0.333 for the total effect, respectively, and were statistically significant at the 5% level. In addition, Model 2 included coefficients for the direct effect of -0.309 and 0.026, which were statistically significant at the 5% and 1% levels, respectively, for the DGGHE intercept – DALY intercept and the DGGHE slope – DALY intercept pathways (see Table 3.7 below).

Table 3.6

Estimates of Mediational Process 1

Path	Total Effect		Direct Effect		Total indirect Effects				Conclusion
					Path coefficient	Confidence Interval		SE	
	Path coefficient	SE	Path coefficient	SE		LB	UB		
IGHE to IDA	0.505***	0.091	0.503	0.089	0.002	0.005	0.012	0.009	No mediation
SGHE to IDA	0.000	0.001	-	-	-	-	-	-	No mediation
IGHE to SDA	0.001	0.001	-	-	0.001	0.177	0.0271	0.001	No mediation
SGHE to SDA	0.333**	0.089	0.331**	0.087	0.001	0.001	0.029	0.007	No mediation

Note. IGHE is the DGGHE intercept, IDA denotes the DALY intercept, SDA denotes the DALY rate, SGHE denotes the DGGHE slope, SE, LB, and UB indicate the standard errors and lower- and upper-bound confidence intervals, respectively. The author standardised and computed path coefficients using the MPLUS 8.7 software.

**p < 0.05; ***p < 0.01.

Table 3.7

Estimates of Mediational Process 2

Path	Total Effect		Direct Effect		Total indirect Effects				Conclusion
					Path coefficient	Confidence Interval		SE	
	Path coefficient	SE	Path coefficient	SE		LB	UB		
IGHE to IDA	*-0.0308***	0.109	-0.309**	0.097	0.110	0.134	0.301	0.034	No mediation
SGHE to IDA	0.000	0.000	0.026***	0.005	0.000	0.000	0.000	0.000	No mediation
SGHE to IDA	-	-	-	-	-	-	-	-	-
SGHE to SDA	-0.003	0.034	-0.008	0.050	0.006	0.008	0.011	0.038	No mediation

Note. IGHE is the DGGHE intercept, IDA denotes the DALY intercept, SDA denotes the DALY slope, SGHE denotes the DGGHE slope, SE, LB, and UB indicate the standard errors and lower- and upper-bound confidence intervals, respectively. Path coefficients were standardised. Source: Author's own work. Computed by the author using the MPLUS 8.7 software.

**p < 0.05; ***p < 0.01.

Table 3.9 displays the estimates of Mediational Processes 1 and 2, which were combined in Model 3 and simultaneously evaluated. This model involved the study's mediators, including malaria, female education, and immunisation. The results shown in Table 3.9 below indicate the existence of mediation in the two pathways. Mediation in the DGGHE slope-DALY slope pathway indicated an indirect effect coefficient that was statistically significant at the 5% level, and mediation in the DGGHE slope – DALY intercept pathway indicated an indirect effect coefficient, which was statistically significant at the 10% level.

Following Van der Weele (2015), this study investigates the two mediation processes simultaneously, considering that the interaction of mediators assessed in a unique model would provide improved results (Van der Weele, 2015). Based on the preliminary results of the three models (Models 1, 2, and 3) presented above, it appears that Model 3 performed well and was superior to Models 1 and 2. This supports our proposal to combine the two mediational processes and simultaneously evaluate them to achieve better results. However, this analysis will be conducted later.

Table 3.8

Estimates of Mediational Processes 1 and 2

Path	Total Effect		Direct Effect		Total indirect Effects				Conclusion
						Confidence Interval			
	Path coefficient	SE	Path coefficient	SE	Path coefficient	LB	UB	SE	
IGHE to IDA	0.488***	0.168	0.413	0.153	0.175	0.159	-1.105	0.159	No mediation
SGHE to IDA	-1.507*	0.877	0.103*	0.012	-1.607*	-2.877	-1.331	0.877	**Partial mediation**
IGHE to SDA	-0.402**	0.183	0.340	0.176	-0.061	0.195	-0.310	0.195	No mediation
SGHE to SDA	-2.710**	1.120			-2.710**	-3.120	-2.619	1.120	**Full mediation**

Note. IGHE is the DGGHE intercept, IDA denotes the DALY intercept, SDA denotes the DALY slope, SGHE denotes the DGGHE slope, SE, LB, and UB indicate the standard errors and lower- and upper-bound confidence intervals, respectively. The author standardised and computed path coefficients using the MPLUS 8.7 software.

$^{**}p < 0.05$; $^{***}p < 0.01$.

The results shown in Table 3.9 above suggested that two pathways from DGGHE growth factors to the DALY growth factors included indirect effects, indicating the existence of mediational processes. However, Table 3.9 does not show which mediator was involved in which pathway or mediational process. Table 3.10 below provides more details on the estimates of the mediational processes and the indirect effects of Model 3.

Table 3.9

Detailed estimates of indirect effects

Path	Model 3	Path	Model 3
Effects from IGHE to IDA		**Effects from SGHE to IDA**	
Direct	0.413	**Direct**	0.103*
Total indirect	0.175	**Total indirect**	-1.607*
IDA ← IBCG ← IGHE	0.014	IDA ← IBCG ← SGHE	-0.209**
IDA ← SBCG ← IGHE	0.186	IDA ← SBCG ← SGHE	0.034
IDA ← IFSEC ← IMA ← IGHE	0.007	IDA ← IFSEC ← IMA ← SGHE	-0.003
IDA ← IFSEC ← SMA ← IGHE	-0.035	IDA ← IFSEC ← SMA ← SGHE	0.007
IDA ← SFSEC ← IMA ← IGHE	0.117	IDA ← SFSEC ← IMA ← SGHE	-0.044
IDA ← SFSEC ← SMA ← IGHE	-1.896**	IDA ← SFSEC ← SMA ← SGHE	0.390*
Effects from IGHE to SDA		**Effects from SGHE to SDA**	
Direct	-0.341*	**Direct**	-
Total indirect	-0.061	**Total indirect**	-2.710**
SDA ← IBCG ← IGHE	-0.015	SDA ← IBCG ← SGHE	0.225**
SDA ← SBCG ← IGHE	0.642	SDA ← SBCG ← SGHE	0.118
SDA ← IFSEC ← IMA ← IGHE	-0.006	SDA ← IFSEC ← IMA ← SGHE	0.002
SDA ← IFSEC ← SMA ← IGHE	0.032	SDA ← IFSEC ← SMA ← SGHE	-0.007
SDA ← SFSEC ← IMA ← IGHE	-0.135	SDA ← SFSEC ← IMA ← SGHE	0.051
SDA ← SFSEC ← SMA ← IGHE	2.192**	SDA ← SFSEC ← SMA ← SGHE	-0.451*
CFI	0.966	*CFI*	0.966
TLI	0.958	*TLI*	0.958
RMSEA	0.05	*RMSEA*	0.05

Note. IDA denotes the DALY intercept, IGHE is the DGGHE intercept, IBCG denotes the immunisation intercept, IFSEC is female education intercept, IGDP represents GDP intercept, IHIV denotes HIV/AIDS intercept, IMA represents malaria incidence intercept, SDA denotes DALY slope, SGHE is DGGHE slope, SBCG denotes immunisation slope, SFSEC represents female education slope, SGDP represents GDP slope, SHIV denotes HIV/AIDS slope, and SMA denotes malaria incidence slope. RMSEA represents the root mean square error of approximation, TLI is the Tucker-Lewis index, and CLI is the comparative fit index. Path coefficients were standardised. Immunisation coverage, malaria, and female education are the mediators of the paths investigated. Computed by the author using the MPLUS 8.7 software.

*p < 0.10; **p < 0.05; ***p < 0.01.

The results in Table 3.10 above indicated a total indirect effect of the DGGHE slope on the DALY intercept with a path coefficient of -1.607, which was statistically significant at the 10% level. A closer look at the specific paths of the pathway from the DGGHE slope to the DALY intercept revealed two specific paths that indicated statistically significant indirect effect coefficients, suggesting the existence of mediational processes. The first specific path was from the DGGHE slope to the DALY intercept via the immunisation intercept, indicating an indirect effect coefficient of -0.209, statistically significant at the 5% level.

This result suggests that the immunisation intercept mediated the relationship between the DGGHE slope and the DALY intercept and was a partial mediation because there was a direct effect between the DGGHE slope and the DALY intercept, as indicated by the direct effect coefficient of 0.103, which was statistically significant at the10%. In addition, the pathway from the DGGHE slope to the DALY intercept also included a specific path that successively went from the DGGHE slope to the DALY intercept through the malaria incidence slope and the female education slope, indicating an indirect effect coefficient of 0.390, which was statistically significant at the 5% level. This suggests that the malaria incidence and female education slopes serially mediated the relationship between the DGGHE slope and DALY intercept in SSA during the study period. Moreover, the mediation was partial because there was a direct effect between the DGGHE slope and the DALY intercept.

The results in Table 3.10 also reveal a total indirect effect of the DGGHE slope on the DALY slope, with a path coefficient of -2.710, statistically significant at the 5% level. A closer look at the specific paths included in the pathway from the DGGHE slope to the

DALY slope revealed two specific paths that indicated indirect effect coefficients, which were statistically significant, also indicating the presence of mediational processes. The first specific path was from the DGGHE slope to the DALY slope via the immunisation intercept, which indicated an indirect effect coefficient of 0.225, statistically significant at the 5% level. This result suggests that the immunisation intercept mediated the relationship between the DGGHE slope and the DALY slope, which was a full mediation because there was no direct effect between the DGGHE and DALY slopes. In addition, the pathway from the DGGHE slope to the DALY slope also included a specific path that successively went from the DGGHE slope to the DALY slope through the malaria incidence and female education slopes, indicating an indirect effect coefficient of -0.451, which was statistically significant at the 10% level. This suggests that the malaria incidence and female education slopes serially mediated the relationship between the DGGHE and DALY slopes in SSA. Moreover, this was a full mediation because there was no direct effect between the DGGHE and DALY slopes.

The pathways from the DGGHE intercept to the DALY intercept and from the DGGHE intercept to the DALY slope indicated that the total indirect effects coefficients were statistically insignificant. However, these pathways contained specific paths that indicated mediational processes because they presented statistically significant and indirect effect coefficients. For example, the specific path from the DGGHE intercept to the DALY intercept via the malaria incidence and female education slopes successively presented an indirect effect coefficient of -1.896, statistically significant at the 5% level.

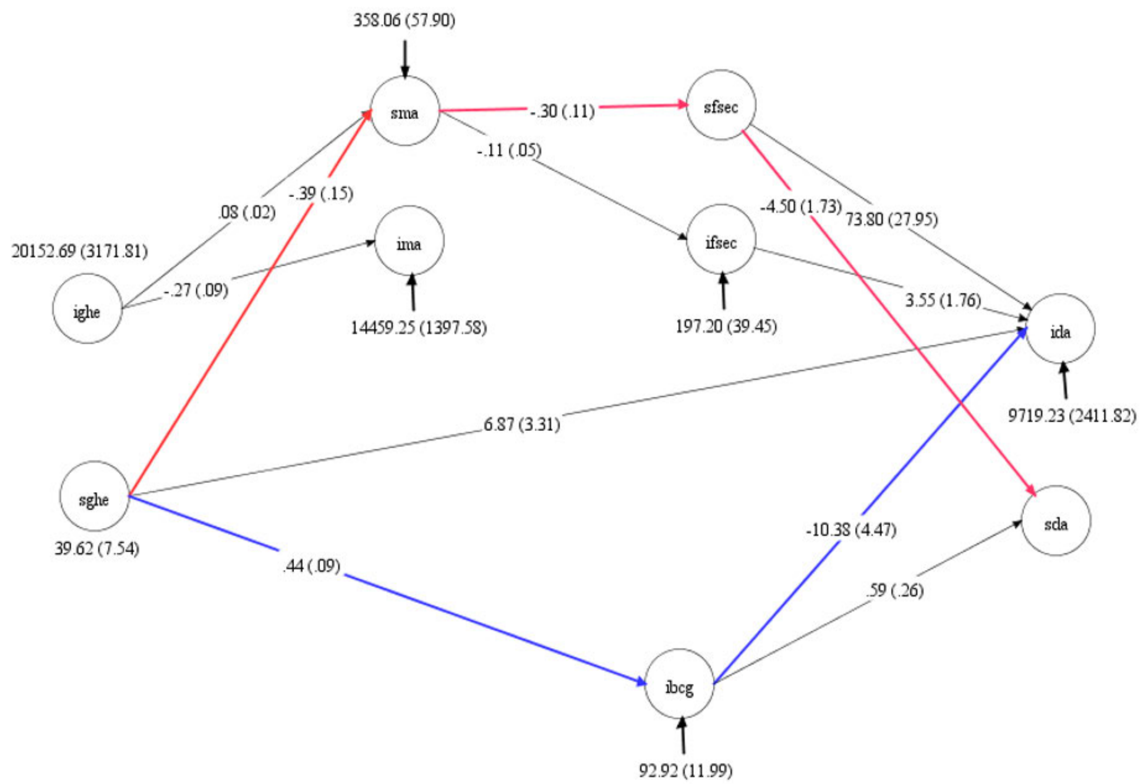
This result suggests that the malaria incidence and female education slopes serially mediated the relationship between the DGGHE and DALY intercepts. This was a full mediation because there was no direct effect between the DGGHE and DALY intercepts. In addition, the specific path from the DGGHE intercept to the DALY intercept via malaria incidence and female education successively presented an indirect effect coefficient of 2.192, statistically significant at the 5% level. This result suggests that the malaria incidence and female education slopes serially mediated the relationship between the DGGHE and DALY intercepts. Moreover, this was a full mediation because there was no direct effect between the DGGHE and DALY intercept.

All the results mentioned above are clarified in Figure 3.4 because they show the pathways that explain the relationship between the DGGHE intercept and slope with the DALY intercept and slope included in Model 3. This figure is valuable because it visualises detailed information on all specific segments of the estimated model, including those involved in the mediational processes. It depicts all the statistically significant segments of pathways underlying the relationship between the DGGHE intercept and slope with the DALY intercept and slope.

Figure 3.3 shows that some segments between the pathways from the DGGHE and DALY growth factors were statistically significant but were not included in any pathway involving a mediating process. Additionally, the immunisation slope construct is shown in the figure to be unrelated to any other construct in the model, as indicated by its absence from the graph. Additionally, these figures reveal no route from the DGGHE intercept to the DALY intercept via the malaria intercept because the malaria intercept is only connected to the DGGHE intercept. Figure 3.3 also indicates no connection between the DGGHE intercept, immunisation intercept, and DALY growth factors.

Figure 3.4

Model 3 path diagram with its estimates



Note. The figure shows the path diagram of Model 3, including path coefficients and standard deviations. IDA denotes DALY intercept, IGHE is DGGHE intercept, IBCG denotes Immunisation intercept, IFSEC is Female education intercept, IMA represents Malaria incidence intercept, SDA denotes DALY slope, SGHE is DGGHE slope, SFSEC represents Female education slope, and SMA denotes Malaria incidence slope. The red arrows represent the significant paths that connect SGHE to SDA through SMA and SFEC. The blue arrows indicate the significant paths connecting SGHE to IDA through IBCG. Path coefficients were standardised. SE are shown in parentheses. For simplicity, GDP and HIV/AIDS are not included as covariates. Computed by the author using the MPLUS 8.7 software.

**p < 0.05; ***p < 0.01.

Sensitivity analysis was conducted by assessing the consistency of the results concerning variations in the number of observations (Seldadyo et al., 2007). To conduct a sensitivity analysis, the four nations with the lowest and highest DALY values were eliminated from the sample, thus reducing the number of observations from 168 to 152. The model fit indices of the newly estimated model for the CFI, TLI, and RMSEA were 0.944, 0.930, and 0.07, respectively. These indices were appropriate and indicated that the model adequately represented the data (Browne & Cudeck, 1992; Klinee, 2016; Jöreskog et al., 2001). In addition, the new model presented statistically significant indirect effects of 3,749 ($p = 0.01$) and -0.597 ($p = 0.05$) for the DGGHE slope – immunisation intercept – DALY intercept and the DGGHE slope – malaria incidence slope – SFEC slope - DALY slope path, respectively. These new results were similar to those obtained from the 168 observation sample and had no bearing on the outcomes of the mediational process. These results suggest that the indirect effects evaluated in this study are robust to variations in the number of observations.

3.5 Discussion

This study examined how PHS affects population health outcomes in sub-Saharan countries. To this end, this study examined the transmission mechanisms of PHS in the relationship between PHS and population health outcomes, focusing on changes in variables over time. The study used the DGGHE and DALY growth factors to measure PHS and population health outcomes, respectively and evaluated the simple and sequential mediation of the relationship between the DGGHE and DALY growth factors by applying a parallel process within an LGCMM framework. We used data from a panel of 42 sub-Saharan countries from 2015 to 2018.

The research results suggested that malaria and female education formed a channel through which DGGHE imparts its effects on the DALY in sub-Saharan countries, and these effects were achieved via specific paths from the DGGHE slope to the DALY slope, via malaria and female education slopes. However, the study found no mediating effects of immunisation in the relationship between DGGHE and the DALY in sub-Saharan countries.

This study also identified the mediating effects between the DGGHE and DALY growth factors. For example, these were identified in the pathways from the DGGHE intercept to the DALY intercept via the malaria incidence and female education slopes, from the DGGHE intercept to the DALY slope via the malaria incidence and female slope education slopes, and from the DGGHE slope to the DALY intercept via the malaria incidence and female education slopes. These pathways involving the initial values of the growth factors were not the focus of our study, which looked at how the variables changed over time.

While the results of the study revealed a negative indirect effect of 0.451 of DGGHE caused by malaria and female education in the relationship between DDGHE and the DALY, they also revealed that there was no direct effect, implying that the mediation of malaria and female education in the relationship between DGGHE and the DALY was complete, that is, a full mediation (Nitzl et al., 2017). Hence, when we consider malaria and education as mediators in the relationship between DGGHE and the DALY, all DGGHE's effects on the DALY pass through these two mediators.

These results also suggested that during the period under study in SSA, the DGGHE slopes were inversely related to the DALY slopes via sequential changes in malaria and female education rates of change. This conclusion is consistent with Hypothesis 1, which states that malaria and female education growth rates serially mediate the relationship between the DGGHE and DALY growth rates in sub-Saharan countries. Although the results support Hypothesis 1, they do not support Hypothesis 2, which states that immunisation growth rates mediate the relationship between the DGGHE and DALY growth rates in sub-Saharan countries.

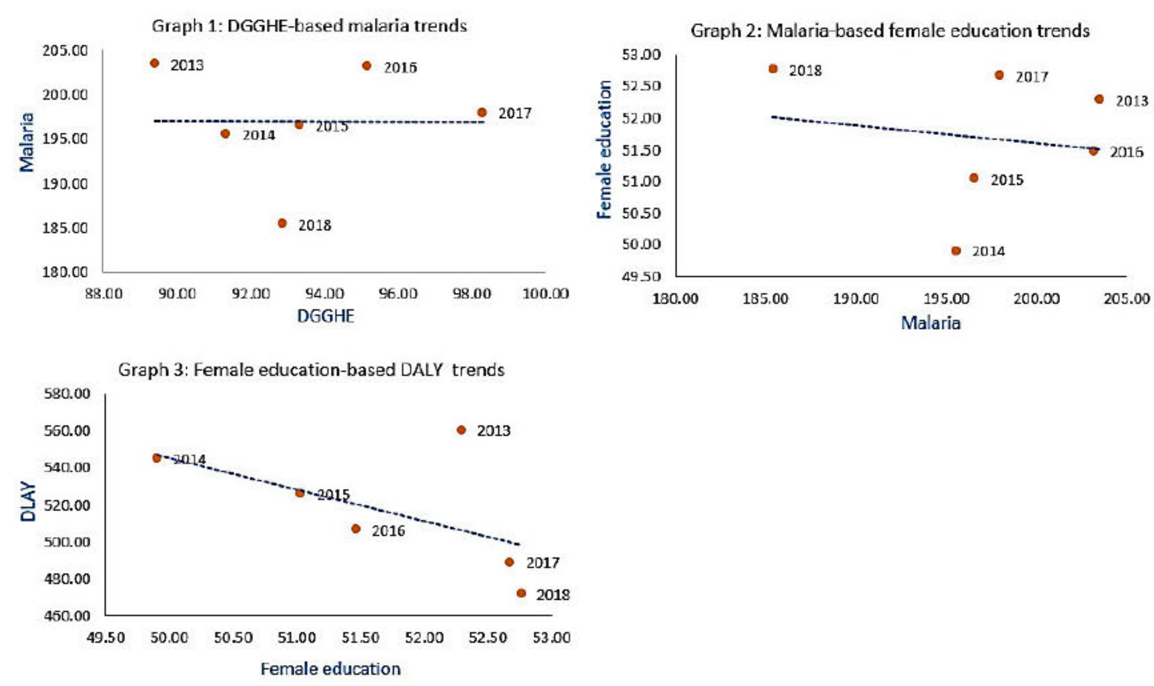
The results indicated that malaria and female education were concurrent transmission channels of DGGHE, suggesting that increased DGGHE growth rates were negatively related to malaria growth rates, and malaria growth rates adversely affected female education growth rates, which positively affected the DALY growth rates. As a result, a total indirect effect of DGGHE growth rates on DALY growth rates was observed.

These findings were anticipated in the SSA region, where a negative correlation was observed between malaria and DGGHE. Additionally, there was a negative correlation between female education and malaria, as well as between the DALY and female education. The graphical representations in Figure 3.4 support these trends. The graphs presented in Figure 3.4 depict the inverse associations observed in the Sub-

Saharan Africa region during the period from 2013 to 2018 between DGGHE and malaria (as shown in Graph 1), malaria and female education (as depicted in Graph 2), and female education and the DALY (as illustrated in Graph 3).

Figure 3.5

DGGHE, malaria, female education and DALY correlation in SSA 2013 - 2018



Note. The graphs in the figure show the negative correlation between malaria and DGGHE (graph 1), malaria and female education (graph 2) and the DALY and female education (graph 3) in SSA from 2013 to 2018. World Development Indicators and Global Burden of Disease databases. Copyrights by World Bank and Institute for Health Metrics Evaluation.

In sub-Saharan Africa, an increase in DGGHE facilitates the provision of resources to sustain efforts to combat malaria, leading to a sustained decline in malaria cases. This phenomenon has been observed in various nations, such as Nigeria, Ghana, and Malawi, where a notable decline in malaria cases has been achieved through the augmented allocation of public funds towards healthcare (Chansa et al., 2020; Oladosu et al., 2022).

Several countries in Sub-Saharan Africa (SSA) have initiated initiatives to impart health and hygiene knowledge to students at the primary school level (Mshida et al., 2020; Thakadu et al., 2018). Consequently, the ongoing decrease in malaria prevalence contributes to women's well-being, enabling their participation in educational pursuits and training programmes focused on hygiene and health. This, in turn, facilitates the acquisition of essential knowledge required to comprehend and address health-related concerns, ultimately leading to improved health outcomes for their family members. National-level repercussions result in enhanced health outcomes, exemplified by decreased disability-adjusted life years (Sokunbi et al., 2022).

The pathways addressed in this study have not been explored in previous studies. However, despite the lack of direct research on the entire pathway, the conclusion derived from analysing each segment of these pathways is theoretically supported by evidence from the existing literature. For example, Omoruyi (2018) and Sede and Nosakhare (2018) investigated the segment from the DGGHE slope to the malaria incidence. Their results suggested that increased PHS, which DGGHE measured in the current study, substantially contributed to reducing malaria cases in the African region, including SSA (Omoruyi, 2018; Sede & Nosakhare, 2018).

Several studies have provided evidence of a relationship between malaria incidence and education, including education for females. The results of these studies reveal the significant negative effects of malaria on education, including female education, with the adverse effects of malaria ranging from school absenteeism (King et al., 2015) to attention deficits and cognitive dysfunction in children (Nankabirwa et al., 2013; Opoku et al., 2016); thus, the need to fight malaria.

The relationship between education, including female education, and population health outcomes has also been investigated. The results indicate that female education has a beneficial influence on the health of the population, as measured by maternal health, neonatal mortality, under-five, and infant mortality (Amwonya et al., 2022; Kaffenberger et al., 2018; Wang, 2021; Wu, 2022). However, to our knowledge, the current study is the first conducted in SSA to examine the transmission mechanisms of PHS by using growth factor variables and LGCMM.

A policy recommendation is for government initiatives in the medical sector to influence transient variables that greatly impact health outcomes. To reduce mortality and morbidity, for instance, governments could initiate interventions affecting factors such as the burden of malaria and female education that can potentially reduce mortality and morbidity conjointly, as measured through the DALY (Aiken et al., 1991).

The primary contribution of the current study to the PHS literature on SSA is the investigation of mediational processes in the relationship between DGGHE and the DALY. This could reveal the channel through which DGGHE affects the DALY. Other contributions include using the LGCMM technique and implementing a multiple mediation approach within the SEM framework.

This study aimed to examine the transmission mechanisms to assess the effectiveness of PHS. This method employs an analysis of the mediation process considering the temporal precedence. Additionally, it considered the possibility that any change in the variable could be decomposed into a change in the initial level and a change in the growth rate, with these two components potentially having opposite directions (Preacher, 2008). This method has the potential to identify sustainable changes in variables that are consistently associated with changes over time and to determine whether initial levels can predict growth rates.

Another contribution of the study was the implementation of multiple mediation analyses that accounted for potential interactions between mediators and avoided biased estimates of indirect effects resulting from a separate evaluation of mediating effects (VanderWeele, 2015).

However, the study had several limitations, including using a short time frame that only allowed data to be collected over four years. Consequently, the underlying transformation process may have been inadequately stated. Future studies should incorporate more time points to increase data quality and outcomes.

The free factor loadings approach was used for the study constructs to estimate the univariate LGCM. To allow the replication of the study, future investigations will need to use a set of factor loadings expressing a precise functional form (Preacher et al., 2008b).

Finally, the DALY, used as a health indicator, only considers the negative elements of population health. Health indicators such as HALE, which capture the positive aspects of health, may be used. Nevertheless, this and the other limitations should not undermine the research results. Instead, they should be viewed as groundwork for future research.

3.6 Chapter summary

The effectiveness of PHS, that is, its positive impact on population health outcomes, continues to be debated worldwide. The question is posed with greater urgency in sub-Saharan countries with indigent populations, limited access to healthcare, and catastrophic medical expenses, as the PHS is a potential tool for addressing these issues. Few studies have examined the effects of PHS on population health outcomes in SSA countries. This study adds to the current body of knowledge by investigating how PHS, as measured by DGGHE, transfers its effects to population health outcomes, as measured by DALYs, to shed light on the contentious association between PHS and population health outcomes.

The results revealed that malaria and female education mediated the relationship between DGGHE and the DALY using the pathway from the DGGHE slope via malaria and female education slopes successively to the DALY slope. However, the results did not reveal any mediating effects of immunisation coverage in the relationship between DGGHE and the DALY in sub-Saharan countries. This suggests that malaria and female education form a pathway through which PHS affect population health outcomes in sub-Saharan countries. The primary policy implication is that governments in SSA should consider sustainable funding for malaria control initiatives and education promotion. Over time, this may reduce morbidity and mortality rates, improving health outcomes.

Malaria and women's education constitute a particular way in which DGGHE influences DALY in SSA countries, as described in this chapter. This serves as a way through which the effectiveness of the DGGHE is illustrated. Some factors might not have been intermediaries in the relationship but may have affected the relationship between

DGGHE and the DALY. The subsequent chapters explain how the study investigated the structural factors that might influence the extent to which DGGHE influences the DALY.

Chapter 4.
The Effectiveness of Public Health Spending in Sub-Saharan Africa: The Moderating Role of Health System Efficiency

4.1 Introduction

Population health in sub-Saharan African countries is generally poor and demands significant attention despite access to various evidence-based interventions that could improve the situation. Moreover, several countries employ PHS to enhance their populations' health outcomes, mitigate catastrophic health spending, and expedite progress towards UHC (Sanoussi et al., 2023; Tangcharoensathien et al., 2023).

Several empirical studies suggest that increasing health expenditures to enhance population health may not produce the expected results because of several factors that could negatively impact the effectiveness of health investments (Bein, 2020; Piabuo & Tieguhong, 2017). Country governance and health system efficiency are two of these factors. Indeed, effective health systems guarantee adequate management of the rising healthcare costs resulting from the rise in health needs. In contrast, strong governance contributes to the rational allocation and use of health resources. Thus, correctly analysing and considering these factors, the number of which may exceed those listed above, can aid in developing more effective PHS interventions that enable the achievement of health goals.

The factors mentioned above negatively impact the effectiveness of PHS in the sub-Saharan region, as supporting evidence indicates. However, the extent to which these factors impact the effectiveness of PHS in sub-Saharan nations is poorly understood and has not been adequately documented. This study focused on one of these factors, namely health system efficiency, and attempts to clarify its role in the effectiveness of PHS in the sub-Saharan region. The availability of solid proof of the role of health system efficiency in the effectiveness of PHS is of particular importance for bolstering efforts to improve the efficiency of health systems and achieve positive health outcomes. Moreover, the impetus for change is evidence-based in this era of the SDGs (Allen et al., 2018).

PHS is an essential policy instrument and one of the primary drivers in the sub-Saharan region for achieving health-related SDGs (Le Blanc, 2015). In SSA, populations are poor and pay a significant portion of their healthcare costs out of pocket, limiting their access to care and exacerbating their poverty by pushing 1.5% of the population below the poverty line (WHO, 2016). The principal goals of PHS are to improve the population's health by increasing access to healthcare and to safeguard the population financially by mitigating catastrophic health expenditures (Sanoussi et al., 2023).

Currently, health financing in SSA focuses more on the PHS, not only because it is a sustainable source of health financing due to its characteristics but also because sub-Saharan countries receive less and less external health assistance (WHO, 2016). In the sub-Saharan region, health financing is limited to enhance the population’s health (Brikci, 2023; Lawal et al., 2022). In 2017, the region recorded the lowest per capita current health expenditure of US$84, compared to the global average of US$1,065. Although sub-Saharan governments committed to allocating 15% of their budgets to health in Abuja in 2011 (OAU, 2001), the average share of public health expenditure in government spending was approximately 7.2% (WHO, 2011). While the sub-Saharan region has recorded poor population health outcomes for many years, lagging in achieving the UHC and health-related SDGs, the main issue is that the low health funds available in the region do not achieve the expected health outcomes (Brikci, 2023; Micah et al., 2019).

PHS-based interventions consistently fail to produce the intended results in SSA. Evidence suggests that this is attributable to health system inefficiency, which can potentially affect the effectiveness of PHS (Ibrahim et al., 2019; Waithaka et al., 2022). However, there is insufficient documentation in SSA regarding how and to what extent health system efficiency influences the impact of PHS on population health outcomes. Therefore, the current study aimed to gain insights into the complex role that health system efficiency plays in the effectiveness of PHS. Moreover, the study sought to address two questions. The first question is whether PHS affects population health outcomes, that is, whether the PHS – population health outcomes theory is validated in the sub-Saharan region. The second is whether health system efficiency inhibits or reinforces the positive effect of PHS on population health outcomes.

The study intended to evaluate health system efficiency's impact and moderating effect on the relationship between PHS and population health outcomes in SSA. The study measured PHS and population health outcomes using DGGHE and the DALY, respectively. In addition, the study applied the GMM estimator based on linear and nonlinear moment conditions to panel data from 43 sub-Saharan countries from 2008 to 2018 to test two hypotheses: (a) an increase in DGGHE reduces DALY and (b) the effect of DGGHE on DALY expands when health system efficiency levels are high. To the best of the researcher's knowledge, this was the first study in SSA to investigate the moderating effects of health system efficiency on the relationship between DGGHE and the DALY.

The primary contribution of the study was methodological. Instead of focusing on the ultimate effects of PHS on population health outcomes, the study examined the factors that influence the direction and/or magnitude of the relationship between PHS and population health outcomes. This may explain why PHS might or might not be effective in enhancing population health outcomes. Second, the study utilised health system efficiency as a moderator of the association between PHS and population health outcomes, addressing all potential effects of health system efficiency on the PHS – population health outcomes association by assessing both its direct effect on population health outcomes and its indirect effect on population health outcomes via its interaction with DGGHE.

Nolte and McKee (2004) consider the health system as a continuum of many factors capable of modifying the DGGHE – DALY relationship (Nolte & McKee, 2004). However, the study estimated population health outcomes using the DALY, a summary measure of population health that provides a more complete picture of the health status of a population than commonly used mortality-based indicators, such as under-five mortality, neonatal mortality, maternal mortality, and life expectancy indicators. Mortality-based indicators do not provide all the information necessary to assess a population's health or compare the effectiveness of interventions because they do not account for the impact of being ill for several years before death or recovery (Gold et al., 2002).

The rest of this chapter is organised as follows. Section 2 provides an overview of the pertinent literature. Section 3 presents the methodology. Section 4 outlines the empirical results. Section 5 discusses the study results, and Section 6 summarises the study.

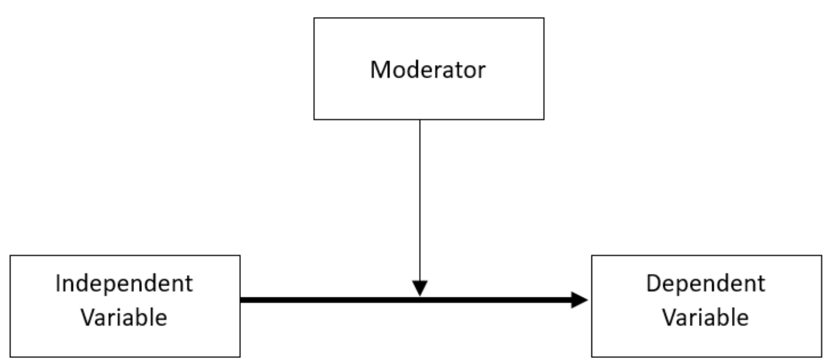
4.2 Literature review

4.2.1 Theoretical framework

To achieve its objective, this research employed the moderation approach originally proposed by Baron and Kenny (1986), which has since undergone a number of advancements (Baron & Kenny, 1986; Hair Jr et al., 2021; Liu & Yuan, 2021). In this approach, the value of a third variable determines the strength of the link between independent and dependent variables (Hair Jr et al., 2021; Patterson, 2023). Figure 4.1 below depicts the conceptual framework of the moderation approach, which indicates that the principal effect of interest is the path from the independent variable to the dependent variable. The arrow pointing to the direct effect indicates that another variable, the moderator, moderates the effect of the independent variable on the dependent variable.

Figure 4.1

Moderation conceptual framework



Note. Statistical diagram of a simple moderation model. Adapted from “The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations,” by R. M. Baron and D. A. Kenny, 1986, *Journal of personality and social psychology*, 51(6), p. 1173. Copyright 1986 by the American Psychological Association, Inc.

4.2.2 Empirical review

Since the 1990s, increasing interest has been in assessing health expenditures at the macro level. The relationship between public health expenditures and population health has been among the most researched topics (Byaro, 2021; Hunt & Link, 2020; Munteh & Fonchin, 2020; Nyamuranga & Shin, 2019; Onofrei et al., 2021). Only a few studies have sought to evaluate this link in emerging regions, particularly in SSA, although several studies have looked at industrialised nations. The exact association between the PHS and population health outcomes in SSA is ambiguous. Some studies have indicated that PHS is effective in improving population health outcomes (Nyamuranga & Shin, 2019; Arthur & Oaikhenan, 2017; Oladosu et al., 2022), whereas others maintain that it is not (Akinlo & Sulola, 2019; Popoola, 2018).

Most of these studies have concentrated on the final effect of PHS on population health outcomes by conducting an impact analysis without examining how this result is attained. However, an impact analysis restricts the scope of an investigation to the final effects of the predictors on the outcome. It disregards factors that may alter the impact of the predictor in the process, thereby affecting the outcome. Yet, changing these factors may alter the direction and/or magnitude of the association between the outcome and predictor. Using only impact analysis, these studies have undoubtedly failed to capture some of the information necessary to address the issue of ineffective PHS in sub-Saharan countries.

Previous studies on primary health systems (PHS) in the Sub-Saharan Africa region have not examined the potential effect of health system efficiency as a moderating factor. However, only a few studies have investigated other variables as moderators of the association between PHS and population health outcomes. These variables are educational quality (Adegoke et al., 2022) and governance (Hilaire, 2015; Kim & Wang, 2019).

