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THE BURDEN OF COMMUNICABLE AND NON-COMMUNICABLE DISEASES IN TWO SELECTED DISTRICTS IN NORTHERN GHANA

BY

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DECLARATION

I, **David Atombire Adumbire**, hereby declare that, except for references to other people's work, which has been duly acknowledged, this is the result of my own research conducted under the joint supervision of Prof. Ayaga Agula Bawah, Prof. Samuel Nii Ardey Codjoe and Dr. Aaron Kobina Christian. I further declare that this work has neither in part nor in whole been presented for another degree.

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DEDICATION

This thesis is dedicated to two categories of people-my mother-Adugbire Awine Azuure, and my children-Atariwine, Atiwine, Wevre, Wineboa and Awinepanga.

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ABSTRACT

Non-communicable diseases (NCDs) and communicable diseases (CDs) are major public health problems in Ghana, as in other developing countries. While research often focuses on population subgroups, such as children or adults, or on specific diseases, recent evidence points to the need to pay attention to all age groups, as both communicable and non-communicable diseases affect populations of all ages. Understanding the causes of death is crucial for designing interventions and resource allocation to avert premature mortality and improve population health and well-being. However, policy and programme planning to prevent premature deaths in many lower- and middle-income countries (LMICs) are hindered by inadequate vital statistics, limited data on disease burden, and a lack of critical analyses of the available data in these settings. This study used data from the Navrongo Health and Demographic Surveillance System (NDSS) site to estimate the impact of communicable and non-communicable diseases on longevity in rural poor contexts in Ghana. Single and multiple decrement life table models were employed to estimate the demographic burden of diseases. Age-specific decomposition analysis was conducted to determine which age groups contributed most to the burden of mortality and thus to longevity if public interventions were implemented to address the different causes of death. The results showed that mortality rates were higher in males than in females. The burden of NCDs was higher (46.0%) compared to CDs (37.4%), with cardiovascular disease being the leading NCD cause of mortality. More males died from NCDs (46.5% vs. 45.7%), while a higher proportion of females died from CDs (40.3% vs. 35.1%). Successfully reducing NCDs through public health interventions would contribute to a 6.7-year improvement in life expectancy, while the elimination of CDs would result in a 5.2-year improvement. Efforts to reduce the burden of diseases and promote the health of the population in the study area should focus more on reducing NCD mortality.

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LIST OF ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
ARI	Acute respiratory infections
BC	Birth of Christ
BoD	Burden of disease
CDC	Centers for Disease Control and Prevention
CDs	Communicable diseases
CHAG	Christian Health Association of Ghana
CHPS	Community-based healthcare planning system
CHFP	Community Health and Family Planning Project
CKI	Community Key Informants
COPD	Chronic Obstructive Pulmonary Diseases
CRA	Comparative Risk Assessment
CSM	Cerebrospinal Meningitis
CVD	Cardiovascular disease
DALYs	Disability-Adjusted Life Years
DHRC	Dodowa Health Research Centre
DHS	Demographic and Health Survey
DSA	Demographic Surveillance Area
DSS	Demographic Surveillance System
EMS	Emergency Medical Services
ETT	Epidemiological Transition Theory
GBD	Global Burden of Diseases
GHE	Global Health Estimates
GHS	Ghana Health Service

GIS	Geographic Information Systems
GSS	Ghana Statistical Service
HALE	Health-adjusted life expectancy
HALYs	Health-adjusted life years
HIV	Human Immune Virus
HRBs	Household Record Books
ICD	International Classification of Diseases
ICF	International Classification of Functioning, Disability and Health
INDEPTH	International Network for the Continuous Demographic Evaluation of Populations and Their Health
KHRC	Kintampo Health Research Centre
KNEM	Kassena-Nankana East Municipal
KNWD	Kassena-Nankana West District
LMICs	Lower and Middle-Income Countries
NCDs	Non-communicable diseases
NDPC	National Development Planning Commission
NDSS	Navrongo Demographic Surveillance Systems
NHRC	Navrongo Health Research Centre
PAHO	Pan American Health Organization
PCVA	Physician Coded Verbal Autopsy
PHC	Population and Housing Census
PYLL	Potential years of life lost
QALYs	Quality-Adjusted Life Years
RALE	Reproductive-Aged Life Expectancy

RIPS	Regional Institute for Population Studies
SCD	Sudden Cardiac Death
SDGs	Sustainable Development Goals
SSA	sub-Saharan Africa
TB	Tuberculosis
UNSDGs	United Nations Sustainable Development Goals
VA	Verbal Autopsy
VRS	Vital Registration System
WHO	World Health Organization
YLL	Years of life lost

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Introduction

Goal three (3) of the United Nations Sustainable Development Goals (UNSDGs) aims to achieve good health and well-being for all ages by combating the epidemics of major communicable diseases, reducing maternal and non-communicable mortality, and lowering road injuries and deaths. The World Health Organisation recognizes three major causes of mortality: communicable, non-communicable, and external causes. However, the two most predominant causes of mortality are communicable and non-communicable diseases. In some settings, communicable causes constitute the leading cause of mortality. The goal of this thesis was to estimate the contribution of communicable and non-communicable diseases to mortality in rural poor contexts in Ghana.

There has been a rise in the prevalence of non-communicable diseases (NCDs) in most developing countries, coexisting with already high communicable diseases (CDs) in Sub-Saharan Africa. The quest, therefore, was to understand which disease contributed most to the health burden of populations living in poor socio-economic neighbourhoods in one of Ghana's poorest regions. This was important because promoting health and improving life expectancy within the population requires understanding the disease that contributed most to the health burden. Additionally, identifying the geographical and demographic variations in disease burden and their contribution to mortality was crucial for developing appropriate interventions to improve population well-being and health.

Unfortunately, most deaths in many developing settings are not officially recorded; hence, their causes remain unknown. In some contexts, the data on causes of mortality are difficult to access or are limited in terms of sociodemographic and household variables. Under these scenarios, knowing the socioeconomic status and other factors that contributed to the disease burden is difficult.

The high burden of communicable diseases in Ghana, coupled with the trends and prevalence of NCDs, have implications for the country's health system and economy, as well as efforts toward achieving the SDGs. Addressing the burden of NCDs is crucial for improving the health and well-being of the population and reducing the economic burden of disease. According to Gwatkin & Heuveline (1997) and Gwatkin et al (1999), communicable disease burdens are said to be higher, particularly in settings with high levels of poverty, weak health systems, and poor environmental conditions. Disease burdens are often disproportionately observed across sociodemographic divides and geographic locations. Socioeconomic inequalities that exist between households significantly influence the impact and prevalence of diseases on different populations. Households that live in regions where poverty levels are high often face higher disease burdens due to limited access to quality healthcare.

The northern part of Ghana has a high incidence of poverty and wide disparities in healthcare access, contributing to varying disease burdens among different households. Poverty tends to exacerbate disease burdens because families with weak resource backgrounds often find it difficult to seek healthcare services, especially when such services are expensive. The Upper East Region is one of the poorest regions in Ghana (Ghana Statistical Service, 2015). An increased prevalence of both CDs and NCDs in the region has cost implications and affects health outcomes. Therefore, evidence is required to understand the mortality burden of CDs and NCDs in the region and to provide pathways toward reducing the burden to improve population well-being and health in the study area and Ghana in general.

Against this background, this study examined the contributions of communicable and non-communicable diseases to mortality among households in the northern part of Ghana. This part of the country usually has the highest number of communicable diseases, particularly cerebrospinal meningitis (CSM) and tuberculosis (TB) (de-Graft Aikins, 2007, Whitson, 2005; Yaka et al., 2008). The increase in non-communicable diseases in the region poses an enormous health burden to the population living within this geographic location.

1.2 Background

Like many other developing countries, Ghana faces a significant burden of disease, along with various healthcare delivery challenges that impact the well-being and health of its population. The country has a substantial demographic burden with a rapidly ageing population, amplifying the challenges posed by both non-communicable diseases, such as cardiovascular conditions, and communicable diseases, such as infectious outbreaks, necessitating a multifaceted approach to healthcare management. However, there is a lack of critical analysis of available mortality data as is the case in many lower and middle-income countries (LMICs), posing significant challenges to effective policy and program planning in these regions (Chandramohan et al., 2008; Chisumpa et al., 2019).

Understanding the causes of mortality and documenting evidence is, therefore, essential in designing cost-effective interventions that could lead to better health outcomes. Regrettably, there is insufficient literature on communicable and non-communicable causes of mortality among different sociodemographic groups and households, particularly those living in the African meningitis belt. This study aims to examine the mortality burden posed by communicable and non-communicable diseases to households living in one of Ghana's deprived and meningitis-prone regions.

Globally, major communicable diseases such as HIV/AIDS, tuberculosis (TB), malaria, and cerebrospinal meningitis (CSM) are among the top causes of death, with over 64 percent of these deaths occurring in Africa (WHO, 2023). In lower and middle-income countries, including Sub-Saharan Africa, there has been a disproportionate increase in the burden of infectious morbidity and mortality generally (Wang et al., 2016; WHO, 2014). It is estimated that communicable diseases account for 40 percent of all adult deaths (Narh-Bana et al., 2012).

Amid the communicable disease burden, NCDs such as diabetes, cardiovascular disease (CVD), and cancer have overtaken communicable causes of mortality (WHO, 2023; Williams et al., 2018). For instance, in 2018, non-communicable diseases were responsible for 71 percent of all global mortalities (NCD Countdown 2030 collaborators, 2018). Sadly, 77 percent of all NCD-related mortalities occurred in LMICs due to multiple factors such as population growth, ageing, urbanization, lack of knowledge and awareness about NCDs, fragile health systems, and poor living conditions (Gouda et al., 2019; Juma et al., 2020; World Health Organization, 2018). In 2023, statistics from the World Health Organisation showed that 74 percent of all deaths worldwide were attributable to NCDs, including heart disease, stroke, cancer, diabetes, and chronic lung disease. Over 75 percent of NCD deaths and 86 percent of the 17 million people who died prematurely before reaching 70 years occurred in low- and middle-income countries (WHO, 2023).

In Ghana, communicable diseases such as malaria, TB, and CSM significantly contribute to overall mortality. For example, in 2020, about 308 people died in the country due to malaria (WHO, 2021 pp. 260). In 2021, about 5.7 million malaria cases were recorded in the country, with 275 deaths (Outbreak News, 2023). In 2016, over 400 suspected cases of CSM were recorded in Ghana, with 90 (22.5 percent) deaths and significant morbidities (Addai-Mensah et al., 2019). In 2020, about

50 deaths were recorded in the country after a similar number of cases were reported (Adjorlolo et al., 2020). The outbreak of meningitis has become common in the northern part of Ghana, especially in the Upper West and Upper East Regions. The increased prevalence of communicable diseases such as CSM in the African meningitis belt could have dire consequences on mortality, population life course, quality of life, and life expectancy. If individuals survived the disease, they could become disabled for the rest of their lives, reducing the quality of life for those within the region.

Evidence suggests that individuals with marginalized characteristics, such as those living in rural areas, and economically poor or illiterate individuals, faced a severe burden of CDs and NCDs (Juma et al., 2020; Ram & Thakur, 2022; Williams et al., 2018). Most people in low-middle-income settings and rural areas, particularly in Sub-Saharan Africa, face difficulties accessing medications, diagnostic equipment, and other health technologies (Africa Renewal, 2017).

Ghana, a middle-income country with about 30.8 million people (GSS, 2021a), is rapidly urbanizing, yet the majority of the population still lives in deprived and disadvantaged areas characterized by poor access to quality healthcare, bad road networks, and high rates of illiteracy. These factors could impact education, screening, diagnosis, and treatment of CDs and NCDs, exacerbating their burden on people living in such settings.

The Upper East Region, one of the poorest in Ghana with a population of 1.3 million people (Ghana Statistical Service, 2021a), is over 80 percent rural with highly dispersed, often hard-to-reach communities. Despite several health interventions, such as the community-based healthcare planning system (CHPS) program, aimed at promoting access to healthcare (Kweku et al., 2020; Nyonator et al., 2005), most health facilities in the region still face challenges related to the availability of medical commodities, basic healthcare equipment, and health personnel (Atiga et al., 2023). All these challenges could have implications for the burden of CDs and NCDs among households in the region.

1.2.1 The concept of disease burden

The concept of a disease burden has been conceptualized variously and differently. In the field of population and public health, there are two main ways to measure a disease burden; biomedical and economic approach. Studies using the biomedical approach to understand the burden of disease are often interested in the quantification of morbidity and mortality, trends and risk attribution (Beltran-Sanchez & Preston, 2007; Murray & Lopez, 1996). With the biomedical method, other sophisticated measures are developed to cover the impact of illness, disability and premature death. Typically, the health-adjusted life years (HALYs), which provide a summary measure of population health, are often used to estimate the burden of disease. This method calculates the combined impact of morbidity and mortality on populations using two approaches: Disability-Adjusted Life Years (DALYs) and Quality-Adjusted Life Years (QALYs) (Gold et al., 2002). The DALYs estimate a disease burden by taking the difference between the current state of health of the individual and where everyone in the population is expected to live up to (standard life expectancy). On the other hand, QALYs are used to estimate the cost-effectiveness of public health intervention by measuring the quantity and quality of life lived. In a joint assessment of the global burden of diseases by the World Health Organization and the World Bank, the disability-adjusted life years (DALYs) lost as a result of the disease was used as a measure of burden (Murray & Lopez, 1996; World Bank, 1993). Other studies (Murray et al., 2003; Murray & Lopez, 1999) have employed the Comparative Risk Assessment (CRA) modules to estimate the global burden of diseases. One serious limitation of these methods, however, is that they require data on the years lived with a disability or disease. In many developing settings, data on population years lived with a disease is difficult to access.

One other approach is the economic approach which estimates the burden of disease focusing on the financial costs of illnesses for individuals, households, healthcare systems and societies. There are two main ways of assessing the burden of disease by the economic approach; indirect cost and direct cost. The direct cost assesses the cost associated with illness prevention, diagnosis and treatment. Thus, the costs of the illness are estimated from the deaths or hospitalizations in the given year. The indirect cost on the other hand assesses the value of labour and productivity losses as a result of the illness or early death.

While all these measures may be useful for country-level and regional assessment of the burden of disease, they each have some theoretical limitations and inconsistencies in capturing the burden at local community, household and family levels to provide context. The economic approach, for instance, is often criticized for its inability to distinguish whether living with a disease is more burdensome or costly than dying from it. The biomedical approach on the other hand has been questioned for ignoring certain types of burden that cannot be captured by simply estimating mortality and morbidity patterns of the disease. For instance, researchers have argued that the biomedical understanding of burden has largely focused on the individual who is ill and tends to ignore the disease burden on households, families and social networks. Meanwhile, evidence has demonstrated an enormous social and economic contribution from households and social networks as caregivers to their relatives who are ill (Barry, 2014).

Given the limitation of these approaches in providing a full understanding of the burden of disease, a more comprehensive methodology, that incorporates demographic tools to gauge the potential gains in life expectancy, is required. In other words, a different approach which captures the social determinants of health and disease impact is needed in population and public health to assess the burden of disease. For example, in his study to assess the burden of stroke in Ghana, Sanuade (2016) conceptualized burden as prevalence, experience and caregiving. While the approach introduced by the study was novel in assessing disease burden, it failed to estimate the potential years of life lost (YLL) as a result of the disease.

In this current study, the burden of CDs and NCDs is conceptualized in the context of prevalence (number of deaths as a result of the disease), potential gains in life expectancy and potential years of life lost (PYLL). The PYLL measures the burden of disease by aggregating the number of years of life lost by individuals in a population between their ages at death and the age they are expected to live (Young, 2004). This is estimated by using the health-adjusted life expectancy (HALE), a measure which summarises population health by calculating the average time in years that a person at any given age can expect to live assuming all things are constant (Gold et al., 2002).

Prevalence of a disease is defined as the proportion of the population that is living with a particular disease at a point in a given time. In other words, it is the proportion of people in a population with a disease or a particular condition at a specific time or over a specified period (Centers for Disease Control and Prevention (CDC, 2012: p.16). The prevalence approach is often employed to estimate the burden of disease (BoD) by estimating the number of cases of death and hospitalizations attributable to the disease in a given year (Jo, 2014). In the current context, trend analysis is adopted to observe the prevalence (number of deaths) of CDs and NCDs within the study area.

1.3 Problem Statement

Globally, the burden of diseases is a burning issue. This is because both developed and developing countries have undergone demographic and epidemiological transitions, which have changed the pattern and distribution of morbidity and mortality among populations and exacerbated the burden on the public health systems (Dye, 2014). Most countries particularly in the African region face a triple burden of diseases; infectious, NCDs and malnutrition. The coexistence of communicable diseases (CDs) and non-communicable diseases (NCDs), along with the rising trend and prevalence of NCDs due to lifestyle changes, presents a significant health burden (WHO, 2021).

Communicable diseases, including lower respiratory infections, diarrheal diseases, and tuberculosis, were ranked, by the World Health Organization (WHO); in 2016, to be among the top 10 causes of death globally. LMICs bear the greatest burden of both communicable and non-communicable diseases as they contribute to a significant cause of mortality in these settings (Morens et al., 2004; World Health Organization, 2018). The Global Burden of Disease Study (2019) revealed that the SSA region is still disproportionately affected by both communicable and non-communicable diseases, despite improvements in health interventions in other regions of the world (Gyasi et al., 2020). For instance, in 2021, approximately 67% of the global population living with HIV/AIDS resided in SSA and out of 38.4 million people living with HIV worldwide, about 25.6 million are in SSA (Moyo et al., 2023). According to the WHO, 95% of global malaria cases and 96% of malaria deaths occur in SSA. In 2021, the Region accounted for around 241 million malaria cases and 627,000 deaths (WHO, 2021b). SSA bears a high burden of TB, accounting for approximately 25% of all global TB cases (WHO African Region, 2023a). Additionally, the prevalence of hypertension in SSA is among the highest globally, with approximately 46% of adults aged 25 years or older affected, according to WHO. Diabetes prevalence in SSA has been rising rapidly. In 2021, it was estimated that around 24 million people were living with diabetes, and this number is projected to increase to 55 million by 2045, according to the International Diabetes Federation (IDF) (WHO African Region, 2023b).

In contrast, regions like North America and Europe have a higher burden of NCDs but lower rates of infectious diseases due to advanced healthcare infrastructure and effective public health interventions. SSA's combination of high rates of both infectious and chronic diseases is relatively unique. However, current disease estimates for the SSA region are scanty and many are based on sparse data, but projections indicate increases in non-communicable diseases (NCDs) due to changes in demographic and epidemiologic transitions (Agyei-Mensah & De-Graft Aikins, 2010; Agyemang et al., 2012; Awini et al., 2014).

In most of these countries, the focus has been on communicable diseases with little attention on the burden of NCDs (Dalal et al., 2011). In the West African region, there are quite a few studies on NCDs and their impact on mortality, including Ouagadougou (Streatfield et al., 2014; Rossier et al., 2014) and few have focused on the causes of death at the household level particularly on NCD mortality. Meanwhile, the burden of both CDs and NCDs remains a serious public health concern across the globe and has a severe long-term effect on survivors. For instance, about 36 million people die every year as a result of NCDs (Roura & Arulkumaran, 2015). Out of this figure, almost 80 percent (29 million) of the deaths are recorded in low- and middle-income countries. Over 9 million of the NCDs related deaths occur in people under the age of 60 years. An earlier study by Roura & Arulkumaran (2015) showed that premature death or disability from heart disease, stroke, diabetes and other NCDs brings about considerable suffering and losses to many countries' economies, particularly in LMICs. This burden could be higher in settings where communicable diseases are more prevalent.

Traditionally, mortality rates are used as central indices to measure health status at the country and community levels (Gardner & Sanborn, 1990, Gardner & Halweil, 2000). While mortality rates are important particularly in the field of demography as they help measure population health status and development outcomes, they have some limitations. One major limitation of using mortality rate to estimate health status is that it is unable to account for causes of premature death and how priorities can be targeted at reducing these deaths (Egunsola et al., 2019). This calls for more robust measurements incorporating mortality causes into the analysis.

Further, due to challenges associated with access to mortality data in many SSA countries, most studies depend on mortality projections and estimates by WHO to understand the diseases that cause death (GBD 2016 Meningitis Collaborators, 2018; Gouda et al., 2019; Horton, 2012; Lozano et al., 2012; Mathers & Loncar, 2006). Nevertheless, some of the findings are generated from scanty data and cannot be applied to sub-national level analysis of causes of mortality (Mathers & Loncar, 2006). Data from Demographic Surveillance Systems (DSS) contribute to filling some of the data gaps in many LMICs in Africa.

Data from DSS are said to be reliable because they help to fill the data inadequacy gaps in these settings. However, to date, studies that have estimated disease burden in Ghana from DSS remain scanty and incomprehensive (Awini et al., 2014; Bawah & Binka, 2007; Sulemana, 2017). More so, these studies vary in terms of subject, target population and geography making their findings unrepresentative and implausible in different contexts.

Although certain populations and places may have a severe burden of a specific disease condition, it is often important to assess its burden on the overall population rather than a target population as in the case of Sulemana, (2017) and Awini et al (2014) studies. The United Nations has advocated for stakeholders and policymakers to establish mechanisms to ensure healthy lives and promote well-being for all at all ages (World Health Organisation, 2017). Against this background, there are growing calls for researchers to generate data and statistics that help to gauge and monitor population health by estimating disease morbidity and mortality (World Health Organization, 2018). Thus, the current study explores the CD and NCD disease burden on households in the Kassena Nankana East Municipality and the Kassena Nankana West District in the Upper East Region of Ghana.

Ghana, like most developing countries, is faced with overlapping risk factors of communicable and non-communicable diseases (Agyei-Mensah & De-Graft Aikins, 2010). Outbreaks of meningitis infections, for instance, have become a yearly public health concern, especially in the northern part of Ghana which exacerbates the burden of communicable diseases in the country (WHO, 2019). In their 2016 annual report for example, the Ghana Health Services had identified that out of 18 deadly epidemics such as cholera, meningitis, yellow fever and others, meningitis was ranked as the third general health risk in the country (Ghana Health Service, 2016). Evidence showed that the Navrongo and Dodowa DSS in Ghana respectively recorded 40.9% and 28.3% NCD mortality in 2014 (Streatfield et al., 2014).

From the foregoing, it is clear that both communicable diseases (CDs) and non-communicable diseases (NCDs) are major burdens of morbidity and mortality in the country. Despite this, the scientific evidence on the burden of these diseases and other causes of death in the country are incomplete and incomprehensive. While there are several studies carried out on NCDs in the country (Agyei-Mensah & De-Graft Aikins, 2010; Agyemang et al., 2012; de-Graft Aikins, 2007; de-Graft Aikins et al., 2014; De-Graft Aikins et al., 2012; de-Graft Aikins, Addo, Ofei, et al., 2012; Karim et al., 2015; Minicuci et al., 2014; Nimako et al.2013; Saeed et al., 2013; Tenkorang &

Kuuire, 2015; Yawson et al., 2016), more of the research often focused on population subgroups such as children or adults or disease-specific focus but recent evidence points to the need to pay attention to all age groups as both communicable and non-communicable diseases are affecting populations of all ages. This study builds on the existing literature and goes further to estimate the impact of communicable and non-communicable diseases on longevity in rural poor contexts in Ghana. In rural and socioeconomically disadvantaged regions, particularly in the northern part of Ghana, the impact of these diseases is more pronounced. The Upper East Region, for instance, is one of the poorest areas in the country, characterized by limited access to healthcare, poor road networks, and high levels of poverty and illiteracy. These conditions make the population particularly vulnerable to both communicable and non-communicable diseases, posing significant challenges to healthcare delivery and health outcomes hence the need to assess the household burden of these diseases.

There are methodological challenges in estimating disease burden due to limited data. This study employed demographic tools and techniques including multiple and single decrement life tables to estimate the mortality burden of CDs and NCDs among households in rural Ghana. In the fields of epidemiology and demography, studies often employ life tables techniques to gauge the potential gains in life expectancy if certain diseases were to be removed from settings where they are endemic (Abubakari et al., 2019; Bawah & Binka, 2007). This is a useful approach which provides vivid information on what can be done to improve the health and well-being of the population by understanding the major diseases that cause death. This approach is a step away from the traditional mortality measurement of rates and ratios. The life table technique provides a good understanding of the number of years that would have been saved or gained if the disease that causes death were to be eradicated from the population. These approaches estimate the average years a person would have lived if he or she had not died younger. The approach is useful in quantifying the socio-economic loss due to early death. Other similar methods include the potentially productive years of life lost (PYPLL), and the valued years of potential life lost (VYPLL) (Rice, 1966; Gardner and Sandorn, 1990).

The life table technique though provides a good measure of mortality, is often limited in quantifying causes of premature deaths and the burden those deaths have on society (Barendregt, 2009). They are also limited in examining risk factors associated with causes of mortality. This study complements this by employing important methods, such as multinomial logistic regression, to estimate the risk factors associated with causes of death. These metrics help to identify and prioritise causes of death as well as quantify the social and economic burden of such deaths to society. Examining a disease burden, in this context, is critical in identifying the control and preventive strategies of the disease. Results from the study help to quantify the demographic impact or burden of CDs and NCDs in Ghana particularly, in the northern part of the country and provide evidence on how to implement health intervention to reduce the disease burden. Finally, the findings provide critical evidence to guide public health interventions, inform policy decisions, and contribute to the broader goal of improving population health and achieving the United Nations Sustainable Development Goal (SDG) 3 of ensuring good health and well-being for all.

1.4 Research Questions

The overall goal of the study was to examine the communicable and non-communicable disease mortality among households in two selected districts in Northern Ghana by answering the following questions:

1. To what extent was the data usable?

2. What are the prevalence and trends of communicable and non-communicable disease mortality among households in the study area?
3. What are the gains in population life expectancy if communicable and non-communicable disease mortality were to be eliminated from the study area?
4. What are the sociodemographic determinants or risk factors associated with the broad causes of mortality in the KNE and KNW districts?

1.5 Research Objectives

The main objective of the study was to examine the communicable and non-communicable disease mortality among households in two selected districts; the Kassena-Nankana East and West districts. Specifically, the study aimed:

1. To assess the level of accuracy and usability of the mortality data.
2. To estimate the prevalence and trends of communicable and non-communicable disease mortality among households in the study area.
3. To assess the potential gains in life expectancy if communicable and non-communicable disease mortality were to be eradicated from the study area.
4. To examine the sociodemographic factors associated with the broad causes of mortality in the KNE and KNW districts.

1.6 The Rationale for the Study

The motivation for this study was drawn from SDG 3. The rationale for the study was premised on three main scenarios; eliminate communicable diseases, reduce NCDs and combat road accidents and injuries. Among the targets for SDG 3 includes target 3.3 which aimed at ending epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combatting hepatitis, water-borne diseases and other communicable diseases. Additionally, target 3.4, of the same goal, is envisioned to reduce premature deaths from non-communicable diseases by by one-third. One important way to achieve this; is an understanding of the double burden of both CDs and NCDs so as to adopt effective strategies for prevention and control. Further, the knowledge of the burden of both diseases might help to provide an integrated and cost-effective intervention that can lead to better health outcomes.

Ghana, like most developing countries, faces overlapping risk factors of communicable and non-communicable diseases. This is as a result of lifestyle modifications which accompany the demographic transition, thereby giving a pathway to NCDs amidst the increased prevalence of communicable diseases. Some notable risk factors of communicable diseases include poverty and poor environmental-related outcomes. Poverty levels in Ghana are high which exacerbates the burden of both communicable and non-communicable diseases. Therefore, the household economic burden of diseases has a negative impact on populations, particularly the poor (Akweongo et al., 2013). Poverty levels are generally high among the populations living within the northern part of Ghana where communicable diseases are high (Ghana Statistical Service, 2014b). According to the Ghana Poverty Index, the districts in these regions constituted the poorest in 2015 (Ghana Statistical Service, 2015). Therefore, CDs and NCDs burden could further deepen poverty levels in the region as households may resort to selling their properties or borrowing from friends and relatives to pay for healthcare (Su et al., 2006).

Over the years, much attention has been focused on communicable diseases, particularly in LMICs to the neglect of non-communicable diseases which have become a competing risk of death in many poor-income settings. Information on the prevalence and how many lives could be saved if both CDs and NCDs were to be eliminated, particularly among rural poor populations has remained incomprehensive. Meanwhile, ending a major disease epidemic has a positive demographic gain, especially in terms of life expectancy. Thus, it is critical to estimate the potential improvement in life expectancy in this region assuming CDs and NCDs were to be reduced or eradicated as causes of mortality among households through major public health interventions.

Again, the relevance of this study hinged on its usage of longitudinal data, from the Navrongo Health Research Centre-one of the sentinel sites in Ghana, to estimate the burden of CDs and NCDs. These sites maintain and monitor vital events (births, deaths, and migration) in a well-defined population. Additionally, these sites periodically collect data on contextual, epidemiological, socio-economic, cultural, and health systems determinants of health. Data from sentinel sites often have high accuracy and reliability. More so, longitudinal data are said to provide useful and unique opportunities for researchers to gauge trends of events and make predictions for future occurrences. Therefore, an analysis of data from well-defined populations provides a useful understanding of the relationships between key aspects of population health.

Presently, there are limited studies in the country that explored the household burden of CDs and NCDs, particularly in Northern Ghana. This study makes a major research contribution by highlighting the mortality burden of CDs and NCDs as well as estimating the potential gains in life expectancy if such diseases were to be eliminated. Overall, this study adds to the body of knowledge by providing specific, actionable insights into the health challenges faced by communities in Northern Ghana, facilitating more informed decision-making and better health outcomes.

The study outcome could contribute to strengthening initiatives or interventions toward reducing the burden of CDs and NCDs in Ghana. Results from the study have helped to quantify the demographic impact or burden of communicable and non-communicable diseases in Ghana particularly the northern part of the country. Finally, the knowledge of the mortality burden could help health service providers in tailoring targeted interventions to reduce the burden of CDs and NCDs.

1.7 Significance of the Study

This study is important because it highlights the demographic and health impact of communicable and non-communicable diseases on the total disease burden in Ghana. The findings serve as a stepping stone for the country's policymakers (both at the national and district levels), to put in place stronger responses and intervention strategies to achieve the objective of eliminating or reducing CD and NCDs burden in the communities within the country's meningitis belt.

Sub-Saharan Africa continues to have a high communicable disease burden with some countries showing low signs of improvement. One of the priority areas of the World Health Organization (WHO) is to promote healthier populations through multi-sector actions and approaches (WHO, 2019). This is to ensure that people everywhere around the globe have better health and the absence of diseases. Additionally, goal three (3) of the United Nations Sustainable Development Goal (UNSDGs), seeks to ensure healthy lives and promote well-being for all ages (United Nations, 2021). A high disease burden in any country has implications for the global achievement of the SDGs. Hence an understanding of the burden of CDs and NCDs is critical to reducing their prevalence and is central to the country's attainment of the agenda 2030.

1.8 Organization of the Study

The study is organized into nine chapters. Chapter One introduced the study by espousing the need for the study and the problem that the research seeks to solve. In this chapter, I explain and justify why it is important to conduct the study. Chapter Two deals with literature review on the subject and provides a detailed explanation of the theoretical basis of the study. The conceptual framework for the study is also presented in this chapter. Chapter Three discusses the methodological processes that were employed in carrying out the study. The main techniques used in analyzing the data, the definition of the variables and how they are measured are also presented here.

Chapter Four presents the results for the evaluation of data accuracy and reliability. This chapter is relevant because the debate about the incompleteness of mortality data, especially in LMICs, is inconclusive. Therefore, the chapter gives the reader a weighing scale upon which the test for accuracy and reliability can be tested. Results for the Myers, Bachi and Whipple's indices are presented here. In this chapter, the reader gets to appreciate the reliability, accuracy and usability of the data. Chapter Five presents the findings related to the prevalence of communicable and non-communicable diseases. The chapter puts spotlight on the broad and specific causes of mortality in the Kassena-Nankana East and West districts from 2012 to 2018. Additionally, the socio-demographic background characteristics and the variation in causes of mortality as well as the geographic distribution of cases are highlighted in this chapter.

In Chapter Six, I examine the factors associated with the causes of mortality. The different socio-demographic background characteristics and the risk of death from communicable, non-communicable and other external causes of death are presented in this chapter. The chapter presents and discusses the proximate determinants of mortality in the study area. This chapter is important to the reader because it underscores the factors that are associated with mortality in the study area. Chapter Seven, presents the potential gains in life expectancy once communicable and non-communicable diseases are assumed to be eliminated in the study area. Multiple and associated single-decrement life table models depicting the demographic burden of CDs, NCDs and external causes of mortality in the study area are highlighted in this chapter.

In Chapter Eight, the results of decomposition analysis are presented. This chapter provides a mirror for the reader to view the age group-specific contribution to the improvement in life expectancy after the elimination of the different causes of mortality. This is a follow-up to the previous chapter which laid credence to the fact that life expectancy, in the study area, would improve after eradicating the major causes of mortality. Chapter Nine provides a summary of the main findings obtained in Chapter Four through Chapter Eight and makes recommendations for policy in the area of interventions to reduce the burden of communicable and non-communicable diseases in Ghana. The chapter concludes the study by providing directions for future research in the area.

1.9 Definition of Terms

Demography is the scientific study of human populations, primarily with respect to their size, their structure and their development.

Disease burden simply refers to the number of deaths and morbidities as a result of a specific disease.

Epidemiology is the study of the distribution and determinants of health-related states and events in specific populations, as well as the application of this knowledge to the control of health problems.

Household disease burden refers to the loss of household members (mortality) as a result of a specific disease as well as the costs that households incur in terms of economic hardships, social isolation and psychological strain due to the illness of a relative.

