2021

The Relationship between government spending on health and mortality from Non-Communicable Diseases: a global level panel data analysis (2000-2016).

Njuguna, Benson Ng'ang'a
Strathmore Business School
Strathmore University

THE RELATIONSHIP BETWEEN GOVERNMENT SPENDING ON HEALTH AND MORTALITY FROM NON-COMMUNICABLE DISEASES: A GLOBAL LEVEL PANEL DATA ANALYSIS (2000-2016)

BY

BENSON NG'ANG'A NJUGUNA

111480

A RESEARCH PROJECT THESIS SUBMITTED TO THE STRATHMORE BUSINESS SCHOOL IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR AN AWARD OF THE DEGREE OF MASTERS IN PUBLIC POLICY

2021

Table of Contents

Declaration

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the dissertation contains no material previously published or written by another person except where due reference is made in the dissertation itself.

Name of Candidate: Benson Ngángá Njuguna

Approval

The dissertation of Benson Ngángá Njuguna was approved by the following:

Name of Supervisor: Professor Robert Mudida

School/Institute/Faculty: Strathmore Business School

Dr. George Njenga

Executive Dean

Strathmore University Business School.

Dr. Bernard Shibwabo

Director, Office of Graduate Studies

Dedication

This research project is dedicated to three generations of strong and resolute women who have all contributed to the person I am today. My grandmother Mary Nyambura Njuguna, my mother Priscilla Wandia Njuguna, and my sister June Nyambura Wandia.

Acknowledgements

I would like to acknowledge all my Strathmore Business School lecturers for the knowledge they imparted me with that enabled me to apply the concepts to this research project.

I would also like to acknowledge Prof Rajesh Vedanthan, New York University, and Prof Sonak Pastakia, Purdue University College of Pharmacy for their advice as I developed the ideas underlying this work.

Abstract

Non-communicable diseases (NCD) cause the most death and disability globally, posing a significant public health threat, with detrimental impact on productivity and economic growth. The United Nations Sustainable Development Goal 3.4 targets reducing NCD related mortality by one third by 2030. In order to accomplish this, domestic government expenditure on health (GEH) has been proposed as a key policy tool to expand access to quality healthcare and reduce premature NCD mortality. GEH as a percentage of gross domestic product (GDP) varies between countries at the global, regional and income group level, however the relationship between domestic GEH and premature mortality from NCDs is currently unknown. This study objectives were to investigate the relationship between domestic GEH and premature NCD mortality from the four major NCDs, the mediating role of access to quality healthcare on this relationship, and the moderating role of country income grouping on this relationship. The study used panel data regression analysis to analyse country level secondary data for the years 2000-2016 for countries which are signatory to the UN SDG. Both fixed and random effects estimations were conducted, with the Wu Hausman test used to identify the most appropriate model. This study found an inverse relationship between domestic GEH and premature NCD mortality, controlling for private expenditure on health, per capita GDP, tertiary education level, and government effectiveness, with a coefficient of -0.049 (p value < 0.01) under a fixed effects assumption, which was favoured by the Wu Hausman test. The study also found no role of access to quality healthcare, as measured using the health access and quality index (HAQI) metric as a mediator in the relationship between domestic GEH and premature NCD mortality. Finally, the study found that country income grouping was a strong moderator in the relationship, becoming stronger and more significant as country income grouping rose. The findings of this study are instructive to policy makers, particularly in ministries of health and ministries of finance on the inverse relationship between domestic GEH and mortality from NCD and provides data in support of the calls to increase public spending on health, particularly given the health and economic benefits attainable from reducing NCD morbidity and mortality and achieving SDG 3.4.

Key words: health expenditure, NCD mortality, health access, health quality

Acronyms

CRD: Chronic respiratory disease

CKD: Chronic kidney disease

CVD: Cardiovascular disease

DAH: Development Assistance in Health

DM: Diabetes Mellitus

GBD: Global burden of disease

GDP: Gross domestic product

GEH: Government expenditure on health

GNI: Gross national income

HAQI: Health access and quality index

HIV/AIDS: Human immunodeficiency virus/Acquired immunodeficiency syndrome

HIC: High Income Country

IHME: Institute for Health Metrics and Evaluation

LMIC: Low and middle income countries

NCD: Non-communicable diseases

OOP: Out of Pocket Payment

PEH: Private expenditure on health

PPP: Purchasing power parity

SSA: Sub-Saharan Africa

SDG: Sustainable development goals

THE: Total health expenditure

UN: United Nations

UHC: Universal health coverage

U5MR: Under-five mortality rate

WDI: World Development Indicators

Chapter One: Introduction

1.1 Introduction

This chapter provides the background of the current study, introducing the key concepts in the fields of non-communicable diseases, access to quality healthcare, and healthcare financing as relates to the guiding policy framework of the UN 2030 sustainable development goals. It then describes the problem statement that the study aims to address, states the research objectives and questions, and highlights the significance of the study.

1.2 Background

1.2.1 Non-communicable diseases

NCDs refer to diseases which are not transmitted from one person to another. NCDs are often chronic in nature, requiring long term treatment to prevent death and disability from their complications. NCDs result from a mix of risk factors which are behavioural (e.g. physical inactivity leading to diabetes mellitus), environmental (e.g. household air pollution causing chronic respiratory diseases), or genetic (e.g. acquired mutations causing breast cancer) (Beaglehole et al., 2011). The four major NCDs are cardiovascular disease (CVD), cancer, diabetes mellitus (DM), and chronic respiratory diseases (CRD) (GBD 2017 DALYs and HALE Collaborators, 2018).

CVD includes stroke, heart attacks, hypertension, heart failure, venous thromboembolism and peripheral artery diseases (GBD 2017 Causes of Death Collaborators, 2018). These diseases cause significant morbidities such as disability and decreased functional capacity. Cancer is often life threatening when not diagnosed early, and requires therapy in the form of chemotherapy or radiotherapy. Treatment is not only expensive and unaffordable to most people in low and middle income countries (LMIC) (Youlden et al., 2012), but also often leaves individuals debilitated during treatment courses, requiring prolonged time off work and other productive activities (Kamal et al., 2017). DM is a disease of high blood glucose, with significant complications if not treated appropriately which include chronic kidney disease and CVD complications such as those described above (Harding et al., 2019). CKD treatment often requires frequent dialysis, which is expensive and leads to loss of time from work (Mushi et al., 2015). CRDs include chronic obstructive pulmonary disease and asthma which require lifelong therapy with expensive treatment modalities such as oxygen, and may lead to CVD complications such as heart failure (Burney et al., 2015).

Given their chronic nature and debilitating complications if untreated, governments, international organisations such as the UN, and donor agencies the world over are in search of solutions to curb the rise of NCDs, and it's devastating impact on human life and global economies.

1.2.2 The human cost of non-communicable disease

NCDs are the leading causes of death globally, responsible for 73% of all deaths in 2017 (GBD 2017 SDG Collaborators, 2018). The four major NCDs described above account for 80% of all these deaths (NCD Countdown 2030 collaborators, 2018). LMICs shoulder the major burden of global mortality, accounting for 80% of NCD deaths (Nugent et al., 2018). WHO estimates that by 2025, mortality from NCDs will rise by 17% globally, and 27% in the Africa region.

In sub-Saharan Africa, an epidemiological shift is in progress, with urbanisation leading to higher exposure of populations to NCD risk factors such as tobacco smoking, harmful alcohol use, poor diet, and physical inactivity. Consequently, the burden of NCDs is on the rise. For example, prevalence of diabetes mellitus rose from 3.4% to 8.9% between 1980 and 2014 (NCD Risk Factor Collaboration (NCD-RisC) – Africa Working Group, 2017). Mortality from cardiovascular disease rose by 81% from 1990 to account for 11.3% of all deaths in 2013 (Mensah et al., 2015). In total, between 1990 and 2017, the proportion of disability adjusted life years attributable to NCDs, a measure of morbidity, rose from 18.6% to 29.8% while the proportion of mortality attributable to NCDs in sub-Saharan Africa rose from 40% to 55% between 2002 and 2019, and is estimated to reach 60% by the year 2030 (Dalal et al., 2011; Gouda et al., 2019)

The unequal burden and progress in addressing NCD mortality is thought to relate to varying levels of investment in strengthening the healthcare infrastructure required to diagnose and treat NCDs, such as the setting up and maintenance of cancer treatment centres (Stefan, 2015), and the availability of essential medicines for the treatment of NCDs (Rockers et al., 2018; Wirtz et al., 2017). High income countries (HICs) have invested in health systems strengthening while LMICs have lagged behind due to their limited resources, dependence on development assistance for health (DAH), and competing health priorities such as the HIV/AIDS pandemic (Jamison et al., 2018; Piatti-Fünfkirchen et al., 2018). With this in mind, there has been a call to action to national governments the world over to increase investment in health to tackle the human cost of NCD, particularly given the devastating economic impact on individuals, households and countries reviewed below.

1.2.3 The economic cost of non-communicable disease

NCDs deplete financial resources from individuals and households. Catastrophic spending on healthcare for some NCDs e.g. cancer occur in up to 60% of households, driving them into poverty (Alam & Mahal, 2014; Jan et al., 2018). Jaspers and colleagues reported that catastrophic healthcare spending for care of NCDs occurs in up to 84% of affected households (Jaspers et al., 2015), regardless of the income level. Jan and colleagues found that catastrophic healthcare spending rose to up to 92% of households when considering individuals with NCDs in the LMIC settings of Tanzania and India (Jan et al., 2018). Such spending includes out of pocket (OOP) payments to access NCD care, as well as premiums for private insurance cover. NCD care becomes more expensive for individuals should

they develop a complication of untreated NCD e.g. a heart attack following untreated hypertension, or CKD following untreated DM (Mushi et al., 2015). This not only depletes households of finances spent on obtaining care for individuals, but it also redirects these resources from potential alternative consumption, savings and investments which could translate to increased GDP and per capita income (Jan et al., 2018).

Over 40% of deaths from NCDs occur in individuals aged 70 and younger, with the majority (80%) of these premature deaths occurring in LMICs (Nugent et al., 2018). This loss of labour and productivity as a result of death, coupled with that lost from disability from NCDs such as stroke, prolonged time off work due to hospitalisation and treatment complications (for example, among CKD patients getting dialysis, or cancer patients getting radiotherapy) stifles economic growth, posing a significant threat to socio-economic development (Jan et al., 2018).

1.2.4 Access to quality healthcare and amenable mortality

NCD care requires lifelong access to quality care to avert amenable mortality and morbidity. Two concepts are inherent in the statement "access to quality healthcare". Access refers to the availability and affordability of healthcare services, and largely relates to healthcare utilisation by a populace (Gulliford et al., 2002). Access incorporates four key domains as highlighted by Gulliford et al, first, that health services are available to a population at need, which incorporates the availability of health workers and health facilities, geographical considerations and the associated direct and indirect costs of physically accessing the services. Second, available services must be usable by the population, that is, they must be both affordable and acceptable. Third, that the use is in a timely fashion to enable prevention, management and treatment of disease in order to prevent unnecessary death and disability. Fourthly, and overarching the three domains above, that access is equitable – enabling all those in need to receive health services.

Quality modifies access by measuring the effectiveness of healthcare services (GBD 2016 Healthcare Access and Quality Collaborators, 2018). Quality for example, refers to whether health facilities not only have available staff, but that the staff is sufficiently skilled (Kruk et al., 2018) or that available medications are not sub-standard or falsified (Tran et al., 2017).

Amenable mortality refers to deaths that should not occur in the presence of quality healthcare (Nolte & McKee, 2008). Access to quality care is a key health policy tool to prevent amenable NCD mortality through the enabling of health services that promote and maintain health among healthy people at risk for NCD, prevention of NCD related complications through appropriate management, and decreasing unnecessary disability and premature deaths. The Health Access and Quality Index (HAQI) is a unique measure that enables assessment of both of these concepts in a single measure – ranging from 0-100, with 100 denoting the highest level of access to quality healthcare (GBD 2016 Healthcare Access and Quality Collaborators, 2018).

1.2.5 Country income groupings

The World Bank groups countries based on their gross national income (GNI) per capita into four categories: low income (≤ 1,035 USD), lower-middle income (1,036-4,045 USD), upper middle income (4,045 – 12535 USD) and high income (≥12536 USD) (Neil Fantom & Umar Serrajudin, 2016). Countries are reclassified every year with new groupings announced on July 1. GNI per capita is expressed in US dollars from the previous year, converted from local country currency based on the atlas methodology – a three-year average of the official exchange rates.

While the income groups reflect country social-economic development, they do not do so fully. Limitations of the methodology include the inability to capture the contribution of informal economic activity in GNI determinations, a problem that may underestimate economic development in low and lower middle income economies where the informal sector is large (Jerven, 2013). Nevertheless, the World Bank Income grouping method is the standard approach to classifying countries based on wealth (Neil Fantom & Umar Serrajudin, 2016).

1.2.6 Guiding policy frameworks

The sustainable development goals adopted by all 193 country members of the United Nations in 2015 aim at partnering to build a peaceful and prosperous world for all people in the planet by 2030. SDG 3, which focuses on improving overall health, states: '*ensure healthy lives and promote well-being for all at all ages'*. Specifically, SDG 3.4 focuses on NCD and states: '*reduce by one third the premature mortality from non-communicable diseases through prevention and treatment…*' As of 2017 however, no country in the world was on track to meet SDG target 3.4 (GBD 2017 SDG Collaborators, 2018).

Nugent and colleagues have demonstrated an integral relationship between SDG 3.4 and other key SDGs related to poverty reduction, universal education, inequality reduction and economic growth among others, emphasising that addressing SDG 3.4 is crucial to the accomplishment of related socio-economic development SDGs (Nugent et al., 2018).

In Africa's Agenda 2063, goal 3 in the first 10-year implementation plan (2014-2023) aspires at a healthy and well-nourished society. While the specific health related targets spelled out in the first 10-year implementation plan focus on reductions in maternal mortality, neonatal mortality and mortality from HIV and Malaria, the proposed strategies which include expanded access to quality healthcare services, increased investment in the healthcare workforce, and promotion of healthy lifestyles to decrease the incidence of NCDs, all would translate to improved care for NCDs and potentially reduced mortality from NCDs.

Kenya has embarked on a journey to achieve Universal Health Coverage (UHC) by 2022. UHC is a plan that ensures all individuals can access essential health services equitably and without suffering catastrophic spending (Global Burden of Disease Health Financing Collaborator Network, 2018).

Kenya piloted UHC in four counties in December of 2018, that is, in Kisumu, Machakos, Nyeri and Isiolo. Part of the urgency of having UHC as a key policy focus in the country is the recognition of the inequalities in accessing NCD care in Kenya as a result of varying income levels. UHC aims at reducing the prevalence of NCD through health promotion and prevention efforts at the primary care level (community, dispensaries, health centres) and enabling affordable access to care for people with NCD to prevent death and disability of associated complications such as heart attacks.

In summary, policy frameworks to address the health and economic threat that NCDs pose are at the international, regional and country level. To attain the above targets in health will require significant and sustained expenditure at both the national and international level dedicated to health financing (Stenberg et al., 2017).

1.2.7 Health financing

Heath financing refers to the "*function of a health system concerned with the mobilization, accumulation and allocation of money to cover the health needs of the people, individually and collectively, in the health system*". There are four sources of health financing in sub-Saharan Africa: i) domestic government health spending; ii) prepaid private spending (e.g. insurance premiums); iii) out-of-pocket spending (e.g. user fee for a health service); and iv) development assistance for health (Micah et al., 2019). Sources (ii) and (iii) are collectively termed private expenditure on health (PEH).

Government health spending represents a crucial pillar to overall development of the health infrastructure in a country, both in terms of human resources for health, and physical infrastructure required for a functioning healthcare system e.g. diagnostic capacity, access to essential medicines and access to treatment procedures (Nugent et al., 2018; Wirtz et al., 2017). In addition, government health spending is a more equitable tool to deliver universal healthcare, as it shields low income populations from being excluded from accessing health services due to high insurance premiums and out-of-pocket payments (Jan et al., 2018; Niessen et al., 2018). Reliance on development assistance for health (DAH) is largely seen as an unsustainable form of health financing and runs counter to regional policy guides on increasing domestic financing for development, as set forth in the Addis Ababa Action Agenda.

Domestic government expenditure on health (GEH) in Africa is currently low, ranging from 0.3% in the Democratic Republic of Congo, to 5.6% in Namibia. OOP payments comprises 40% of total healthcare expenditure in Africa to plug the deficit, putting individuals at risk for catastrophic healthcare spending and/or death and disability from untreated NCDs (Niessen et al., 2018; Piatti-Fünfkirchen et al., 2018).

In response to the growing infectious disease epidemic at the turn of the millennium, heads of African states pledged to work towards allocating a minimum of 15% of their national budgets towards improvement of the health sector, recognising the key role that government spending on healthcare has

towards improving health infrastructure, and subsequently, health outcomes, a theme that has been re-emphasised in the UN SDGs whereby SDG 3a aims at substantially increasing health financing in developing countries. Current mean spending on health as a percentage of GDP is 5.6% in LMIC, lower than the target 7.5% needed to achieve UHC and SDG health goals, and a far cry from the 15% set by the Abuja declaration (Stenberg et al., 2017).

Underinvestment in health by governments impacts access to quality healthcare in several ways (Niessen et al., 2018). First, it leads to a lack of adequate infrastructure for the diagnosis and treatment of common diseases. Secondly, fiscal underinvestment leads to increased private expenditure on health, thereby contributing to inequitable access to care since only those individuals able to make OOP payments or procure insurance are guaranteed access to quality care. NCD care in particular, poses a key challenge if relying on PEH. This is because the chronic nature of NCDs requires sustained access to health services, often over an individual's entire life after diagnosis e.g. medicine will be taken for life for a disease like hypertension (Jan et al., 2018). In addition, diagnostic and treatment modalities for cancer are particularly expensive, and unaffordable to most people in sub-Saharan Africa (Stefan, 2015). Consequently, low income populations are less likely to sustainably afford the high OOP payments or insurance premiums required to care for NCDs and as such, are highly dependent on government health system strengthening efforts to increase access to quality health services for NCD care (Piatti-Fünfkirchen et al., 2018). These effects are part of the reason why there has been a global push since 1978 at the Alma Ata declaration to achieve UHC (Hone et al., 2018).

Health financing for control of NCDs has received special emphasis due to the growing burden of NCDs and economic burden this poses to countries (Jan et al., 2018), their chronic nature which impose unique barriers to sustaining care through private expenditure (Youlden et al., 2012), and the persistence of communicable diseases such as AIDS, tuberculosis and Malaria which continue to attract majority of DAH (Njuguna et al., 2018). Subsequently, GEH is thought to be the most sustainable path to health financing for NCD control, while at the same time being cognizant of the government fiscal space, that is, without adversely affecting other important government services (Meheus & McIntyre, 2017). One approach to this is to set reasonable targets that meet this balance for countries which ensures that a minimum set of effective and cost-effective interventions have been deployed for the prevention and control of NCDs. Current proposed targets based on empirical research using infant mortality rates and domestic GEH levels in the MDG era (Meheus & McIntyre, 2017) set this at 5% of GDP, while modelling studies that forecast required spending in the SDG era to achieve UHC (Stenberg et al., 2017) propose a more ambitious 7.5% of GDP.