Adegoke et al. (2022) evaluated the moderating effects of education quality in their study on the roles of health expenditure and quality of education on health outcomes, as measured by infant mortality, maternal mortality, and life expectancy at birth. The study applied the panel spatial correlation consistent method to panel data from 2000 to 2020 from a selection of sub-Saharan nations. The results revealed that the quality of education moderated the relationship between health and health outcomes, as interactions between health expenditure and education quality reduced neonatal and maternal mortality and increased life expectancy (Adegoke et al., 2022).

Governance in SSA has been the subject of extensive scholarly investigation, particularly concerning PHE. For example, Ibukun (2021) evaluated the significance of governance, as defined by the degree of corruption, bureaucracy, political stability, regulatory quality, rule of law, and government effectiveness, when studying the effect of health expenditure, as measured by PHS and private health spending, on health outcomes, as measured by infant mortality, under-five mortality, and life expectancy at birth. The research employed two-stage least squares regression using a set of fifteen Western African nations from 2000 to 2018. The results indicate that health expenditures are not correlated with infant and under-five mortality rates, while life expectancy at birth is correlated positively with health expenditures (Ibukun, 2021).

Langnel and Buracom (2020) investigated the impact of governance and health expenditure on infant mortality using panel data from 32 SSA countries from 2000 to 2015. They utilised a system-generalized method of moment and found no direct correlation between health expenditure and governance and infant mortality. Nevertheless, the estimate of the interaction between government effectiveness and health spending exhibits significance and indicates a negative correlation with infant mortality. This suggests that the effectiveness of health expenditure in countries within Sub-Saharan Africa (SSA) can potentially be elucidated by the governance levels of these countries (Langnel & Buracom, 2020).

Adeagbo (2022) assessed the effect of governance issues on health outcomes when examining the relationship between government health expenditure and population health outcomes in Sub-Saharan Africa (SSA). The study applied the GMM panel regression method to the panel data from 2000 to 2017. According to the findings, health outcomes in SSA countries improved due to increased government spending on health. In addition, the effect of government health expenditure on health outcomes in SSA countries is not contingent on the quality of governance, and there is insufficient evidence to suggest that governance quality directly impacts health outcomes improvement in SSA (Adeagbo, 2022).

Kim and Wang (2019) examined the effect of governance quality, as a moderator, on the relationship between governance quantity and health outcomes, as measured by U5 mortality and life expectancy at birth. The study found that the quality of governance had distinct effects on the relationship between the quantity of governance and health outcomes, as the effective quality of governance enhanced the effect of government size on health outcomes (Kim & Wang, 2019).

Hilaire (2015) reevaluated the PHS-population health outcomes link in African countries, concentrating on the interaction between governance and PHS and its effects on population health outcomes, defined by infant mortality rate, life expectancy at birth, and under-five mortality rate. The study applied the fixed effects model (FE) and GMM estimators to a panel of 43 African nations from 1996 to 2012. The results suggested that total health expenditure and PHS substantially affected health outcomes. However, the role of governance and its interaction with PHS appeared complex (Hilaire, 2015).

The results of the reviewed studies indicate that, when examining the association between PHS and population health outcomes, it is crucial to investigate the factors that may alter the nature of this relationship, as this may reveal why PHS is ineffective. In addition, analysing the effects of PHS on population health outcomes using mortality-based indicators of population health outcomes may only provide partial information because they only capture the mortality aspects of health expenditure benefits and not the morbidity portion, which will be underestimated (Arvidsson et al., 2022; Claxton et al., 2015).

Therefore, using the DALY to measure population health outcomes is favourable because this indicator incorporates both mortality and morbidity factors. Thus, by utilising the DALY, the current study incorporated the influence of health expenditures on survival gains and health-associated quality of life (Ochalek et al., 2020). In addition, it should be noted that most previous research has ignored the dynamic nature of the PHS – population health outcomes link as well as the endogeneity of regressors and unobserved specific effects, which is problematic (Baltagi, 2005; Lin & Wooldridge, 2019). However, the study sought to address the shortcomings identified in the reviewed studies.

4.3 Methodology

4.3.1 Data description and sources

The data utilised in this study were sourced from various databases, including the Global Health Data Exchange (GHDex), World Development Indicators (WDI), and Global Health Expenditures (GHED). These databases provided data for the period spanning from 2008 to 2018 (IHME, 2022; Kaufmann & Kraay, 2022; WHO, 2021a; World Bank, 2021). The only data about health system efficiency were obtained by estimating technical efficiency scores using the stochastic frontier approach. Due to the limited data available for some countries, the study was limited to a sample of 39 sub-Saharan countries[1]. All data were cross-referenced to other sources, such as the country's national health accounting reports, to ensure consistency before the analysis. Table 4.1 presents a comprehensive summary of the study variables, encompassing their corresponding descriptions, sources and expected signs.

---

[1] The list of countries included in the study is in Appendix 1. For this analysis, Angola, Central African Republic, Comoros, Gabon, Guinea-Bissau, Liberia, Somalia, South Sudan, and Zimbabwe were excluded due to lack of data.

Table 4.1

Variable descriptions and sources

Description		Indicators	Type of variable	Sources	Expected sign
Current health expenditure	che	Current health expenditure, per capita, PPP (cst 2017 intl $)	Covariate	WDI	Positive
DALY, total	daly	Disability-Adjusted Life Years (per 10,000 people)	Dependent	GHDex	-
DGGHE, total	dgghe	Domestic general government health expenditures, per capita, PPP (cst 2017 intl $)	Covariate (main)	GHED	Negative
Domestic helth resource mobilisation	ghe_gdp	Domestic general government health expenditures (% of GDP)	Covariate	WDI	Negative
Economic Prosperity	gdp	GDP per capita, PPP (constant 2010 international $)	Covariate	WDI	Negative
Female education	femed	School enrollment, primary, female (% gross)	Covariate	WDI	Negative
Health Life expectancy	hale	Life expectancy at birth (Years)	Dependent	WDI	(2)
Health prioritisation	ghe_gge	Domestic general government health expenditures (% government expenditures)	Covariate	WDI	Negative
Health system efficiency	hse	Health system efficiency scores	Covariate	(1)	Negative
Malaria	mala	Incidence of malaria (per 1,000 population at risk)	Covariate	HNP	Positive
Out-of-pocket spending	oop	Out-of-pocket expenditure per capita, PPP (constant 2017 international $)	Covariate	WDI	Negative
Pollution	co2	CO2 emissions (metric tons per capita)	Covariate	WDI	Positive
Urbanisation	Urb	Urban population (% of total population)	Covariate	WDI	Positive

Note. (1) SFA generates health system efficiency. (2) Life expectancy is the dependent variable in the stochastic frontier model. Variables included in the study dataset from 2008 to 2018.

The outcome variable in the stochastic frontier model employed in this study was healthy life expectancy (HALE). HALE is a positive summary measure of population health. The decision to exclude the DALY as the outcome variable in developing the stochastic frontier model was based on its characterization as a negative health outcome indicator. This choice aligns with the primary objective of health systems, which is to prevent the occurrence of adverse consequences. In regressing HALE, the study utilised CHE, GDP, and urbanisation rates (URB) as input variables. CO2 emission (CO2) was among the instrumental variables. All variables within the HALE function were in logarithmic form. Technical efficiency scores were derived from the residuals of the HALE regression as a measure of health system efficiency scores. The stochastic frontier efficiency model was specified as follows:

$$\mathbf{ln}(\boldsymbol{HALE_{it}}) = \boldsymbol{\alpha} + \boldsymbol{\beta_1}\,\mathbf{ln}(\boldsymbol{CHE_{it}}) + \boldsymbol{\beta_2}\,\mathbf{ln}(\boldsymbol{GDP_{it}}) + \boldsymbol{\beta_3}\,\mathbf{ln}(\boldsymbol{URB_{it}}) + \boldsymbol{\tau_i} - \boldsymbol{TE_{it}} \quad 4.1$$

$$\text{With } TE_{it} = \eta_i + ln(CHE_{it}) + \gamma_2\, ln(CO2_{it}) + \gamma_3\, ln(URB_{it}) + \mu_1 \quad 4.2$$

where $\ln(HALE_{it})$ is log output for country i at time t $(i = 1, \ldots N \ and\ t = 1, \ldots T)$, $\ln(CHE_{it})$, $\ln(GDP_{it})$ and $\ln(URB_{it})$ are endogenous log inputs, τ_i consists of random country effects, TE_{it} is technical (in)efficiency, including $\eta_i \geq 0$ is persistent inefficiency, $\mu_1 \geq 0$ is transient inefficiency, and it is the noise term. Hung-pin and Kumbhakar (2022) provide detailed development and hypotheses of the model (Hung-pin & Kumbhakar, 2022).

To estimate the stochastic frontier model, the study applied the estimator for the endogenous panel stochastic production frontier model suggested by Karakaplan (2018), considering the output-oriented efficiency measurement. The stochastic frontier model results and a summary of efficiency scores are presented in Table 4.2 below.

Table 4.2

Estimated stochastic frontiers

Variables	**SFA MODEL**
Current health expenditures, per capita, log	0.041*** (3.70)
GDP per capita, , log	0.023 (1.26)
Urbanization rates, log	0.289*** (11.44)
Constant	2.953*** (43.91)
Year Dummies	No
No of Obs	473
F test	460.64
eta Endogeneity Test	0.18

Note. Dependent variable is healthy life expectancy, log. Standard errors are shown in parentheses. The P-value of the eta endogeneity test was reported. Computed using the STATA software version 17.

*p < 0.10; **p < 0.05; ***p < 0.01.

In the production function, output elasticity was represented by CHE, GDP, and URB coefficients. Except for the GDP elasticity, all of these elasticity values were positive and statistically significant. Regarding the extent of elasticities, URB, which measured the environment, was the most influential factor in determining output, followed by CHE. The sign and magnitude of the constant term indicated significant technological progress.

Table 4.3 below summarises the technical efficiency levels as measures of the health system efficiency score.

Table 4.3

Summary of health system efficiency scores

Estimator	n	M	Median	SD	Minimum	Maximum
Karakaplan	473	0.686	0.673	0.117	0.495	0.994

Note. M and SD represent the mean and SD, respectively. Computed using the STATA software version 17.

Table 4.3 above shows, as measured by the technical efficiency indicators, that the health system efficiency scores varied between 0.495 and 0.994, with a mean score of 0.686.

As in Dhimar et al. (2021), the current study used DALY as the dependent variable. This is because it considers mortality and morbidity when measuring population health (Dhimal et al., 2021). The current study also used two major covariates of interest: DGGHE and health system efficiency. DGGHE is a meaningful indicator of how much governments spend on health to ensure citizens have access to healthcare (Jordi et al., 2020; Micah et al., 2019). It is expected that an increase in the DGGHE will reduce the DALY.

Following Zhou (2018), the current study selected health system efficiency, as measured by health system efficiency scores, as a moderating variable because, as the framework for producing healthcare, it was closely connected with both DGGHE and health outcomes (Zhou, 2018). Increasing health system efficiency was expected to decrease DALY and ensure that DGGHE was spent efficiently. This analysis was intended to control for other variables that influenced population health in SSA. These included malaria, education, government priorities, and health funding sources. Based on the health literature, these variables were selected and measured using the following indicators: malaria incidence (Kioko et al., 2013), female school enrolment (Mirowsky & Ross, 2017), DGGHE as a share of government expenditure, indicating the government's priority to spend on health out of its resources (Ithibu & Amendah, 2019), and DGGHE as a share of GDP, indicating the fiscal space for health (Ithibu & Amendah, 2019; Ssozi & Amlani, 2015).

The study used CO2 emissions, life expectancy at birth, out-of-pocket expenditure per capita, and GDP variables as instruments for the regression. The variables used in the primary analysis with DALY as the dependent variable are listed in Table 4.4 below.

4.3.2 Empirical models and estimation technique

4.3.2.1 Empirical models.

Following the theoretical framework adopted and the types of variables included in the analysis, the study considered two approaches to conduct the investigation. The first approach was the stochastic frontier approach used for generating health system efficiency scores, and the second approach was the moderation analysis conducted by applying the GMM estimation method.

The study employed the stochastic frontier approach to estimate technical efficiency as a measure of health system efficiency. This method was chosen because it allowed the calculation of technical efficiency, which, in turn, was used to determine the health system efficiency scores. Technical efficiency is the maximum output from a unit input (Erena et al., 2021). This measure allowed the identification of which health systems are performing well.

The stochastic frontier approach was introduced to address the issue of random error in the deterministic approach (Bhat & Kaur, 2022). Contrary to the prevalent view that deviations from the production frontier are the result of inefficient production units, this approach considers that stochastic estimates of technical efficiency include a measure of random error, which is one of the components of the compound error term of a stochastic production frontier (Bhat & Kaur, 2022). Thus, determining whether production deviations from the production frontier are due to country-specific factors or random factors from the outside world is feasible.

The study considered the stochastic frontier production function for panel data developed by Battese and Coelli (1995), specified in Equation 4.1 below.

$$\boldsymbol{Y_{it} = exp(x_{it}\beta + V_{it} - U_{it})} \qquad 4.1$$

where Y_{it} denotes the production at the t-th observation (t = 1, 2 .... T) for the i-th country (i = 1, 2 .... , N); x_{it} is a (1 x k) vector of values of identified functions of inputs of production and other explanatory factors associated with the i-th country at the t-th observation; β is a (k x 1) vector of unidentified parameters to be projected; the V_{it}s are presumed to be independent and identically distributed N(0, σ_V^2) random errors, freely distributed of the U_{it}s; the U_{it}s are non-negative random variables related to technical inefficiency of production, which are presumed to be independently distributed such that U_{it} is obtained by truncation (at zero) of the normal distribution with mean, $z_{it}\delta$, and variance, σ^2; z_{it} is a (1 x m) vector of explanatory variables related to the technical inefficiency of countries' production over time, and δ is an (m x 1) vector of unknown coefficients.

The technical inefficiency effects, the U_{it}s are assumed to be a function of a set of explanatory variables, the z_{it}, and an unspecified vector of coefficients, δ. The explanatory factors in the efficiency model may incorporate some input factors in the stochastic frontier, given the inefficiency effects are stochastic (Battese & Coelli, 1995).

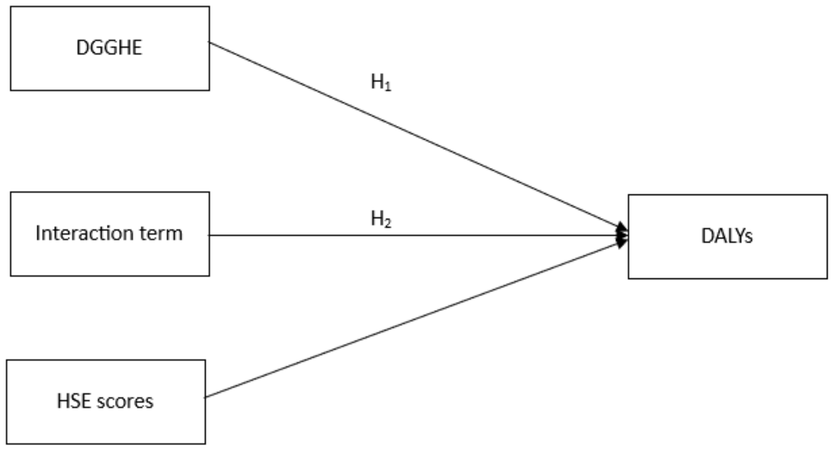
The benefits of using the stochastic frontier method are manifold compared with the existing method for efficiency estimation. The stochastic frontier approach enables estimating a frontier function that accounts for both random error and the inefficiency component. This approach also allows for estimating standard errors and testing hypotheses, which were previously challenging with deterministic frontiers because they violated certain maximum likelihood regularity constraints. Estimating efficiency with the stochastic frontier method requires a priori knowledge of the functional form, however, and distributional assumptions for the estimation of the technical efficiency component of the model.

The study's selection of the stochastic frontier method can be explained by the change in healthcare output in SSA, sometimes due to uncontrollable causes, such as economic, political, and other shocks. More details on the advantages and disadvantages of the stochastic frontier method can be found in the literature (Babalola & Moodley, 2020; Karakaplan, 2022).

The second approach, the moderation analysis, was selected to investigate how much the health system efficiency affected the magnitude and/or size of the association between PHS and population health outcomes as measured by DGGHE and the DALY, respectively. The study expected the moderator to affect the relationship between DGGHE and the DALY. Therefore, the simple moderation analysis suggested by Memon et al. (2020) was selected for the analysis (Memon et al., 2020). The study considered the conceptual framework in Figure 4.1 above, the types of variables included in the study, and evidence in the health and economic literature to develop the model illustrated in Figure 4.2 below for testing the study hypotheses. The model included three causal paths fed into the DALY outcome variable (see Figure 4.2 below).

Figure 4.2

Statistical diagram of the moderation analysis



Note. The arrows pointing to the DALY represent the path coefficients that measure the impacts of DGGHE, health system efficiency, and the interaction term on the DALY. The interaction term variable is generated from DGGHE and health system efficiency scores. The moderation hypothesis (H2) would be supported if the interaction term were significant. For simplicity, the graph does not present the control variable impacts. Adapted from "The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations," by R. M. Baron and D. A. Kenny, 1986, *Journal of personality and social psychology*, 51(6), p. 1173. Copyright 1986 by the American Psychological Association, Inc.

Considering the significance of DGGHE in reducing the DALY and the critical role of country governance in the efficacy of DGGHE, which has been extensively documented, the following hypotheses were derived.

H_1: Increased DGGHE is related to a lower DALY in SSA

H_2: Health system efficiency moderates the relationship between DGGHE and the DALY in SSA

4.3.2.2 Estimation technique.

The study adopted the GMM estimation technique to control for country-specific characteristics. However, with this method, any attempt to disregard time- or country-specific unobserved effects present across countries in standard time series or cross-sectional analyses may lead to bias. Moreover, GMM estimation accounts for the ongoing existence of the dependent factor, the issue of missing variables, endogeneity, error in measurement, and country-specific variability. When the number of cross-sections is greater than the number of periods (N > T), the GMM estimation method is efficient (Arellano & Bond, 1991).

The study utilised the GMM estimator to estimate linear dynamic panel data models with linear and nonlinear moment conditions developed by Ahn and Schmidt (1995). Nonlinear moment conditions improve a model's efficiency when added to the difference-GMM moment conditions (Ahn & Schmidt, 1995). While these moment conditions are dismissed when combined with the system-GMM moment conditions, they remain valid even when the system-GMM level model moment conditions are not (Blundell & Bond, 1998). Additionally, although the GMM estimator with only linear moment conditions has a closed-form solution, this is not the case when nonlinear moment conditions are present.

To assess the consistency of their GMM estimator, Ahn and Schmidt (1995) rely on two specification tests: the Arellano–Bond and Sargan-Hansen tests (Arellano & Bond, 1991). The Arellano–Bond test for serial correlation [AR (2)] determines whether the first-difference residuals exhibit a second-order serial correlation. The null hypothesis states that residuals do not exhibit serial correlation. If the null hypothesis cannot be rejected, there is no second-order serial correlation, and the GMM estimator is consistent. The Sargan-Hansen test examines the null hypothesis of overidentification restrictions (Kiviet & Kripfganz, 2021). The instruments are valid, and the model specification is accurate if this null hypothesis is not rejected.

The moderation approach proposed by Aiken and West was used to investigate the moderating effect on the relationship between the DALY and DGGHE (Aiken et al., 1991), which was assessed using the interaction term of the DGGHE variable and health system efficiency scores. This approach has been recently used by Nam and Ryu (2023) to evaluate the moderating role of official development assistance, governance, and national competitiveness in the link between human development and foreign direct investments in Asia (Nam & Ryu, 2023). Erdiaw-Kwasie and colleagues also used the model to assess how circular economy understanding moderates the effect of organisational variables on circular economy routine adoption (Erdiaw-Kwasie et al., 2023).

Three steps summarise this approach: (1) estimating the models with and without the interaction term and verifying the significance and goodness of the model with the interaction compared to the model without the interaction term, and (2) conducting the moderation assessment if the model with the interaction is significant – the moderation model must include mean-centred variables, and (3) plotting the interaction points and interpreting the interaction effect. Detailed descriptions of moderator effects and a framework for their estimation and interpretation are provided in the literature (Hair Jr et al., 2021; Liu & Yuan, 2021).

All analyses were performed in the study using Version 17 of the STATA software (StataCorp, 2019), and the XTDPDGMM package (Karakaplan, 2018) was used to estimate the study model.

4.4 Empirical results

4.4.1 Descriptive statistics

The descriptive statistics for the variables included in the main empirical study are presented in Table 4.4 below. Owing to time and space constraints, this section focuses on three primary variables: the DALY, health system efficiency, and DGGHE. Table 4.4 below shows that the DALY indicators averaged 559 DALYs per 10,000 people during the study period, with an SD of 162. This SD demonstrated an inevitable fluctuation in the DALY across sub-Saharan countries, which was expected given the significant regional health disparities.

The mean and the SD of 0.68 and 0.02, respectively, for the health system efficiency scores showed a limited disparity in the inefficiency of the health systems in SSA. The average DGGHE value was $113.5, with an SD of 178.39. This remarkably high SD value suggested high variability of DGGHE across the countries under study. Countries such as the Democratic Republic of Congo and Guinea, for example, had the lowest values of approximately $2.44 and $4.75, respectively. In contrast, Botswana and Seychelles had the highest values of $800.81 and $1,040.55, respectively.

Table 4.4

Descriptive statistics and correlations for study variables, 2008 - 2018

#	Variable	n	M	SD	1	2	3	4	5	6	7	8	9	10	11
1	Disability-Adjusted Life Years (per 10,000 people)	473	559.33	162.48	1										
2	DDGHE per capita, PPP (constant 2010 international $)	473	113.50	178.39	-0.107**	1									
3	Health system efficiency scores	473	0.69	0.12	0.0035	-0.444***	1								
4	GDP per capita, PPP (constant 2010 international $)	473	2421.08	3122.13	-0.220***	0.790***	-0.492***	1							
5	Out-of-pocket expenditure per capita, PPP (constant 2010 international $)	473	79.93	107.65	-0.231***	0.455***	-0.264***	0.777***	1						
6	Incidence of malaria (per 1,000 population at risk)	464	206.93	156.25	0.438***	-0.385***	0.126***	-0.175***	0.021	1					
7	CO2 emissions (metric tons per capita)	473	1.06	1.89	-0.139***	0.699***	-0.494***	0.858***	0.611***	-0.170***	1				
8	DGGHE, as a % of GDP	473	1.74	1.13	0.033	0.658***	-0.180***	0.277***	0.01	-0.472***	0.3256	1			
9	DGGHE, as a % of government expenditures	473	6.62	3.21	-0.062	0.503***	0.0199	0.152***	0.013	-0.405***	0.198***	0.796***	1		
10	School enrollment, primary, female (% gross)	473	100.28	21.60	-0.166***	0.107**	0.253***	-0.109**	-0.170***	-0.145***	-0.087*	0.352***	0.354***	1	
11	Life expectancy at birth (Years)	473	60.49	5.85	-0.779***	0.382***	0.106**	0.342***	0.265***	-0.404***	0.188***	0.130***	0.226***	0.110**	1

Note. M and SD represent the mean and SD, respectively. Partial correlations are presented below the diagonal. Computed using the STATA software version 17.

*p < 0.10. **p < 0.05. ***p < 0.01

Following the correlation between the study variables illustrated in Table 4.5 above and focusing on the main study variables, DGGHE per capita had a negative correlation with the DALY, health system efficiency had a positive correlation with DGGHE, and health system efficiency did not have a statistically significant correlation with the DALY. Although a negative correlation between DGGHE and the DALY was expected, a negative correlation between DGGHE and health system efficiency was not expected.

4.4.2 Model estimates

Table 4.5 below presents the estimates of the restricted Model 1 and unrestricted Model 2, excluding the control variables. Model 2 included the interaction term, whereas Model 1 did not. These regression estimates provided the basis for applying Step 1 of the methodology. Both models had negative coefficients for DGGHE, which were statistically significant at 5%, suggesting that DGGHE was negatively related to the DALY. The health system efficiency scores were not significant in either model.

The magnitude of the DGGHE coefficient in Model 1 (b = -0.167; p = 0.045) was smaller than that in Model 2 (b = -0.504; p = 0.023). The interaction term (b = -0.881; p = 0.060) included in Model 2 was statistically significant at the 10% level. These results suggested that Model 2 was better than Model 1, as the inclusion of the interaction term improved Model 2; that is, the magnitude of the DGGHE coefficient was better in Model 2. Therefore, Model 2 was selected for Step 2.

Table 4.5 below presents the results obtained for Models 1 and 2 when applying the Ahn and Schmidt (1995) estimator.

Table 4.5

Results for Models 1 and 2 using the Ahn and Schmidt (1995) estimator.

Variables	MODEL I (restricted model)	MODEL II (unrestricted model)
DGGHE, log	**-0.167** (0.81)**	**-0.504** (0.214)**
Health system efficiency, log	.821 (4.051)	3.432 (2.825)
Interaction term (DGGHE, log & Health system efficiency, log)	-	**-0.881*(0.456)**
Constant	**7.354*** (1.778)**	**8.285*** (1.106)**
Year Dummies	Yes	Yes
No of Observations	473	473
No of Instruments	60	60
Arellano-Bond test for autocorrelation (AR 1)	0.092	0.056
Arellano-Bond test for autocorrelation (AR 2)	0.904	0.215
Sargan-Hansen test (2-step weighting matrix)	0.999	0.996
Sargan-Hansen test (3-step weighting matrix)	0.639	0.599

Note. The dependent variable is DALY. Log, Standard errors are shown in parentheses. The p-values reported for the AR(..) and Sargan-Hansen tests. Computed using the STATA software version 17.

*p < 0.10; **p < 0.05; ***p < 0.01.

Model 2 provided two pieces of information. First, it confirmed the negative relationship between the DALY and DGGHE revealed in Model 1, indicating that a percentage change in DGGHE was associated with a 0.504 percentage point decrease in the DALY in the short term at the 5% significance level. Consequently, the link between DGGHE and the DALY was inelastic. Second, Model 2 provided evidence of a moderating effect on the relationship between the DALY and DGGHE because the coefficient on the interaction term was statistically significant (b = -0.882*). This moderation is discussed in more depth further down.

Table 4.6 below presents moderation analysis estimates. The table includes the estimates of the main, reduced instruments and no-constant models estimated with mean-centred predictors (Iacobucci et al., 2016). The table also includes control variables. The main model results indicated that the interaction between DGGHE and health system efficiency scores to predict DALY was statistically significant at the f5%

level (b = -0.754, p = 0.049). These results supported Hypothesis 2, that health system efficiency moderates the relationship between the DALY and DGGHE. The results also indicated that the model constant and the controlled variables, including the incidence of malaria and domestic general government health expenditure as a share of GDP, were statistically significant at the 1% level, as shown in Table 4.7 below.

Table 4.6

Moderation analysis estimates

Variables	Main Model	Reduced instruments Model	No constant Model
DGGHE, log	**-0.348*** (0.054)**	**-0.347*** (0.050)**	**-0.348*** (0.054)**
Health system efficiency, log	-1.107 (0.915)	-1.155 (1.166)	-1.107 (0.915)
Interaction term (DGGHE, log & Health system efficiency, log)	**-0.754 ** (0.371)**	**-0.764 ** (0.399)**	**-0.754 ** (0.371)**
Incidence of malaria, log (lag1)	**0.046***(0.016)**	**0.048***(0.016)**	**0.046***(0.016)**
DGGHE % of GDP, log	**0.585*** (0.144)**	**0.593*** (0.121)**	**0.585*** (0.144)**
DGGHE % of government expenditures, log	-0.070 (0.095)	-0.063 (0.113)	-0.070 (0.095)
Female education, log (lag2)	-0.031 (0.113)	-0.041 (0.119)	-0.031 (0.113)
Female education, log (lag3)	-0.216 (0.218)	-0.238 (0.258)	-0.216 (0.218)
Constant	**6.200*** (0.050)**	**6.199*** (0.058)**	-
Year Dummies	Yes	Yes	Yes
No of Observations	337	337	337
No of Instruments	35	33	35
Arellano-Bond test for autocorrelation (AR 1)	0.057	0.028	0.057
Arellano-Bond test for autocorrelation (AR 2)	0.271	0.284	0.271
Sargan-Hansen test (2-step weighting matrix)	0.784	0.715	0.784
Sargan-Hansen test (3-step weighting matrix)	0.163	0.174	0.163

Note. Dependent Variable is DALY, log. Standard errors are shown in parentheses. The p-values reported for AR(..) and Sargan-Hansen tests. Computed using the STATA software version 17.

**p < 0.05; ***p < 0.01.

The results revealed that malaria incidence and national government health expenditure as a percentage of GDP could also be considered in the analysis of DALY in

SSA. The main model exhibited good econometric properties, following the model fit indices. At standard levels of significance, the [AR (2)] did not reject the null hypothesis, clearly showing that the residuals were serially uncorrelated, and the p-value of the Sargan-Hansen tests for over-identification restrictions did not reject the null hypothesis, indicating that the instruments were acceptable. The study carried out a thorough mediation analysis based on the results in Table 4.7 below, which presents the marginal effects of the DGGHE and health system efficiency interaction that predicted the DALY.

Table 4.7

Marginal effects of interaction terms

#	DGGHE	HSE	Interaction Marginal effects	#	DGGHE	HSE	Interaction Marginal effects
1	-2.984 (Min)	-0.312 (Min)	6.237 *** (0.917)	16	0 (Mean)	0.165 (+1SD)	5.902 *** (0.207)
2	-2.984 (Min)	-0.165 (-1SD)	6.510 *** (0.631)	17	0 (Mean)	0.329 (+2SD)	5.675 *** (0.405)
3	-2.984 (Min)	0 (Mean)	6.815 *** (0.438)	18	0 (Mean)	0.385 (Max)	5.599 *** (0.473)
4	-2.984 (Min)	0.165 (+1SD)	7.120 *** (0.540)	19	1.254 (+1SD)	-0.312 (Min)	6.691 *** (0.409)
5	-2.984 (Min)	0.329 (+2SD)	7.425 *** (0.836)	20	1.254 (+1SD)	-0.165 (-1SD)	6.289 *** (0.261)
6	-2.984 (Min)	0.385 (Max)	7.529 *** (0.951)	21	1.254 (+1SD)	0 (Mean)	5.839 *** (0.165)
7	-1.254 (-1SD)	-0.312 (Min)	6.422 *** (0.584)	22	1.254 (+1SD)	0.165 (+1SD)	5.389 *** (0.247)
8	-1.254 (-1SD)	-0.165 (-1SD)	6.420 *** (0.370)	23	1.254 (+1SD)	0.329 (+2SD)	4.940*** (0.411)
9	-1.254 (-1SD)	0 (Mean)	6.417 *** (0.211)	24	1.254 (+1SD)	0.385 (Max)	4.788 *** (0.471)
10	-1.254 (-1SD)	0.165 (+1SD)	6.414 *** (0.312)	25	3.071 (Max)	-0.312 (Min)	6.885 *** (0.670)
11	-1.254 (-1SD)	0.329 (+2SD)	6.411 *** (0.543)	26	3.071 (Max)	-0.165 (-1SD)	6.194 *** (0.498)
12	-1.254 (-1SD)	0.385 (Max)	6.410 *** (0.628)	27	3.071 (Max)	0 (Mean)	5.421 *** (0.399)
13	0 (Mean)	-0.312 (Min)	6.557 *** (0.416)	28	3.071 (Max)	0.165 (+1SD)	4.647 *** (0.465)
14	0 (Mean)	-0.165 (-1SD)	6.354 *** (0.238)	29	3.071 (Max)	0.329 (+2SD)	3.874 *** (0.646)
15	0 (Mean)	0 (Mean)	6.128 *** (0.084)	30	3.071 (Max)	0.385 (Max)	3.612 *** (0.720)

Note. HSE denotes health system efficiency. Computed using the STATA software version 17.

**p < 0.05; ***p < 0.01.

The results in Table 4.8 above suggested that at one SD above the DGGHE mean (+1SD ≥ DGGHE > 0), when health system efficiency is one SD below the mean (HSE =

-1SD), the marginal effect of the interaction term on the DALY is 6.289, which is greater than when health system efficiency is one SD above the mean (interaction marginal effects (IME = 5.389). At one SD below the DGGHE mean (-1SD ≤ DGGHE < 0), when health system efficiency is one SD below the mean (HSE = -1SD), the marginal effect of the interaction term on the DALY is 6.42, which is smaller than when health system efficiency is one SD above the mean (IME=6.414).

This revealed that countries with high DGGHE and low health system efficiency had a high DALY, whereas those with high DGGHE and high health system efficiency had a low DALY. Furthermore, these results implied that countries with low government spending on health and low health system efficiency had a high DALY compared with countries with low government spending on health and high health system efficiency, which had a low DALY.

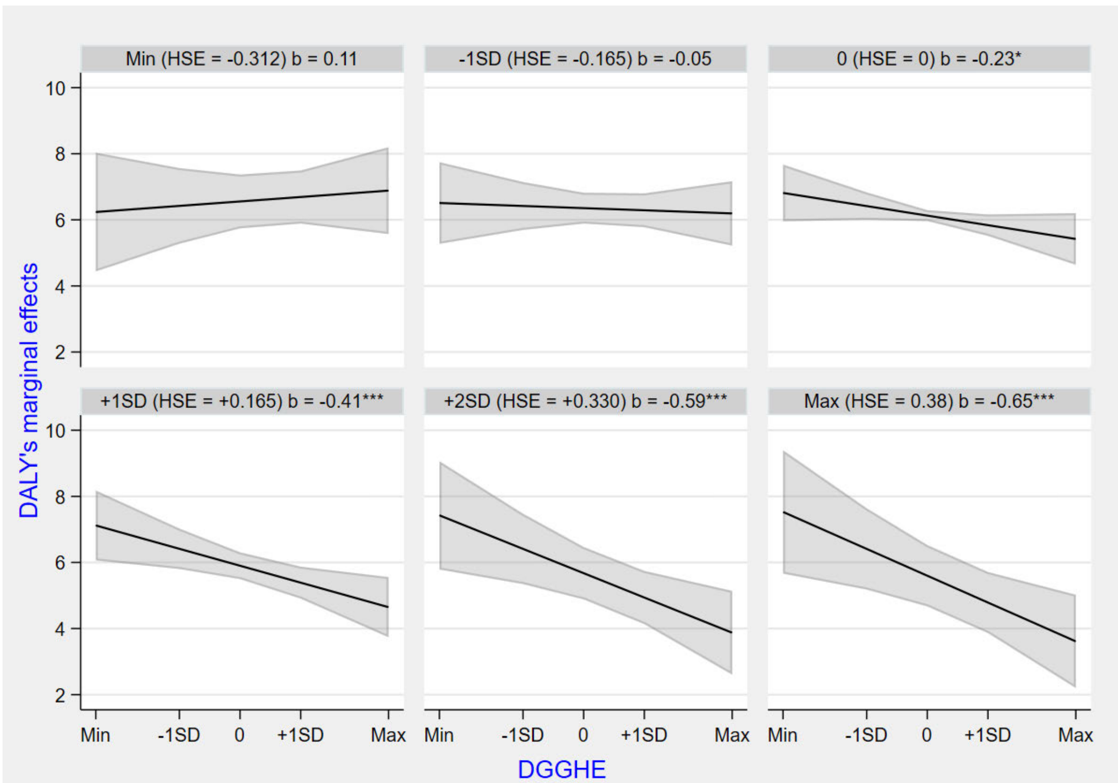
Figure 4.2 above shows the marginal effects curves and provides additional graphical information that led to an understanding of the effects of the interaction term on the DGGHE – DALY relationship. In Figure 4.3 below, the DALY's marginal curves are presented as a function of DGGHE at six different levels of health system efficiency (minimum, - 1SD, 0, +1SD, +2SD, and maximum).

Figure 4.2 below presents the slopes or marginal effects of the interaction term. The figure reveals that the slope of DALY changed from positive (but not statistically significant) at the point where the health system efficiency value was minimal to slightly negative at the point where the health system efficiency value reached the mean value. It then became significantly steeper at the point where the health system efficiency value was maximal.

At points where the DGGHE coefficients were statistically significant, that is, the health system efficiency mean was zero, the DALY marginal effect curves had negative slopes, showing that the strength of moderation decreased with increasing DGGHE levels. This suggested that the moderator had a decreasing strengthening effect. Moreover, the strengthening nature of moderation was supported by all the coefficients of DGGHE. However, the health system efficiency scores and the moderating variables presented in Table 4.8 above were negative (Gardner et al., 2017). Figure 4.3 below presents the marginal effects of the interaction term.

Figure 4.3

Marginal effects of the interaction term



Note. HSE denotes health system efficiency. From the top left to the bottom right, the marginal effects of DGGHE on the DALY are presented when the HSE varies from minimum SD, -1SD, 0SD, +1SD, +2SD, to maximum SD, respectively, with 95% confidence intervals. Computed using STATA version 17 software.