Prevalence of a disease is defined as the proportion of the population that is living with a particular disease at a point in a given time. In other words, it is the proportion of people in a population that has a disease or a particular condition at a specific point in time or over a specified period of time. In the current study, the prevalence was defined as the percentage of deaths due to a certain cause (e.g NCD) among all deaths.

Life expectancy is an indicator of population longevity which summarises the mortality experiences of a population at diverse ages during the life course into a single index that may be derived from a life table calculated from the age-specific death rates.

Life Expectancy at Birth is the average number of years a hypothetical cohort of people born in a specific year is expected to live if the current mortality rate at each age remains constant in the future.

Life Table is an organized tabular display of probabilities of dying and life expectancies at each age or age group for a given population based on the Age-specific Death Rates prevailing at that time.

A verbal autopsy is an oral postmortem process through which information on the events leading to the death of an individual is obtained from the relative of the deceased person using a standardized questionnaire (Bawah et al., 2014).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Every research study benefits from earlier works to guide its design and analysis. Thus, it is common for studies to dedicate a chapter to reviewing relevant literature in the subject area. In line with this, this chapter focuses on existing literature regarding the burden of communicable and non-communicable diseases. It discusses research on the causes of death, the prevalence and incidence of infectious diseases, and the potential gains in life expectancy if infectious and non-communicable diseases were eradicated. Additionally, the chapter explores factors identified by previous studies as influencing morbidity and mortality related to communicable and non-communicable diseases. The theoretical frameworks for the study are also presented. The epidemiological transition theory, a useful framework for understanding and assessing factors associated with specific disease mortality and morbidity, as well as the conditions under which they may rise or fall, is discussed. The chapter also examines the application of this framework in the study, along with other theories guiding the conceptualization of the study variables.

2.2 Accuracy and Quality of Mortality Data

Accurate and reliable mortality data are essential for demographic and epidemiologic analysis of the factors contributing to a population's longevity or lack thereof. However, the reviewed literature suggests that the accuracy and quality of mortality data may be affected by age misreporting and digit preference bias. Inaccurate or incomplete mortality data complicate public health planning, resource allocation, and policy decisions (Hill et al., 2009), making it essential to continuously improve data collection methods, invest in VRS, and adopt statistical techniques that account for these reporting biases.

Gaps in mortality data often arise due to several factors, including the lack of comprehensive and reliable vital registration systems (VRS), especially in low- and middle-income countries. In many African and Asian countries, vital events such as births and deaths are underreported, leading to significant data inaccuracies (Mikkelsen et al., 2015). This is further compounded by age misreporting and the cultural or social factors that influence the reporting of deaths. For instance, age heaping—where respondents round ages to preferred digits (e.g., 0 and 5)—can distort mortality statistics, particularly among older populations (Rosenwaike & Stone, 2003, Pardeshi, 2010; Glei et al., 2019).

A study by Elo et al. (2013) in the United States aimed to validate age data from the Long-Life Family Study using early-life census records. The authors found that 11 percent of participants ages at the time of the interview were inconsistent with census records. In Costa Rica, Glei et al. (2019) evaluated mortality data quality using estimates from 1950 to 2013, observing that the age pattern of adult and elderly mortality was suspiciously lower than that of infant and child mortality, raising concerns about the quality of the data. In India, Pardeshi, (2010) assessed the accuracy of age data from community surveys using statistical analysis techniques. The author found that the data were of poor quality, with age heaping at ages ending in '0' and '5', and 42 percent of the population reported incorrect ages.

In another Indian study, Basannar et al. (2022) used Whipple's and Myer's Index to quantify age heaping and misreporting in survey data. They found a Whipple's Index of 117.75 for males and 116.34 for females. Additionally, 11 percent of male participants and 25 percent of female participants misreported their ages. Several studies (Elo et al., 2013; Fayehun et al., 2019; Womack et al., 2020) have highlighted inconsistencies in mortality data related to age reporting, raising concerns about data collection methods and the reliability of mortality estimates, especially in settings without comprehensive vital registration systems (VRS).

In the African region, Lyons-Amos & Stones (2017) analyzed age-heaping trends across 34 sub-Saharan African countries using DHS data from 1987 to 2015. They found significant improvements in age-reporting quality in Nigeria and Ghana, while countries like Mali and Ethiopia saw increases in age-misreporting. They noted that age misreporting remains a common problem in the region, with 5 percent of respondents misreporting their ages. In Nigeria, Al-Haddad et al.(2013) examined age heaping and cancer rate estimation using census and cancer registry data, finding that age heaping was particularly pronounced.

Several factors influence the reporting of demographic events, including the education level of respondents and the perceived importance of the event. Cultural context can also play a role; for example, there is an avoidance of numbers like 4 and 13 in Eastern and Western cultures, respectively (Poston & Bouvier, 2010; J. S. Siegel & Swanson, 2004). Additionally, social norms and religious practices, such as immediate burials and cultural taboos about reporting infant, twin, homicide, and suicide deaths, contribute to low or inaccurate reporting in parts of Africa (Habaasa, 2022; Pison et al., 2018). In many African countries, a "good death" is associated with old age, leading to the overreporting of deceased relatives' ages to signify longevity (Omoregbe, 1993). This preference for certain digits can result in age heaping on digits ending in 0 or 5. Such misreporting may lead to the misclassification of individuals into incorrect age groups, affecting both mortality levels and differentials.

Scholars like Irma & Preston (1992) have argued that individuals may under- or over-report their ages, which can affect data quality and policy decisions related to resource allocation. Some may intentionally misreport their age or lack accurate information about their birth date. Others may do so to gain benefits tied to specific age categories. For example, Budd and Ginnane (1981) reported that in 19th-century Ireland, many people inflated their ages to qualify for pension benefits before reaching the legal age. Such misreporting can lead to data errors, especially in settings lacking robust vital registration systems, where illiteracy is prevalent, or where vital events are reported on behalf of others (Glei, Paz, Aburto et al., 2021; Swanson & Siegel, 2004; Elo, Mykata Senastiani et al., 2013; Pison, Masquelier et al., 2016; Randal & Coast, 2016).

Given the potential for errors in mortality data through age misreporting, it was crucial to evaluate the accuracy and quality of the data before using it. The evaluation helped to estimate the magnitude of errors and their impact on results, guiding necessary adjustments. Various analytical tools have been developed to measure the extent of errors in demographic data, including Graphical Methods, UN Age Ratio Scores, Whipple's Index, Myers Index, Bachi Index, and Death Distribution Methods (Siegel & Swanson, 2004). Whipple's and Myers Blended Index are commonly used to identify systematic misreporting of ages ending in 0 and 5, as well as digit avoidance and heaping.

2.3 Causes of Death Analysis

The reviewed literature has underscored the importance of mortality analysis, particularly cause-specific mortality analysis. Jha (2012) provided evidence suggesting that the world's best investment in reducing premature mortality is through counting the dead. Studies such as Baiden et al (2007) and Murray et al (2011) also presented evidence showing that obtaining information on the prevalence of specific diseases and their contribution to morbidity and mortality is critical for successful healthcare interventions. This information, as the authors suggest, helps stakeholders in the health sector plan and allocate resources to enhance service delivery (Chisumpa et al., 2019; Herbst et al., 2011).

Additionally, mortality is a key component of the population growth process, and analyzing it helps to understand the changing population structure of a country. Incorporating demographic variables into planning is indispensable for success. Variables such as population growth, composition, distribution, and mortality trends are crucial for planning because knowledge of future population dynamics is essential for setting realistic objectives. For example, the infant mortality rate (IMR), which estimates the number of infant deaths (under one year of age) per 1,000 live births, is often used as an indicator of a country's health status and overall development (Tuoyire & Ayetey, 2018). Understanding this information at the sub-national level is crucial for planning health services at the district level. Mortality rates and future trends allow planners to develop profiles of cause-specific deaths and disease prevalence, thereby enabling the creation of healthcare strategies that meet the population's health needs (Owusu et al., 2021).

Given this background, many scholars have developed an interest in mortality (Abubakari et al., 2019; Allotey & Reidpath, 2001; Bawah & Binka, 2007; Lankoandé et al., 2022; Lozano et al., 2012; Mubeta et al., 2023; Narh-Bana et al., 2012; Ohene et al., 2011; Ramroth et al., 2012; WHO, 2016). The Global Burden of Disease Study, for example, provides estimates of morbidity and mortality on a global scale, which are useful for national planning. However, one limitation of these reports is their inability to capture and present data at the sub-national level. A considerable number of studies have also analyzed cause-specific mortality using hospital data (Houle et al., 2015; Narh-Bana et al., 2012; Ohene et al., 2011). However, the limitation of these studies is their inability to generalize findings due to data limitations. Moreover, data from hospital settings and censuses often raise concerns about reliability (Lankoandé et al., 2022). Evidence suggests that cause-of-death data collected through censuses have significant limitations, including the lack of systematic procedures to determine the causes of death (Chisumpa et al., 2019). One of the risks of using unreliable data is the potential for projection errors, which is why it is crucial to use accurate data when producing health estimates and projections.

In light of these challenges, verbal autopsy data becomes invaluable. In settings without a vital registration system, verbal autopsy-based mortality surveillance is a useful approach for identifying specific causes of death (Fottrell, 2009). The present study relied on verbal autopsy data to estimate the burden of communicable and non-communicable diseases on households in rural northern Ghana.

2.4 Household Burden of Communicable and Non-communicable Diseases

As stated earlier, communicable diseases are mainly caused by pathogenic microorganisms, including viruses, bacteria, protozoa, parasites, and fungi, and their mode of spread is through direct or indirect contact with unhygienic conditions (Prüss-Ustün et al., 2014). Non-communicable diseases, on the other hand, are associated with genetic, physical inactivity and lifestyle-related factors (WHO, 2023d).

Both communicable and non-communicable diseases pose a major health burden to many households across the globe. This is because household and family members are integral to the overall care system for persons with severe illness. While the general healthcare system provides medical care to patients, the affected family members usually provide social, economic, financial, and psychological support to the victims. This care and support can be in high demand by patients who suffer from non-communicable diseases (NCDs) and may become physically dysfunctional and require intensive care. Most communicable and non-communicable diseases tend to leave varying degrees of disability in the patient, implying that the management of these diseases and care for victims can be burdensome to families. For example, caring for relatives with severe stroke and diabetes has both emotional and practical impacts on the caregiver due to the care demands of NCD patients.

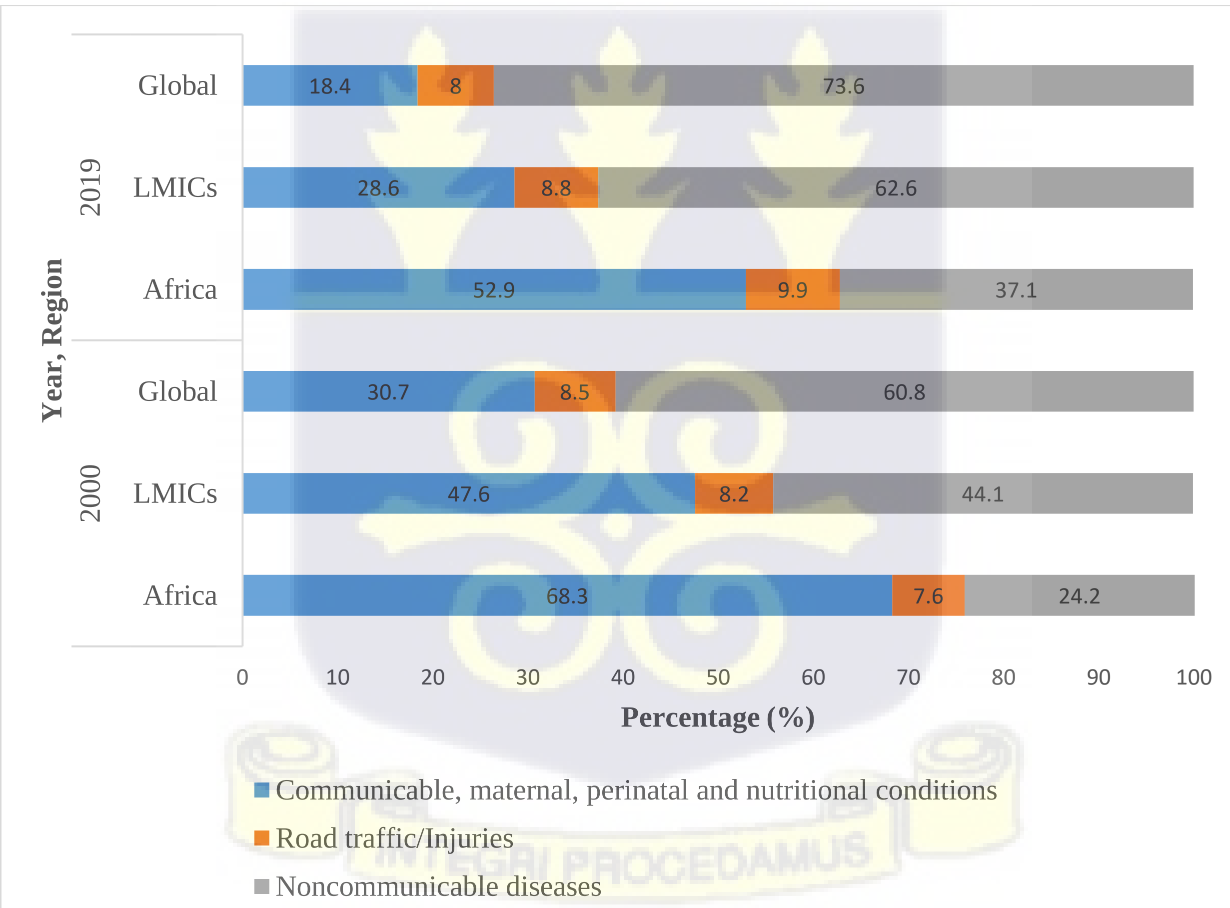
In the fields of epidemiology and demography, mortality rates are basic tools used to measure and estimate disease burden at the national, sub-national, and community levels (Gardner & Sanborn, 1990, Gardner & Halweil, 2000). In this regard, a disease burden simply refers to the number of deaths and morbidities resulting from that disease.

Although non-communicable diseases, including hypertension, stroke, and diabetes, affect individuals of all ages, both urban and rural residents, and people from various socioeconomic backgrounds, the morbidity and mortality burden of these diseases tends to vary across different geographic regions and among different socioeconomic groups. At the national and sub-national levels, the burden can also vary. For instance, an earlier study by Roura & Arulkumaran (2015) showed that premature death or disability from heart disease, stroke, diabetes, and other NCDs causes considerable suffering and economic loss in many countries, particularly in low- and middle-income countries (LMICs). Nugent (2008) provided evidence that non-communicable diseases (NCDs) increase economic and health burdens in many low- and middle-income countries.

2.5 All-cause mortality

The World Health Organisation has categorized all causes of mortality into three major categories: communicable diseases, non-communicable diseases, and road traffic and injuries. Globally, non-communicable diseases (NCDs) have consistently been the leading cause of mortality since the year 2000, followed by communicable diseases (CDs) and then road traffic and injuries. However, in many low and middle-income countries (LMICs), including those in the African region, CDs have remained the primary cause of mortality, followed by NCDs. Figure 2.1 displays the trends in the broad causes of mortality from 2000 to 2019 at both regional and global levels. The trends show that while communicable disease mortality is declining, mortality from injuries and NCDs is increasing in many parts of the world.

Figure 2.1: Trends in the broad cause of mortality from 2000 to 2019 by the regional and global levels

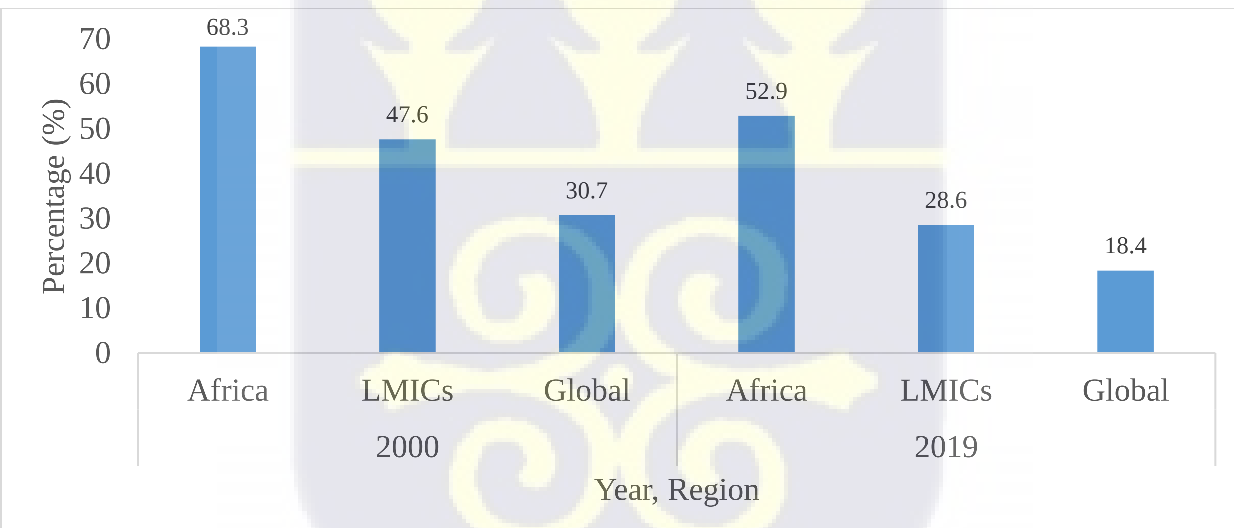


Source: (World Health Organization, 2020).

2.6 Prevalence of Communicable Disease Morbidity and Mortality

The burden of communicable diseases varies by specific population and among different geographic locations and contexts. Generally, data suggest that all communicable causes of death across the globe have declined from 30.7 percent in 2000 to 18.4 percent in 2019 (WHO, 2022). However, in many low-middle-income countries, the figures remain unacceptably high. The CD burden in this region was estimated to be 46.8 percent of all-cause mortality in 2019. In the African region, the data show that more than half (52.9 percent) of the deaths that occurred in 2019 were attributable to communicable diseases (WHO, 2022). Figure 2.2 displays the communicable disease burden from 2000 to 2019 by the regional and global levels.

Figure 2.2: Communicable, maternal, perinatal and nutritional conditions of Mortality



Source: World Health Statistics 2022.

In terms of the specific communicable causes of mortality, the following sub-sections present and discuss the prevalence of these specific diseases in the global, regional and national context.

2.6.1 Cerebrospinal Meningitis

CSM is a recurrent health issue in the northern regions of Ghana, which lie within the African meningitis belt. Epidemics often occur during the dry season, leading to significant morbidity and mortality. The disease is highly infectious and can cause severe complications or death if not promptly treated. Understanding the trends and mortality rates of CSM in the Kassena-Nankana Districts is essential to guide public health interventions, vaccination strategies, and early response systems during outbreaks.

The literature review suggested that meningitis has been a consistent public health burden, with its impact increasing in recent years. The case-fatality rates and incidence of the disease vary across regions, countries, and age groups. Globally, the case-fatality rate can reach up to 70% (WHO, 2018; CDC, 2012). In Africa, meningitis cases have risen since 1905, with 2,628,283 cases and 151,808 deaths reported between 1928 and 2018 (Mazamay et al., 2021). The highest number of cases occurred in 1996, with Nigeria being particularly affected, recording 552,821 cases over the study period and 9,646 suspected cases in 2017 alone. Meningitis remains a major health challenge in sub-Saharan Africa (SSA), causing significant mortality, including 839 deaths in Nigeria in 2017 (World Health Organization, 1998; Cuevas et al., 2007; Molesworth et al., 2003). Studies indicated that approximately 350 million people in Africa live in areas at risk for meningitis epidemics (Teyssou & Muros-Le Rouzic, 2007). In 2017, it was estimated that 25% of meningitis survivors in Africa may suffer from neurological complications (Aku, Lessa, Asiedu-Bekoe, et al., 2017).

Meningitis incidence increased globally from 2.5 million in 1990 to 2.82 million in 2016, with the highest rates in the African meningitis belt (GBD 2016 Meningitis Collaborators, 2018). Ghana recorded 70,508 cases between 1928 and 2018, with significant outbreaks in the 1950s and 2000s

(Mazamay et al., 2021). Other countries in the meningitis belt, such as Niger, Burkina Faso, and Sudan, have also experienced large-scale epidemics, with thousands of cases and deaths recorded (García-pando et al., 2014; World Health Organization, 1998). More recent outbreaks in Ghana's northern regions from 2010 to 2021 saw hundreds of cases and high mortality rates, with case-fatality rates between 36% and 50% (Holliman et al., 2007; Mackie et al., 1992).

Between the years 2010 and 2015, about 1,176 cases of CSM were recorded in the northern part of Ghana (Kaburi, Kubio, Kenu, Nyarko, et al., 2017). From 2015 to 2016, 133 cases of meningitis were recorded in the Northern, Upper West and Upper East regions of Ghana (Aku et al., 2017b). Between the early month of 2008 to the end of 2010, as high as 163 cases were reported (Owusu et al., 2012). Out of about 400 cases reported in 2016, close to 90 people were reported to have died in the country as a result of the disease (Amidu, Antuamwine, Addai-Mensah, et al., 2019). Between 2016 and 2017, studies (Amidu, Antuamwine, Addai-Mensah, et al., 2019; Kaburi, Kubio, Kenu, Ameme, et al., 2017) conducted in 41 districts in the northern part of the country have reported that 285 out of 330 case sample frame, (CSF) tested positive for CSM. Other studies have shown that the mortality rates of CSM in the country ranges between 36 percent and 50 percent (Holliman et al., 2007; Mackie et al., 1992). In 2018 for example, by the end of the meningitis season, 843 cases, 60 deaths and a case fatality rate (CFR) of 6.9 percent were recorded in the Upper West region. Similarly, within the same period in 2019, 757 cases, 21 deaths and a case fatality of 2.8 percent were documented in the region (WHO, 2019). In 2020, about 33 people died in the Upper West Region as a result of the disease (Citi Newsroom, 2020). In 2021, 49 people were reported to have died in the region due to CSM.

2.6.2 Tuberculosis

Tuberculosis is one of the leading causes of infectious deaths worldwide. Its infections remained a major burden of health, particularly in low-middle income countries where comorbidities of NCDs are high. Across the globe, about 153 million people are reported to have died from tuberculosis and other respiratory infections in 2019. In the African region, the tuberculosis burden constitutes 30 percent of all deaths reported.

In Ethiopia, a study by Meles et al. (2023) examined the causes and trends of adult mortality in the southern part of the country using data from 2009 to 2011. The authors found tuberculosis as the leading cause of adult mortality with 16.8 percent. Still, a similar study by Melaku et al.(2014) in northern Ethiopia found tuberculosis (15.9 percent), cerebrovascular diseases (7.3 percent) and accidental falls (3.9) as the major specific causes of adult mortality. Additionally, the authors found that the cumulative burden of CD was 34.9 percent.

Tuberculosis (TB) is a significant contributor to the communicable disease burden in Ghana. In 2021, the incidence of tuberculosis in Ghana was 136 cases per 100,000 people. The incidence of tuberculosis in Ghana fell gradually from 212 cases per 100,000 people in 2002 to 136 cases per 100,000 people in 2021. In 2020, the estimated incidence of TB in the country was around 44,000 cases, corresponding to an incidence rate of 147 cases per 100,000 people. The disease is also a major cause of mortality, contributing to approximately 5,700 deaths in the same year. Among TB cases, 4.2% are estimated to have multidrug-resistant TB (MDR-TB), complicating treatment and increasing healthcare costs (Rudman et al., 2020)

Efforts to combat TB in Ghana include active case-finding initiatives, which have led to a projected reduction in TB mortality. From 2019 to 2040, interventions like enhanced diagnostic services and improved treatment adherence are expected to avert an estimated 56,000 TB cases and prevent 26,400 deaths (Kuupiel et al., 2023; Rudman et al., 2020). Despite improvements in healthcare services and testing capacity, challenges such as geographical accessibility to diagnostic facilities and treatment centres continue to hinder Ghana's TB control efforts, especially in rural regions (Kuupiel et al., 2023).

2.6.3 Malaria

Malaria remains one of the leading causes of morbidity and mortality in Ghana, particularly in the northern regions, including the Kassena-Nankana Districts. It is a major public health concern and significantly contributes to the communicable disease burden. The high transmission rates and the prevalence of the disease make it a critical area of study to understand its impact on mortality trends. Including malaria in the study allows for the assessment of intervention effectiveness, such as insecticide-treated nets, antimalarial drugs, and public health campaigns, which are crucial in informing future control measures.

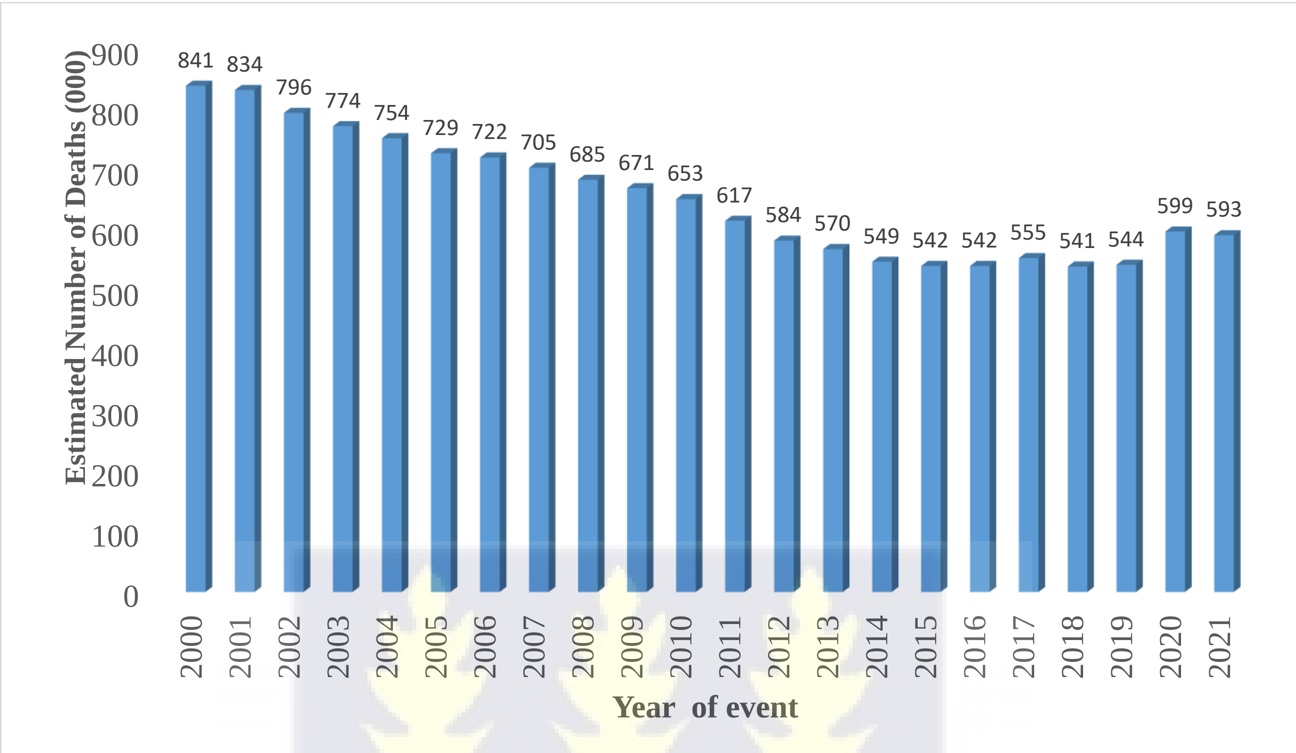
Historically, the discovery of malaria spanned different civilizations and periods. According to Miller et al. (1994), malaria in Africa can be traced back to Egyptian relics from 3200 and 1304 BC. In India, cases were recorded between 1500 and 800 BC. The Chinese medical text, Nei Chin, diagnosed malaria symptoms such as headaches, chills, and fevers around 2700 BC, based on Bruce-Chwatt's (1988) account. Greek literature also referenced malaria, with poets like Homer mentioning it in The Iliad (circa 750 BC), and philosophers like Aristotle and Plato recognizing the disease.

Hippocrates documented malaria symptoms around 450-370 BC (Sherman, 1998). Modern scientific discovery, however, is attributed to French military doctor Alphonse Laveran, who identified the malaria parasite in 1880. Ronald Ross later discovered the transmission of malaria by Anopheles mosquitoes in 1897 (Cox, 2013).

Although several curative and preventive measures have been adopted globally to control malaria, it continues to be among the top ten leading causes of mortality worldwide. According to the World Health Organisation's report in 2020, over 229 million cases of malaria were recorded in 2019 worldwide and many of them resulted in deaths.

In sub-Saharan Africa, twenty-nine countries in the Region contribute to 95 percent of the global burden of malaria with variation and intensity across the different countries. In four countries in the region; Nigeria (27 percent), the Democratic Republic of the Congo (12 percent), Uganda (5 percent), Mozambique (4 percent) and Niger (3 percent), they jointly contribute to about 51 percent of all the cases that were recorded in 2019 globally (WHO, 2020b). In 2021, WHO reported about 619, 000 malaria deaths worldwide (WHO, 2023). According to the Organisation, 96 percent of these deaths occurred in African countries. Figure 2.3 displays the trends in malaria mortality in the WHO African Region from 2000 to 2021. The trends show that malaria mortality in the region ranges from 841, 000 deaths to 593, 000 deaths over the reporting period. Although the data show that there has been a decline in malaria mortality in the region, the recent figures are still high.

Figure 2.3: Estimated number of malaria deaths in the WHO African Region, 2000–2021



Source: World Malaria Report, 2022

The people at high risk of malaria infection include infants, children under 5 years, pregnant women, travellers and people with HIV or AIDS (WHO, 2023c). Additionally, different geographic regions and areas are considered malarious regions and inhabitants in those locations are said to be at greater risk of infections.

In the Gambia, a study by Jasseh et al (2014) examined the disease-specific mortality burden among a rural population using data from 1998 to 2007. The authors observed that malaria was one of the leading causes of death in the population accounting for 12.9 percent of the deaths recorded for the period. Also, a longitudinal study in rural Tanzania by Narh-Bana et al (2012) to understand the cause-specific adult deaths from 2003 to 2007, shows that malaria is the second leading cause of death accounting for 13.2 percent of all the deaths recorded. Similarly, a study by Meles et al. (2023) in southern Ethiopia found malaria as the second leading cause of adult mortality at 9.7 percent while intestinal infectious diseases accounted for 9.6 percent of the deaths recorded. Cumulatively, the authors found that all CDs accounted for close to half (49.2 percent) of the deaths recorded within the period.

In Ghana, malaria remains a significant public health issue in the country, particularly in rural and underserved regions. Bawah & Binka (2007) reported that malaria accounted for one-third of deaths in their study population. Similarly, a study by Awini et al. (2014) estimated the causes of adult deaths in a rural district in southern Ghana using verbal autopsy data. The authors found that communicable diseases were the leading cause of death, with malaria being the primary cause, resulting in a cause-specific mortality rate of 1.06 deaths per 1,000 person-years. In 2019, data from the WHO's Global Health Estimates (GHE) indicated that malaria was the sixth leading cause of death in Ghana, with a cumulative burden of 36.72 deaths per 100,000 population (World Health Organization, 2020). WHO estimates also showed that approximately 308 people died from malaria in Ghana in 2020 (WHO, 2021 pp. 260). In 2021, about 5.7 million malaria cases were recorded in the country, leading to 275 deaths (Outbreak News, 2023). In 2021, around 5.7 million cases of malaria were recorded, with 275 deaths (Heuschen et al., 2022). This emphasizes the persistent challenge malaria poses despite ongoing efforts to control it.

2.6.4 HIV/AIDS

The reviewed literature suggests that HIV/AIDS remains endemic in many parts of the world. The World Health Organization (WHO) estimated that approximately 37.7 million people globally were living with HIV in 2020 (WHO, 2022). In the same year, global HIV-related mortality was estimated at 680,000 deaths. The African region carries the heaviest burden, contributing to 40%

of global HIV/AIDS-related mortality. In 2022, the number of people living with HIV globally was 39.0 million (WHO, 2023a).

In a study conducted by Narh-Bana et al. (2012) in rural Tanzania, the researchers examined cause-specific adult deaths from 2003 to 2007. They found that HIV/AIDS remained the leading cause of adult mortality, accounting for 20.4% of all deaths. In Ghana, HIV/AIDS is a significant contributor to the communicable disease burden. A study by Owusu et al. (2021) reported that HIV was among the top ten institutional causes of death at health facilities in 2017 and the 12th leading institutional cause of death in 2018. In 2020, it was estimated that around 350,000 people were living with HIV in the country, with an adult prevalence rate of about 1.6%. The annual incidence of HIV was recorded at 5.1 per 1000 uninfected adults, and AIDS-related deaths averaged 16,500 per year. Although antiretroviral therapy (ART) coverage has improved to 60% by 2020, many challenges remain, including reducing the incidence rate and increasing access to treatment (Boah et al., 2023; WHO, 2023a)

This burden, combined with other infectious diseases like malaria and tuberculosis, puts considerable pressure on Ghana's healthcare system. HIV/AIDS remains one of the top contributors to morbidity and mortality, particularly among young adults, despite progress in treatment accessibility. A comprehensive understanding of the leading causes of communicable disease-related mortality in the Kassena-Nankana Districts was critical and contributed to evidence-based policy-making, improved healthcare planning, and targeted interventions aimed at reducing the overall disease burden in the region.