The impact of inadequate GEH has been demonstrated on several disease outcomes and has been associated with worse outcomes in infant, under five, and maternal mortality, as well as on life expectancy (Li & Yuan, 2019; Noel, 2017). These findings have translated into increased investment

in health and have led to significant progress, including the attainment of MDG 4: reducing child mortality by more than two thirds as of 2015 (Moucheraud et al., 2016).

1.3 Problem statement

Non communicable diseases are the leading causes of death and disability globally, responsible for 73% of all deaths in 2017 (GBD 2017 SDG Collaborators, 2018), the most recent year for which estimates are available. Death and disability leads to losses in productivity which hampers economic growth, particularly in developing countries which shoulder 80% of all premature deaths from NCDs, that is, deaths occurring among individuals aged less than 70 years (Nugent et al., 2018). Morbidity and mortality from NCDs can be averted through utilisation of healthcare services among at risk individuals, and individuals with disease (Nolte & McKee, 2008), for example, daily use of medication for hypertension can prevent future heart attacks and mortality, however, access to quality healthcare is low in developing countries, leading to disparities in care and higher morbidity and mortality from NCDs (GBD 2016 Healthcare Access and Quality Collaborators, 2018). Furthermore, given the chronic nature of NCDs, the cost of care for NCDs leads to catastrophic spending for individuals and households in the form of out of pocket spending (Jan et al., 2018), and in the long term, is unsustainable for the majority of low and middle income individuals (Alam & Mahal, 2014). Calls for universal healthcare coverage recognise the crucial need for government investment in health to protect individuals and households from catastrophic healthcare spending associated with NCDs, improve access to quality NCD care, and decrease mortality from NCDs for their population, and government expenditure on health is seen as the key policy tool to achieve this (Piatti-Fünfkirchen et al., 2018).

Government expenditure on health as a percentage of gross domestic product varies globally, ranging from 0.3% in the Democratic Republic of Congo to 13.9% in the USA as at 2016 according to the World Bank. The relationship between government expenditure on health and health outcomes has been explored for life expectancy, infant mortality, under 5 mortality, and maternal mortality, where increased government expenditure on health is associated with reduced mortality and increased life expectancy. The relationship between government expenditure on health and mortality from non-communicable disease however, has not been adequately described at the global level (Marton et al., 2015). Secondly, GEH has been hypothesised to increase personal access to quality healthcare, a crucial pathway to improved health outcomes in NCD care, but few studies have evaluated this relationship (GBD 2016 Healthcare Access and Quality Collaborators, 2018). Finally, prior research has been limited to specific regions e.g. East Africa (Bein et al., 2017) or the EU region (Maruthappu et al., 2015) which often have similar levels of healthcare spending based on their GDP, and may miss to identify important moderating effects of country level income on the relationships between government expenditure on health, NCD mortality, and access to quality healthcare.

From a policy perspective, while several targets for domestic GEH have been proposed for governments to work towards, these are based on empirical research using infant mortality rates and domestic GEH levels in the MDG era (Meheus & McIntyre, 2017), or utilising modelling studies to forecast required spending in the SDG era to achieve UHC (Stenberg et al., 2017). While these targets form a crucial starting point, comparison of different health outcomes may lead to inappropriate conclusions on the appropriate spending targets, while modelling techniques have residual uncertainties. Empirical research on domestic GEH targets as they relate to NCD mortality is therefore required to further aid policy making.

To address these research gaps therefore, this study investigates the relationship between government expenditure on health and mortality from non-communicable diseases using panel data analysis of available global data, spanning the period between 2000 and 2016. Secondly, the role of access to quality healthcare as a mediator of this relationship is investigated. Finally, how this relationship is moderated by country income level is assessed for the four World Bank income group classifications (low income, lower-middle income, higher-middle income and high income).

1.4 Overall objective

To assess the relationship between government expenditure on health and non-communicable disease mortality rates across the world

1.5 Specific objectives

i. To investigate the relationship between government expenditure on health and premature mortality from non-communicable diseases
ii. To investigate access to quality healthcare as a mediator of the relationship between government expenditure on health and premature mortality from non-communicable diseases
iii. To investigate the moderating effect of country income grouping on the relationship between government expenditure on health and premature mortality from non-communicable diseases

1.6 Research questions

i. Is there an independent relationship between government expenditure on health and non-communicable disease mortality rates in the world?
ii. Is the relationship between government expenditure on health and non-communicable disease mortality mediated by access to quality healthcare?
iii. Is there a moderating effect of country level World Bank income group classification on the relationship between government expenditure on health and non-communicable disease mortality rates?

1.7 Significance of the study

This study is of significance to academic scholars in that it adds to the literature that aims to understand the relationship between health expenditure and health outcomes. Specifically, given that prior literature on the relationship between GEH and NCD outcomes has focussed on individual countries, this study addresses this gap by being the first study on global level data. In addition, debates continue on the exact causal links between GEH, inequalities in access to quality healthcare, and NCD mortality (Curtis, 2018; Niessen et al., 2018; Stuckler, 2008), this study findings adds to these debates by exploring the role of access to quality care as a causal pathway in the relationship between GEH and NCD mortality.

For policy makers, this study is of significance because a UN interagency taskforce on NCDs has highlighted the need for building investment cases to governments to justify increased spending towards achieving SDG 3.4. In addition, increasing government spending on health is only one policy tool to improving health outcomes, and it's effectiveness may vary depending on factors such as baseline socio-economic development and the effectiveness of governance of public funds. In aid of this policy goal, achievement of the study objectives above is expected to: inform governments of the impact of domestic government spending on health on prevailing mortality rates from NCDs, which are the leading causes of death globally; identify potential gaps and opportunities to better leverage GEH to further address NCD mortality by directing resources towards addressing access to quality healthcare barriers, and; identifying whether different policies in GEH should be in place in different regions based on income groups to better prioritise financial resource use in combating NCD mortality

1.8 Scope

This study focusses on country level rates of NCD mortality deriving from the four major NCDs (cardiovascular disease, cancer, diabetes mellitus and chronic respiratory diseases), country level data on access to quality healthcare, and corresponding domestic GEH. Data is sourced for each of the 193 UN member states that have signed onto the UN SDGs and obtained from the World Development Indicators (WDI) Database, the World Governance Indicators (WGI) Database, the Institute for Health Metrics and Evaluation (IHME) database, and the WHO's global health observatory (GHO) for the years 2000-2016. The global scope of this study is chosen for the following reasons: first, countries in a specific region (e.g. sub-Saharan Africa) tend to have similar levels of domestic GEH, and clustered health outcomes (GBD 2016 Healthcare Access and Quality Collaborators, 2018). This lack of variability would make regression techniques unlikely to identify significant relationships, if indeed they exist. Second, a key focus of this study is to evaluate the moderating effect of country level income on any relationship between domestic GEH and NCD mortality – this objective would not be met if there was only focus on an individual country or region, due to similar income grouping. Thirdly, as an econometric method, panel data analysis is more robust if utilising more units (countries in this case)

and time (years) data. Finally, prior studies have utilised a similar methodological approach successfully (Rana et al., 2018; Ray & Linden, 2020).

1.9 Organisation of the Dissertation

Following the introduction provided in this chapter, Chapter 2 delves into prior relevant research that summarises the relevant theoretical debates and empirical research, and unearths gaps and opportunities amenable to research. Chapter 3 then describes the study methods used in this study. Chapter 4 presents the study results in their entirety, while Chapter 5 discusses the study findings in the context of prior research, and the theory. Chapter 6 provides the conclusion and policy recommendation based on the findings of this study.

Chapter Two: Literature Review

2.1 Introduction

This chapter provides a summary of relevant literature that informs the research questions proposed in this study. It begins by discussing the theoretical framework that guides the study. It then proceeds to review empirical literature around the specific relationship between government expenditure on health (GEH) and disease related mortality, as well as other determinants of mortality. The chapter concludes with a summary of the identified gaps, providing a conceptual framework for the proposed study, and a description of how the study variables will be operationalized to test the research hypotheses.

2.2 Review of theoretical debates

Public health practitioners agree that NCDs are the number one threat to human health globally (Marquez & Suhrcke, 2005), and rightfully so, because NCDs accounted for 73% of all deaths in 2017 (GBD 2017 SDG Collaborators, 2018). The four major NCDs (cardiovascular disease, cancer, diabetes mellitus and chronic respiratory disease) account for 80% of all these deaths (NCD Countdown 2030 collaborators, 2018). In 2016, NCDs were responsible for 61% of the total disability adjusted life years (Chen et al., 2018), a measure of the overall burden of disease that factors in both death and disability. The mortality and morbidity effects of NCDs are a significant impediment to development, considering that there are 8.3 million premature deaths annually, that is, deaths occurring among people aged less than 70 years, from NCDs, with consequential losses on labour and productivity (Nugent et al., 2018).

The morbidity from NCDs detrimentally affects productivity directly and indirectly. Directly, economists have argued that ill health results in days off work and reduced participation in the labour market, with labour losses estimated at 4% and 6% of labour hours from women and men respectively. Indirectly, spouses of ill persons and other close relations may also withdraw from the labour market and/or education opportunities in order to serve as caretakers of the ill persons (Marquez & Suhrcke, 2005). Mortality from NCDs further decreases productivity in a more easily discernible fashion, that is removal of persons who are still of productive potential from the workforce. Indeed, over 40% of deaths from NCDs occur in individuals aged 70 and younger, with the majority (80%) of these premature deaths occurring in LMICs (Nugent et al., 2018). Consequently, the economic costs of premature NCD related mortality are estimated to lead to global losses of 47 Trillion USD between 2010 and 2030. Finally, economists have also argued that the care for NCDs is costly to the affected individual and household, and this leads to reduced disposable income to spend on consumption of non-health related goods and services, savings, and investments, leading to reduced economic potential at the individual, household and national level with consequent decline in national incomes consumption (Bertram et al., 2019).

NCDs as a barrier to economic growth is of particular concern to developing countries, where NCDs occur earlier. For example, the prevalence of NCDs among people aged 60 years and below in low income countries is four times higher than those in high income countries (Kostova et al., 2017). This situation is made direr by estimates of a rising prevalence of NCDs. It is projected that in 2020, NCDs will account for 70% of all deaths in developing countries, 50% of which will be premature (Islam et al., 2014).

Increasing domestic government expenditure on health (GEH) has been cited as a necessary prerequisite to decreasing premature mortality from NCD and achieving SDG 3.4 (Stenberg et al., 2017), however, prior studies used to justify this have utilised forecasting techniques, with few studies utilising existing data to justify a relationship between health expenditure and NCD related outcomes (Marton et al., 2015; Mays & Smith, 2011). Furthermore, the disproportionally high mortality from NCDs, both in overall and premature mortality terms, in lower income countries begs the question of what its drivers are, and how they relate to development. Understanding the effect of GEH on NCD mortality is a crucial first step to determining how effective GEH is as a policy tool in tackling the NCD burden. A discussion of the theoretical underpinning for this relationship, the health production function is presented below. Secondly, two additional theories have been advanced to account both for the disproportionately rising prevalence of NCDs, and its higher mortality in developing countries. The first one is the rise of behavioural risk factors in transitioning economies as they undergo development, while the second one is concerned with socio-economic inequalities that reduce access to quality care for individuals in developing countries. Both are also discussed, in order to elucidate additional theoretical considerations on what role, if any, GEH has on reducing health access disparities and NCD mortality in countries at different development stages.

2.2.1 Health production function theory

The health production function builds on the traditional economics production function which relates the quantity of goods produced and the quantity of inputs required to produce it, which can be represented by the general simple equation:

$$\mathbf{Y = f\,(k, L)}$$

Where Y is the output, k represents capital, and L is labour.

The original health production model was formulated in 1972 by Michael Grossman (Grossman, 1972; Nixon & Ulmann, 2006). The Grossman model was concerned with individual health, treating good health as an inheritable capital good, that depreciates with time unless investment is made into it, and can be represented as:

$$\mathbf{H = f\,(x)}$$

Where H is individual health output, and x is a vector of individual health inputs that include nutritional intake, education, income, public goods consumption, health seeking behaviour, genetic and environmental endowment.

Several studies have gone on to utilise the Grossman model to evaluate relationships between health outcomes and health expenditure (Arthur & Oaikhenan, 2017). However, as argued by (Nixon & Ulmann, 2006) application of the Grossman model to studies evaluating health outcome and health expenditure relationships using aggregate level data may yield misleading findings, since assumptions in the Grossman model consider individual level health. For example, they highlight that health is a normal economic good, which individuals invest more of their income into, as their income rises, while at the aggregate level, health becomes a luxury good, such that countries are unlikely to prioritise it, until higher priority needs at the macro level such as national security, are first addressed.

Subsequently, researchers have built on the Grossman model to produce an appropriate health production function at the macro-level, while retaining the theoretical grounding of the Grossman model. In this instance, the overall healthcare system is treated as a production unit aimed at producing good health as its output (Arthur & Oaikhenan, 2017), with the various resources that go into the healthcare system considered as the inputs. Furthermore, acknowledging that health outcomes are also affected by other socio-economic and environmental determinants, these are often also included as inputs, albeit as control variables when the key relationship under investigation is that between health expenditure and health outcomes. Fayissa and Gutema (Fayissa & Gutema, 2008), for example, derived a health production function for SSA as below:

$$\mathbf{H=f\ (Y,\ S,\ V)}$$

Where H, the health output is aggregate health defined by country-level life expectancy at birth, and their inputs, Y, S and V, are vectors of per-capita social, economic and environmental inputs that determine life-expectancy at birth.

Despite an overlap in the nature of the variables in the two models, for example, per capita income in the health production function can be compared to individual income in the Grossman model, Nixon and Ulmann's arguments above still hold, and in addition, they add that in translating health research findings to policy decisions, the macro-level health production function is more appropriate. The main objective of this proposed study is to investigate how government expenditure affects NCD mortality, the goal being to evaluate its relevance as a policy tool in achieving SDG 3.4. It plans on utilising aggregate data at the country level, and therefore, adopts the health production function as proposed by Nixon and Ulmann.

Depending on the health outcomes of interest, researchers have then specified the health production function based on the key variables that they theorise affect their chosen health outcome. Makuta and

O'Hare, for example, in their study in SSA, specify a health production function where the outputs are life expectancy at birth and under-five mortality, and the inputs are public spending on health, quality of governance measures, female literacy rate, and sanitation (Makuta & O'Hare, 2015). Similarly, other studies, most of which are reviewed in the next section on empirical work, have utilised a similar approach to evaluate the association between health expenditure and health outcomes such as infant mortality, maternal mortality, under-five mortality and life expectancy (Akinlo & Sulola, 2019; Fayissa & Gutema, 2008; Nicholas et al., 2016; Novignon & Lawanson, 2017).

The health production function theory thus provides the theoretical framework underpinning objective one of this study which investigates the relationship between government expenditure on health and premature mortality from NCDs.

With this overall framework in mind, the next two theoretical discussions dig deeper into the underlying assumptions around health production in NCD mortality as far as NCDs are concerned, pointing out key gaps of understanding.

2.2.2 Economic transition theory

Beaglehole and collegues argue that the majority of NCDs have five shared risk factors: tobacco use, consumption of foods high in saturated and trans-fats, consumption of food and drinks high in salt and sugar, physical inactivity, and harmful consumption of alcohol (Beaglehole et al., 2011). Economic growth enables and promotes the urbanisation, technological advancement and ability to 'consume' all the above risk factors. Urbanisation encourages more sedentary lifestyles, for example, instead of having to walk or use bicycles from one place to the next, individuals can now afford to drive or be driven to various destinations. Technological innovations have enabled cheap production of unhealthy foods such as sugar sweetened beverages, and inclusion of trans-fat in foods, making unhealthy diets more affordable, particularly among low income individuals (Lent et al., 2014).

Stuckler adds to this debate by positing that macroeconomic and macrosocial factors are key drivers of NCD mortality (Stuckler, 2008). He commences with a health transition model from a healthy person, to one at behavioural risk, then clinical risk, morbidity and finally mortality. To illustrate this, a healthy person could consume a high salt diet (behavioural risk) that leads to hypertension (clinical risk). Hypertension can progress to a disabling haemorrhagic stroke (morbidity) which if not intervened on, could lead to death (mortality). Stuckler argues that economic flows, economic growth, and technological advances shifts healthy individuals progressively towards the right of this spectrum. Economic flows permit movement of unhealthy diets to developing countries. Economic growth raises incomes and changes consumption behaviour and lifestyle habits, with strong marketing increasing the desirability of unhealthy habits by promoting them as status symbols, for example dining out is preferred to home cooked meals, while being driven is preferred to walking or riding a bike. Finally, technological flows shift labour from an agrarian society to one related to intellectual property

production – leading to more sedentary workplaces, more job opportunities in urban areas, and migration from rural areas.

These authors successfully argue that economic growth leads to the rise of behavioural risk factors and subsequently, the growth of NCDs. They however fail to discuss how this subsequently drives mortality rates. Stuckler's model for instance, explains the rising prevalence of NCDs, but doesn't explain the rising morbidity and mortality. Furthermore, he posits that economic growth has a varying effect on behaviour and NCD mortality based on the wealth of the country, that is, that these factors increase mortality in low income countries, do not affect mortality in middle income countries, and decrease mortality in high income countries (Stuckler, 2008). Indeed, his supporting empirical work employing multivariate regression on cross sectional data supports this theory, an interesting finding which he supports by proposing that individuals in developing and developed countries change their lifestyle habits differently in response to economic growth, with those in developed world adopting healthy habits and the opposite happening in the developing world. Assuming this is true, however, it would still explain a high prevalence, but not a high mortality from NCDs, because NCDs are treatable for the most part, so long as there is access to quality healthcare (Kruk et al., 2018). Nevertheless, the economic transition theory suggests that there are expected differences between countries in different economic blocks as far as NCD outcomes are concerned, and as such form the theoretical underpinning for objective three of this study, which examines the moderating effect that country income grouping may have, on any relationship between government expenditure on health and premature NCD mortality.