*p < 0.10; ***p < 0.01.

A sensitivity analysis was performed to assess the robustness of the moderation analysis results. The following adjustments were made to the main model to develop the reduced instruments and no-constant models, as presented in Table 4.7. First, the model instruments were reduced from 35 to 33 to estimate the reduced Instruments model, as Roodman (2009) suggests (Roodman, 2009). This adjustment caused a slight decrease in the DGGHE coefficient from -0.348 to -0.347, which remained statistically significant at the 10% level, and a slight increase in the interaction term from -0.754 to -0.764, which also remained statistically significant at the 5% level. Then, the constant term was dropped from the main model to build the no-constant model. The newly estimated models did not change the parameters of interest in the main model. The above adjustments to the main model suggested that the study results were robust.

4.5 Discussion

PHS remains one of the essential instruments for improving population health outcomes and achieving health-related goals in developing regions, such as SSA. However, the relationship between the two variables remains ambiguous in the region, as it does elsewhere and requires further investigation. The study examined the association between PHS and population health outcomes, as evaluated by DGGHE and the DALY, respectively, to assess how health system efficiency influences this relationship in sub-Saharan countries. The study found that increased DGGHE reduces the DALY in this region and that health system efficiency moderated the relationship between DGGHE and DALY.

First, the empirical results demonstrate the statistically significant negative impact of DGGHE on the DALY. This result was consistent with the study's first hypothesis: that an increase in DGGHE is associated with a decrease in the DALY in sub-Saharan countries. This result was expected because the obstacles to healthcare access in SSA are substantial and can only be overcome by increasing DGGHE. Undoubtedly, most people in sub-Saharan countries are impoverished, and their low incomes constitute a significant barrier to accessing healthcare, which private hospitals mostly deliver. In these countries, state-owned and funded health facilities are preferred alternatives because of their affordability. However, their number and services are limited.

In this context, it is anticipated that increased DGGHE will affect more individuals. The DGGHE elasticity of -0.348 found in the study was consistent with previous studies that found that the impact of health spending on reducing public health outcomes had elasticities ranging from -0.110 to -0.380. The research results of the studies conducted by Novignon and Lawanson (2017), Makuta and O'Hare (2015), and Farag et al. (2013) were consistent with the results of the current study despite its using mortality-related indicators as measures of population health outcomes. However, the outcomes of the study by Nicholas et al. (2016) contradicted the results of the present study (Nicholas et al., 2016).

The current study demonstrated that DGGHE and health system efficiency interacted to predict the DALY. The interaction term coefficient of -0.754, which was statistically significant at the 5% level, supported the study's second hypothesis, which was that health system efficiency moderates the association between DGGHE and the DALY. As illustrated in Figure 4.3 above, the results revealed that the moderating effect of health system efficiency reinforces the impact of DGGHE on the DALY. This moderating effect could be considered decremental, meaning its strength decreases as health system efficiency increases. Although increases in DGGHE resulted in DALY reductions in sub-Saharan countries on average, countries on the verge of implementing measures to improve health system efficiency, that is, those with low health system efficiency, experienced larger DALY reductions. Countries with low health system efficiency often encounter wastage of health resources, presenting significant opportunities for enhancing population health outcomes through actions to improve health system efficiency.

Determining the statistical significance and validity ranges of interaction effects is essential for studying moderating effects (Murphy & Aguinis, 2022). Moreover, assessing the moderator's range of validity for which the predictor outcome's slope is significantly different from zero provides a measure of the effort required to enhance the moderator's value so that the predictor achieves the desired impact on the outcome. To this end, a range of techniques employing computer tools and visualisations have been developed and shown to be effective in helping to understand the relevance of interaction effects (Murphy & Aguinis, 2022).

For instance, Figure 4.3, which visualises the marginal moderator effects, reveals that DGGHE was meaningful to the DALY only for those countries with health system efficiency scores one SD or more below the mean. This was essential information since it indicated efforts to raise health system efficiency to reach a point where DGGHE effectively decreased the DALY. In addition, the study identified additional factors that should not be disregarded as contributing to a reduction in the DALY. These factors included the prevalence of malaria and DGGHE as a share of GDP (Bloom & Canning, 2008; Girum et al., 2019).

The study's results explained why DGGHE may have had no insignificant or marginally low impact on population health outcomes indicators, which was also the case in other studies. In the context of the study, it is possible that the ineffectiveness of PHS could be traced to extremely low health system efficiency scores caused by dysfunctions that prevented the health system from achieving improved health outcomes regardless of the level of PHS intervention. Notably, while the results of the study provided evidence for an increase in DGGHE and an improvement in health system efficiency, this was a necessary but insufficient condition, as the reduction in the DALY may have depended on other factors that were not considered in the study because of a lack of country-level data.

The policy implication of the research results is that governments in SSA should ensure the efficiency of their health systems by promoting initiatives that enhance the organisation and delivery of services. This will guarantee effective healthcare for the population and help avoid wasting health resources, resulting in a high return on healthcare spending.

The study's main contribution was methodological in that it examined the factors influencing the strength and/or magnitude of the relationship between PHS and population health outcomes rather than investigating the final effects of PHS on population health outcomes. In addition, the study employed health system efficiency as a moderator of the relationship between PHS and population health outcomes. This addressed all potential impacts of health system efficiency on the PHS – population health outcomes relationship by assessing both the direct effect of PHS on population health outcomes and its indirect effect on population health outcomes via its interaction with DGGHE. In addition, the study estimated population health outcomes using the DALY, a summary of population health that provides a comprehensive view of a population's health state than typically used mortality indicators, such as under-five, neonatal and maternal mortality, or life expectancy.

The present study was limited by insufficient time observations for some control variables relevant to sub-Saharan countries, such as the poverty level, physician count, and hospital bed count. The panel data used in the study could have been of higher quality if there had been more observations on these variables, which would have permitted their inclusion. In addition, the indicator used to measure population health outcomes was not comprehensive because it only included detrimental outcomes. The use of a summary measure of population health indicators that measures positive health outcomes could provide additional insight into this topic. However, these limitations should not invalidate the current study's results but be viewed as a starting point for future research.

4.6 Chapter summary

In sub-Saharan countries, population health is poor and requires special attention despite access to various evidence-based interventions that could improve the situation. Moreover, PHS is commonly implemented in many countries to improve population health outcomes, minimise catastrophic medical costs, and accelerate progress towards UHC. As in other parts of the world, the relationship between PHS and population health outcomes in the sub-Saharan region is ambiguous and requires exploration. Therefore, the study examined the relationship between PHS and population health outcomes, as measured by DGGHE and the DALY, respectively, to determine how health system efficiency influences this relationship in sub-Saharan countries.

The study used the GMM estimator proposed by Ahn and Schmidt (1995) and the three-stage moderation technique proposed by Aiken and West (1991) on panel data from sub-Saharan countries from 2008 to 2018. The study's results provided empirical evidence that increasing DGGHE will reduce the DALY in sub-Saharan countries and revealed the moderating effect of health system efficiency, which detrimentally reinforces the reduction in DALY. The policy implication is that governments in SSA should ensure the efficiency of their health systems by promoting initiatives that enhance the organisation and delivery of services. This will ensure that the population receives effective healthcare and that health resources are efficiently utilised, resulting in a high return on investment or healthcare spending.

While this chapter has examined the efficiency of health systems as a structural factor influencing the extent to which DGGHE affects DALY, the following chapter examines another structural factor specific to SSA to assess how it influences how DGGHE affects the DALY.

Chapter 5.
The Effectiveness of Public Health Spending in Sub-Saharan Africa: Investigating the Moderating Role of Governance using the PLS-SEM Approach

5.1 Introduction

The contribution of health to economic growth is widely acknowledged in the economic literature, and several strategies have been proposed to enhance health. However, the justification for increased PHS to improve health is frequently based on its effects on economic growth, development, and poverty reduction (Barro, 2013; Diyoke, 2019; Lawanson & Umar, 2021; Panneer et al., 2022). Nevertheless, sub-Saharan countries have adopted PHS to enhance population health because of population poverty and the lagging achievement of the SDG health objectives (Montes et al., 2020).

Compared with private health expenditure and external health aid, PHS is a better policy tool for improving access to healthcare and reducing the negative effects of the high proportion of out-of-pocket health expenditures, thus preventing the exacerbation of poverty in the sub-Saharan region, where 1.9% of the population lived below the international poverty line of US$1.90 per day in 2011 (PPPs) (Montes et al., 2020). PHS has been recognised as a useful tool for achieving universal health coverage (Piatti-Fünfkirchen & Schneider, 2018). However, private healthcare expenditure, including out-of-pocket costs, accounts for a greater share of health spending in sub-Saharan countries. This increases the population's financial burden for healthcare, limits access to healthcare, and, as a result, exacerbates poverty (Le Blanc, 2015).

External health assistance is given to countries based on the donors' objectives, which determine the allocation to specific health programmes. However, it is common for these health programmes to not align with the top priorities of the recipient countries receiving the assistance, such as combatting prevalent diseases, improving maternal and child health, enhancing healthcare access and infrastructure, addressing public health emergencies, and reducing mortality rates. In addition, these initiatives have become scarce owing to economic downturns (Schäferhoff et al., 2019).

Developing nations, including sub-Saharan countries, have been confronted with contradictory results regarding leveraging increased PHS to enhance population health outcomes (Langnel & Buracom, 2020). Numerous studies on the effectiveness of PHS have ignored or misrecorded crucial regional characteristics that influence the effectiveness of PHS, yielding contradictory results and inconsistent conclusions. The context in which sub-Saharan countries operate is characterised by certain factors, including country governance, influencing PHS's effectiveness in improving health outcomes.

Poor governance is considered one of the most significant obstacles to delivering public health services in SSA and requires special attention (Hillermann, 2022; Issa, 2023; National Academies of Sciences & Medicine, 2018). The adverse effects of poor governance on the health sectors can be explained from two perspectives. First, poor governance can hinder the effectiveness of PHS with large budget allocations to the health sector, not resulting in expected improvements in health outcomes. For example, the negative externalities of poor governance, such as institutional corruption, a lack of accountability and transparency, and arbitrary policymaking, can undermine the effectiveness of PHS by allowing resources to be wasted or diverted (Vian, 2020). Second, an increase in per capita national income may not be sufficient to improve health outcomes due to poor governance. For example, bribes paid to gain access to healthcare can absorb an increase in a household's disposable income and maintain the level of use of healthcare facilities (Naher et al., 2020).

Considering the above, studies on PHS effectiveness in SSA must consider all aspects of country governance. However, many studies have been conducted on country governance in SSA. These studies have analysed the six components of governance, assessing their direct effects on either population health outcomes or PHS (Doucouliagos et al., 2021; Ibukun, 2021; Langnel & Buracom, 2020; Odhiambo et al., 2015). However, few studies have explored how governance influences the relationship between PHS and population health outcomes. Conducting moderation analysis in this context is essential because it leads to understanding how governance may interact with other variables and influence its effects on population health outcomes.

Past studies have used the components of governance separately while assessing their moderating effects, disregarding how these components can interact to increase the effect of country governance on the relationship between PHS and population health outcomes (Hilaire, 2015; Makuta & O'Hare, 2015; Rajkumar & Swaroop, 2008). In addition, most of the methods employed in these past studies have imposed a distribution on the data and residuals, not allowed for small sample sizes, and assumed that the variables are independent. They cannot handle missing data and omitting independent variables (Hair et al., 2021). Therefore, the current study aimed to address the abovementioned issues by jointly evaluating three governance components using PLS-SEM, an increasingly popular method for estimating complex models with latent and observed variables, allowing for data requirements flexibility.

The study aimed to determine how country governance influenced the relationship between PHS and population health outcomes in SSA during the period under study. Therefore, the study addressed two questions: (1) Does increased PHS relate to lower population health outcomes? (2) Does effective governance enhance the effects of PHS on population health outcomes?

The study measured PHS and population health outcomes using DGGHE and the DALY, respectively. DGGHE is a key policy instrument for accelerating progress towards universal health and achieving health-related SDG because it represents the national resources the government has overall control (WHO, 2018a). The DALY is a summary measure of population health that considers both mortality and morbidity to characterise the health of a specific population (Gold & Field, 1998).

Three dimensions of governance (control of corruption, government effectiveness, and voice accountability) were jointly employed to measure country governance as a moderator of the link between DGGHE and the DALY. Control of corruption refers to the extent to which a government successfully prevents and combats corruption within its institutions and public sectors. Government effectiveness refers to how efficiently and competently a government implements and delivers public policies and services. Voice accountability refers to the ability of citizens and civil society groups to express their opinions, concerns, and demands and to participate in the decision-making processes of governance.

The PLS-SEM was applied to panel data from 43 sub-Saharan countries from 2013 to 2019 using publicly available data. To the best of the researcher's knowledge, this was the first study in SSA to investigate three governance components jointly as moderators of the relationship between DGGHE and the DALY by applying the PLS-SEM

The remainder of this chapter is structured as follows. The relevant literature is reviewed in Section 2. The third section discusses the methodology employed for the study. The empirical results are discussed in Section 4. In Section 5, the results are discussed. Section 6 concludes the chapter.

5.2 Literature review

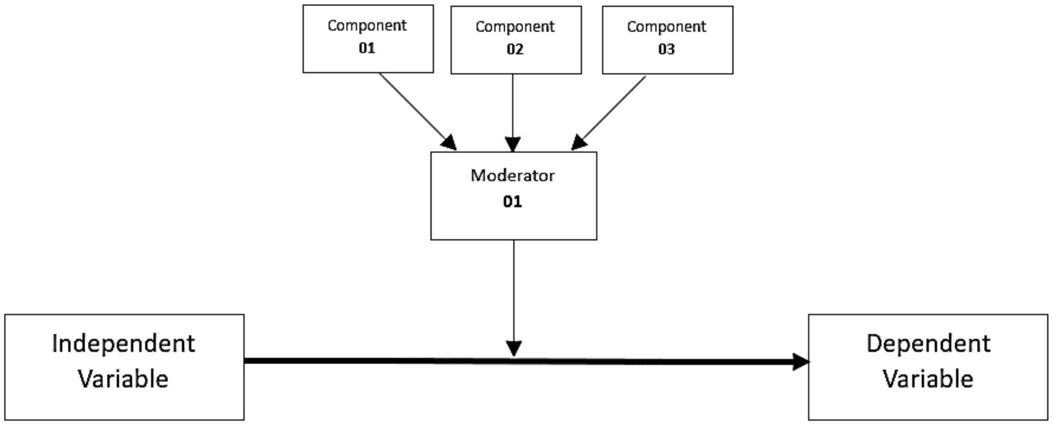
This section first provides the framework within which governance was studied, then reviews empirical studies on the link between PHS and health outcomes, and finally presents the hypotheses.

5.2.1 Theoretical framework

This study utilised the moderation approach initially introduced by Baron and Kenny (1986) to achieve its objective, which has subsequently seen several developments (Hair Jr et al., 2021; Liu & Yuan, 2021). This approach posits that the strength of the relationship between independent and dependent variables is determined by the value of a third variable (Hair Jr et al., 2021; Patterson, 2023). Figure 5.1 below depicts the conceptual framework of the moderation approach, which indicates that the principal effect of interest is the path from the independent variable to the dependent variable. The arrow pointing to the direct effect indicates that another variable, the moderator, moderates the effect of the independent variable on the dependent variable.

Figure 5.1

Moderation conceptual framework



Note. A diagram illustrating a moderation model in which a second order latent moderator with three components influences (b) the relationship between the independent and dependent variables (a). Adapted from Introduction to mediation, moderation, and conditional process analysis: A regression-based approach (3rd ed., p.235), A. F. Hayes, 2022, The Guilford Press. Copyright 2022 by The Guilford Press.

Governance research is conducted from three theoretical perspectives: the conceptualisation of government quality and quantity, the scope and kind of government quality, and the direct or indirect role of government quality in a causal process (Kim & Wang, 2019). The study considered the third perspective because the investigation explored the moderating effect of governance quality on the effectiveness of PHS in enhancing population health outcomes. This perspective would reveal all the potential effects of governance, as it allowed for the simultaneous evaluation of the direct effect of governance and its moderating effects via interaction with other variables. Adopting this framework had the potential to clarify the ambiguous nature of the relationship between PHS and population health outcomes.

5.2.2 Empirical review

Empirical research on the relationship between PHS and population health outcomes in SSA is limited and inconclusive (Ayimaleh, 2023; Frank & Mcineka, 2021; Kamiya, 2010; Nketiah-Amponsah, 2019; Ochiaka & Akuma, 2021; Weibo & Yimer, 2019). Most of these studies have focused on assessing the overall direct effect of PHS on population health outcomes rather than investigating how critical factors in SSA, such as poor governance, might moderate the relationship between PHS and population health outcomes.

A few studies have investigated the moderating effect of governance quality on the effectiveness of PHS on population health outcomes in sub-Saharan countries. For example, Rajkumar and Swaroop (2008) investigated the importance of governance, as defined by the extent of corruption and the quality of bureaucracy, when assessing the effectiveness of PHS in reducing child mortality rates. The study applied OLS regressions to several countries' cross-sectional data from 1990, 1997, and 2003. The results suggested that the quality of governance could largely explain disparities in the effectiveness of PHS, as PHS reduced child death rates more in countries with effective governance (Rajkumar & Swaroop, 2008).

The study conducted by Boundioa and Thiombiano (2023) examines the impact of governance quality on the association between public health expenditure and life expectancy at birth within the West African Economic and Monetary Union. The data encompassing the period from 1996 to 2018 was subjected to a threshold-effect analysis. The study's findings indicate a significant relationship between public health expenditure and life expectancy, particularly when the quality of governance is high. This suggests that the quality of governance acts as a moderating variable, influencing the impact of public health expenditure on life expectancy (Boundioa & Thiombiano, 2023).

Hilaire (2015) reassessed the PHS – population health outcomes nexus in African countries, focusing on the interaction between governance and PHS and its effect on population health outcomes as measured by life expectancy at birth, the infant mortality rate, the under-five mortality rate, and adult death rates. The study applied FE and GMM estimators to a panel of 43 African countries from 1996 to 2012. The results revealed that total health expenditures per capita and PHS significantly impacted health outcomes. However, the role of governance and its interaction with PHS appeared to be mixed (Hilaire, 2015).

The impact of governance and health expenditure on infant mortality was examined by Langnel and Buracom (2020) using panel data encompassing 32 SSA countries from 2000 to 2015. Using a system-GMM method, they determined that infant mortality, health expenditure, and governance do not correlate directly. However, the estimated interaction between health spending and government effectiveness is statistically significant and suggests an inverse relationship with infant mortality. This implies that assessing the governance levels in Sub-Saharan African (SSA) nations could potentially shed light on the effectiveness of health expenditure in those regions (Langnel & Buracom, 2020).

Another study by Makuta and O'Hare (2015) investigated whether the quality of governance modified the impact of PHS on health outcomes, as measured by under-five mortality and life expectancy at birth in SSA. They applied a two-stage least-squares regression technique to panel data from 43 countries in SSA from 1996–2011. The results revealed that PHS had a statistically significant impact on health outcomes, leading to improvement. Moreover, the elasticities related to under-five mortality ranged between -0.09 and -0.11, and those related to life expectancy at birth ranged between 0.35 and 0.60. In addition, the results indicated a significant interaction between the quality of governance and PHS, suggesting that an improvement in the quality of governance would enhance the overall impact of PHS, such that in countries with a higher quality of governance, improvement in population health outcomes would be higher than in countries with a lower quality of governance (Makuta & O'Hare, 2015).

Finally, Ibukun (2021) assessed the moderating effect of the quality of governance when studying the effect of health expenditure, as measured by PHS and private health spending, on health outcomes, as measured by infant mortality, under-five mortality, and life expectancy at birth in the West African sub-region. The study applied two-stage least squares regression on a panel of 15 Western African countries from 2000–2018. The results revealed a negative relationship between health expenditures and infant mortality and under-five mortality but a positive relationship between health expenditures and life expectancy at birth. Additionally, the results demonstrated that countries with effective governance might obtain greater benefits from their PHS (Ibukun, 2021).

The research reviewed above used distinct governance dimensions in separate regression models. Consequently, the possibility of these governance dimensions interacting and influencing population health outcomes was overlooked, leading to adverse effects and the risk of drawing inaccurate or misleading conclusions. These studies also evaluated population health outcomes using mortality-based indicators, meaning their research overlooked the increased morbidity associated with improvements in medical treatments that allow people to live longer. Using population health indicators that consider this fact is preferable as they will contribute to good analytical outcomes. Finally, these studies used estimators, such as OLS, FE, two least squares (2SLS), and GMM. The shortcomings of these estimators and the risks they pose to study results have been widely documented; therefore, the current study aimed to address them.

5.2.3 Hypotheses development

The literature on public health and economics recognises PHS as one of the tools used to enhance population health outcomes and advance UHC (Rad et al., 2013; Yardim et al., 2010). Numerous studies have empirically demonstrated that PHS improves population health outcomes, supporting the PHS – population health outcomes nexus. For example, Anyanwu and Erhijakpor (2009) examined the effectiveness of total and public health expenditures on population health outcomes as proxied by under-five and infant mortality rates. They applied two-stage OLS estimation to panel data from African countries. Their results revealed that both total health expenditure and public health expenditures per capita had a significant negative effect on under-five and infant mortality rates, with total health expenditure elasticities of -0.21 and -0.22 for under-five and infant mortality, respectively, and PHS elasticities of -0.25 and -0.21 for under-five and infant mortality, respectively (Anyanwu & Erhijakpor, 2007).

Grekou and Perez (2014) conducted a study between 2000 and 2011 to determine the factors contributing to SSA's high child mortality rate. Using panel data from 45 sub-Saharan nations with fixed and random effects and instrumental variables for model estimation, they discovered that increased public health expenditures significantly reduced child and under-five mortality. However, the reduction in mortality rates was much lower (Grekou & Perez, 2014). Another study by Novignon and Lawanson (2017) examined the relationship between PHS and child health outcomes, as measured by infant mortality, under-five mortality, and neonatal mortality rates, using fixed and random effects panel data regression models and data from 45 sub-Saharan countries from 1995 to 2011 The results revealed a negative, significant association between PHS and population health outcomes, with elasticities of -0.11, -0.15, and -0.08 for infant, under-five, and neonatal mortality rates, respectively (Novignon & Lawanson, 2017).

In the studies reviewed above and in the related literature, PHS is important in improving population health outcomes. Therefore, by measuring PHS and population health outcomes using DGGHE and the DALY, respectively, the study proposed the following hypothesis:

H_1: Increased DGGHE is related to lower DALY in SSA.

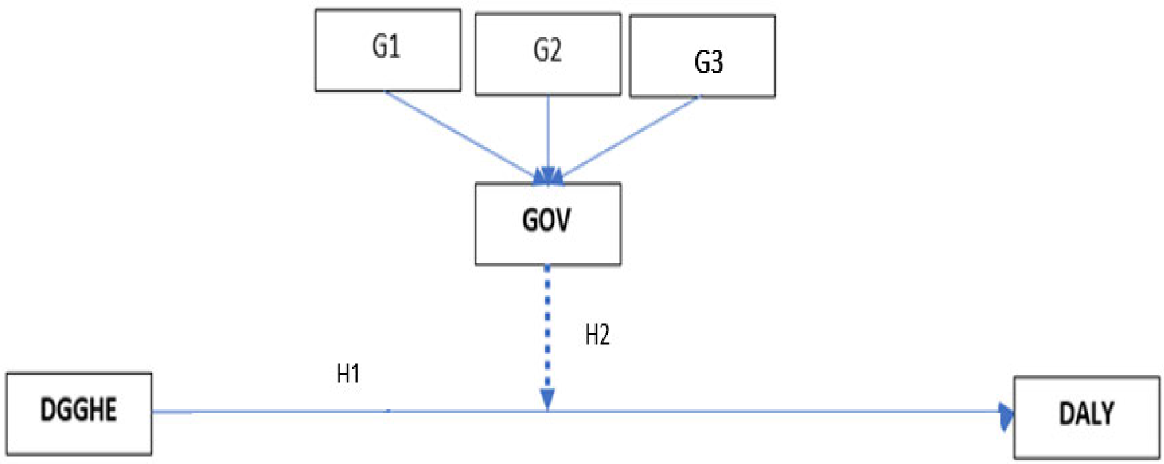
The significance of country governance to PHS has received considerable attention. Grossman (1972) discusses the relationship between health expenditure and health outcomes, demonstrating that it is required to invest in an individual's social capital, for example, through PHS, to maintain and/or improve an individual's social capital. However, it should be recognised that health spending occurs within a well-established institutional framework strongly influenced by governance (Folland et al., 2016). Moreover, when economists and policy analysts agree on the importance of good governance for improving a country's economic performance and, consequently, the well-being of the population, they also emphasised the impact of the quality of governance on the effectiveness of PHS (Ibukun, 2020; Naher et al., 2020). The World Health Organisation's 2016 report reinforces the above views: "Good governance is critical to improving the effectiveness of PHS" (WHO, 2016b). Drawing on the above arguments, the study proposed the following hypothesis:

H2: Governance quality moderates the relationship between DGGHE and the DALY

Figure 5.2 below presents the moderation hypotheses. The figure shows how hypotheses H1 and H2 are related. The model illustrates that the relationship between DGGHE and the DALY is affected by the influence of country governance (made up of three of its components), which can change its magnitude and/or direction.

Figure 5.2

Moderation analysis hypotheses



Note. DGGHE is the covariate of interest, DALY is the outcomes variable, and governance (GOV) is the moderator, which is a latent variable made up by its component corruption control (G1), government effectiveness (G2), and voice accountability (G3). The path from DGGHE to DALY (H1) denotes the impact of DGGHE on DALY, and the path from country governance to the effect of DGGHE (H2) represents the moderating effect of governance. For simplicity, the graph does not present the control variable impacts. Adapted from Introduction to mediation, moderation, and conditional process analysis: A regression-based approach (3rd ed., p.235), A. F. Hayes, 2022, The Guilford Press. Copyright 2022 by The Guilford Press.

5.3 Methodology

5.3.1 Data description and sources

This section examines the data from a panel of 42 Sub-Saharan African countries[2] from 2013 to 2019, subject to data availability. By choosing 42 countries and the period from 2013 to 2019, an up-to-date and relevant temporal framework was established, which facilitated the assessment of the effectiveness of PHS. The selected study period made it possible to exclude the period of the COVID-19 pandemic, which had substantial repercussions in early 2020, could be omitted. The selection of countries allowed us to exclude certain countries from the research based on discrepancies in the quality and comprehensiveness of the available data. These factors could have had a negative effect on the accuracy and comparability of the results. Data were obtained from the Global Health Data Exchange (GHDex), World Development Indicators (WDI), World Governance In indicators (WGI), and Global Health Expenditures (GHE) databases for 2013–2019 (IHME, 2022; Kaufmann & Kraay, 2022; WHO, 2021a; World Bank, 2021). Before the analysis, all data were compared with other sources, such as the country's national health accounting reports, to guarantee consistency. Table 5.1 summarises the study variables, including their respective descriptions, sources and expected signs.

[2] The list of countries includes in the study is in Appendix 1.1. For this analysis, Djibouti, Mauritius, Seychelles, Somalia, South Sudan, and Sudan were excluded due to lack of data.

Table 5.1

Variable descriptions and sources

Description		Indicators	Type of variable	Sources	Expected sign
Control of corruption	ccor	Control of Corruption: Estimate	Covariate	WGI	Negative
DALY, total	daly	Disability-adjusted life years All causes Both (per 100,000 people)	Dependent	GHDex	-
DGGHE, total	dgghe	DGGHE per capita, PPP (cst 2017 intl $)	Covariate (main)	GHED	Negative
Female education	femed	School enrollment, primary, female (% gross)	Covariate	WDI	Negative
Government Effectiveness	govef	Government Effectiveness: Estimate	Covariate	WGI	Negative
Incidence of Malaria	mala	Incidence of HIV, all (per 1,000 uninfected population)	Covariate	WDI	Positive
Incidence of Tuberculosis	tb	Incidence of tuberculosis (per 100,000 people)	Covariate	WDI	Positive
Prevalence of HIV/AIDS	hiv	Incidence of malaria (per 1,000 population at risk)	Covariate	WDI	Positive
Voice accountability	voc	Voice and Accountability: Estimate	Covariate	WGI	Negative

Note. Variables included in the study dataset from 2013 to 2019

Regarding the data on governance dimensions (control of corruption, government effectiveness, and voice accountability), each country was assigned a score (value) ranging from -2.5 to +2.5 for each indicator. A score of -2.5 indicates a very low rating, while a score of +2.5 indicates a very high rating (Kaufmann & Kraay, 2008). The use of governance indicators has sparked substantial academic discussions. Objections generally focus on the importance of carefully selecting which indicators to include and how to use them, as each indicator has distinct information about governance (Bersch & Botero, 2014). As scholars and practitioners understand, governance quality comprises multiple concepts. When discussing governance quality, one is often presented with several subdimensions that shape the overall concept of governance quality (LeRoux, 2009). Nevertheless, these subdimensions cannot be accurately represented by a single indicator. Consequently, the subdimensions of governance quality, also highly visible in codes of conduct, should be considered formative constructs.

Consequently, it is suggested that governance quality should be quantified through a second-order formative construct in which the latent variable “governance quality” is composed of other latent variables defined by a set of concrete indicators. This construct type is called a "reflective first-order, formative second-order" construct (Hair et al., 2017). The study selected three components to measure governance based on data availability and indicator relevance in the African context.

In the study, therefore, governance was a second-order construct created from corruption control (G1), government effectiveness (G2), and voice accountability (G3) as first-order construct indicators. Although they all relate to the same topic, these governance components were modelled as reflexive constructs because they were expected to interact and have the same antecedent and outcome (Sarstedt et al., 2016).

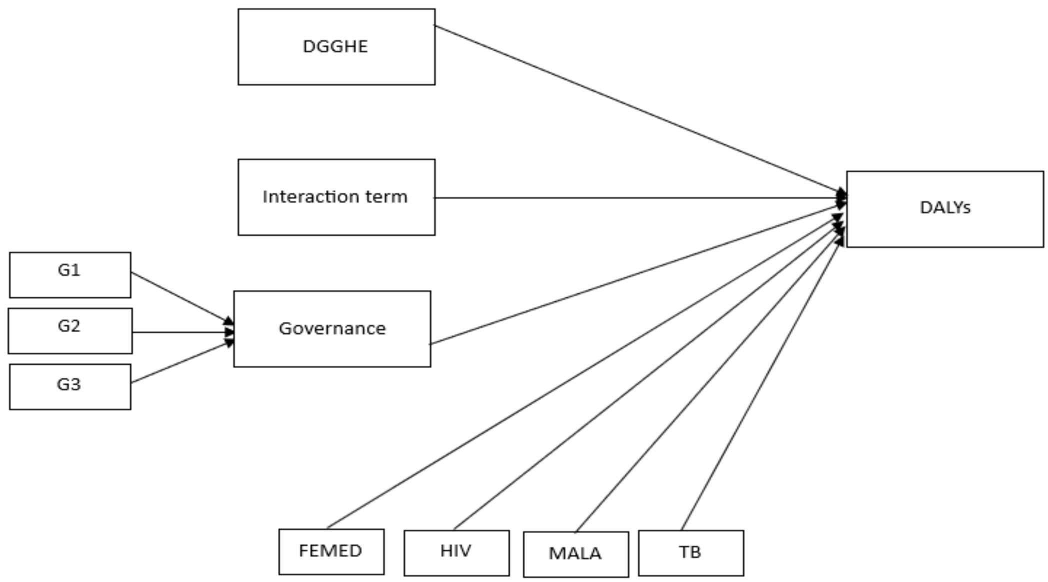
5.3.2 Empirical model and estimation technique

5.3.2.1 Empirical model.

Based on the conceptual framework in Figure 5.1 above, the types of variables included in the analysis, and evidence in the health and economic literature, the study employed the model illustrated in Figure 5.3 below to test the hypotheses. This model incorporated one endogenous construct (DALY), five exogenous constructs (DGGHE, malaria incidence (MALA), tuberculosis incidence (TB), HIV/AIDS incidence (HIV), female education (FEMED), and governance (GOV), and one interaction term (DGOV). Except for governance, all the variables were first-order constructs. Governance was a second-order construct, which included the first-order constructs of corruption control (G1), government effectiveness (G2), and voice accountability (G3). Manifesting variables are not presented in the figure because of space constraints.

Figure 5.3

Statistical diagram of the moderation analysis



Note. The construct DGGHE is the variable of interest, constructs female education (FEMED), incidence of malaria (MALA), incidence of tuberculosis (TB), and prevalence of HIV are control variables. The lines from corruption control (G1), government effectiveness (G2), and voice accountability (G3) indicate the composition of the governance construct. All lines towards DALY denote the construct effects on DALY, with that from the interaction term variable representing the moderating effect of country governance. Adapted from Introduction to mediation, moderation, and conditional process analysis: A regression-based approach (3rd ed., p.241), A. F. Hayes, 2022, The Guilford Press. Copyright 2022 by The Guilford Press.

The numerous pathways between variables depicted in Figure 5.3 above provided a basis for investigating a variety of hypotheses. However, this analysis focused primarily on the pathway from DGGHE to the DALY and that from the interaction term to the DALY, as both pathways were relevant to the hypotheses the study aimed to test.

5.3.2.2 Estimation technique.

The study used the PLS-SEM method for model estimation. In contrast to covariance-based SEM, PLS-SEM enables the development and assessment of complex models encompassing latent and observed variables, facilitating the examination of cause-effect relationships. The increasing popularity and extensive utilisation of PLS-SEM in economic and public health research can be attributed to its proficiency in estimating complex models and its flexible data requirements (Albassam, 2020; Bala et al., 2022; Frank & Mcineka, 2021; Moya-Clemente et al., 2020; Ramírez-Orellana et al., 2021).

PLS-SEM was deemed suitable for this investigation due to the study's objective of assessing a theoretical model. This was achieved by using a dataset with an unknown distribution. This approach does not enforce a specific distribution on the dataset and exhibits minimal limitations in measurement scales, sample size, and residual distributions. Furthermore, this approach does not assume complete independence among variables, effectively deals with missing data, and exhibits robustness in the presence of data skewness and the omission of independent variables (Hair et al., 20212). Several methodological expansions of PLS-SEM have been devised to offer researchers and practitioners diverse technical options to achieve their analytical objectives. Some examples encompass moderation, mediation, multi-group analysis, latent class segmentation, and predictive analysis.

The present study applied the moderation analysis technique within the PLS-SEM framework to assess the models. This approach incorporates interaction terms, primarily derived through the application of the product indicator, orthogonalization, and two-step techniques (Henseler & Chin, 2010). The two-step technique proposed by Chin (1998) is widely regarded as appropriate for use in PLS-SEM (Chin, 1998). This is due to recent progress in the utilisation of the path coefficient model within the context of PLS-SEM, as well as its effectiveness in overcoming the limitations associated with product indicator and orthogonalisation techniques (Henseler & Fassott, 2010; Henseler et al., 2015).

5.3.3 Data analysis

The two-step method proposed by Chin (1998) and Henseler and Fassott (2010) was used to achieve the study objective. The procedure comprised two steps: evaluating the measurement models of the study constructs and using the structural model to assess the proposed research hypotheses.

In the first stage, the assessment of measurement models was conducted whereby the relationships between constructs and their manifest variables were investigated based on Hair et al.'s (2017) guidelines (Hair Jr et al., 2017). Low-order constructs (LOC) and Higher-order constructs (HOC) were addressed in this step, as LOCs are created from manifest variables, and HOCs from LOCs are reflexive models because their observed variables reflect them. Hair et al. (2017) presented three methods for evaluating measurement models: internal consistency reliability, convergent validity, and discriminant validity. Internal consistency estimates dependability based on the intercorrelations of the observed indicator variables. Composite reliability is used to measure internal consistency reliability because Cronbach's alpha is sensitive to the number of elements on a scale and tends to underestimate it. Nunally and Bernstein (1994) suggest a composite reliability of .7 or higher to be regarded as acceptable (Nunnally & Bernstein, 1994).

Convergent validity refers to how well a measure corresponds with other measures of the same construct. To assess the convergent validity of reflective constructs, researchers look at the outer loadings of the variables and the average variance extracted (AVE). The factor loading of an item on the underlying construct is used to measure its reliability. A factor loading of .7, according to Hair et al. (2017), suggests that an item's validity is acceptable. Segars (1997) states that an AVE of .50 or greater is appropriate. Discriminant validity refers to the extent to which a construct is distinct from other constructs according to empirical criteria. Henseler et al. (2015) propose utilising the heterotrait-monotrait ratio (HTMT) of correlations to measure discriminant validity. The HTMT between two constructs near 1 implies that discriminant validity is lacking.