2.6.5 Other Communicable Diseases

Several communicable diseases remain a major health burden to communities. Therefore, there was a need to provide a holistic view of the communicable diseases impacting the Kassena-Nankana Districts, highlighting areas that require intensified public health action and targeted interventions to reduce mortality and improve community health. Some of these diseases include acute respiratory infections (ARI), diarrhoeal diseases, Intestinal infectious diseases, rabies and viral Hepatitis.

ARIs, including pneumonia, are among the leading causes of mortality, especially in children under five years of age in Ghana and other low-income settings (WHO, 2023). ARIs are prevalent in the Kassena-Nankana Districts due to factors such as poor indoor air quality, overcrowded living conditions, and inadequate access to healthcare services. Including ARIs in the study will highlight the burden of these infections and inform interventions such as improved vaccination coverage, better access to antibiotics, and public health education on hygiene and respiratory health (Williams et al., 2022). In rural Gambia, Jasseh et al (2014) found that communicable diseases are responsible for about half (49.9 percent) of the deaths recorded from 1998 to 2007, with the most common infections being acute respiratory infections (ARI) (13.7 percent).

Diarrhoeal diseases are a major cause of morbidity and mortality in Ghana, particularly among children under five, due to contaminated water sources, poor sanitation, and inadequate hygiene practices (UNICEF, 2022). In the Kassena-Nankana Districts, the prevalence of diarrhoeal diseases is compounded by seasonal variations and limited access to safe drinking water. Including these diseases in the study allows for an evaluation of the effectiveness of interventions such as water, sanitation, and hygiene (WASH) programs, and guides targeted efforts to reduce their incidence and associated mortality (Kwabena et al., 2023). Morens et al. (2004) noted that diarrhoeal disease is a common morbidity and mortality burden for people living in developing countries particularly among young children under 5 years of age.

Intestinal infectious diseases, including typhoid fever and parasitic infections, are prevalent in Ghana due to poor sanitation, unsafe food handling, and limited access to clean water (GHS, 2022). These diseases contribute significantly to the communicable disease burden in the Kassena-Nankana Districts. Their inclusion in the study will provide insights into the trends of these infections and help assess public health measures like food safety programs, mass deworming, and improvements in water quality (Addo-Yobo, 2023).

Rabies is a neglected tropical disease with a nearly 100% case fatality rate once clinical symptoms appear. The disease is endemic in Ghana, with significant public health implications due to inadequate control of stray dog populations and limited access to post-exposure prophylaxis (PEP) (WHO, 2023). Rabies cases are often underreported, making it essential to include them in the study to capture the true burden and inform strategies for improved vaccination of domestic animals, public education, and better access to PEP (Mensah, 2023).

Viral hepatitis, particularly hepatitis B and C, poses a significant health challenge in Ghana due to high prevalence rates, chronic nature, and the potential for progression to liver cirrhosis or cancer (Owusu et al., 2023). The Kassena-Nankana Districts, like many other regions, experience a considerable burden of hepatitis due to factors like unsafe medical practices, mother-to-child transmission, and lack of awareness about vaccination. Including viral hepatitis in the study will help assess the impact of vaccination programs, early diagnosis, and treatment availability, guiding future health policies aimed at reducing its prevalence and associated mortality (GHS, 2022).

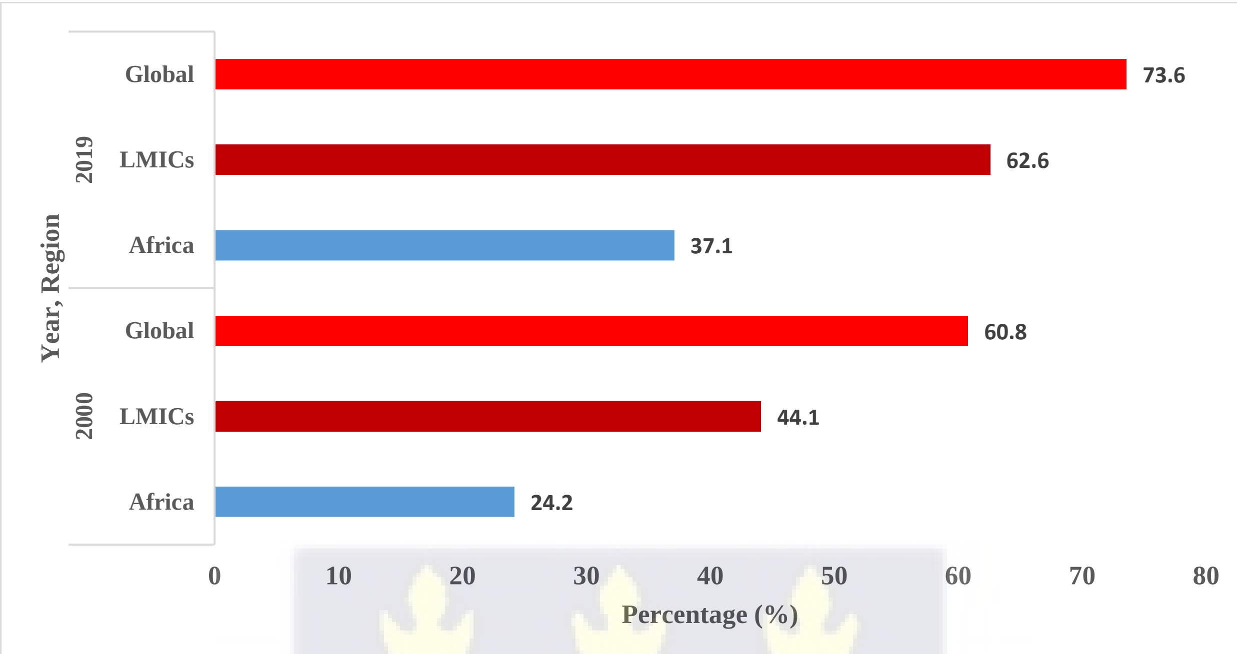
2.7 Prevalence of Non-Communicable Disease Morbidity and Mortality

Globally, non-communicable diseases (NCDs) have become a major public health concern due to their burden on populations and health systems. In 2010, the World Health Organization (WHO) reported that 71 percent of deaths worldwide were due to NCDs (World Health Organization, 2010). A study by Roura & Arulkumaran (2015) indicated that approximately 36 million people died each year from NCDs. Of this figure, their study noted that nearly 80 percent (29 million) of deaths occurred in low- and middle-income countries. They also observed that over 9 million of these deaths affected individuals under the age of 60.

Several studies, including those by Islam et al. (2014) and Mendis et al. (2015), reported similar findings. In 2014, Islam et al. estimated that NCDs caused 42 percent of premature deaths in individuals aged 30-70 years, with 48 percent of these deaths occurring in low- and middle-income countries (Islam et al., 2014; Mendis et al., 2015). Between 2007 and 2017, the United Nations (2015) estimated that deaths from NCDs increased by 22.7 percent, rising from 21.5 percent to 23.9 percent (United Nations, 2015).

In sub-Saharan Africa, Gouda et al.(2019) examined the NCD burden using data from 1990 to 2017. Their study found that Disability-Adjusted Life-Years (DALYs) related to NCDs increased from 90.6 million in 1990 to 151.3 million in 2017. According to the World Health Statistics 2022, the global burden of NCDs in 2019 was 73.6 percent, while in the African region, the burden was estimated at 37.1 percent (as displayed in Figure 2.4). Across low- and middle-income countries (LMICs), the NCD burden increased from 44.1 percent in 2000 to 62.6 percent in 2019.

Figure 2.4: Non-communicable causes of death, 2000-2019 by region



Source: World Health Statistics 2022.

According to a 2023 World Health Organization factsheet on non-communicable diseases (NCDs), approximately 41 million people (74 percent) die annually due to NCDs. The report further noted that over 15 million of these deaths occurred among individuals aged 30 to 69 years, highlighting the significant loss to the global productive labor force. Low- and middle-income countries (LMICs) bear the greatest burden of NCDs due to lower levels of awareness and poor treatment and control mechanisms (Lloyd-Sherlock et al., 2017). For instance, the WHO reported that 77 percent of all NCD deaths occurred in LMICs, and 86 percent of over 17 million people who died annually from NCDs before the age of 70 were from these settings.

Annually, more than 18 million people worldwide die from cardiovascular diseases, 9.3 million from cancers, 4.1 million from chronic respiratory diseases, and 2.0 million from diabetes (WHO, 2023). Collectively, these four groups of NCDs (cardiovascular, cancers, chronic respiratory, and diabetes) were responsible for over 80 percent of all premature deaths globally. Additionally, more than 6 million people across the globe died from NCDs related to stroke, ischemic heart disease, chronic obstructive pulmonary disease, and lung cancer.

In sub-Saharan Africa, a study by de-Graft Aikins et al. (2010a) indicated that stroke, hypertension, diabetes, and cancers caused increases in adult hospitalizations and deaths compared to communicable diseases such as HIV/AIDS or tuberculosis. In Tanzania, Narh-Bana et al. (2012) showed that NCD mortality increased from 16 percent in 2003 to 24 percent in 2007, with cerebrovascular diseases accounting for 11 percent of all NCD mortality. Accidents and injuries were responsible for 9 percent of the deaths. Another study by Meles et al. (2023) found that NCDs caused 35 percent of all adult mortality in Ethiopia from 2009 to 2011, while Melaku et al.(2014) identified NCDs as the leading cause of adult mortality in northern Ethiopia, accounting for 36.4 percent of all deaths.

Another study in Ethiopia by Bayray et al. (2017) used hospital data from 2011 to 2015 to examine the levels and trends of mortality. The authors noted that HIV/AIDS, neonatal sepsis, congestive heart failure, gastrointestinal diseases, and asphyxia were key specific causes of mortality. Additionally, NCDs were found to be the major cause of mortality, accounting for 44.1 percent of all deaths. In contrast, the proportion of deaths due to communicable diseases and external causes were 29.2 percent and 4.2 percent, respectively.

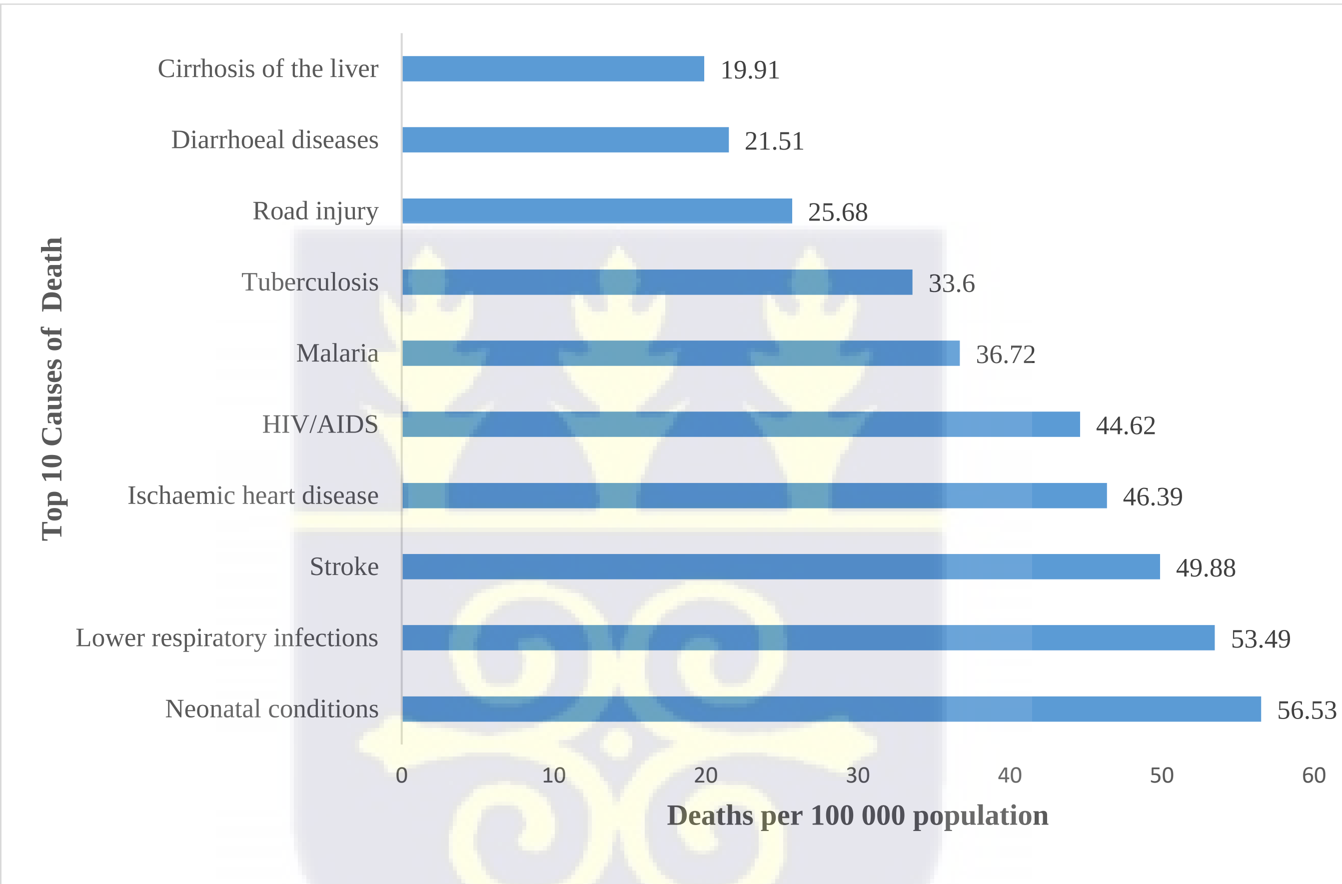
In Ghana, the WHO's African regional estimates indicated that NCDs and injuries contributed to 46 percent of morbidity and 40 percent of mortality in the country (Horton, 2012). A study by Ohene et al. (2011) on adolescent mortality at the Korle-Bu Teaching Hospital found that NCDs accounted for 41 percent of all adolescent deaths. Furthermore, Ofori-Asenso & Garcia (2016) reported that cardiovascular diseases and diabetes contributed significantly to the NCD burden in Ghana. The Ministry of Health's 2012 policy document noted that NCDs accounted for 65 percent of all deaths in the country, with an estimated 86,200 deaths annually—56 percent of these deaths occurred before the age of 70. Hypertension, a leading cause of NCD mortality, was reported to have a prevalence rate that increased from 19 to 48 percent Bosu (2010). Boakye et al.(2023) found hypertension prevalence at 23 percent, along with other NCDs such as diabetes (4 percent), dyslipidemia (3.1 percent), stroke (2.1 percent), heart diseases (1.5 percent), and chronic obstructive pulmonary disease (COPD) at 0.4 percent. The study revealed that the overall NCD prevalence among the participants was about 27 percent.

Owusu et al. (2021) examined mortality rates and causes of death in Ghanaian health facilities between 2017 and 2018. The study found that NCDs were the leading cause of death, with 8,714 deaths, representing 5.5 deaths per 1,000 admissions. Hypertension emerged as the most common NCD cause of death. Another study by Awini et al. (2014) in southern Ghana estimated that NCDs accounted for 28.3 percent of adult deaths, with a cause-specific mortality rate of 2.93 deaths per 1,000 person-years, with stroke being the leading NCD cause of death in the area.

2.8 Top Ten Causes of Mortality in Ghana

Ghana, like many developing countries, experienced high rates of infant and under-five mortality. Therefore, it was not surprising that the WHO reported neonatal conditions as the leading cause of mortality in the country in 2022. Figure 2.5 shows the top ten causes of mortality in Ghana. Lower respiratory infections and stroke were the second and third leading causes of mortality in the country in 2022. Stroke, for instance, accounted for about 50 deaths per 100,000 population (World Health Statistics, 2022). This data was consistent with the Centers for Disease Control (CDC) fact sheet on the top ten causes of mortality in the country. However, the CDC fact sheet showed that malaria, stroke, and lower respiratory infections were the leading causes of death in Ghana in 2022. Additionally, the report indicated that neonatal disorders, ischemic heart disease, HIV/AIDS, tuberculosis, diarrheal diseases, diabetes, cirrhosis, and other chronic liver diseases were among the top ten causes of mortality in the country (Centre for Disease Control, 2022).

Figure 2.5: Top Ten Causes of Mortality in Ghana



Source: World Health Statistics 2022.

2.9 Determinants and Risk Factors Associated with Communicable Diseases

Communicable diseases (CDs) are caused by infectious agents such as bacteria, viruses, fungi, and parasites. Their spread is influenced by several key determinants and risk factors, which can be categorized into biological, environmental, socioeconomic, and behavioural factors. Biologically, the immune status of individuals significantly affects susceptibility to communicable diseases. For example, people with weakened immune systems, such as those with HIV/AIDS or malnutrition, are more prone to infections like tuberculosis or pneumonia (Rabie & Goussard, 2016). Also, certain genetic predispositions may increase susceptibility to infections. For instance, individuals with sickle cell trait are less susceptible to malaria but may be prone to other complications (WHO, 2020b).

Environmentally, many communicable diseases are climate-sensitive. For example, tropical climates with high temperatures and humidity provide favourable conditions for vector-borne diseases such as malaria and dengue fever (World Health Organization, 2020). Poor sanitation and inadequate access to clean water promote the spread of diseases like cholera, typhoid, and diarrheal diseases. Overcrowded living conditions also contribute to airborne diseases like tuberculosis (Bärnighausen et al., 2017). Air pollution, especially in urban areas, can exacerbate respiratory diseases such as influenza and COVID-19, contributing to higher transmission rates (Prüss-Ustün et al., 2016).

Regarding the socioeconomic determinants, low-income populations are at higher risk of communicable diseases due to limited access to healthcare, inadequate housing, and poor nutrition (Marmot, 2005). In many developing countries, poverty correlates with higher incidences of malaria, tuberculosis, and HIV/AIDS (Bärnighausen et al., 2017). Also, lower levels of education are associated with limited knowledge of preventive measures, leading to poor hygiene practices and lower immunization rates, further increasing susceptibility to infectious diseases (Suthar et al., 2013). Inadequate healthcare infrastructure in resource-limited settings delays diagnosis, treatment, and prevention efforts, facilitating the spread of communicable diseases (Jamison et al., 2013).

On the behavioral and lifestyle factors, lack of regular handwashing, especially in children and in communities with poor sanitation facilities, facilitates the spread of infectious agents like bacteria and viruses (Aiello et al., 2008). Additionally, engaging in unprotected sex or having multiple sexual partners increases the risk of sexually transmitted infections such as HIV, syphilis, and gonorrhea (UNAIDS, 2019). Moreso, intravenous drug use and substance abuse with shared needles significantly increases the risk of bloodborne diseases, including HIV and hepatitis (Centers for Disease Control and Prevention (CDC), 2020).

Further, cultural and social factors including social norms, and stigma and discrimination can influence the risk of communicable diseases. In some cultures, practices like close physical contact, communal eating, or attending large gatherings increase the risk of disease transmission (Ehlers, 2006). Also, stigma surrounding diseases like HIV/AIDS discourages individuals from seeking care or adhering to treatment, leading to higher transmission rates (Nyblade et al., 2009).

Again, increased international travel and migration facilitate the spread of communicable diseases across borders, as seen during outbreaks of diseases such as Ebola, Zika, and COVID-19 (Tatem et al., 2017). Also, crowded refugee camps with limited healthcare and poor sanitation are hotspots for disease outbreaks, including cholera, measles, and respiratory infections (Connolly et al., 2004).

Public Health Interventions significantly influence communicable disease burden. Lack of access to vaccines or vaccine hesitancy contributes to the re-emergence of diseases like measles and polio in certain regions (Omer et al., 2009), while misuse and overuse of antibiotics have contributed to the rise of drug-resistant strains of bacteria, making diseases like tuberculosis and gonorrhoea harder to treat (World Health Organization, 2018a). In summary, communicable diseases are shaped by a complex interplay of biological, environmental, socioeconomic, and behavioural factors. Understanding these determinants is crucial for designing effective public health interventions to mitigate their spread and impact.

2.10 Determinants and Risk Factors Associated with Non-communicable Diseases

Various factors influence NCD risk, including socio-demographic, socio-cultural, geographic, and environmental, as well as lifestyle and behavioural factors. The primary risk factors associated with NCDs, as identified by most studies, included tobacco use, physical inactivity, the harmful use of alcohol, unhealthy diets, and air pollution (World Health Organization, 2023). Tobacco use, although in decline, accounted for 46 percent of chronic obstructive pulmonary diseases in 2019 globally (COPD) (Pan American Health Organization (PAHO), 2019). Evidence suggested that smoking rates across many parts of the world were higher among men, but an increase was observed among younger women. Data showed that the proportion of women who smoked was projected to rise to 20 percent by 2025 (WHO, 2010). In the African region, the prevalence of smoking was projected to increase from 15.8 percent in 2010 to 21.9 percent by 2030 (World Health Organization, 2017). In Ghana, the prevalence of smoking among males in 2014 was 4.8 percent, while for females, it was 0.1 percent (GSS; GHS; ICF International, 2014). Regionally, the Northern region had the highest smoking prevalence (31.2 percent), followed by the Upper East (22.5 percent) and Upper West regions (7.9 percent) (Brathwaite et al., 2017). Tobacco use, whether through smoking or chewing, was associated with an increased risk of CDs and NCDs. Globally, 20 percent of all TB mortality was attributable to smoking, and more than 93,000 deaths in 2017 were linked to exposure to secondhand smoke (Pan American Health Organization (PAHO), 2019).

The Global Health Risk Estimation Report by the World Health Organization identified major risk factors associated with global mortality, including hypertension (13 percent), obesity (5 percent), tobacco use (9 percent), physical inactivity (6 percent), and high blood glucose (6 percent) (World Health Organization, 2009). Most studies attributed population ageing, urban transition, and poor nutrition as risk factors associated with NCDs. The growth of urbanization tended to reduce physical activity, thereby predisposing individuals to the risk of NCDs. The epidemiological and urban transitions in the African region, for example, led to lifestyle modifications that shifted the impact of diseases (Dye, 2014). The literature argued that changes in lifestyle factors such as alcohol intake, tobacco use, physical inactivity, and sedentary behavior, which accompanied these transitions, predisposed individuals to the risk of NCDs.

A study in Ghana by Boakye et al (2023) examined the prevalence and determinants of NCDs among adult Ghanaians. Boakye et al. noted that factors such as age, sex, BMI, alcohol intake, and family history strongly influenced the occurrence of NCDs. Aging, obesity, and lifestyle factors complicate and increase the risk of NCDs. Globally, data showed that 1 in 4 adults was physically inactive, while 80 percent of adolescents were also physically inactive (WHO, 2021a). Physically inactive individuals were 20–30 percent more likely to be at risk of death compared to those who were physically active (Haileamlak, 2019). Despite this, physically inactive and sedentary lifestyles were on the rise in Ghana. A survey by Boakye et al (2023) revealed that more than half (54 percent) of respondents were physically inactive, and the majority (80 percent) engaged in sedentary lifestyles. Global efforts aimed to reduce the prevalence of physical inactivity to 10 percent by 2025 (WHO, 2021a), though this goal had not yet been achieved. Physical inactivity-related NCD mortality rates remained high. In 2012, physical inactivity accounted for about 9 percent of NCD deaths worldwide (Lee et al., 2012), and by 2022, it accounted for 7.2 percent of all-cause mortality and 7.6 percent of cardiovascular disease mortality worldwide (Katzmarzyk et al., 2022). In LMICs, these figures were higher, with physical inactivity contributing to 69 percent of all-cause mortality and 74 percent of cardiovascular disease mortality. A longitudinal ageing study in India by Behera & Pradhan (2022) concluded that physical inactivity was a major contributor to NCDs in the country.

Moreover, poor or unhealthy diets were recognized as factors contributing to the risk of NCDs, while healthy diets were found to improve and reduce the risk of cardiovascular disease, stroke, diabetes, and cancers. Codjoe et al. (2016) reported that increased urbanization in Ghana led to a growing preference for pre-prepared foods or diets. Meanwhile, many studies (Gesteiro et al., 2022; Todd et al., 2010) documented that food consumed away from home had poor diet quality, which could negatively impact nutritional outcomes and diet-related NCDs in the country. For example, a study conducted among the adult population in the United States found that one additional meal consumed away from home lowered diet quality by two points on the Healthy Eating Index (Todd et al., 2010). The authors found that the more adults ate away from home, the more likely they were to be classified as nutritionally poor.

In addition, education was identified as an important variable influencing health outcome and the risk of NCDs. Evidence showed that lower levels of education were related to the incidence and prevalence of NCDs. In Tanzania, Narh-Bana et al. (2012) observed that improvements in educational attainment reduced the risk of dying from NCDs. Similarly, a study by Oshio & Kan (2019) examined the predictors of NCD incidence among middle-aged Japanese individuals and found that education level predicted the incidence of selected NCDs.

2.11 Determinants of All Causes of Death

Health outcomes of individuals are influenced by their characteristics and behaviours, the physical environment, and the socioeconomic environment (World Health Organisation, 2017a).. This section explored studies on the determinants of all causes of mortality. Several factors influenced the causes of death, including age, sex, disease history, socioeconomic status, place of residence, and healthcare systems. These factors were broadly categorized into two: (1) socioeconomic and cultural factors, and (2) accessibility of health services.

2.11.1 Socio-Economic Status and Causes of Mortality

Socioeconomic status (SES) is a complex construct determined by an individual's or group's relative position within a society. In epidemiologic research, SES is measured using education, income, marital status, occupation or employment status, and financial wealth. Socioeconomic status influences well-being and health outcomes, which have implications for mortality and survival. In general, there is an association between SES and mortality within population groups (Saydah et al., 2013). A study by Karim et al. (2015) showed that socioeconomic factors associated with chronic disease conditions included marital status, occupation, level of education, and income levels.

A study by Soloway (2017) showed that low SES strongly predicted morbidity and early mortality. The author found that mortality during the period was higher among people with low SES than among those with high SES, with hazard ratios of 1.42 for men and 1.34 for women. A similar study, which sought to understand socioeconomic status and premature mortality among 1.7 million men and women from seven high-income WHO member countries, found that respondents with low SES had higher mortality compared to those with high SES (Stringhini et al., 2017). The study reported that, in general, low SES reduced life expectancy by 2.1 years between ages 40 and 85.

The most extensive work on the association between SES and disease risk was conducted by Sidorchuk et al (2009) on SES and cancer incidence rates. The authors reviewed and performed a meta-analysis of 64 studies on the link between SES and lung cancer incidence rates. They found that education and income significantly influenced risk factors associated with lung cancer prevalence. The study found that lower education increased the risk of lung cancer by 1.61 times more for those in low SES compared to those in high SES.

Additionally, studies linked the causes of infectious diseases, particularly diarrheal diseases, to poverty, housing location, access to clean water and sanitation, and the presence of specific organisms in water (Murray et al., 2003). Some social, behavioural, and environmental factors, including education and occupation, diet, smoking, air pollution, physical activity, BMI, and blood pressure, were observed to predispose individuals to cardiovascular diseases (Murray et al., 2003).

Economically deprived areas were documented in studies to present adverse effects and be more vulnerable to infectious diseases than others. For example, Samir et al., (2020), in their community COVID-19 vulnerability index in India, observed that in economically deprived areas, a higher percentage of inhabitants with poor access to water, sanitation, and hygiene facilities and poor healthcare service utilization were more exposed to communicable disease infections. In rural Bangladesh and São Paulo, it was observed that both education and occupational status were associated with all-cause mortality (Duncan et al., 1995; Hurt et al., 2004). In Taiwan, Mete, (2005) reported a strong association between socioeconomic characteristics and mortality in the country.

Another variable observed in the literature to influence causes of mortality was marital status. Two main hypotheses explained these relationships: social selection and social causation hypotheses (Averett et al., 2008; Joung et al., 1998). The social selection hypothesis posited that healthier persons are selected for marriage while unhealthy persons remain unmarried (Averett et al., 2008). In other words, marriage partner selection often favoured healthy individuals over unhealthy ones. According to the social causation hypothesis, marital status served as a catalyst, exposing individuals to social and economic conditions that shaped health outcomes. Research suggested that marriage provided a shield against adverse health outcomes through health behavioural modifications and increased social networks gained from the union ((Robards et al., 2012; Verbrugge, 1979). Gähler (2006), for instance, documented that divorcee, both men and women, were at higher risk of psychological distress relative to their married and cohabitating counterparts. Similarly, Kaplan & Kronick (2006) provided evidence suggesting that never-married individuals were at higher risk of dying from communicable or infectious diseases. The authors noted that, among the U.S. population, premature mortality rates were higher among never-married men and women.

In Ghana, Tuoyire & Ayetey's (2018) study found that married women had a higher relative risk ratio [RRR=2.14, 95% CI=1.29-3.84] of being hypertensive compared to never-married women. In South Africa, Shoko (2011) found that formerly married women had a higher relative risk of dying compared to those who were married.

In Germany, mortality risk was found to be lower among married individuals and those with tertiary education compared to other SES groups (Montano, 2021). In South India, participants with low SES were observed to have a higher incidence of mortality across all age groups and for all causes of death (Mohan & Muliyil, 2009). In China, an increase in the number of years of schooling was associated with a 5 percent decrease in mortality among elderly men and women (Liang et al., 2000). This amplified Gwatkin & Heuveline's (1997) argument that there was a sharp, dramatic contrast between different socioeconomic classes and the risk of infectious diseases, with the poor being much more likely to die from infectious and parasitic diseases (IPDs).

The literature showed that household wealth status significantly impacted healthcare utilization, which in turn affected causes of death. Household wealth determines the type of healthcare services one can afford. The highest-income groups are more likely to afford the cost of travel and healthcare services compared to the lowest-income groups. A study by O'Donnell (2007) reported that the poor in third-world countries had less access to health services as compared to the developed world. Kim and Richardson (2014) found similar results in their study which assessed the impact of socioeconomic inequalities and lack of health insurance on healthcare utilization among the elderly in the United States. They observed that higher levels of income and assets, along with possessing private health insurance, were significant predictors of healthcare utilization. Arcury et al. (2005) observed that enabling factors such as household income and need factors like physical and mental health measures and the number of conditions were significantly associated with healthcare utilization among their study respondents. Additionally, wealth status shaped lifestyle and behavioural patterns that made individuals more susceptible to diseases that caused death. The ODPHP noted that education, economic stability, community safety, and availability of adequate housing and healthy food were important social determinants of health (ODPHP (US Department of Health and Human Services, 2017).

Adjei et al. (2014) found that belief (religion) and other socio-demographic characteristics such as culture, educational level, and residential area influenced the use of healthcare services. Their study found that Muslim and Catholic adolescents, for example, were less likely to use modern contraceptive methods due to religious restrictions compared to their counterparts whose religions did not impose such restrictions (Adjei et al., 2014). Religious affiliation or traditions play a crucial role in determining health utilization. For example, Lahana et al.(2011) found that place of residence and ethnicity affected health service utilization in Greece.

Occupation or employment status influenced causes of mortality. Studies showed that the type of occupation had a significant association with mortality causes (Paglione et al., 2020; Zhang et al., 2015). In the United States, Zhang et al. (2015) reported that the nature of one's occupation affected the risk of sudden cardiac death (SCD). Similarly, Zhang et al. (2015) found a significant association between occupation and all causes of mortality, as well as specific causes of death, in a longitudinal study conducted in Rome. They found that, compared with employed individuals, both unemployed men and women had a higher risk of dying from all causes, with hazard ratios of HR=1.99 (95% CI 1.92 to 2.06) and HR=1.49 (95% CI 1.39 to 1.60), respectively. In South Africa, Kootbodien et al. (2018) reported a positive correlation between occupation and tuberculosis mortality. The authors noted that agricultural workers had a relatively higher risk of dying from tuberculosis (RRR=3.58, 95% CI 2.96 to 4.32).

Education was another variable recognized for its association with health and diseases. Some level of education is expected to enhance knowledge and awareness of the risk factors associated with diseases that cause death, thus encouraging precautions to avoid infection and improve health. In South Africa, Kootbodien et al. (2018) found that compared to individuals with higher education, those with only primary or no education had a higher risk of dying from tuberculosis. However, in a longitudinal study among Italian citizens aged 30-74 years between 2001 and 2012, Cacciani et al. (2015) observed an inverse relationship between education and overall mortality.

2.11.2 Socio-Demographic Factors and Causes of Death

Causes of death are associated with socio-demographic factors, including age, sex, and marital status. An individual's age has a significant correlation with causes of death, as it influences various health-seeking behaviours and outcomes, and mortality often varies by age.

A study by Boakye et al. (2023) showed that older people were more likely to suffer from NCDs compared to younger individuals. The authors noted, "people aged 35 to 49 years were 3.03 times more likely to suffer from NCDs than those aged 18 to 34 years (AOR = 3.03, CI = 1.61–5.69, P<0.001), and those aged between 50–64 years were 9.22 times more likely to suffer from NCDs compared to those aged 18 to 34 years (AOR = 9.22, CI = 4.11–20.68, P<0.001)." This pattern might have been due to the association between age and exposure to risk factors that predispose individuals to NCDs. Age was found to be significantly related to the risk of hypertension, diabetes, stroke, and dyslipidemia. As a result, the prevalence of these diseases tended to increase with age.

Another significant demographic variable observed to influence health outcomes was sex or gender. The sex differences in morbidity and mortality had already been established in the literature (Crimmins et al., 2019; Goudge et al., 2009; Jacobsen et al., 2008; Obermeyer et al., 2010). Obermeyer et al. (2010) studied adult mortality in 44 countries using data from 1974-2006 and found that male mortality in Ghana was higher than that of females. Several theories underscored the sex differences in morbidity and mortality, ranging from biological, and psychological, to social explanations (Jacobsen et al., 2008). Most of the literature suggested that sex differences within the population had implications for disease impact and how individuals coped and responded to infections (Goudge et al., 2009). According to the morbidity-mortality paradox, females lived longer than males but spent more of their total life expectancy in poorer health (Austad, 2006; Lego et al., 2019). This means that although women often have a higher life expectancy, they are more likely to experience chronic conditions, disabilities, or prolonged periods of poor health compared to men.