2.2.3 Socio-economic inequality theory

The acquisition of an NCD should not equate to a death sentence (Kruk et al., 2018). Hypertension is treatable with drugs that cost as low as 15 Ksh for a month's dose (Rockers et al., 2018). Among patients with diabetes mellitus, daily use of drugs such as statins significantly reduces the likelihood of future fatal myocardial infarctions (heart attacks) and strokes (Stone et al., 2014). Among patients with a heart attack, timely intervention in the form of percutaneous coronary intervention or coronary artery bypass graft surgery saves lives (Ibanez et al., 2018). Even cancers with the worst prognosis are treatable if diagnosed at an early stage (Hawkes, 2019). These examples have a common denominator that interventions exist that can prevent mortality from NCDs, or at a minimum, prolong life among people with NCDs. The second theory of what drives NCD mortality thus stems from this, and explores how a country's or individual's wealth may affect their ability to access these interventions and subsequently, how this affects mortality from an NCD.

Wagstaff argues that there is a complex relationship between health and wealth (Wagstaff, 2002). On the one hand, as discussed earlier, ill health decreases productivity directly and indirectly, reduces disposable income for education, savings and investments, and decreases individual, household and country wealth. On the other hand, lower socio-economic status predisposes individuals to unhealthy

habits such as the consumption of low cost, high calorie fast foods. There is therefore a clustering of the behavioural risk factors described by (Beaglehole et al., 2011), in people of low socio-economic status, not just those with increased income as described by (Stuckler, 2008), leading to a higher prevalence of NCDs among this vulnerable population, a theory also supported by (Niessen et al., 2018).

Secondly, lower socio-economic status often accompanies lower education status, with a causal relationship in both directions (Cutler & Lleras-Muney, 2010). Low education predisposes poorer individuals to lack of knowledge on healthy lifestyle habits and the harm of unhealthy habits, limited awareness of NCD risk factors, and limited awareness of how NCDs present, that is, early warning signs for an NCD. This leads to a lower rate of early diagnosis of NCDs, meaning that by the time a diagnosis is made, there is already substantial morbidity. For example, while uncomplicated hypertension can be treated at relatively low cost, it is common for the first diagnosis of hypertension to be made in an individual in an LMIC to be on presenting to a hospital with a disabling stroke, which is more costly to manage, and has a high mortality risk (Yan et al., 2016).

Thirdly, even when early diagnosis is made, (Wagstaff, 2002) argues that poverty limits freedom to access health services needed to care for NCD. By virtue of their chronic nature, NCDs require lifelong care. For example, a patient with hypertension will likely need blood pressure control medications for the rest of their life (Jan et al., 2018). Patients therefore face a high cost burden to treat NCDs over a lifetime compared to acute conditions such as Malaria, leading to many poor people without the capability to do so and foregoing treatment. Wagstaff posits that it is this requirement that introduces inequalities in sustaining care of NCDs and subsequently, leads to worse outcomes in people of lower socio-economic status. Even within individual countries, poorer individuals face worse health outcomes than their wealthier counterparts. In support of this theory, (Curtis, 2018) recently concluded that there is agreement on the fact that socio-economic inequalities affect health outcomes. However, he adds that the gap that persists in this debate is understanding how exactly this relationship is mediated, that is the specific causal pathway, in order to understand what government interventions are appropriate to address this.

A key policy tool that has been advanced by authors, and accepted by national governments, and world bodies such as WHO and the UN, is the scale up of universal healthcare (Global Burden of Disease Health Financing Collaborator Network, 2018; Jamison et al., 2018; Kruk et al., 2018; Wirtz et al., 2017). This argument simply builds on the preceding discussion on eliminating the disparities in sustainably accessing healthcare for individuals of low socio-economic status with NCDs. The backbone for universal healthcare is widely recognised to be domestic government expenditure on health. However, to date, there has been significant underinvestment in NCD care, particularly by governments in developing countries (Piatti-Fünfkirchen et al., 2018).

(Marquez & Suhrcke, 2005) have posited that this lack of investment in combatting the NCD crisis is the absence of empirical, rigorous economic data, stating that "public health experts have failed to make the case for adequate funding." Other authors have supported this view, highlighting that economic evidence is needed to spur the kind of multisectoral action at the national level that will prevent and control NCDS (Bertram et al., 2019; Etienne, 2018). Consequently, they have called on countries to conduct economic analyses, composed of both return on investment analysis and institutional and context analysis in order to provide both the economic and political "lay of the land" to enable NCD prevention and control action.

Recalling that the health production function theory is based on a production function that considers health as an output of a health system with various inputs comprised of the health system's resources, the health system resources in this case may be viewed in the traditional economic production function as labour (healthcare personnel and ancillary staff required for the health system to work) and capital (financial resources, infrastructure, diagnostic and treatment technology and medicines). In applying the health production function to expenditure based research, health expenditure is considered the primary economic input since labour and all other components of the health system require expenditure to be deployed within the health system, assuming social and environmental inputs are held constant. All these components are theorised to improve access to quality healthcare, and lend themselves to an investigation of how well government expenditure on health may improve, if at all, access to a healthcare system, that is of sufficient quality to prevent amenable mortality.

Understanding the role of health inequalities in assessing the relationship between government expenditure on health, and health outcomes was previously complicated by the conceptual and methodological limitations of measuring inequalities in health access (Curtis, 2018; Leon et al., 2001). The introduction of the healthcare access and quality index (HAQI) score which measures personal access to quality healthcare, coupled with the availability of longitudinal data on health expenditures and NCD mortality, may potentially address this prior limitation (Curtis, 2018; GBD 2016 Healthcare Access and Quality Collaborators, 2018), creating a platform on which assessment of the impact of government expenditure on NCD outcomes can be evaluated. The socio-economic inequality theory is therefore the framework underpinning objective two of this study which investigates access to quality healthcare, a measure of health inequality, as the mediating pathway between government expenditure on health and premature mortality from NCDs.

The next section builds on these theoretical debates with empirical work.

2.3 Review of empirical literature

Section 2.3 focuses on prior work evaluating the relationships between health expenditure, health outcomes, and access to quality healthcare, and other determinants that affect these relationships.

Reviewed studies are organised starting with regional studies (developed regions, developing regions, and the African region), global level studies, and finally individual country studies.

2.3.1 Health expenditure and health outcomes

The majority of studies evaluating the relationship between health expenditure and health outcomes have focussed on outcomes such as infant mortality, under 5 mortality, maternal mortality, and life expectancy (Somé et al., 2019). This was justified and informed by the UN Millennium Development Goals which had a particular focus on reducing maternal and child mortality (Moucheraud et al., 2016). Their findings have been mixed, yet offer translatable insights that are worth highlighting.

(Rahman et al., 2018) in their panel data analysis study of 15 countries in the SAARC-ASEAN region evaluated the unique effect of GEH and PEH on health outcomes. Using data spanning 1995-2014, they found that GEH increased crude death rate, decreased infant mortality, but had no effect on life expectancy. PEH on the other hand, reduced crude death rate and infant mortality, but also had no effect on life expectancy. In addition, they reported that the effect of PEH on reducing infant mortality was higher than that on GEH. These findings suggest that how GEH is used, i.e., good governance, may be a more important predictor of health outcomes than how much the GEH is (Akinlo & Sulola, 2019). The authors however did not include any governance explanatory variables to explain this variation. Another limitation of the study is the use of crude death rate as a health outcome variable which while helpful in understanding overall death rates – mixes different causes of death and fails to account for age and sex differences. Age and sex standardised death rates that disaggregate different causes of death (e.g fatal injuries and accidents, disease related death etc) make for more meaningful comparisons (GBD 2017 Causes of Death Collaborators, 2018).

Akinlo et al. reported that increasing GEH was associated with higher (worse) under-5 and infant mortality in a panel data analysis study of 10 sub-Saharan Africa countries for the period 2000-2008. In contrast, they found that increasing total health expenditure (THE), which was defined as both GEH and private expenditure on health (PEH), was associated with reduced under-five and infant mortality, concluding that GEH was more likely to be inefficiently used therefore not translate to improved health outcomes (Akinlo & Sulola, 2019). Despite this assumption, the authors did not include any variables to control for government efficiency to support their conclusion.

In another panel data analysis study including 48 African countries for the period 2000-2015, Some et al. found that THE had a significant inverse relationship with infant mortality, under-five mortality (U5MR) and maternal mortality and a positive relationship with life expectancy (Somé et al., 2019). A limitation of the study was the lack of disaggregation of GEH and PEH to assess for the specific effect of both on health outcomes. Similar findings and limitations were found in the panel data analysis study by (Nketiah-Amponsah, 2019) that included 46 countries for the period 1996-2015 for three health outcomes: under-five mortality, maternal mortality and life expectancy.

Bein and collegues found that increasing THE led to increased life expectancy, and reduced neonatal, infant and under five mortality in a panel data analysis study of 8 East African countries for the period 2000-2014 (Bein et al., 2017). A key limitation of the study was the poor model specification which only assessed one independent variable (health expenditure) and included no control variables, resulting in low R-square values that make it difficult to draw conclusions from the study. In addition, they did not disaggregate the impact of GEH and PEH on the health outcomes.

Novignon et al reported that in a panel data analysis study of 45 African countries for the period 1995-2011, increasing THE led to a decrease in infant, under-five, and neonatal mortality. In evaluating the unique effects of expenditure based on its source, they further found that GEH and not PEH, significantly improved health outcomes (Novignon & Lawanson, 2017). Similarly, (Nicholas et al., 2016) reported that in a panel data analysis study of 40 sub-Saharan Africa countries for the period 2000-2010, increasing GEH was associated with reduced infant and under-five mortality while PEH had no significant association with either child health outcomes.

A key limitation of the above studies is the focus on an individual region, which may have less variability in health spending and health outcomes, and in addition may not permit a meaningful evaluation of the moderating effect of income on the relationship between health expenditure and health outcomes.

At the global level, Rana et al. reported that THE was significantly associated with life expectancy, infant and under-five mortality, but not with maternal mortality (Rana et al., 2018). Their panel data analysis study included data from 1995-2014 for 161 countries. The authors proposed that other factors such as road infrastructure and access to hospitals may better explain variation in maternal mortality, while child mortality outcomes may be more sensitive to health expenditure due to direct impact of immunization programs and other primary care activities. A key limitation of the study however was the lack of disaggregation between GEH and PEH.

A second global level panel data analysis study by Ray and Linden overcame this limitation. These authors included data from 195 countries and territories from 1995-2014 (Ray & Linden, 2020). They found that GEH had a positive correlation with life expectancy, and an inverse correlation with infant mortality. They also found that PEH only had significant correlation with life expectancy in poor countries but not in rich countries, and had no correlation with infant mortality in either. The authors therefore concluded that GEH was a more effective policy tool to improving health outcomes.

The glaring gap in the literature from the above review is the lack of global or regional data on the relationship between health expenditure and NCD outcomes, the leading cause of death and disability globally (GBD 2017 Causes of Death Collaborators, 2018). Only two studies were found to address this question which are highlighted below.

In the first of these studies, (Marton et al., 2015) used panel data analysis and included data from 159 counties in Georgia, USA spanning the years 2000-2011. They reported that increased public health spending was associated with increased early deaths, including increases in heart disease, diabetes mellitus and asthma related deaths. The authors hypothesised that their negative findings may have been due to either ineffective administration of public money earmarked for health or a simultaneous decrease in PEH, however they did not control for either governance effectiveness or PEH, a key limitation of their study. A contrasting study in the USA using panel data analysis of national data for 1993-2005 found that a 10% increase in public health spending in the USA led to a significant decrease in cardiovascular disease, diabetes mellitus and cancer mortality by 3.2%, 1.4% and 1.1% respectively (Mays & Smith, 2011). The findings from these studies however are not extrapolable to other global settings as they focus on an individual high income country (HIC).

The above studies also highlight the important role of other determinants of health outcomes such as private expenditure on health, education level, GDP per capita, and governance which may be confounders. These are discussed in detail in sections 2.3.3 to 2.3.6.

2.3.2 Health expenditure and access to quality healthcare

Two concepts are inherent in the statement "access to quality healthcare". Access refers to the availability and affordability of healthcare services, and largely relates to healthcare utilisation by a populace. Quality modifies access by measuring the effectiveness of healthcare services (GBD 2016 Healthcare Access and Quality Collaborators, 2018). Quality for example, refers to whether health facilities have sufficiently skilled healthcare staff (Kruk et al., 2018) or that available medications are not sub-standard or falsified (Tran et al., 2017). Access to quality care is a key health policy tool to prevent amenable mortality, i.e. deaths that should not occur in the presence of quality healthcare (Nolte & McKee, 2008).

In a landmark study, Kruk et al evaluated the impact of low utilisation or low quality of healthcare in 61 representative LMIC countries in 2016 (Kruk et al., 2018). They found that of 19.3 million total deaths, 8.6 million (45%) were amenable through healthcare intervention. Of these 8.6 million amenable deaths, 3.6 million (42%) were as a result of the lack of access to healthcare, while the majority 5 million (58%) were due to low quality care among patients who did access healthcare services. Furthermore, CVD deaths comprised 2.9 million (33%) of the amenable deaths, and of these, 84% were due to poor quality care. Amenable cancer deaths (477000) were more commonly caused by the lack of access to healthcare (89%) than low quality care (11%). In addition, the authors reported that poor quality care led to 224 million years of life lost, highlighting a significant blow to economic productivity in these LMICs. An earlier study of OECD countries found amenable mortality was 23% and 30% among men and women respectively (Nolte & McKee, 2008), lower than the 45% reported in

this study, and highlighting that lower income countries have more 'room for improvement' to prevent amenable mortality.

GEH represents the bulk of the funding by which public healthcare infrastructure is established and maintained in a country. According to (Nicholas et al., 2016), GEH provides the health "inputs" – physical infrastructure (both buildings that serve as health facilities, as well as diagnostic equipment), human capital (training and remuneration), and essential drugs for the treatment of disease. This provides the base from which other health financing resources enhance access to healthcare e.g. DAH to fund specific programs such as vaccination efforts using the human capital trained and supported by GEH, or OOP payments enabling access to medicines stocked at health facilities, but not provided for free.

The availability of these health inputs has been correlated to important health outcomes related to access to quality care. Vedanthan et al. reported that both the health worker density and mean hypertension treatment rate rose with income group increases in their global level study of 68 countries (Vedanthan et al., 2019), and found a significant association between health worker density (input) and hypertension treatment rates (health outcome). In the study by (Nketiah-Amponsah, 2019) focussing on 46 African countries, increased physician population was associated with increased life expectancy and reduced under-five mortality.

Recently however, the Institute for health metrics and evaluation (IHME) has introduced a novel comprehensive measure of access to quality healthcare – the health access and quality index (HAQI), which measures access to personal quality health care on a scale of 0-100, with 0 being the worst and 100 being the best (GBD 2016 Healthcare Access and Quality Collaborators, 2018). As of 2016, Norway had the best HAQI (96.6) while that of the Central African Republic (CAR) was the worst globally (18.6). In addition, the authors found that best HAQI measures were concentrated in Europe while most of the worst performers on the HAQI were in sub-Saharan Africa.

This global level study also evaluated the relationship between healthcare expenditure and HAQI and found that both THE and GEH were significantly positively associated with HAQI, while health inputs such as both the physical (available hospital beds) and human capital (staff) were positively associated with HAQI. The study did not evaluate the relationship between HAQI and PEH, the relationship between HAQI and NCD mortality, and did not examine the moderating effect of country income on any of the relationships they examined. The authors proposed a need for other evaluations into the relationships between other health financing measures and HAQI (GBD 2016 Healthcare Access and Quality Collaborators, 2018).

2.3.3 Private expenditure on health and health outcomes

PEH refers to individual OOP payments and insurance premiums made towards the purchase of insurance by individuals. Higher PEH is expected to increase individual ability to access quality care leading to less morbidity and mortality.

In the study from the SAARC-ASEAN region discussed above (Rahman et al., 2018), increasing PEH was associated with decreased crude death rate whereas increasing GEH was associated with increased crude death rate. In addition, PEH was inversely associated with infant mortality to a larger extent than GEH. In the African region, Akinlo and collegues found that increasing THE (which included both GEH and PEH) was associated with reduced child mortality whereas GEH alone was not (Akinlo & Sulola, 2019). While it is reasonable then to conclude that PEH was responsible for the improved health outcomes, the study did not appropriately disaggregate the two expenditures so it is difficult to draw firm conclusions. Additional studies from the African region by (Novignon & Lawanson, 2017) and (Nicholas et al., 2016) reported that PEH had no significant impact on child health outcomes in sub-Saharan Africa. In the only global level study, (Ray & Linden, 2020) reported that PEH had no significant association with infant mortality, and was associated with increased life expectancy only in poor countries.

2.3.4 Education and health outcomes

Education has been proposed to improve understanding of individual health and comprehension of health information such as the importance of adherence to medicines, and how the health system works (Curtis, 2018). In addition, education is an important determinant of income capacity, that is, higher education increases likelihood of earning more income (Somé et al., 2019), and potentially, the ability to spend more on PEH (Grossman, 1972). Specifically in the case of NCDs, more educated people are likely to adopt healthier behaviours such as regular exercise and improved diet, particularly after an NCD diagnosis, and discontinue negative behaviours such as smoking, and harmful alcohol use and sedentary lifestyle (Cutler & Lleras-Muney, 2010).

Three studies in the African region examined the relationship between health outcomes and education. Some et al. found that increasing mean years of schooling was associated with lower infant mortality, under-five mortality and higher life expectancy (Somé et al., 2019). When focussing specifically on female education, they found that more years in primary schooling for women was associated with lower maternal mortality, infant mortality, under-five mortality and increased life expectancy. Similar findings were reported by (Novignon & Lawanson, 2017), who found that higher education, measured as secondary school enrolment as percentage of gross school enrolment, was associated with lower infant and under five mortality rates. Furthermore, (Nicholas et al., 2016) found that higher female literacy rate was associated with reduced maternal mortality, infant and under-five mortality. In the only

global level study available, (Ray & Linden, 2020) found that higher primary education completion rates were associated with lower infant mortality rates, and higher life expectancy.

2.3.5 GDP per capita and health outcomes

The higher a country's GDP per capita (also known as per capita income), the higher an individual's ability to spend on goods and services. This would not only include a higher capacity to spend on healthcare, that is, PEH as described above, but could also indirectly lead to higher ability to spend on better nutrition, better education, water, and sanitation which indirectly affects health outcomes (Nicholas et al., 2016). In addition to reflecting individual capacity to spend, GDP per capita is also the most commonly used indicator of country wealth. Consequently, higher GDP per capita increases the government's ability to spend – both on healthcare and on other indirect determinants of health such as those described above (Nicholas et al., 2016).

GDP per capita was associated with increased life expectancy and reduced infant mortality in a study from Asia but had no effect on crude death rate (Rahman et al., 2018). In the African setting, Akinlo et al reported that increasing GDP per capita was associated with reduced child mortality (Akinlo & Sulola, 2019). Increasing GDP per capita was associated with reduced under-five mortality, maternal mortality and increased life expectancy in another African study (Nketiah-Amponsah, 2019). GDP per capita was associated with reduced infant mortality but had a less significant association with neonatal or under-five mortality in the sub-Saharan Africa study by (Novignon & Lawanson, 2017). In another sub-Saharan Africa study, GDP per capita was significantly associated with improved maternal and child health outcomes (infant mortality and under-five mortality) (Nicholas et al., 2016).