If the study presented the required characteristics, the constructs addressed and evaluated would be utilised in two structural equation models (ME and MI), which were developed in the second stage. The model excluding the interaction term (ME) was a reflexive model in which each latent variable was reflected by its observed variables. This model comprised six reflexive LOCs because each indicator measured the errors imposed on a latent variable (Henseler et al., 2009). Instead of an interaction term, the model in the study included five covariates related to the dependent variable. This model was utilised to test the first study hypothesis of the existence of the relationship that the moderator was expected to influence (Aiken et al., 1991).

The model, including the interaction term (MI) was a higher-order reflexive-reflexive model comprising nine lower-order constructs (LOCs), one higher-order construct (HOC), and an interaction term. The HOC was a latent variable that LOCs reflected. The internal consistency, discriminant validity, and convergent validity of the HOC were examined using the disjoint two-phase approach (Sarstedt et al., 2019). The MI model was used to evaluate Hypothesis 2, which proposed that governance would moderate the relationship between DGGHE and DALY. Both the ME and MI models were evaluated using the structural model evaluation approach, which included the evaluation of collinearity, relevance and significance of the pathway coefficients, coefficient of determination (R2), effect size (f2), predictive relevance (Q2), and predictive power (q2) (Hair Jr et al., 2017).

The MI model was used to perform moderation analysis following the three steps proposed by Memon et al. (2020). The first examines the magnitude and significance of the moderating effect, as indicated by the coefficient of the interaction term, which helps determine the existence of the moderating effect. The second computes the effect size. The latter visually assesses the magnitude and direction of the moderating effect using a basic slope graph (Memon et al., 2020).

The size and effect of the pathway coefficients were estimated using the bootstrapping procedure of the PLS-SEM algorithm with 5000 bootstrapping samples, using the no sign change option, full bootstrapping, bias-corrected and bootstrapping, two-tailed test, and standard parameters with mean value replacement for missing values. The significance of the estimates was assessed using a 5% significance level and bias-corrected 95% confidence intervals (Hair Jr et al., 2017). Data were analysed using SmartPLS 3.3.8 software (Ringle et al., 2015).

5.4 Empirical results

5.4.1 Model assessment

5.4.1.1 Measurement model.

The results used to assess the measurement models for the lower-order construct are presented in Tables 5.2 and 5.3 below. Table 5.2 shows the low-order construct's estimates of internal consistency and convergent validity, Table 5.3 shows the low-order construct's estimates of discriminant validity.

Table 5.2

Estimates of internal consistency/convergent validity (low-order construct)

Constructs	Indicators	OUTER LOADINGS (>.70)	Composite Reliability (>.70)	Average Variance Extracted (>.50)
	daly22013	0.995		
	daly22014	0.995		
	daly22015	0.999		
DALY	daly22016	0.999	0.999	0.995
	daly22017	0.999		
	daly22018	0.998		
	daly22019	0.996		
	dgghe17_2013	0.997		
	dgghe17_2014	0.999		
	dgghe17_2015	0.995		
DGGHE	dgghe17_2016	0.994	0.999	0.992
	dgghe17_2017	0.997		
	dgghe17_2018	0.994		
	dgghe17_2019	0.994		
	femed2013	0.938		
	femed2014	0.969		
	femed2015	0.967		
FEMED	femed2016	0.952	0.980	0.876
	femed2017	0.926		
	femed2018	0.901		
	femed2019	0.897		
	g1cor2013	0.976		
	g1cor2014	0.986		
	g1cor2015	0.994		
G1	g1cor2016	0.993	0.996	0.974
	g1cor2017	0.993		
	g1cor2018	0.988		
	g1cor2019	0.977		
	g2eff2013	0.977		
	g2eff2014	0.985		
	g2eff2015	0.989		
G2	g2eff2016	0.993	0.996	0.974
	g2eff2017	0.994		
	g2eff2018	0.992		
	g2eff2019	0.979		
	g6voa2013	0.973		
	g6voa2014	0.986		
	g6voa2015	0.988		
G6	g6voa2016	0.992	0.995	0.967
	g6voa2017	0.993		
	g6voa2018	0.981		
	g6voa2019	0.971		
	hivprev2013	0.999		
	hivprev2014	1.000		
	hivprev2015	1.000		
HIV	hivprev2016	1.000	1.000	0.999
	hivprev2017	1.000		
	hivprev2018	1.000		
	hivprev2019	0.999		
	malinc2013	0.929		
	malinc2014	0.973		
	malinc2015	0.989		
MALA	malinc2016	0.995	0.990	0.931
	malinc2017	0.925		
	malinc2018	0.970		
	malinc2019	0.972		
	tb2013	0.965		
	tb2014	0.981		
	tb2015	0.994		
TB	tb2016	0.999	0.996	0.972
	tb2017	0.997		
	tb2018	0.990		
	tb2019	0.975		

Note. Computed using the SmartPLS 3.3.8 software.

As shown in Table 5.2 above, all factor loadings, composite reliability, and average variance extracted exceeded the minimum threshold (in parentheses). They satisfied the advised standards, suggesting the constructs' internal consistency and convergent validity.

Table 5.3 below shows the low-order construct's estimates of discriminant validity.

Table 5.3

Estimates of discriminant validity (low-order construct)

Paths	HTMT ratio	Confidence intervale	
		LB	UB
DGGHE -> DALY	0.128	0.029	0.312
FEMED -> DALY	0.207	0.057	0.409
FEMED -> DGGHE	0.032	0.016	0.029
HIV -> DALY	0.229	0.028	0.478
HIV -> DGGHE	0.650	0.437	0.806
HIV -> FEMED	0.177	0.047	0.339
MALA -> DALY	0.408	0.146	0.662
MALA -> DGGHE	0.476	0.323	0.595
MALA -> FEMED	0.120	0.057	0.154
MALA -> HIV	0.407	0.150	0.596
TB -> DALY	0.265	0.033	0.503
TB -> DGGHE	0.574	0.273	0.780
TB -> FEMED	0.038	0.022	0.033
TB -> HIV	0.707	0.509	0.822
TB -> MALA	0.313	0.094	0.545
g1 -> DALY	0.219	0.042	0.446
g1 -> DGGHE	0.539	0.310	0.706
g1 -> FEMED	0.262	0.081	0.487
g1 -> HIV	0.312	0.056	0.560
g1 -> MALA	0.314	0.121	0.547
g1 -> TB	0.078	0.050	0.112
g2 -> DALY	0.297	0.092	0.504
g2 -> DGGHE	0.638	0.433	0.777
g2 -> FEMED	0.238	0.084	0.436
g2 -> HIV	0.394	0.144	0.625
g2 -> MALA	0.274	0.086	0.507
g2 -> TB	0.153	0.074	0.380
g2 -> g1	0.847	0.747	0.908
g6 -> DALY	0.100	0.026	0.282
g6 -> DGGHE	0.407	0.118	0.573
g6 -> FEMED	0.238	0.078	0.457
g6 -> HIV	0.154	0.026	0.382
g6 -> MALA	0.184	0.041	0.416
g6 -> TB	0.087	0.025	0.221
g6 -> g1	0.717	0.489	0.866
g6 -> g2	0.678	0.462	0.812

Note. LB and UB indicate the lower- and upper-bound confidence intervals at 5% and 95 %, respectively. Computed using the SmartPLS 3.3.8 software.

As shown in Table 5.3 above, all HTMT ratios between the two constructs were not close to 1, suggesting a discriminant validity (Hair Jr et al., 2017).

Tables 5.4 and 5.5 below provide the results utilised to evaluate the measurement models for the high-order construct. Table 5.4 below shows the higher-order construct's internal consistency and convergent validity estimates, and Table 5.5 below shows the high-order construct's estimates of discriminant validity.

Table 5.4

Estimates of internal consistency/convergent validity (low-order construct)

Constructs	Indicators	OUTER LOADINGS (>.70)	Composite Reliability (>.70)	Average Variance Extracted (>.50)
DALY	daly22013	0.995	0.999	0.995
	daly22014	0.995		
	daly22015	0.999		
	daly22016	0.999		
	daly22017	0.999		
	daly22018	0.998		
	daly22019	0.996		
DGGHE	dgghe17_201	0.997	0.999	0.992
	dgghe17_201	0.999		
	dgghe17_201	0.995		
	dgghe17_201	0.994		
	dgghe17_201	0.997		
	dgghe17_201	0.994		
	dgghe17_201	0.994		
FEMED	femed2013	0.947	0.980	0.877
	femed2014	0.971		
	femed2015	0.965		
	femed2016	0.957		
	femed2017	0.914		
	femed2018	0.891		
	femed2019	0.906		
GOV	g1	0.945	0.930	0.818
	g2	0.960		
	g6	0.799		
HIV	hivprev2013	0.999	1.000	0.999
	hivprev2014	1.000		
	hivprev2015	1.000		
	hivprev2016	1.000		
	hivprev2017	1.000		
	hivprev2018	1.000		
	hivprev2019	0.999		
MALA	malinc2013	0.929	0.990	0.931
	malinc2014	0.973		
	malinc2015	0.989		
	malinc2016	0.995		
	malinc2017	0.925		
	malinc2018	0.970		
	malinc2019	0.972		
TB	tb2013	0.965	0.996	0.972
	tb2014	0.981		
	tb2015	0.994		
	tb2016	0.999		
	tb2017	0.997		
	tb2018	0.990		
	tb2019	0.975		

Note. Estimate thresholds are in parentheses. Computed using the SmartPLS 3.3.8 software.

As shown in Table 5.4 above, all factor loadings, composite reliability, and average variance extracted exceeded the minimum threshold (in parentheses). They satisfied the advised standards, suggesting the constructs' internal consistency and convergent validity.

Table 5.5 below shows the high-order construct’s estimates of discriminant validity.

Table 5.5

Estimates of discriminant validity (high-order construct)

Paths	HTMT ratio	Confidence intervale	
		LB	UB
DGGHE -> DALY	0.128	0.030	0.261
FEMED -> DALY	0.207	0.050	0.423
FEMED -> DGGHE	0.032	0.017	0.030
GOV -> DALY	0.239	0.083	0.460
GOV -> DGGHE	0.610	0.342	0.751
GOV -> FEMED	0.285	0.108	0.491
HIV -> DALY	0.229	0.038	0.472
HIV -> DGGHE	0.650	0.420	0.793
HIV -> FEMED	0.177	0.050	0.340
HIV -> GOV	0.330	0.119	0.564
MALA -> DALY	0.408	0.111	0.625
MALA -> DGGHE	0.476	0.301	0.589
MALA -> FEMED	0.120	0.050	0.165
MALA -> GOV	0.297	0.113	0.501
MALA -> HIV	0.407	0.139	0.594
TB -> DALY	0.265	0.042	0.536
TB -> DGGHE	0.574	0.263	0.771
TB -> FEMED	0.038	0.025	0.035
TB -> GOV	0.118	0.048	0.203
TB -> HIV	0.707	0.535	0.820
TB -> MALA	0.313	0.090	0.527

Note. LB and UB indicate the lower- and upper-bound confidence intervals at 5% and 95%, respectively. Computed using the SmartPLS 3.3.8 software.

As shown in Table 5.5 above, all HTMT ratios between the two constructs were not close to 1, suggesting discriminant validity (Hair Jr et al., 2017). Moreover, based on these results, the ME and MI structural models were developed and assessed. The results are presented in the following sections.

5.4.1.2 Structural model.

5.4.1.2.1 ME model.

The evaluation results of the ME structural model are provided in Tables 5.6 to 5.11. Table 5.6 below presents the variance inflation factors (VIF) of all the constructs used in the ME model.

Table 5.6

Variance inflation factors of ME model constructs

Constructs	VIF
DGGHE	2.026
FEMED	1.091
HIV	2.625
MALA	1.330
TB	2.109

Note. Computed using the SmartPLS 3.3.8 software.

Table 5.6 above shows that none of the construct predictors suffered from multicollinearity. Thus, they were not highly correlated with each other. Moreover, the VIF values for the model constructs were not greater than 5.

Table 5.7 below presents the estimates of the ME model effects concerning the relationships between the DALY, DGGHE, FEMED, HIV, MALA, and TB without the moderator, as presented in the ME model.

Table 5.7

Estimates of ME model effects

Consequent variable / Antecedent variable	Unstandardized path coefficient	t	SE	95% confidence intervals
DALY				
DGGHE	-0.396**	2.378	0.166	[-0.706, -0.059]
FEMED	-0.244	1.734	0.141	[-0.492, 0.078]
HIV	0.552**	2.379	0.232	[0.109, 1.012]
MALA	0.497***	3.631	0.137	[0.199, 0.745]
TB	0.254	1.126	0.225	[-0.203, 0.689]

Note. FEMED, HIV, MALA, and TB stand for female education, HIV/AIDS incidence, malaria incidence and tuberculosis incidence, respectively. N = 43. Computed using the SmartPLS 3.3.8 software.

**p < 0.05; ***p < 0.01

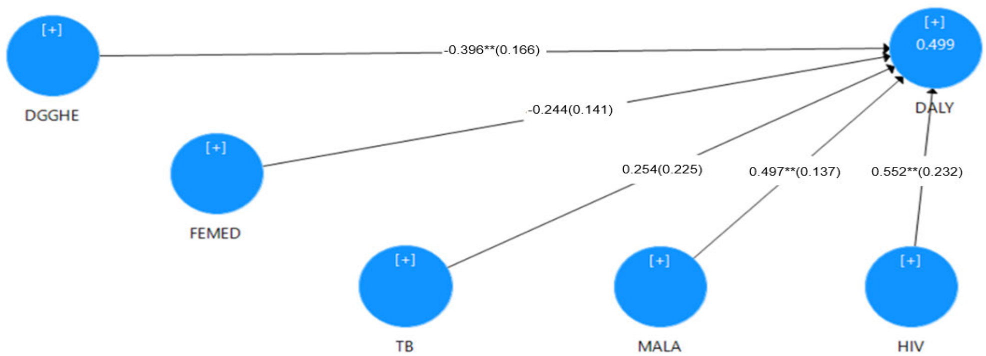
According to Table 5.7 above, the effect of HIV (0.552) on the DALY was the strongest, followed by MALA (0.497) and DGGHE (0.396), respectively. These were only statistically significant paths; their bias-corrected 95% confidence intervals did not contain zero. Table 5.7 also revealed a negative and statistically significant correlation between the DALY and DGGHE. This result suggested that increasing DDGHE levels in SSA would enhance the DALY health indicator. Moreover, the implication is that countries with high levels of locally sourced public spending are expected to be more efficient producers of health, i.e., healthier, than those with low levels of public spending on health.

A positive and statistically significant relationship existed between the DALY and MALA, suggesting that a high prevalence of malaria would increase the DALY because of the additional disease burden it causes. Similarly, the HIV variable had a positive impact on DALY, thereby increasing the disease burden of the population.

Figure 5.4 below graphically presents the relationship between the DALY, FEMED, HIV, MALA, and TB variables. In addition, the figure clarifies the results presented in Table 5.7 above.

Figure 5.4

ME Model estimates



Note. Computed using SmartPLS 3.3.8 software. ME model with standardised path coefficients. Standard errors are in parentheses. Estimated R2 displayed on the DALY construct. R2 indicator is displayed on the DALY construct. Path coefficients are on the arrows with the standard errors in parenthesis.

**p < 0.05; ***p < 0.01

Figure 5.4 above shows the pathways linking all the constructs to the DALY, the dependent construct under investigation. The figure presents all pathways, whether they were statistically significant or not. However, significant pathways are indicated by stars next to the path coefficients.

Table 5.8 below presents the R-squared (R^2) indicator for the DALY, which was the only dependent variable of the ME model. Table 5.8 indicates an estimate R^2 of 0.499 for the DALY, which was statistically significant at all levels, and its bias-corrected 95% confidence interval did not contain zero. This indicated that the covariates of the ME model accounted for 49.9% of the variation in the DALY dependent variable. This R^2 value is considered moderate for endogenous latent variables (Henseler et al., 2015).

Table 5.8

R^2 indicator for the DALY in the ME model

Construct	R-squared	t	SE	95% confidence intervals
DALY	0.499***	4.889	0.041	[0.222, 0.630]

Note. Computed using the SmartPLS 3.3.8 software.

***p < 0.05

Table 5.9 `below presents the effect sizes of the ME model trajectories. The results revealed that only the effect sizes of the DGGHE → DALY and FEMED → DALY trajectories were statistically significant because their bias-corrected 95% confidence intervals did not contain zero. According to the guidelines for f^2 evaluation, the effect size of FEMED on DALY was small, and that of DGGHE was medium (Cohen, 1988).

Table 5.9

Indicators of effect sizes in the ME model

Path	Effect sizes(F2)	95% confidence intervals
DGGHE -> DALY[a]	0.155	[0.477, 0.281]
FEMED -> DALY[a]	0.109	[0.201, 0.247]
HIV -> DALY	0.232	[-0.139, 0.319]
MALA -> DALY	0.371	[-0.055, 0.451]
TB -> DALY	0.061	[-0.710, 0.277]

Note. FEMED is female education, MALA represents malaria incidence, HIV denotes HIV/AIDS incidence, and TB represents tuberculosis incidence. [a] The interval of the effect sizes does not include zero. Computed using the SmartPLS 3.3.8 software.

Table 5.10 below presents the predictive relevance indicator for the DALY endogenous construct. The results revealed a value of 0.482 for this indicator (Q^2). Following the rule of thumb, this value indicated that the external constructs (DGGHE, FEMED, MALA, HIV and TB) had predictive relevance for the endogenous construct under investigation (Hair Jr et al., 2017).

Table 5.10

Indicator of predictive relevance of the DALY in the ME model

Constructs	SSO	SSE	Predictive relevance Q^2 (=1-SSE/SSO)
DALY	301	156	0.482
DGGHE	301	301	
FEMED	301	301	
HIV	301	301	
MALA	301	301	
TB	301	301	

Note. FEMED is female education, MALA represents malaria incidence, HIV denotes HIV/AIDS incidence, and TB represents tuberculosis incidence. SSE denotes the sum of squared prediction errors based on comparing the predicted and original data. SSO stands for the sum of squared prediction errors based on prediction with mean. Computed using the SmartPLS 3.3.8 software.

Table 5.11 below presents the predictive power indicators of the ME model constructs. Indicators (q^2) were generated using the following equation:

$$\boldsymbol{q^2_{x \to y}} = \frac{Q^2_{included} - Q^2_{excluded}}{1 - Q^2_{included}} \quad 5.1$$

where

$Q^2_{included}$ results from the previous blindfolding estimation and $Q^2_{excluded}$ value is derived from a re-estimation of the model following the deletion of a specific predecessor of the endogenous latent variable (Hair Jr et al., 2017).

Table 5.11 also indicates that according to the rule of thumb, TB, FEMED, and DGGHE had low predictive power for the DALY, whereas HIV and MALA hade medium and high predictive power, respectively.

Table 5.11

Predictive power indicators of the ME model constructs

Excluded construct	Predictive power (q2)
DGGHE	0.143
FEMED	0.098
HIV	0.224
MALA	0.349
TB	0.052

Note. FEMED is female education, MALA represents malaria incidence, HIV denotes HIV/AIDS incidence, and TB represents tuberculosis incidence. Computed using the SmartPLS 3.3.8 software.

5.4.1.2.2 MI model.

The evaluation results of the MI structural model are provided in Tables 5.12 to 5.16. Table 5.12 below presents the indicators of the VIF of the constructs in the MI model.

Table 5.12

Variance inflation factor for MI model

Constructs	VIF
DGGHE	3.279
FEMED	1.210
GOV	2.059
HIV	2.635
MALA	1.330
TB	2.405

Note. VIF is the variance inflation factor. Computed using the SmartPLS 3.3.8 software.

According to the results in Table 5.12 above, the collinearity between predictor constructs was not a concern for the model, as all VIF values were less than the threshold of 5.

Table 5.13 below presents the estimated results of the MI model that shows the relationship trajectories between DALY, DGGHE, FEMED, HIV, FEMED, MALA TB, and GOV.

Table 5.13

Estimates of the MI model effects

Outcome / antecedent variable	Unstandardised Path coefficients	t	SE	95% confidence intervals
DALY				
DGGHE	-1.277**	2.588	0.493	[-2.308, -0.465]
DGOV	0.464**	2.064	0.225	[0.143, 1.060]
FEMED	-0.285**	2.502	0.114	[-0.512, -0.056]
GOV	0.106	0.536	0.198	[-0.268, 0.518]
HIV	0.627**	2.228	0.281	[-0.001, 1.132]
MALA	0.506***	3.697	0.137	[0.185, 0.740]
TB	0.371	1.627	0.228	[-0.071, 0.768]
FEMED				
GOV	0.278**	2.227	0.125	[-0.023, 0.487]

Note. N = 43. FEMED, HIV, MALA, TB, and GOV stand for female education, HIV/AIDS incidence, malaria incidence, tuberculosis, and governance, respectively. DGOV denotes the interaction term between DGGHE and governance. Computed using the SmartPLS 3.3.8 software.

**$p < 0.05$; ***$p < 0.01$

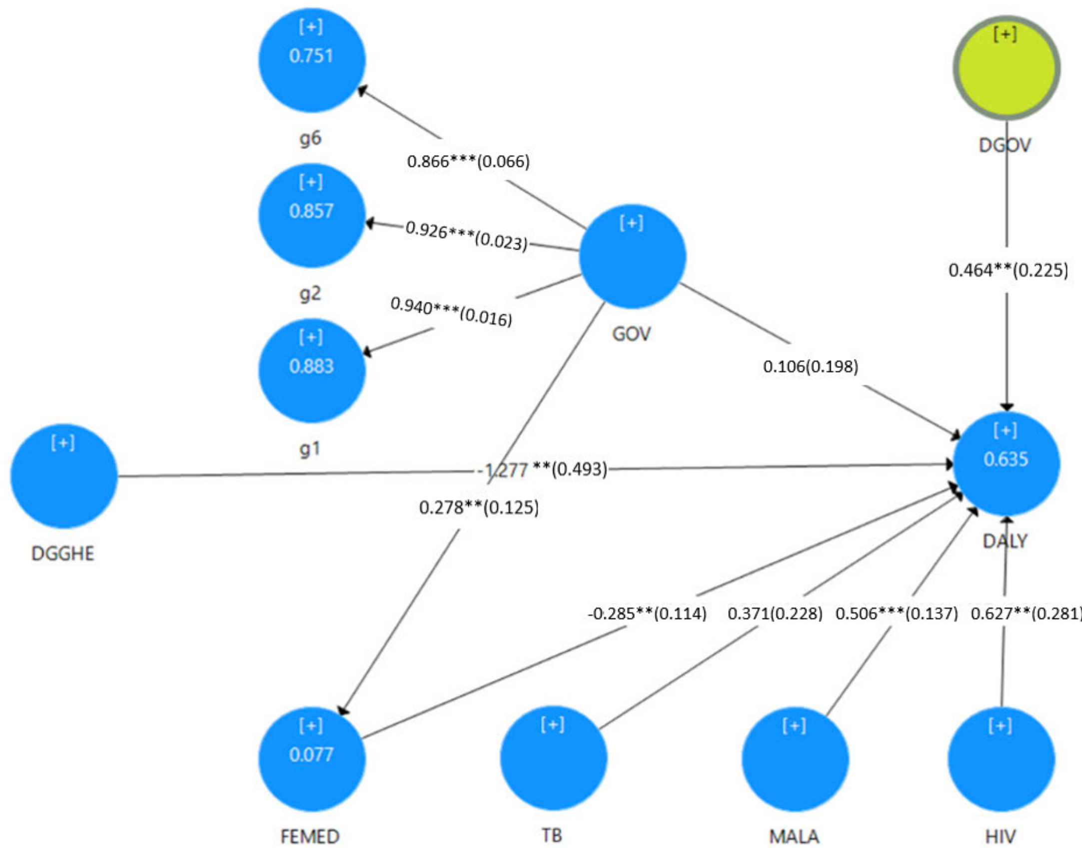
According to Table 5.13 above, the effect of DGGHE (-1.275) on the DALY was the strongest, followed by HIV (0.627), MALA (0.506), DGOV (0.464) and FEMED (-0.285), respectively. These were the only statistically significant paths; their bias-corrected 95% confidence intervals did not contain zero. The results in Table 5.13 above revealed a negative and statistically significant correlation between the DALY and DGGHE and between DALY and female education. Therefore, these results suggested that increased DGGHE and female education levels would lead to lower DALY levels in SSA. In addition, the results suggest countries with high levels of locally sourced public spending and a high level of education would be more efficient producers of health, i.e., healthier, than those with low levels of public spending on health.

A positive and statistically significant relationship existed between the DALY and MALA variables. Consequently, a high prevalence of malaria might increase the DALY due to the additional disease burden it causes. Additionally, the HIV variable had a positive impact on DALY, which suggests that the added disease burden on the population would increase the DALY. Most importantly, the statistically significant DGOV coefficient indicated a moderating effect in the model assessed.

Figure 5.5 below graphically presents the relationship between the DALY, FEMED, HIV, MALA, and TB variables. This presentation clarifies the results displayed in Table 5.13 above.

Figure 5.5

MI Model estimates



Note. MI model with standardised path coefficients. Standard errors are in parentheses. Estimated R^2 displayed for DALY, FEMED, G1, G2, and G3 constructs. Path coefficients are on the arrows with the standard errors in parenthesis. Own work.

**p < 0.05; ***p < 0.01.

Figure 5.5 above shows the pathways linking all the constructs to the DALY, the dependent construct under investigation. The model presents an estimate R^2 of 0.499 for the DALY dependent variable. This R^2 was statistically significant at all levels, and its bias-corrected 95% confidence interval did not contain zero. This indicated that the covariates of the ME model accounted for 49.9% of the variation in the DALY dependent variable. This R^2 value is considered moderate for endogenous latent variables (Henseler et al., 2015).

Table 5.14 below presents the R^2 estimates for the DALY and FEMED endogenous variables. DALY and FEMED had R^2 estimates of 0.63 and 0.07, respectively, as shown in the table. The R^2 value for FEMED was insignificant, whereas, for the DALY, it was significant, with a bias-corrected 95% confidence interval that did not include zero. The R2 value for the DALY measured how well the model accounted for the variability observed in the DALY data. In this case, it showed a moderate degree of explanation. Moreover, R^2 increased from 0.49 to 0.63 when the moderator and interaction term were added to the ME model to create the MI model. This was advantageous from a predictive standpoint and indicated that moderation analysis could be implemented appropriately with the MI model if the other model fit parameters are good (see Table 5.14 below).

Table 5.14

R-squared indicator for the MI model

Constructs	R-squared	t	SE	95% confidence intervals
DALY	0.635**	7.902	0.094	[0.335, 0.730]
FEMED	0.077	1.113	0.260	[0.001, 0.241]

Note. Computed using the SmartPLS 3.3.8 software.

**$p < 0.05$

The effect sizes of the MI model paths are presented in Table 5.15 below. The results in the table revealed that only the effect sizes of the DGGHE→DALY, MALA→DALY, and FEMED→DALY paths were statistically significant because their bias-corrected 95% confidence intervals did not contain zero. According to the guidelines for assessing f^2, the effect size of FEMED on the DALY was small, whereas that of DGGHE and MALA were medium (Cohen, 1988) (see Table 5.15 below).

Table 5.15

Effect size indicators in the MI model

Paths	MI model	
	Effect sizes (f2)	95% confidence intervals
DGGHE -> DALY	0.509	[1.177, 1.706]
FEMED -> DALY	0.180	[0.358, 0.340]
HIV -> DALY	0.403	[-0.561, 0.700]
MALA -> DALY	0.528	[0.260, 0.783]
TB -> DALY	0.156	[-0.693, 0.426]
DGOV -> DALY	0.368	[0.149, 0.749]
GOV -> DALY	0.015	[-0.536, 0.321]
GOV -> FEMED	0.084	[-0.520, 0.136]

Note. Computed using the SmartPLS 3.3.8 software.

Table 5.16 below shows the predictive relevance indicators for the DALY and FEMED endogenous constructs. In addition, the table indicates 0.551 and 060 as estimates for DALY and FEMED, respectively. These values were greater than zero, indicating that all external constructs hade predictive relevance for the endogenous constructs under investigation (Hair Jr et al., 2017).

Table 5.16

Predictive relevance indicator for the MI model

Constructs	SSO	SSE	Predictive relevance Q^2 (=1-SSE/SSO)
DALY	301	135	0.551
DGGHE	301	301	
FEMED	301	283	0.060
HIV	301	301	
MALA	301	301	
TB	301	301	
DGOV	43	43	
GOV	903	903	

Note. SSE denotes the sum of squared prediction errors based on comparing the predicted and original data. SSO stands for the sum of squared prediction errors based on prediction with mean. Computed using the SmartPLS 3.3.8 software.

Standardised root mean square residual (SRMR) indicators were used in the study to measure model fit based on the PLS-SEM. Table 5.17 below provides the SRMR results for both the ME and MI models.

Table 5.17

SRMR model indices

	ME model	MI model
SRMR	0.04	0.07

Note. Computed using the SmartPLS 3.3.8 software.

ME and MI had SRMR indices of 0.04 and 0.07, respectively, according to Table 5.17 above. These values were acceptable from 0 to 0.08, suggesting that both models were parsimonious (Hu & Bentler, 1999). In other words, the fit of the models was deemed satisfactory as they demonstrated an adequate level of parsimony, indicating a good balance between model complexity and explanatory power.

5.4.2 Moderation assessment

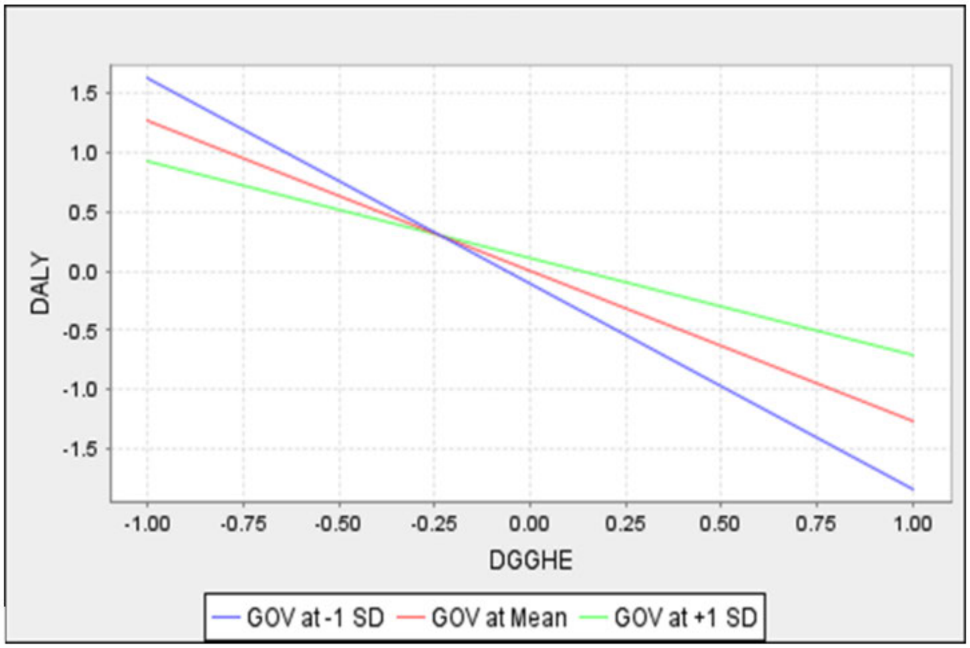
The significance of the coefficient for DGGHE was of great interest, as it indicated a relationship between DGGHE and the DALY upon which the moderation analysis was based. However, the significance of the DGOV coefficient was the study's primary focus, as it made it possible to conclude that the relationship between DGGHE and the DALY, which was under investigation, was subject to a moderating effect. According to Table 5.13 above, the DGGHE and DGOV coefficients of -1.27 and 0.46, respectively, were statistically significant. Their significance was supported by their p-values and the absence of a zero in their bias-corrected bootstrap 95% confidence intervals.

These results revealed that, for the average levels of governance (GOV = 0SD), DGGHE had a negative impact of -1.277 on the DALY. For higher levels of governance (GOV = +1SD), DGGHE had a negative impact of -0.813 on the DALY. For lower levels of governance (GOV = -1SD), DGGHE had a negative impact of -1.741 on the DALY. These results suggested that the negative relationship between DGGHE and the DALY would be attenuated by high levels of governance and strengthened by low levels of governance, implying that governance could exert a weakening substitutional interaction effect on the relationship between DGGHE and the DALY (Gardner et al., 2017).

The results in Table 5.13 also revealed that the moderator (GOV) did not affect the DALY. However, the moderating effect was determined by the significance of the coefficients for DGGHE and DGOV. A simple slope graph was constructed to understand the moderation analysis results better. Figure 5.6 below illustrates this simple slope graph of the moderating effect of GOV using PLS. The figure depicts the relationship between DGGHE (x-axis) and DALY (y-axis) at the governance's lower, medium, and upper levels. The blue, red, and green lines represent the lower, medium, and upper levels of governance at minus one SD (one SD below the mean), zero SD (at the mean), and plus one SD (one SD above the mean), respectively. The line indicating the lowest level of governance is steeper than the other lines in the graph, and the line indicating the middle level of governance is steeper than the line indicating the highest level.

Figure 5.6

Simple slope graph of the moderating effect of governance



Note. A visual representation of the moderation of the effect of DGGHE on DALY by the country's governance. "Low" refers to 1 SD below the mean (-1SD), and "high" refers to 1 SD above the mean (+1SD) for GOV. Own work.

All lines indicating the level of governance intersect in the graph at the point where the SD of DGGHE equals -.25 (SD = -.25), as depicted in Figure 5.6. This indicates a disordinal interaction, a crossover point where the moderating effects diverge on each side (Mueller & Hancock, 2018). Any level of DGGHE corresponded to a high DALY on the left side of the crossover point, where the level of governance was low (-1SD) compared with the intermediate and high levels of governance. However, on the right side of the crossover point, at any level of DGGHE, there was a low DALY where the level of governance was low (-1SD) compared with the intermediate and high levels of governance. To confirm the existence of the moderating effect of governance, the study considered the interaction term effect size f^2. According to Table 5.15 above, the effect size f^2 on the interaction term was 0.368%. This value indicated a substantial impact (Hair Jr et al., 2017).

5.5 Discussion

The poor health of the population is a major challenge in SSA. However, PHS is a key policy strategy for improving population health while protecting the population from the high burden of medical costs. Recent studies have highlighted the need to assess the effectiveness of PHS in sub-Saharan countries in connection with country governance, as poor governance is a major issue in these countries where limited health expenditure does not always achieve the desired results. The study aimed to determine how a country's governance affects the relationship between PHS and population health outcomes, as measured by DGGHE and DALY. To achieve the study’s objective, two hypotheses were examined by applying the PLS-SEM to data from a panel of 42 sub-Saharan nations from 2013 to 2019.

The study's results suggested that DGGHE might significantly reduce the DALY in sub-Saharan countries and that this effect could be moderated by country governance, as measured simultaneously by three indicators: control of corruption, government effectiveness, and voice accountability. The empirical results indicate that an increase in DGGHE was associated with a reduction in the DALY in sub-Saharan countries. This result was consistent with Hypothesis 1, which proposed that an increase in DGGHE is associated with a decrease in DALY. This conclusion was expected, given that the sub-Saharan population faces many barriers to accessing healthcare and that DGGHE remains the most appropriate means of overcoming this problem. This is because DGGHE can protect people from the high burden of healthcare costs in addition to improving access to healthcare.

The majority of the sub-Saharan population is impoverished and unable to afford health services, most of which are provided by pricey private facilities. The healthcare facilities these populations have access to are government-owned and limited in number, services, and quality of care. Therefore, an increase in DGGHE should ideally increase access to health through increased services in hospitals and improve public hospitals' healthcare quality. Thus, increasing DGGHE would allow more of the population to access healthcare, thereby improving health outcomes. The study's conclusion was consistent with those of Novignon and Lawanson (2017), Nyamuranga and Shin (2019), and Kiross et al. (2020), as these studies also demonstrated that an increase in DGGHE was associated with a decrease in DALY, which was proxied in their studies by population health outcomes indicators, such as infant or maternal mortality.