In contrast, men generally have shorter lifespans but tend to have fewer years of debilitating health conditions before death. The paradox highlights the complexity of health outcomes, where longevity (mortality) and quality of life (morbidity) do not always align. This is attributed to various factors already mentioned like the biological differences, social behaviours, and healthcare access. For instance, men may engage in more risky behaviours, which leads to higher mortality, while women might face more age-related health issues as they live longer.

A study by Avdic et al.(2019), for instance, examined sex differences in sickness absence and the morbidity-mortality paradox using longitudinal administrative data. The study found that men had higher mortality in 18 diagnoses, with 57 percent having a higher risk of dying from neoplasm. Women, in contrast, had increased morbidity absence but lower mortality rates. These differences could be due to better health-seeking behaviour, earlier diagnosis, or biological resilience to some diseases among women than men.

Another study by Grippo et al. (2020), for instance, found more COVID-19 deaths among men than women. Possible explanations for the higher death rates in men included smoking, genetic factors, and alcohol consumption, which were largely associated with men (Agrawal et al., 2021). Another reason could be that women tended to engage in more positive and precautionary behaviors than men, which might explain the male-female health-survival paradox. Harris et al. (2006) documented that men were more likely to engage in health-related risks, resulting in higher rates of injury and disease than women. In Ghana, evidence showed that males were more likely to die from NCDs than their female counterparts (Awini et al., 2014). A report by the Ministry of Health revealed that 58 percent of NCDs in the country were among males, with an age-standardized NCD death rate of 817 per 100,000 for males and 595 per 100,000 for females (Ministry of Health, 2012a). The NCD cause-specific mortality varied between men and women.

However, some studies argued against the oversimplification and generalization that males lived shorter but healthier lives, while females lived longer but in worse health (Crimmins et al., 2019; Macintyre et al., 1996). These authors believed that such oversimplifications did not provide a clear understanding of sex differences in health. For example, Crimmins et al. (2019) demonstrated that sex differences in morbidity and mortality rates varied across different dimensions of health, historical times, and between countries. Given the discordance in the literature, it was important to understand the link between sex and cause-specific mortality in the study area.

2.11.3 Religion or Spirituality and Causes of Mortality

There is already a large body of literature highlighting a strong link between religion and health outcomes, such as morbidity and mortality (Durkheim, 1951; Hill et al., 2020; Karim et al., 2015; Minicuci et al., 2014; Saeed et al., 2013). Some earlier studies (Idler et al., 2017; Mineau et al., 2004) have called for the inclusion of religion in the social determinants of health framework due to its significance for health outcomes. Moreover, many studies Moreover, many of the studies (George et al., 2002; McCullough et al., 2000) that have linked religion and health status argued that religion offered several benefits to health, including behavioural norms, social support, health practices, and psychosocial resources. One of the most referenced works on suicide, for example, is by Emile Durkheim (1951), who noted that social support and integration are critical factors affecting individual health. This finding was later corroborated by Waite & Lehrer (2003), who studied the health benefits of marriage and religion, noting that religious affiliation helps improve health status and life expectancy by providing a broader social network, which offers social support, defines behavioural norms, and provides instrumental assistance, thus reducing mortality risk.

Ghana is a multi-religious country, with the majority of the population being Christian (71.3%), followed by Muslims (19.9%), African traditional religion (3.2%), and others (5.6%) (Ghana Statistical Service, 2021c). This demographic makeup could have implications for health outcomes. For instance, in analyzing chronic diseases in Ghana, Karim et al. (2015) noted that individuals affiliated with religions other than Christianity were more likely to report lung diseases. Additionally, the literature debate suggests that religion, spirituality, and cultural practices shape health-seeking behaviors, which are significantly related to causes of death.

The influence of religion, spirituality, and cultural practices on health-seeking behaviours is well documented in various studies, and this influence significantly impacts causes of death. A study in Nigeria by Okonofua et al.(2017) found that religious and cultural beliefs influenced delays in seeking maternal healthcare, which contributed to maternal mortality. Women with strong religious convictions, particularly in rural areas, were more likely to delay seeking modern medical interventions during childbirth, opting instead for traditional or spiritual solutions. This delay was often associated with higher risks of maternal and neonatal death due to preventable complications. This highlights how religious and cultural beliefs can result in life-threatening delays in medical intervention, thus contributing to higher mortality rates.

In Ghana, traditional medicine and spiritual healing are often sought before formal healthcare, especially in rural areas. A study by Tsey et al. (2016) showed that many Ghanaians, particularly those who believe in the influence of spirits or ancestors on illness, first seek help from traditional healers or religious leaders before turning to modern medical facilities. This behaviour can result in late-stage diagnoses of diseases like cancer and hypertension, contributing to high mortality rates from these conditions. Such delays can limit the effectiveness of treatment and lead to worse health outcomes.

Religious beliefs can also affect treatment adherence. In a study conducted by Maman et al. (2009) in Tanzania, some individuals living with HIV/AIDS believed that their faith or prayers could heal them, leading to non-adherence to antiretroviral therapy (ART). This resulted in poorer health outcomes, faster disease progression, and higher mortality rates. The study emphasized that while religious practices provided social support, they also contributed to medical non-compliance, which worsened patient outcomes.

The belief in spirit children (as discussed in the previous section) plays a significant role in child mortality in some parts of West Africa, including Ghana and Nigeria. Denham et al. (2010) reported that in certain communities, children believed to be "spirit children" were killed shortly after birth because they were considered to be malevolent spirits sent to bring harm to the family. This cultural practice, deeply rooted in spiritual beliefs, directly contributes to infant mortality. The study highlighted that this belief system hinders appropriate health-seeking behaviors, as families avoid medical care for children perceived as "otherworldly."

Denham et al. (2010) defined a spirit child as “a child that has a large head, is born with teeth or a beard, spies on its parents, and vanishes when the parents are not looking.” In Ghana, some children are subjected to infanticide because they are viewed as spirit children sent “from the bush” to bring misfortune to the family. Denham et al. (2010) explained that the spirit child phenomenon among the Nankani has a significant influence on child mortality. Spirit children are seen as responsible for illness, disability, and misfortune within the family and community.

In Nigeria, spirit children, or "Abiku" and "Ogbanje," are believed to be born multiple times, usually dying shortly after birth (Ogunjuyigbe, 2004). Ogunjuyigbe's (2004) study on local perceptions and attitudes towards "Abiku" children found that belief in these spirit children affected causes of morbidity and mortality among children under five. The concept of Ogbanje raises a debate between Western and local perspectives on mortality (Schneider, 2017; Schneider et al., 2020) because belief in spirit children plays a significant role in discussions of childhood illness and death. Despite education, residence type, and exposure to modernization, many women in Nigeria continue to believe in spirit children, resulting in limited medical intervention for their children. Among the Yorubas, spirit children are thought to belong to the spirit world and die shortly after birth because their purpose on earth is unfulfilled (Maduekwe et al., 2017). In such societies, the child's brief existence is not discussed or recognized after death, affecting death reporting, registration, and certification.

In Ghana, Badasu et al. (2018) explored the link between educational status and beliefs about non-communicable diseases (NCDs) in children. They found that educational status strongly influenced the belief that non-communicable diseases (NCDs) in children were caused by enemies. A study conducted by Baider & Surbone (2014) on cancer patients in South Africa showed that a significant proportion of patients delayed or refused chemotherapy or surgery because they believed in spiritual healing. Religious leaders sometimes encouraged patients to rely solely on prayers or faith-based healing rather than medical treatments. This belief in divine intervention delayed timely medical intervention, exacerbating disease progression and increasing mortality rates.

Given the strong link between religion and health outcomes as supported by previous studies, the present study posits that the religious affiliation of a deceased person predicts possible causes of death in the study area.

2.11.4 Geographic Factors, Seasonality and Causes of Mortality.

Many studies, using geographic, epidemiologic, and public health lenses, have provided evidence suggesting that where people live significantly influences their health outcomes, particularly the causes of death (Curtis, 2004; Pearce et al., 2006, 2015). This is because different places or regions have distinct characteristics, which may result in disproportionate access to healthcare services. This disparity can affect the overall health of populations living in these areas. Subedi et al. (2019) demonstrated that geography significantly influences mortality. The authors found that remote areas face geographic barriers, limited healthcare services, and unmet healthcare needs, all of which impact health outcomes.

Additionally, various environmental risk factors can act as pathways influencing specific causes of death. Air pollution is one of the leading contributors to NCD deaths, with approximately 6.7 million deaths worldwide attributed to it (WHO, 2023d). Air pollution differs by geographic location and season, presenting distinct risk factors to various population groups. In Brazil, an earlier study revealed a strong association between air pollutants and the risk of death from respiratory and cardiovascular diseases (Gouveia & Fletcher, 2000). The authors noted that older individuals were at a higher risk of air pollution-associated mortality. Similarly, a study by Adeyemi et al. (2019) in Nigeria showed that child mortality varies across geographical regions due to differences in potential risk factors of mortality.

Moreover, a body of literature suggests that the seasons of the year influence certain diseases and the risk of death associated with them (Burkart et al., 2011; Feinstein, 2002; Kynast-wolf et al., 2005; Nakaji et al., 2004; Rossum et al., 2001). Different seasons pose varied risk factors for mortality. For example, studies linking environmental factors to causes of mortality often examine these through climate-epidemiologic lenses (Huynen et al., 2001; Rau & Doblhammer, 2003). Rau & Doblhammer (2003) documented that low temperatures facilitate the survival of bacteria in droplets, increasing the risk of pulmonary infections. On the other hand, cold temperatures are said to have adverse effects on the human immune system, reducing its ability to resist respiratory infections. Thus, breathing cold air can increase the risk of pulmonary infections due to bronchoconstriction.

Additionally, seasonal behaviours and activities of the population can influence disease causation and mortality risk. For instance, the risk of infection may increase during periods of seasonal congregation, such as school terms or sessions (Bjørnstad et al., 2002), seasonal migration, or due to the increasing transmission of diseases such as measles (Ferrari et al., 2008). In Japan, Nakaji et al. (2004) studied the seasonal changes in mortality statistics from the leading causes of death between 1970 and 1999. The authors observed that the season of the year significantly influenced mortality from coronary heart disease, stroke, communicable infections, and other causes. They reported higher overall mortality rates in the winter, particularly from infectious and parasitic diseases, respiratory diseases, cardiovascular diseases, diabetes, and accidents. Similarly, Kynast-wolf et al. (2005) studied seasonal death patterns and mortality in Burkina Faso, finding that overall mortality was higher during the dry season (November to May). The authors attributed this to infections like meningitis, which are more prevalent during this period, and also noted high child mortality at the end of the rainy season, likely due to malaria, which is predominant in Burkina Faso during the rainy season.

Feinstein (2002) studied the seasonality of deaths in the United States by age and cause from 1994 to 1998, finding that mortality rates were higher in winter, with respiratory and cardiovascular diseases as the primary contributors to excess deaths. The study also observed that younger individuals who died of external causes were more likely to die in the summer, while older individuals who died from the same causes were more likely to die in winter. Additionally, Rau et al. (2017) examined the seasonality of mortality causes in the U.S. from 1959 to 2014, reporting that circulatory and respiratory diseases dominated mortality causes during winter.

In Bangladesh, Burkart et al. (2011) found seasonal effects on mortality and causes of death from daily death counts collected by the Bangladesh Bureau of Statistics (BBS). They reported higher mortality rates during the cold season, with respiratory (18%), cardiovascular (14%), and infectious diseases (14%) as the major contributors to mortality in the country from 2002 to 2007.

Based on these findings, the present study examined the year of death, month of death, and season of death to investigate their causal relationships with broader mortality causes in the study area. Obtaining information on the influence of seasonal and other related factors is essential for implementing public health interventions aimed at reducing seasonal excess mortality in the country.

2.11.5 Institutional and Healthcare Delivery Factors and Cause of Mortality

The health delivery system plays a critical role in improving service quality and health outcomes. An effective and robust health system can deliver better quality services that can avert premature deaths through a rapid response system. However, a weak and fragile health system, characterized by a scarcity of capital and human resources for healthcare delivery, among other factors, can undermine the implementation of sustainable health interventions. This has implications for the different causes of death and their impact on longevity. A qualitative study by Amu et al. (2021) on the management of chronic NCDs in Ghana revealed a myriad of factors that hinder the effective control of NCDs. The authors observed that factors such as inadequate logistics, work-related stress due to heavy workloads, poor utility supply, and financial incapability of patients to afford the cost of managing their conditions constrained the management of NCDs in the country. In the current study, the place of death variable was used as a proxy for measuring institution-related causes of death.

2.12 Potential Gains in Life Expectancy if Communicable and Non-communicable diseases were to be eliminated in Ghana

Evidence shows that when a major disease which causes death is eliminated, substantial gains in population life expectancy can be achieved. This is because the number of deaths attributed to that disease decreases. Globally, premature deaths place a significant burden on society, particularly in terms of the productive labour force. Individuals who die before reaching the general life expectancy are considered a loss to society. If not for their untimely deaths, they would have contributed to the social and economic well-being of their communities.

Studies by Abubakari et al. (2019) and Bawah & Binka (2007) have demonstrated that eliminating diseases that contribute to the health burden can lead to improvements in population longevity. Similarly, a study by Canudas-Romo et al. (2014) found potential improvements in life expectancy through the elimination of maternal mortality in developed countries. The authors observed that reducing or eliminating maternal mortality in developed countries could result in gains of about five years in reproductive-aged life expectancy (RALE). However, in sub-Saharan Africa, averting maternal mortality could significantly increase life expectancy, ranging from 0.24 to 1.47 years (Canudas-Romo et al., 2014).

Against this backdrop, the anticipation is that if communicable diseases (CDs) and non-communicable diseases (NCDs) were to be eliminated in Ghana, the gains in life expectancy would be significant, given that both groups of diseases contribute heavily to morbidity and mortality in the country. Understanding this potential requires examining the current disease burden and the impact of both CDs and NCDs on public health.

According to the World Health Organization (WHO), in 2019, life expectancy in Ghana was 64 years for men and 67 years for women. Eliminating CDs could lead to substantial increases in life expectancy. Given the large proportion of the population, especially children, affected by diseases like malaria and respiratory infections, eliminating these would drastically reduce child mortality rates. For example, in sub-Saharan Africa, malaria elimination is projected to result in a 3–10-year increase in life expectancy for children under five (Gallup & Sachs, 2001). Bawah and Binka (2007), for example, observed that life expectancy at birth would likely increase by more than six years if malaria were eliminated as a major cause of death.

The elimination of NCDs would primarily extend life expectancy for older adults. According to studies, eliminating cardiovascular diseases alone could add up to 6 years of life expectancy globally (O'Flaherty & Capewell, 2018; Snyder & Muntner, 2020). In Ghana, where CVDs are a growing cause of death, especially in urban areas, this could lead to similar gains. Diabetes and cancers also lead to premature deaths and long-term disability. Their elimination could add another 2–4 years to life expectancy (Bosu, 2015; Floyd, 2018), especially as more middle-aged and elderly individuals survive longer due to the absence of these chronic conditions.

If both CDs and NCDs were eliminated simultaneously, the combined gain in life expectancy could be dramatic. This is because the Elimination of CDs could contribute to around 3–5 years of life expectancy (Lozano et al., 2012), primarily due to reductions in child mortality and deaths from infections among young adults. Also, the elimination of NCDs could add approximately 5–7 years (Agyemang & Bhopal, 2013), particularly through reductions in cardiovascular deaths, strokes, diabetes complications, and cancers. Thus, total gains in life expectancy could range from 8 to 12 years, potentially pushing the average life expectancy in Ghana from around 65 years to over 75–80 years (World Health Organization (WHO), 2019).

Various metrics and concepts were developed in the 1980s to better understand disease burden and to estimate societal losses due to premature deaths (Centers for Disease Control, 1982). Some of these metrics or summary measures are useful for estimating the gains that can be achieved when the disease burden is reduced. These include life expectancy (LE) and healthy life expectancy (HALE) (Mathers et al., 1999). These metrics were introduced by the World Health Organization (WHO) as summary measures of the health status achieved by populations (Mathers et al., 1999; World Health Organization, 2000). To measure these improvements, demographic tools such as life table techniques are often employed to estimate gains in life expectancy when a particular disease is eliminated as a major cause of mortality. By using life table techniques, it is possible to estimate the disease burden by examining the years of potential life lost (YPLL) due to the disease.

This study used life table techniques and decomposition analysis to estimate the impact of communicable diseases (CDs) and non-communicable diseases (NCDs) on the longevity of households in two selected districts in northern Ghana. This research is especially important given the limited studies on the topic, despite the increasing prevalence and double burden of these diseases in the country.

2.13 Conceptual and Theoretical Framework

Three main theories served as the foundation for this study: the Epidemiological Transition Theory (ETT), the Explanatory Model of Disease, and the Social-Ecological Theory of Health Determinants. These theories were relevant to the study for the following reasons. First, the ETT provided a better understanding of the prevalence and trends of communicable and non-communicable diseases among the population. It helped in understanding the changes in disease patterns and mortality over time. Second, the Explanatory Model of Disease is critical for understanding the impact or burden of diseases on society. It also complemented the Social-Ecological Theory of Health Determinants by helping to explore factors associated with the causes of death in the study area. Finally, the Social-Ecological Theory helps to identify the factors contributing to morbidity and mortality within the community. In other words, this theory identifies the determinants of health status and mortality in the study area. The theory helped in understanding how different environments (social, physical, economic) impact health outcomes. This allows for more tailored and effective interventions.

2.13.1 The Epidemiological Transition Theory (ETT)

The Epidemiologic Transition Theory describes the changing patterns of population age distributions, mortality, fertility, life expectancy, and causes of death. The theory was developed by Omran (1971), using data from England, Wales, Sweden, Japan, Chile, and Ceylon. It presented an explanation for the shift from infectious to chronic diseases that supposedly accompanied modernization (Weisz & Olszynko-Gryn, 2010). Initially, three main phases of transition were identified. The first phase was the "age of pestilence and famine," characterized by high mortality and no population growth.

Following the first stage, the second phase, known as the "age of receding pandemics," saw mortality decline and exponential population growth. In the third stage, the “age of degenerative and man-made diseases,” mortality continued to decline until it stabilized at a low level. In other words, as societies developed, they experienced a shift in disease patterns. Over time, acute infectious diseases decreased, degenerative diseases became more prominent, and there was a gradual shift in the age pattern of mortality from younger to older ages (Omran, 1971).

However, after Omran's work in 1971, subsequent stages of the transition were extended. This extension occurred because Omran's original formulation never explicitly stated that infectious and parasitic diseases would be eliminated at any point in a population’s life course. Additionally, it failed to predict future trends in age-related diseases (Jay et al., 1998). The extension introduced "the fourth stage of the epidemiologic transition," known as the “Age of Delayed Degenerative Diseases,” characterized by the continued presence of major degenerative causes of death from Omran's third stage but with a significantly delayed average age at death. However, the possible re-emergence of infectious and parasitic diseases due to demographic and health circumstances hinted at a return to the first stage of the epidemiologic transition. This recent pattern of disease and changes in demographic features led some researchers to hypothesize a new fifth stage of the epidemiologic transition, called the “Re-emergence of Infectious and Parasitic Diseases” (Jay et al., 1998; Olshansky & Ault, 1988).

This theory was particularly important for this study, as it helped explain the incidence and prevalence of communicable and non-communicable diseases in a world undergoing an epidemiologic transition with a double burden of diseases. The epidemiologic transition theory proved to be a valuable tool for classifying levels of mortality. More importantly, it provided a foundation for comparing the relative risks of death across population sub-groups over time.

Furthermore, the theory was most relevant as it provided a clearer way of understanding the relationships among disease patterns (prevalence), mortality patterns (trends), and population dynamics such as age, sex, place of residence, and income status. The application of the epidemiologic transition theory in this study centered on its ability to focus on the complex changes in patterns of health and disease, as well as the interactions between these patterns and their demographic, economic, and sociological determinants and consequences. Guided by this theory, it was essential to explore the relationships between the socio-demographic background and health status of the study population.

2.13.2 The Social-Ecological Model

The Social-Ecological Theory was propounded by Bronfenbrenner (1979). According to this theory, population health is influenced by a number of individual, interpersonal, organizational, social, environmental, political, and economic factors (McLeroy et al., 1988). In other words, an individual or population's state of health results from multilevel factors and outcomes emerging from the micro, meso, and macro levels of every society. The literature suggested that the health of a population or individual tended to reflect the social, cultural, bio-behavioural, economic, physical, and medical influences within the broader context of risk, protective, and resilience factors shaping the dynamic epidemiology of population change (Defo, 2014). The theory allowed for a deeper understanding of health outcomes, beyond just focusing on biology, physiology, and anatomy. Figure 2.6 displays the framework of the Social-Ecological Theory of health determinants.

Figure 2.6. The social ecology of health determinants.

Source: Adapted from McLeroy, Steckler, and Bibeau, (1988).

The theory also helped recognize the social determinants that played a major role in health promotion and disease prevention. These social determinants included a complex set of political, social, and economic forces (e.g., employment, gender, income) that shaped the conditions in which one was born, grew, lived, and worked, as well as the age group one belonged to (Raphael, 2009). These conditions influence the health of individuals, communities, and jurisdictions through the distribution of wealth, power, and resources (Lucyk, 2016).

The Social-Ecological Theory understands health as being influenced by the interaction between the individual, the group or community, and the physical, social, and political environments. One key strength of the theory was its recognition of the complex role played by different factors in disease outbreaks, as well as the success or failure of interventions aimed at preventing them (Popa-Velea & Purcarea, 2014). The theory supports the development of multi-level interventions, addressing health issues at various levels simultaneously (e.g., individual, community, policy), which can be more effective than single-level interventions. It also provides a framework that is useful for policymakers to identify and address the various social determinants of health, guiding the creation of comprehensive health policies. The theory allows for a dynamic understanding of health determinants, recognizing that these influences can change over time and across different contexts. Moreso, it encourages the integration of knowledge from various disciplines, including sociology, psychology, public health, and environmental science, leading to more robust and holistic health strategies.

The theory was particularly important to this study because infectious disease transmission is influenced by human behaviour and socio-cultural, environmental, and political factors. Moreover, the strategies adopted to prevent, combat, eliminate, reduce, or slow the transmission of infections during spikes or outbreaks arose from individuals undertaking significant and intense behavioural changes both locally and nationally (Caulkins et al., 2020). In this view, the ultimate goal of fighting a disease infection would be clearly within the remit of social psychology, as much as virology and epidemiology.

This theory was therefore relevant to the study, as it allowed for a careful exploration of all the factors that influenced collective solidarity and lasting behavior change. For instance, during infectious disease outbreaks, the success of efforts to slow or contain the spread largely depended on social, community, and individual-level factors. In 2020, for example, the World Health Organization (WHO) prescribed protocols such as physical and social distancing, the use of face masks, frequent handwashing, the use of alcohol-based sanitisers, and regular exercise as interim measures to reduce the rapid spread of Coronavirus Disease 2019 (COVID-19) after the organization declared it a global pandemic in March 2020. However, adherence to these protocols and the strategies individuals adopted to cope with the disease depended largely on social and psychological factors, including public reactions to the pandemic, values, community leadership, perceptions of personal and collective efficacy, collective identity, and social norms (Van Bavel et al., 2020).

Therefore, understanding the household burden of communicable and non-communicable diseases relied on applying the lessons of the Social-Ecological Model of health determinants. This model provided insights that directly informed public policy, as well as individual and collective behaviour. Its application in the study allowed for the inclusion of individual-level variables (such as age, and sex), social variables (education, marital status, religion), community-level variables (place of residence, rural/urban), and economic variables (income, occupation), among others.

2.13.3 Explanatory Model of Disease

Kleinman (1981) used the concept of the explanatory model to provide an understanding of diseases from the individual's perspective. He opined that people's perceptions of a disease are largely based on their knowledge, experience, and how they cope with the illness. The explanatory model helps in understanding what constitutes an illness: its definition, perceived causes, symptoms, duration, severity, expected consequences, appropriate treatment, and anticipated outcomes. However, Kleinman recognized the role of culture in healthcare-seeking behaviors and treatment outcomes. Therefore, the explanatory model is important for providing insight into the cultural nuances of the risk factors associated with infectious diseases and their implications for seeking treatment. It is also useful for understanding people's experiences in relation to the burden of infectious diseases. Morbidity and mortality tend to disrupt income streams and valuable economic resources through premature death (Rice, 2000). In demography, this is measured using the YPLL and VYPLL metrics, as stated earlier in this chapter.

2.13.4 Limitation of the Theories Used

The Epidemiological Transition Theory (ETT) has been influential in understanding how patterns of mortality and disease change over time. However, it has several limitations. Some of the key limitations included the oversimplification of complex epidemiological transitions into distinct stages, which may not accurately reflect the variability and complexity of real-world transitions. The theory is also criticized for its Eurocentric focus because the model prediction is based largely on historical data from European countries and may not be universally applicable, particularly in low- and middle-income countries with different historical and cultural contexts. Also, the theory has neglected the social determinants of health and focuses on the biological and medical factors while neglecting social, economic, and environmental determinants of health, which play a crucial role in shaping disease patterns.

Additionally, the theory tended to give a static view of health transitions, failing to account for the dynamic and ongoing nature of changes in health patterns. The ETT does not also adequately address the rise of new diseases or the re-emergence of old diseases, which can disrupt the predicted stages of the transition. The focus on the shift from infectious to chronic diseases can overlook the continued burden of infectious diseases in many parts of the world.

The Social-Ecological Theory of health determinants, on the other hand, has been recognized for acknowledging the complex interplay of various factors influencing health, including individual behaviours, social relationships, community environments, and broader societal influences. However, it has several limitations including measurement challenges because quantifying and measuring the impact of various social and ecological factors can be difficult, leading to challenges in research and evaluation. It is also very challenging to attribute health outcomes to specific factors within the social-ecological model, making it harder to identify which interventions are most effective. The model may require integration with other theoretical frameworks to fully capture the complexity of health determinants, adding another layer of complexity to its application. Again, the model's emphasis on social and environmental determinants might sometimes underplay the role of individual agency and personal responsibility in health outcomes.

With regard to the Explanatory Model of Disease, one limitation is that while it emphasizes the role of cultural context in understanding diseases, it may oversimplify or generalize the complexity of cultural beliefs, potentially leading to misinterpretation or stereotyping of a population's health behaviors. Also, the model is heavily reliant on individual perspectives and personal experiences, which can vary widely. This subjectivity might hinder the ability to develop universally applicable medical interventions or treatments.

The limitations of these theories suggest that while they provide valuable insights into the study of health transitions and experience of illness, they should be used alongside other models to ensure a holistic understanding of health and disease. In light of this, the three theories were used complementarily to understand the impact of communicable and non-communicable diseases on households in the study area.

2.14 Conceptual Framework of the study

The conceptual framework in my study was motivated by the Social-Ecological Theory propounded by Bronfenbrenner (1979) and later modified by McLeroy et al. (1988) as the Social-Ecological Model of health determinants. Additionally, the framework was driven by the epidemiologic transition theory by Omran (1971), which described the changing patterns of population age distributions, mortality, fertility, life expectancy, and causes of death.

This study's framework demonstrated the relationship between the independent, intermediate, and dependent variables. Most studies (Dalal et al., 2011; Tenkorang & Kuuire, 2015; Julianne Williams et al., 2018) in the reviewed literature connected the development of communicable and non-communicable diseases (CDs and NCDs) to many factors, including age, sex, income levels, educational status, alcohol use, smoking, air quality, access to quality healthcare, diet, and physical activity. Other factors included place of residence (rural/urban), occupation, and religious affiliation. In their study on the developmental origins of health and disease, Baird et al. (2017) referred to these combined factors as genetic, environmental, behavioral, psychosocial, preconception, and pregnancy-related.

Based on the reviewed literature, this study conceptualized these variables and categorized them as independent variables, which included socio-demographic, geographic, and institutional factors. Although these factors, as observed in the literature, were said to have a direct impact on morbidity and mortality, their effect could be moderated or influenced by certain variables known here as intermediate variables. These variables, as captured in the conceptual framework, included seasonal, medical, and lifestyle factors. The dependent variable in this study was the cause of death, which was measured in three categories: dying from CDs, NCDs, or external causes.

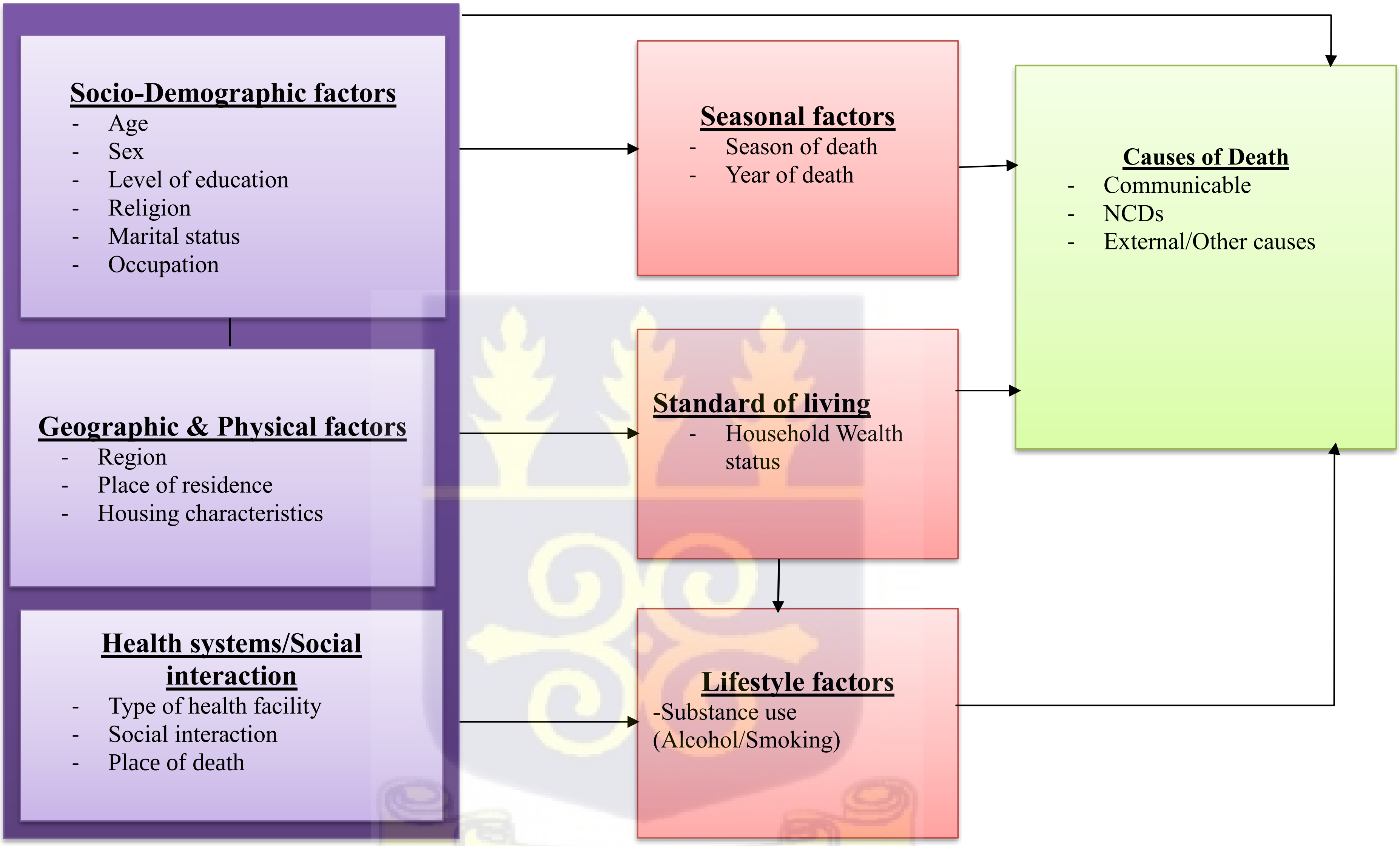
Age was hypothesized to have a direct influence on the probability of dying from specific causes. I hypothesized that infants and young children were more likely to die from infectious causes of death, whereas adults and older individuals were more likely to die from NCD-related causes compared to infants and young children. Additionally, socio-demographic factors affect the standard of living or lifestyle factors which influence the risk of dying from specific causes.

Occupation was another variable strongly connected with morbidity and mortality. According to the Ghana Statistical Service (2013), occupation focuses on specific economic activities that individuals engage in for their livelihood. A person's occupation was seen to directly influence the risk of dying from specific causes of death. Occupation also indicated labour force participation and economic contribution. It defined social status and could influence access to healthcare in case of illness. The type of occupation might also shape physical activity levels, placing individuals at risk for certain conditions.

Furthermore, the educational level of an individual was observed to have a strong link with the risk of dying from specific diseases. An increase in education level could lead to a rise in economic status and decision-making power when it came to accessing and affording healthcare. The place of residence (urban/rural) and its characteristics also had implications for the risk of death from specific causes. Urbanization tended to reduce physical activity and expose individuals to unhealthy lifestyles and dietary patterns, increasing the risk of NCDs. Religion influenced health-seeking behaviour, with different faiths (e.g., Christianity, Islam) shaping beliefs and practices that affected healthcare access and health outcomes.

In sum, this conceptual framework integrates socio-demographic, geographic, institutional, and lifestyle factors to provide a comprehensive understanding of the multiple layers that affect health outcomes in the study population. It serves to explain how morbidity and mortality are shaped by complex interactions between individual, community, and societal factors.