2.3.6 Governance and health outcomes

Increasing GEH is one policy tool to achieve better health outcomes, however, it is dependent on how well assigned expenditure is used as earmarked. GEH is cited as highly fungible and liable to misappropriation (Akinlo & Sulola, 2019). Therefore, similar GEH levels may translate to different effects on health outcomes depending on how efficiently and effectively the money is used.

Several studies, all from the Africa region, have tried to control for the impact of governance when assessing the relationship between health expenditure and health outcomes. Some et al found that improved governance, measured by an author defined metric (index of governance) led to increased life expectancy and reduced maternal mortality (Somé et al., 2019). Interestingly, they found no significant relationship between governance and child mortality, highlighting that governance may be more important for certain health outcomes but not others, or that funds dedicated to some programs may be more fungible than others. The index of governance metric defined by the authors (an average of six World Bank defined measures of governance: voice and accountability, political stability, government

effectiveness, regulatory quality, rule of law, and control of corruption) is however a non-standard measure, which may make it difficult to compare findings across different studies.

Government effectiveness is a measure developed by the World Bank group that rates government performance based on the quality of public and civil service and their independence from political influence, as well as the quality of policy formulation and implementation. Nketiah et al found that increased government effectiveness was associated with reduced under-five mortality but not maternal mortality, and increased life expectancy (Nketiah-Amponsah, 2019). Improved regulatory quality on the other hand was associated with reduced maternal mortality but had no effect on life expectancy or maternal mortality. A significant limitation of this study is the lack of a detailed methodology section to permit contextualisation of the findings. A different measure of governance, government effectiveness as defined by the International country risk guide (ICRG) group, was used by Nicholas and collegues, who found that improved government effectiveness significantly reduced maternal mortality, but had no significant effect on infant or under-five mortality (Nicholas et al., 2016).

2.3.7 Income group effect on the relationship between GEH and health outcomes

Income may be an important moderating variable in the relationship between health expenditure and NCD mortality. (Rana et al., 2018) provide important considerations why this may be the case. First, baseline levels of mortality may vary based on development and income such that with increased development, higher income countries enjoy substantially better health outcomes, such that additional health expenditure has a lower marginal return on health outcomes than would the same amount in lower income countries with worse baseline health outcomes. Second, efficiency of resource use may be higher in developed countries due to availability of better infrastructure and better governance e.g. stronger institutions, lower corruption and misappropriation of funds allocated to the health sector. Thirdly, individual income level differences introduce individual differences in their ability to demand and consume for healthcare through OOP payments and better insurance coverage (Nicholas et al., 2016).

Indeed, in their global level study, (Rana et al., 2018) demonstrated the moderating role of income group on the association between THE and various health outcomes. Infant mortality, under-five mortality and life expectancy were all significantly associated with THE at the global level, yet the relationship was more pronounced and more consistently observed in low income and lower middle income countries. The study however failed to disaggregate GEH from PEH, whose relationship with health outcomes may be moderated differently by income group.

In the other global level study by (Ray & Linden, 2020), GEH significantly increased life expectancy in lower income countries with no significant effect on higher income countries who already had baseline high rates of life expectancy. Furthermore, GEH decreased infant mortality in lower income countries but not in higher income countries while PEH had no effect on infant mortality in lower

income countries, yet surprisingly was associated with higher (worse) infant mortality in higher income countries.

In their country level study in Georgia, (Marton et al., 2015) found that stratifying counties by income group demonstrated that the impact of increased public health funding on heart disease mortality was smaller in high income counties than in low and middle income counties.

2.4 Summary of gaps in the theoretical and empirical literature

The above review reveals that NCDs are responsible for the majority of death and disability globally. In addition, they are a significant barrier to country economic growth as a result of loss of labour through lives lost and disability, loss of capital used up in addressing healthcare needs, and subsequently, reduced productivity. It is also evident that the large burden of NCDs, morbidity from NCDs, and mortality form NCDs is disproportionately borne by people of low socio-economic status, such as those in developing regions such as Africa. The leading theory advanced for this finding is disparities in accessing quality healthcare services which may be unaffordable in the long term for poorer individuals. To address this, universal healthcare has been proposed, with domestic government expenditure on health recommended as the backbone to fund NCD control efforts. A key gap in the theoretical literature however, is how exactly government expenditure on health addresses these disparities, and contributes to reduced NCD mortality.

The relationship between GEH and health outcomes has been extensively evaluated at the regional and global level for important outcomes such as maternal mortality, infant mortality, under-five mortality and life expectancy as reviewed above. This review however, only found two studies evaluating the relationship between health expenditure and NCD related health outcomes, with both of them focussing on a single country, the USA (Marton et al., 2015; Mays & Smith, 2011). There is therefore a key gap in the empirical literature on the relationship between government expenditure on health and NCD mortality rates at the global level.

2.5 Conceptual framework

Building on the theoretical frameworks emerging from (Curtis, 2018; Grossman, 1972; Wagstaff, 2002), it is anticipated that domestic government expenditure on health as a policy tool may improve access to quality healthcare, particularly among individuals of low socio-economic status who are unable to sustainably afford healthcare services for chronic NCDs. Increasing access to quality care can prevent amenable mortality in NCD management, that is, mortality that should not occur in the presence of effective healthcare (Nolte & McKee, 2008). One previous study found a significant relationship between access to quality care and health expenditure in 2016 (GBD 2016 Healthcare Access and Quality Collaborators, 2018).

Reviewed studies also reveal that other determinants of access to quality care and health outcomes including mortality include private expenditure on health, per capita income, education level, and government effectiveness. In addition, country wealth may introduce baseline differences in socio-economic development and consequently, health outcomes, with higher income countries being more developed and having prevailing better outcomes in terms of NCD care. Indeed, LMICs shoulder 80% of the global mortality from NCD (Nugent et al., 2018). Such differences imply that health expenditure may have a different impact on NCD mortality, that is, that country income may moderate any relationship observed between GEH, access to quality healthcare, and NCD mortality. These relationships are summarised in the conceptual framework of this study (Figure 1). Objective one of the proposed work aims to evaluate the relationship between GEH and NCD mortality, the leading cause of death globally. Objective two aims to investigate the role of access to quality healthcare as a mediating pathway in the relationship between GEH and NCD mortality. In the event of an insignificant finding in Aim 1, a mediation analysis will help reveal whether there is truly a relationship between GEH and HAQI, and if so, generate discussion and further points of research on what then keeps this from translating to improved health outcomes as far as NCD mortality is concerned. On the contrary, if there's a significant finding (be it a positive or inverse correlation) in Aim 1, the mediation analysis will assess whether the prior described theoretical assumptions are a potential mediating pathway, and if not, generate discussion and future research on what it is that may mediate the relationship between GEH and NCD mortality. Finally, objective three examines the moderating effect of income grouping on the relationships explored in objective 1 and 2, by subdividing countries into their World Bank defined country grouping: high income, higher middle-income, lower middle-income and low income. The empirical literature reviewed identified that it is possible for the overall effect of GEH on a global level to be different from what it is once baseline income grouping is factored in (Marton et al., 2015; Rana et al., 2018; Ray & Linden, 2020). This suggested that while for example Aim 1 may show a significant effect, such an effect may not be seen in one income group and vice versa, due to the differences in baseline healthcare infrastructure, such that it's possible that as a policy tool, government's expenditure may have differential effects on health outcomes in different income groups, regardless of the overall effect at a global level.

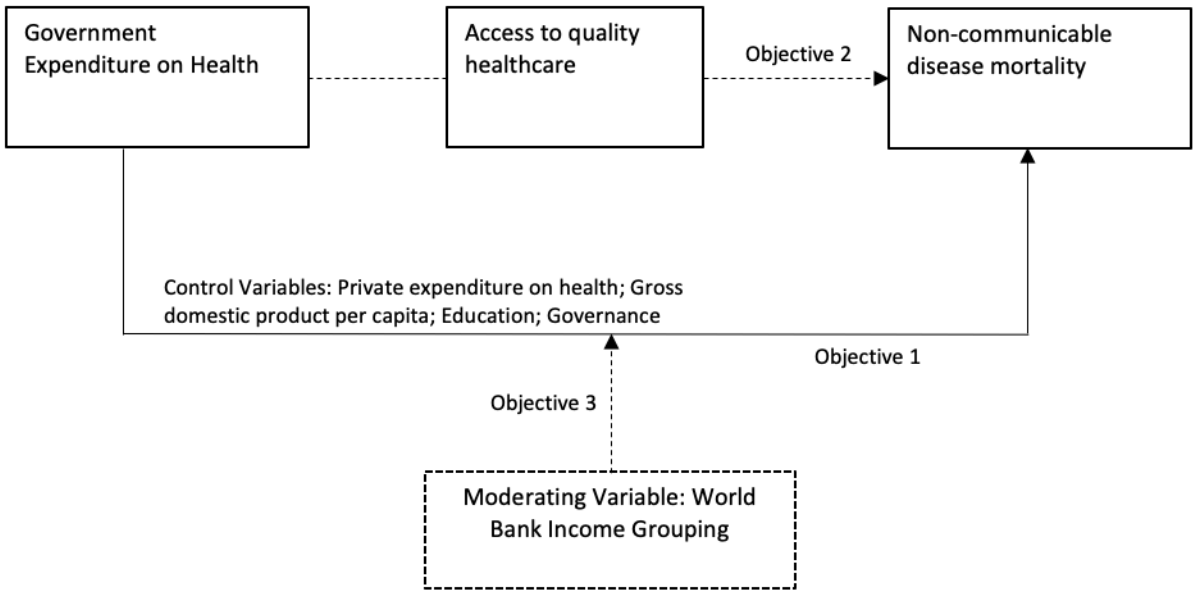

Figure 1: Conceptual framework of the relationship between government expenditure on health and non-communicable disease mortality

2.6 Research hypotheses

i. Government expenditure on health is inversely correlated with NCD mortality rate
ii. Access to quality healthcare mediates the relationship between government expenditure on health and NCD mortality rate
iii. Country income grouping moderates the relationship between government expenditure on health and NCD mortality rate, with higher income reducing the significance of the relationship

2.7 Operationalization of variables

The three dependent variables in this study are: percentage mortality from CVD, cancer, diabetes or CRD between exact ages 30 and 70, a marker of premature mortality, NCD mortality rate quantified as the age-standardised death rate per 100,000 persons; and access to quality healthcare, quantified as the health access and quality index (HAQI). The main independent variable shall be domestic government expenditure on health (GEH), quantified in terms of domestic GEH as a percentage of gross domestic product (GDP). Control variables shall include: private expenditure on health (PEH) quantified as a percent of GDP, GDP per capita, quantified as adjusted GDP per capita in current US international dollars; education level, quantified as the percentage of individuals within a country enrolling into tertiary education; and government effectiveness, quantified as the government effectiveness index (Table 1).

Table 1: Definition of variables and sources		
Variable	**Definition**	**Database Source**
Non-communicable disease mortality	1. Mortality from CVD, cancer, diabetes or CRD between exact ages 30 and 70 (%) 2. Age-standardised death rate from NCDs per 100,000 persons for both sexes	World Development Indicators
Access to quality healthcare	Healthcare access and quality index	Institute for Health Metrics and Evaluation
Government expenditure on health	Domestic government expenditure on health as a % of GDP	World Development Indicators
Private expenditure on health	Domestic private expenditure on health as a % of GDP	World Development Indicators
Education	Tertiary school enrolment, (% gross)	World Development Indicators
Gross domestic product per capita	Purchasing power parity adjusted GDP per capita in international dollars	World Development Indicators
Government Effectiveness	Government Effectiveness Index	World Governance Indicators

Chapter Three: Methodology

3.1 Introduction

This chapter describes the methods used to explore the relationships between domestic GEH and NCD mortality, including the data sources used, data analysis considerations and statistical tests utilised.

3.2 Research philosophy

This proposed study embraces a positivist research philosophy, relying on quantitative analysis of available secondary data to test the stated hypotheses.

3.3 Study design

This was an exploratory study that employed the panel data analysis regression method of econometric analysis. Panel analysis was appropriate for the evaluation as it permits analysis of both cross sectional and longitudinal data, in this case, the evaluation of multiple country data on NCD mortality and government expenditure on health over time (2000-2016). The base year was selected as it was the first year that systematic data on NCD mortality begun to be collected at a global level, while the final year 2016, was the latest year for which this data was available at the time of this study commencement. The panel data set was an interrupted data set since mortality data is availed periodically and not annually, that is, for premature NCD mortality data, this was 2000, 2005, 2010, 2015 and 2016.

3.4 Data sources

The study utilised secondary data obtained from several publicly available sources (open source). Data on premature NCD mortality, domestic GEH, PEH, education, GDP per capita, and income grouping were obtained from the World Bank's World Development Indicators database (WDI). Data on the second measure of mortality, age-standardised NCD mortality for both sexes per 100,000 persons was obtained from the WHO's global health observatory database. Data on the health access and quality index (HAQI) was obtained from the Institute for Health Metrics and Evaluation (IHME) database, while data on government effectiveness was be obtained from the World Governance Indicators Database (WGI).

The above data sources all permit open access download and use of their data in the form of excel sheets. Once the data were downloaded, they were merged, cleaned and exported to Stata for analysis.

3.5 Sample size

Purposive sampling was used to obtain data for the 193 countries in the world who are member states of the UN and have signed on to the UN 2030 SDGs which include SDG 3, a direct focus of this study. All attempts were made to ensure that a balanced data set was obtained to enhance the rigor of the analysis. The time period under study is 2000 to 2016. The choice of inclusion of all countries for whom

data was available was based on the need to understand the relationship between GEH and NCD mortality at the global level, in addition to further elucidating this relationship based on income group differences to evaluate the moderating role of income on this relationship. Focussing on an individual country, region, or income group would not enable the objectives of this study to be met. In addition, the proposed approach did not preclude use of this data to disaggregate findings based on region e.g. Africa, if necessary. A longer time period was also anticipated to increase robustness of the findings (Rana et al., 2018).

3.6 Data analysis

Descriptive statistics are presented for all variables and covariates and summarised in appropriate graphs and tables. Inferential analysis utilised the panel data analysis regression method of econometric analysis. Panel data analysis is a form of regression analysis that is appropriate for this evaluation as it permits analysis of both cross sectional and longitudinal data, in this case, the evaluation of multiple country data on NCD mortality, access to quality healthcare, and government expenditure on health over time (2000-2016) (Bein et al., 2017; Rahman et al., 2018). For objective two, simple mediation analysis was used to first test the effect of domestic GEH on HAQI, then test the effect of HAQI on NCD mortality, and finally test the effects of both domestic GEH and HAQI on NCD mortality to assess for partial or full mediation (MacKinnon et al., 2002). For objective three, world bank income classification, based on gross national income per capita, was introduced as a moderating variable to the relationship between domestic GEH and premature NCD mortality, and its significance examined using the F-test for moderation.

3.6.1 Approach to handle missing data

All available data from the 193 signatory countries of the UN SDG was sought for the variables of interest from 2000-2016. However, it was anticipated that there would be some missing values for key variables across some units and/or time, resulting in missing data. Where such values are missing at random, the missing observations were ignored. The decreased sample size while leading to less precise regression estimates, was expected to do so only slightly, if at all (Wooldridge, 2013). While imputation of this data was possible, it was not expected that such imputation would significantly improve precision of the regression estimates in a panel data set (Wooldridge, 2013). For missing data that was not missing at random, for example, individual countries in prolonged armed conflict, leading to missing data for several years within the series, these countries were eliminated from the analysis altogether, as the non-stochastic missingness of the data would introduce significant bias to the regression model. Consequently, while the aim of the study was to include all 193 countries, in an effort to have a balanced panel and improve the rigor of the analysis, the final number of units (countries) included in the regression were less. Our approach to handling missing data was informed by prior econometric methods theory (Wooldridge, 2013) as well as global level studies which employed a similar approach

to missing data and yielded robust findings despite a final lower number of countries than originally sought (Rana et al., 2018; Ray & Linden, 2020).

3.6.2 Model

The equation used for the panel data analysis was derived off the health production function as used in prior similar studies (Nicholas et al., 2016; Rana et al., 2018), and specified for the study objectives.

The main health outcome of interest was premature NCD mortality, in line with SDG 3.4. The key health input in the production function of interest was domestic government expenditure in health (Stenberg et al., 2017), with consideration to other inputs that are known to impact risk of death from an NCD such as private expenditure on health, per capita income, and education level (Jan et al., 2018; Niessen et al., 2018; Rossier et al., 2014; Stuckler, 2008; Williams et al., 2018). Government effectiveness was also included as a control variable as prior studies proposed it affects how well public health resources are deployed in trying to improve health (Akinlo & Sulola, 2019; Nketiah-Amponsah, 2019; Rajkumar & Swaroop, 2008; Somé et al., 2019). The health production function for this study was therefore conceptualised as:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + \varepsilon_{it} \ldots \text{(i)}$$

Where:

i represents country

t represents time

Y represents the vector of dependent variables

β_0 is the y-intercept

X_{it} is a matrix of the independent variables

β_1 is the vector of the coefficients of the independent variables

α_i represents time constant errors that vary across countries

ε_{it} is a vector of time varying errors that also vary across countries

Objective 1: Relationship between GEH and NCD Mortality

Expanding equation (i) to fit objective 1 of this study gives:

$$NMR_{it} = \beta_0 + \beta_1 GEH_{it} + \beta_j Z_{it} + \alpha_i + \varepsilon_{it} \ldots \text{(ii)}$$

Where:

NMR = NCD mortality rate

GEH = Domestic government expenditure on health

β_j = Vector of coefficients of control variables

Z_{it} = Matrix of control variables

Based on the literature review presented in chapter two, the equation was further expanded as below:

$$NMR_{it} = \beta_0+\beta_1 GEH_{it}+\beta_2 PEH_{it} + \beta_3 Edu_{it} + \beta_4 GDPPC_{it} + \beta_5 GV_{it} + \alpha_i + \varepsilon_{it} \ldots \text{(iii)}$$

Where:

PEH = Private expenditure on health

Edu = Tertiary enrolment rate

GDPPC = GDP per capita

GV = Governance effectiveness

Objective 2: Access to quality care as a mediator of the relationship between GEH and NCD mortality

For objective 2, the Baron and Kenny model of mediation analysis was used to test for mediation of the relationship between GEH and NCD mortality by access to quality healthcare (Baron & Kenny, 1986; MacKinnon et al., 2002). The model is summarised in figure 2 below.