The empirical results of the current study also revealed a positive interaction effect on the negative association between DGGHE and DALY, as the coefficients of DGGHE and DGOV were -1.277 and 0.464, respectively. These results indicated that, for the average levels of governance (GOV = 0SD), DGGHE has a negative impact on the DALY of -1.277. For higher levels of governance (GOV = +1SD), DGGHE had a negative impact on DALY of -0.813. For lower levels of governance (GOV = -1SD), DGGHE had a negative impact on DALY of -1.741. This result suggested that the negative relationship between DGGHE and the DALY might be mitigated by high levels of governance and strengthened by low levels of governance, indicating that governance exerts a weakening substitutional interaction effect on the relationship between DGGHE and the DALY (Gardner et al., 2017).

The difference in the direction of the main (DGGHE) and interaction (DGOC) effects observed in the study leads to a disordered moderation represented by a crossover point, the importance of which is essential for a better interpretation of the results since the moderating effects diverge on either side of this point. The difference in direction between the main (DGGHE) and interaction (DGOC) effects leads to a disordinal moderation manifested by a crossover point, the understanding of which is essential for a more accurate interpretation of the results, as the moderating effects diverge on either side of this point. Moreover, in a disordinal interaction, each main effect of the independent variables only correctly predicts the outcome approximately 50% of the time (Schmidt & Pförtner, 2020). Before this point, lower levels of DGGHE are associated with a high DALY when governance is weak but with a low DALY when governance is intermediate or strong.

This is the case, for instance, for countries with low DGGHE and weak governance that are moving towards good governance (e.g., anti-corruption measures) but still have a high DALY. After this point, however, DGGHE is related to a low DALY when governance is weak but to a high DALY when governance is intermediate or strong. This situation implies that there is a point at which implementing good governance in countries with low DGGHE could result in a substantial improvement in the DALY.

Similar to previous studies, the current research revealed that factors such as female education as well as the prevalence of HIV/AIDS, malaria and TB contribute to the DALY, which, in simple terms, refers to the overall burden of disease and injuries in a population. The lower the DALY value, the better the overall health and well-being of the population (Mirowsky & Ross, 2017). Ignoring the above factors while investigating the effectiveness of DGGHE could be misleading, as health evidence suggests that healthcare, the main focus of PHS, contributes to approximately 28% of the population's health outcomes' improvement (Park et al., 2015). Thus, The study results revealed that in examining the effectiveness of the DGGHE, governments in sub-Saharan countries should consider how country governance interacts with PHS to improve population health outcomes and try to adjust PHS and governance levels to achieve the desired population health outcomes.

The study contributed to the existing literature on health expenditure by proving the negative relationship between PHS and population health outcomes. It demonstrated the moderating effect of governance on this relationship. In addition, the study contributed methodologically by using the PLS-SEM approach to analyse the proposed models. This approach allowed the modelling of latent constructs under non-normality conditions in small sample sizes), maximised the explanation of variance of endogenous variables, and predicted latent construct values using multiple regressions (Chin et al., 2003; Hair Jr et al., 2017).

Investigating the moderating effects of governance, as measured by its three components, was an additional contribution of the current research to the literature. This metric/method considered the association between these components and their joint effects on the relationship between DGGHE and the DALY. However, some of the control variables pertinent to sub-Saharan countries lacked sufficient time series data, thus limiting the scope of the study. A large number of observations would have improved the quality of panel data, thus providing more information about the subject. However, these drawbacks do not invalidate the study's results but may operate as a foundation for future research.

5.6 Chapter summary

Poor population health is a challenge in SSA, and while PHS is a crucial tool for enhancing population health, sub-Saharan countries struggle to achieve better health outcomes as the result of increased PHS. Their settings, characterised by poor governance, prevent them from achieving the desired health outcome, especially with limited spending on health. The study aimed to determine how country governance might affect the relationship between PHS and population health outcomes, as measured by DGGHE and the DALY, respectively. The study results revealed that increased DGGHE was related to a reduced DALY in many sub-Saharan countries during the period under study and that country governance exerted a weakening substituting interaction effect on the relationship between DGGHE and the DALY.

The study demonstrated the positive effects of macro-level PHS on population health outcomes due to strong governance. However, when examining the effectiveness of DGGHE, several additional factors must be considered, as the health literature indicates that healthcare, the primary goal of PHS, contributes approximately 28% to population health outcomes improvement. Therefore, the models proposed in the study might enable national policymakers to understand how governance in SSA might interact with PHS to improve population health outcomes and control specific factors. This information allows governments to adjust their PHS and governance to achieve their desired population health outcomes.

Considering the contradictory results of past studies concerning the impact of PHS on population health outcomes, the present study investigated structural factors that may indirectly influence the effectiveness of PHS in enhancing population health outcomes. Moreover, considering the impact of PHS on population health outcomes, the question arises as to which types of data should be used to measure the efficacy of PHS and their effects on the research. In this context, the following chapter will explain the investigation into whether the use of disaggregated data would be superior to the use of aggregate data, typically employed to measure PHS.

Chapter 6.
The Effectiveness of Public Health Spending in Sub-Saharan Africa: Evaluation based on Disaggregated versus Aggregated Health Spending

6.1 Introduction

The SDGs are a set of 17 aspirational goals with 169 targets that aim to solve the world's problems by taking bold and transformative steps towards a sustainable environment, ensuring that no one is left behind, and making the world a place where everyone is treated equally (WHO, 2016a). SDGs are universally recognised development agendas, with the expectation that people worldwide are concerned, familiar, and inclined to participate in achieving the Goals (Olaniyi et al., 2022). SDG 3 calls for several actions, including ending AIDS, TB, hepatitis, and other communicable and non-communicable epidemics and infections, reducing the worldwide maternal/child mortality rate, and halving the number of lives lost because of road accidents (Global Burden of Disease Collaborative Network, 2015). The implementation of SDG3 is critical in sub-Saharan countries, where the population's health is predominantly affected by HIV/AIDS, malaria, and TB epidemics, as well as other communicable and non-communicable diseases (Bell & Hansen, 2021; United Nations, 2019b). Therefore, achieving SDG 3 will improve the health of the sub-Saharan populations.

Within this framework, sub-Saharan governments are implementing various health interventions, such as PHS, which is recommended as a sustainable and equitable funding source (Barroy et al., 2016). However, several studies have examined the effectiveness of PHS in sub-Saharan countries and had mixed results. For instance, Singh (2014) examined the effectiveness of PHS in a systematic review of literature published between 1985 and 2012. According to this meta-analysis, increases in PHS were associated with improvements in people's health in some respects. However, other studies have argued that there is a paucity of empirical data on how PHS variations influence population health (Mays & Smith, 2011).

The diversity and complexity of public health programmes contribute to the inconsistency of results and lack of evidence. The functions of public health agencies include those involved with communicable disease control, air quality, potable water access, emergency preparedness, birth outcomes, and vital records (Issel et al., 2011). To evaluate these programmes, however, studies typically examine total (per capita) PHS (Singh, 2014), and this aggregation can hide variations in spending for specific programmes, diseases, and outcomes. Likewise, aggregating public health expenditures at the state level can obscure the distinct spending patterns of local public health departments (Bernet et al., 2018). Therefore, various studies have cautioned against the risk of using aggregated data, which is summarised information, when evaluating the effectiveness of PHS, as this can lead to misleading conclusions about the health programmes being evaluated (Hjalte & Glenngard, 2007). Using disaggregated data, which are broken down into their components, to evaluate the effectiveness of PHS might lead to more accurate results.

Despite the risk of misleading conclusions, SSA continues to rely on aggregate data to evaluate the effectiveness of PHS. Therefore, the present study endeavoured to show that using disaggregated data when assessing the effectiveness of PHS is beneficial and will ensure that evaluations provide appropriate conclusions. To achieve this objective, the study assessed the effect of disease-specific PHS on disease-specific health outcomes and compared this to the impact of global PHS. The evaluation provided insights in using disaggregated data to measure PHS when evaluating the effectiveness of PHS.

As mentioned above, aggregated data from resource allocations and health outcomes are mainly used for evaluating the effectiveness of healthcare interventions. In contrast, this study measured population health outcomes and PHS using disaggregated data on the DALY using DGGHE. Disaggregated data can assist measure the effectiveness of health interventions and track progress towards health goals. Thus, there were two forms of the DALY: The HIV/AIDS-related DALY and the TB-related DALY. The rationale for adopting these two indicators is that HIV/AIDS and TB are two of the top five killer diseases in SSA for which data were available. These two diseases remain major public health problems in sub-Saharan countries, where they receive special attention from the government (Bell & Hansen, 2021).

Of all the regions in the world, SSA is the most severely affected by HIV/AIDS. In 2019, 26 million HIV/AIDS cases were recorded, accounting for 70.7% of the global prevalence of the illness. More than 1.3 million people were infected with HIV/AIDS in the region, accounting for two-thirds of all new infections worldwide. Millions of HIV-related deaths were recorded in 2019, accounting for 74.0% of all deaths globally (IHME, 2022).

SSA is also particularly vulnerable to TB, which in 2019 affected 257.1 million people. However, 2.1 million people were newly infected with TB in this region in 2019, and more than 0.4 million TB-related fatalities occurred, accounting for 33.0% of the global total (IHME, 2022). In SSA, the overlap and clustering of HIV/AIDS and TB exacerbate the public health effects of both diseases (Mendenhall, 2017). However, there is no comprehensive data to determine the incidence of this coinfection in SSA; hence, the study hypothesises that TB has no influence on HIV/AIDS mortality and focuses on HIV/AIDS and TB separately.

As a measure of PHS, DGGHE represents the national resources the government completely controls. It protects people from catastrophic health costs and is a crucial policy tool for accelerating progress towards UHC and achieving health targets (Meheus & McIntyre, 2017; United Nations, 2019a). However, the disaggregation of data would enable spending to be assessed regarding the associated diseases. Therefore, the study added to the current literature on PHS by providing evidence related to data aggregation and disaggregation to measure HS's effect in SSA.

The study applied the GMM estimator based on linear and nonlinear moment conditions (Ahn & Schmidt, 1995) to panel data from 31 sub-Saharan countries collected from publicly available databases between 2013 and 2019 (IHME, 2022; World Bank, 2021; World Bank, 2022; WHO, 2021). The research revealed that data on PHS disaggregated by disease, such as HIV/AIDS and TB, provides a better measure of PHS effectiveness than aggregated data. In other words, the study emphasised the need for disease-specific PHS data to evaluate government interventions and enhance a particular population's health outcome. To the best of the researcher’s knowledge, this was the first study to compare the effectiveness of PHS on health population health outcomes using disaggregated data.

The remaining sections of this chapter are divided into six: The second section examines the relevant literature; the research methodology is discussed in Section 3. In Section 4, the empirical results are presented. The results are discussed in Section 5, and the study is concluded in Section 6.

6.2 Literature Review

6.2.1 Theoretical framework

The model developed by Fayissa and Gutena (2008) was adopted as the study's theoretical foundation. This SSA health production function is based on Grossman's (1972) model, which considers the production structure's social, economic, and environmental inputs. Fayissa and Gutena (20-06) contend that production function factors could be aggregated into macro-level indicators and represented as per capita variables organised by subsectors (Fayissa & Gutema, 2008).

6.2.2 Empirical review

Since the 1990s, there has been growing interest in evaluating the impact of health expenditure at the macro level. Moreover, investigating the relationship between PHS and population health outcomes remains a central topic in empirical studies of health spending (Weibo & Yimer, 2019). However, the relationship between PHS and population health outcomes as a research topic is only emerging in SSA, where compared to developed regions, only a few studies have investigated it. In addition, the existing research on the relationship between PHS and population health outcomes in SSA is ambiguous. Some researchers have failed to find a connection between these two variables.

For example, Popoola (2018) and Ogungbenle et al. (2013) discovered that PHS did not affect neonatal mortality, under-five mortality, or life expectancy at birth (Ogungbenle et al., 2013; Popoola, 2018). Furthermore, using the GMM method, Kamiya (2010) analysed the factors contributing to child mortality in low-income countries, including SSA, and discovered that higher PHS levels did not reduce child mortality (Kamiya, 2010). Filmer and Pritchett (1999) studied the effects of public health and other expenditures on infant and child mortalities. They applied two-stage least-squares regression to cross-sectional data from 45 countries, 22 in SSA. According to their results, PHS was not a significant predictor of mortality. In addition, Filmer and Pritchett (1999) pointed out that income per person, income inequality, women's education, ethnic diversity, and religion were the top five factors responsible for various mortality rates (Filmer & Pritchett, 1999).

Several studies have, nevertheless, reported a positive association between PHS and population health outcomes. For instance, Anyanwu and Erhijakpor (2009) examined the relationship between health spending as measured by total health expenditure and public health expenditure and population health outcomes defined by infant and under-five mortality. They applied instrumental variables and FE estimators to a panel of sub-Saharan countries. Anyanwu and Erhijakpor (2009) found that total and public health expenditures negatively affected infant and under-five mortality. However, public health expenditure had a slightly greater impact on population health outcomes than total health expenditures (Anyanwu & Erhijakpor, 2009).

Using the FE estimator, Arthur and Oaikhenan (2017) analysed the effectiveness of health spending in SSA. Public health expenditure. Primary health expenditure (PriHE) was used to measure health expenditure. In contrast, indicators of mortality incidence (MI), under-five mortality, and life expectancy at birth were used to evaluate population health outcomes. According to Arthur and Oaikhenan’s (2017) results, health spending substantially impacted population health outcomes. When comparing the effects on MI and under-five mortality, PHS was more effective than PriHE; however, PriHE was more effective when comparing the effects on life expectancy at birth (Arthur & Oaikhenan, 2017).

Novignon and Lawanson (2017) used fixed- and random-effects panel data regression models to examine the relationship between healthcare expenditure and health outcomes in SSA. Infants, children under 5, and neonatal mortality rates were used to assess health outcomes, while PriHE and public health expenditure were used to measure health expenditures. A negative and significant link was found between health spending and health outcomes, with health spending elasticities of -0.11, -0.15, and -0.08

for under-five, neonatal, and infant mortality, correspondingly (Novignon & Lawanson, 2017).

Bernet et al. (2018) evaluated the effect of PHS on population health outcomes using aggregated and disaggregated data. They disaggregated data on PHS by age using infant-related PHS and used the infant mortality rate as a proxy for population health outcomes. The study found that using disaggregated data on PHS, as opposed to aggregated data, provided a more accurate indication of the effectiveness of PHS in enhancing population health outcomes (Bernet et al., 2018).

Lim et al. (2022) systematically reviewed the relationships between sexually transmitted diseases (STDs) and total as well as STD-specific public health expenditure. The study provided evidence that increases in both general and STD-specific government health spending led to a decline in the prevalence of STDs. Nevertheless, STD-specific government health spending had a greater impact on STD rates than overall public health expenditure (Lim et al., 2022).

Finally, Kiross et al. (2020) applied the random-effects model to investigate how health spending in terms of data disaggregated in terms of financing sources affected infant and neonatal mortality in SSA. The conclusions indicated that public and external health expenditure negatively impacted infant and neonatal mortality, and PriHE did not impact infant or neonatal mortality (Kiross et al., 2020).

The investigations above produced varying outcomes due to variations in the research methods; indicators used to measure PHS, and the differentiation between aggregated and disaggregated data. A three-point summary of the methodological issues of studies investigating the effectiveness of PHS can be devised: (1) aggregating all government health spending into a single aggregate variable, thereby preventing the differentiation between different spending items. It is advised to disaggregate expenditures into health-specific categories, as doing so can provide policymakers, researchers, and the general public with more comprehensive data that can inform decisions regarding healthcare funding, resource distribution, and the overall effectiveness of healthcare systems (Dieleman et al., 2015; Sirrs, 2021); (2) ignoring both serial correlation and reverse causation that may result from cyclical patterns between expenditure and health outcomes (Leszczensky & Wolbring, 2022); and (3) ignoring the possibility that PHS might be influenced by other time-varying variables that were not included in the analysis, thereby introducing endogeneity issues, where the relationship between PHS and other variables might be biased or distorted (Singh, 2014). The degree to which each study reviewed suffered from one or more of the issues mentioned above may explain, at least in part, the inconsistent body of evidence on the efficacy of PHS. Failure to consider the issues mentioned above in a study leads to biased and/or inconsistent estimates. Addressing these challenges opens the door for further research on the subject, although the current study sought to fill the gap in the literature. The study evaluated the effectiveness of public health spending by employing disaggregated spending specifically related to the disease being investigated. This approach improved the accuracy of the PHS effectiveness since it excluded from the analysis the spending related to other diseases that were not under investigation.

6.3 Methodology

6.3.1 Data description and sources

Data were obtained from the Global Health Data Exchange (GHDex), World Development Indicators (WDI), World Governance In indicators (WGI), and Global Health Expenditures (GHE) databases for 2013–2019 (IHME, 2022; Kaufmann & Kraay, 2022; WHO, 2021a; World Bank, 2021). Due to the limited data availability in some countries, the study was limited to 31 sub-Saharan countries[3]. All data were cross-referenced to other sources, such as the country's national health accounting reports, to ensure consistency before the analysis. Table 6.1 overviews the study variables, including their respective descriptions, sources and expected signs.

---

[3] The list of countries included in the study is in Appendix 1.1. For this analysis, Angola, Burundi, Cameroon, Chad, Djibouti, Equatorial Guinea, Eritrea, Gambia, Guinea-Bissau, Lesotho, Madagascar, Mauritius, Rwanda, Seychelles, Sierra Leone, Somalia, South Sudan, and Sudan were excluded due to lack of data.

Table 6.1

Variable descriptions and sources

Description		Indicators	Type of variable	Sources	Expected sign
DALY attributable to HIV/AIDS	daly_hiv	DALY (per 100,000 people)	Dependent	GHDex	-
DALY attributable to Tuberculosis	daly_tb	DALY attributable to Tuberculosis (per 100,000 people)	Dependent	GHDex	-
DGGHE spent on tuberculosis	dgghe_tb	DGGHE on Tuberculosis per capita, PPP (cst 2017 intl $)	Covariate (main)	GHED	Negative
DGGHE spent onHIV/AIDS	dgghe_hiv	DGGHE on HIV/AIDS per capita, PPP (cst 2017 intl $)	Covariate (main)	GHED	Negative
DGGHE, total	dgghe	DGGHE per capita, PPP (cst 2017 intl $)	Covariate (main)	GHED	Negative
Economic prosperity	gdp	GDP per capita, PPP (cst 2017 intl $)	Covariate	WDI	Negative
Female education	femed	School enrollment, primary, female (% gross)	Covariate	WDI	Negative
Female population	fem_sh	Population, female (% of total population)	Covariate	WDI	Negative
Government Effectiveness	govef	Government Effectiveness: Estimate	Covariate	WGI	Negative
Health prioritisation	dgghe_gge	DGGHE as % of general government expenditure	Covariate	GHED	Negative
Immunization	imm	Immunization, DPT (% of children ages 12-23 months)	Covariate	WDI	Negative
Pollution	co2	CO2 emissions (metric tons per capita)	Covariate	WDI	Positive
Regulatory Quality	regq	Regulatory Quality: Estimate	Covariate	WGI	Negative
Rule of Law	ruol	Rule of Law: Estimate	Covariate	WGI	Negative

Note. Variables included in the study dataset from 2013 to 2019.

The use of DALY indicators is a prevalent used in scholarly works to assess a given population's health outcomes (Bell & Hansen, 2021; Sarkodie & Owusu, 2020; Weaver et al., 2022). The DALY is a summary measure of population health that shows the overall effect of a disease in terms of mortality and morbidity. The DALY is a robust metric for assessing a given population's overall health status, as it considers not only the number of deaths but also the burden of disease and disability (Novignon & Lawanson, 2017). It was designed to help the World Bank decide how to invest in health and set priorities for health programmes worldwide (World Bank, 1993). HIV and tuberculosis are significant diseases that result in a high mortality rate within SSA. Consequently, countries in the region are actively pursuing strategies to eliminate these diseases. The variables DALY_hiv and DALY_tb represent population outcomes associated with HIV and tuberculosis, respectively (Bell & Hansen, 2021).

The research specifically concentrated on tuberculosis occurrences in individuals who do not have HIV infection, as data are scarce regarding the simultaneous presence of HIV/AIDS and tuberculosis. In this regard, the inclusive enumeration of HIV/AIDS cases encompassed all instances of opportunistic infections linked to HIV, including tuberculosis (TB), whereas the specific count for TB solely encompassed cases of TB in individuals not affected by HIV.

The indicators of DGGHE were the pertinent independent variables for the study. Numerous health economics studies have utilised the DGGHE to assess PHS, as it represents the government-controlled national financial resources spent on health services for all diseases and is regarded as an effective way to finance healthcare sustainably (Ithibu & Amendah, 2019; Maele et al., 2019; Saxenian et al., 2019). DGGHE has been proposed as a key policy instrument for expanding access to high-quality healthcare while financially safeguarding the population from healthcare costs (Barroy et al., 2016). Unlike aggregate PHS, commonly used in health-spending studies, DGGHE excludes external funds.

The current study used three indicators derived from the DGGHE variable and linked to spending on preventive and curative treatments. The variables under consideration are as follows: overall spending (DGGHE), spending related to HIV/AIDS (DGGHE_hiv), and spending related to tuberculosis (DGGHE_tb). Based on the mainstream health literature, an increase in these DGGHE indicators are expected to decrease DALY.

In addition to the DGGHE indicators, several control variables were included to increase the precision of the coefficients of PHS variables in the estimated models. In economic and public health studies, real GDP per capita is a common indicator of economic prosperity (Daoud, 2020). Economic prosperity plays a significant role in shaping health expenditure. Enhanced economic prosperity increases a nation's ability to purchase and build better health infrastructures (Stefko et al., 2020). High economic prosperity also broadens the government's revenue base, which increases its capacity to spend on health service delivery and support household health capital expenditures. Moreover, people living in richer countries live longer (Sen, 1999).

In the study, increased economic prosperity, as measured by GDP, was expected to decrease DALY. Based on the available literature on economics and health, the study used other control variables, such as female education, pollution, female population, government effectiveness, immunisation, regulatory quality, and the rule of law (Adeagbo, 2022; Bernet et al., 2018; Linden & Ray, 2017; Nketiah-Amponsah, 2019; Weibo & Yimer, 2019).

Noted, the number of variables included in this study (Table 6.1) may prompt researchers to propose their reduction by implementing Principal Component Analysis (PCA). This particular scenario may not be conducive to the study due to the method used and the number of models that need to be estimated. Out of the 14 variables included In the present study, two variables, namely DALY_hiv and DALY_tb, serve as outcome variables. Additionally, DGGHE, DGGHE_hiv, and DGGHE_tb are considered variables of interest and are utilised in each of the estimated four models. The GMM estimator used as a model estimator integrates some variables as instruments. Hence, the remaining quantity of variables is not large enough to require a reduction in dimensionality through PCA.

6.3.2 Empirical model and estimation technique

6.3.2.1 Empirical model.

Following Oaikhenan (2017), the study used the empirical model Fayissa and Gutema (2008) developed to evaluate the hypotheses. This health production function for SSA was based on Grossman's (1972) model, which considers social, economic, and environmental inputs in the production structure. The model contends that production function factors can be aggregated into macro-level indicators and represented as per capita variables organised by subsectors (Fayissa & Gutema, 2008). This study examines the relationship between health spending and health outcomes in Sub-Saharan Africa (SSA) by analysing data at the country level, hence necessitating the consolidation of many metrics. The model suggested by Fayissa and Gutena (2008) is the sole existing framework tailored for this particular study focused on the African region and has been employed in several research conducted in African contexts (Akpa & Adegbenro, 2023; Attamah & Kalu, 2020; Chireshe & Ocran, 2020; Novignon & Lawanson, 2017).

The empirical model for this study is derived using the production function represented by the following equation.

$$\boldsymbol{h} = \boldsymbol{f}(\boldsymbol{Y}, \boldsymbol{S}, \boldsymbol{E}, \boldsymbol{\varphi}) \qquad 6.1$$

where h is the health outcome and Y, S, and E are the per capita vectors of economic, social, and environmental factors, respectively. $\boldsymbol{\varphi}$ is health endowment caused by genetic or environmental factors. Moreover, in this analysis.

In its scalar form, Equation 6.1 can be rewritten as:

$$\boldsymbol{h} = f(y_1, y_2, \dots, y_n,\ s_1, s_2, \dots, s_g,\ e_1, \mathrm{e}, \dots, e_m) \qquad 6.2$$

where $\boldsymbol{h}$ is the individual's health status measured by DALY, $(y_1, y_2, \dots, y_n) = Y$; $(s_1, s_2, \dots, s_g) = S$; $e_1, e_2, \dots, e_m) = E$; and n, g, and m are the variables of each factor, respectively.

By employing calculus, Equation 6.2 may be mathematically manipulated to get its explicit version expressed as:

$$\boldsymbol{h} = \boldsymbol{A} \prod \boldsymbol{Y}^{\alpha_i} \prod \boldsymbol{S}^{\beta_k} \prod \boldsymbol{E}^{\gamma_j} \qquad 6.3$$

Where $\boldsymbol{\alpha_i}$, $\boldsymbol{\beta_k}$, and $\boldsymbol{\gamma_j}$ are elasticities.

It can be seen from Equation 6.3 that $\boldsymbol{A}$ provides an estimation of the initial health stock that Grossman (1972) identified. This measure assesses the state of health that would have been observed in the absence of any health improvement or decline resulting from changes in socioeconomic and environmental determinants included in the production system.

In empirical analysis, it is important to note that each group of production factors may contain several variables, the number of which may not be uniform depending on the research context. Also, Behrman and Deolalikar (1988) warn of the potential pitfalls of empirical analysis, stressing the importance of taking into account a wide variety of inputs rather than focusing solely on those associated with public health measures or curative healthcare in developed countries (Behrman & Deolalikar, 1988). In the present empirical investigation, DALY indicators are indicators of the population health outcomes; the variables designating economic factors are restricted to public health spending (y1) and economic prosperity (y2), as measured by GDP per capita and DGGHE indicators, respectively; social factors are confined to female education (s1); and environmental factors are comprised of immunisation (e1), the female population (e2), government effectiveness (e3), and the rule of law (e4).

The empirical model used in the study, as represented by Equation 6.4, is a modified form of Equation 6.3, incorporating the variables under investigation. Following that, the model was transformed into a logarithmic form.

$$\boldsymbol{lnDALY_{it}} = \boldsymbol{ln\Omega_i} + \sum\boldsymbol{\alpha_i}(\boldsymbol{lnDGGHE_{it}}) + \sum\boldsymbol{\beta_i}(\boldsymbol{lnGDP_{it}}) + \sum\boldsymbol{\gamma_i}(\boldsymbol{lnFEMED_{it}})$$

$$+\sum\boldsymbol{\delta_i}(\boldsymbol{lnFP_{it}}) + \sum\boldsymbol{\theta_i}(\boldsymbol{lnIMM_{it}}) + \sum\boldsymbol{\rho_i}(\boldsymbol{lnRL_{it}}) + \sum\boldsymbol{\sigma_i}(\boldsymbol{lnGE_{it}}) + \boldsymbol{u_{it}} + \boldsymbol{\varepsilon_{it}} \qquad 6.4$$

where $\boldsymbol{lnDALY_{it}}$ represents the logarithm of health outcomes of country i at time t as measured by the DALY variables (DALY_hiv and DALY_tb); $\boldsymbol{lnDGGHE_{it}}$ represents the logarithm of public health spending of country i at time t, as measured by the DGGHE variables (DGGHE, DGGHE_hiv and DGGHE_tb), $\boldsymbol{lnGDP_{it}}$ measures the logarithm of the economic prosperity of country i at time t, $\boldsymbol{lnFEMED_{it}}$ denotes the logarithm of social factors of country i at time t, as measured by female education, $\boldsymbol{lnFP_{it}}$ is the logarithm of the female population in country i at time t, $\boldsymbol{lnIMM_{it}}$ is the logarithm of immunisation in country i at time t, $\boldsymbol{lnRL_{it}}$ is the logarithm of the rule of law in country i at time t, and

$\boldsymbol{lnGE_{it}}$ is the logarithm of government effectiveness in country i at time t. Constants α_i, β_i, γ_i, δ_i, θ_i, ρ_i, and σ_i are DGGHE, GDP, FEMED, FP, IMM, RL and GE elasticities, respectively. $ln\Omega$ is the logarithm of the constant term. u_{it} and ε_{it}.are the unobserved variables and the error term, respectively. Based on the body of evidence in public health and economic literature, the study proposes the following hypotheses:

H1: An increase in DGGHE (aggregated and disaggregated) is related to a decrease in the DALY-specific variables.

H2: Disaggregated DGGHE is more effective than aggregated DGGHE in reducing disaggregated DALY.

6.3.2.2 Estimation technique

The study adopted the GMM estimation technique to achieve its objective. GMM considers the dependent variable's ongoing existence, endogeneity (missing variables, simultaneity, and measurement error), and nation-specific heterogeneity (Blundell & Bond, 1998). Moreover, GMM is efficient when the number of cross-sections exceeds the number of periods (Arellano & Bond, 1991). The GMM estimator that Ahn and Schmidt (1995) proposes was implemented in the study because it is an estimator of linear dynamic panel data models based on linear and nonlinear moment conditions. Nonlinear moment conditions improve the model's efficiency when added to the difference-GMM moment conditions (Ahn & Schmidt, 1995).

Although these moment conditions become redundant when combined with the system-GMM moment conditions, they remain valid even if the system-GMM moment conditions are not satisfied (Blundell & Bond, 1998). In addition, whereas GMM estimators with linear moment conditions have a closed-form solution, nonlinear moment conditions do not (Ahn & Schmidt, 1995). To assess the consistency of their GMM estimator, Ahn and Schmidt (1995) rely on two specification tests: the Arellano–Bond and Sargan–Hansen tests (Arellano & Bond, 1991). The [AR (2)] was devised to determine if the first-difference residuals exhibit a second-order serial correlation. The null hypothesis states that residuals do not exhibit serial correlation. The test presents evidence of no second-order serial correlation and that the GMM predictor remains valid if the null hypothesis cannot be rejected. The Sargan-Hansen test is then applied to evaluate the null hypothesis of overidentification restrictions. The instruments are valid, and the model specification is accurate if this null hypothesis is not rejected (Kiviet & Kripfganz, 2021).

The study estimated four models. The DALY related to HIV/AIDS was the outcome measure for the HMOD1 and HMOD2 models, which measured PHS using disaggregated and aggregated data, respectively. The DALY related to TB was the outcome measure for the TMOD1 and TMOD2 models, in which PHS was measured using disaggregated and aggregated data, respectively. For each group of the HMOD and TMOD models, the effects of disaggregated PHS were compared with those of aggregate PHS. The quality of the model estimates and the scale of the multiplier effects of PHS were used to determine the best HMODs and TMODs.

Even if public spending is not entirely productive, the multiplier effect of public spending in a given economic sector, be it health or another, improves the sector's outcomes (Onaran & Oyvat, 2023; Stiglitz et al., 2006). Public spending investment promotes growth by increasing the economy's productive capacity. It is an investment in human capital with the expected multiplier effect of improving health outcomes (Raga, 2022). Therefore, this study considered a better model with a significant coefficient on the PHS variable and a larger PHS multiplier effect (Mwamkonko, 2021; Yoshida & Kenmochi, 2011). All variables were incorporated into the study models in logarithmic form so that the results could be compared with those of previous studies. The regulatory quality, government effectiveness, and the rule of law variables were rescaled from 1 to 5 to obtain logarithmic values. The XTDPDGMM package from STATA Version 17 was used to perform the analyses (Kripfganz, 2021; StataCorp, 2019).

6.4 Empirical results

6.4.1 Descriptive statistics

Table 6.2 below presents the descriptive statistics for the variables included in the study. However, owing to space constraints, this section addresses the main variables in the study. Over the study period, the average DALY_hiv and DALY_tb were 5,347 and 1,922 per 10,000 people, respectively. The SD of DALY_hiv was 5,640, whereas that of DALY_tb was 1,496. These figures suggest that in the sub-Saharan region, the values of DALY_hiv and DALY_tb were highly dispersed around their respective means. For example, Sao Tome has the lowest HIV/AIDS burden, with 12 DALYs per 10,000 people, whereas Eswatini has the highest HIV/AIDS burden, with 21,430 DALYs per 10,000 people. The data also indicated that 35% of the countries in the region had an HIV/AIDS burden greater than the regional average of 5,346 days per 10,000 people.

Table 6.2

Descriptive statistics, 2013–2019

Variable	Observation	Mean	Standard deviation	Minimum	Maximum	Shapiro–Wilk W coeff
DALY attributable to HIV/AIDS	217	5346.594	5640.239	11.669	28704.410	0.830***
DALY attributable to Tuberculosis	217	1921.895	1496.166	360.167	9415.468	0.635***
DGGHE spent onHIV/AIDS	217	14.827	33.613	0.030	196.802	0.474***
DGGHE, total	217	108.494	176.373	3.588	881.148	0.593***
DGGHE spent on tuberculosis	217	2.125	5.178	0.004	28.509	0.445***
Female education	217	101.373	16.293	62.008	148.772	0.966***
Female population	217	50.411	0.840	49.059	52.454	0.927***
Government Effectiveness	217	2.384	1.094	0.000	5.000	0.972***
Health prioritisation	217	6.745	3.046	1.032	15.290	0.938***
Immunization	217	80.751	15.011	23.000	99.000	0.859***
Economic prosperity	217	4703.648	4289.202	717.740	18552.810	0.765***
Pollution	217	0.863	1.458	0.027	8.212	0.515***
Regulatory Quality	217	2.385	0.931	0.000	5.000	0.991
Rule of Law	217	2.482	1.089	0.000	5.000	0.983***

Note. N = 217. Computed using the STATA software version 17.

***p < 0.01

Over the study period, sub-Saharan countries recorded DGGHE, DGGHE_hiv, and DGGHE_tb per capita averages of $108.50, $14.83, and $2.13, with SDs of 176.37, 33.61, and 5.18, respectively. These results also showed that the DGGHE indicators were widely dispersed around their mean values. This emphasised inequalities in health spending among sub-Saharan states. During the study period, several countries in this region, including the D.R. Congo and the Central African Republic, recorded extremely low DGGHE averages of $6.11 and $5.16, respectively. In contrast, Botswana and the Republic of South Africa recorded high DGGHE averages of $710.73 and $620.21, respectively, up to six times the regional average and one hundred times the lowest DGGHE.

Table 6.2 above shows no substantial dispersion around the mean values of the remaining study variables. The Shapiro-Wilk coefficients depicted in Table 6.2 indicate that, except for regulatory quality, none of the variables in the study were normally distributed. The variance inflation factor (VIF) test was performed for each study model, and the results are presented in Table 6.3 below. Moreover, the VIF estimates presented in Table 6.3 indicated no multicollinearity issue in the study models (Miles, 2015).

Table 6.3

Variance inflation factor indicators

	HMOD1	HMOD2	TMOD1	TMOD2
Variance Inflation Factor (VIF)	2.78	1.70	5.16	1.65

Note. Computed using the STATA software version 17.

The estimates of the pairwise correlations are shown in Table 6.4 below. The results in the table revealed that there was no statistically significant correlation between DALY_tb and the other variables. However, DALY_hiv was related to DALY_tb, DGGHE per capita, DGGHE_hiv, and DGGHE_tb. Except for the DGGHE-DGGHE_hiv correlation, none of the correlations exceeded the collinearity threshold of 0.7, which, according to Kennedy (2008), indicates a collinearity issue (see Table 6.4 below) (Kennedy, 2008).

Table 6.4

Pairwise correlations

	daly_hiv	daly_tb	dgghe	dgghe_hiv	dgghe_tb
daly_hiv	1				
daly_tb	0.412***	1			
dgghe	0.580***	-0.040	1		
dgghe_hiv	0.593***	0.022	0.883***	1	
dgghe_tb	0.484***	0.008	0.600***	0.456***	1

Note. Computed using the STATA software version 17.

*** p < .001; ** p < .05

6.4.2 Model estimates

Tables 6.5 and 6.6 below present the parameter estimates of HMOD and TMOD models from the regressions using Ahn and Schmidt's (1995) GMM estimator. In addition, Tables 6.5 and 6.6 show that all the study models exhibited a good fit. The p-values for the Arellano-Bond AR (2) autocorrelation tests for HMOD1, HMOD2, TMOD1, and TMOD2 were 0.002, 0.007, 0.036, and 0.034, respectively. None of the HMOD models rejected the null hypothesis at the 1% significance level, whereas the TMOD models rejected it at the 5% percent level. This suggested that none of the study models had serially correlated residuals. The Sargan-Hansen tests for overidentifying restrictions yielded no p-values less than 0.10 for any model. This result revealed that the null assumption could not be rejected for any of the study models, indicating that the instruments used in the study models were valid.

Table 6.5 below presents the estimated parameters for the two HIV/AIDS models, HMOD1, and HMOD2. While both models used the DALY_hiv as outcome variables, HMOD1 used aggregated DGGHE to measure PHS, and HMOD2 used HIV/AIDS-related DGGHE as a measure of PHS.