Figure 2.7: Conceptual Framework of the study



2.15 Gaps in Studies

To date, studies in Ghana that estimated disease burden from the demographic surveillance surveys (DSS) remained scanty and incomplete (Awini et al., 2014; Bawah & Binka, 2007; Sulemana, 2017). Moreover, these studies varied in terms of subject, target population, and geography, making their findings unrepresentative and implausible in different contexts. Although certain populations and places may have faced a severe burden of a specific disease condition, it is important to assess its burden on the overall population rather than on a targeted population, as seen in the studies by Sulemana (2017) and Awini et al. (2014). Though also important, an analysis of specific causes of mortality often ignores the overall picture of the total disease burden.

Additionally, there was a complete neglect of studies estimating the causes of mortality at the household level. Meanwhile, sociodemographic and household-level characteristics significantly influenced health outcomes in many settings. Thus, ignoring household characteristics in understanding any disease burden did not portray an accurate picture, which could affect interventions and efforts to reduce such diseases. The current study sought to fill this gap by estimating the burden of CDs and NCDs at the household level, focusing on the entire population irrespective of age and sex.

The global Sustainable Development Goals enjoined all countries to adopt strategies that would help improve the well-being and health of everyone, regardless of age and sex. Thus, knowing the number of people who died and the causes of those deaths was one way to reduce premature deaths globally. This study was contextualized around three main scenarios captured as critical components of SDG 3. The first scenario was that communicable diseases had been fought and eliminated in line with SDG target 3.3. Therefore, the study estimated the disease burden on life expectancy in the absence of communicable causes. The second and third scenarios respectively examined the impact on health assuming certain public health interventions were put in place, and that NCDs and external causes were reduced as major causes of mortality from the population, as envisioned by SDG targets 3.4 and 3.6. This approach helped to target interventions that could yield maximum health benefits with limited resource allocation. In the era of SDGs, studies employing such techniques in disease modelling were considered innovative and are encouraged.

CHAPTER THREE

STUDY AREA PROFILE AND METHODOLOGY

3.1 Introduction

This chapter outlines the methodological process of the study and describes the study area. Additionally, it explains the measurements of the study variables and highlighted the data analysis techniques and other metrics used to achieve the study's results. The chapter begins with a description of the study region and districts to provide readers with the context and setting in which the study was conducted. It concludes with a summary to help the reader grasp the key aspects of the chapter.

3.2 Study Region or Areas

The study was carried out in the Upper East Region of Ghana. The region is located in the northeastern part of the country, between longitudes 00 and 10 West and latitudes 10° 30' N and 11° N. It shares boundaries with the Upper West Region of Ghana to the west, Burkina Faso to the north, the Republic of Togo to the east, and the Northern Region of Ghana to the south (as shown in Figure 3.1). The region has a total land area of 8,842 sq. km, which accounts for about 2.7 percent of the total land area of Ghana (GhanaDistricts, 2023). According to the 2021 Population and Housing Census (PHC), the population of the region was one million, three hundred and one thousand, two hundred and twenty-six (1,301,226) people, with an estimated annual growth rate of 1.2 percent (Ghana Statistical Service, 2021). The region had a population density of 147.2 persons per square kilometre and 264,404 households. According to the 2021 PHC report, about 75 percent of the population resided in rural areas. In terms of administration and governance, the region had 15 administrative districts and municipalities. At the time this study was conducted, the region had 4 municipalities and 11 districts (Ministry of Local Government and Rural Development (MLGRD), 2019).

Figure 3.1 Map of Upper East Region

Source: https://en.wikipedia.org/wiki/Districts_of_Ghana.

According to the Ghana Statistical Service (2021), the average household size in the Upper East Region was 4.8 people per household, which was higher than the national average of 3.6 people. Overcrowding had been identified as a predisposing factor associated with the spread of infectious diseases. Hodgson et al. (2001), for instance, observed that exposure to or close contact with a case, and sharing a bedroom with an infected person, put people at risk of contracting meningitis.

In 2018, the region recorded the highest number (2.6 deaths per 1000 admissions) of institutional deaths from pneumonia infections compared to other regions in Ghana (Owusu et al. 2021).

In terms of health infrastructure, the region had one of the poorest healthcare systems and amenities in the country (Ghana Statistical Service, 2021). It was also one of the regions classified under Ghana's meningitis belt. Incidences of infectious diseases such as CSM, tuberculosis, and malaria are high in the region. The region experienced two major seasons: dry and wet (rainy) seasons. CSM mostly occurred during the dry season and ended when the rains set in (Whitson, 2005; Yaka et al., 2008).

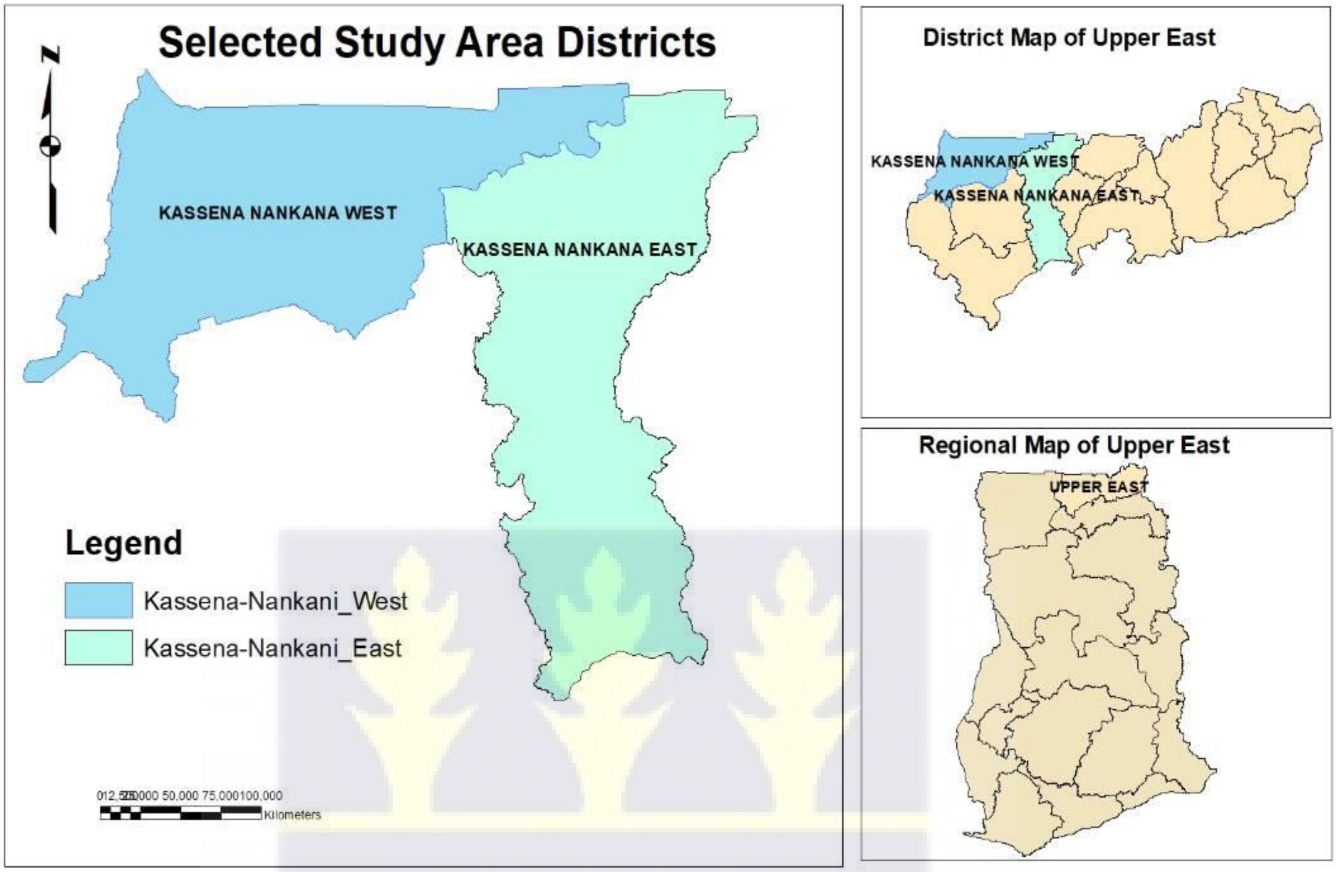
Additionally, the Upper East Region has been noted to be one of the poorest regions in Ghana, with subsistence agriculture as the mainstay of the population. More than 70 percent of the population lived below the poverty line (National Development Planning Commission (NDPC), 2012). As one of the regions in northern Ghana, its poverty roots date back to the colonial era, when neglect of its productive potential widened the inequality gap between it and the South (Nabila, 1972). Mapping the incidence of poverty in Ghana showed a high concentration of poverty in the northern part of the country (Ghana Statistical Service, 2015). The high levels of poverty in the region implied that the onset of infectious diseases and NCDs could further impoverish many families. This is because, as noted by Arrow et al. (2004), in communities where poverty was pervasive, households were often distressed when epidemics occurred, and their meagre resources were depleted. In other words, the emergence of infectious diseases and NCDs forced households to forgo basic necessities such as food, shelter, and clothing to cover healthcare costs. It was observed that many people in rural communities in the Region struggled to access basic healthcare, and they often had to travel long distances to be attended to by specialists (Africa Renewal, 2017; Ghana Health Service, 2018).

In 2018, for instance, the Upper East Region recorded the second-highest percentage (30.4 percent) of institutional causes of death at health facilities in the country, just behind Greater Accra (30.8 percent) (Owusu et al., 2021). In the same year, the region also recorded the highest road traffic accident mortality rate (0.9 deaths per 1000 admissions) in the country. In light of these challenges, it became important to estimate the impact of causes of death on longevity in the region to inform policy interventions aimed at improving population well-being.

3.3 Study Districts

The study was conducted in the Kassena-Nankana East and West districts of the Upper East Region of Ghana (as shown in Figure 3.2). Until 2007, the two districts were one, known as the Kassena-Nankana District, with Navrongo as the district capital. However, in 2007, the district was split into two—Kassena-Nankana East and Kassena-Nankana West, with their capitals being Navrongo and Paga, respectively.

Figure 3.2: Map Showing Study Districts



According to the 2021 Ghana Population and Housing Census (PHC), the total population of the two districts was one hundred and ninety thousand, six hundred and thirty (190,630) people. Together, the two districts recorded 42,813 households. The Kassena-Nankana West District had a population of 90,735, with a population density of 111.8 persons per square kilometre and an average of 4.5 people per household. The Kassena-Nankana East Municipality, on the other hand, recorded a population of 99,895, with a population density of 115.4 persons per square kilometre and an average of 4.1 people per household.

The Grusi (Kassena) and Gurene (Nankana) were the main indigenous tribes in both districts, along with smaller immigrant populations from other parts of Ghana. These minor ethnic groups included the Mamprusis, Kantosi, Builsa, Moshie, Zambrama, and a few immigrant workers from neighbouring Burkina Faso (Ghana Statistical Service, 2014a). These populations coexisted over the years, which enhanced the development of the districts. Except for the two district capitals, settlement patterns in both districts were largely dispersed, particularly in rural communities.

The major food crops produced included groundnuts, sorghum, maize, beans, rice, millet, pepper, onions, and tomatoes. Livestock reared in the two districts included cattle, sheep, goats, poultry, pigs, and donkeys, mostly on a subsistence basis. Small-scale agro-processing activities, such as fibre, cotton, groundnut paste and nuts, shea butter, Dawadawa, and rice, were also present. There were two main markets in Navrongo, along with seven satellite markets in Manyoro, Gaani, Natugnia, Kologo Nayire, Kologo Kulengo, Biu, and Naaga. In Kassena-Nankana West, the markets included Paga, Sirigu, Kandiga, Chiana, Mirigu, and Nabango.

3.3.1 Healthcare Facilities and the Choice of the Study Districts

The number of health facilities in a particular area partly helped gauge healthcare access and delivery. In the Kassena-Nankana East Municipality, there were a total of twenty-six (26) healthcare facilities (Kassena Nankana Municipal Assembly, 2021). These included 20 CHPS compounds, 2 private clinics, 1 district hospital, 2 healthcare centres, and 1 CHAG clinic. The War Memorial Hospital was the only major government hospital in the municipality. Additionally, the Municipality had Emergency Medical Services (EMS), which delivered critical medical care, basic pre-hospital support, and transport to healthcare facilities, especially for injured and critically ill patients. The Municipality faced numerous healthcare delivery challenges, including inadequate equipment, limited hospital facilities, low doctor/nurse-to-patient ratios, and a shortage of operative health facilities. The ratio of doctors to the population in the Municipality was 1:63,381, while the nurse-to-population ratio was 1:823.

In Kassena-Nankana West District, there were a total of thirty-seven (37) health facilities across nine (9) administrative sub-districts (Kassena Nankana West District Assembly, 2021). These included six (6) health centres and thirty-one (31) functional CHPS compounds. Additionally, 212 community-based surveillance volunteers were trained in Integrated Management of Childhood Illnesses, disease surveillance, filariasis control, breastfeeding, and sanitation (Kassena-Nankana West District Assembly, 2021). The district had no hospital but had six (6) chemical shops and three (3) traditional healers. The nurse-to-patient population ratio was 1:672 in 2016. The district faced challenges such as inadequate numbers of critical staff, including midwives and medical assistants, which affected the delivery of healthcare services. The two districts shared only one district hospital, the War Memorial Hospital, located in Navrongo—the district capital of Kassena-Nankana East Municipality. However, the Bolgatanga Regional Hospital and other regional health facilities, such as Amiah Hospital and Afrikids Medical Centre, were accessible to some people from these two districts.

The motivation for choosing these districts was based on the fact that they fell under the geographic catchment area of the Navrongo Health Research Centre (NHRC). The NHRC is one of three research centres of the Research and Development Division of the Ghana Health Service, alongside the Kintampo Health Research Centre (KHRC) and the Dodowa Health Research Centre (DHRC). Moreover, the NHRC is one of 49 HDSS sites across 20 countries in Africa, Asia, and Oceania, which monitored population dynamics in their respective areas of operation (International Network for the Continuous Demographic Evaluation of Populations and Their Health (INDEPTH)) (Bangha et al., 2017; Wak et al., 2017).

The NHRC, located in Navrongo in the Kassena-Nankana Municipality of the Upper East Region of Ghana, had maintained a Demographic Surveillance System (DSS) since 1993, which monitored demographic events such as pregnancies, births, deaths, and migrations into and out of the Kassena-Nankana East Municipality and West District (Bawah & Binka, 2007). The Centre carried out several health interventions and disease burden research, which was relevant to the current study. Additionally, the Centre consistently collected verbal autopsy data on the causes of death for all deceased household members within its DSS (Bawah et al., 2014). These causes of death included both communicable and non-communicable diseases, making the choice of the districts appropriate since verbal autopsy data was a key source for the current study. Therefore, the selection of these districts was based on the fact that they fell under the NHRC's surveillance. The study obtained data on general and specific causes of death in these districts, which helped estimate overall causes of death and those attributable to communicable and non-communicable diseases.

Moreover, because the Centre monitored the entire population of the study area, it provided an opportunity to assess the relationship between socio-demographic characteristics and the risk of dying from either CD or NCD causes. It also allowed for better estimates of potential gains in life expectancy, assuming public health interventions were implemented and a particular cause of mortality was eliminated or reduced as a major cause of death in the population under NHRC surveillance.

3.4 Source of Mortality Data

The data for this study were obtained from the Navrongo Demographic Surveillance Systems (NDSS) of the Navrongo Health Research Centre. The NDSS began in 1992, and the first wave of data updates occurred in July 1993. Since its inception, the NDSS consistently monitored the population of all individual registered members within the demographic surveillance area (DSA) (Oduro et al., 2012). The Demographic Surveillance Area (DSA) covered the two Kassena-Nankana districts of the Upper East Region of Ghana, with a land area of 1,675 square kilometres along the Ghana-Burkina Faso border.

Although the government of Ghana, through an Executive Instrument, separated the then Kassena-Nankana District into the Kassena-Nankana East Municipal (KNEM) and the Kassena-Nankana West District (KNWD) in February 2008, the NDSS continued to monitor the population of the two districts as a single Demographic Surveillance Area (DSA). However, in 2015, a comprehensive data abstraction programme was developed that allowed for the splitting of the NDSS dataset into KNE and KNW sites (Navrongo Health Research Centre, 2016). Through this process, all clusters, compounds, and households were categorized as belonging to either KNEM or KNWD based on their location. The splitting of the HDSS by administrative district helped monitor and estimate the population and health indicators for each district.

The NDSS provided a platform for launching health and biomedical research in the Kassena-Nankana Districts of Ghana (Oduro et al., 2012). The objectives of the NDSS included monitoring the socio-demographic dynamics of the two districts, providing data samples for various research protocols, and offering a platform for evaluating the impact of various interventions implemented in the study area. To monitor population dynamics, the NDSS collected data on births, deaths, migrations, pregnancies and their outcomes, marriages, and vaccination status of children under three years of age. Additionally, household socio-economic data (including housing characteristics and household possessions) were occasionally obtained to serve as a proxy for the wealth index. The educational status of persons aged six years and above was also collected annually during the first round of the year. With household socio-economic, educational status, health, and other background information, the NDSS provided a viable platform that supported other studies within the districts. This support ranged from providing a sampling frame to measuring the health, social, and demographic impact of public health interventions within the geographic area.

Generally, the NDSS maintained a register for the population within its catchment area. The catchment area (DSA) was divided into five zones (North, South, East, West, and Central). The zones were further divided into subzones (fieldworkers' working areas), and the subzones were further divided into clusters (equivalent to enumeration areas) to facilitate fieldwork and research activities at the Centre. A cluster consists of a number of compounds or houses within a defined geographical area. As of December 2015, the NDSS had 247 clusters, with an average of 95 compounds per cluster. The cluster system facilitated data collection, management, and analysis. Each compound or house was given a unique number based on a three-level identification system: subzone, cluster, and household.

Within each compound or house, all households and their members were given unique identification numbers. Information on household members was recorded and kept in a register called household record books (HRBs). The HRBs were used to maintain the demographic profile of the population. Data collection and updates for the NDSS were carried out every four months by trained fieldworkers and supervisors, allowing for the registration of all new persons and their households. Field visits also offered fieldworkers the opportunity to update the socio-demographic characteristics of the people and households within the DSA. The main document used by fieldworkers to update the demographic profile of people within the DSA was the HRB. The HRB contained the names of compounds and their numbers in a cluster, which fieldworkers used during their visits. During field visits, fieldworkers visited every compound within the cluster. At each compound, the fieldworker would mention the names of all registered members according to their households. Generally, the household head or any adult member provided information on each member's presence or absence. If a household member were temporarily absent (e.g., at school, farm, or market), the fieldworker would indicate in the HRB that the individual was temporarily absent.

Under the NDSS, children born to women already registered were recorded as soon as they were born and became members of the DSA for surveillance. During routine visits, pregnancies of all registered women and their outcomes were recorded in the NDSS. NDSS fieldworkers also took note of live births to visitors or immigrants in the DSA, allowing for the registration of the eligible mother and her child or children during the next round of visits. This approach improved the accuracy of birth dates for newborns and enhanced the reporting of births for mothers with recurrent in and out-migration. It also improved the reporting of pregnancy outcomes, as expectant mothers were observed and followed up after the notification of a pregnancy outcome for registration during field visits.

The NDSS helped improve the documentation and reporting of mortality. Deaths of all registered and eligible members of the NDSS were recorded, regardless of the place of death. Deaths were generally better known than births in the NDSS. Therefore, deaths were less likely to be underreported. However, due to cultural and religious beliefs, newborn children not yet registered in the NDSS and deaths of children under five years old were sometimes not reported. For example, among the Kassena and Nankana, there was a belief in spirit children who were thought to cause illness, disability, and misfortune within families and communities (Denham et al., 2010). Such children were subjected to infanticide because they were considered spirits sent “from the bush” to harm the family. Deaths resulting from the spirit child phenomenon were neither discussed nor recognized, affecting NDSS death records, particularly for infants and neonates who died shortly after birth. Information on the causes of death among the population in the study area was obtained through verbal autopsies (VAs).

Additionally, the NDSS adopted the Community Key Informants (CKI) system and Geographic Information Systems (GIS) as innovative strategies to improve data collection. The CKI system helped improve the recording of pregnancies, births, other pregnancy outcomes, and infant and neonatal deaths. In the CKI system, well-known individuals in the communities were trained to record any pregnancies, births, and deaths in their respective communities. This approach was useful because some respondents might not report certain demographic events (e.g., pregnancy loss or neonatal death) to NDSS fieldworkers during visits. Evidence suggests that deaths at very young ages and infant and child mortality in Ghana were often underreported (Ghana Statistical Service, 2010). The CKIs provided a viable alternative, as they were always present in the communities and could record such events and report them to NDSS fieldworkers.

Data collected by NDSS fieldworkers underwent several quality checks to ensure data quality standards were maintained. These included field supervisors checking questionnaires for completeness and consistency, automated range and consistency checks, and a double-entry system before logging the data into registers and entering it into the HDSS database.

Regarding verbal autopsies (VAs), the NDSS employed similar high-data-quality approaches. Supervisors and fieldworkers were recruited and trained to conduct VA interviews. They visited households of deceased persons to collect information from close relatives on the signs and symptoms leading to death using a standardized WHO/INDEPTH questionnaire (version 2007). Two or more physicians independently assigned the probable cause of death using WHO's International Classification of Diseases (ICD-10) guidelines. An earlier study indicated that data from the NDSS were reliable and accurate (Wak et al., 2017). Therefore, the choice of the two districts was appropriate since data from the NDSS provided a viable opportunity for understanding the burden of communicable and non-communicable diseases among the population in the study area. This study obtained data spanning from 2012 to 2018 to analyze the trends and prevalence of the causes of mortality within the study area.

3.5 Mortality Data Collection Tool

The cause of death information was obtained through verbal autopsies (VA) conducted on individuals who were registered members of the Navrongo Health and Demographic Surveillance System (HDSS) (Oduro et al., 2012). A verbal autopsy is an oral postmortem process in which information on the events leading to an individual's death is gathered from a relative using a standardized questionnaire (Baiden et al., 2007; Bawah et al., 2014). This approach is often employed in settings where vital registration systems (VRS) with medical certification of deaths are incomplete or absent. My study relied on HDSS verbal autopsy data to estimate potential gains in life expectancy, assuming that public health interventions were implemented and communicable and non-communicable diseases were reduced to non-public health significance and are no longer major causes of death in the study area.

In collecting verbal autopsy data, the NHRC recruited and trained field workers to conduct interviews in the local languages, particularly Kassem and Gurene (Nankam). The informants for verbal autopsy interviews were spouses or close family members of the deceased (Bawah et al., 2014). When a death was reported, trained supervisors and field workers visited the households of the deceased to conduct oral postmortem interviews, gathering information on the signs and symptoms leading to the death using a standardized questionnaire.

Once the information was collected, two or more physicians independently reviewed it to determine the possible cause of death (Baiden et al., 2007; Bawah & Binka, 2007; Setel et al., 2005). The specific cause was assigned based on the agreement of at least two physicians. My study utilized complete verbal autopsy data from 2012 to 2018 to present the causes of death in the study area.

The limitations of using VA tools to ascertain causes of death have been documented in previous studies (Herrera et al., 2017; Ramroth et al., 2012; Valecha et al., 2011). These limitations include low sensitivity and specificity in measuring malaria mortality (Herrera et al., 2017) and difficulty in identifying malaria as a cause of death in holoendemic malaria regions (Ramroth et al., 2012). Additionally, verbal autopsy tools have been criticized for potential misclassification of causes of death, particularly in controversial estimates of malaria mortality in India (Valecha et al., 2011).

However, in the absence of a reliable death registration system, which is a common issue in many sub-Saharan African (SSA) countries, verbal autopsy data provides a viable alternative for analyzing and estimating causes of death (Ohene et al., 2011; Ramroth et al., 2012; Rankin et al., 2012). Alternatively, in areas without a vital registration system, health facility-based clinical autopsies can provide useful mortality estimates (Ohene et al., 2011). Yet, in many SSA countries, most deaths occur outside health facilities, making it difficult to obtain reliable cause-of-death estimates for the entire population (Dalal et al., 2011). Additionally, access to health facility-based autopsy data can be challenging, and when available, the data often suffer from incomplete or duplicate entries, which can affect analysis (Sanuade et al., 2014). Furthermore, such data may overlook deaths attributable to social and cultural factors (Moyer et al., 2016).

Previous studies (Baiden et al., 2007; Moyer et al., 2016; Murray et al., 2014; Narh-Bana et al., 2012; Sankoh & Byass, 2012; Setel et al., 2005; Ye et al., 2012) have shown that verbal autopsy tools are standardized, comprehensive, innovative, and contextually applicable, making the data they produce reliable and accurate. Most studies, therefore, rely on VA tools for analyzing causes of death (Murray et al., 2014; Sankoh & Byass, 2012; Ye et al., 2012). For example, Sankoh & Byass (2012) emphasized the role of VA tools in identifying causes of death, especially in areas where most deaths occur outside health facilities. Fottrell & Byass (2010) argued that VA tools create opportunities for obtaining reliable, timely, and useful cause-specific mortality information for individuals who may have lived, gotten sick and died without contact with formal health services.

Studies from various countries have highlighted the significant role of VA tools in determining causes of death. In Tanzania, Narh-Bana et al. (2012) used VA data to estimate adult mortality patterns and risk factors. In Sri Lanka and many other parts of the world, there is growing interest in using VA tools to improve mortality statistics (Dharmaratne et al., 2011). In Mozambique, VA tools are employed to gather cause-of-death data during the national census to develop national statistics (Setel, 2011). One key advantage of VA tools over hospital-based certification is that they allow for questions related to risk factors and health-seeking behaviour prior to death (Murray et al., 2011). VA tools can also provide insights into social, economic, behavioural, and health system factors that may have contributed to a person's death.

To address the limitations of VA tools, the Physician Coded Verbal Autopsy (PCVA) approach is often used to ascertain probable causes of death. As mentioned earlier, the Navrongo HDSS engages two physicians to independently assign the probable cause of death using WHO's International Classification of Diseases (ICD-10) guidelines. One challenge with the PCVA method is that it can be expensive and time-consuming (Murray et al., 2014). However, the introduction of computerized algorithms has minimized these difficulties (Houle et al., 2015; Murray et al., 2014). In the Navrongo HDSS, causes of death are collected using VA tools and determined through the PCVA method. Therefore, my study relied on the verbal autopsy (VA) data component of the NHDSS, which employed a standard VA tool for data collection.

The NDSS used four different VA tools to obtain information from different population groups. The VA tool for infants collected information on deaths that occurred between 0 to 2 years of age. The children's VA instrument was used for those aged 2 to 11 years. For women aged 12 to 50 years, a specific VA instrument was employed. Finally, the last VA instrument gathered information on women over 50 and men aged 12 and above. My study covered the general population.

3.6 Data Management

The Navrongo Health Research Centre has several mechanisms in place to ensure that data quality standards are maintained to provide high-quality data. These include regular visits to monitor and supervise data collectors and conducting re-interviews at selected households (Wak et al., 2017). About 3–5 percent of surveillance households (totalling over 30,000) are randomly sampled for re-interviews by quality control supervisors. The results from these re-interviews are then compare with the fieldworkers' interviews by a Field Headquarters team. Any discrepancies in the interviews are reconcile and resolve by the supervisor and fieldworkers on-site.

Other strategies to ensure high-quality data include checking all completed registers and event forms for accuracy, internal consistency, misquotations, and completeness. Data collection instruments and questionnaires undergo rigorous review by supervisors to ensure they are completed with no blanks, inconsistencies, or errors before being sent for data entry. Questionnaires found to have been completed with errors are usually return to the field for resolution if the errors could not be immediately resolved. Additionally, the NDSS hold monthly review meetings (Zonal meetings) for field staff to report on their activities and assess their performance. With these mechanisms in place, the HDSS data was relatively high in terms of quality and reliability (Wak et al., 2017).

Upon obtaining the data, I further conducted a data-cleaning exercise, using Stata version 17, to ensure completeness. Individuals with age-missing data were not included in the analysis. The age variable was crucial because of the study's objective of examining the impact of CDs and NCDs on longevity.

3.7 Period of Data Coverage

The study included all deaths from 2012 to 2018. During this period, a total of 6,198 deaths were recorded, encompassing all causes of death. However, 46 of the deaths did not have information on the date of birth and year of birth, which is used to compute the age at death and hence were excluded from the analysis. A total of 6,152 deaths were included in the final analysis. The study included all deaths and the entire population to understand the different causes of death and identify the specific groups within the population that were affected. The reported deaths occurred either in health facilities, at home, or while en route to a health facility.

3.8 Measurement of Variables

This section describes how both the dependent and independent variables were measured. The variables presented are based on the literature review discussed in Chapter Two. Table 3.1 presents a complete description and summary of the measurement of all variables in the study.

Table 3.1 Measurement and Conceptualisation of Study Variables

Variable Type	Variable	Description (how variables are measured)
Explanatory Variables	Religion	The religion was categorized into Catholic, Traditional, Other Christians, Other
	Educational level	Level of education categorised as No education, Primary, Secondary, Tertiary
	Age of death	Age in years categorized in age groups including 0-4, 5-9, 10-14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80+
	Sex	1= Male, 2= Female
	Social Economic Status	The wealth quintile was categorized as least poor, less poor, poor, poorest and very poor.
	Occupation	Measured as a Farmer, Trader, Government/Private Employee and Student
	Year of Death	Years from 2012 to 2018
	Month of Death	Months of the Year
	Season of Death	Wet/Dry
	Place of death	Home, Hospital, On the way to the facility, Other health facilities and other
Dependent Variable	Causes of Death	The outcome variables of the study included communicable, non-communicable and external (Road Traffic and Injury) causes of death.

Author's construct, 2023.

3.8.1 Dependent Variables

The dependent variable of the study is the cause of death. The cause of mortality was categorized into three main outcome variables as conceptualized by the study. These included communicable, non-communicable, and road traffic accidents and injury or external causes of death. These classifications are based on the WHO's major causes of mortality (World Health Organization, 2020) and the Global Burden of Disease Classifications (Murray & Lopez, 1996).

Infectious or communicable causes of death were considered in this study as deaths resulting from infections and parasitic diseases, including malaria, meningitis, hepatitis, etc. Non-communicable causes refer to deaths related to non-communicable diseases such as diabetes, stroke, hypertension, etc. The third category of the dependent variable, termed external or other causes of death, was defined as deaths attributable to self-harm, accidents, and other injuries such as suicide.

3.8.2 Independent variables

Several factors shaped and influenced morbidity and mortality among populations. The US Department of Health and Human Services, (2017) and the Social-Ecological Theory indicated that social determinants of population health included factors such as education, economic stability, community safety, and the availability of adequate housing and healthful food. Additionally, individual biological and genetic characteristics, such as inherited diseases and conditions, influence health outcomes. Socio-demographic and economic characteristics, such as sex, age, ethnicity, and employment status, also had implications for health outcomes.

In my study, the age-at-death variable was calculated by taking the difference between the date of death and the date of birth. All deaths that occurred between 1st January 2012 and 31st December 2018 were considered, and the age at death was estimated. The age in years was categorized into the following age groups: 0-4, 5-9, 10-14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, and 80+.

Other socioeconomic status variables, including occupation, education, and marital status, were identified in the literature as playing a significant role in individual well-being and health outcomes, thus influencing mortality or survival. The type of occupation an individual held affected their physical activity and exposure to certain conditions that could result in early death. Therefore, the occupation of the deceased persons prior to their death was considered to understand its influence on mortality. The occupation variable in this study was categorized as Farmer, Trader, Government/Private Employee, and Student.

Wealth status, which may define social class, could limit or promote access to resources and healthcare. Wealth quintiles were used in this study to measure wealth status, categorized as least poor, less poor, poor, poorest, and very poor. The religion of respondents was categorized as Catholic, Traditional, Other Christians, or Other.

Education, as identified in the reviewed literature, was one of the key socio-economic determinants of causes of death. The level of education in this study was categorized as No education, Primary, Secondary and Tertiary or higher. The season of death was categorized as dry or wet. Marital status was categorized as Never married, Married, Divorced, or Widowed.

3.8.3 Method of Data Analysis

The first part of the data analysis involved evaluating data quality. Evidence suggested that age misreporting was a common problem in many low- and middle-income countries (LMIC) settings, where levels of education and interest in knowing one's date of birth were often low. Under such circumstances, it was recommended that steps be taken to assess data quality to avoid misleading interpretations and estimations. In my study, age heaping and digit preference were obtained by computing the Whipple's, Myers, and Bachi Indexes.

Whipple's Index

The Whipple's Index was used to estimate age heaping for ages ending in terminal digits "0" and "5" " (Spoorenberg, 2007). The Index was calculated by dividing the total population at complete ages by one-fifth of the total population from age groups 23-62 years and multiplying by 100. The total value of the Whipple's Index ranged from 0 to 500. A value of 0 indicated no report for ages ending in digits '0' and '5'. A value of 100 indicated no preference for digits '0' or '5', and a maximum of 500 occurred when individuals preferred the digits '0' and '5' in the age data. The result of the Index was interpreted as shown in Table 3.2.

Table 3.2: Whipples Index Interpretation

Whipple's Index Value	**Quality of data (Interpretation)**
<105	Highly accurate
105–109.9	Fairly accurate
110–124.9	Approximate
125–174.9	Rough
≥175	Very rough

Source: (Pardeshi, 2010).