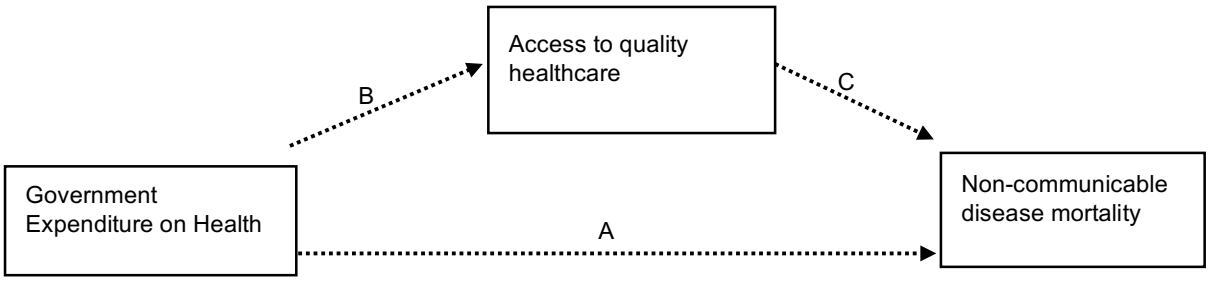

Figure 2: Schematic relationship of the proposed mediation pathway between domestic government expenditure on health and NCD mortality

Where A represents the direct relationship between domestic GEH and NCD mortality, B represents the relationship between domestic GEH and the mediating variable, access to quality healthcare, and C represents the relationship of both domestic GEH and access to quality healthcare to NCD mortality.

The Baron and Kenny model uses four steps to test for mediation:

Step 1: Test for a significant relationship between the dependent and independent variable. In this study, this is the relationship represented as A and obtained using a modified form of equation (ii):

$$NMR_{it} = \beta_0+\beta_{m1} GEH_{it}+ \beta_j Z_{it} + \mu_{it} \ldots \text{(iv)}$$

Where:

β_{m1} is the coefficient of GEH in a single variable relationship to the NCD mortality rate

μ is an error term

Step 2: Test for a significant relationship between the independent variable and the mediating variable. In this study, this is the relationship represented as B in figure 2, and was obtained by equation (v) below:

$$HAQI_{it} = \beta_0 + \beta_1 GEH_{ct} + \beta_j Z_{it} + \mu_{it} \ldots (v)$$

Where

HAQ = Health access and quality index, the proposed mediating variable

Step 3: Test for a significant relationship between the mediating variable and the dependent variable, in a model that uses both the independent variable and the mediating variable as predictors of the dependent variable. In this study, this is the relationship represented as C and obtained by equation (vi) below

$$NMR_{it} = \beta_0 + \beta_{m2} GEH_{ct} + \beta_{m3} HAQI_{it} + \beta_j Z_{it} + \mu_{it} \ldots (vi)$$

Where

β_{m2} is the coefficient of GEH in the relationship with NCD mortality rate

β_{m3} is the coefficient of HAQI in the relationship with the NCD mortality rate

Step 4: Calculate the mediated effect using the coefficient differencing method. In this study, this was obtained by differencing the coefficients of domestic GEH in equation (vi) and (iv), that is:

$$\text{Mediated effect} = \beta_{m2} - \beta_{m1}$$

Objective 3: Income group classification as a moderator of the relationship between government expenditure on health and NCD mortality

For objective 3, world bank income classification, based on gross national income per capita, was introduced as a moderating variable to the relationship between domestic GEH and premature NCD mortality, and the F-test for moderation was conducted to assess for significance (Frazier et al., 2004).

3.6.3 Test for poolability of data

To test for poolability of the available data, that is, whether panel data analysis was needed versus a standard ordinary least squares (OLS) regression. The Breusch and Pagan Lagrangian Multiplier test was used. The null hypothesis of the test is that variances across the different cross-sectional units (in this case countries) are zero, in which case panel analysis would be unnecessary.

3.6.4 One-way versus two-way effects

Similar to adjusting for country effect if panel effects are demonstrated above where the assumption is an unobserved country-specific heterogeneity that is time invariant (one way effects), the secular trend (time effect) can also be adjusted for using a two-way effects model to account for unobserved time-specific heterogeneity that is country invariant. This was also done for the study, with the more precise model identified in objective one being selected for all the preceding analysis.

3.6.5 Fixed and random effects

Fixed and random effect methods are estimation techniques to deal with the effect of unobserved (unmeasured) variables. The fixed effects estimator rids the regression model of all time constant unobserved variables by utilising pooled ordinary least squares (OLS) based on time demeaned variables. To illustrate, the time demeaned form of equation (i) in the general model:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + \varepsilon_{it} \ldots (i)$$

Would become:

$$\ddot{Y}_{it} = \beta_1 \ddot{X}_{it} + \ddot{\varepsilon}_{it} \ldots (vii)$$

Note that in the time-demeaned equation (vii), β_0 and αi, which represents all time constant factors that affects the dependent variable have been removed. The fixed effects estimator is unbiased when four assumptions hold (Wooldridge, 2013). First, it assumes that unobserved heterogeneity between countries (αi) is correlated with one or more of the independent variables included in the model. Secondly, that the relationship is strictly exogenous, that is, the independent variables are not dependent in any way on the dependent variable. Thirdly, that the error term ε_{it} (unmeasured time varying errors) are homoscedastic, that is, that the size of ε_{it} is the same regardless of the actual value of the independent variables. Fourthly, that ε_{it} is uncorrelated across time. When these assumptions do not hold, the random effects estimator is preferred.

The random effects estimator assumes that unobserved heterogeneity between countries isn't correlated to the independent variables across time, and as such retains αi in the regression model in order to account for the effect of these unmeasured time-constant factors. The model relies on generalised least squares (GLS) instead of OLS and results in a form of equation 1 that becomes:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + V_{it \ldots i}$$

Where Vit is a composite error term that includes both time-constant and time-varying unmeasured heterogeneity.

Hypothesis testing for fixed versus random effects

The Wu-Haussmann test was used to evaluate which model between the fixed effects (i.e. that unobserved heterogeneity between countries is related to the independent variables included in the model) and random effects (i.e. that unobserved heterogeneity between countries occurs at random and isn't related to the independent variables) was most appropriate for drawing conclusions (Nicholas et al., 2016; Rahman et al., 2018).

Under the null and alternate hypothesis of the Wu-Haussmann test:

$$H_o: \text{Cov}(\alpha_i, x_{it}) = 0$$

$$H_{1:} \text{Cov}(\alpha_i, x_{it}) \neq 0$$

The test of significance was set at 0.05, with a significant p-value. The null hypothesis assumes that random effects produce better estimates of the regression model and therefore a significant p-value result leads to rejection of the null hypothesis, meaning that the fixed effects model is more precise.

3.6.6 Sensitivity analyses

To test the robustness of the regression models used, two sets of sensitivity analyses were carried out: the first one used a different NCD mortality outcome (age-standardised NCD mortality rate per 100,000 persons) for all three study objectives. This measure of NCD mortality is more inclusive than that used in our main analysis as it measures out mortality from all NCDs, not just the four major NCDs, as well as being more age inclusive. In the second sensitivity analysis, dynamic panel data analysis was introduced, evaluating the effect of GEH in the prior year on present day NCD mortality.

3.7 Research quality

This study has several limitations that impacts the research quality. First, it relied on secondary data from various publicly available databases. Therefore, inaccuracies in the original dataset may have affected the study findings. However, the selected databases are historically considered to be reliable and accurate and were also used in prior studies as reviewed in Chapter 2. Secondly, government expenditure in health may not be an accurate reflection of the resources committed specifically towards non-communicable disease care, and as such any relationship identified between GEH and NCD mortality may not be a direct relationship. The hypothesis proposed however, is that overall GEH is a good marker for investment in strengthening healthcare infrastructure and permitting gains in all disease care. Furthermore, similar analysis has been conducted for communicable disease mortality, infant mortality and maternal mortality with robust findings obtained (Nicholas et al., 2016; Rahman et al., 2018; Rana et al., 2018). Thirdly, reverse causality is another problem that is inherent in all forms of regression analysis (Curtis, 2018). For example, while the premise of this study was that improved GEH

leads to reduced NCD mortality, it may be that reduced NCD mortality leads to improved GEH, perhaps as a result of overall better health status of the population and subsequently, increased productivity, higher GDP, and higher capacity for the government to spend on healthcare. The mediation analysis (objective 2) however attempted to address this limitation by assessing a possible direction of the relationship. Finally, it may be that while healthcare spending in a particular year does not affect the NCD mortality rate for that year, but the investment in health infrastructure are realised several years after. To address this limitation, we also performed sensitivity analyses using a lagged spending variable in the model to test for effects on NCD outcomes one year later.

3.8 Research ethics

This study was approved by the Strathmore University Institutional Ethics Review Committee of the and a research license to conduct the study was then obtained from the Kenya National Commission of Science and Technology (NACOSTI).

Chapter Four: Results

4.1 Introduction

This chapter presents the study findings, commencing with descriptive analysis of the main variables, and then presenting the findings from the regression analysis for the three objectives of the study.

4.2 Data description

Of the 193 countries who are the UN member states sampled for this study, 13 countries were excluded as they had missing data for key variables. Andorra, Dominica, Marshall Islands, Monaco, Nauru, Palau, San Marino, St. Kitts & Nevis, and Tuvalu were missing NCD mortality outcome data for all years, South Sudan was missing GEH and PEH data, Democratic People's Republic of Korea (North Korea) and Somalia were missing GEH, PEH and GDP per capita data and Liechtenstein was missing all data except for government effectiveness. The final panel data set therefore had 180 countries. All retrieved variables were continuous data, except for World Bank country income grouping data which was ordinal data.

4.3 Descriptive analysis

The main dependent variable (premature NCD mortality) was available for the years 2000, 2005, 2010, 2015, and 2016, so all primary analysis was based on data from these years. The baseline characteristics are summarized in Table 2 below over the study period, where mean and standard deviation were reported for continuous variables, and proportion was calculated for categorical variables.

Table 2: Summary Statistics of Key Variables Over the Study Period

Year	2000		2005		2010		2015		2016	
Continuous variables	**Mean (SD)**		**Mean (SD)**		**Mean (SD)**		**Mean (SD)**		**Mean (SD)**	
	N = 105		N = 113		N = 118		N = 114		N = 112	
Premature NCD mortality from CVD, cancer, DM and CRD (%)	22.7	(6.1)	21.5	(6.1)	19.7	(5.8)	17.9	(5.6)	17.3	(5.5)
Age standardized NCD mortality rate (per 100,000 persons, both sexes)	655.8	(169.4)	NA		587.7	(162.2)	534.4	(156.1)	516.8	(155.3)
Domestic government expenditure on health (%)	3.0	(1.8)	3.2	(1.9)	3.4	(2.3)	3.9	(2.4)	4.0	(2.4)
Private expenditure on health (%)	2.5	(1.6)	2.4	(1.2)	2.5	(1.2)	2.5	(1.3)	2.4	(1.2)
HAQI (%)	54.4	(23.0)	56.3	(22.3)	59.7	(23.1)	NA		68.1	(20.9)
GDP per capita ($)	10678.4	(12022.1)	13555.0	(15599.5)	17138.1	(19069.8)	22980.0	(22053.9)	25153.8	(23045.8)
School enrolment (%)	26.1	(21.4)	31.7	(26.1)	36.4	(27.6)	43.7	(27.2)	47.8	(28.4)
Government effectiveness (percentile rank)	52.1	(28.4)	51.3	(26.9)	52.4	(28.6)	57.1	(26.2)	59.2	(25.1)
Categorical variable	**Count (%)**		**Count (%)**		**Count (%)**		**Count (%)**		**Count (%)**	
Income class	105	(100.0%)	113	(100.0%)	118	(100.0%)	114	(100.0%)	112	(100.0%)
Low	36	(34.3%)	33	(29.2%)	25	(21.2%)	12	(10.5%)	11	(9.8%)
Lower-middle	27	(25.7%)	33	(29.2%)	30	(25.4%)	28	(24.6%)	27	(24.1%)

Upper-middle	19	(18.1%)	21	(18.6%)	28	(23.7%)	31	(27.2%)	30	(26.8%)
High	23	(21.9%)	25	(22.1%)	35	(29.7%)	43	(37.7%)	44	(39.3%)
Missing classification	0	(0.0%)	1	(0.9%)	0	(0.0%)	0	(0.0%)	0	(0.0%)

NA: HAQI data not available for 2015

4.3.1 Trends in key study measures

Premature mortality from the four major NCDs (CVD, Cancer, DM and CRD) averaged 19.8% globally over the 16-year period, trending downwards from 22.7% in 2000 to 17.3% in 2016, a trend that's also visualised in Figure 2 below. Similarly, over the same period, age-standardised NCD mortality rate also decreased, from 655.8 to 516.8 per 100,000 persons. Over the same period, access to quality healthcare, as measured using HAQI, increased globally from 54.4% to 68.1%.

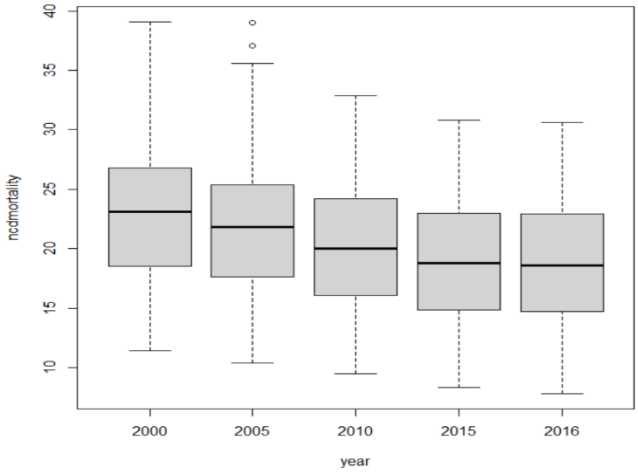

Figure 2: Box blot of mean premature NCD mortality over the study period

Domestic GEH, the study's main independent variable averaged 3.5% over the 16-year period, rising from 3% in 2000 to 4% in 2016. Over the same period, mean PEH, remained relatively stable, with a global average of 2.4%.

Per capita GDP rose over the study period from a global average of 10678.4 in 2000 to 25153.8 USD per capita in 2016. Gross tertiary school enrolment also rose over the same period from 26.1% to 47.8%. Government effectiveness also rose, with the mean percentile rank of countries rising from 52.1 to 59.2 from 2000 to 2016 respectively.

4.3.2 Income grouping

Over the study period, country wealth improved, with the proportion of countries classified as low income decreasing from 34.3% in 2000 to 9% in 2016, while that of countries classified as lower middle-income decreased from 25.7% in 2000 to 24.1% in 2016. The proportion of countries classified as upper middle income rose from 18.1% to 26.8% over the study period, while that of countries classified as high income rose from 21.9% in 2000 to 39.3% in 2016.

4.4 Objective 1: The relationship between government expenditure on health and non-communicable disease mortality rate

The results of the panel regression analysis for objective 1, that is, the relationship between government expenditure on health and non-communicable disease mortality rates globally, are presented in this sub section. Prior to the regression analysis, findings for the diagnostic test: the test for poolability of data is first presented which evaluates whether panel data analysis is actually needed, in lieu of simple ordinary least squares (OLS).

4.4.1 Breusch and Pagan Lagrangian multiplier test

The Breusch and Pagan LM test returned a significant result, a chi-statistic of 510.6 ($p < 0.0000$), denoting that there was significant heterogeneity between the various cross-sections (countries), and therefore simple OLS regression is inappropriate, that is, that panel effects are present in this data set.

Figure 3 below is a box plot of premature NCD mortality by country over the study period, visually also showing the between country variability in the main dependent outcome.

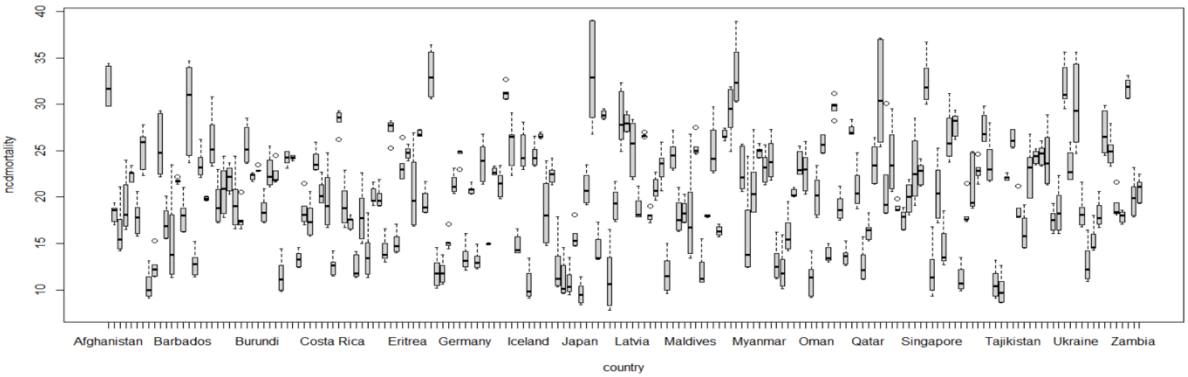

Figure 3: Boxplot of Premature NCD mortality rates by country and year

4.4.2 One-way versus Two-way error model

We ran both one-way and two-way error models for the primary objective. However, the two-way model yielded inconsistent and imprecise findings, for example, in the fixed effects two-way model, the adjusted R-squared was - 0.22. This is however expected, given the available panel data set has a large number of countries over a smaller time period which is not long enough to see time effects, making such an analysis severely underpowered. For this reason, all subsequent analyses are presented using the one-way model, consistent with prior similar studies with large cross sections over a comparatively smaller period of time (Rahman et al., 2018).

4.4.3 Fixed and Random Effects

The dependent variable was found to be skewed (non-normal) and the relationship between the dependent and independent variables mostly non-linear. It was therefore assumed that a multiplicative (log-linear) model was most appropriate for econometric analysis, formulated as:

$$Y = \prod X^{\beta} \Leftrightarrow \log Y = \sum \beta \log X$$

Hence, in this case, the model in equation (iii) using logarithm transformation was expressed as

$$\log NMR_{it} = \beta_0 + \beta_1 \log GEH_{it} + \beta_2 \log PEH_{it} + \beta_3 \log Edu + \beta_4 \log GDPPC_{it} + \beta_5 \log GV_{it} + \alpha_i + \varepsilon_{it}$$

Where

i is the index for country, and *t* is the index for year

NMR indicates the outcome of premature NCD mortality rate

GEH, PEH, EDU, GV are short for domestic government expenditure on health, domestic private expenditure on health, tertiary school enrolment rate, and government effectiveness, respectively

α_i denotes the country-specific effects, and it is estimated individually for each country in a fixed effects model, while assumed to follow a normal distribution with mean 0 in a random effects model

ε_{it} is the independent identically distributed error term for each observation following a normal distribution with mean 0

Results of the panel regression are presented in Table 3 below, for both fixed and random effects models.