Table 6.5

HMOD estimates

Variables	HMOD1	HMOD2
DGGHE, log	0.034 (0.169)	
DGGHE_hiv, log		**-0.049* (0.026)**
Economic prosperity, log	-0.080 (0.376)	**0.364* (0.190)**
Female education, log	0.122 (0.253)	0.497 (0.304)
Government Effectiveness, log	0.055 (0.060)	0.011 (0.021)
Rule of Law, log	0.018 (0.028)	0.006 (0.008)
Female population, log	-24.409 (15.451)	-13.732 (19.992)
Constant	**103.498* (60.185)**	56.601 (78.134)
Year Dummies	Yes	Yes
No of Observations	217	217
No of Instruments	42	36
Variance Inflation Factor (VIF)	2.78	1.70
Arellano-Bond test for autocorrelation (AR 1)	0.177	0.082
Arellano-Bond test for autocorrelation (AR 2)	0.002	0.007
Sargan-Hansen test (2-step weighting matrix)	0.888	0.922
Sargan-Hansen test (3-step weighting matrix)	0.365	0.123

Note. Dependent variable is DALY_hiv, log. Standard errors are shown in parentheses. The P-values reported for AR(..) and Sargan-Hansen tests. Estimates were obtained from the Ahn and Schmidt estimator. Computed using the STATA software version 17.

**p < 0.10.

The HMOD1 results showed that the effect of aggregate DGGHE on the DALY_hiv was not statistically significant ($b = 0.034$, $p = 0.844$). This result did not support

Hypothesis 1 because the coefficient of aggregate DGGHE was positive and statistically insignificant, implying that aggregate DGGHE is not associated with the DALY attributable to HIV/AIDS in sub-Saharan countries. Whereas all control variables were statistically insignificant at all levels, the model constant (b = 103.500; p = 0.096) was positive and statistically significant at the t10% level, indicating that the sub-Saharan region had a persistent HIV/AIDS burden over time.

According to the estimates provided by the HMOD2 in Table 6.5, it can be observed that the allocation of DGGHE resources towards HIV/AIDS in sub-Saharan Africa significantly influences the Disability-Adjusted Life Years (DALY) associated with HIV/AIDS. Based on the results in Table 6.5, it can be observed that an increase of 10% in per capita in DGGHE spent on HIV/AIDS is associated with a reduction of 0.490% in the DALY attributed to HIV/AIDS, assuming all other factors remain constant. The observed negative elasticity of -0.049 between DGGHE_hiv and DALY_hiv supports Hypothesis 1. While the model constant and other controlled variables were statistically insignificant, the results indicated that economic prosperity had a significant positive effect on HIV/AIDS, with a 10% rise in economic prosperity leading to a 3.64% increase in DALY attributable to HIV/AIDS ceteris paribus. The association between economic prosperity and HIV/AIDS prevalence in Africa generally demonstrates a pattern wherein economic prosperity is associated with a decrease in HIV/AIDS rates. However, it is important to acknowledge that specific circumstances and causes may arise that might potentially result in an increase in HIV/AIDS cases, even in the presence of economic growth. As an illustration, it is worth noting that economic prosperity has the potential to influence shifts in sexual conduct. Specifically, heightened disposable income may contribute to an upsurge in precarious sexual behaviours, thereby elevating the likelihood of HIV transmission (Lindskog & Durevall, 2021).

Moreover, it is frequently seen that economic development is closely associated with urbanisation. This process entails a significant influx of individuals seeking employment opportunities and improved living standards, relocating to urban areas.

Consequently, these cities often exhibit greater rates of HIV prevalence, mostly attributed to variables such as an elevated occurrence of risky sexual practises (Rizvi et al., 2020).

The regression results for the two TB models, TMOD1 and TMOD2, are presented in Table 6.6 below. TMOD1 included aggregated DGGHE as a measure of PHS, whereas TMOD2 included TB-related DGGHE as a measure of PHS. Both the models used DALY_tb as the outcome variable (see Table 6.6 below).

Table 6.6

TMOD estimates

Variables	**TMOD1**	**TMOD2**
DGGHE, log	0.036 (0.060)	
DGGHE_tb, log		**-0.009*** (0.003)**
Health prioritisation, log	-0.006 (0.053)	**0.070* (0.037)**
Regulatory Quality, log	0.000 (004)	0.008 (0.006)
Pollution, log	-0.071 (0.077)	0.006 (0.090)
Rule of Law, log	-0.000 (0.002)	0.002 (0.002)
Immunization, log	0.066 (0.085)	**0.090* (0.052)**
Constant	**7.008*** (0.317)**	**6.980*** (0.294)**
Year Dummies	Yes	Yes
No of Observations	217	217
No of Instruments	42	36
Variance Inflation Factor (VIF)	5.16	1.65
Arellano-Bond test for autocorrelation (AR 1)	0.114	0.139
Arellano-Bond test for autocorrelation (AR 2)	0.036	0.034
Sargan-Hansen test (2-step weighting matrix)	0.755	0.655
Sargan-Hansen test (3-step weighting matrix)	0.365	0.123

Note. Dependent variable is DALY_tb, log. Standard errors are shown in parentheses. The p-values reported for the AR(..) and Sargan-Hansen tests. Computed using the STATA software version 17.

*p < 0.10; ***p < 0.01.

The TMOD1 result revealed that the effect of aggregate DGGHE on the DALY attributable to TB was not statistically significant (b = 0.364, p = 0.550). This result contradicted Hypothesis 1 because the coefficient of aggregate DGGHE was positive and statistically insignificant. This indicated that aggregate DGGHE was unrelated to the DALY attributable to TB in sub-Saharan countries. Whereas all control variables were statistically insignificant, the constant term in the model (b = 7.008; p = 0.000) was positive and statistically significant at all levels, implying that, despite efforts to eradicate TB in sub-Saharan countries, some TB burden persists. The TMOD2 results showed that DGGHE spent on TB had a statistically significant effect on the DALY attributable to TB at all levels (b = - 0.009, p = 0.007).

This result implied that a 10% increase in the per capita DGGHE spent on TB resulted in a 0.09% decrease in the DALY attributable to TB in sub-Saharan countries, ceteris paribus. This result showed a DGGHE_tb elasticity concerning the DALY_tb - 0.009, indicating that DGGHE spent on TB was negatively associated with the DALY attributable to TB in sub-Saharan countries. Whereas control variables, such as the rule of law, CO2 emissions, and regulatory quality, were statistically insignificant, others, including health prioritisation and the constant term, were statistically significant. As indicated previously, both TMOD1 and TMOD2 had good econometric properties.

This study used the root mean square error (RMSE) and multiplier effects of DGGHE to compare the HMODs and TMODs and get the best model of each group model. The root mean square error (RMSE) is a widely used statistic in model evaluation to determine the most optimal model among a set of compared models. A smaller root mean square error (RMSE) score indicates a superior model, implying that, on average, the model's predictions exhibit greater proximity to the actual values (Ahmed et al., 2020; Hodson, 2022). The model selection method considered the tax multiplier aspect of DGGHE and its subsequent multiplier impacts. The role of DGGHE as a source of revenue for the government is significant since it functions as a tax instrument. Analysing the spillover effects of adopting interventions based on the PHS requires a thorough understanding of the multiplier effects of DGGHE on health (Gechert, 2017).

The root mean square error estimation has been performed utilising the mathematical formula presented in Equation 6.3.

$$\boldsymbol{RMSE} = \sqrt{\frac{\sum_{i=1}^{N} \|y(i) - \hat{y}(i)\|^2}{N}} \quad 6.3$$

where N represents the total number of data points, $y(i)$ denotes the i-th measurement, and $\hat{y}(i)$ represents the corresponding prediction for that measurement.

The DGGHE multiplier of the DALY was computed for each model by employing the formula specified in Equation 6.4.

$$\boldsymbol{M} = \boldsymbol{1}/(\boldsymbol{1} - \boldsymbol{b}) \quad 6.4$$

where *b* represents the coefficient of the DGGHE indicators.

Table 6.7 presents the RMSEs associated with the HMODs and TMODs. Meanwhile, Table 6.8 provides the estimates of multiplier effects of DGGHE on population health outcomes, as measured by the DALY indicators.

Table 6.7

Estimates of root mean square errors.

	Model with aggregated DGGHE	Model with disaggregated DGGHE
HIV Models	0.129	0.120
TB Models	0.037	0.035

Note. Computed using the STATA software version 17.

According to Table 6.7, models with disaggregated DGGHE in both HMODs and TMODs presented lower RMSE estimates. This suggests that models with disaggregated DGGHE are better.

Table 6.8

Estimates of multiplier effects of DGGHE

	HM0D1	HM0D2	TM0D1	TM0D2
DALY multiplier	-	0.953	-	0.991

Note. Computed using the STATA software version 17.

According to Table 6.8, there were no multiplier effects for models HMOD1 and TMOD1 with aggregated DGGHE because these models did not have a significant coefficient for DGGHE, which would allow calculating the multiplier. Therefore, an increase in DGGHE did not affect the DALY_HIV and DALY_TB. In contrast, the HMOD2 and TMOD2 models with disaggregated DGGHE indicated estimated multipliers, which would reduce the DALY_hiv and DALY_tb by -0.047 (0.953 − 1) and -0.009 (0.991 − 1), respectively, with increased disaggregated DGGHE.

According to the estimation results in Tables 6.5, 6.6, 6.7 and 6.8 above, the models with disaggregated PHS had the best estimates of the effectiveness of PHS.

6.5 Discussion

Sub-Saharan countries are working on various initiatives to improve the health of their populations and SDG). Despite these efforts, it is unclear how effective PHS is in improving health outcomes in this region. Previous research has produced conflicting results, possibly because it relied on aggregated data to measure PHS.

To gain better insights, the study endeavoured to assess the effectiveness of PHS using disaggregated data to measure its impact. Therefore, the study focused on disease-specific spending to understand how this would indicate the effectiveness of PHS in sub-Saharan countries. By comparing the impact of disease-specific PHS on specific health outcomes with the impact of broader PHS, the study sought to provide valuable insights into the effectiveness of different approaches in improving health outcomes in the region. Whereas DGGHE, DGGHE_hiv, and DGGHE_tb were employed as PHS measures, DALY_hiv and DALY_tb were used to measure population health outcomes.

The study concluded that in SSA, DGGHE spent on HIV/AIDS and TB provided better evidence of the PHS effectiveness when compared with the aggregate DGGHE. Moreover, the HIV/AIDS-based models revealed a negative and statistically significant DGGHE_hiv elasticity of -0.049, suggesting that in SSA, a 10% increase in per capita DGGHE spent on HIV/AIDS would yield a 0.49% decrease in the DALY attributed to HIV/AIDS, ceteris paribus. This result was consistent with Hypothesis 1 and was expected because the vast majority of the population in SSA is poor and relies on few existing public healthcare facilities.

Most health services in this region are privately owned and unaffordable. The high cost of these services to patients limits access to healthcare (Olaniyi et al., 2022). In this context, increased PHS on HIV/AIDS is expected to better health outcomes for most of the population by enhancing access to and quality of care in public health facilities. This conclusion was consistent with the results of previous studies (Granich et al., 2016; Viriyathorn et al., 2021). In contrast to previous research based on mortality-related indicators of population health outcomes, such as under-five and infant mortality rates, the study's results were based on the DALY, a measure of population health outcomes that accounts for morbidity and mortality.

The negative and statistically significant DGGHE_tb elasticity of -0.009 suggested that a 10% increase in per capita DGGHE) spent on TB led to a 0.09% decrease in the DALY (Disability-Adjusted Life Years) attributed to TB. This result was also consistent with Hypothesis 1 and was expected for the same reasons stated above in terms of HIV/AIDS care. Moreover, this result was consistent with the conclusions of several previous studies, which indicated that PHS played an important role in TB reduction (Bergonzoli et al., 2016; Liu et al., 2020; Wagstaff & Cleason, 2004).

To evaluate Hypothesis 2, the study investigated the estimates of DGGHE indicator coefficients and multiplier effects on health indicators of the DALY for each model included in the study. In the HMOD model, aggregate DGGHE, as a measure of PHS in the HMOD1 model, had a non-significant coefficient, whereas DGGHE_hiv, as a measure of PHS in the HMOD2 model, had a significant coefficient with the predicted sign.

The impact of the DGGHE indicators on DALY related to HIV/AIDS was examined, and the results showed interesting results. In the HMOD1 model, an increase in the overall aggregated DGGHE did not change DALY. However, in the HMOD2 model, when the specific DGGHE_hiv multiplier increased, it decreased DALY, indicating that DGGHE_hiv had a stronger effect on population health outcomes. This suggested that DGGHE_hiv contributed to reducing DALY, while the overall aggregated DGGHE did not significantly affect the DALY.

In the TMOD model group, the results showed that aggregated DGGHE used as a measure of PHS) in the TMOD1 model, had a non-significant coefficient. However, when using DGGHE_tb as a measure of PHS in the TMOD2 model, it had a significant coefficient with the expected direction.

Looking at the impact of DGGHE indicators on the DALY related to TB, the results revealed that an increase in aggregated DGGHE did not lead to any change in the DALY in the TMOD1 model. However, in the TMOD2 model, an increase in DGGHE_tb led to a 0.09 decrease in the DALY, suggesting that the DGGHE_tb multiplier had a stronger effect on population health outcomes. This implied that DGGHE_tb contributed to reducing DALY, while aggregated DGGHE did not significantly affect the DALY.

These results supported Hypothesis 2, which suggested that disaggregated or targeted DGGHE is more effective than aggregated DGGHE in reducing disaggregated DALY variables. These results were anticipated because of the evidence from the economic literature, which suggests that an increase in untargeted public social spending may generate the intended outcomes. However, these outcomes are significantly lower than those resulting from increased targeted public social spending (Ducanes et al., 2006). The results of the study were supported by the studies by Sing (2014), Bernet et al. (2018), and Kiross et al. (2020,) which compared the impact of aggregated PHS with that of disaggregated PHS and found that the use of disaggregated public spending as opposed to aggregated health spending provides a more accurate indication of the PHS effectiveness.

The policy implication of the results is that governments in SSA should mobilise resources to strengthen the collection of disaggregated health data and ensure that these data are publicly available to evaluate the PHS effectiveness. As they can differentiate between different spending items, disaggregated data may help governments be on the right track when determining where to allocate health funds and investments to close health gaps.

The study contributed to the expanding literature on health spending by demonstrating the advantages of using disaggregated data to measure PHS when investigating its effectiveness. However, the lack of disaggregated data on PHS and population health outcomes in SSA limited the study period and number of variables in the form of disease-specific expenditures, which should have been included. This limitation does not invalidate the study's results but may serve as a foundation for future research.

6.6 Chapter summary

Countries in SSA are extremely concerned with improving the health of their populations and attaining SDG 3. To this end, most studies have explored diverse PHS-based interventions. However, implementing these interventions raises concerns about their ability to achieve health objectives. This issue is exacerbated by the interchangeable use of different data types (aggregated or disaggregated) to measure the PHS, leading to inconsistent evaluation results if an inappropriate data type is selected. The study aimed to demonstrate that the use of disaggregated data in SSA provides a more accurate assessment of the effectiveness of PHS than aggregated data.

The study endeavoured to understand how PHS affected health outcomes in sub-Saharan countries, specifically those related to HIV/AIDS and TB. To do this, they looked at different types of PHS indicators:

- Aggregated PHS, which is the overall amount of money spent on health services in a country, represented by DGGHE
- Disaggregated PHS for HIV/AIDS, which represented the portion of the health expenditure dedicated specifically to HIV/AIDS-related services.
- Disaggregated PHS for TB, which represented the portion of the health expenditure allocated to tuberculosis-related services.

The GMM estimator was used to analyse the data, which led to meaningful conclusions from panel data collected over time from multiple countries. This analysis revealed that when evaluating the effectiveness of publicly funded health services in reducing health problems related to HIV/AIDS and TB in sub-Saharan countries, it was more meaningful to consider the PHS indicators that were specifically allocated for HIV/AIDS and TB (disaggregated indicators). Using the overall amount of health expenditure (aggregated PHS) as an indicator did not indicate a reduction in HIV/AIDS and TB-related health issues compared with the targeted PHS indicators for HIV/AIDS and TB.

These results imply that governments in SSA should consider using disaggregated data when investigating the effectiveness of implemented PHS-based interventions. This would be a good basis for decisions about health fund allocation. In addition, governments should promote the collection of disaggregated data and make it accessible to the public. This would ensure a more accurate evaluation of PHS effectiveness and improved decision-making in countries.

Chapter 7.
Conclusion and Recommendations

7.1 Introduction

This chapter concludes the thesis by outlining the contributions of each chapter towards achieving the research objective. The following section gives a brief overview of the study, followed by a section summarising the chapters in terms of the research questions and results. Furthermore, the chapter discusses the specific contributions that the study made to the existing literature and explores their implications. Additionally, policy recommendations based on the results are presented. It is important to acknowledge the study's limitations; therefore, the chapter also discusses this. Lastly, an outline of potential avenues for future research is provided.

7.2 Overview of study

The study aimed to evaluate the influence of structural factors on the effectiveness of PHS in SSA and, therefore, formulated the following research questions:

- Do structural factors function as channels through which PHS impacts population health outcomes in SSA?
- Does the efficiency of the health system influence the extent to which PHS impacts population health outcomes in SSA?
- Does the effectiveness of PHS in SSA depend on a country's governance?
- When evaluating the efficacy of PHS, is disaggregated data preferable to aggregate data for measuring PHS?

To answer these research questions, the study employed various quantitative methodologies explained in the thesis. Chapter 3 explained using the SEM to analyse the mediation process between PHS and population health outcomes, considering changes in the initial level and growth rate. Chapter 4 described the regression method applied to investigate the moderating effect of health system efficiency, using the GMM moments as the estimator. Chapter 5 explained using the PLS-SEM to investigate the moderating effect of country governance. Chapter 6 explained the study's use of a regression method for estimating the study model using the GMM estimator.

The thesis explained the study's use of the production function approach to link outcomes and covariates, treating health outcome indicators as outputs of the health production function. Within this function, various inputs, including health spending, were considered as an investment in healthcare.

The study used the DGGHE and the DALY as indicators to measure PHS and population health outcomes. DGGHE represented the domestic resources controlled by the government, while DALY provided a summary measure of population health. The study relied on secondary data from panel data collected from selected sub-Saharan countries and employed various econometric packages for conducting the analyses.

7.3 Reconciliation of chapters

This section presents the main research results regarding the questions addressed in Chapters 3-6, following the introductory chapter and literature review. These chapters explored and delved into specific aspects of the research to provide comprehensive insights into the study's objectives.

How the study addressed the first research question was explained in Chapter 3. In other words, the chapter described the investigation to determine whether structural factors functioned as channels for the impact of PHS on population health outcomes in SSA. The chapter explained the two mediational processes evaluated within the LGCM framework, evaluating mediational processes in parallel. Specifically, mediators were evaluated on two paths, from PHS growth factors measured by DGGHE to PHS growth factors measured by the DALY. The chapter highlighted how sequential tests were conducted on the first path using the malaria and women's education indices and on the second path whereby immunisation coverage was examined. The research results reported in this chapter indicated that malaria and female education served as channels through which DGGHE impacted DALY in sub-Saharan countries. These effects were observed through specific paths from the DGGHE slope to the DALY slope, mediated by malaria and female education slopes. However, the study did not find mediating effects of immunisation in the relationship between DGGHE and the DALY in sub-Saharan countries. The results suggested that in SSA, the slopes of DGGHE were inversely related to the slopes of DALY via sequential changes in malaria and female education rates of change. The conclusion was that malaria and female education jointly functioned as transmission channels of DGGHE, with increased DGGHE growth rates being negatively related to malaria growth rates, subsequently affecting female education growth rates and ultimately positively influencing DALY growth rates through an observed total indirect effect.

Chapter 4 focused on the second research question, which assessed the extent to which health system efficiency influenced the effect of PHS on population health outcomes in SSA. The chapter explained the moderation framework that Aiken et al. (1991) and Baron and Kenny (1986) suggested. In addition, the chapter explained the investigation of the relationship between DGGHE and the DALY and the testing of the interaction term between health system efficiency and DGGHE. The chapter described the research results, which revealed a negative relationship between DGGHE and the DALY, suggesting that an increase in DGGHE was associated with a decrease in the DALY in sub-Saharan countries.

The chapter also explained that DGGHE and health system efficiency interacted to predict the DALY, indicating that health system efficiency moderated the association between DGGHE and the DALY. Moreover, the chapter indicated that the study found that the moderating effect of health system efficiency was decremental, with its strength decreasing as health system efficiency increased. Notably, DGGHE was found to be meaningful to the DALY only for those countries with health system efficiency scores of one standard deviation or more below the mean.

The results presented in Chapter 4 provided insights into why DGGHE might have been perceived to have no significant or aa marginally low impact on population health outcome indicators in some studies. The ineffectiveness of PHS in some cases could be attributed to extremely low health system efficiency scores, causing dysfunctions that prevented the health system from being seen to achieved improved health outcomes, irrespective of the level of PHS intervention. However, it was acknowledged that the reduction in the DALY may also depend on other factors not considered in the study due to the lack of country-level data.

Chapter 5 explained how the study addressed the third research question by investigating whether the effectiveness of PHS in influencing population health outcomes in SSA depended on country governance. PHS and population health outcomes were measured using DGGHE and DALY, respectively. The study used the two-step approach proposed by Chin (1998) and Henseler and Fassott (2010) within the PLS-SEM framework to conduct the moderation analysis. Country governance was a second-order construct moderator created from three of its components: corruption control, government effectiveness, and voice accountability, as first-order construct indicators. The results indicated that DGGHE significantly reduced the DALY in sub-Saharan countries, suggesting that an increase in DGGHE was associated with a reduction in DALY. Furthermore, the study identified a moderating effect of country governance, as measured simultaneously by the three indicators mentioned above, on the relationship between DGGHE and the DALY in SSA. The analysis revealed that the negative relationship between DGGHE and the DALY was mitigated by high levels of governance and strengthened by low levels of governance, indicating that governance exerted a weakening substitutional interaction effect on the relationship between DGGHE and DALY.

Lastly, Chapter 6 explained how the study answered the fourth research question, investigating whether measuring PHS with disaggregated rather than aggregated data when studying PHS effectiveness was preferable. The theoretical framework described in this chapter was based on Grossman's (1972) model, developed by Fayissa and Gutena (2008). The chapter explained how the study estimated four models, with the DALY related to HIV/AIDS as the outcome measure for the HMOD1 and HMOD2 models and the DALY related to TB for the TMOD1 and TMOD2 models. The models measured PHS using disaggregated and aggregated data, respectively.

The results indicated no relationship between DGGHE and the DALY in models where aggregated data measured PHS. In contrast, models where PHS was measured by disaggregated data (DGGHE spent on HIV/AIDS and TB) demonstrated the relationship between DGGHE and DALY. The study found that PHS measured by disaggregated data provided better evidence of PHS effectiveness in SSA than aggregated DGGHE data. These findings were consistent with evidence from the economic literature, suggesting that an increase in untargeted public social spending may generate intended outcomes. Still, these outcomes are significantly lower than those resulting from increased targeted public social spending.

The results presented in this thesis contributed to a deeper understanding of the role of PHS role in achieving health-related SDGs and accelerating progress towards UHC. In addition, the study emphasised the importance of considering and controlling the factors discussed throughout the thesis to discern PHS's reliable contribution to improving population health outcomes.

7.4 Limitations of the study

This thesis has made a significant contribution by providing valuable insights into the effectiveness of public health spending in enhancing population health outcomes in Sub-Saharan Africa. However, the thesis identified certain limitations that may have had the potential to enhance its overall quality and depth. The thesis is subject to a number of limitations, which are outlined below. The availability and reliability of data, specifically in SSA, where the lack of consistency in health data undermines the comparability and precision of the results. The direct applicability of the results from this thesis to all SSA countries may be limited, owing to the considerable variation in health systems, socio-economic factors, and governance frameworks across the region. The use of data available up to 2019 fails to consider subsequent political, economic, and epidemiological developments or transformations that might influence the effectiveness of public health spending. Due to the challenge of establishing a direct causal relationship between PHS and population health outcomes, the research could not account for all the intricate factors that influence health outcomes in SSA. The research failed to capture all relevant aspects of effectiveness, and some outcomes may be difficult to quantify because effectiveness is difficult to measure accurately due to the multitude of factors that influence health outcomes. Lastly, due to the study's timing constraints, a comprehensive evaluation of the long-term consequences and sustainability of public health spending, which could require years or even decades to materialise, may not be feasible.

7.5 Contribution to literature

The primary contribution of this study to the existing body of literature is the identification of structural factors that have the potential to impede the effectiveness of PHS in sub-Saharan countries. This contribution translates into the following results:

- The study presents novel evidence that highlights the combined role of malaria and female education as a pathway through which PHS can impact population health outcomes in SSA.
- The study establishes, for the first time, that the efficiency of the health system plays a moderating role in the association between PHS and mortality and morbidity-based population health outcomes.
- The findings of this study also indicate that the governance of a country, as measured by measures of corruption control, government performance, and voice accountability, may have a significant role in mitigating the impact of PHS on population health outcomes in SSA.
- The study findings also suggest that disease-specific disaggregated PHS yields more reliable evidence of PHS's effectiveness than aggregated PHS.

In addition, the research included novel methodologies such as Latent Growth Curve Mediation Modelling, Partial Least Squares Structural Equation Modelling, and multiple mediation analysis to assess the effectiveness of the PHS.

7.6 Recommendations

This section makes recommendations for policy and future research based on the results.

7.6.1 Recommendations for policy

Incorporating the following recommendations into policy development and implementation could pave the way for more effective publicly funded health services in sub-Saharan Africa.

Sustainable malaria control

Given the significant impact of malaria on population health outcomes, governments in SSA should prioritise sustainable funding for malaria control programmes. Long-term, predictable, and domestically funded initiatives can help combat vector-borne diseases like malaria effectively. By investing in sustainable malaria control, countries can reduce morbidity and mortality rates, improving overall health outcomes.

Promote female education

Recognizing the crucial role of female education as a channel for improving population health, governments should prioritise efforts to promote and enhance educational opportunities for girls and women in SSA. Educated women tend to make informed health-related decisions, positively influencing health outcomes for themselves and their families. By investing in female education, countries can create a ripple effect of improved health across generations.

Strengthen health system efficiency.

To maximise the impact of publicly funded health services, policymakers should focus on enhancing the efficiency of their health systems. By investing in initiatives that improve the organisation and delivery of healthcare services, governments can ensure effective healthcare for the population. This approach would not only optimise resource utilization but also lead to a higher return on healthcare spending, ultimately benefiting the population's overall health.

Role of country governance

Acknowledging the moderating effect of country governance on the relationship between PHS and population health outcomes, governments in SSA should carefully assess how governance interacts with PHS interventions. Aligning PHS and governance levels to achieve desired population health outcomes could lead to more impactful and sustainable improvements in public health.

Disaggregated data for informed decision-making

To gain a comprehensive understanding of PHS effectiveness, governments should invest in strengthening the collection and accessibility of disaggregated health data. Disaggregated data provides valuable insights into specific spending items, enabling policymakers to make well-informed decisions on resource allocation and investments to address health disparities effectively.

7.6.2 Recommendations for future research

The following recommendations are made for future research:

- Data quality and time frames: Future research could incorporate more time points and use precise functional forms to estimate univariate LGCMs, thus improving data quality and outcomes.
- Alternative measures: Future studies could use measures, such as HALE instead of DALY, to better understand the positive aspects of health impacted by PHS.

- Comprehensive panel data: Future research can contribute to knowledge by using larger sets of observations and improving panel data quality. This will enable researchers to explore various variables and provide more comprehensive information.
- Relevant control variables: Future research should include control variables, such as poverty level, physician count, and hospital bed count, to provide a more nuanced understanding of the factors influencing the relationship between PHS and population health outcomes.
- Disaggregated data: Future research should consider exploring different disaggregation criteria and collecting many observations to overcome data limitations. This will allow researchers to conduct more in-depth analyses and draw more robust conclusions.

By addressing these opportunities for future research, scholars can further advance the understanding of the effectiveness of PHS in SSA.

REFERENCES

Adeagbo, M. O. (2022). *Public Health Expenditure, Governance and Health Outcomes in Sub-Saharan Africa* [Ph.D. Thesis, Kwara State University (Nigeria)]. ProQuest Dissertations Publishing https://www.proquest.com/

Adedokun, S. T., & Yaya, S. (2020). Childhood morbidity and its determinants: evidence from 31 countries in sub-Saharan Africa. *BMJ global health*, *5*(10), e003109. https://doi.org/10.1136/bmjgh-2020-003109

Adegoke, Y. O., George, G., & Mbonigaba, J. (2022). Sustainable thresholds, health outcomes, health expenditures and education nexus in selected African countries: quadratic and moderation modelling. *Globalization and health*, *18*(1), 84. https://doi.org/10.1186/s12992-022-00876-8

Adeleye, B. N., Bengana, I., Boukhelkhal, A., Shafiq, M. M., & Abdulkareem, H. K. (2022). Does human capital tilt the population-economic growth dynamics? Evidence from Middle East and north African countries. *Social Indicators Research*, *162*(2), 863-883. https://doi.org/10.1007/s11205-021-02867-5

Ahmed, M., Ahmad, S., Raza, M. A., Kumar, U., Ansar, M., Shah, G. A., Parsons, D., Hoogenboom, G., Palosuo, T., & Seidel, S. (2020). Models calibration and evaluation. *Systems modeling*, 151-178. https://doi.org/10.1007/978-981-15-4728-7_5

Ahn, S. C., & Schmidt, P. (1995). Efficient estimation of models for dynamic panel data. *Journal of econometrics*, *68*(1), 5-27. https://doi.org/10.1016/0304-4076(94)01641-C

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. sage. ISBN 0761907122

Akazili, J., Aikins, M., & Binka, F. N. (2007). Malaria treatment in Northern Ghana: What is the treatment cost per case to households? *African Journal of Health Sciences*, *14*(1), 70-79. https://doi.org/10.4314/ajhs.v14i1.30849

Akinlo, A. E., & Sulola, A. O. (2019). Health care expenditure and infant mortality in sub-Saharan Africa. *Journal of Policy Modeling*, *41*(1), 168-178. https://doi.org/10.1016/j.jpolmod.2018.09.001

Akpa, E., & Adegbenro, M. (2023). Fiscal Policy Measures, Income Inequality and Health Outcomes of Countries in SSA. *Acta Universitatis Danubius. Œconomica*, *19*(4), 55-76. https://doi.org/https://orcid.org/0009-0007-0189-4674

Albassam, B. A. (2020). A model for assessing the efficiency of government expenditure. *Cogent Economics & Finance*, *8*(1), 1823065. https://doi.org/10.1080/23322039.2020.1823065

Alebel, A., Demant, D., Petrucka, P., & Sibbritt, D. (2021). Effects of undernutrition on mortality and morbidity among adults living with HIV in sub-Saharan Africa: a systematic review and meta-analysis. *BMC infectious diseases*, *21*, 1-20. https://doi.org/10.1186/s12879-020-05706-z

Ameye, H., & De Weerdt, J. (2020). Child health across the rural–urban spectrum. *World Development*, *130*, 104950. https://doi.org/10.1016/j.worlddev.2020.104950

Amwonya, D., Kigosa, N., & Kizza, J. (2022). Female education and maternal health care utilization: evidence from Uganda. *Reproductive Health*, *19*(1), 1-18. https://doi.org/10.1186/s12978-022-01432-8.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The review of economic studies*, *58*(2), 277-297. https://doi.org/10.2307/2297968

Arthur, E., & Oaikhenan, H. E. (2017). The effects of health expenditure on health outcomes in Sub-Saharan Africa (SSA). *African Development Review*, *29*(3), 524-536. https://doi.org/10.1111/1467-8268.12287

Arvidsson, R., Chordia, M., & Nordelöf, A. (2022). Quantifying the life-cycle health impacts of a cobalt-containing lithium-ion battery. *The International Journal of Life Cycle Assessment*, *27*(8), 1106-1118. https://doi.org/doi.org/10.1007/s11367-022-02084-3

Atake, E. H. (2021). Socio-economic inequality in maternal health care utilization in Sub-Saharan Africa: Evidence from Togo. *The International Journal of Health Planning and Management*, *36*(2), 288-301. https://doi.org/10.1002/hpm.3083

Attamah, N., & Kalu, C. U. (2020). Economic globalization and population health outcomes in Nigeria: implications of achieving the health sustainable development goals (sdgs). *International Journal of Scientific and Research Publications*

(IJSRP), *10*(10), 537-564. https://www.ijsrp.org/research-paper-1020/ijsrp-p10671.pdf https://www.ijsrp.org/research-paper-1020/ijsrp-p10671.pdf

Ayadi, M. F., & Lawanson, A. O. (2020). The Changing Pattern of Healthcare Financing in Sub-Saharan Africa: Implications for Health Outcomes. *African Journal of Health Economics*, *9*(2), 32-50. https://doi.org/10.35202/AJHE.2020.923250

Ayimaleh, G. N. (2023). *How Public Health Expenditure Affect Health Outcomes in Cameroon* [Ph.D. Thesis, Walden University]. Walden University. https://scholarworks.waldenu.edu

Babalola, T. K., & Moodley, I. (2020). Assessing the efficiency of health-care facilities in Sub-Saharan Africa: a systematic review. *Health Services Research and Managerial Epidemiology*, *7*, 12. https://doi.org/10.1177/2333392820919604

Bain, L. E., Aboagye, R. G., Dowou, R. K., Kongnyuy, E. J., Memiah, P., & Amu, H. (2022). Prevalence and determinants of maternal healthcare utilisation among young women in sub-Saharan Africa: cross-sectional analyses of demographic and health survey data. *BMC public health*, *22*(1), 647. https://doi.org/10.1186/s12889-022-13037-8

Baker, D. P., Leon, J., Smith Greenaway, E. G., Collins, J., & Movit, M. (2011). The education effect on population health: a reassessment. *Population and development review*, *37*(2), 307-332. https://doi.org/10.1111/j.1728-4457.2011.00412.x

Bala, M. M., Singh, S., Kumar, N., & Janor, H. (2022). Predicting key drivers for health care expenditure growth in the Middle East region: a Grossman-PLS modeling approach. *Expert Review of Pharmacoeconomics & Outcomes Research*(just-accepted). https://doi.org/10.1080/14737167.2022.2073222

Baltagi, B. (2005). *Econometric analysis of panel data* Wiley; 3rd edition ISBN 978-0470014561

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of personality and social psychology*, *51*(6), 1173. https://doi.org/10.1037//0022-3514.51.6.1173

Barro, R. J. (2013). Health and economic growth. *Annals of Economics and Finance*, *14*(2), 329-366. http://ftp.aefweb.net/WorkingPapers/w572.pdf http://ftp.aefweb.net/WorkingPapers/w572.pdf

Barroy, H., Sparkes, S., Dale, E., & Organization, W. H. (2016). *Assessing fiscal space for health expansion in low-and-middle income countries: a review of the evidence*. World Health Organization. Switzerland. ISBN Lincense: CC BY-NC-SA 3.0 IGO

Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical economics*, *20*(2), 325-332. https://doi.org/10.1007/BF01205442

Behrman, J. R., & Deolalikar, A. B. (1988). Health and nutrition. *Handbook of development economics*, *1*, 631-711. https://doi.org/10.1016/S1573-4471(88)01017-4

Bein, M. (2020). The association between medical spending and health status: A study of selected African countries. *Malawi Medical Journal*, *32*(1), 37-44. https://doi.org/10.4314/mmj.v32i1.8

Bein, M. A., Unlucan, D., Olowu, G., & Kalifa, W. (2017). Healthcare spending and health outcomes: evidence from selected East African countries. *African health sciences*, *17*(1), 247-254. https://doi.org/10.4314/ahs.v17i1.30

Bell, D., & Hansen, K. S. (2021). Relative burdens of the COVID-19, malaria, tuberculosis, and HIV/AIDS epidemics in sub-Saharan Africa. *The American journal of tropical medicine and hygiene*, *105*(6), 1510. https://doi.org/10.4269/ajtmh.21-0899

BeLue, R. (2017). The role of family in non-communicable disease prevention in Sub-Saharan Africa. *Global health promotion*, *24*(3), 71-74. https://doi.org/10.1177/1757975915614190

Berger, M. C., & Messer, J. (2002). Public financing of health expenditures, insurance, and health outcomes. *Applied Economics*, *34*(17), 2105-2113. https://doi.org/10.1080/00036840210135665

Bergonzoli, G., Castellanos, L. G., Rodríguez, R., & Garcia, L. M. (2016). Determinants of tuberculosis in countries of Latin America and the Caribbean. *Pan American journal of public health*, *39*, 101-105. https://www.scielosp.org/pdf/rpsp/2016.v39n2/101-105/en
https://www.scielosp.org/pdf/rpsp/2016.v39n2/101-105/en

Bernet, P. M., Gumus, G., & Vishwasrao, S. (2018). Effectiveness of public health spending on infant mortality in Florida, 2001–2014. *Social Science & Medicine*, *211*, 31-38. https://doi.org/10.1016/j.socscimed.2018.05.044

Bersch, K., & Botero, S. (2014). Measuring governance: Implications of conceptual choices. *The European Journal of Development Research*, *26*(1), 124-141. https://doi.org/10.1057/ejdr.2013.49

Bhat, N. A., & Kaur, S. (2022). Technical Efficiency Analysis of Indian IT Industry: A Panel Data Stochastic Frontier Approach. *Millennial Asia*, 09763996221082199. https://doi.org/10.1177/0976399622108

Bhutta, Z. A., Das, J. K., Walker, N., Rizvi, A., Campbell, H., Rudan, I., & Black, R. E. (2013). Interventions to address deaths from childhood pneumonia and diarrhoea equitably: what works and at what cost? *The lancet*, *381*(9875), 1417-1429. https://doi.org/Interventions to address deaths from childhood pneumonia and diarrhoea equitably: what works and at what cost?