The Whipples Index was computed using the following formulae;

$$\text{Whipple's Index for the 5} - \text{year range } (W_5) = \left(\frac{P_{25} + P_{35} + P_{45} + P_{55}}{\frac{1}{10} \sum_{i=23}^{62} P_i} \right) * 100$$

$$\text{Whipple's Index for the 10} - \text{year range } (W_0) = \left(\frac{P_{30} + P_{40} + P_{50} + P_{60}}{\frac{1}{10} \sum_{i=23}^{62} P_i} \right) * 100$$

$$\text{Whipple's Index for digit } W_{0+5} = \left(\frac{P_{25} + P_{35} + P_{45} + P_{55} + P_{30} + P_{40} + P_{50} + P_{60}}{\frac{1}{5} \sum_{i=23}^{62} P_i} \right) * 100$$

Myers Blended Index

The Myers Blended Index was derived from the Bachi Index. The Myers Blended Index was primarily used to assess and evaluate age heaping in the mortality data. The Index was computed through the following steps:

1. Summed the digits for the population of the lower age limits, which were ages 10-89.

2. Summed the digits for the second population, excluding those in step 1 (ages 10-89), which were ages 20-89.

3. Obtained the products by multiplying each sum of ages by the corresponding weights.

4. Summed each product result to obtain the blended population.

5. Generated a proportion of the blended population to understand how each digit preference reported deviated from ten (10).

After assessing the data quality and plausibility, I proceeded with a univariate analysis. This involved descriptive statistics, such as frequency tables, percentages, and charts, to describe the socio-demographic background characteristics of the participants (age, sex, marital status, religion, level of education, wealth status, place of death, and occupation). Additionally, I analyzed the prevalence of communicable diseases (CDs), non-communicable diseases (NCDs), and external causes of death in the study area at this stage.

The third stage involved a bivariate analysis using cross-tabulations and chi-square tests to determine the differences in the causes of death by socio-demographic characteristics. Furthermore, the chi-square test was used to examine the relationship between background characteristics and causes of death. The confidence level was set at an alpha value of 0.05, so p-values less than 0.05 were considered statistically significant.

Additionally, a multinomial logistic regression was used to examine factors associated with communicable and non-communicable diseases in Ghana. Finally, single and multiple decrement life table techniques were employed to estimate the potential improvements in longevity, assuming CDs and NCDs were averted as major causes of death in the study area.

3.9 Ethical Consideration and Consent to Participate

The Navrongo Health Research Centre has an Internal Review Board that reviews and provides ethical clearance for all data collection and research conducted by the Centre. Informed consent was sought from all participants prior to data collection. For minors (individuals younger than the age of 16), consent to participate was obtained from their parents or legal guardians. This is secondary data that we generated and analyzed. The Navrongo Health Research Centre which provided the data has an ethics committee that ensures that all participants get ethical clearance. The Navrongo Health Research Centre's Internal Review Board number is FWA00000250 and the identifier is IBR00000802 (https://navrongo-hrc.org/institutional-review-board-irb/).

The causes of death data were obtained from the Navrongo Health Demographic Surveillance System. Introductory letters were written on my behalf by the Director of the Regional Institute for Population Studies to the Director of the Centre. These letters introduced me as a Doctoral student of the Institute seeking to obtain data for a PhD research thesis. I submitted hard copies of the letters to the Centre's administration and made subsequent follow-ups for the data.

3.10 Chapter Summary

The chapter highlighted the methods employed to achieve the study results. It provided the context under which the study region and districts were chosen, as well as the data source. The chapter made a case that information on causes of death was critical and needed to inform policy, planning, program implementation, resource allocation, monitoring, and evaluation. Yet, in many countries, due to a lack of complete vital registration systems with medical certification of deaths, this critical information was often a misplaced priority for policymakers and decision-makers. Thus, the HDSS, which employed the verbal autopsy tool to collect causes of death data in the Kassena-Nankana East and West Districts, provided a viable opportunity to understand the burden of communicable and non-communicable diseases. The next chapter presented an evaluation of the mortality data.

CHAPTER FOUR

EVALUATION OF ACCURACY OF MORTALITY DATA

4.1 Introduction

This chapter evaluates the level of accuracy and quality of the data using demographic analytical tools. It presents results for the Whipple's, Myers, and Bachi Indexes. This is relevant because, while demographic data, particularly mortality rates, are useful for estimating population health status and national development planning, the evidence from the reviewed literature points to issues of accuracy and reliability of mortality data from LMIC settings. Accurate and reliable mortality data are often required when developing and designing appropriate policies to address factors that cause mortality. However, accessing mortality data in most Sub-Saharan African countries is difficult or usually unavailable. In instances where the data are available, they might have been underreported or overreported. Age misreporting is said to be one critical error that affects mortality analysis and interpretations in many studies. Therefore, when using mortality data, initial steps need to be taken to understand the data quality and its plausibility before proceeding to analyze it.

4.2 Evaluation of Age Data

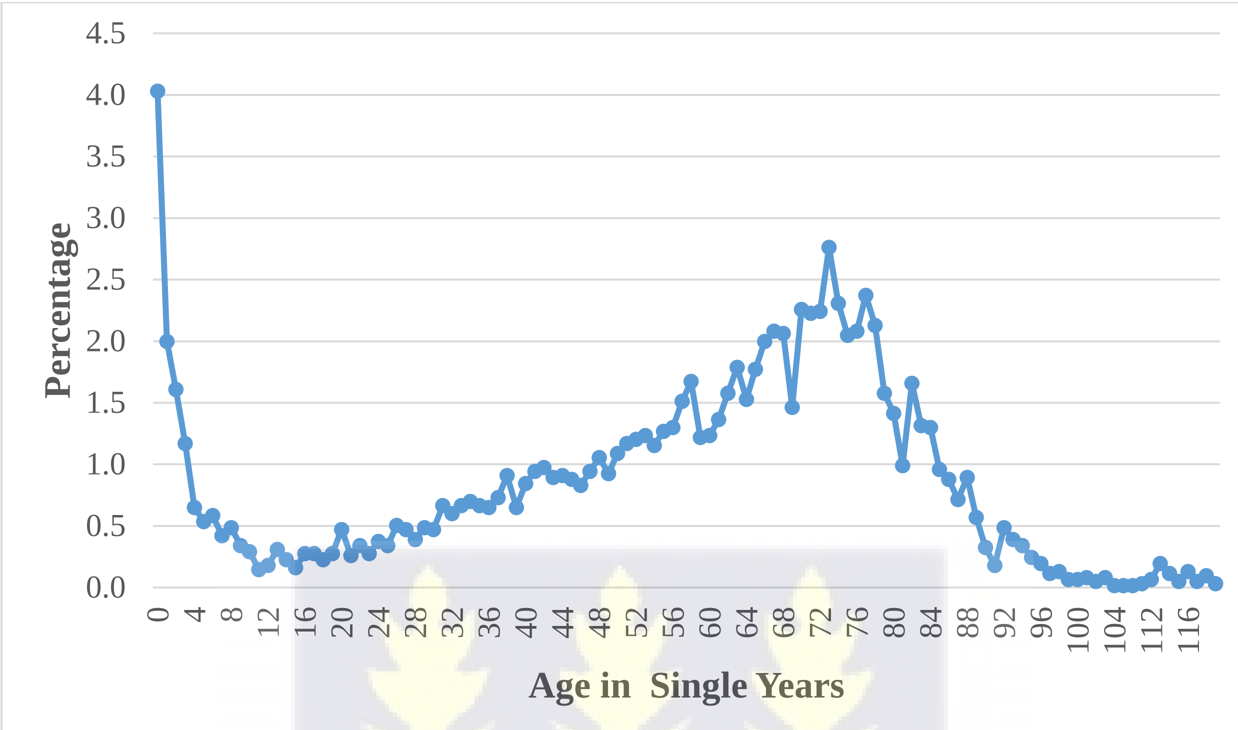
Age data are important for the estimation of population characteristics and their changes. They are equally important for building socioeconomic indicators and tracking health-related disease burdens (Randall & Coast, 2016). Additionally, age was an important indicator for assessing the quality of data concerning the cause of death. For instance, pediatric diseases differ from adult diseases (Benchimol et al., 2011). Therefore, knowing which causes of death posed a severe burden on a particular age group was an important step toward designing strategies to reduce that burden. However, age data, in many LMICs, are said to be associated with misreporting and misclassification, which, in turn, affects mortality analysis and interpretation.

As stated earlier, some studies usually used graphical data evaluation techniques to understand age heaping or age misreporting. In my study, the graphical methods, Whipple's, Myers, and Bachi Indexes, were used to evaluate the age data.

4.2.1 Graphical Approach

Figure 4.1 presents a graphical illustration of the number of deaths by single-year age. The pictorial representation allowed for a quick examination of the patterns of death by age as well as a visual inspection to detect inherent errors in the mortality data. The figure showed that there was age heaping in preference for selective digits. The graph depicted a zig-zag pattern of mortality with respect to age. The high-pointed tip of the graph indicated selective age digit preference, particularly for ages ending in 0 and 5. The downward-pointed tip indicated that a few cases of age heaping were reported for digits ending in 2, 3, 4, 7, and 8. By visual inspection, it was clear that the cases of age heaping occurred between the ages of 47-84 years.

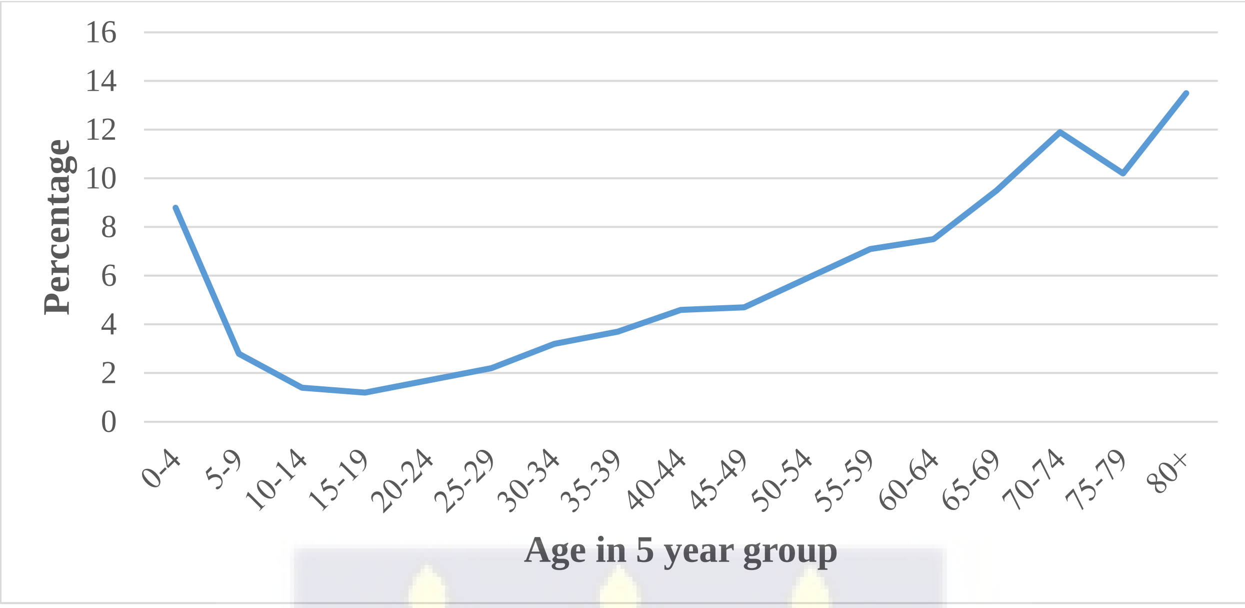
Figure 4.1: Percentage distribution of Deaths by single-year age



Source: Navrongo HDSS (2012-2018).

Age heaping influenced estimates for socio-demographic and economic variables, as well as mortality analysis. Therefore, knowing that some ages were heaped, it was important to resolve this by taking steps to smooth the curve. The age at death was categorized into 5-year groupings and used for the analysis. The results showed that when the ages were grouped into 5-year intervals, the curve became smoother compared to the single-year data (as shown in Figure 4.2).

Figure 4.2: Percentage distribution of Deaths by 5-year age grouping



Source: Navrongo HDSS (2012-2018).

4.2.2 Myers and Bachi Index

Although the graphical method provided a fair understanding of age heaping or misreporting, it had a significant limitation in estimating the extent of errors associated with age misreporting. The Myers and Bachi indexes, therefore, served as better alternatives for validating and evaluating the quality of age data. Table 4.1 shows the results for the Myers and Bachi indices, which were 6.61 and 3.31, respectively. The results from the Myers index implied that the average deviation from the last digits of the expected frequency was 6.61 percent, meaning that about 7 percent of the ages at death were misreported, with no apparent digit preference. Similarly, the Bachi index indicated no digit preference or avoidance of certain digits. These results suggested that the quality of age reporting within the data was moderate, and the values of both indices implied no significant digit preference or age heaping.

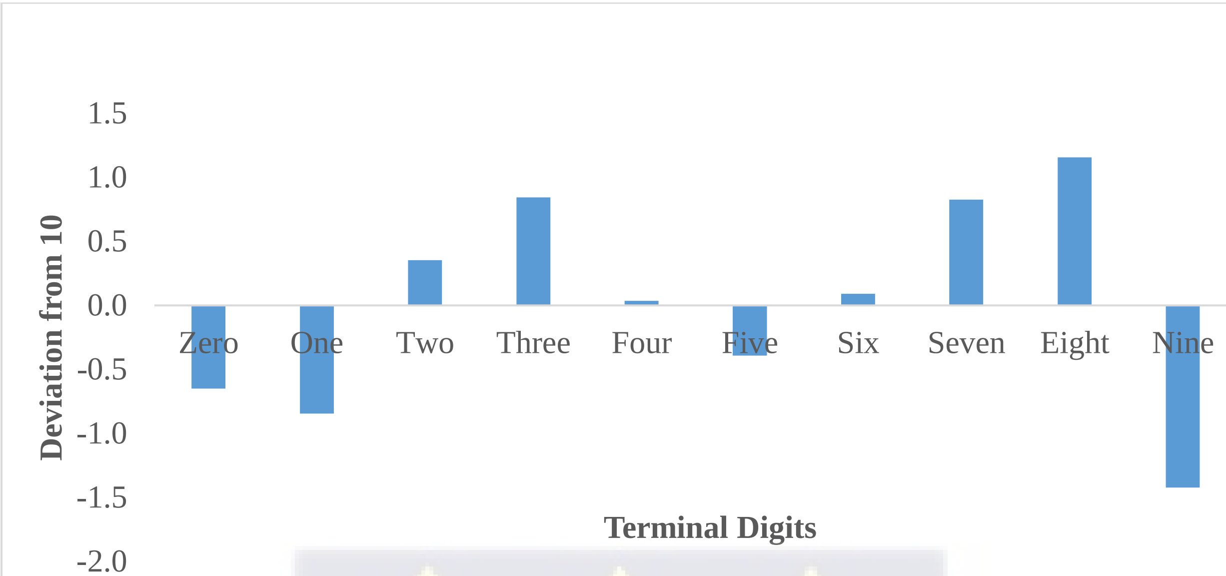
Table 4.1: Myers and Bachi Index of Age Validation

Digit Preference	Ages 10-89			Ages 20-89			Blended Pop.	Proportion of Blended Pop.	Deviation from 10
	Sum (10-89)	Weight	Product	Sum (20-89)	Weight	Product	Sum of Products		
0	497	1	497	479	9	4311	4808	9.35	-0.65
1	478	2	956	469	8	3752	4708	9.16	-0.84
2	540	3	1620	529	7	3703	5323	10.35	0.35
3	569	4	2276	550	6	3300	5576	10.84	0.84
4	523	5	2615	509	5	2545	5160	10.04	0.04
5	498	6	2988	488	4	1952	4940	9.61	-0.39
6	524	7	3668	507	3	1521	5189	10.09	0.09
7	560	8	4480	543	2	1086	5566	10.83	0.83
8	575	9	5175	561	1	561	5736	11.16	1.16
9	441	10	4410	424	0	0	4410	8.58	-1.42
Total	—	—	—	—	—	—	51416	100.00	6.61/2= 3.31

Source: Navrongo HDSS (2012-2018).

Figure 4.3 shows the deviation of the proportion of the blended population from 10 along each of the terminal digits. The results indicated that when reporting the age of the deceased, most relatives preferred the terminal digits '2', '3', '7', and '8'. The least preferred digits were '9', '1', '5', and '0'.

Figure 4.3: Deviation of Proportion of Blended Population from 10



Source: Navrongo HDSS (2012-2018).

The Whipple's Index was another mathematical method used to evaluate the data regarding age heaping around the digits zero (0) and five (5). The index assumed that errors in age reporting were most significant around these digits. It also assumed that age heaping on digits 0 and 5 occurred between the ages of 23 and 62 years. The Whipple's Index presumed that individuals under age 23 might not know their correct age, and others may need to report on their behalf. Additionally, individuals above age 60 were considered too old and might rely on others to report for them. In this study, verbal autopsy data were collected from relatives who reported events for deceased persons, potentially influenced by the memory of the respondents. In this context, the Whipple's Index served as a useful tool to assess the accuracy and reliability of the mortality data. The Index was computed as follows;

$$W_5 = \left(\frac{P_{25} + P_{35} + P_{45} + P_{55}}{\frac{1}{10} \sum_{i=23}^{62} P_i} \right) * 100$$

$$W_0 = \left(\frac{P_{30} + P_{40} + P_{50} + P_{60}}{\frac{1}{10} \ \sum_{i=23}^{62} P_i} \right) * 100$$

$$W_{0+5} = \left(\frac{P_{25} + P_{35} + P_{45} + P_{55} + P_{30} + P_{40} + P_{50} + P_{60}}{\frac{1}{5} \ \sum_{i=23}^{62} P_i} \right) * 100$$

Where P_{25}, P_{35}, P_{45} and P_{55} are the population for ages ending 25, 35, 45 and 55 respectively.

Also, P_{30}, P_{40}, P_{50} and P_{60} are the population for ages ending 30, 40, 50 and 60 respectively.

The $\sum_{i=23}^{62} P_i$, in the formula, is the summation of ages from 23 to 62 years.

W_{10} *and* W_5 are the age heaping for the digits 0 and 5 respectively.

Thus;

$$W_5 = \left(\frac{21 + 41 + 54 + 78}{\frac{1}{10}(17 + 23 + 21 + 31 + 29 + 24 + 30 + \cdots \ldots + 103 + 75 + 76 + 84 + 97)} \right) * 100$$

$$W_5 = \left(\frac{194}{\frac{1}{10}(2200)} \right) * 100$$

$$W_5 = \left(\frac{194}{220)} \right) * 100$$

$$W_5 = 88.18$$

The for W_5 (88) implies that there was no preference among the population to report ages ending at digit 5 years.

For the W_0, it was computed as follows

$$W_0 = \left(\frac{29 + 52 + 67 + 76}{\frac{1}{10}(17 + 23 + 21 + 31 + 29 + 24 + 30 + \cdots \ldots + 103 + 75 + 76 + 84 + 97)}\right) * 100$$

$$W_0 = \left(\frac{224}{\frac{1}{10}(2200)}\right) * 100$$

$$W_0 = \left(\frac{224}{220)}\right) * 100$$

$$W_0 = 101.82$$

Similarly, to the value for W_5, the value for W_0 (102) means that there was no complete preference for people to report the ages of their deceased relatives for digits ending at 0. However, it was observed that some people slightly preferred to report the ages ending at digit 0.

For the W_{0+5}, it was computed as;

$$W_{0+5} = \left(\frac{21 + 41 + 54 + 78 + 29 + 52 + 67 + 76}{\frac{1}{5}(17 + 23 + 21 + 31 + 29 + 24 + 30 + \cdots \ldots + 103 + 75 + 76 + 84 + 97)}\right) * 100$$

$$W_{0+5} = \left(\frac{418}{\frac{1}{5}(2200)}\right) * 100$$

$$W_{0+5} = \left(\frac{418}{440}\right) * 100$$

$$W_{0+5} = 95$$

Generally, the results from the Whipple's Index (95) showed that the quality of age reporting within the population was highly accurate. This means that the ages reported in the mortality data are highly accurate and hence analysis from the data can be reliable.

4.3 Discussion

Historically, mortality rates were the central indexes for measuring the health status of a population because they provided information on who was dying and from what cause. Typically, to understand and measure the category of the population dying from a particular cause, the age variable was often used. However, age misreporting was common, particularly in settings where knowing one's date of birth was not considered important. Age misreporting, however, affected mortality analysis and interpretation, which in turn impacted policy formulation and targeting. Against this backdrop, the study evaluated mortality data to ascertain age-heaping bias using the Whipple's and Myers indices. The results showed that the age reporting in the data was highly accurate, with low age heaping.

Of the 6,152 deaths recorded during the study period, the total population within the age groups 23 to 62 years was 2,200. Those whose ages were reported with the terminal digit "0" numbered 224, while those with the terminal digit "5" were 194. The Whipple's Index for the 10-year age range was 101.82, and for the 5-year age range, it was 88.18. The Whipple's Index for ages reported with terminal digits "0" or "5" was 95. The Myers Blended Index for the population was 3.31. These results indicated that, although age heaping occurred, there was no strong preference for certain digits, and misreporting of ages was not widespread. The Whipple's Index (W_{0+5}=95) demonstrated that the age data was highly accurate, making the analysis reliable. Overall, the three indices (Myers, Bachi, and Whipple's) supported the conclusion that age reporting was accurate.

The findings of this study contrasted with the assertion by Randall and Coast (2016) that age misreporting is pervasive in sub-Saharan Africa due to high illiteracy and social irrelevance of knowing one’s date of birth or age. Additionally, the study’s results contrasted with those of other studies (Elo et al., 2013; Fayehun et al., 2019; Womack et al., 2020). For instance, Womack et al. (2020) used the Whipple’s Index to evaluate data accuracy in Sierra Leone and found that reported ages among people with Ebola were highly inaccurate (239.9). Fayehun et al. (2019) used the same method in Nigeria and found a preference for digits 0 and 5, with Whipple's Index ranging from 217.3 in 2002 to 202.5 in 2013, indicating very rough data. In Ghana, Biritwum et al. (2013) found that about 12 percent of participants reported their ages incorrectly. Similarly, Basannar et al. (2022) in India found significant age misreporting in their survey. However, the results of this study were consistent with those of Lyons-Amos & Stones (2017), who reported that age misreporting in sub-Saharan Africa was around 5 percent, with Ghana and Nigeria showing improvement in age reporting quality.

Data accuracy is critical in guiding policy direction and informing timely decisions. In health, inaccurate age reporting could affect interventions aimed at addressing diseases in specific populations. The analysis in this chapter supported earlier studies (Chandramohan et al., 2008; Lankoandé et al., 2022; Wak et al., 2017), highlighting the reliability and accuracy of data from demographic surveillance systems (DSS). Surveys such as the DHS and census should employ similar methods to avoid severe age heaping, as Al-Haddad et al. (2013) reported in Nigeria. Evidence from this chapter suggests that the age-reported data was highly accurate and reliable. The next chapter examined the specific and broad causes of mortality in the study area, presenting the prevalence of communicable and non-communicable causes of death.

CHAPTER FIVE

GENERAL AND SPECIFIC CAUSES OF MORTALITY

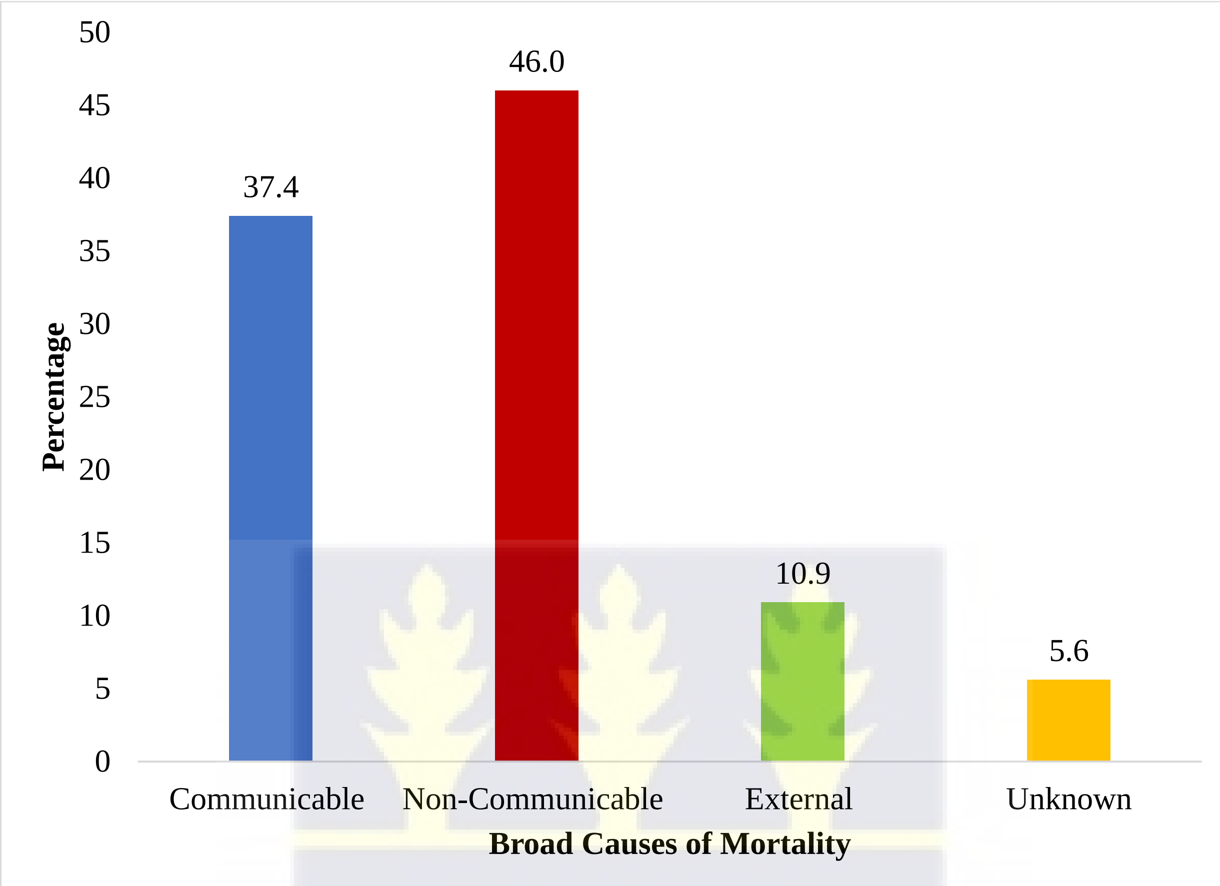
5.1 Introduction

The chapter presents results on the broad and specific causes of death in the Kassena-Nankana East Municipality and West District between 2012 and 2018. The chapter also presents trends and differentials in mortality in the study area.

5.2 General and Specific Causes of Mortality

Broadly, communicable diseases contributed to about 37.4 percent of the mortality burden in the study area (as shown in Figure 5.2). On the other hand, non-communicable diseases remained the leading cause of mortality in the study area, constituting 46.0 percent of the deaths recorded during the period. In total, non-communicable, external and other unknown causes accounted for about sixty-three (63) percent of the deaths that occurred between 2012 and 2018.

Figure 5.1: Broad Causes of Mortality, KNE & KNW, 2012-2018



Source: Navrongo HDSS (2012-2018).

In terms of specific causes of mortality, Table 5.1 shows the results of all causes of death in the Kassena-Nankana East Municipality and West District between 2012 and 2018. Generally, within the study period, deaths in the study area were attributed to thirty-nine (39) specific causes (as displayed in Table 5.1). All other specified and unspecified infectious and parasitic diseases accounted for 11.5 percent of all deaths in the study area during this period. Additionally, intestinal infectious diseases and diarrhoeal diseases accounted for 7.5 percent of all causes of death. Malaria and tuberculosis continued to be among the major disease burdens, contributing 4.4 and 2.5 percent, respectively, of all causes of death in the study districts. Acute respiratory infections, including pneumonia, contributed to about 5 percent of all deaths recorded during the period. Deaths due to HIV/AIDS infections accounted for 2 percent, while a portion of deaths was attributable to Meningitis infection.

In general, cerebrovascular and cardiovascular diseases (13.0 percent), infectious and parasitic diseases (11.5 percent), transport accidents and injury (9.6 percent), and intestinal infectious and diarrhoeal diseases (7.5 percent) were the top four leading specific causes of death in the study area. Acute abdominal conditions and gastrointestinal disorders contributed to 8.2 percent of all deaths during the study period. Largely, the spirit child phenomenon, birth injuries, and malnutrition were the major causes of child and infant mortality in the study area. On the other hand, about 6 percent of the deaths could not be attributed to any specific causes and were categorized as undetermined or unknown due to insufficient information to establish the causes of death. Additionally, non-attribution to any specific causes arose when there was no agreement between coders (physicians) on the plausible causes of death.

Table 5.1: Causes of Death in the Kassena-Nankana East Municipality and West District

Causes of Death	Number of cases	Percentage
Communicable	**2298**	**37.4**
All other unspecified infectious and parasitic diseases	533	8.7
Intestinal infectious diseases & diarrhoeal diseases	460	7.5
Acute respiratory infections (incl. pneumonia)	288	4.7
Malaria	271	4.4
All other specified infectious and parasitic diseases	171	2.8
Tuberculosis	151	2.5
HIV/AIDS	125	2.0
Prematurity and low birth weight	124	2.0
Other respiratory system illness	80	1.3
Meningitis	38	0.6
Viral Hepatitis	26	0.4
Maternal related causes	22	0.4
Rabies	9	0.1

Causes of Death	Number of cases	Percentage
Non-Communicable	**2838**	**46.0**
Cerebro-& Cardio vascular disease	800	13.0
All other gastro-intestinal disorders	318	5.2
Unspecified non-communicable disease	299	4.9
Disorders of kidney & Urinary Disorders	234	3.8
Cirrhosis of liver	212	3.4
Acute abdominal conditions (incl. intestinal obstruction)	182	3.0
Ischaemic heart disease	163	2.6
Neoplasm of respiratory tract	114	1.9
Mental & behavioural disorders	97	1.6
Hypertensive heart disease	92	1.5
Disorders of the nervous system	60	1.0
Asthma	55	0.9
Epilepsy	53	0.9
Anaemia	41	0.3
Peptic ulcer disease	30	0.5
Diabetes mellitus	25	0.4
Malnutrition	18	0.3
Hepatoma	17	0.3
All Congenital Malformations	17	0.3
Chronic obstructive lung disease	11	0.2
External	**672**	**10.9**
Transport accident & Injury	593	9.6
Intentional Self harm& other intentional	27	0.4
Assault	27	0.5
All Other Specified Causes	18	0.3
Spirit child	6	0.1
Tetanus	1	0.0
Undetermined/ No Specific information	**344**	**5.6**
Grand Total	**6152**	**100**

Source: Navrongo HDSS (2012-2018).

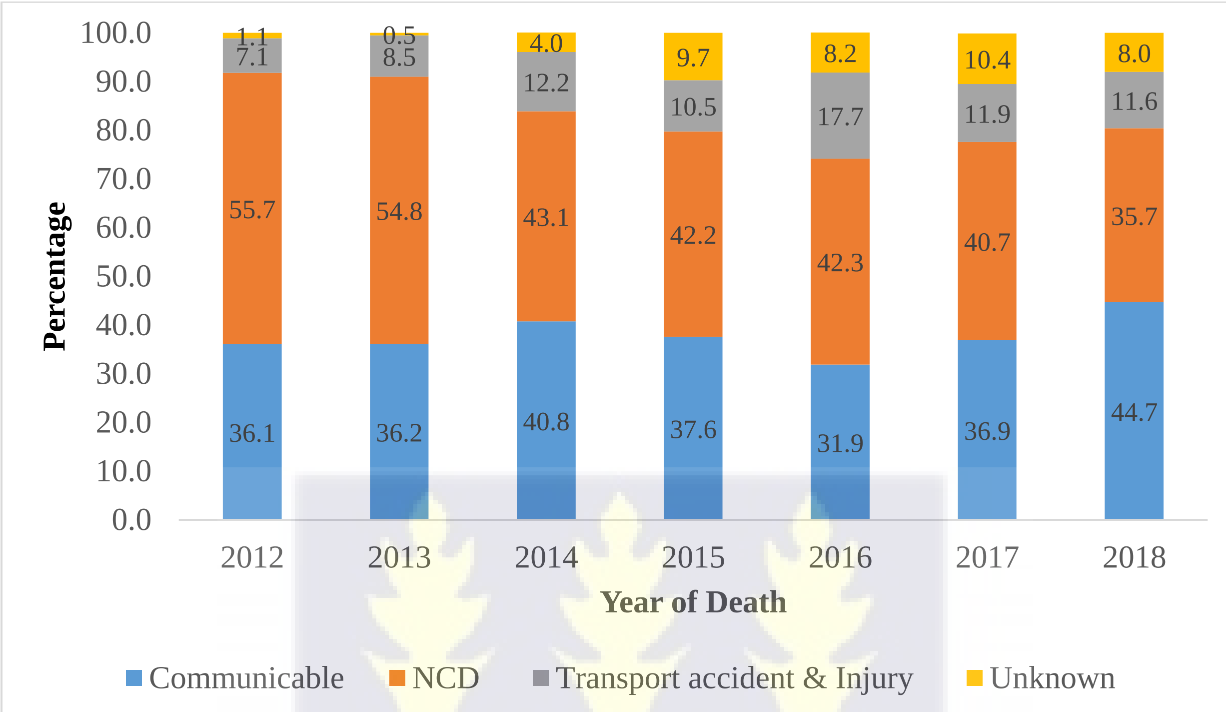
5.3 Trends in broad causes of mortality in Kassena-Nankana East and Kassena-Nankana West Districts from 2012-2018

Figure 5.2 illustrated the trends of the broad causes of mortality in the KNE and KNW districts from 2012 to 2018. The results indicated that the total burden of diseases in the study area had declined over time. A total of 6,152 deaths were recorded during the study period. NCDs consistently remained the leading cause of death from 2012 to 2018. It was evident that CDs and NCDs remained the major causes of mortality in the study area over time.