Table 3: Fixed and Random Effects Regression Output for premature NCD mortality rate and GEH

	Premature NCD mortality rate ~ GEH			
	Fixed		**Random**	
Government expenditure	-0.049	**	-0.048	**
Private expenditure	-0.073	***	-0.074	***
GDP per capita	-0.234	***	-0.206	***
School enrolment	-0.022		-0.011	
Government effectiveness	0.011		0.020	
R-squared	0.584		0.783	

adj R-squared	0.416	0.781
Between-ind var share	NA	89.1%
Hausman test	***	

Note: "**" for p<0.01; "***" for p<0.001

Both the fixed and random effect models show consistent results that there is a significant inverse relationship between GEH and NCD mortality. According to the fixed effect model, for instance, it is expected that the NCD mortality rate would decrease by 0.049% for a 1% increase in GEH, controlling for private expenditure on health, GDP per capita, tertiary school enrolment and government effectiveness.

Of note, in both fixed and random effects models, the PEH and GDP per capita are also statistically significantly inversely correlated with premature NCD mortality, while neither tertiary school enrolment nor government effectiveness was.

The Hausman test yielded a significant result, with a chi-square statistic of 165.9 (p value <0.0000), favouring the fixed effects model over the random effects model.

4.5 Objective 2: Investigating the role of access to quality healthcare as a mediating variable in the relationship between GEH and NCD Mortality

The findings from objective 2, that is investigating access to quality healthcare as a mediator in the relationship between GEH and NCD mortality is presented in this section.

Table 4 shows the results from the mediation analysis, under both the fixed and random effects assumptions, using the Baron and Kenny Method (Baron & Kenny, 1986; VanderWeele, 2016) whereby three regression equations were constructed and run: (1) Dependent variable (NCD mortality) ~ independent variable (GEH); (2) Assessed Mediator (HAQI) ~ Independent variable (GEH); and (3) Dependent variable (NCD Mortality) ~ independent variable (GEH) + mediator (HAQI).

$\log NMR_{it} = \beta_0 + \beta_1 \log GEH_{it} + \beta_2 \log PEH_{it} + \beta_3 \log Edu + \beta_4 \log GDPPC_{it} + \beta_5 \log GV_{it} + \alpha_i + \varepsilon_{it}$ (Mediation analysis equation 1)

$\log HAQI_{it} = \beta_0 + \beta_1 \log GEH_{it} + \beta_2 \log PEH_{it} + \beta_3 \log Edu + \beta_4 \log GDPPC_{it} + \beta_5 \log GV_{it} + \alpha_i + \varepsilon_{it}$ (Mediation analysis equation 2)

$\log NMR_{it} = \beta_0 + \beta_1 \log GEH_{it} + \beta_2 \log PEH_{it} + \beta_3 \log Edu + \beta_4 \log GDPPC_{it} + \beta_5 \log GV_{it} + \beta_6 \log HAQI_{it} + \alpha_i + \varepsilon_{it}$ (Mediation analysis equation 4)

For the establishment of a mediation effect, the independent variable must affect the mediator in equation 2, and the mediator must affect the dependent variable in equation 3.

As shown in Table 4 below, the association between the assessed mediator (HAQI) and the independent variable (GEH) is model-specific, whereby it is non-significant in the fixed effects model, and significant in the random effects model. In the random effects model, GEH is statistically significantly positively associated with HAQI.

Table 4: Results of the mediation analysis for both fixed and random effects models

	Premature NCD mortality rate ~ GEH			
	Fixed		**Random**	
Mediation				
(1) Coefficient of GEH in Mortality ~ GEH	-0.060	**	-0.056	**
(2) Coefficient of GEH in HAQI ~ GEH	-0.009		0.029	*
(3) Coefficient of GEH in Mortality ~ GEH + HAQI	-0.061	**	-0.059	**

Note: "." for p<0.1; "*" for p<0.05; "**" for p<0.01; "***" for p<0.001

However, even in the random effects model, the introduction of HAQI into the model (equation 3 in table 4) leads to a higher coefficient of GEH (-0.059) than in the primary model (equation 1) which is -0.056, contrary to what would be expected with a mediating variable in which case part of the independent variable's effect on the dependent variable is realized through the mediator pathway, so a reduced magnitude of effect is expected when introducing the proposed mediator into the primary regression model.

4.6 Objective 3: Investigating the role of income grouping as a moderating variable in the relationship between GEH and NCD mortality

The findings from objective 3, that is, investigating the role of income grouping as a moderating variable in the relationship between GEH and NCD mortality is presented in this subsection.

Two sets of analyses were carried out for objective 3. A moderation assessment was conducted by adding the interaction term between income class and government expenditure in the model, as well as all the corresponding lower-order terms (Frazier et al., 2004). The effect of the interaction term was evaluated using the *F* test. The regression equation used for the moderation analysis was therefore:

$$\log NMR_{it} = \beta_0 + (\beta_1 \log GEH_{it} * income\ class) + \beta_2 \log PEH_{it} + \beta_3 \log Edu + \beta_4 \log GDPPC_{it} + \beta_5 \log GV_{it} + \alpha_i + \varepsilon_{it}$$

Where income class was either low income, lower middle-income, upper middle-income or high income.

In addition, subgroup analysis of the main regression was also conducted to explore the association in objective 1 stratified by income class. Table 5 shows the results of the moderation analyses under both the fixed and random effects assumptions.

Both the fixed and random effects models found that the moderating effect of country income is significant, with the strength of the inverse association between NCD mortality and GEH increasing with rising country income, that is government expenditure had a stronger protective effect on NCD mortality as the income level increases.

Table 5: Results of moderation analysis

	Premature NCD mortality rate ~ GEH			
	Fixed		**Random**	
Moderation				
F test for interaction term	***		***	
Effect of Government expenditure on premature NCD mortality				
Low income countries	0.005		0.014	
Lower-middle income countries	-0.014		0.002	
Upper-middle income countries	-0.115	**	-0.127	***
High income countries	-0.295	***	-0.305	***
Subgroup analysis				
Effect of Government expenditure on premature NCD mortality				
Low income countries	-0.021		-0.010	
Lower-middle income countries	-0.029		-0.012	
Upper-middle income countries	-0.071	.	-0.071	.
High income countries	-0.127	***	-0.158	***

Note: "." for p<0.1; "*" for p<0.05; "**" for p<0.01; "***" for p<0.001

The trend is also visible in the subgroup analysis, whereby the inverse association between GEH and NCD mortality only becomes significant for upper middle-income and high income countries, with its effect been strongest in high-income countries.

4.7 Sensitivity Analyses

Tables 6 and 7 show the results of the sensitivity analysis for all three study objectives.

Table 6: Sensitivity analyses using age-standardized NCD mortality rate for the three study objectives

	Age-standardized mortality rate ~ GEH			
	Fixed		**Random**	
Government expenditure	-0.026		-0.038	*
Private expenditure	-0.056	**	-0.051	***
GDP per capita	-0.208	***	-0.182	***
School enrolment	-0.018		-0.014	
Government effectiveness	0.012		0.007	
R-squared	0.611		0.942	
adj R-squared	0.399		0.941	
Between-ind var share	NA		88.5%	
Hausman test		***		
Moderation				
F test for interaction term	***		***	
Effect of Government expenditure on outcome				
Low income countries	0.018		0.022	
Lower-middle income countries	0.007		0.003	
Upper-middle income countries	-0.105	**	-0.123	***
High income countries	-0.228	***	-0.252	***
Subgroup analysis				
Effect of Government expenditure on outcome				
Low income countries	-0.020		-0.005	
Lower-middle income countries	-0.015		-0.020	
Upper-middle income countries	-0.051		-0.053	
High income countries	-0.054		-0.099	**
Mediation				
Coefficient of Geh in Mortality ~ Geh	-0.037		-0.051	*
Coefficient of Geh in HAQI ~ Geh	-0.009		0.029	*

Coefficient of Geh in Mortality ~ Geh + HAQI	-0.037	-0.053 **

Note: "." for p<0.1; "*" for p<0.05; "**" for p<0.01; "***" for p<0.001

Overall, the findings from the first sensitivity analysis are consistent with the main study with one exception, in the fixed effects model of the main regression (objective one), the inverse relationship between GEH and NCD mortality rate was not statistically significant when age standardised NCD mortality rate is used.

The dynamic model also yielded consistent findings for the study objectives.

Table 7: Sensitivity analyses using dynamic panel data model with 1 year lagged GEH

	NCD mortality rate ~ 1-year lagged GEH	
	Fixed	**Random**
Main regression		
Government expenditure	-0.031 .	-0.034 .
Private expenditure	-0.082 ***	-0.083 ***
GDP per capita	-0.272 ***	-0.225 ***
School enrollment	-0.005	0.004
Government effectiveness	0.016	0.017
R-squared	0.566	0.745
adj R-squared	0.349	0.742
Between-ind var share	NA	93.7%
Hausman test	***	
Moderation		
F test for interaction term	***	***
Effect of Government expenditure on outcome		
Low income countries	0.023	0.033
Lower-middle income countries	0.002	0.017
Upper-middle income countries	-0.086 *	-0.106 **
High income countries	-0.200 ***	-0.227 ***
Subgroup analysis		
Effect of Government expenditure on outcome		
Low income countries	-0.007	0.008
Lower-middle income countries	-0.073	-0.053

Upper-middle income countries	-0.084	.	-0.091	*
High income countries	-0.121	**	-0.151	***
Mediation				
Coefficient of Geh in Mortality ~ Geh	-0.031	.	-0.034	.
Coefficient of Geh in HAQI ~ Geh	0.001		0.037	**
Coefficient of Geh in Mortality ~ Geh + HAQI	-0.030		-0.034	
Coefficient of HAQI in Mortality ~ Geh + HAQI	-0.075		0.050	

Note: "." for p<0.1; "*" for p<0.05; "**" for p<0.01; "***" for p<0.001

4.8 Chapter Summary

The study findings have been reported in the preceding chapter. In summary, the study finds that GEH is inversely correlated to premature NCD mortality from the four major NCDs (CVD, cancer, DM and CRDs). The study also found that this relationship is not mediated by access to quality healthcare, but it also found a significant moderating effect of country income, been stronger as country income rises. In the next chapters, all these findings are discussed in the context of prior research, study limitations and policy implications.

Chapter Five: Discussion, Conclusions and Recommendations

5.1 Introduction

This chapter discusses the study findings in light of existing research, commencing with the trends in the main predictor and outcome variable, and then each of the study objectives and concludes with the study limitations. The conclusions and policy recommendations then follow.

5.2 Trends in NCD mortality and domestic government expenditure on health

Premature mortality attributable to the four major NCDs (CVD, Cancer, DM and CRD) has decreased globally between 2000 and 2016, confirming the trend observed by (Martinez et al., 2020) in their recent study over the period of 1990 to 2017. The indicator used for premature mortality in this study, the probability of death from one of the four major NCDs between exact ages 30 and 60 is the indicator for tracking progress on SDG 3.4 (NCD Countdown 2030 collaborators, 2018), but is incomprehensive in that it excludes other major causes of premature NCD deaths such as suicides related to mental health disorders, which are a growing contributor to NCD deaths. The measure also arbitrarily excludes premature deaths from NCDs that may occur outside the age bracket of 30-60 years (Martinez et al., 2020). The secondary mortality indicator assessed in our sensitivity analysis, that is, age-standardised NCD mortality rate per 100000 persons is more inclusive and showed a similar trend.

Domestic GEH as a percentage of GDP was low in this study, with a global average of 3.5%, slightly increasing from 3.0% to 4.0% between 2000 and 2016, similar to a 2018 report by the WHO on public spending on health. This is however short of the proposed 5% minimum identified in previous studies as necessary to achieve SDG health goals, including UHC (Mcintyre et al., 2017; Stenberg et al., 2017). Measuring GEH as a percentage of GDP offers several advantages, including the contextualization of domestic GEH within a country's economic activity level, and providing insight on how much a country prioritizes health (Mcintyre et al., 2017). The trend in rise can be explained by economic growth, as confirmed by global per capita GDP more than doubling, from USD 10,678 in 2000 to USD 25,154 in 2016. However, the 1% rise in domestic GEH compared with the rise in GDP over the same period of time is inadequate, and may reflect a lack of prioritisation of public health spending as country income rises. For example, if the same trend was to continue, it would take until 2032 to reach the 5% minimum target of domestic GEH, past the 2030 SDG target. The economic case for investing in NCDs lies in reducing avertable morbidity and mortality from NCDs that impairs labour, productivity and economic growth (Jan et al., 2018) translating in the long-term to economic growth. Illustrative of this, (Hutchinson et al., 2019) demonstrated that in Jamaica, spending on a package of NCD prevention and treatment interventions required had a return on investment of 2.2.

5.3 The relationship between NCD mortality and government expenditure on health

The main objective of this study was to evaluate the relationship between domestic GEH and NCD mortality. We found that domestic GEH is inversely correlated with both premature NCD mortality from the four major NCDs, and age-standardised NCD mortality rate per 100,000 persons, controlling for domestic PEH, per capita GDP, education level and government effectiveness. From this study, a 1% increase in GEH is associated with a 0.049% decrease in premature NCD mortality. To illustrate the effect of this intuitively, in 2016 the total premature deaths from NCDs in low and middle income countries was 14.49 million. Therefore, a 10% increase in domestic GEH would be associated with a reduction of approximately 700,000 premature deaths among individuals aged 30-70 years, the most economically productive age group within a society.

These findings are similar to those of (Mays & Smith, 2011), who reported increased public health spending was associated with decreases in deaths related to CVD, DM or Cancer in the USA. These findings are also similar to those of (Ray & Linden, 2020) who found that domestic GEH was inversely associated with infant mortality globally. These findings however differ from those of (Marton et al., 2015), who reported that increased public spending on health was associated with increased early deaths from heart disease, diabetes or asthma. Their study cited a moral hazard problem – whereby increased public health resources may have crowded out PEH which led to worse outcomes, as well as potential inefficient use of public funds. However, they did not control for PEH or government effectiveness in their study, a limitation overcome by this current study. I also found that mean PEH did not change much globally, actually decreasing from 2.5% to 2.4% between 2000 and 2016, while GEH consistently rose over the same period from 3.0% to 4.0%, which may support the 'moral hazard' problem raised by (Marton et al., 2015). However, given the potential for catastrophic health expenditure related to NCD diagnosis and treatment when relying on PEH, the observed trend in declining PEH is a welcome one, particularly in LMICs (Jan et al., 2018).

The relationship between domestic GEH and premature NCD mortality did not differ significantly between the fixed and random effects model, for example, the coefficient for GEH is -0.049 and -0.048 in the fixed and random effects model. The Hausman test favoured the fixed effect model, a finding that is supported by the violation of the base assumption of the random effects model – that unmeasured/omitted variables are uncorrelated to the independent variables (Wooldridge, 2013). This violation can be illustrated by considering a key omitted variable in this study – health seeking behaviour. Health seeking behaviour is defined as "*any action or inaction undertaken by individuals who perceive themselves to have a health problem or to be ill for the purpose of finding an appropriate remedy*" (Latunji & Akinyemi, 2018), and varies between settings. For NCD care, health seeking behaviour is positively associated with education level and income status, reflecting improved understanding of ill health and its consequences, as well as increased financial capacity to access

medical care (Rasul et al., 2019). This omitted variable would therefore be expected to be correlated with variables such as per capita GDP, education level and domestic PEH in this study.

This study also found that domestic PEH, and per capita GDP were inversely correlated with premature NCD mortality. While there are no studies to make direct comparisons to NCD related outcomes for either domestic PEH or per capita GDP, these findings are similar to those by (Rahman et al., 2018), who found that in the SAARC-ASEAN region, PEH was inversely correlated with crude death rate and infant mortality. Our findings however differ from those of (Ray & Linden, 2020) who reported PEH had no effect on global rates of infant mortality, as well as two studies in the African setting by (Nicholas et al., 2016; Novignon & Lawanson, 2017) who also reported PEH was not associated with child mortality outcomes. Our dissimilar findings are likely due to differences in the choice of health outcomes which make direct comparison difficult. Infant and under-five mortality may not be as sensitive to PEH as NCD outcomes, as interventions to avert the former, such as infant and child vaccination programs to prevent diarrhoeal illness, the leading cause of under-five mortality, are more amenable to GEH and improved socio-economic status. In support of this, multiple studies reported that per capita GDP was inversely associated with infant and child mortality and overall, our study findings on reduced premature NCD mortality with increasing per capita GDP is consistent with other findings of improved health outcomes such as maternal mortality, infant mortality, under-five mortality and life expectancy, with increasing country wealth (Akinlo & Sulola, 2019; Nicholas et al., 2016; Nketiah-Amponsah, 2019; Rahman et al., 2018).

This study found that education level and government effectiveness were not significantly associated with premature NCD mortality. The finding of an insignificant association between education and premature NCD mortality is inconsistent with prior studies and theory. (Ray & Linden, 2020) in their global study reported reduced infant mortality with higher levels of education, while regional studies in Asia and Africa consistently found that increased education level was associated with lower infant, neonatal, maternal and under five-mortality (Nicholas et al., 2016; Novignon & Lawanson, 2017; Rahman et al., 2018; Somé et al., 2019). Theoretically, higher education levels are expected to increase health seeking behaviour, access to, and awareness of health information, and personal income, all of which should lead to improved health outcomes (Curtis, 2018; Cutler & Lleras-Muney, 2010). This study's counterintuitive findings therefore may be due to the choice of our education variable – tertiary school enrolment rate, which is different from the prior studies which used female literacy rate, mean years of schooling, primary education completion rate or secondary school enrolment rates. Our choice of tertiary school enrolment was informed by two reasons: firstly, it may be a better correlate to critical thinking skill development which would be required to make decisions on trade-offs and cost-offsets that informed both policy decisions amidst limited resources at the government level, as well as personal decisions about obtaining and sustaining access to NCD care. Secondly, of all the potential education variables, it is the most consistently available over the study period.

Our findings of an insignificant association between government effectiveness and premature NCD mortality are similar to those of (Nketiah-Amponsah, 2019), who found no significant relationship between GEH and either maternal mortality or life expectancy. They nevertheless differ from findings of a significant inverse relationship between GEH and under five mortality in the same study. Other studies have used alternative definitions or measures of good governance; however, we chose government effectiveness as it is a measure of the quality of public and civil service delivery as well as the quality of policy formulation and implementation – which are directly relevant to this study's aims. The lack of a significant relationship between premature NCD mortality and government effectiveness may imply that more downstream factors such as resource availability, rather than the efficiency or effectiveness of their use may be more important, consistent with frequent calls for increased investment into NCD care (Nugent et al., 2018).

In summary, this study findings support the hypothesis for objective one, that domestic GEH is significantly inversely associated with premature NCD mortality, controlling for domestic PEH, per capita GDP, education level, and government effectiveness, and as such, may represent a crucial policy tool to addressing premature NCD mortality.