Bloom, D. E., & Canning, D. (2008). Population health and economic growth. *Health and growth*, *53*. http://hdl.handle.net/10986/28036 http://hdl.handle.net/10986/28036

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, *87*(1), 115-143. https://doi.org/10.1016/S0304-4076(98)00009-8

Boachie, M. K., Ramu, K., & Põlajeva, T. (2018). Public health expenditures and health outcomes: New evidence from Ghana. *Economies*, *6*(4), 58. https://doi.org/10.3390/economies6040058

Bognini, J. D., Samadoulougou, S., Ouedraogo, M., Smart, F., Kankoye, D. T., Sankoh, O., & Kirakoya-Samadoulougou, F. (2022). What are the trends in seeking health care for fever in children under-five in Sierra Leone? evidence from four population-based studies before and after the free health care initiative. *PloS one*, *17*(2), e0263364. https://doi.org/10.1371/journal.pone.0263364

Bollen, K. A., & Curran, P. J. (2006). *Latent curve models: A structural equation perspective*. John Wiley & Sons. https://doi.org/10.1002/0471746096 ISBN 0471746088

Bongaarts, J. (2016). *World Health Organization Health in 2015: From MDGs, Millennium Development Goals, to SDGs, Sustainable Development Goals Geneva: WHO Press, 2016. 212 p. $60.00 (pbk.)*. Wiley Online Library. https://doi.org/https://doi.org/10.1111/padr.12006

Boundioa, J., & Thiombiano, N. (2023). Threshold effect of governance quality in the relationship between public health expenditure and life expectancy at birth in the West African Economic and Monetary Union. https://doi.org/doi.org/10.21203/rs.3.rs-3280225/v1

Brikci, N. (2023). Innovative domestic financing mechanisms for health in Africa: An evidence review. *Journal of Health Services Research & Policy*, 13558196231181081. https://doi.org/10.1177/13558196231181

Budhdeo, S., Watkins, J., Atun, R., Williams, C., Zeltner, T., & Maruthappu, M. (2015). Changes in government spending on healthcare and population mortality in the European union, 1995–2010: a cross-sectional ecological study. *Journal of the*

Royal Society of Medicine, *108*(12), 490-498. https://doi.org/10.1177/0141076815600

Byaro, M. (2021). Commentary: on the effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis. *Health economics review*, *11*, 1-3. https://doi.org/10.1186/s13561-021-00310-6

Byaro, M., Mayaya, H., & Pelizzo, R. (2022). Sustainable Development Goals for Sub-Saharan Africans' by 2030: A Pathway to Longer Life Expectancy via Higher Health-Care Spending and Low Disease Burdens. *African Journal of Economic Review*, *10*(2), 73-87. https://doi.org/10.22004/ag.econ.320582

Cashin, C., Sparkes, S., & Bloom, D. (2017). *Earmarking for health: from theory to practice* (9241512202). https://portal-uat.who.int/fctcapps/sites/default/files/kh-media/e-library-doc/2020/07/earmarking-for-health-from-theory-to-practice.pdf

Castillo-Zunino, F., Keskinocak, P., Nazzal, D., & Freeman, M. C. (2021). Health spending and vaccination coverage in low-income countries. *BMJ global health*, *6*(5), e004823. https://doi.org/10.1101/2020.11.10.20229245

Chansa, C., Yoo, K. J., Nkhoma, D., Piatti, M., Ally, M., Kuguru, T. L., Borrazzo, J., Hettinger, P., Zamawe, C. O. F., & Schneider, P. (2020). *Public Spending In Health Sector in Malawi*. https://openknowledge.worldbank.org/server/api/core/bitstreams/f6697750-f07e-5ce6-b8b1-d1cfe79513fb/content

Cheong, J., MacKinnon, D. P., & Khoo, S. T. (2003). Investigation of mediational processes using parallel process latent growth curve modeling. *Structural equation modeling*, *10*(2), 238-262. https://doi.org/10.1207/S15328007SEM1002_5

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. In G. A. Marcoulides (Ed.), *Modern methods for business research* (pp. 295-336). Lawrence Erlbaum Associates Publishers.

Chin, W. W., Marcolin, B. L., & Newsted, P. R. (2003). A partial least squares latent variable modeling approach for measuring interaction effects: Results from a Monte Carlo simulation study and an electronic-mail emotion/adoption study. *Information systems research*, *14*(2), 189-217. https://doi.org/10.1287/isre.14.2.189.16018

Chireshe, J., & Ocran, M. K. (2020). Health care expenditure and health outcomes in sub-Saharan African countries. *African Development Review*, *32*(3), 349-361. https://doi.org/10.1111/1467-8268.12444

Clarke, S. E., Jukes, M. C., Njagi, J. K., Khasakhala, L., Cundill, B., Otido, J., Crudder, C., Estambale, B. B., & Brooker, S. (2008). Effect of intermittent preventive treatment of malaria on health and education in schoolchildren: a cluster-randomised, double-blind, placebo-controlled trial. *The lancet*, *372*(9633), 127-138. https://doi.org/10.1016/S0140-6736(08)61034-X

Claxton, K., Martin, S., Soares, M., Rice, N., Spackman, E., Hinde, S., Devlin, N., Smith, P. C., & Sculpher, M. (2015). Methods for the estimation of the National Institute for Health and Care Excellence cost-effectiveness threshold. *Health Technology Assessment (Winchester, England)*, *19*(14), 1. https://doi.org/10.3310/hta19140

Culyer, T., & Maynard, A. K. (1997). *Being reasonable about the economics of health: selected essays by Alan Williams*. Edward Elgar Publishing. ISBN 978-1858986487

Daoud, A. (2020). The wealth of nations and the health of populations: A quasi-experimental design of the impact of sovereign debt crises on child mortality. *arXiv preprint arXiv:2012.14941*. https://doi.org/10.48550/arXiv.2012.14941

De Figueiredo, A., Johnston, I. G., Smith, D. M., Agarwal, S., Larson, H. J., & Jones, N. S. (2016). Forecasted trends in vaccination coverage and correlations with socioeconomic factors: a global time-series analysis over 30 years. *The Lancet Global Health*, *4*(10), e726-e735. https://doi.org/10.1016/S2214-109X(16)30167-X

Dhimal, M., Chirico, F., Bista, B., Sharma, S., Chalise, B., Dhimal, M. L., Ilesanmi, O. S., Trucillo, P., & Sofia, D. (2021). Impact of air pollution on global burden of disease in 2019. *Processes*, *9*(10), 1719. https://doi.org/10.3390/pr9101719

Dhrifi, A., Alnahdi, S., & Jaziri, R. (2021). The causal links among economic growth, education and health: Evidence from developed and developing countries. *Journal of the Knowledge Economy*, *12*, 1477-1493. https://doi.org/10.1007/s13132-020-00678-6

Dicker, D., Nguyen, G., Abate, D., Abate, K. H., Abay, S. M., Abbafati, C., Abbasi, N., Abbastabar, H., Abd-Allah, F., & Abdela, J. (2018). Global, regional, and national age-sex-specific mortality and life expectancy, 1950–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The lancet*, *392*(10159), 1684-1735. https://doi.org/10.1016/S0140-6736(18)31891-9

Dieleman, J. L., Yamey, G., Johnson, E. K., Graves, C. M., Haakenstad, A., & Meara, J. G. (2015). Tracking global expenditures on surgery: gaps in knowledge hinder progress. *The Lancet Global Health*, *3*, S2-S4. https://doi.org/10.1016/S2214-109X(15)70075-6

Diyoke, K. (2019). Impact of HIV/AIDS Burden on Economic Growth in Selected Sub Saharan Africa (SSA) Countries: Evidence from a Dynamic System GMM Estimates. *AIDS Burden on Economic Growth in Selected Sub Saharan Africa (SSA) Countries: Evidence from a Dynamic System GMM Estimates*. https://ssrn.com/abstract=4228402 https://ssrn.com/abstract=4228402

Doucouliagos, C., Hennessy, J., & Mallick, D. (2021). Health aid, governance and infant mortality. *Journal of the Royal Statistical Society Series A: Statistics in Society*, *184*(2), 761-783. https://doi.org/doi.org/10.1111/rssa.12679

Dzingirai, M. (2023). Health Financing Challenges Towards Accomplishment of Sustainable Development Goals. In *Handbook of Research on Quality and Competitiveness in the Healthcare Services Sector* (pp. 63-83). IGI Global. https://doi.org/10.4018/978-1-6684-8103-5.ch004

Ekirapa-Kiracho, E., Ssennyonjo, A., Cashin, C., Gatome-Munyua, A., Olalere, N., Ssempala, R., Mayora, C., & Ssengooba, F. (2022). Strategic purchasing arrangements in Uganda and their implications for universal health coverage.

Health Systems & Reform, *8*(2), 2084215. https://doi.org/10.1080/23288604.2022.2084215

Erdiaw-Kwasie, M. O., Abunyewah, M., Yusif, S., & Erdiaw-Kwasie, A. (2023). Does circular economy knowledge matter in sustainable service provision? A moderation analysis. *Journal of Cleaner Production*, *383*, 135429. https://doi.org/10.1016/j.jclepro.2022.135429

Erena, O. T., Kalko, M. M., & Debele, S. A. (2021). Technical efficiency, technological progress and productivity growth of large and medium manufacturing industries in Ethiopia: A data envelopment analysis. *Cogent Economics & Finance*, *9*(1), 1997160. https://doi.org/10.1080/23322039.2021.1997160

Etches, V., Frank, J., Ruggiero, E. D., & Manuel, D. (2006). Measuring population health: a review of indicators. *Annu. Rev. Public Health*, *27*, 29-55. https://doi.org/10.1146/annurev.publhealth.27.021405.102141

Evans, T. G. (1994). *Why are some people healthy and others not? The determinants of health of populations*. Berlin, Boston: De Gruyter. https://doi.org/10.1515/9783112421628

Eze, P., Lawani, L. O., Agu, U. J., Amara, L. U., Okorie, C. A., & Acharya, Y. (2022). Factors associated with catastrophic health expenditure in sub-Saharan Africa: A systematic review. *PloS one*, *17*(10), e0276266. https://doi.org/10.1371/journal.pone.0276266

Fayissa, B., & Gutema, P. (2008). A health production function for Sub-Saharan Africa (SSA). *Department of Economics and Finance Working Paper Series*.

http://capone.mtsu.edu/berc/working/health.pdf
http://capone.mtsu.edu/berc/working/health.pdf

Filmer, D., & Pritchett, L. (1999). The impact of public spending on health: does money matter? *Social Science & Medicine*, *49*(10), 1309-1323. https://doi.org/10.1016/S0277-9536(99)00150-1

Folland, S., Goodman, A. C., & Stano, M. (2016). *The economics of health and health care: Pearson new international edition*. Routledge. ISBN 9781138208049

Frank, O., & Mcineka, T. T. (2021). Health Financing and Health Outcomes in Sub-Saharan Africa: A PLS-SEM Application. *Elementary Education Online*, *20*(4), 1251-1251. https://doi.org/10.17051/ilkonline.2021.04.142

Frimpong, A. O., Amporfu, E., & Arthur, E. (2022). Effects of public and external health spending on out-of-pocket payments for healthcare in sub-Saharan Africa. *Health Policy and Planning*, *37*(9), 1129-1137.

Galadima, A. N., Zulkefli, N. A. M., Said, S. M., & Ahmad, N. (2021). Factors influencing childhood immunisation uptake in Africa: a systematic review. *BMC public health*, *21*(1), 1-20. https://doi.org/10.1186/s12889-021-11466-5

Galjour, J., Havik, P., Aaby, P., Rodrigues, A., & Mpinga, E. K. (2021). Chronic political instability and the HIV/AIDS response in Guinea-Bissau from 2000 to 2015: a systematic review. *Tropical medicine and infectious disease*, *6*(1), 36. https://doi.org/10.3390/tropicalmed6010036

Gao, C., Shi, D., & Maydeu-Olivares, A. (2020). Estimating the maximum likelihood root mean square error of approximation (RMSEA) with non-normal data: A Monte-

Carlo study. *Structural equation modeling: a multidisciplinary journal*, *27*(2), 192-201. https://doi.org/10.1080/10705511.2019.1637741

Gardner, R. G., Harris, T. B., Li, N., Kirkman, B. L., & Mathieu, J. E. (2017). Understanding "it depends" in organizational research: A theory-based taxonomy, review, and future research agenda concerning interactive and quadratic relationships. *Organizational Research Methods*, *20*(4), 610-638. https://doi.org/10.1177/1094428117708856

Gatome-Munyua, A., Sieleunou, I., Sory, O., & Cashin, C. (2022). Why is strategic purchasing critical for universal health coverage in sub-Saharan Africa? *Health Systems & Reform*, *8*(2), e2051795. https://doi.org/Why is strategic purchasing critical for universal health coverage in sub-Saharan Africa?

Gebeyehu, D. T., East, L., Wark, S., & Islam, M. S. (2022). Disability-adjusted life years (DALYs) based COVID-19 health impact assessment: A systematic review protocol. *PloS one*, *17*(9), e0274468. https://doi.org/10.1186/s12889-023-15239-0

Gechert, S. (2017). On theories and estimation techniques of fiscal multipliers. http://hdl.handle.net/10419/181469 http://hdl.handle.net/10419/181469

Girum, T., Shumbej, T., & Shewangizaw, M. (2019). Burden of malaria in Ethiopia, 2000-2016: findings from the Global Health Estimates 2016. *Tropical Diseases, Travel Medicine and Vaccines*, *5*(1), 1-7. https://doi.org/10.1186/s40794-019-0090-z

Global Burden of Disease Collaborative Network. (2015). *Global Burden of Disease Study 2015 (GBD 2015) Life Expectancy, All-Cause and Cause-Specific Mortality 1980-*

2015. Seattle, United States of America: Institute for Health Metrics and Evaluation (IHME). https://ghdx.healthdata.org

Global Fund. (n.d.). *Strategic Initiatives*. https://www.theglobalfund.org/en/applying-for-funding/sources-of-funding/strategic-initiatives/

Gold, M. R., & Field, M. J. (1998). *Summarizing population health: directions for the development and application of population metrics*. ISBN 0-309-06099-0

Gold, M. R., Stevenson, D., & Fryback, D. G. (2002). HALYS and QALYS and DALYS, Oh My: similarities and differences in summary measures of population Health. *Annual review of public health*, *23*(1), 115-134. https://doi.org/10.1146/annurev.publhealth.23.100901.140513

Gold, P., & John, U. (2013). Accelerating empowerment for sustainable development: the need for health systems strengthening in sub-Saharan Africa. *Am J Public Health Res*, *1*(7), 152-158. https://doi.org/10.12691/ajphr-1-7-2

Grekou, C., & Perez, R. (2014). Child Mortality in Sub–Saharan Africa: Why Public Health Spending Matters. *EconomiX–CNRS, Université Paris Ouest–Nanterre La Défense Working Paper. Nanterre: Université Paris Ouest*.

Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political economy*, *80*(2), 223-255. https://www.jstor.org/stable/1830580 https://www.jstor.org/stable/1830580

Hair Jr, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)*. Sage publications. ISBN 1544396333

Hair Jr, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., Ray, S., Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2021). *Moderation analysis*. Springer Cham. ISBN 978-3-030-80519-7

Hart, R. A., & Clark, D. H. (1999). Does size matter? Exploring the small sample properties of maximum likelihood estimation. Annual Meeting of the Midwest Political Science Association,

Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York, NY : The Guilford Press. ISBN LCCN 2021031108

Health Canada. (1998). *Taking Action on Population Health.* . Health Canada, Ottawa, Ontario. https://publications.gc.ca/collections/Collection/H88-3-30-2001/pdfs/other/taph_e.pdf

Henseler, J., & Chin, W. W. (2010). A comparison of approaches for the analysis of interaction effects between latent variables using partial least squares path modeling. *Structural equation modeling*, *17*(1), 82-109. https://doi.org/doi.org/10.1080/10705510903439003

Henseler, J., & Fassott, G. (2010). Testing moderating effects in PLS path models: An illustration of available procedures. In *Handbook of partial least squares* (pp. 713-735). Springer. https://doi.org/https://doi.org/10.1007/978-3-540-32827-8

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the* *academy of marketing science*, *43*(1), 115-135. https://doi.org/10.1007/s11747-014-0403-8

Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The use of partial least squares path modeling in international marketing. In *New challenges to international marketing*. Emerald Group Publishing Limited. https://doi.org/10.1108/S1474-7979(2009)0000020014

Hilaire, H. G. (2015). On the relationship between public health spending, governance and health outcomes: Evidence from Africa countries. *Revue d'Economie Théorique et Appliquée*, *1840*, 7277. http://bec.uac.bj/uploads/publication/8fb243e85aa799a88dd729764c1ea91a.pdf
http://bec.uac.bj/uploads/publication/8fb243e85aa799a88dd729764c1ea91a.pdf
Hillermann, L. (2022). The Continuum of Care for the Neonate: A Critical Review. *African Journal of Inter/Multidisciplinary Studies*, *4*(1), 100-111. https://doi.org/10.51415/ajims.v4i1.971

Hipp, J. R., & Bauer, D. J. (2006). Local solutions in the estimation of growth mixture models. *Psychological methods*, *11*(1), 36. https://doi.org/10.1037/1082-989X.11.1.36

Hjalte, F., & Glenngard, A. (2007). *What Factors Determine the Demand for Health Expenditure Data in Sub-Saharan Africa?* https://www.sida.se/

Hodson, T. O. (2022). Root-mean-square error (RMSE) or mean absolute error (MAE): When to use them or not. *Geoscientific Model Development*, *15*(14), 5481-5487. https://doi.org/10.5194/gmd-15-5481-2022

Hsu, Y.-C. (2013). The efficiency of government spending on health: Evidence from Europe and Central Asia. *The Social Science Journal*, *50*(4), 665-673. https://doi.org/10.1016/j.soscij.2013.09.005

Hung-pin, L., & Kumbhakar, S. C. (2022). Panel stochastic frontier model with endogenous inputs and correlated random components. *Journal of Business & Economic Statistics*, *41*(1), 80-96. https://doi.org/10.1080/07350015.2021.2001341

Hunt, D. J., & Link, C. R. (2020). Better outcomes at lower costs? The effect of public health expenditures on hospital efficiency. *Applied Economics*, *52*(4), 400-414. https://doi.org/10.1080/00036846.2019.1646405

Iacobucci, D., Schneider, M. J., Popovich, D. L., & Bakamitsos, G. A. (2016). Mean centering helps alleviate “micro” but not “macro” multicollinearity. *Behavior research methods*, *48*(4), 1308-1317. https://doi.org/10.3758/s13428-015-0624-x

IBM SPSS. (2019). *IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0.* . Armonk, NY: IBM® Corporation https://www.ibm.com/spss

Ibrahim, M. D., Daneshvar, S., Hocaoğlu, M. B., & Oluseye, O.-W. G. (2019). An estimation of the efficiency and productivity of healthcare systems in sub-Saharan Africa: health-centred millennium development goal-based evidence. *Social Indicators Research*, *143*(1), 371-389. https://doi.org/10.1007/s11205-018-1969-1

Ibukun, C. O. (2021). The role of governance in the health expenditure–health outcomes nexus: insights from West Africa. *International Journal of Social Economics*, *48*(4), 557-570. https://doi.org/10.1108/IJSE-06-2020-0404

Igartua, J.-J., & Hayes, A. F. (2021). Mediation, moderation, and conditional process analysis: Concepts, computations, and some common confusions. *The Spanish Journal of Psychology*, *24*, e49. https://doi.org/10.1017/SJP.2021.46

IHME, Institute For Health Metrics and Evaluation,. (2022). *Global Burden of Disease Study 2022 Data Input Sources Tool | GHDx*. Institute for Health Metrics Evaluation. http://ghdx.healthdata.org/gbd-2019/data-input-sources

Issa, M. (2023). The Pathway to Achieving Universal Health Coverage in the Democratic Republic of Congo: Obstacles and Prospects. *Cureus*, *15*(7), e41935. https://doi.org/10.7759/cureus.41935

Ithibu, A., & Amendah, D. (2019). Domestic financing for HIV, TB and malaria in Global Fund High Impact Asia countries. https://aidspan.org/download/domestic-financing-for-hiv-tb-and-malaria-in-global-fund-high-impact-asia-countries-2/# https://aidspan.org/download/domestic-financing-for-hiv-tb-and-malaria-in-global-fund-high-impact-asia-countries-2/#

Jagger, C., Crimmins, E. M., Saito, Y., Yokota, R. T. D. C., Van Oyen, H., & Robine, J.-M. (2020). *International handbook of health expectancies* (Vol. 9). Springer. https://doi.org/10.1007/978-3-030-37668-0

Jha, A., Kickbusch, I., Taylor, P., & Abbasi, K. (2016). Accelerating achievement of the sustainable development goals. *352*, i409. https://doi.org/10.1136/bmj.i409

Jo, M.-W., Go, D.-S., Kim, R., Lee, S. W., Ock, M., Kim, Y.-E., Oh, I.-H., Yoon, S.-J., & Park, H. (2020). The burden of disease due to covid-19 in korea using disability-adjusted life years. *Journal of Korean medical science*, *35*(21). https://doi.org/10.3346/jkms.2020.35.e199

Jordi, E., Pley, C., Jowett, M., Abou Jaoude, G. J., & Haghparast-Bidgoli, H. (2020). Assessing the efficiency of countries in making progress towards universal health coverage: a data envelopment analysis of 172 countries. *BMJ global health*, *5*(10), e002992. https://doi.org/10.1136/bmjgh-2020-002992

Jowett, M., Brunal, M. P., Flores, G., & Cylus, J. (2016). *Spending targets for health: no magic number*. World Health Organization. https://apps.who.int/iris/handle/10665/250048

Kaffenberger, M., Pritchett, L., & Sandefur, J. (2018). Estimating the impact of women's education on fertility, child mortality, and empowerment when schooling ain't learning'. *línea], disponible en: https://www. hks. harvard. edu/publications/estimating-impact-womens-education-fertility-child-mortality-and-empowermentwhen, consultado el*, *10*. https://www.riseprogramme.org/sites/www.riseprogramme.org/files/publications/Kaffenberger.pdf https://www.riseprogramme.org/sites/www.riseprogramme.org/files/publications/Kaffenberger.pdf

Kamiya, Y. (2010). Determinants of health in developing countries: Cross-country evidence. *No 10E009, OSIPP Discussion Paper, Osaka School of International Public Policy, Osaka University*. https://www.osipp.osaka-u.ac.jp/archives/DP/2010/DP2010E009.pdf

Karakaplan, M. (2018). *xtsfkk: Stata Module for Endogenous Panel Stochastic Frontier Models*. Retrieved 53 from Boston College, Department of Economics, Statistical Software Components (SSC) S458445

Karakaplan, M. U. (2022). Panel stochastic frontier models with endogeneity. *The Stata Journal*, *22*(3), 643-663. https://doi.org/10.1177/1536867X221124539

Kaufmann, D., & Kraay, A. (2008). Governance indicators: where are we, where should we be going? *The World Bank Research Observer*, *23*(1), 1-30. https://mpra.ub.uni-muenchen.de/8212/1/MPRA_paper_8212.pdf https://mpra.ub.uni-muenchen.de/8212/1/MPRA_paper_8212.pdf

Kaufmann, D., & Kraay, A. (2022). *Worldwide Governance Indicators, 2022* World Bank Group. http://www.govindicators.org/

Kennedy, P. (2008). *A guide to econometrics, 4th Edition*. MIT Press. ISBN 9780585202037

Kenny, D. A., & Milan, S. (2012). Identification: A non-technical discussion of a technical issue. In *Handbook of structural equation modeling* (pp. 145-163). The Guilford Press.

Khan, M. S., Meghani, A., Liverani, M., Roychowdhury, I., & Parkhurst, J. (2018). How do external donors influence national health policy processes? Experiences of domestic policy actors in Cambodia and Pakistan. *Health Policy and Planning*, *33*(2), 215-223. https://doi.org/ 10.1093/heapol/czx145

Kim, S., & Wang, J. (2019). Does quality of government matter in public health?: comparing the role of quality and quantity of government at the National Level. *Sustainability*, *11*(11), 3229. https://doi.org/10.3390/su11113229

Kindig, D., & Stoddart, G. (2003). What is population health? *American journal of public health*, *93*(3), 380-383. https://doi.org/10.2105/ajph.93.3.380

King, N., Dewey, C., & Borish, D. (2015). Determinants of primary school non-enrollment and absenteeism: results from a retrospective, convergent mixed methods, cohort study in rural Western Kenya. *PloS one*, *10*(9), e0138362. https://doi.org/10.1371/journal.pone.0138362

Kioko, U. M., Mwabu, G., & Kimuyu, P. (2013). The economic impact of malaria on wage earnings in Kenya: a household level investigation. *Int J Educ Res*, *1*(4). http://hdl.handle.net/11295/39535 http://hdl.handle.net/11295/39535

Kiross, G. T., Chojenta, C., Barker, D., & Loxton, D. (2020). The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis. *Health economics review*, *10*(1), 1-9. https://doi.org/10.1186/s13561-020-00262-3

Kiviet, J. F., & Kripfganz, S. (2021). Instrument approval by the Sargan test and its consequences for coefficient estimation. *Economics Letters*, *205*, 109935. https://doi.org/10.1016/j.econlet.2021.109935

Kreuter, M., & Lezin, N. (2001). *Improving everyone's quality of life: a primer on population health*. Group Health Community Foundation, Seattle.

https://www.yumpu.com/en/document/view/4911039/improving-everyones-quality-of-life-center-for-community-health-

Kripfganz, S. (2021). XTDPDGMM: Stata module to perform generalized method of moments estimation of linear dynamic panel data models. . *EconPapers, Economics at your fingers*. https://EconPapers.repec.org/RePEc:boc:bocode:s458395 https://EconPapers.repec.org/RePEc:boc:bocode:s458395

Kyu, H. H., Abate, D., Abate, K. H., Abay, S. M., Abbafati, C., Abbasi, N., Abbastabar, H., Abd-Allah, F., Abdela, J., & Abdelalim, A. (2018). Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The lancet*, *392*(10159), 1859-1922. https://doi.org/10.1016/S0140-6736(18)32335-3

Langnel, Z., & Buracom, P. (2020). Governance, health expenditure and infant mortality in sub-Saharan Africa. *African Development Review*, *32*(4), 673-685. https://doi.org/10.1111/1467-8268.12470

Lawal, S. A., Henderson, D., & Ogunniyi, A. (2022). Revisiting the need to strengthen health systems in Africa for better mental health care delivery. *Nigerian Health Journal*, *22*(2), 225-243. http://orcid.org/0000-0002-0344-311X http://orcid.org/0000-0002-0344-311X

Lawanson, O. I., & Umar, D. I. (2021). The life expectancy–economic growth nexus in Nigeria: the role of poverty reduction. *SN business & economics*, *1*, 1-26. https://doi.org/doi.org/10.1007/s43546-021-00119-9

Le Blanc, D. (2015). Towards integration at last? The sustainable development goals as a network of targets. *Sustainable Development*, *23*(3), 176-187. https://doi.org/10.1002/sd.1582

Lera-Lopez, F., Wicker, P., & Downward, P. (2016). Does government spending help to promote healthy behavior in the population? Evidence from 27 European countries. *Journal of Public Health*, *38*(2), e5-e12. https://doi.org/10.1093/pubmed/fdv071

LeRoux, K. (2009). Paternalistic or participatory governance? Examining opportunities for client participation in nonprofit social service organizations. *Public Administration Review*, *69*(3), 504-517. https://doi.org/10.1111/j.1540-6210.2009.01996.x

Leszczensky, L., & Wolbring, T. (2022). How to deal with reverse causality using panel data? Recommendations for researchers based on a simulation study. *Sociological methods & research*, *51*(2), 837-865. https://doi.org/10.1177/00491241198824

Lim, S., Pintye, J., Seong, H., & Bekemeier, B. (2022). Estimating the Association Between Public Health Spending and Sexually Transmitted Disease Rates in the United States: A Systematic Review. *Sexually Transmitted Diseases*, *49*(7), 462-468. https://doi.org/10.1097/OLQ.0000000000001627

Lin, W., & Wooldridge, J. M. (2019). Testing and correcting for endogeneity in nonlinear unobserved effects models. In *Panel data econometrics* (pp. 21-43). Elsevier. https://doi.org/10.1016/B978-0-12-814367-4.00002-2

Linden, M., & Ray, D. (2017). Life expectancy effects of public and private health expenditures in OECD countries 1970–2012: Panel time series approach. *Economic Analysis and Policy*, *56*, 101-113. https://doi.org/10.1016/j.eap.2017.06.005

Lindskog, A., & Durevall, D. (2021). To educate a woman and to educate a man: Gender-specific sexual behavior and human immunodeficiency virus responses to an education reform in Botswana. *Health economics*, *30*(3), 642-658. https://doi.org/10.1002/hec.4212

Liu, H., & Yuan, K.-H. (2021). New measures of effect size in moderation analysis. *Psychological methods*, *26*(6), 680. https://doi.org/10.1037/met0000371

Liu, J., Han, Z., Veuthey, J., & Ma, B. (2020). How investment in public health has impacted the prevalence of tuberculosis in China: A study of provincial variations between 2005 and 2015. *The International Journal of Health Planning and Management*, *35*(6), 1546-1558. https://doi.org/10.1002/hpm.3034

Liu, L. C., & Flay, B. R. (2009). Evaluating mediation in longitudinal multivariate data: Mediation effects for the Aban Aya Youth Project drug prevention program. *Prevention Science*, *10*(3), 197-207. https://doi.org/10.1007/s11121-009-0125-1

Longfield, K., Smith, B., Gray, R., Ngamkitpaiboon, L., & Vielot, N. (2013). Putting health metrics into practice: using the disability-adjusted life year for strategic decision making. *BMC public health*, *13*(2), 1-13. https://doi.org/10.1186/1471-2458-13-S2-S2

Lopez, A. D., Mathers, C. D., Ezzati, M., Jamison, D. T., & Murray, C. J. (2006). Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *The lancet*, *367*(9524), 1747-1757. https://doi.org/10.1016/S0140-6736(06)68770-9

López, A. D., Murray, C. J., & WHO. (1994). *Global comparative assessments in the health sectordisease burden, expenditures and intervention packages*. ISBN 9241561750

Maele, N. V., Xu, K., Soucat, A., Fleisher, L., Aranguren, M., & Wang, H. (2019). Measuring primary healthcare expenditure in low-income and lower middle-income countries. *BMJ global health*, *4*(1), e001497. https://doi.org/10.1136/bmjgh-2019-001497

Makuta, I., & O'Hare, B. (2015). Quality of governance, public spending on health and health status in Sub Saharan Africa: a panel data regression analysis. *BMC public health*, *15*(1), 932. https://doi.org/10.1186/s12889-015-2287-z

Mallaye, D., & Yogo, T. U. (2018). Health Aid and Child Mortality in Developing Countries: Accounting for Transmission Mechanisms. *Working Papers, African Economic Research Consortium*. https://EconPapers.repec.org/RePEc:aer:wpaper:349 https://EconPapers.repec.org/RePEc:aer:wpaper:349

Martinez, R., Morsch, P., Soliz, P., Hommes, C., Ordunez, P., & Vega, E. (2021). Life expectancy, healthy life expectancy, and burden of disease in older people in the

Americas, 1990–2019: a population-based study. *Revista Panamericana de Salud Pública*, *45*. https://doi.org/10.26633/RPSP.2021.114

Mays, G. P., & Smith, S. A. (2011). Evidence links increases in public health spending to declines in preventable deaths. *Health affairs*, *30*(8), 1585-1593. https://doi.org/10.1377/hlthaff.2011.0196

Meheus, F., & McIntyre, D. (2017). Fiscal space for domestic funding of health and other social services. *Health Economics, Policy and Law*, *12*(2), 159-177. https://doi.org/10.1017/S1744133116000438

Memon, M. A., Cheah, J.-H., Ramayah, T., Ting, H., Chuah, F., & Cham, T. H. (2019). Moderation analysis: issues and guidelines. *Journal of Applied Structural Equation Modeling*, *3*(1), 1-11. https://doi.org/10.47263/JASEM.3(1)01

Memon, M. A., Ting, H., Cheah, J.-H., Thurasamy, R., Chuah, F., & Cham, T. H. (2020). Sample Size for Survey Research: Review and recommendations. *Journal of Applied Structural Equation Modeling*, *4*(2), i-xx. https://doi.org/10.47263/JASEM.4(2)01

Mendenhall, E. (2017). Syndemics: a new path for global health research. *The lancet*, *389*(10072), 889-891. https://doi.org/10.1016/S0140-6736(17)30602-5

Micah, A. E., Chen, C. S., Zlavog, B. S., Hashimi, G., Chapin, A., & Dieleman, J. L. (2019). Trends and drivers of government health spending in sub-Saharan Africa, 1995–2015. *BMJ global health*, *4*(1), e001159. https://doi.org/10.1136/bmjgh-2018-001159

Miles, J. (2015). Tolerance and variance inflation factor. *Wiley statsref: statistics reference online*. https://doi.org/10.1002/9781118445112.stat06593

Mirowsky, J., & Ross, C. E. (2017). *Education, social status, and health*. Routledge. ISBN 1351328085

Montes, J., Silwal, A., Newhouse, D., Chen, F., Swindle, R., & Tian, S. (2020). *How Much Will Poverty Rise in Sub-Saharan Africa in 2020?* (Vol. 20). World Bank Group. **https://openknowledge.worldbank.org/server/api/core/bitstreams/f8b6ad68-64b2-531c-99f4-80de3b3c331f/content**

Moya-Clemente, I., Ribes-Giner, G., & Pantoja-Díaz, O. (2020). Identifying environmental and economic development factors in sustainable entrepreneurship over time by partial least squares (PLS). *PloS one*, *15*(9), e0238462. https://doi.org/10.1371/journal.pone.0238462

Mshida, H., Malima, G., Machunda, R., Muzuka, A. N., Banzi, J., Gautam, O. P., Mbeguere, M., Smith, K., Cairncross, S., & Shana, E. S. (2020). Sanitation and hygiene practices in small towns in Tanzania: the case of Babati District, Manyara Region. *The American journal of tropical medicine and hygiene*, *103*(4), 1726. https://doi.org/10.4269/ajtmh.19-0551

Munteh, P., & Fonchin, A. (2020). Public health expenditure and child mortality rate as determinants of full immunization coverage and poverty rates in Cameroons. *ARC J Clin Case Rep*, *6*(1), 17-30. https://doi.org/10.2147/CEOR.S380900

Murphy, K. R., & Aguinis, H. (2022). Reporting Interaction Effects: Visualization, Effect Size, and Interpretation. *48*(8). https://doi.org/10.1177/01492063221088516

Murray, C. J., Salomon, J. A., & Mathers, C. (2000). A critical examination of summary measures of population health. *Bulletin of the world Health Organization*, *78*, 981-994. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2560826/pdf/10994282.pdf https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2560826/pdf/10994282.pdf

Mustapha, R. A., Onikosi-Alliyu, S. O., & Babalola, A. (2021). Impact of Government Health Expenditure on Health Outcomes in the West African Sub-Region. *Folia Oeconomica Stetinensia*, *21*(1), 48-59. https://doi.org/10.2478/foli-2021-0004

Muthén, L., & Muthén, B. (2017). *Mplus: Statistical Analysis with Latent Variables: User's Guide (Version 7)*. Los Angeles, CA: Authors.