However, between 2012 and 2018, the study area witnessed a significant decline in NCD mortality, from 55.7 percent to 35.7 percent, respectively. On the other hand, CD mortality rose from 36.1 percent in 2012 to 40.8 percent in 2014, then declined to 37.6 percent and remained below 40 percent between 2015 and 2017, before rising again to 44.7 percent in 2018.

Within the period, external causes, such as road traffic accidents, injury, and self-harm were highest in 2016 (17.7 percent) and lowest in 2012 (7.1 percent). Over the years, there were several deaths whose causes were unknown. The highest proportion of unknown deaths was recorded in 2017 (10.4 percent), followed by 2015 (9.7 percent). Although the figures for unknown deaths were on the decline, it appeared that recent years had recorded higher numbers than in the early 2000s.

Figure 5.2:Trends of the broad causes of mortality in the KNE and KNW districts from 2012-2018



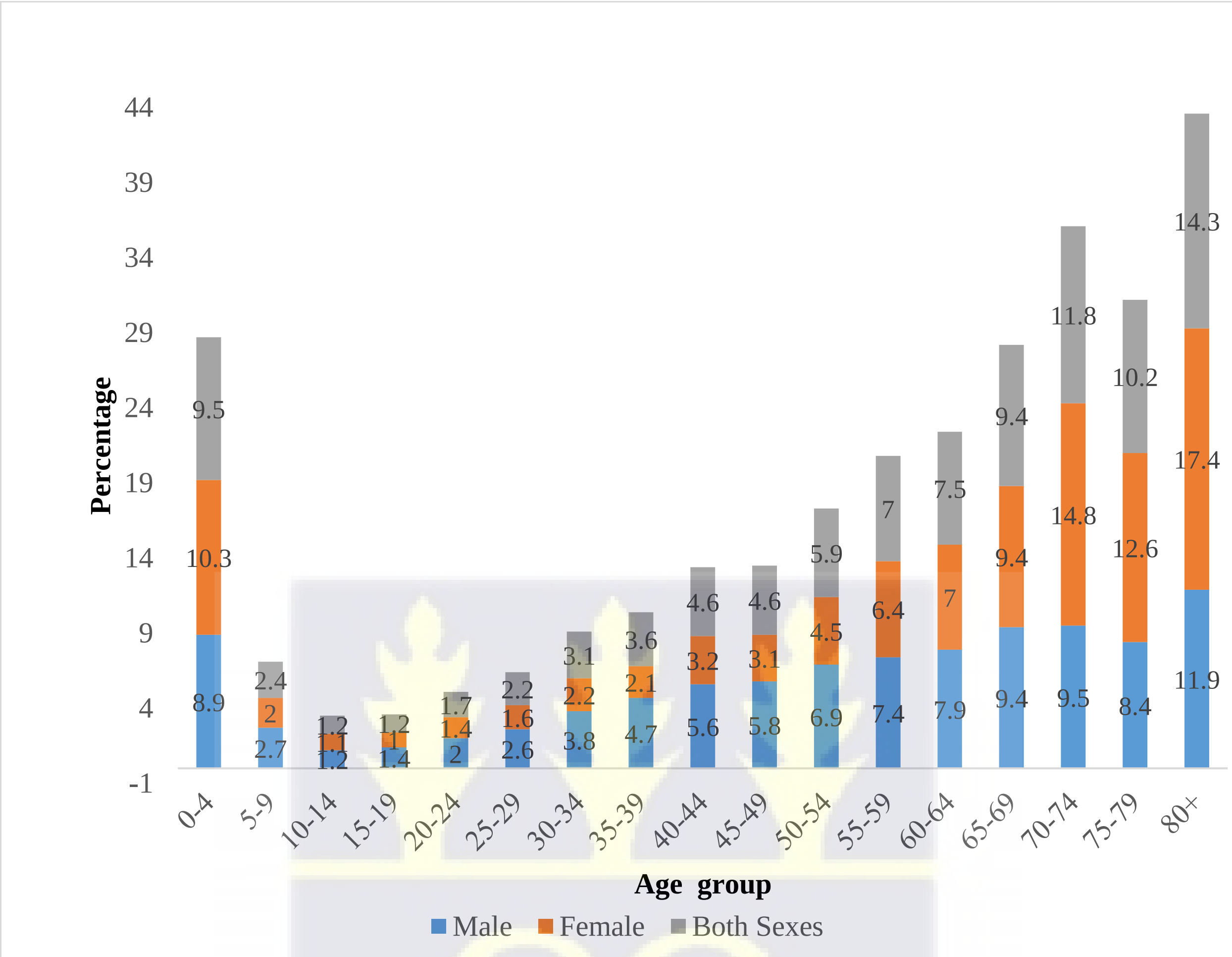
Source: Navrongo HDSS (2012-2018).

5.4 Socio-demographic and Background Characteristics of Deaths

Figure 5.3 shows the distribution of deceased persons by age and sex. The ages at death was categorized into five-year groups. According to the results, most deaths occurred at 80 years and above (14.3 percent), followed by those in the 70-74 years age group (11.8 percent). The results also revealed that infant and under-five mortality constituted the fourth-highest proportion of the deaths recorded during the period, accounting for about 10 percent of the total deaths.

In terms of mortality distribution by sex, the results indicated that mortality rates were higher in males than in females. More than half (57.1 percent) of the 6,152 deaths recorded were males, while females constituted 42.9 percent.

Figure 5.3: Distribution of mortality by age and sex



Source: Navrongo HDSS (2012-2018).

Table 5.2 shows the distribution of mortality by background characteristics. Regarding wealth quintiles and mortality, persons categorized as the least poor had the highest proportion (29.9 percent) of deaths, followed by those in the less poor quintile. A high proportion (42.8 percent) of the deceased persons were married, followed by those who were widowed. The smallest proportion (10.2 percent) of the deceased persons had never been married. The majority (67.3 percent) of the deceased persons were farmers, while the least proportion (3.8 percent) were students.

Regarding educational level, the highest proportion (77.8 percent) of the deceased persons had no education, followed by those with primary education (12.8 percent). The least proportion (2.8 percent) of the deceased persons had tertiary education.

With regard to religion, individuals who belonged to the Christian religion constituted more than half (56.7 percent) of the deceased persons, while those practicing traditional religion accounted for about 40 percent of the deaths recorded within the study period. Finally, about two-thirds (65.5 percent) of the deceased persons died at home, and about 29 percent of them died at the hospital.

Table 5.2 Distribution of mortality by background characteristics

Variable	Number	Percentage
SES		
Least Poor	1823	29.9
Less Poor	1557	25.5
Poor	1453	23.8
Poorest	176	2.9
Very Poor	1097	18
Marital Status		
Married	2308	42.8
Never married	549	10.2
Widowed	1964	36.4
Divorced/Separated	570	10.6
Occupation		
Farmer	3627	67.3
Trader	298	5.5
Government/Private employee	271	5
Student	206	3.8
Other	989	18.3
Education		
No education	4192	77.8
Primary	690	12.8
Secondary	356	6.6
Tertiary	152	2.8
Religion		
Catholic	20	3.4
Traditional	234	39.6

Variable	Number	Percentage
Other Christian	315	53.3
Other	22	3.7
Place of Death		
Home	4029	65.5
Hospital	1786	29.1
On the way to the facility	115	1.9
Other Health Facility	104	1.7
Other	114	1.9

Source: Navrongo HDSS (2012-2018).

Table 5.3 shows the distribution of mortality by year and season. Regarding the year of death, a high proportion of the deaths occurred in 2012, 2013, and 2015, in that order. The smallest proportion of deaths was recorded in 2018 (10.2 percent). In relation to the season of death, more than half (59.1 percent) of the deaths occurred during the dry season. A higher proportion of the deaths occurred in September (9.5 percent), October (9.3 percent), and March (8.9 percent), in that order.

Table 5.3 Distribution of Mortality by Year and Season of Death

Variable	Number	Percentage
Year of Death		
2012	1110	18.0
2013	1112	18.1
2014	682	11.1
2015	947	15.4
2016	769	12.5
2017	904	14.7
2018	628	10.2
Month of Death		
Jan	449	7.3
Feb	483	7.9
Mar	550	8.9
Apr	523	8.5
May	478	7.8
Jun	470	7.6
Jul	498	8.1

Variable	Number	Percentage
Aug	530	8.6
Sep	587	9.5
Oct	575	9.3
Nov	497	8.1
Dec	512	8.3
Season of Death		
Wet	2517	40.9
Dry	3635	59.1

Source: Navrongo HDSS (2012-2018).

5.5 Broad Causes of Mortality by Background Characteristics

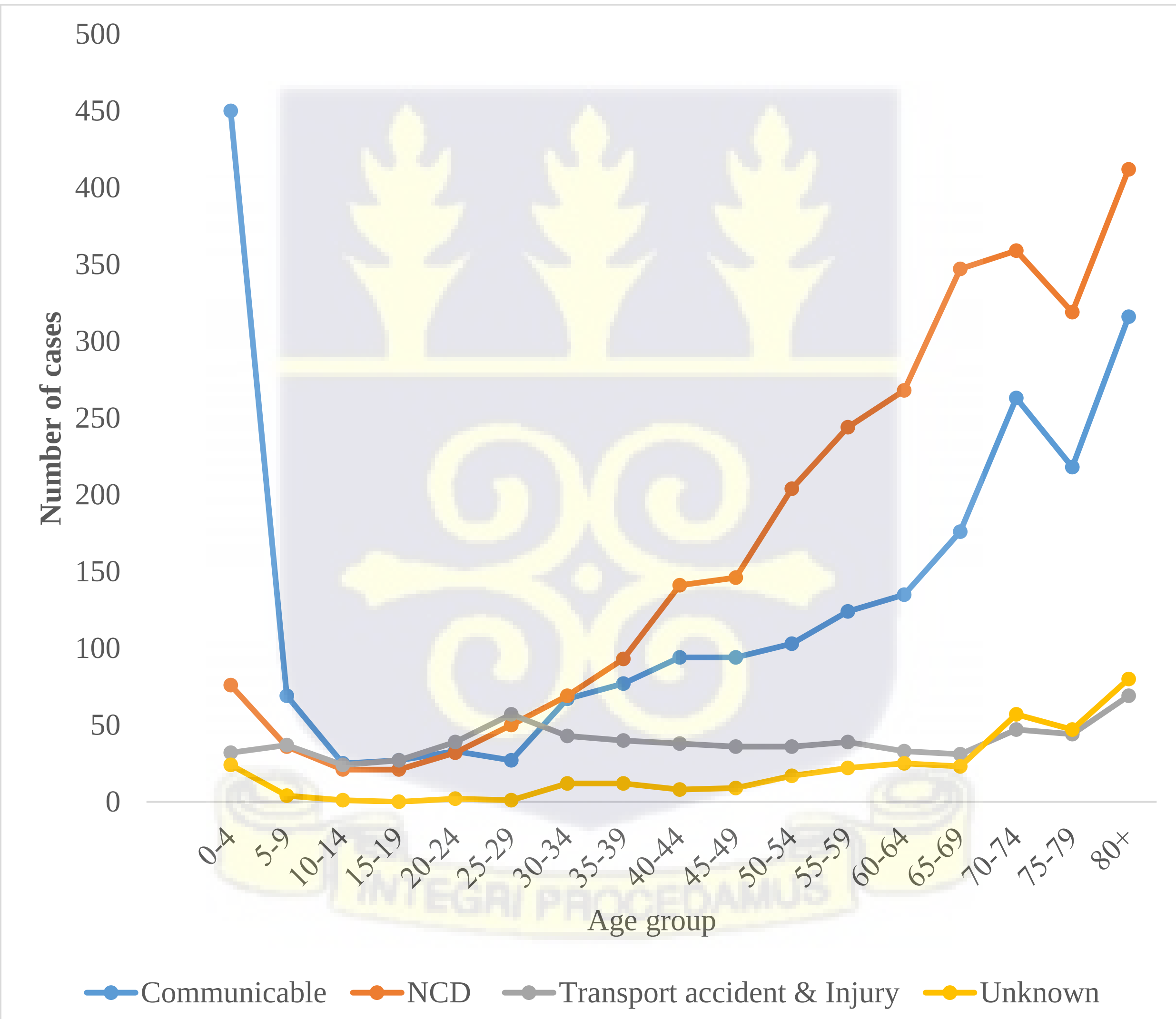
The study conducted a cross-tabulation of age, sex, educational attainment, religion, marital status, socio-economic status, place of death, occupation, season, and year of death with the dependent variable, cause of death. The results from the Pearson independent chi-square test showed that, except for the season of death, all the independent variables were significantly related to the cause of mortality. Figure 5.4 displays the results for the broad causes of mortality by the age category of deceased persons. The age pattern of mortality followed an inverted U-shaped pattern, similar to mortality trends in many developing countries.

The highest proportion (77.3 percent) of deaths attributable to communicable diseases was recorded among those aged 0-4 years. Those aged 5-9 years recorded the second-highest proportion (47.3 percent) of deaths due to communicable diseases, while the third highest was among those aged 80 years or older (36.0 percent). Conversely, the highest proportion (60.1 percent) of non-communicable disease deaths was recorded among the 65-69 age group, with the second highest among the 60-64 age group (58.1 percent). The 55-59 age category recorded the third-highest percentage of deaths due to non-communicable causes (56.9 percent).

Regarding external causes of death, the highest proportion (42.2 percent) of deaths occurred in the 25-29 age group, followed by the 20-24 age group (36.8 percent). The 15-19 age category recorded the third-highest percentage of deaths due to external causes (36.0 percent).

Most of the deaths labeled as undetermined or unknown occurred among those aged 80 years or older (9.1 percent), followed by the 70-74 age category, and the third highest percentage was reported among the 75-79 age category.

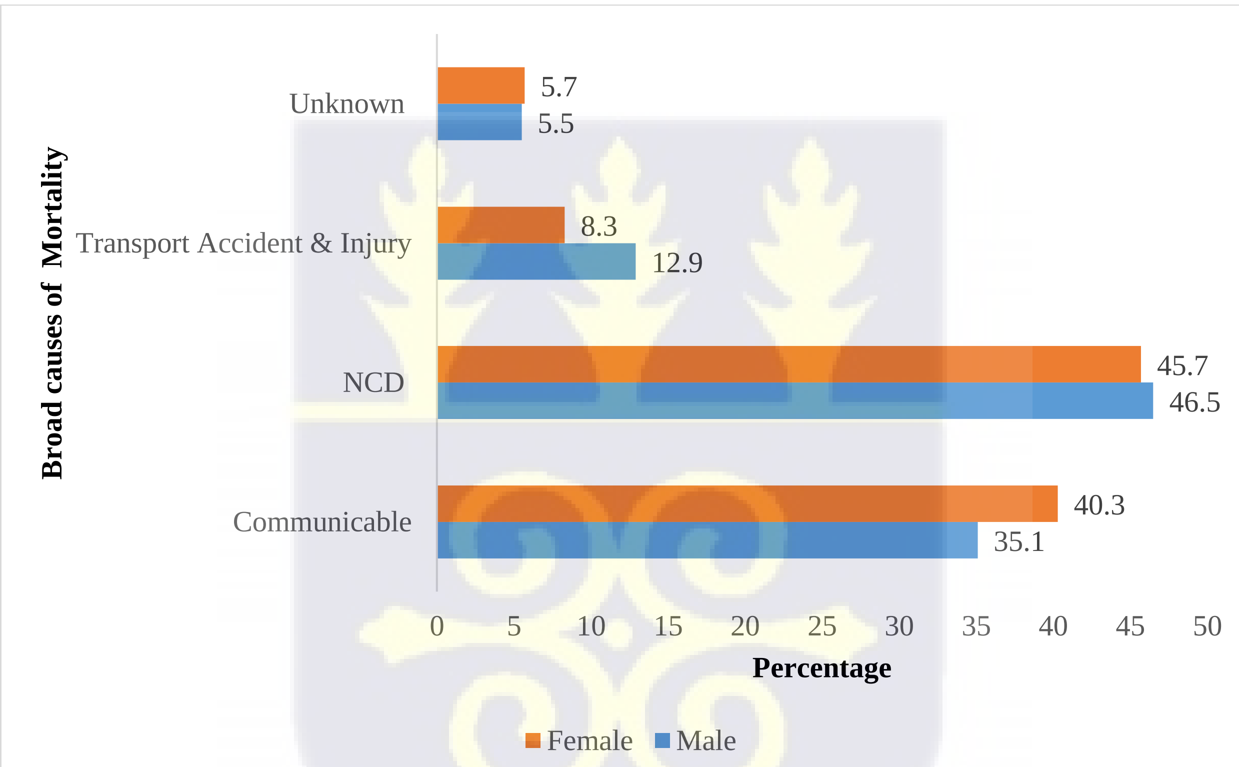
Figure 5.4:Age-Specific Mortality by Broad Causes



Source: Navrongo HDSS (2012-2018).

Across the sexes, there were marked differences in the risk of dying from various causes of death. The majority of deaths due to NCDs were recorded among men. Additionally, most deaths resulting from transport accidents and injuries were reported for men (12.1 percent). The proportion of mortality due to communicable diseases was higher among females (40.3 percent) than males (35.1 percent). The percentage of women who died from non-communicable causes was 46 percent (as shown in Figure 5.5).

Figure 5.5:Broad Causes of Mortality by Sex



Source: Navrongo HDSS (2012-2018).

The socio-demographic and background characteristics of the study participants, along with the prevalence of communicable and non-communicable diseases across the independent variables, are presented in Table 5.3. Regarding socio-economic status (SES) and causes of death, the results showed that the highest proportion of people who died from communicable diseases was reported among the least and less poor categories (38 percent), followed by the very poor (37.6 percent) and the poorest (35.7 percent) in that order. A similar pattern was observed for deaths associated with non-communicable causes and undetermined deaths. A slightly higher proportion (47.1 percent) of deaths attributable to non-communicable causes were recorded among deceased persons from poor households in the wealth quintile. Transport accident and injury deaths were slightly higher (21.0 percent) among deceased persons from the poorest households in the wealth quintile.

Marital status significantly influenced causes of mortality at the bivariate level. Among the deceased persons who were married, more than half (54.1 percent) died of NCD causes. One-quarter (25.1 percent) of the deceased persons who were unmarried died from transport accidents and injury-related causes. In terms of occupation, more than half (51.0 percent) of the deceased persons who were farmers died of NCD causes, while one-third (33.1 percent) died due to communicable causes. Similarly, of the deceased persons who were government or private sector employees, more than half (53.9 percent) died of NCD causes, while about 25 percent died of communicable causes. More than one-third (35.4 percent) of the deceased persons who were students died of NCD causes, while about 32 percent and 31 percent died due to communicable and external causes, respectively.

Regarding education, more than half (51.7 percent) of deceased persons' deaths were due to NCDs, while about one-third (33.8 percent) died from communicable causes. Of the deceased persons who had tertiary education, the majority (57.5 percent) died of NCD causes, while CDs and, transport accidents and injuries were responsible for 19.0 percent and 19.6 percent of the deaths, respectively. Regarding religion and cause of mortality, more than half (55.0 percent) of those who belonged to the Catholic religious denomination died due to NCD causes, while one-fifth (20.0 percent) died from communicable causes.

Regarding the place of death, it was found to be significantly related to the cause of mortality. Of the deaths that occurred at home, a higher proportion (48.5 percent) were due to non-communicable causes, while more than one-third (35.6 percent) were related to communicable causes. Overall, 65 percent of all deaths occurred at home, while 29 percent occurred in the hospital. The smallest proportion of deaths occurred either on the way to a facility or at other health facilities. A high proportion of the deaths that occurred either on the way to a health facility or at other health facilities were due to communicable causes of death (52.2 percent and 56.7 percent, respectively). It was observed that the majority of the deaths that occurred at other places were related to transport accidents and injuries.

Table 5.4: Socio-demographic, background characteristics and Causes of Mortality

Variable	Total (N)	Communicable (%)	Non-communicable (%)	External (%)	Unknown (%)	P-value
Age Group						<0.001
0-4	582	77.3	13.1	5.5	4.1	
5-9	146	47.3	24.7	25.3	2.7	
10-14	71	35.2	29.6	33.8	1.4	
15-19	75	36.0	28.0	36.0	0.0	
20-24	106	31.1	30.2	36.8	1.9	
25-29	135	20.0	37.0	42.2	1.9	
30-34	191	35.1	36.1	22.5	0.7	
35-39	222	34.7	41.9	18.0	5.4	
40-44	281	33.5	50.2	13.5	2.8	
45-49	285	33.0	51.2	12.6	3.2	
50-54	360	28.6	56.7	10.0	4.7	
55-59	429	28.9	56.9	9.1	5.1	
60-64	461	29.3	58.1	7.2	5.4	
65-69	577	30.5	60.1	5.4	4.0	

Variable	Total (N)	Communicable (%)	Non-communicable (%)	External (%)	Unknown (%)	P-value
70-74	726	36.2	49.4	6.5	7.9	
75-79	628	34.7	50.8	7.0	7.5	
80+	877	36.0	47.0	7.9	9.1	
Sex						<0.001
Male	3511	35.1	46.5	12.9	5.5	
Female	2641	40.3	45.7	8.3	5.7	
SES						0.002
Least Poor	1823	38.1	46.2	9.9	5.8	
Less Poor	1557	38.2	45.4	9.2	7.2.	
Poor	1453	35.7	47.1	11.9	5.2	
Poorest	176	35.8	38.1	21.0	5.1	
Very Poor	1097	37.6	45.5	11.2	5.7	
Marital Status						<0.001
Married	2308	29.1	54.1	11.7	5.0	
Unmarried	549	29.1	41.0	25.1	4.7	
Widowed	1964	36.3	49.5	6.9	7.3	
Divorced/Separated	570	38.4	47.7	8.2	5.6	
Occupation						<0.001
Farmer	3627	33.1	51.0	9.3	6.5	
Trader	298	38.9	40.3	16.8	4.0	
Government/Private employee	271	24.7	53.9	18.1	3.3	
Student	206	31.6	35.4	31.1	1.9	
Other	989	31.7	53.7	9.1	5.5	
Education						<0.001
No education	4192	33.8	51.7	8.1	6.4	
Primary	690	31.9	43.9	21.2	3.0	
Secondary	356	28.1	45.2	21.3	5.3	
Tertiary	153	19.0	57.5	19.6	3.9	
Religion						0.007
Catholic	20	55.0	20.0	15.0	10.0	
Traditional	234	31.2	52.1	10.7	6.0	
Other Christian	315	35.6	53.7	4.4	6.3	
Other	22	36.4	45.5	9.1	9.1	
Place of Death						<0.001
Home	4029	35.6	48.5	9.0	6.9	
Hospital	1786	40.7	45.4	11.5	2.4	
On the way to the facility	115	52.2	29.6	13.0	5.2	

Variable	Total (N)	Communicable (%)	Non-communicable (%)	External (%)	Unknown (%)	P-value
Other Health Facility	104	56.7	28.8	11.5	2.9	
Other	114	15.8	5.3	68.4	10.5	

Source: Navrongo HDSS (2012-2018).

Table 5.5 shows the distribution of causes of mortality by year and season. The results indicated that the year of death significantly influenced the causes of mortality. Consistently, non-communicable causes of death recorded the highest proportion of deaths, with the exception of the year 2018 when communicable diseases overtook non-communicable diseases (44.7 percent versus 35.7 percent). For instance, of the deaths that occurred in 2012, non-communicable mortality was more than half (55.7 percent), while communicable causes constituted 36.1 percent of the total. A similar trend was observed across the years.

In contrast, it was noted that transport accident and injury deaths were highest (17.7 percent) in 2016, while 2012 recorded the lowest proportion of transport accident and injury deaths (7.1 percent). The highest number of deaths classified as undetermined was reported in 2017 (10.4 percent).

The month of death was not statistically significant concerning the cause of death. However, more than one-third of the communicable causes of death occurred between October and December. Conversely, more non-communicable causes of death occurred in March (51.8 percent). External causes of death were more common in January (14.9 percent), followed by May (12.6 percent) and August and September (10.4 percent). Again, there was no relationship between the season of death and the cause of death at the bivariate level of analysis. It was, however, observed that the highest proportion of non-communicable causes of death occurred in the wet season (46.9 percent), while the proportion of communicable causes of death was higher in the dry season (38.6 percent).

Table 5.5: Season and Causes of Mortality

Variable	Total (N)	Communicable (%)	Non-communicable (%)	External (%)	Unknown (%)	P-value
Year of Death						<0.001
2012	1110	36.1	55.7	7.1	1.1	
2013	1112	36.2	54.8	8.5	0.5	
2014	682	40.8	43.1	12.2	4.0	
2015	947	37.6	42.2	10.5	9.7	
2016	769	31.9	42.3	17.7	8.2	
2017	904	36.9	40.7	11.9	10.4	
2018	628	44.7	35.7	11.6	8.0	
Month of Death						0.046
Jan	449	36.7	43.7	14.9	4.7	
Feb	483	37.1	46.6	11.6	4.8	
Mar	550	30.5	51.8	11.3	6.4	
Apr	523	35.2	45.9	11.9	7.1	
May	478	37.9	42.9	12.6	6.7	
Jun	470	36.0	47.0	11.5	5.5	
Jul	498	35.5	46.0	12.4	6.0	
Aug	530	36.2	47.9	10.4	5.5	
Sep	587	39.2	44.8	10.4	5.6	
Oct	575	43.1	46.3	6.3	4.3	
Nov	497	41.2	44.1	9.9	4.8	
Dec	512	39.1	45.9	9.4	5.7	
Season of Death						0.194
Wet	2517	35.6	46.9	11.7	5.8	
Dry	3635	38.6	45.6	10.4	5.5	

Source: Navrongo HDSS (2012-2018).

5.6 Discussion of Chapter Results

The chapter examined the broad and specific causes of mortality in the KNE and KNW districts from 2012 to 2018. It also discussed and presented the distribution of broad causes of mortality by background characteristics. Furthermore, the association between broad causes of death and socio-demographic background characteristics was examined at the bivariate level using the Pearson chi-square independent test. The analysis generally indicated that the causes of mortality were significantly associated with the individual's age, sex, wealth status, marital status, educational level, religion, year of death, and the place where the death occurred (as shown in Tables 5.2 and 5.3). The findings of the study confirmed the theoretical framework that suggested background characteristics significantly influenced causes of death.

The results showed that the major causes of mortality in the study area from 2012 to 2017 remained non-communicable diseases (NCDs), followed by communicable diseases (CDs), and transport accidents and injuries. However, in 2018, communicable diseases were the leading causes of mortality. This was consistent with the epidemiological transition theory, which explains the shift in the burden of diseases associated with changing population age structures. Generally, the major burden of disease to households in the study was NCDs, contributing to 46.0 percent of premature mortality. Communicable diseases, on the other hand, were responsible for 37.4 percent of the total disease burden of mortality in the study area. About 11 percent of the deaths were due to road traffic accidents and injuries, while almost six (5.6) percent of the deaths were attributed to unknown causes. The results corroborated the WHO estimates of the leading causes of death in Ghana, which reported stroke as the number one cause of death in the country in 2019, with 56.5 deaths per 100,000 population. Stroke represented a significant burden of NCDs, thus aligning with the results of the study. The study results were also similar to the WHO Africa report that estimated NCDs accounted for 43 percent of all-cause mortality in Ghana in 2022 (WHO Africa, 2022). Data from the World Health Statistics also suggested that NCDs have overtaken CDs in the global burden of diseases. A factsheet produced by WHO in 2023 documented that 77 percent of

NCD deaths were reported in low- and middle-income countries (LMICs). This was evident as most of the deaths recorded in the study area were attributable to NCDs. An earlier study in Ghana by de-Graft Aikins et al. (2010) showed that stroke, hypertension, diabetes, and cancers were the major typologies of NCDs that accounted for increases in hospital admissions and mortality in the country. Again, the study results were comparable to those reported by Labrique et al. (2013) in Bangladesh. The authors observed that 48 percent of deaths reported among reproductive-age women in the country were attributable to NCDs, while the rest of the deaths were related to maternal causes (22 percent), infection (17 percent), injury (9 percent), and others (4 percent).

Additionally, the data showed that external causes of mortality, such as transport accidents and injuries, self-harm, spirit child, assault, and others, were the third leading cause of premature mortality in the study area. In terms of specific causes of mortality, the results showed that cerebrovascular and cardiovascular diseases (13.0 percent), infectious and parasitic diseases (11.5 percent), transport accidents and injuries (9.6 percent), and intestinal infectious and diarrheal diseases (7.5 percent) were the leading specific causes of death in the study area. These results were similar to a previous study by Meles et al. (2023) in southern Ethiopia, where the authors found that intestinal infectious diseases were the second leading cause of mortality. Additionally, the results were comparable to Bawah et al. (2014) in their study on road traffic mortalities in northern Ghana, which found that 18 percent of the deaths reported in the Kassena-Nankana districts in 2010 were due to injuries. My study found road transport accidents and injuries to be the third leading specific cause of mortality, accounting for about 10 percent of the deaths reported in the study area for the period of 2012 to 2018. Similar to the present results, Owusu et al. (2021) reported in 2018 that the Upper East Region had the highest road traffic accident mortality in Ghana.

My study identified infectious and parasitic diseases, intestinal infectious diseases and diarrheal diseases, acute respiratory infections, malaria, tuberculosis, and HIV/AIDS as the six leading communicable causes of mortality in the study area. Malaria remained endemic in the study area and was identified as the seventh leading specific cause of mortality. These findings were similar to those obtained by Narh-Bana et al. (2012) in Tanzania, as well as those of Bawah & Binka (2007) and Owusu et al. (2021) in Ghana. In Tanzania, Narh-Bana et al. reported that HIV/AIDS was the major cause of adult mortality. In my study, it was observed that about 3 percent of the deaths were attributable to HIV/AIDS. In Ghana, Owusu et al. (2021) reported that HIV/AIDS was one of the top ten causes of death in the country in 2017. Also similar to the current study, the Bawah & Binka study documented malaria as the leading cause of mortality among the study participants.

The highest number of deaths recorded during the study period occurred among males rather than females. More than half (57.1 percent) of the deaths recorded were males, while females constituted 42.9 percent. The mortality differentials between males and females had already been reported in earlier studies (Awini et al., 2014; Goudge et al., 2009; Jacobsen et al., 2008; Obermeyer et al., 2010; Oti et al., 2014). For instance, Obermeyer et al.'s study, which covered 44 countries, also found higher mortality among men in Ghana than women. Awini et al. found similar results among adult deaths in southern Ghana. In their study on non-communicable disease mortality among adults in Nairobi, Oti et al. (2014) reported similar trends, finding that of the total number of deaths recorded in the Nairobi Urban Health and Demographic Surveillance System (NUHDSS) from 2003 to 2011, 62 percent were males, while 38 percent were females.

Studies (Crimmins et al., 2019; Jacobsen et al., 2008) attributed the sex mortality differential to biological, psychological, and social factors. The sex differences in mortality confirmed the gender mortality paradox, which suggests that men have higher mortality than women (Avdic et al., 2019; Lego et al., 2019). Similarly, in Nigeria, Olanrewaju et al. (2019) documented evidence suggesting that cultural and patriarchal norms create significant barriers to men's health, confirming the higher mortality among men in my study. Among Hispanic men, Valdez et al. (2018) provided similar sociocultural barriers that affect men's health. The authors pointed out that men often shy away from seeking treatment for ailments to protect their pride of self-control and self-reliance, fearing that seeking healthcare would be perceived as emasculating. In Ghana, evidence shows that male mortality is consistently higher than that of females across the administrative regions in the country (Ghana Statistical Service, 2010).

Regarding sex and broad causes of mortality, the data showed that the majority of deaths due to NCDs and external causes were recorded among men. Conversely, the proportion of mortality resulting from communicable diseases was higher for females (40.3 percent) than for males (35.1 percent). The sex differential in the causes of mortality had been documented by previous studies (Awini et al., 2014; Harris et al., 2006; Ministry of Health, 2012). For instance, according to a report by Ghana’s Ministry of Health, NCD mortality in the country in 2012 was higher among men (58 percent) than females. A study by Harris et al. (2006), published by the American Psychological Association, suggested that men engage in more risky behaviors than women. Therefore, it was not surprising that the results of my study indicated that men had higher mortality due to injury and accident-related causes than women.

The distribution of mortality by age depicted an inverted U-shape, reflecting the age pattern of mortality in many developing countries, where mortality peaks in childhood, declines in youthful age groups, and picks up again at older ages (Chisumpa et al., 2019). About 10 percent of the deaths occurred in infancy, while most deaths occurred after age 80 years. A similar pattern of mortality had been reported in previous studies (Anteneh et al., 2013; Koné et al., 2015).

A higher proportion of the deaths was among people who were married, had no education, belonged to the least poor households, were farmers, and were affiliated with the Christian religion. Most broad causes of death occurred among individuals with no education. This was similar to an earlier study (Dalstra et al., 2005), which reported a higher prevalence of most diseases among people belonging to the lower education category. With regard to the year of death, a slightly higher proportion of deaths was recorded in 2012 and 2013, and most (65.5 percent) of the deaths recorded during this period occurred at the homes of the deceased. This contrasts with findings in more developed settings, where less than one-fifth (18.5 percent) of deaths in England and Wales occurred at home (Barclay & Arthur, 2008).