5.4 Access to quality healthcare as a mediator of the relationship between NCD mortality and GEH

This study found no mediating role of access to quality healthcare, as measured using the HAQI metric, on the relationship between GEH and premature NCD mortality. While at first glance the role of HAQI as a mediator seemed model specific, with the random effects model showing significance, a closer look at the mediation analysis revealed that HAQI may actually be a mild confounder in the relationship between domestic GEH and premature NCD mortality, instead of a mediator, since the coefficient of domestic GEH rose once HAQI was introduced as a control variable, instead of decreasing as would be expected with true mediation.

In this study, domestic GEH was not significantly associated with HAQI. Fullman and collegues reported a positive but moderate correlation between government spending as a fraction of total health expenditure and HAQI using 2016 data (GBD 2016 Healthcare Access and Quality Collaborators, 2018). Their different findings may be due to varying variable choice, per capita healthcare spending versus spending as a percentage of GDP, or the different analysis choices, correlation in the study by Fullman and collegues using 2016 data, versus panel data analysis using data spanning 2000-2016 in this study.

Nevertheless, our counterintuitive findings suggest that the relationship between domestic GEH and premature NCD mortality may be mediated by another pathway. The goal of mediation in regression analysis is to further our understanding beyond correlation between the predictor and the outcome variable, particularly when evidence of correlation already exists (Frazier et al., 2004). It helps identify

how and why a predictor variable relates to the outcome variable. Our insignificant findings therefore suggest only that HAQI in itself as a measure of access to quality healthcare, is not that pathway. Indeed, our findings suggest that HAQI may function more as a control variable that affects NCD mortality independently, rather than as a mediating variable. However, the coefficient of HAQI in the regression model incorporating domestic GEH, HAQI and the other control variables was non-significant, suggesting that it's effect may be insignificant, controlling for other independent variables. HAQI measures personal level of access to quality healthcare, which may be less sensitive to domestic GEH, compared to other aggregate measures of access to healthcare such as health worker and health facility density (Vedanthan et al., 2019). Nonetheless, these measures would only be able to quantify access but not quality, which has a significant effect on mortality from NCDs (Kruk et al., 2018).

In summary, this study found that access to quality healthcare, as measured using the HAQI metric, is not the mediating pathway in the relationship between domestic GEH and premature NCD mortality. Future studies should investigate the role of HAQI as an independent predictor of NCD mortality.

5.5 Country income grouping as a moderating variable on the relationship between NCD mortality and GEH

This study found that country income grouping had a moderating role on the relationship between domestic GEH and NCD mortality. Specifically, rising income per capita enhanced the inverse relationship between domestic GEH and NCD mortality, with domestic GEH predicting lower NCD mortality in upper middle income and high income countries but not in low and lower middle income countries. This finding was consistently observed in both fixed and random effects model, in the sensitivity analysis, and when the relationship was assessed using sub-group analysis. This finding however ran counter to theory and prior studies. (Rana et al., 2018) found that the effect of total health expenditure on infant mortality, under-five mortality, and life expectancy was more pronounced and consistent in low and lower middle income countries, while (Ray & Linden, 2020) found that GEH was associated with higher life expectancy and lower infant mortality in lower income countries but not in higher income countries. Several factors may explain our findings. First, and most importantly, health status is poorest in lower income countries, including for NCDs, where mortality is highest in LMICs. This implies that larger investments in the form of domestic GEH are required to improve health status than those seen over the study period in LMICs. A WHO 2018 report on public health spending, which relied on the same data as we used in this study, showed that between 2000 and 2016, public spending on health as a percentage of GDP barely rose in low and lower middle-income countries, while that in high income countries rose by more than 1.5%. This suggests that the mean rise in domestic GEH observed in our study could be accounted for primarily by upper middle income and high income countries, with far lower rises in low income and lower middle income countries.

Second, our findings could be the result of using a different health outcome, NCD mortality, which perhaps is less sensitive to GEH in lower income countries. Of note, in a study in Georgia, USA, a high income country, (Marton et al., 2015) reported that public health funding had a higher effect on heart disease mortality in lower income counties than higher income counties. Third, the efficiency of public resource use that may be higher as country income rises – perhaps due to better health governance as well as less misappropriation of public health funding, since lower income countries consistently perform poorest across governance measures.

In summary, our study found a significant enhancing moderating effect of country income grouping on the relationship between domestic GEH and NCD mortality rates.

5.6 Study limitations

This is the first study to evaluate the relationship between domestic GEH and premature NCD mortality at the global level, explore a potential mediating pathway, and evaluate the moderating role of country income on the relationship. Nevertheless, it has several limitations. The premature mortality indicator chosen, only accounts for four NCDs (CVD, cancer, DM, and CRD), so is inadequate in comprehensively addressing the relationship between domestic GEH and all premature mortality from NCDs, excluding causes such as suicides from mental health disorders which are on the rise (Martinez et al., 2020). Mortality proportion attributable to NCDs is also affected by changes in other causes of death, for example, a higher mortality from other causes e.g. communicable, maternal and nutritional disorders may lead to a lower proportion of deaths attributable to NCDs (Martinez et al., 2020). Using age-standardised mortality rate in the sensitivity analyses however mitigates in part the above two limitations, and reported similar and consistent findings. Nevertheless, some caution is needed for interpretation of our findings.

The specific effect of domestic GEH on NCD is not discernible due to the use of aggregate level data. Future studies will need to assess this relationship using program level funding data dedicated towards NCDs which is unavailable at this time. Additionally, the analysis uses secondary data from 2000-2016, and within this time period, relies on years when global mortality data is provided (2000, 2005, 2010, 2015 and 2016). This however reflects the period when global reports on NCD mortality have been released, with the next iteration expected to be released in 2021. The use of secondary data may carry over inaccuracies in the original dataset which may affect this study findings. However, the selected databases are historically considered to be reliable and accurate.

Finally, endogeneity may be a problem in panel data analysis techniques and may arise if decisions about healthcare spending are strongly influenced by the health outcome in question, e.g. a country with higher rates of NCD mortality decides to spend more to combat the burden (Marton et al., 2015), however, if this were the case, we'd expect the rise in domestic GEH to be higher in low income and

lower middle income countries than it is in higher income countries given the higher NCD mortality rates, a trend that is not seen.

5.7 Conclusions

Objective one of this study was to investigate the relationship between government expenditure on health and non-communicable disease mortality rates globally. To this effect, the main hypothesis was that domestic government expenditure on health is inversely correlated with NCD mortality rate. This study confirmed this main study hypothesis by finding that domestic GEH is significantly inversely correlated with premature NCD mortality from the four major NCDs (CVD, Cancer, DM, and CRD), and also with age standardised NCD mortality per 100,000 persons, whereby increasing domestic GEH is associated with a decrease in NCD mortality, controlling for domestic PEH, per capita GDP, tertiary education level, and government effectiveness.

Objective two of this study was to investigate access to quality healthcare as a mediator of the relationship between government expenditure on health and non-communicable disease mortality. To this effect, the underlying hypothesis for objective two was that access to quality healthcare mediates the relationship between government expenditure on health and NCD mortality rate. This study findings however rejected this hypothesis, finding that access to quality healthcare, as measured using the HAQI metric, is not the pathway by which the relationship between domestic GEH and either premature mortality from the four major NCDs, as well as age-standardised total mortality from NCDs is mediated,

Objective three of this study was to investigate the moderating effect of country income grouping on the relationship between government expenditure on health and non-communicable disease mortality. To this effect, the underlying hypothesis for objective three was that country income grouping moderates the relationship between government expenditure on health and NCD mortality rate, with higher income reducing the significance of the relationship. This study findings confirmed that country income grouping has a significant moderating effect on the relationship between domestic GEH and premature NCD mortality as well age-standardised total mortality from NCDs, controlling for domestic PEH, per capita GDP, tertiary education level, and government effectiveness. However, counter to the study hypothesis, the moderating effect is enhancing, such that as income group rises, the strength of the association between domestic GEH and NCD mortality increases.

These study conclusions form the basis of our policy recommendations.

5.8 Policy recommendations

Governments must prioritise domestic GEH, by increasing allocation of their own revenue towards healthcare. As country income rises, there is generally an increase in expenditure, including towards the health sector. While this study found a rising trend in domestic GEH globally, this was however comparatively smaller, 1% over the study period, compared with a doubling of GDP over the same

period – implying that governments have not prioritised domestic health spending, despite its notable effects on health and economic growth. This prioritisation is particularly important in low income and lower middle income countries, where even higher investment in the form of domestic GEH is needed as these countries report higher premature mortality from NCDs, and have also had stagnant public spending on health compared to their higher income countries over the period of 2000-2016, as noted by a 2018 WHO report on public spending on health. In the same report, it was highlighted that prioritisation reflects choices by politicians and policy makers. Such choices can be influenced through findings such as those by this study, whereby we've demonstrated that increasing domestic GEH is associated with a decrease in premature NCD mortality among a very productive age group in society, that is, individuals aged 30-60 years. The potential of reducing premature mortality in this age group through investment in health is supported by prior investment cases for NCD care, whereby the downstream economic benefits of NCD control policies offset the cost that governments incur in implementing such policies.

An illustrative example comes from an investment case analysis conducted in Jamaica (Hutchinson et al., 2019), whereby investing in NCD prevention and control efforts targeting major risk factors for cardiovascular disease, diabetes mellitus, and chronic respiratory diseases was estimated to cost 37.8 billion Jamaican dollars over a fifteen-year period, but offered corresponding economic benefits of 81.3 billion Jamaican dollars over the same period, a return on investment of 2.2. Of note, over the first five years of the program, the program would nearly break even, with a short-term return on investment of 0.96. The economic benefits were tied to increased productivity as a result of an increased human labour pool secondary to reduced absenteeism from work as a result of NCD related disability and mortality, as well as decreased healthcare related expenditure, which diverts capital away from savings and investments which spur economic growth.

In prioritising domestic GEH, the initial goal will be to achieve the identified minimum target of 5% domestic GEH as a percentage of country GDP that is needed to achieve UHC, from the 2016 level reported by our study of 4%. However, our study indicates that the current rate of increase is too slow, since given the current trend, it would be expected that the 5% target as a global average would be reached in 2032, two years after the SDG target of 2030. Of note though, this represents the global average, and so it is the case that individual countries and governments yet to reach the target, may reach it faster than others. The 5% target that is recommended by prior studies was proposed based on the previous millennium development goals, and was formulated based on the target of decreasing infant mortality to the MDG targets (Meheus & McIntyre, 2017).

Our study findings however, suggest that the 5% target would still fall short of what's required to achieve SDG 3.4, that is decreasing premature NCD mortality by a third by 2030. To demonstrate this based on our analysis, the risk of premature NCD mortality would need to fall by a third from its 2015

level, to 11.9% by 2030. This represents a 31.2% reduction in the risk of premature NCD mortality from the 2015 number, which corresponds to a 63.7% rise in domestic GEH from its 4% level in 2016, to 6.5%. We estimate therefore, that domestic GEH will need to rise significantly beyond the 5% level, to around 6.5%, to achieve SDG 3.4, and proposes this as the target that domestic governments need to aspire to.

Expanding domestic GEH within a country's fiscal space, that is sustainably doing so without adversely affecting other important government services requires more broad based solutions such as increasing government revenue generation through improved tax compliance as well as more novel solutions which include excise taxes on tobacco, alcohol, trans fats, salt and sugar sweetened beverages which have all demonstrated effectiveness in increasing government revenue, with important health effects on NCD prevention. (Sassi et al., 2018) estimated that increasing taxes on tobacco products by 50% and alcoholic beverages by 40% would generate as much as 25% more revenue for low and middle income governments. Such windfall could be directed in part, towards supplementing domestic GEH.

Our finding of an absent mediating effect of HAQI on the relationship between domestic GEH and premature NCD mortality also has an instructive policy implication. Theory suggests that government spending on healthcare provides the base through which the majority of the population can sustainably access health services, particularly in low and middle income countries. It is therefore concerning that this relationship was not demonstrated by this study, implying a need for future investigations in this domain. However, immediately, given that the goal of UHC is to expand access to healthcare, UHC implementation should include access to quality healthcare as one of their monitoring and evaluation measures to assess whether this goal is being met. If it is indeed demonstrated to be consistently absent, then it may be that the individuals who depend on public healthcare are not the ultimate beneficiaries of such efforts if government investment in health is not improving their access to quality healthcare services, necessitating changes in the policies themselves, or their implementation.

References

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

Alam, K., & Mahal, A. (2014). Economic impacts of health shocks on households in low and middle income countries: A review of the literature. *Globalization and Health*, *10*, 21. https://doi.org/10.1186/1744-8603-10-21

Arthur, E., & Oaikhenan, H. E. (2017). *The Effects of Health Expenditure on Health Outcomes in Sub-Saharan Africa (SSA)*. https://doi.org/10.1111/1467-8268.12287

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), 1173–1182. https://doi.org/10.1037//0022-3514.51.6.1173

Beaglehole, R., Bonita, R., Horton, R., Adams, C., Alleyne, G., Asaria, P., Baugh, V., Bekedam, H., Billo, N., Casswell, S., Cecchini, M., Colagiuri, R., Colagiuri, S., Collins, T., Ebrahim, S., Engelgau, M., Galea, G., Gaziano, T., Geneau, R., … NCD Alliance. (2011). Priority actions for the non-communicable disease crisis. *Lancet (London, England)*, *377*(9775), 1438–1447. https://doi.org/10.1016/S0140-6736(11)60393-0

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

Bertram, M., Banatvala, N., Kulikov, A., Belausteguigoitia, I., Sandoval, R., Hennis, A., Webb, D., & Tarlton, D. (2019). Using economic evidence to support policy decisions to fund interventions for non-communicable diseases. *BMJ (Clinical Research Ed.)*, *365*, l1648. https://doi.org/10.1136/bmj.l1648

Burney, P., Jarvis, D., & Perez-Padilla, R. (2015). The global burden of chronic respiratory disease in adults. *The International Journal of Tuberculosis and Lung Disease: The Official Journal of the International Union Against Tuberculosis and Lung Disease*, *19*(1), 10–20. https://doi.org/10.5588/ijtld.14.0446

Chen, S., Kuhn, M., Prettner, K., & Bloom, D. E. (2018). The macroeconomic burden of noncommunicable diseases in the United States: Estimates and projections. *PloS One*, *13*(11), e0206702. https://doi.org/10.1371/journal.pone.0206702

Curtis, L. J. (2018). An economic perspective on the causal explanations for the socioeconomic inequalities in health. *Revista Panamericana De Salud Publica = Pan American Journal of Public Health*, *42*, e53. https://doi.org/10.26633/RPSP.2018.53

Cutler, D. M., & Lleras-Muney, A. (2010). Understanding differences in health behaviors by education. *Journal of Health Economics*, *29*(1), 1–28. https://doi.org/10.1016/j.jhealeco.2009.10.003

Dalal, S., Beunza, J. J., Volmink, J., Adebamowo, C., Bajunirwe, F., Njelekela, M., Mozaffarian, D., Fawzi, W., Willett, W., Adami, H.-O., & Holmes, M. D. (2011). Non-communicable diseases in sub-Saharan Africa: What we know now. *International Journal of Epidemiology*, *40*(4), 885–901. https://doi.org/10.1093/ije/dyr050

Etienne, C. F. (2018). Advancing the economics of noncommunicable diseases in the Americas. *Revista Panamericana De Salud Publica = Pan American Journal of Public Health*, *42*, e94. https://doi.org/10.26633/RPSP.2018.94

Fayissa, B., & Gutema, P. (2008). A Health Production Function for Sub-Saharan Africa (SSA). *Middle Tennessee State University, Department of Economics and Finance, Working Papers*.

Frazier, P. A., Tix, A. P., & Barron, K. E. (2004). Testing Moderator and Mediator Effects in Counseling Psychology Research. *Journal of Counseling Psychology*, *51*(1), 115–134. https://doi.org/10.1037/0022-0167.51.1.115

GBD 2016 Healthcare Access and Quality Collaborators. (2018). Measuring performance on the Healthcare Access and Quality Index for 195 countries and territories and selected subnational locations: A systematic analysis from the Global Burden of Disease Study 2016. *Lancet (London, England)*, *391*(10136), 2236–2271. https://doi.org/10.1016/S0140-6736(18)30994-2

GBD 2017 Causes of Death Collaborators. (2018). Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980-2017: A systematic analysis for the Global Burden of Disease Study 2017. *Lancet (London, England)*, *392*(10159), 1736–1788. https://doi.org/10.1016/S0140-6736(18)32203-7

GBD 2017 DALYs and HALE Collaborators. (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. *Lancet (London, England)*, *392*(10159), 1859–1922. https://doi.org/10.1016/S0140-6736(18)32335-3

GBD 2017 SDG Collaborators. (2018). Measuring progress from 1990 to 2017 and projecting attainment to 2030 of the health-related Sustainable Development Goals for 195 countries and territories: A systematic analysis for the Global Burden of Disease Study 2017. *Lancet (London, England)*, *392*(10159), 2091–2138. https://doi.org/10.1016/S0140-6736(18)32281-5

Global Burden of Disease Health Financing Collaborator Network. (2018). Trends in future health financing and coverage: Future health spending and universal health coverage in 188 countries, 2016-40. *Lancet (London, England)*, *391*(10132), 1783–1798. https://doi.org/10.1016/S0140-6736(18)30697-4

Gouda, H. N., Charlson, F., Sorsdahl, K., Ahmadzada, S., Ferrari, A. J., Erskine, H., Leung, J., Santamauro, D., Lund, C., Aminde, L. N., Mayosi, B. M., Kengne, A. P., Harris, M., Achoki, T., Wiysonge, C. S., Stein, D. J., & Whiteford, H. (2019). Burden of non-communicable diseases

in sub-Saharan Africa, 1990-2017: Results from the Global Burden of Disease Study 2017. *The Lancet. Global Health*, *7*(10), e1375–e1387. https://doi.org/10.1016/S2214-109X(19)30374-2

Grossman, M. (1972). On the Concept of Health Capital and the Demand for Health. *Journal of Political Economy*, *80*(2), 223–255. JSTOR.