Mwamkonko, M. A. (2021). Can Governments Enhance Long-run Growth by Reallocating Public Expenditure? Empirical Evidence from Tanzania. *African Journal of Economic Review*, *9*(2), 238-256. https://www.ajol.info/index.php/ajer/article/view/206478/194701 https://www.ajol.info/index.php/ajer/article/view/206478/194701

Nafziger, E. W., & Yoder, J. C. (2021). The economics of development. *Mennonites and Post-Colonial African Studies*, *397*(99), 114-127. https://doi.org/10.1108/01443589510086998

Naher, N., Hoque, R., Hassan, M. S., Balabanova, D., Adams, A. M., & Ahmed, S. M. (2020). The influence of corruption and governance in the delivery of frontline health care services in the public sector: A scoping review of current and future prospects in low and middle-income countries of south and south-east Asia. *BMC public health*, *20*, 1-16. https://doi.org/10.1186/s12889-020-08975-0

Nam, H.-J., & Ryu, D. (2023). FDI and human development: The role of governance, ODA, and national competitiveness. *Journal of International Financial Markets, Institutions and Money*, *85*, 101769. https://doi.org/10.1016/j.intfin.2023.101769

Nankabirwa, J., Wandera, B., Kiwanuka, N., Staedke, S. G., Kamya, M. R., & Brooker, S. J. (2013). Asymptomatic Plasmodium infection and cognition among primary schoolchildren in a high malaria transmission setting in Uganda. *The American journal of tropical medicine and hygiene*, *88*(6), 1102. https://doi.org/10.4269/ajtmh.12-0633

National Academies of Sciences, E., & Medicine. (2018). The critical health impacts of corruption. In *Crossing the global quality chasm: improving health care worldwide*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK535646/

Nicholas, A., Edward, N.-A., & Bernardin, S. (2016). The effect of health expenditure on selected maternal and child health outcomes in Sub-Saharan Africa. *International Journal of Social Economics*, *43*(12), 1386-1399. https://doi.org/10.1108/IJSE-08-2015-0199

Nketiah-Amponsah, E. (2019). The Impact of Health Expenditures on Health Outcomes in Sub-Saharan Africa. *Journal of Developing Societies*, *35*(1), 134-152.

Nolte, E., & McKee, M. (2004). *Does health care save lives? Avoidable mortality revisited*. The Nuffield Trust, London, England. https://researchonline.lshtm.ac.uk/id/eprint/15535 ISBN 1902089944

Novignon, J., & Lawanson, A. O. (2017). Health expenditure and child health outcomes in Sub-Saharan Africa. *African Review of Economics and Finance*, *9*(1), 96-121.

https://www.ajol.info/index.php/aref/article/view/162145/151659
https://www.ajol.info/index.php/aref/article/view/162145/151659

Nuhu, K. M., McDaniel, J. T., Alorbi, G. A., & Ruiz, J. I. (2018). Effect of healthcare spending on the relationship between the Human Development Index and maternal and neonatal mortality. *International health*, *10*(1), 33-39. https://doi.org/10.1093/inthealth/ihx053

Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric Theory*. New York, McGraw-Hill. ISBN 9780070478497

Nyamuranga, C., & Shin, J. (2019). Public health expenditure and child mortality in Southern Africa. *International Journal of Social Economics*, *46*(9), 1137-1154. https://doi.org/10.1108/IJSE-12-2018-0643

OAU, (Organisation for African Unity). (2011). *The 2001 Abuja Declaration*. https://au.int/sites/default/files/pages/32894-file-2001-abuja-declaration.pdf

Ochalek, J., Wang, H., Gu, Y., Lomas, J., Cutler, H., & Jin, C. (2020). Informing a cost-effectiveness threshold for health technology assessment in China: a marginal productivity approach. *Pharmacoeconomics*, *38*(12), 1319-1331. https://doi.org/10.1007/s40273-020-00954-y

Ochiaka, R. E., & Akuma, F. O. (2021). Impact of Government Health Expenditure on Health Outcomes in Nigeria. *Medical and Health Sciences European Journal*, *5*(2). https://aspjournals.org/Journals/index.php/mhsej/article/view/42
https://aspjournals.org/Journals/index.php/mhsej/article/view/42

Odhiambo, S. A., Wambugu, A., & Ng'ang'a, T. K. (2015). Has Quality of Governance Affected the Effectiveness of Health Expenditure on Adult Health in Sub-Saharan Africa? *European Scientific Journal*, *11*(16), 1857 – 7881. https://doi.org/10.1186/s12889-015-2287-z

OECD, (Organisation for Economic Co-operation and Development). (1996). *Shaping the 21st century: the contribution of development cooperation*. https://www.oecd.org/dac/2508761.pdf

OECD, WHO, & Eurostat. (2011). *A System of Health Accounts*. https://doi.org/10.1787/9789264116016-en

Ogungbenle, S., Olawumi, O., & Obasuyi, F. (2013). Life expectancy, public health spending and economic growth in Nigeria: A vector autoregressive (VAR) model. *European Scientific Journal*, *9*(19). https://core.ac.uk/download/pdf/236408152.pdf https://core.ac.uk/download/pdf/236408152.pdf

Okwan, F., & Kovács, P. (2019). Determinants of maternal mortality in Sub-Saharan Africa: a cause-effect model assessment. *Hungarian Statistical Review*, *2*(2), 15-31. http://real.mtak.hu http://real.mtak.hu

Oladosu, A. O., Chanimbe, T., & Anaduaka, U. S. (2022). Effect of public health expenditure on health outcomes in Nigeria and Ghana. *Health Policy OPEN*, *3*, 100072. https://doi.org/10.1016/j.hpopen.2022.100072

Olalere, N., & Munyua-Gatome, A. (2020). Public financing for health in Africa: 15% of an elephant is not 15% of a chicken. *Africa Renewal [Internet]*. https://sparc.africa/ https://sparc.africa/

Olayiwola, S., Adedokun, A. S., & Olusanya, S. (2020). Government Health Expenditure and Health Outcomes in Nigeria. *Journal of Economics and Policy Analysis*, *5*(2), 89-102. https://orcid.org/0000-0002-4138-8019 https://orcid.org/0000-0002-4138-8019

Omoruyi, A. (2018). Impact of Public and Private Health Expenditure on Malaria Cases in Nigeria. *Journal of Finance, Governance and Strategic Studies*, *1*(1). https://www.researchgate.net https://www.researchgate.net

Onaran, O., & Oyvat, C. (2023). The effects of public spending in the green and the care economy: the case of South Korea. *Available at SSRN 4528510*. https://doi.org/10.2139/ssrn.4528510

Onofrei, M., Vatamanu, A.-F., Vintilă, G., & Cigu, E. (2021). Government health expenditure and public health outcomes: a comparative study among EU developing countries. *International Journal of Environmental Research and Public Health*, *18*(20), 10725. https://doi.org/10.3390/ijerph182010725

Opoku, E. C., Olsen, A., Browne, E., Hodgson, A., Awoonor-Williams, J. K., Yelifari, L., Williams, J., & Magnussen, P. (2016). Impact of combined intermittent preventive treatment of malaria and helminths on anaemia, sustained attention, and recall in Northern Ghanaian schoolchildren. *Global health action*, *9*(1), 32197. https://doi.org/10.3402/gha.v9.32197

Osakede, U. A. (2021). Public health spending and health outcome in Nigeria: the role of governance. *International Journal of Development Issues*, *20*(1), 95-112. https://doi.org/10.1108/IJDI-10-2019-0169

Panneer, S., Kantamaneni, K., Palaniswamy, U., Bhat, L., Pushparaj, R. R. B., Nayar, K. R., Soundari Manuel, H., Flower, F. L. L., & Rice, L. (2022). Health, economic and social development challenges of the COVID-19 pandemic: strategies for multiple and interconnected issues. *Healthcare*, *10*(5), 770. https://doi.org/10.3390/healthcare10050770

Park, H., Roubal, A. M., Jovaag, A., Gennuso, K. P., & Catlin, B. B. (2015). Relative contributions of a set of health factors to selected health outcomes. *American Journal of Preventive Medicine*, *49*(6), 961-969. https://doi.org/10.1016/j.amepre.2015.07.016

Patterson, A. C. (2023). Is Economic Growth Good for Population Health? A Critical Review. *Canadian Studies in Population*, *50*(1), 1. https://doi.org/10.1007/s42650-023-00072-y

Piabuo, S. M., & Tieguhong, J. C. (2017). Health expenditure and economic growth-a review of the literature and an analysis between the economic community for central African states (CEMAC) and selected African countries. *Health economics review*, *7*(1), 1-13. https://doi.org/10.1186/s13561-017-0159-1

Piatti-Fünfkirchen, M., & Schneider, P. (2018). From stumbling block to enabler: the role of public financial management in health service delivery in Tanzania and Zambia.

Health Systems & Reform, *4*(4), 336-345. https://doi.org/10.1080/23288604.2018.1513266

Popoola, T. O. (2018). Health outcomes in Sub-Saharan Africa Countries: An analysis of key determinants. *Modern Health Science*, *1*(1), p8-p8. https://doi.org/10.30560/mhs.v1n1p8

Preacher, K. J. (2008). *Latent Growth Curve Modeling*. SAGE Publications, Inc. ISBN 1315755645

Rad, E. H., Vahedi, S., Teimourizad, A., Esmaeilzadeh, F., Hadian, M., & Pour, A. T. (2013). Comparison of the effects of public and private health expenditures on the health status: a panel data analysis in eastern mediterranean countries. *International journal of health policy and management*, *1*(2), 163. https://doi.org/10.15171/ijhpm.2013.29

Raga, S. (2022). Fiscal Multipliers: a review of fiscal stimulus options and impact on developing countries. *Supporting Economic Transformation.* . https://set.odi.org/wp-content/uploads/2022/01/Fiscal-multipliers-review.pdf
https://set.odi.org/wp-content/uploads/2022/01/Fiscal-multipliers-review.pdf
Rajkumar, A. S., & Swaroop, V. (2008). Public spending and outcomes: Does governance matter? *Journal of development economics*, *86*(1), 96-111. https://doi.org/doi.org/10.1016/j.jdeveco.2007.08.003

Ramírez-Orellana, A., del Carmen Valls Martínez, M., & Grasso, M. S. (2021). Using Higher-Order Constructs to Estimate Health-Disease Status: The Effect of Health System Performance and Sustainability. *Mathematics*, *9*(11), 1228.

https://www.mdpi.com/2227-7390/9/11/1228/pdf https://www.mdpi.com/2227-7390/9/11/1228/pdf

Ranabhat, C. L., Jakovljevic, M., Dhimal, M., & Kim, C.-B. (2020). Structural factors responsible for universal health coverage in low-and middle-income countries: results from 118 countries. *Frontiers in public health*, *7*, 414. https://doi.org/10.3389/fpubh.2019.00414

Reiner Jr, R. C., & Hay, S. I. (2022). The overlapping burden of the three leading causes of disability and death in sub-Saharan African children. *Nature Communications*, *13*(1), 7457. https://doi.org/10.1038/s41467-022-34240-6

Rendell, N., & Sheel, M. (2022). Health security in the Pacific: expert perspectives to guide health system strengthening. https://doi.org/10.1371/journal.pgph.0000529

Ringle, C. M., Wende, S., & Becker, J.-M. (2015). SmartPLS 3. *Boenningstedt: SmartPLS GmbH*, *584*.

Rizvi, F., Williams, J., Maheen, H., & Hoban, E. (2020). Using social ecological theory to identify factors associated with risky sexual behavior in cambodian adolescent girls and young women aged 10 to 24 years: a systematic review. *Asia Pacific Journal of Public Health*, *32*(2-3), 71-80. https://doi.org/10.1177/10105395209114

Robine, J.-M., Jagger, C., Mathers, C. D., Crimmins, E. M., & Suzman, R. M. (2003). *Determining health expectancies*. John Wiley & Sons. ISBN 0-470-84397-7

Roesch, S. C., Norman, G. J., Adams, M. A., Kerr, J., Sallis, J. F., Ryan, S., Calfas, K. J., & Patrick, K. (2009). Latent growth curve modeling of adolescent physical activity:

Testing parallel process and mediation models. *Journal of Health Psychology*, *14*(2), 313-325. https://doi.org/10.1177/1359105308100216

Roodman, D. (2009). A note on the theme of too many instruments. *Oxford Bulletin of Economics and statistics*, *71*(1), 135-158. https://doi.org/10.1111/j.1468-0084.2008.00542.x

Sadr-Azodi, N. (2019). *Following the 2001 Abuja Declaration of committing 15 percent government expenditure on health, is Africa making progress towards universal health coverage?* https://repositori.upf.edu/bitstream/handle/10230/42989/Sadr-Azodi_universal_health_MUESIOL_02.pdf?sequence=1&isAllowed=y

Sanoussi, Y., Zounmenou, A. Y., & Ametoglo, M. (2023). Catastrophic health expenditure and household impoverishment in Togo. *Journal of Public Health Research*, *12*(3), 22799036231197196. https://doi.org/10.1177/22799036231197196

Sarkodie, S. A., & Owusu, P. A. (2020). How to apply dynamic panel bootstrap-corrected fixed-effects (xtbcfe) and heterogeneous dynamics (panelhetero). *MethodsX*, *7*, 101045. https://doi.org/10.1016/j.mex.2020.101045

Sarstedt, M., Hair, J. F., Ringle, C. M., Thiele, K. O., & Gudergan, S. P. (2016). Estimation issues with PLS and CBSEM: Where the bias lies! *Journal of Business Research*, *69*(10), 3998-4010. https://doi.org/10.1016/j.jbusres.2016.06.007

Sarstedt, M., Hair Jr, J. F., Cheah, J.-H., Becker, J.-M., & Ringle, C. M. (2019). How to specify, estimate, and validate higher-order constructs in PLS-SEM. *Australasian Marketing Journal (AMJ)*, *27*(3), 197-211. https://doi.org/10.1016/j.ausmj.2019.05.003

Sauerberg, M., Guillot, M., & Luy, M. (2020). The cross-sectional average length of healthy life (HCAL): A measure that summarizes the history of cohort health and mortality. *Population Health Metrics*, *18*(1), 1-17. https://doi.org/10.1186/s12963-021-00254-3

Saxenian, H., Bharali, I., Ogbuoji, O., & Yamey, G. (2019). A quantitative analysis of sources of changes in government expenditures on health, 2000 to 2015: what can we learn from experience to date? *Gates Open Research*, *3*. https://doi.org/10.12688/gatesopenres.12900.2

Schäferhoff, M., Martinez, S., Ogbuoji, O., Sabin, M. L., & Yamey, G. (2019). Trends in global health financing. *365*. https://doi.org/10.1136/bmj.l2185

Scheirer, M. A., & Dearing, J. W. (2011). An agenda for research on the sustainability of public health programs. *American journal of public health*, *101*(11), 2059-2067. https://doi.org/10.2105/AJPH.2011.300193

Schmidt, K., & Pförtner, T.-K. (2020). Job insecurity, sickness presenteeism and the moderating effect of workplace health promotion. *Journal of Occupational and Environmental Medicine*, *62*(11), 937-942. https://doi.org/10.1097/JOM.0000000000001997

Sede, I. P., & Nosakhare, I. (2018). Government Health Expenditure and Malaria in Nigeria. *YOBE JOURNAL OF ECONOMICS (YOJE)*, 19. https://www.researchgate.net https://www.researchgate.net

Selig, J. P., & Preacher, K. J. (2009). Mediation models for longitudinal data in developmental research. *Research in human development*, *6*(2-3), 144-164. https://doi.org/10.1080/15427600902911247

Sen, A. (1999). Economics and health. *The lancet*, *354*, SIV20. https://doi.org/10.1016/s0140-6736(99)90363-x

Shi, D., DiStefano, C., Zheng, X., Liu, R., & Jiang, Z. (2021). Fitting latent growth models with small sample sizes and non-normal missing data. *International journal of behavioral development*, *45*(2), 179-192.

Shrestha, S., & Stopka, T. J. (2022). Spatial Epidemiology and Public Health. In *Geospatial Technology for Human Well-Being and Health* (pp. 49-77). Springer. https://doi.org/10.1007/978-3-030-71377-5_4

Sirrs, C. (2021). The health of nations: International health accounting in historical perspective, 1925–2011. In *Accounting for health* (pp. 359-385). Manchester University Press. https://doi.org/10.7765/9781526135179.00023

Sokunbi, T. O., Omojuyigbe, J. O., Bakenne, H. A., & Adebisi, Y. A. (2022). Nigeria End Malaria Council: What to expect. *Annals of Medicine and Surgery*, *82*, 104690. https://doi.org/10.1016/j.amsu.2022.104690

Soluk, J., Miroshnychenko, I., Kammerlander, N., & De Massis, A. (2021). Family influence and digital business model innovation: the enabling role of dynamic capabilities. *Entrepreneurship Theory and Practice*, *45*(4), 867-905. https://doi.org/10.1177/1042258721998946

Ssozi, J., & Amlani, S. (2015). The effectiveness of health expenditure on the proximate and ultimate goals of healthcare in Sub-Saharan Africa. *World Development*, *76*, 165-179. https://doi.org/10.1016/j.worlddev.2015.07.010

StataCorp, L. (2019). Stata Statistical Software: Release Vol. 16.

Steensma, S. M.-C. (2012). *Disability-Adjusted Life Years: An Indicator to Measure Burden of Disease in Québec*. https://policycommons.net/

Stefko, R., Gavurova, B., Ivankova, V., & Rigelsky, M. (2020). Gender inequalities in health and their effect on the economic prosperity represented by the GDP of selected developed countries—Empirical study. *International Journal of Environmental Research and Public Health*, *17*(10), 3555. https://doi.org/10.3390/ijerph17103555

Stenberg, K., Hanssen, O., Edejer, T. T.-T., Bertram, M., Brindley, C., Meshreky, A., Rosen, J. E., Stover, J., Verboom, P., & Sanders, R. (2017). Financing transformative health systems towards achievement of the health Sustainable Development Goals: a model for projected resource needs in 67 low-income and middle-income countries. *The Lancet Global Health*, *5*(9), e875-e887. https://doi.org/10.1016/S2214-109X(17)30263-2

Stiglitz, J., Ocampo, J. A., Spiegel, S., Ffrench-Davis, R., & Nayyar, D. (2006). *Stability with growth: macroeconomics, liberalization and development*. OUP Oxford. ISBN 0191647799

Sullivan, D. F. (1971). A single index of mortality and morbidity. *HSMHA health reports*, *86*(4), 347. https://stacks.cdc.gov/view/cdc/62814 https://stacks.cdc.gov/view/cdc/62814

Tandon, A., & Cashin, C. (2010). *Assessing public expenditure on health from a fiscal space perspective* [Working Paper]. Washington, D.C. : World Bank Group. ISBN License: CC BY 3.0 IGO

Tangcharoensathien, V., Panichkriangkrai, W., Witthyapipopsakul, W., & Patcharanarumol, W. (2023). COVID-19 Aftermath: Direction Towards Universal Health Coverage in Low-Income Countries: Comment on" Health Coverage and Financial Protection in Uganda: A Political Economy Perspective". *International journal of health policy and management*, *12*. https://doi.org/10.34172/ijhpm.2022.7519

Tatoglu, F. Y. (2011). The relationships between human capital investment and economic growth: A Panel Error Correction Model. *Journal of Economic and Social Research*, *13*(1), 77.

Thakadu, O. T., Ngwenya, B. N., Phaladze, N. A., & Bolaane, B. (2018). Sanitation and hygiene practices among primary school learners in Ngamiland district, Botswana. *Physics and Chemistry of the Earth, Parts A/B/C*, *105*, 224-230. https://doi.org/10.1016/j.pce.2018.02.006

Toor, J., Echeverria-Londono, S., Li, X., Abbas, K., Carter, E. D., Clapham, H. E., Clark, A., de Villiers, M. J., Eilertson, K., & Ferrari, M. (2021). Lives saved with vaccination for 10 pathogens across 112 countries in a pre-COVID-19 world. *Elife*, *10*, e67635. https://doi.org/10.7554/eLife.67635

Traoré, O. (2021). Convergence in public health expenditure across the Sub-Saharan African countries: does club convergence matter? *Health economics review*, *11*(1), 1-14. https://doi.org/10.1186/s13561-021-00316-0

Troeger, C. E., Khalil, I. A., Blacker, B. F., Biehl, M. H., Albertson, S. B., Zimsen, S. R., Rao, P. C., Abate, D., Ahmadi, A., & brahim Ahmed, M. L. C. (2020). Quantifying risks and interventions that have affected the burden of diarrhoea among children younger than 5 years: an analysis of the Global Burden of Disease Study 2017. *The Lancet Infectious Diseases*, *20*(1), 37-59. https://doi.org/10.1016/S1473-3099(19)30401-3

United Nations. (1995). *Copenhagen declaration on social development* (World Summit for Social Development, Issue. https://www.un.org/development/desa/dspd/world-summit-for-social-development-1995/wssd-1995-agreements/cdosd-introduction.html

United Nations. (2019a). *Healthcare and economic growth in Africa*. Economic Commission for Africa, Addis Ababa, Ethiopia. https://hdl.handle.net/10855/43118 ISBN 9290234091

United Nations. (2019b). *World Mortality 2019: Highlights* ((ST/ESA/SER.A/432)). https://www.un.org

VanderWeele, T. (2015). *Explanation in causal inference: methods for mediation and interaction*. Oxford University Press. https://psycnet.apa.org/record/2015-10736-000 ISBN 978-0199325870

Vian, T. (2020). Anti-corruption, transparency and accountability in health: concepts, frameworks, and approaches. *Global health action*, *13*(sup1), 1694744. https://doi.org/10.1080/16549716.2019.1694744

Wagstaff, A., & Cleason, M. (2004). *The Millennium Development Goals for Health: Rising to the challenge* World Bank. https://doi.org/10.1596/0-8213-5767-0

Waithaka, D., Cashin, C., & Barasa, E. (2022). Is performance-based financing a pathway to strategic purchasing in sub-Saharan Africa? A synthesis of the evidence. *Health Systems & Reform*, *8*(2), e2068231. https://doi.org/10.1080/23288604.2022.2068231

Wang, H., Abbas, K. M., Abbasifard, M., Abbasi-Kangevari, M., Abbastabar, H., Abd-Allah, F., Abdelalim, A., Abolhassani, H., Abreu, L. G., & Abrigo, M. R. (2020). Global age-sex-specific fertility, mortality, healthy life expectancy (HALE), and population estimates in 204 countries and territories, 1950–2019: a comprehensive demographic analysis for the Global Burden of Disease Study 2019. *The lancet*, *396*(10258), 1160-1203. https://doi.org/10.1016/S0140-6736(20)30977-6

Wang, T. (2021). The effect of female education on child mortality: evidence from Indonesia. *Applied Economics*, *53*(27), 3207-3222. https://doi.org/10.1080/00036846.2021.1877253

Weaver, M. R., Joffe, J., Ciarametaro, M., Dubois, R. W., Dunn, A., Singh, A., Sparks, G. W., Stafford, L., Murray, C. J., & Dieleman, J. L. (2022). Health Care Spending Effectiveness: Estimates Suggest That Spending Improved US Health From 1996 To 2016: Study examines health care spending effectiveness, the ratio of an increase in spending per case of illness or injury to an increase in disability-adjusted life-years averted per case. *Health affairs*, *41*(7), 994-1004. https://doi.org/10.1377/hlthaff.2021.01515

Weibo, X., & Yimer, B. (2019). The Effect of Healthcare Expenditure on the Health Outcomes in Sub-Saharan African Countries. *Asian Journal of Economics, Business and Accounting*, 1-22. https://doi.org/10.9734/ajeba/2019/v12i430158

West, D. M., Villasenor, J., & Schneider, J. (2017). Health governance capacity: Enhancing private sector investment in global health. *The brookings private sector global health R&D project. Center for Technology innovation at brookings*. https://www.brookings.edu/wp-content/uploads/2017/03/cti_20170329_health_governance_capacity.pdf https://www.brookings.edu/wp-content/uploads/2017/03/cti_20170329_health_governance_capacity.pdf

WHO. (2014). *World Health Organization African Region Expenditure Atlas, November 2014*. Regional Office for Africa. World Health Organization. https://iris.who.int/handle/10665/145197 ISBN 9290232730

WHO. (2016a). *Health in 2015: from MDGs, millennium development goals to SDGs, sustainable development goals*. Geneva: WHO Press. https://doi.org/10.1111/padr.12006 ISBN 924156511X

WHO. (2016b). *Public financing for health in Africa: from Abuja to the SDGs*. https://www.afro.who.int/sites/default/files/2017-06/WHO-HIS-HGF-Tech.Report-16.2-eng.pdf

WHO. (2017). *New perspectives on global health spending for universal health coverage*. World Health Organization. http://apps.who.int/iris. ISBN Licence: CC BY-NC-SA 3.0 IGO

WHO. (2018a). *New perspectives on global health spending for universal health coverage*. Geneva: World Health Organization. ISBN Licence: CC BY-NC-SA 3.0 IGO

WHO. (2018b). *The State of Health in the WHO African Region: An analysis of the status of health, health services and health systems in the context of the Sustainable Development Goals*. Brazzaville: WHO Regional Office for Africa. https://www.afro.who.int/ ISBN Licence: CC BY-NC-SA 3.0 IGO

WHO. (2019). *World Health Statistics 2019: Monitoring Health for the SDGs, sustainable development goals*. Geneva: World Health Organization. ISBN Licence: CC BY-NC-SA 3.0 IGO.

WHO. (2020). *World health statistics 2020: Monitoring health for the SDGs, sustainable development goals.* . World Health Organization. https://iris.who.int/handle/10665/332070 ISBN License: CC BY-NC-SA 3.0 IGO

WHO. (2021a). *Global health expenditure database: NHA indicators*. Retrieved 23 May 2022 from https://apps.who.int/nha/database/ViewData/Indicators/en

WHO. (2021b). *World health statistics 2020: monitoring health for the SDGs, sustainable development goals*. World Health Organization. ISBN 9241565705

Wolf, L. A. (2016). How Do I Know If It Works? Deciding on Measured Outcomes in Research Planning. *Journal of Emergency Nursing*, *42*(3), 282-283. https://doi.org/10.1016/j.jen.2016.03.004

Wolfson, L. J., Gasse, F., Lee-Martin, S.-P., Lydon, P., Magan, A., Tibouti, A., Johns, B., Hutubessy, R., Salama, P., & Okwo-Bele, J.-M. (2008). Estimating the costs of achieving the WHO-UNICEF Global Immunization Vision and Strategy, 2006-2015. *Bulletin of the world Health Organization*, *86*, 27-39. https://doi.org/10.2471/blt.07.045096

World Bank. (2013). *The World Bank Annual Report 2013*. Washington, DC. http://hdl.handle.net/10986/16091 ISBN 0821399373

World Bank. (2021). *World development indicators*. The World Bank. Retrieved 10 March 2021 from https://databank.worldbank.org/source/world-development-indicators

World Health Organization. (2020). *World health statistics 2020: monitoring health for the SDGs, sustainable development goals*. World Health Organization. https://apps.who.int/iris/handle/10665/332070 ISBN License: CC BY-NC-SA 3.0 IGO

Wu, H. (2022). The effect of maternal education on child mortality in Bangladesh. *Population and development review*, *48*(2), 475-503. https://doi.org/10.1111/padr.12467

Xu, P., Zhao, X., Li, H., & Guo, S. (2022). Spatial effect analysis of health expenditure and health output in China from 2011 to 2018. *Frontiers in public health*, *10*. https://doi.org/10.3389/fpubh.2022.794177

Yoshida, M., & Kenmochi, T. (2011). Multiplier effects of public services in a two-sector model of monopolistic competition. *The Japanese Economic Review*, *62*, 272-288. https://doi.org/10.1111/j.1468-5876.2010.00517.x

Zhou, Y. (2018). Analysis on the Effect of Medical System Efficiency on Residents' Health: Based on Panel Quantile Regression Model. *Chinese Health Economics*(12), 66-69. https://caod.oriprobe.com https://caod.oriprobe.com

Appendices

Appendix 1:

List of countries

Country	
Angola	Liberia
Benin	Madagascar
Botswana	Malawi
Burkina Faso	Mali
Burundi	Mauritania
Cabo Verde	Mauritius
Cameroon	Mozambique
Central African Republic	Namibia
Chad	Niger
Comoros	Nigeria
Congo, Dem. Rep.	Rwanda
Congo, Rep.	Sao Tome and Principe
Cote d'Ivoire	Senegal
Equatorial Guinea	Seychelles
Eritrea	Sierra Leone
Eswatini	Somalia
Ethiopia	South Africa
Gabon	South Sudan
Gambia, The	Sudan
Ghana	Tanzania
Guinea	Togo
Guinea-Bissau	Uganda
Kenya	Zambia
Lesotho	Zimbabwe

Note. This list includes all the sub-Saharan countries. Selected countries aer used in each chapter based on the availability of data for the variable used.

Appendix 2:

PHS as a proportion of overall public spending in SSA, 2001-2018

Coutnry	2001	2006	2011	2016	2018
Angola	5.97	4.72	4.58	5.43	5.36
Benin	6.00	5.53	5.40	3.73	2.96
Botswana	8.18	8.18	9.63	11.21	11.54
Burkina Faso	4.94	6.54	6.59	11.03	8.78
Burundi	6.66	6.48	8.23	10.39	8.31
Cabo Verde Republic of	11.17	8.92	8.61	10.39	10.39
Cameroon	5.34	5.18	3.21	1.81	1.96
Central African Republic	10.72	9.18	2.93	4.95	3.91
Chad	11.87	7.14	3.69	5.73	4.87
Comoros	4.12	5.18	7.24	3.04	3.99
Congo	3.32	2.08	2.34	2.89	3.49
Côte d'Ivoire	4.46	3.86	4.39	4.85	5.12
Dem. Rep. of the Congo	2.50	2.50	2.53	3.81	4.48
Djibouti	5.97	7.23	8.47	4.07	4.31
Equatorial Guinea	1.41	1.44	1.47	2.50	3.23
Eritrea	2.01	1.54	2.35	2.35	2.35
Eswatini	9.28	12.62	14.28	8.22	9.97
Ethiopia	8.98	5.08	2.09	5.02	4.76
Gabon	4.54	5.76	7.29	9.20	9.42
Gambia	6.31	6.31	6.31	6.66	5.14
Ghana	7.19	9.56	12.07	6.54	6.42
Guinea	2.47	1.88	3.18	4.11	3.85
Guinea-Bissau	15.14	12.56	2.52	2.36	2.75
Kenya	7.09	6.81	7.98	8.03	7.23
Lesotho	9.03	7.05	8.91	9.41	9.61
Liberia	6.38	6.33	5.05	3.90	5.20
Madagascar	12.27	10.18	13.94	17.51	10.48
Malawi	7.04	5.29	6.78	9.68	8.67
Mali	5.75	5.55	2.94	5.43	5.67
Mauritania	2.42	3.56	4.40	5.76	6.98
Mauritius	7.02	7.30	7.36	10.20	10.20
Mozambique	6.32	5.67	4.34	6.00	5.76
Namibia	15.98	15.75	10.64	10.47	10.65
Niger	8.34	13.54	8.30	5.69	8.35
Nigeria	2.78	7.32	2.77	4.87	3.88
Rwanda	3.66	7.20	8.90	8.88	8.88
Sao Tome and Principe	6.89	1.69	4.31	8.00	10.76
Senegal	9.01	8.27	5.63	4.46	4.96
Seychelles	8.03	7.91	8.29	9.50	10.18
Sierra Leone	13.15	6.52	4.13	7.91	3.60
South Africa	10.62	13.10	14.68	15.29	15.29
Sudan	11.37	9.44	7.04	12.94	6.17
Togo	2.99	3.83	5.67	4.26	5.49
Uganda	8.33	7.17	6.90	5.18	4.17
United Rep. of Tanzania	8.80	13.51	6.76	9.52	9.41
Zambia	11.11	8.76	6.17	7.16	7.16

Note. Computed using data from WHO (2021).

Appendix 3:

Ethical clearance

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

19-10-2021
Mr Wa Ntita Serge Kabongo (213574214)
School Of Acc Economics&Fin
Westville

Dear Mr Wa Ntita Serge Kabongo,

Original application number: 00014478
Project title: The effectiveness of public health spending in Sub-Saharan Africa

Exemption from Ethics Review

In response to your application received on 19-10-2021, your school has indicated that the protocol has been granted **EXEMPTION FROM ETHICS REVIEW.**

Any alteration/s to the exempted research protocol, e.g., Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through an amendment/modification prior to its implementation. The original exemption number must be cited.

For any changes that could result in potential risk, an ethics application including the proposed amendments must be submitted to the relevant UKZN Research Ethics Committee. The original exemption number must be cited.

In case you have further queries, please quote the above reference number.

PLEASE NOTE:
Research data should be securely stored in the discipline/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours sincerely,

[redacted]ahomedy**
Academic Leader Research
School Of Acc Economics&Fin

Wa Ntita Serge Kabongo

2118 Purcell court, London, Ontario N5W 0A3 • 519 694 6179 • sergekwn@yahoo.fr

Highly motivated, organized, and detail-oriented professional with over 3 years of experience in research and data analysis. Proficient in statistical software and knowledgeable about common types of health study designs. Possesses strong problem-solving skills, critical thinking abilities, and is goal-oriented. Demonstrates effective teamwork and excellent written and oral communication skills in both English and French.

1. RESEARCH AREAS

Health Outcomes Research, Healthcare Financing, Chronic Disease Prevention and Management.

2. TECHNICAL SKILLS

Statistical and Analytical Skills: Skilled in regression analysis, hypothesis testing, and data visualization; Able to derive actionable insights from complex datasets.
Research Methodology Expertise: Familiar with various study designs in health research; Experienced in designing and executing research studies; Ensures validity and reliability of findings.
Econometric Modeling Proficiency: Strong knowledge of econometric techniques; Applies econometric modeling to healthcare economics.
Adaptability and Continuous Learning: Comfortable with statistical estimation techniques; Eager to learn advanced methodologies; Quick learner of new software and technologies.
Software Proficiency: Proficient in Microsoft Office Suite, STATA, R, TSP, SMARTPLS and MPLUS for modeling; SQL Server for data management; Quick to adapt to new software.

3. PROFESSIONNAL EXPERIENCE

Carrefour Communautaire Francophone de London — London Ontario, Canada
Manager of Immigration Services — *March 2020 - Present*
Coordinator of Mentorship Program — *September 2017 – March 2020*

Health Economics and HIV/AIDS Research Division — Durban, South Africa
Research Assistant — *May 2015 - September 2016*

School of Accounting, Economics and Finance, UKZN — Durban, South Africa
Tutor (Micro and Macroeconomics, grades 1 and 2) — *February 2014 - September 2016*

Sonangol Congo S.a.r.l, (Oil company, 210 employees)	Kinshasa, DR Congo
Administrative Director	*March 2004 – September 2011*
Sales Manager	*March 1999 – March 2004*
Cabinet of the Oil Minister, Government of DRC	Kinshasa, DR Congo
Research Advisor	*February 1998 – March 1999*

4. EDUCATION

University of South Wales — South Wales, United Kingdom

- *Master of Sciences in Public Health, 2021*

University of KwaZulu-Natal — Durban, South Africa

- *Master of Commerce in Economics, December 2015*
- *Bachelor of Commerce Honors in Economics, June 2014*

Université de Kinshasa, — Kinshasa, DR Congo

- *Bachelor of Commerce Honors in Math Economics, August 1999*

Institut Supérieur de Commerce — Kinshasa, DR Congo

- *Bachelor of Commerce in Finances, August 1995*

5. PUBLICATIONS

Kabongo, W. N. S., & Mbonigaba, J. (2024). *Public health spending in Sub-Saharan Africa: exploring transmission mechanisms using the latent growth curve mediation model.* Health Economics Review, 14(1), 14.

Bokana, K.G and Kabongo, W.N.S, (2019). *Modelling real private consumption expenditure in South Africa to test the absolute income hypothesis.* Journal of Economics and Behavioral Studies, 10(5), 138-155.

Kabongo, W.N.S. and Mbonigaba, J., (2018). *Demand-side determinants of access to healthcare services: Empirical evidence from Africa.* SPOUDAI-Journal of Economics and Business, 67(4), pp.3-22.

Bokana, K.G and Kabongo, W.N.S, (June 2016). Determinants of access to healthcare in Africa: Application of the robust standard errors for panel regressions with cross-sectional dependence. *Paper presented at the International Conference for Academic Disciplines, Boston, MA.*