Gulliford, M., Figueroa-Munoz, J., Morgan, M., Hughes, D., Gibson, B., Beech, R., & Hudson, M. (2002). What does "access to health care" mean? *Journal of Health Services Research & Policy*, *7*(3), 186–188. https://doi.org/10.1258/135581902760082517

Harding, J. L., Pavkov, M. E., Magliano, D. J., Shaw, J. E., & Gregg, E. W. (2019). Global trends in diabetes complications: A review of current evidence. *Diabetologia*, *62*(1), 3–16. https://doi.org/10.1007/s00125-018-4711-2

Hawkes, N. (2019). Cancer survival data emphasise importance of early diagnosis. *BMJ (Clinical Research Ed.)*, *364*, l408. https://doi.org/10.1136/bmj.l408

Hone, T., Macinko, J., & Millett, C. (2018). Revisiting Alma-Ata: What is the role of primary health care in achieving the Sustainable Development Goals? *Lancet (London, England)*, *392*(10156), 1461–1472. https://doi.org/10.1016/S0140-6736(18)31829-4

Hutchinson, B., Small, R., Acquah, K., Sandoval, R., Nugent, R., Davidson, T., Belausteguigoitia, D. I., Banatvala, N., Webb, D., Tarlton, D., Kulikov, A., Prieto, E., & Santi, K. (2019). The investment case as a mechanism for addressing the NCD burden: Evaluating the NCD institutional context in Jamaica, and the return on investment of select interventions. *PloS One*, *14*(10), e0223412. https://doi.org/10.1371/journal.pone.0223412

Ibanez, B., James, S., Agewall, S., Antunes, M. J., Bucciarelli-Ducci, C., Bueno, H., Caforio, A. L. P., Crea, F., Goudevenos, J. A., Halvorsen, S., Hindricks, G., Kastrati, A., Lenzen, M. J., Prescott, E., Roffi, M., Valgimigli, M., Varenhorst, C., Vranckx, P., Widimský, P., & ESC Scientific Document Group. (2018). 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the

management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). *European Heart Journal*, *39*(2), 119–177. https://doi.org/10.1093/eurheartj/ehx393

Islam, S. M. S., Purnat, T. D., Phuong, N. T. A., Mwingira, U., Schacht, K., & Fröschl, G. (2014). Non-communicable diseases (NCDs) in developing countries: A symposium report. *Globalization and Health*, *10*, 81. https://doi.org/10.1186/s12992-014-0081-9

Jamison, D. T., Alwan, A., Mock, C. N., Nugent, R., Watkins, D., Adeyi, O., Anand, S., Atun, R., Bertozzi, S., Bhutta, Z., Binagwaho, A., Black, R., Blecher, M., Bloom, B. R., Brouwer, E., Bundy, D. A. P., Chisholm, D., Cieza, A., Cullen, M., … Zhao, K. (2018). Universal health coverage and intersectoral action for health: Key messages from Disease Control Priorities, 3rd edition. *Lancet (London, England)*, *391*(10125), 1108–1120. https://doi.org/10.1016/S0140-6736(17)32906-9

Jan, S., Laba, T.-L., Essue, B. M., Gheorghe, A., Muhunthan, J., Engelgau, M., Mahal, A., Griffiths, U., McIntyre, D., Meng, Q., Nugent, R., & Atun, R. (2018). Action to address the household economic burden of non-communicable diseases. *Lancet (London, England)*, *391*(10134), 2047–2058. https://doi.org/10.1016/S0140-6736(18)30323-4

Jaspers, L., Colpani, V., Chaker, L., van der Lee, S. J., Muka, T., Imo, D., Mendis, S., Chowdhury, R., Bramer, W. M., Falla, A., Pazoki, R., & Franco, O. H. (2015). The global impact of non-communicable diseases on households and impoverishment: A systematic review. *European Journal of Epidemiology*, *30*(3), 163–188. https://doi.org/10.1007/s10654-014-9983-3

Jerven, M. (2013). *Poor Numbers: How We Are Misled by African Development Statistics and What to Do about It*. Cornell University Press. https://www.jstor.org/stable/10.7591/j.ctt1xx4sk

Kamal, K. M., Covvey, J. R., Dashputre, A., Ghosh, S., Shah, S., Bhosle, M., & Zacker, C. (2017). A Systematic Review of the Effect of Cancer Treatment on Work Productivity of Patients and Caregivers. *Journal of Managed Care & Specialty Pharmacy*, *23*(2), 136–162. https://doi.org/10.18553/jmcp.2017.23.2.136

Kostova, D., Chaloupka, F. J., Frieden, T. R., Henning, K., Paul, J., Osewe, P. L., & Asma, S. (2017). Noncommunicable Disease Risk Factors in Developing Countries: Policy Perspectives. *Preventive Medicine*, *105S*, S1–S3. https://doi.org/10.1016/j.ypmed.2017.09.027

Kruk, M. E., Gage, A. D., Joseph, N. T., Danaei, G., García-Saisó, S., & Salomon, J. A. (2018). Mortality due to low-quality health systems in the universal health coverage era: A systematic analysis of amenable deaths in 137 countries. *Lancet (London, England)*, *392*(10160), 2203–2212. https://doi.org/10.1016/S0140-6736(18)31668-4

Latunji, O. O., & Akinyemi, O. O. (2018). FACTORS INFLUENCING HEALTH-SEEKING BEHAVIOUR AMONG CIVIL SERVANTS IN IBADAN, NIGERIA. *Annals of Ibadan Postgraduate Medicine*, *16*(1), 52–60.

Lent, M. R., Vander Veur, S. S., McCoy, T. A., Wojtanowski, A. C., Sandoval, B., Sherman, S., Komaroff, E., & Foster, G. D. (2014). A randomized controlled study of a healthy corner store initiative on the purchases of urban, low-income youth. *Obesity (Silver Spring, Md.)*, *22*(12), 2494–2500. https://doi.org/10.1002/oby.20878

Leon, D. A., Walt, G., & Gilson, L. (2001). Recent advances: International perspectives on health inequalities and policy. *BMJ (Clinical Research Ed.)*, *322*(7286), 591–594. https://doi.org/10.1136/bmj.322.7286.591

Li, J., & Yuan, B. (2019). Understanding the effectiveness of government health expenditure in improving health equity: Preliminary evidence from global health expenditure and child mortality rate. *The International Journal of Health Planning and Management*, *34*(4), e1968–e1979. https://doi.org/10.1002/hpm.2837

MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods*, *7*(1), 83–104. https://doi.org/10.1037/1082-989x.7.1.83

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*, 932. https://doi.org/10.1186/s12889-015-2287-z

Marquez, P. V., & Suhrcke, M. (2005). Combating non-communicable diseases. *BMJ (Clinical Research Ed.)*, *331*(7510), 174. https://doi.org/10.1136/bmj.331.7510.174

Martinez, R., Lloyd-Sherlock, P., Soliz, P., Ebrahim, S., Vega, E., Ordunez, P., & McKee, M. (2020). Trends in premature avertable mortality from non-communicable diseases for 195 countries and territories, 1990-2017: A population-based study. *The Lancet. Global Health*, *8*(4), e511–e523. https://doi.org/10.1016/S2214-109X(20)30035-8

Marton, J., Sung, J., & Honore, P. (2015). Does More Public Health Spending Buy Better Health? *Health Services Research and Managerial Epidemiology*, *2*, 2333392815580750. https://doi.org/10.1177/2333392815580750

Maruthappu, M., Ng, K. Y. B., Williams, C., Atun, R., Agrawal, P., & Zeltner, T. (2015). The association between government healthcare spending and maternal mortality in the European Union, 1981-2010: A retrospective study. *BJOG: An International Journal of Obstetrics and Gynaecology*, *122*(9), 1216–1224. https://doi.org/10.1111/1471-0528.13205

Mays, G. P., & Smith, S. A. (2011). Evidence links increases in public health spending to declines in preventable deaths. *Health Affairs (Project Hope)*, *30*(8), 1585–1593. https://doi.org/10.1377/hlthaff.2011.0196

Mcintyre, D., Meheus, F., & Røttingen, J.-A. (2017). What level of domestic government health expenditure should we aspire to for universal health coverage? *Health Economics, Policy, and Law*, *12*(2), 125–137. https://doi.org/10.1017/S1744133116000414

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

Mensah, G. A., Roth, G. A., Sampson, U. K. A., Moran, A. E., Feigin, V. L., Forouzanfar, M. H., Naghavi, M., Murray, C. J. L., & GBD 2013 Mortality and Causes of Death Collaborators. (2015). Mortality from cardiovascular diseases in sub-Saharan Africa, 1990-2013: A systematic analysis of data from the Global Burden of Disease Study 2013. *Cardiovascular Journal of Africa*, *26*(2 Suppl 1), S6-10. https://doi.org/10.5830/CVJA-2015-036

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

Moucheraud, C., Owen, H., Singh, N. S., Ng, C. K., Requejo, J., Lawn, J. E., Berman, P., & Countdown Case Study Collaboration Group. (2016). Countdown to 2015 country case studies: What have we learned about processes and progress towards MDGs 4 and 5? *BMC Public Health*, *16 Suppl 2*, 794. https://doi.org/10.1186/s12889-016-3401-6

Mushi, L., Marschall, P., & Fleßa, S. (2015). The cost of dialysis in low and middle-income countries: A systematic review. *BMC Health Services Research*, *15*(1), 506. https://doi.org/10.1186/s12913-015-1166-8

NCD Countdown 2030 collaborators. (2018). NCD Countdown 2030: Worldwide trends in non-communicable disease mortality and progress towards Sustainable Development Goal target 3.4. *Lancet (London, England)*, *392*(10152), 1072–1088. https://doi.org/10.1016/S0140-6736(18)31992-5

NCD Risk Factor Collaboration (NCD-RisC) – Africa Working Group. (2017). Trends in obesity and diabetes across Africa from 1980 to 2014: An analysis of pooled population-based studies. *International Journal of Epidemiology*, *46*(5), 1421–1432. https://doi.org/10.1093/ije/dyx078

Neil Fantom & Umar Serrajudin. (2016). *The World Bank's Classification of Countries by Income*. https://openknowledge.worldbank.org/handle/10986/23628

Nicholas, A., Edward, N.-A., & Bernardin, S. (2016). *The effect of health expenditure on selected maternal and child health outcomes in Sub-Saharan Africa*. https://doi.org/10.1108/IJSE-08-2015-0199

Niessen, L. W., Mohan, D., Akuoku, J. K., Mirelman, A. J., Ahmed, S., Koehlmoos, T. P., Trujillo, A., Khan, J., & Peters, D. H. (2018). Tackling socioeconomic inequalities and non-communicable diseases in low-income and middle-income countries under the Sustainable Development agenda. *Lancet (London, England)*, *391*(10134), 2036–2046. https://doi.org/10.1016/S0140-6736(18)30482-3

Nixon, J., & Ulmann, P. (2006). The relationship between health care expenditure and health outcomes. Evidence and caveats for a causal link. *The European Journal of Health Economics: HEPAC: Health Economics in Prevention and Care*, *7*(1), 7–18. https://doi.org/10.1007/s10198-005-0336-8

Njuguna, B., Vorkoper, S., Patel, P., Reid, M. J. A., Vedanthan, R., Pfaff, C., Park, P. H., Fischer, L., Laktabai, J., & Pastakia, S. D. (2018). Models of integration of HIV and noncommunicable disease care in sub-Saharan Africa: Lessons learned and evidence gaps. *AIDS (London, England)*, *32 Suppl 1*, S33–S42. https://doi.org/10.1097/QAD.0000000000001887

Nketiah-Amponsah, E. (2019). The Impact of Health Expenditures on Health Outcomes in Sub-Saharan Africa. *Journal of Developing Societies*, *35*(1), 134–152. https://doi.org/10.1177/0169796X19826759

Noel, J. K. (2017). Public health care funding modifies the effect of out-of-pocket spending on maternal, infant, and child mortality. *Health Care for Women International*, *38*(3), 253–266. https://doi.org/10.1080/07399332.2016.1254217

Nolte, E., & McKee, C. M. (2008). Measuring the health of nations: Updating an earlier analysis. *Health Affairs (Project Hope)*, *27*(1), 58–71. https://doi.org/10.1377/hlthaff.27.1.58

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.

Nugent, R., Bertram, M. Y., Jan, S., Niessen, L. W., Sassi, F., Jamison, D. T., Pier, E. G., & Beaglehole, R. (2018). Investing in non-communicable disease prevention and management to advance the Sustainable Development Goals. *Lancet (London, England)*, *391*(10134), 2029–2035. https://doi.org/10.1016/S0140-6736(18)30667-6

Piatti-Fünfkirchen, M., Lindelow, M., & Yoo, K. (2018). What Are Governments Spending on Health in East and Southern Africa? *Health Systems and Reform*, *4*(4), 284–299. https://doi.org/10.1080/23288604.2018.1510287

Rahman, M. M., Khanam, R., & Rahman, M. (2018). Health care expenditure and health outcome nexus: New evidence from the SAARC-ASEAN region. *Globalization and Health*, *14*(1), 113. https://doi.org/10.1186/s12992-018-0430-1

Rajkumar, A. S., & Swaroop, V. (2008). Public spending and outcomes: Does governance matter? *Journal of Development Economics*, *86*(1), 96–111. https://doi.org/10.1016/j.jdeveco.2007.08.003

Rana, R. H., Alam, K., & Gow, J. (2018). Health expenditure, child and maternal mortality nexus: A comparative global analysis. *BMC International Health and Human Rights*, *18*(1), 29. https://doi.org/10.1186/s12914-018-0167-1

Rasul, F. B., Kalmus, O., Sarker, M., Adib, H. I., Hossain, M. S., Hasan, M. Z., Brenner, S., Nazneen, S., Islam, M. N., & De Allegri, M. (2019). Determinants of health seeking behavior for chronic non-communicable diseases and related out-of-pocket expenditure: Results from a cross-sectional survey in northern Bangladesh. *Journal of Health, Population and Nutrition*, *38*(1), 48. https://doi.org/10.1186/s41043-019-0195-z

Ray, D., & Linden, M. (2020). Health expenditure, longevity, and child mortality: Dynamic panel data approach with global data. *International Journal of Health Economics and Management*, *20*(1), 99–119. https://doi.org/10.1007/s10754-019-09272-z

Rockers, P. C., Laing, R. O., & Wirtz, V. J. (2018). Equity in access to non-communicable disease medicines: A cross-sectional study in Kenya. *BMJ Global Health*, *3*(3), e000828. https://doi.org/10.1136/bmjgh-2018-000828

Rossier, C., Soura, A. B., Duthé, G., & Findley, S. (2014). Non-Communicable Disease Mortality and Risk Factors in Formal and Informal Neighborhoods, Ouagadougou, Burkina Faso: Evidence from a Health and Demographic Surveillance System. *PloS One*, *9*(12), e113780. https://doi.org/10.1371/journal.pone.0113780

Sassi, F., Belloni, A., Mirelman, A. J., Suhrcke, M., Thomas, A., Salti, N., Vellakkal, S., Visaruthvong, C., Popkin, B. M., & Nugent, R. (2018). Equity impacts of price policies to promote healthy behaviours. *Lancet (London, England)*, *391*(10134), 2059–2070. https://doi.org/10.1016/S0140-6736(18)30531-2

Somé, J., Pasali, S., & Kaboine, M. (2019). *Exploring the Impact of Healthcare on Economic Growth in Africa*. https://doi.org/10.11114/AEF.V6I3.4110

Stefan, D. C. (2015). Cancer Care in Africa: An Overview of Resources. *Journal of Global Oncology*, *1*(1), 30–36. https://doi.org/10.1200/JGO.2015.000406

Stenberg, K., Hanssen, O., Edejer, T. T.-T., Bertram, M., Brindley, C., Meshreky, A., Rosen, J. E., Stover, J., Verboom, P., Sanders, R., & Soucat, A. (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

Stone, N. J., Robinson, J. G., Lichtenstein, A. H., Bairey Merz, C. N., Blum, C. B., Eckel, R. H., Goldberg, A. C., Gordon, D., Levy, D., Lloyd-Jones, D. M., McBride, P., Schwartz, J. S., Shero, S. T., Smith, S. C., Watson, K., Wilson, P. W. F., & American College of Cardiology/American Heart Association Task Force on Practice Guidelines. (2014). 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: A report of the American College of Cardiology/American Heart Association Task Force on

Practice Guidelines. *Journal of the American College of Cardiology*, *63*(25 Pt B), 2889–2934. https://doi.org/10.1016/j.jacc.2013.11.002

Stuckler, D. (2008). Population causes and consequences of leading chronic diseases: A comparative analysis of prevailing explanations. *The Milbank Quarterly*, *86*(2), 273–326. https://doi.org/10.1111/j.1468-0009.2008.00522.x

Tran, D. N., Njuguna, B., Mercer, T., Manji, I., Fischer, L., Lieberman, M., & Pastakia, S. D. (2017). Ensuring Patient-Centered Access to Cardiovascular Disease Medicines in Low-Income and Middle-Income Countries Through Health-System Strengthening. *Cardiology Clinics*, *35*(1), 125–134. https://doi.org/10.1016/j.ccl.2016.08.008

VanderWeele, T. J. (2016). Mediation Analysis: A Practitioner's Guide. *Annual Review of Public Health*, *37*, 17–32. https://doi.org/10.1146/annurev-publhealth-032315-021402

Vedanthan, R., Ray, M., Fuster, V., & Magenheim, E. (2019). Hypertension Treatment Rates and Health Care Worker Density. *Hypertension (Dallas, Tex.: 1979)*, *73*(3), 594–601. https://doi.org/10.1161/HYPERTENSIONAHA.118.11995

Wagstaff, A. (2002). Poverty and health sector inequalities. *Bulletin of the World Health Organization*, *80*(2), 97–105.

Williams, J., Allen, L., Wickramasinghe, K., Mikkelsen, B., Roberts, N., & Townsend, N. (2018). A systematic review of associations between non-communicable diseases and socioeconomic status within low- and lower-middle-income countries. *Journal of Global Health*, *8*(2), 020409. https://doi.org/10.7189/jogh.08.020409

Wirtz, V. J., Hogerzeil, H. V., Gray, A. L., Bigdeli, M., de Joncheere, C. P., Ewen, M. A., Gyansa-Lutterodt, M., Jing, S., Luiza, V. L., Mbindyo, R. M., Möller, H., Moucheraud, C., Pécoul, B., Rägo, L., Rashidian, A., Ross-Degnan, D., Stephens, P. N., Teerawattananon, Y., 't Hoen, E. F. M., … Reich, M. R. (2017). Essential medicines for universal health coverage. *Lancet (London, England)*, *389*(10067), 403–476. https://doi.org/10.1016/S0140-6736(16)31599-9

Wooldridge, J. M. (2013). *Introductory Econometrics: A Modern Approach*. South-Western Cengage Learning.

Yan, L. L., Li, C., Chen, J., Miranda, J. J., Luo, R., Bettger, J., Zhu, Y., Feigin, V., O'Donnell, M., Zhao, D., & Wu, Y. (2016). Prevention, management, and rehabilitation of stroke in low- and middle-income countries. *ENeurologicalSci*, *2*, 21–30. https://doi.org/10.1016/j.ensci.2016.02.011

Youlden, D. R., Cramb, S. M., Dunn, N. A. M., Muller, J. M., Pyke, C. M., & Baade, P. D. (2012). The descriptive epidemiology of female breast cancer: An international comparison of screening, incidence, survival and mortality. *Cancer Epidemiology*, *36*(3), 237–248. https://doi.org/10.1016/j.canep.2012.02.007