However, the findings corroborated most works in Africa, which documented that dying at home was more prevalent in the region than at health facilities (Anteneh et al., 2013; Beng et al., 2009; Hansen et al., 2002). Similar to the current results, Anteneh et al. (2013) found the prevalence of dying at home in Ethiopia to be 71.3 percent. Similarly, high rates of deaths at home were reported in Mexico by Pivodic et al. (2015).

Of the deaths at home, my study observed that almost half were due to NCD-related causes, while more than one-third (35.6 percent) were associated with CDs, and about 9 percent were a result of external causes of death. The place of death can be used as a proxy to measure healthcare accessibility, as it can be influenced by many factors. Gomes & Higginson (2006) identified factors associated with death at home, including sociodemographic characteristics, patient’s preferred place of death, hospital bed availability, hospital admissions, social support, healthcare policy, and cultural factors. While my study could not pinpoint a specific reason for the high proportion of deaths at home, it is reasonable to attribute these deaths to a lack of access to healthcare facilities and other challenges associated with accessing healthcare in many developing settings, as documented by de-Graft Aikins, Addo, Offei, et al.(2012). Evidence suggests that most people in the Upper East Region, where the study was conducted, have difficulty accessing healthcare due to a limited number of specialists and few higher-level health facilities (Africa Renewal, 2017). Even where health facilities exist, they are not without challenges.

The data showed that close to thirty percent (29.1 percent) of the deaths occurred at the hospital. Two possible reasons could account for the lower proportion of deaths recorded at the hospital compared to those that occurred at home. On one hand, challenges in healthcare accessibility might have served as a barrier to many people in high-risk and emergency situations. On the other hand, better emergency care in hospitals may have prevented more deaths than would have occurred in the community. The results of my study supported Owusu et al. (2021), which found that the Upper East Region had the second-highest (30.4 percent) rate of institutional deaths at health facilities in 2018, after Greater Accra (30.8 percent). The results of my study contrasted with those of Barclay's study in England and Wales, which reported a high proportion (58.3 percent) of deaths at hospitals. In France, Gisquet et al (2016) documented the proportion of hospital deaths at 60 percent. As previously stated, several factors can determine the place of death. It should also be noted that there were significant differences in the conditions that resulted in death and where the death occurred. Tan et al. (2019) provided evidence supporting the link between the place of death and the conditions causing the death. It was observed that of the deaths occurring in hospitals, more than one-third (40.7 percent) were CD-related causes, and about 45 percent were NCD causes.

Most deaths that occurred on the way to the health facility (52.2 percent) and other health facilities besides hospitals (56.7 percent) were CD-related causes of mortality.

The results of my study were similar to those reported in an earlier study by Melaku et al.(2014), which found tuberculosis (15.9 percent), cerebrovascular diseases (7.3 percent), and accidental falls (3.9 percent) as major specific causes of adult mortality. Additionally, the authors found that NCDs (36.4 percent), CDs (34.9 percent), and external causes (12.3 percent), in that order, were the major causes of adult mortality in northern Ethiopia. Similarly, my study found NCDs as the leading cause of death, followed by CDs and external causes, including transport accidents and injuries, maternal causes, tetanus, and low birth weight, among others. Also, the present results were similar to those reported by Fantahun et al. (2008) in Ethiopia, except that they reported higher figures for communicable causes (53 percent). Similar to my study, Fantahun et al. found that non-communicable mortality constituted 47 percent of the deaths in their study, compared to 46.0 percent in the present study.

Again, these results were similar to those noted by Bayray et al. (2017). Bayray et al. reported that NCDs (44.1 percent), CDs (29.2 percent), and external causes (4.2 percent), in that order, were the major causes of mortality in Ethiopia. These findings confirmed the general assertion that NCDs have overtaken CDs in many developing settings where CDs used to be the leading causes of death.

However, the results in the current study were dissimilar to those found in rural Gambia by Jasseh et al. (2014). The authors found that communicable diseases were responsible for about half (49.9 percent) of the deaths recorded from 1998 to 2007, with the most common infections being acute respiratory infections (ARI) (13.7 percent), malaria (12.9 percent), and pulmonary tuberculosis (10.2 percent). The present results also differed from those reported by Koné et al. (2015) from the Taabo Demographic Surveillance System in Côte d'Ivoire. The authors noted that communicable diseases were the leading causes of mortality, accounting for 58.9 percent of the deaths, while the rest were attributable to NCDs (18.9 percent), trauma and injury (3.8 percent), and maternal and neonatal conditions (8.3 percent).

Again, in contrast to the present results, Awini et al. (2014) found CDs as the major cause of mortality among adults in Southern Ghana, followed by NCDs. Similarly, the findings of this study contrasted with those reported by Meles et al. (2023). Meles et al. reported that CDs were the major causes of adult mortality in Ethiopia, with a cumulative burden of 49 percent of all deaths.

From the analysis, it was observed that while the total burden of diseases in the study area declined over the years, the burden of NCDs had overtaken that of CDs during the period. The evidence suggested that households within the study area faced a double burden of NCDs and CDs, with other external causes contributing to premature mortality among the population. The evidence presented in this current study, where NCDs had overtaken CDs as causes of mortality, appeared somewhat different and unique in the African and many LMIC contexts, where CDs are still the leading causes of mortality (Jasseh et al., 2014; Koné et al., 2015; World Health Organization, 2020). The results of the present study highlighted two important health policy issues. First, it confirmed the "protracted polarized framework," which describes the double burden of diseases accompanying Ghana's demographic and epidemiological transitions (Agyei-Mensah & De-Graft Aikins, 2010). This is because the trends and prevalence of NCD and CD burdens in the study area suggested that both diseases had co-existed for a long time in Ghana. Additionally, the trends in NCDs indicated that these are no longer emerging diseases in many poor and developing settings but an alarming epidemic (Ndubuisi, 2021). Secondly, the results contrasted with binary notions that categorized diseases as affecting either the wealthy or the poor (Singh & Singh, 2008). Given the socioeconomic background of the setting where the study was conducted, it would be difficult to assert again that NCDs are diseases associated with the rich while communicable diseases are associated with the poor (Gwatkin et al., 1999). These findings suggested that more programmatic efforts are needed from the Disease Control Department of the Ghana Health Service while existing strategies and programs are strengthened to prevent and control NCDs in the study area, in particular, and the country in general.

In summary, households in the KNEM and KNW districts bore a double burden of NCDs and CDs, with other external causes contributing to premature mortality, as shown in this chapter. The task in the next chapter is to understand the factors associated with the broad causes of mortality. This is important for resource targeting to reduce the burden of diseases.

CHAPTER SIX

PROXIMATE DETERMINANTS OF MORTALITY

6.1 Introduction

The chapter examines factors associated with mortality in the KNEM and KNW districts using a multinomial logistic regression. Demographic variables, including age and marital status, as well as socio-economic and socio-cultural variables, such as educational attainment, household wealth status, and religion, are examined to understand their influence or association with the risk of dying from CDs, NCDs, and external causes, including road traffic accidents and injuries. The analysis was restricted to these causes because they are currently the major public health concerns in Ghana. Additionally, the WHO generally categorizes causes of mortality under these major areas. The likelihood ratio chi-square test was used to test the association between independent variables and causes of mortality. In measuring the relationships between independent variables and the cause of mortality, the chi-square statistic with an alpha of 0.05 significance level, or a 95% confidence interval, was used. The regression results are shown in Tables 6.1 and 6.2.

6.2 Sociodemographic Factors Associated with Causes of Death in the KNE and KNW

In a regression framework, the association between socio-demographic characteristics and causes of mortality was investigated. The assumption was that individual characteristics such as age, sex, marital status, educational attainment, occupation, and religion of affiliation directly influenced the risk of death from communicable, non-communicable, and external causes of mortality. In Chapter Five (bivariate results), these variables were found to be statistically significant with the causes of mortality in the study. Thus, in the first model, only these variables were included to understand their association with the causes of death. Table 6.1 presents the results of the multinomial logistic regression analysis.

The results showed that the overall model was a good fit. The Nagelkerke's R^2 value ($R^2 = 0.136$) suggested that the socio-demographic variables explained approximately 14 percent of the variations in the causes of mortality, with a log-likelihood of 317.49. Additionally, the overall model was statistically significant at the 95% confidence interval.

The results indicated that individuals aged 0 to 14 years were significantly less likely to die from non-communicable causes than communicable causes compared to those aged 75 years and above. For instance, people aged 0 to 14 years were 62 percent less likely to die from non-communicable causes than communicable causes compared to those aged 75 years and above ($p<0.05$). Although not statistically significant, those aged 15 to 44 years had an increased relative risk of dying from non-communicable causes than communicable causes by more than 17 percent compared to those who were 75 years or older.

However, when comparing people who died from external causes to those who died from communicable causes, a different pattern was observed. The results showed that the relative risk ratio (RRR) of dying from external causes rather than communicable causes was significantly higher for people aged 0 to 14 years compared to those aged 75 years and above. For instance, compared to those aged 75 years and above, those aged 0 to 14 years were 1.40 times as likely to die from external causes than communicable causes (RRR = 1.40; $p<0.05$).

Regarding sex, the results showed that males were 55 percent significantly less likely to have died from non-communicable causes than communicable causes compared to their female counterparts (RRR = 0.45; $p<0.05$). Although not statistically significant, a similar pattern was observed when comparing those who died from communicable causes to those who died from external causes.

Males had a lower relative risk of dying from external causes than communicable causes compared to females (RRR = 0.65; p<0.05).

Marital status was significantly related to the cause of death. Individuals who were in a marital union were significantly 0.76 times more likely to have died from non-communicable causes than communicable causes compared to those who were formerly married (RRR = 1.76; p<0.05). The same pattern was observed when comparing those who died from external causes to communicable causes. Those who were in a marital union were 0.89 times significantly more likely to have died from external causes than communicable causes compared to those who were formerly married (RRR = 1.89; p<0.05).

Being in trading was found to be statistically significant with the cause of death. It was observed that those who were traders were 59 percent significantly less likely to have died from non-communicable causes than communicable causes compared to those who were engaged in other forms of occupation (RRR = 0.41; p<0.05). Similarly, students were found to have a 90 percent decreased relative risk of dying from non-communicable causes than communicable causes compared to those in other occupations (RRR= 0.10; p<0.05). Comparatively, a closer but contrasting pattern was observed when examining the risk of death from external and communicable causes. It was observed that farmers were 24 percent significantly less likely to have died from external causes than communicable causes compared to those in other occupations (RRR = 0.76; p<0.05).

Compared to individuals with higher education, those with secondary education were 5.44 times significantly more likely to have died from non-communicable causes than communicable causes (RRR = 6.44; p<0.05). Similarly, those with secondary education were 63 percent significantly more likely to have died from external causes than communicable causes compared to those with higher education (RRR = 6.44; p<0.05).

Religion of affiliation was observed to affect the risk of dying from CDs and external causes. When comparing the risk of dying from external and communicable causes, individuals who belonged to the Christian religion were 55 percent significantly less likely to have died from external causes than communicable causes compared to those who belonged to the traditional religion (RRR = 0.45; p<0.05). Although not statistically significant, individuals who belonged to the Christian religion were 37 percent less likely to have died from non-communicable causes than communicable causes compared to those who belonged to the traditional religion (RRR = 0.63; p<0.05).

Table 6.1: Multinomial logistic regression of sociodemographic factors and causes of mortality

Determinant	**Non-communicable vs. Communicable**		**External vs. Communicable**	
	RRR (SE)	95% CI	RRR (SE)	95% CI
Age Group (ref:75+)				
0-14	0.38** (1.32)	[0.19-0.81]	1.40*** (0.53)	[0.49-3.98]
15-44	1.17 (0.22)	[0.76-1.81]	0.71 (0.42)	[0.31-1.61]
45-74	0.71 (0.32)	[0.21-1.15]	0.71 (0.42)	[0.31-1.61]
Sex (ref: female)				
Male	0.45*** (0.75)	[0.68-1.78]	0.65 (0.72)	[0.23-1.54]
Marital Status (ref: formerly in union)				
In Union	1.76*** (0.24)	[1.09-2.83]	1.89*** (0.38)	[0.89-3.99]
Never in Union	1.20 (0.42)	[1.10-2.13]	1.77 (0.02)	[1.70-1.77]

Determinant	Non-communicable vs. Communicable		External vs. Communicable	
Occupation (ref: Other)				
Farmer	0.76 (0.21)	[0.50-1.15]	0.76*** (0.37)	[0.37-1.55]
Trader	0.41*** (0.44)	[0.17-0.96]	0.89 (0.55)	[0.30-2.60]
Government/Private	1.31 (0.95)	[0.20-8.37]	0.87 (1.52)	[0.04-2.77]
Student	0.10*** (1.19)	[0.01-0.99]	0.54 (1.32)	[0.04-7.24]
Education (ref: higher)				
No education	1.32 (1.31)	[0.10-2.99]	0.59 (1.72)	[0.02-7.24]
Primary	1.28 (1.38)	[1.08-3.29]	0.58 (1.80)	[0.02-6.15]
Secondary	6.44*** (1.57)	[2.29-7.19]	1.63*** (1.96)	[0.04-4.10]
Religion (ref: Traditional)				
Christian	0.63 (0.22)	[0.41-0.96]	0.45* (0.35)	[0.23-0.91]

log likelihood = 317.49 **Pseudo R^2 = 0.136 Prob>chi2 = 0.000**

***p<0.05

RRR = Relative Risk Ratio SE = Standard Error

Source: Navrongo HDSS (2012-2018).

6.3 Determinants of mortality in the KNE and KNW

Similar to the observations in Section 6.2, this section modelled all the independent and intermediate variables from the conceptual framework to understand their association with the causes of death. Table 6.2 presents the results of the multinomial logistic regression analysis of factors associated with mortality causes. The Nagelkerke's R^2 value (R^2 = 0.189) suggested that the independent variables explained approximately 19 percent of the variations in the causes of mortality, with a log-likelihood of 786.660. Additionally, the overall model was a good fit and was statistically significant at the 95% confidence interval.

As in the first model in Section 6.2, the effect of age on mortality causes remained significant after including wealth status, year, place, and season of death in the model. Compared to individuals aged 75 years and above, those aged 15 to 44 years were 64 percent less likely to have died from non-communicable causes than communicable causes (RRR = 0.36; p =<0.05). Sex remained a significant factor; males were 1.23 times more likely to have died from non-communicable than communicable causes compared to females (RRR = 1.23; $p < 0.05$).

In terms of socioeconomic status, deceased persons from the least poor households were 38 percent more likely to have died from non-communicable than communicable causes compared to those from very poor households (RRR = 1.38; $p < 0.05$). A similar trend was observed for external causes, with individuals from the least poor households being 49 percent more likely to have died from external causes than communicable causes compared to those from very poor households (RRR = 1.49; $p < 0.05$). Marital status also showed a significant association; married individuals were 68 percent more likely to have died from non-communicable than communicable causes compared to those formerly married (RRR = 1.68; $p < 0.05$).

Although occupation was not statistically significant, government workers were 11 percent more likely to have died from non-communicable than communicable causes compared to other occupations (RRR = 1.11, SE = 0.99). Farmers were 32 percent less likely to have died from external than communicable causes compared to those in other occupations (RRR = 0.68; SE = 0.39).

Regarding education, those with secondary education were 5.04 times more likely to have died from non-communicable than communicable causes compared to those with higher education (RRR = 6.04; $p < 0.05$). Those with primary education were 4 percent less likely to die from non-communicable than communicable causes (RRR = 0.96, $p < 0.05$). The secondary education group was also 3.22 times more likely to have died from external causes compared to those with higher education (RRR = 3.22; $p < 0.05$). No significant relationship was found between having no education and the risk of dying from communicable, non-communicable, or external causes.

Religious affiliation remained a significant factor. Christians were 41 percent less likely to have died from non-communicable than communicable causes compared to those practicing traditional religion (RRR = 0.59; $p < 0.05$). Christians were also 55 percent less likely to have died from external causes than communicable causes (RRR = 0.45; $p < 0.05$). The year of death did not significantly affect the cause of death when comparing communicable and non-communicable causes. However, for external versus communicable causes, dying in 2015 (RRR = 0.26; $p < 0.05$) and 2017 (RRR = 0.15; $p < 0.05$) significantly reduced the risk of death from external causes.

Season of death was not a significant determinant, but place of death was. Deceased persons who died at home had a 47 percent reduced risk of dying from non-communicable compared to communicable causes (RRR = 0.53; $p < 0.05$), but dying at the hospital had no significant effect on this comparison. When comparing communicable and external causes, dying at home reduced the risk of external causes by 87 percent (RRR = 0.13; $p < 0.05$), and dying at the hospital reduced the risk by 83 percent compared to those who died elsewhere (RRR = 0.17; $p < 0.05$).

Table 6.2: Multinomial logistic regression of sociodemographic factors and causes of mortality

Determinant	**Non-communicable vs. Communicable**		**External vs. Communicable**	
	RRR (SE)	95% CI	RRR (SE)	95% CI

Determinant	Non-communicable vs. Communicable		External vs. Communicable	
Age Group (ref:75+)				
0-14	0.24 (0.23)	[0.17-0.76]	0.34 (0.23)	[0.20-0.76]
15-44	0.36*** (0.38)	[0.25-2.68]	1.18 (0.55)	[0.40-3.44]
45-74	1.07 (0.23)	[0.68-3.78]	0.61 (0.44)	[0.26-1.44]
Sex (ref: female)				
Male	1.23*** (0.75)	[0.68-1.78]	0.65 (0.72)	[0.23-1.54]
Socio Economic Status (ref: very poor)				
Least	1.38*** (0.20)	[0.79-3.72]	1.49*** (0.43)	[0.65-3.43]
Poor	1.40 (0.28)	[0.56-5.65]	1.81 (0.49)	[0.69-4.77]
Marital Status (ref: formerly in union)				
In Union	1.68*** (0.25)	[1.03-2.73]	1.79 (0.40)	[0.82-3.92]
Never in Union	1.56 (0.53)	[1.33-2.73]	2.16 (0.00)	[2.10-4.17]
Occupation (ref: Other)				
Farmer	0.76 (0.22)	[0.49-1.17]	0.68 (0.39)	[0.32-1.45]
Trader	0.43 (0.46)	[0.17-1.07]	0.64 (0.61)	[0.20-2.12]
Government/Private	1.11 (0.99)	[0.16-7.75]	1.09 (1.57)	[0.50-2.37]
Student	0.11 (1.21)	[0.01-1.14]	0.64 (1.28)	[0.05-2.17]
Education (ref: higher)				
No education	1.04 (1.39)	[0.07-15.65]	0.91 (1.87)	[0.02-3.05]
Primary	0.96*** (1.46)	[0.06-16.69]	0.95 (1.96)	[0.20-2.10]
Secondary	6.04*** (1.65)	[0.24-15.05]	3.22*** (2.13)	[0.05-4.17]
Religion (ref: Traditional)				
Christian	0.59*** (0.23)	[0.37-0.92]	0.45*** (0.37)	[0.22-0.94]
Year of Death (ref: 2018)				
2012	1.41 (0.40)	[0.64-3.09]	0.64 (0.59)	[0.20-2.02]

Determinant	Non-communicable vs. Communicable		External vs. Communicable	
2013	1.31 (0.41)	[0.59-2.89]	0.35 (0.68)	[0.09-1.33]
2014	0.79 (0.45)	[0.33-1.90]	0.61 (0.64)	[0.18-2.14]
2015	0.74 (0.39)	[0.34-1.59]	0.26*** (0.64)	[0.07-0.90]
2016	1.01 (0.42)	[0.44-2.32]	0.69 (0.63)	[0.20-2.36]
2017	0.70 (0.39)	[0.33-1.49]	0.15*** (0.67)	[0.41-0.56]
Season of Death (ref: Dry)				
Wet	1.13 (0.20)	[0.76-1.69]	1.19 (0.34)	[0.62-2.31]
Place of Death (ref: Other)				
Home	0.53*** (0.73)	[0.13-2.21]	0.13*** (0.79)	[0.03-0.62]
Hospital	0.29 (0.74)	[0.11-1.96]	0.17*** (0.80)	[0.04-0.84]

log likelihood = 882.49 **Pseudo R2 = 0.189 Prob>chi2 = 0.000**

p<0.05

RRR = Relative Risk Ratio SE = Standard Error

Source: Navrongo HDSS (2012-2018).

6.4 Discussion

The chapter examined the determinants of broad causes of mortality in the KNE and KNW districts from 2012 to 2018. The social-ecological theory of health determinants posited that morbidity and mortality among populations were influenced by individual, interpersonal, organizational, social, environmental, political, and economic factors (McLeroy et al., 1988). Against this background, the study adopted a two-step approach to understand the factors associated with the causes of mortality in the study area.

First, individual sociodemographic factors, including age, sex, marital status, occupation, education, and religion of affiliation, were modelled into a multinomial logistic regression model.

It was observed that all the variables were important determinants of causes of mortality, similar to the results obtained at the bivariate level of analysis. It was found that when compared to non-communicable and communicable causes, being aged 0 to 14 years, male, married, a trader, and having secondary education were significantly related to the causes of death. On the other hand, when external causes were compared with communicable causes, being aged 0 to 14 years, male, married, a farmer, having secondary education, and being affiliated with the Christian religion were significantly related to the causes of death. This indicated that there were significant variations in the broad causes of death by an individual's sociodemographic and household characteristics. This finding was consistent with the social-ecological theory of health determinants, which suggested that individual-level factors directly impacted health outcomes.

The second stage of the analysis involved adding economic, geographic, and seasonal factors into the multinomial logistic regression model, including household socioeconomic status, place of death, season of death, and year of death. The results showed that all the variables remained significant determinants of causes of mortality except occupation and season of death, which were consistently found not to be significant predictors at both the bivariate and multivariate levels of analysis.

The results were similar to previous works (Awini et al., 2014; Dalal et al., 2011; Lozano et al., 2012; Narh-Bana et al., 2012; Owusu et al., 2021; Tenkorang & Kuuire, 2015) conducted in different settings and contexts. In Tanzania, Narh-Bana et al. (2012) conducted a cause-specific analysis of adult mortality from 2003 to 2007 and found that age and socioeconomic status were significantly associated with causes of death. My study observed that while being 0 to 14 years old was significantly associated with non-communicable causes of death, such individuals had a 62 percent reduced risk of dying from non-communicable causes compared to communicable causes relative to those aged 75 years and above. The household socioeconomic status of deceased persons was also found to be associated with the cause of death. Deceased persons from the least poor socioeconomic households had a 38 percent increased risk of death from non-communicable causes compared to communicable causes relative to those from very poor households (RRR = 1.38; $p < 0.05$). A similar association between age and causes of mortality was found among young adult and middle-aged populations in Ethiopia (Fantahun et al., 2008). Low economic status may expose individuals to poor nutrition, sanitation, and environmental conditions, which are risk factors associated with communicable disease causes.

A study examining the determinants of non-communicable diseases among adult Ghanaians reported that age significantly influenced NCD prevalence, with older adults having an increased risk of these diseases (Boakye et al., 2023). My results were similar to the findings of that study. Additionally, my study observed a link between household economic or wealth status and the cause of death. A similar linkage was observed in more developed settings (Saydah et al., 2013; Soloway, 2017). Soloway (2017) found higher mortality among people with low economic or wealth status compared to those with high economic or wealth status, with hazard ratios of 1.42 for men and 1.34 for women. A similar pattern was observed in my study, where individuals from the least household economic or wealth status were 49 percent more likely to have died from external causes than communicable causes. Economic status often serves as insurance, offering protection when accessing healthcare. Healthcare costs could also be prohibitively expensive for those with low household economic status, potentially explaining the results observed in these studies and mine. The effect of household economic or wealth status on the cause of mortality, particularly for NCD and CD risk, could have significant implications for public health interventions targeting the poor.

The results of my study indicated that sex was an important determinant of the cause of death. It was observed that, in the absence of economic, geographic, and seasonal factors, males had a 55 percent reduced risk of death from non-communicable causes compared to communicable causes (RRR = 0.45; $p < 0.05$). However, the proportion of males who died of NCDs was higher than that of females, highlighting the need for public health interventions targeting the male population to reduce NCDs. This finding was consistent with Awini et al.'s (2014) study in Ghana, which reported a higher risk of dying from NCDs for males than females. However, the direction of cause-specific mortality in the present analysis was altered when economic, geographic, and seasonal factors were included in the model, with males showing a 23 percent increased risk of death from non-communicable causes. The higher mortality rate of women from communicable diseases compared to men can be attributed to a combination of biological (immune system differences), social (cultural practices), economic (poverty), and healthcare-related factors (access and quality care).. These results were consistent with Boakye et al. (2023) in Ghana, although they found that females had a 1.32 times higher risk of death from NCDs. My findings also contrasted with an earlier study in Ethiopia (Fantahun et al., 2008), which did not find any significant relationship between cause-specific mortality and sex.

Additionally, the data indicated that marital status influenced the cause of death. Compared to deceased persons who were formerly married, those who were married had an increased risk of dying from NCDs than CDs. Although not statistically significant, married individuals were also at a higher risk of dying from CDs than external causes relative to those who were formerly married. This finding contrasted with Kaplan & Kronick's (2006) study in the United States, which reported that married individuals were at lower risk of dying from communicable and external causes of death. However, my study did not establish any link between marital status and cause of death when comparing external causes with CD causes.

The results also showed that being a government worker was associated with the cause of death. The effect of occupation on cause-specific mortality, particularly NCD risk, could have important implications for public health interventions targeting workplaces. Workplace health screenings are often used as mechanisms for screening and treating individuals, and identifying high-risk occupations may help refocus health providers on promoting positive behaviors to reduce risk. Additionally, implementing award packages and incentives for employees to achieve specific health goals could enhance workplace interventions to reduce the CD and NCD burden.

The findings of my study differed from those reported in previous studies (Karim et al., 2015; Kootbodien et al., 2018; Paglione et al., 2020). In South Africa, Kootbodien et al. (2018) found a relationship between occupation and the risk of tuberculosis mortality among agricultural workers in South Africa. In contrast, my results showed that farmers had a reduced risk of dying from external causes compared to communicable causes relative to other occupations. The link between job type and mortality risk has been established in various contexts (Paglione et al., 2020), highlighting how different jobs pose varying exposure risks.

Moreover, my study suggested that educational level significantly predicted the cause of death, although the direction of the relationship was not straightforward. Having secondary education consistently predicted the cause of mortality. Compared to those with higher education, individuals with secondary education had a higher risk of death from NCDs than CDs (RRR = 6.04, $p < 0.05$), as well as a higher risk of death from external causes compared to CD causes. These findings align with existing literature that positions education as a key determinant of health outcomes (Beltrán-sánchez & Andrade, 2016; Dalstra et al., 2005; Sommer et al., 2015; WHO, 2020a). However, different levels of education present varied risks associated with dying from CD, NCD, or external causes. My results also aligned with findings from Murray et al. (2003), which reported an association between education level and disease risk, particularly cardiovascular diseases. Additionally, similar patterns were observed in Brazil, where adults with no education had higher levels of diabetes, hypertension, and heart disease compared to those with higher education (Beltrán-sánchez & Andrade, 2016).). However, my study did not find an association between communicable, NCD, and external causes of death among people without formal education.

Many studies have documented the association between religion and health outcomes (Karim et al., 2015; Lloyd-Sherlock et al., 2017; Minicuci et al., 2014). My findings were consistent with these studies, showing that deceased persons affiliated with the Christian religion were 41 percent less likely to have died from NCDs compared to CDs relative to those affiliated with traditional religion (RRR = 0.59; $p < 0.05$). This could partly be due to religion influencing health-seeking behavior and treatment preferences.

In Ghana, Badasu et al. (2018) showed how non-communicable diseases among children in the country were perceived based on belief systems. The notion that NCDs in children were caused by enemies, as observed by the authors, had serious implications for the NCD burden in the country. Similar to the present results, Karim et al. (2015) found a significant association between religious affiliation and the risk of chronic disease conditions in Ghana. The authors observed that individuals who belonged to the Christian religion were more likely to report having lung disease compared to those affiliated with other religions. Generally, religion provides some benefits to individuals, including defining norms of behaviour, providing social support, health practices, and psychosocial resources. These factors acted in various ways to shape and improve health status and reduce the risk of mortality. In Mexico, an earlier study showed that religious participation reduced the risk of mortality for all causes of death (Hill et al., 2020).

The results of my study contrasted with those reported in an earlier study in the United States (Idler et al., 2017). In that study, the authors found that religious affiliation had no statistical significance with the risk of mortality. My study results underscored the need for stakeholders in health to explore churches, schools, and other venues as potential avenues for health intervention programs, given the evidence that religious affiliation is an important social determinant of health outcomes. Evidence from other studies showed that members of religions that prescribed and proscribed health behaviors and practices strongly influenced health outcomes (George et al., 2002). Therefore, recognizing that religious affiliation influences the risk of disease infection is relevant for public health interventions aimed at reducing the disease burden in Ghana.

In addition to the above factors, substantial literature has found an association between the season of the year and the risk of mortality (Burkart et al., 2011; Feinstein, 2002; Kynast-wolf et al., 2005). However, the findings from my study lacked evidence to support the seasonality-mortality hypothesis. Consistently, the season of death was not found to be an important determinant of cause of death at both the bivariate and multivariate levels of analysis. Though not significant, when comparing deceased persons who died in the dry season to those who died in the wet season, the latter were at a higher risk of dying from non-communicable causes than communicable causes. This finding closely resembled those of previous studies (Burkart et al., 2011; Feinstein, 2002; Rau et al., 2017). The results were also similar but slightly contrasted with an earlier study in Burkina Faso (Kynast-Wolf et al., 2005). Similar to the findings of my study, Kynast-Wolf et al. found that mortality among children was higher towards the end of the rainy season, which the authors attributed to probable malaria infections, predominantly high during the rainy season.

Additionally, similar to my study, the authors found overall mortality to be higher in the dry season (November to May), which they attributed to possible infections from meningitis, more prevalent during the dry season. However, my study reported higher relative risk ratios for dying during the wet season.

Finally, the data showed that deaths occurring at home were significantly associated with the cause of death. Compared to deceased persons who died in other locations, those who died at home (RRR = 0.53; $p < 0.05$) had a 47 percent reduced relative risk of dying from non-communicable causes than communicable causes. The association between the place of death and the conditions causing death has already been established in previous studies (Gomes & Higginson, 2006; Tan et al., 2019). For instance, Gomes & Higginson (2006) documented from their study among terminally ill cancer patients that the location of death involved a network of factors, including patients' low functional status, preference, home care, living with relatives, and extended family support. While these factors may not entirely apply to my study, they may partly explain the results. Transportation network challenges, limited access to health facilities, and financial issues could also be factors associated with place of death and risk of mortality. The results from my study highlighted the need to understand the factors influencing where deaths occur. Tan et al (2019) showed that dying at home was associated with being female and aged 85 years and older. Additionally, the authors noted that diabetes mellitus and cerebrovascular disease mortality were associated with a higher likelihood of home death compared to malignant neoplasm mortality. My study results indicated that non-communicable causes of death were less likely to occur at home, confirming previous findings. However, the results showed that a high proportion of NCD mortalities occurred at home, suggesting that efforts to reduce the health burden of diseases must extend beyond hospital settings to include home care, particularly for the elderly and chronically ill patients, to improve their health status. The next chapter presents the impact of communicable and non-communicable diseases on longevity in the study area.

CHAPTER SEVEN

IMPACT OF COMMUNICABLE AND NON-COMMUNICABLE DISEASES ON LONGEVITY

7.1 Introduction

This chapter presents the impact of CDs and NCDs on longevity. To understand the different burdens that CDs and NCDs posed to households living in the study area, multiple and single decrement life table techniques are employed. The chapter, presents multiple and associated single decrement life tables for the general population. Additionally, multiple and associated single decrement life tables are presented for the broad causes of mortality in the KNEM and the KNW. The chapter also presents the age-specific causes of mortality. Separate life tables for males and females in the study districts are presented in Appendix I and II, respectively.

7.2 Life Expectancy

Table 7.1 presents the overall life table showing the general mortality of the KNEM and KNW districts in 2016. In 2016, a total of 769 deaths were recorded. According to the results, the estimated overall crude mortality rate for the study area was 4.7 deaths per 1,000. The child mortality rate (${}_4M_1$) in the study area during the period was estimated at 0.0040 per 1,000 child deaths. The probability of dying between ages 0–4 for those who survived to celebrate their first year of birth was 0.0158. The results showed an overall life expectancy of 67.8 years for the KNEM and KNW districts in 2016. The higher life expectancy in the Kassena Nankana East and West Districts compared to the national average in Ghana as of 2016 (63.5 years) (WHO, 2018), could be attributed to several factors unique to the area.

First, the Kassena Nankana Districts have been the focus of several health interventions, particularly through the Navrongo Health Research Centre (NHRC). These interventions, such as immunization programs, malaria control initiatives, maternal and child health services, and community-based health planning and services (CHPS), have significantly reduced mortality rates, especially among infants and young children, contributing to improved life expectancy.

Additionally, compared to urban areas in Ghana, Kassena Nankana East and West Districts are largely rural and may have lower exposure to urban health risks such as pollution, traffic accidents, and lifestyle diseases (e.g., hypertension, diabetes). The rural setting may reduce exposure to these risk factors, contributing to better overall health and longevity. Also, the presence of health facilities and outreach services such as CHPS compounds has improved access to primary healthcare, leading to early detection and treatment of diseases. This has reduced preventable deaths and improved health outcomes, which positively impacts life expectancy.

Moreover, the local diet, which is often rich in traditional and less processed foods, might contribute to better health outcomes. Additionally, active lifestyles due to agrarian practices could result in lower rates of lifestyle-related illnesses, which are common causes of death in other parts of the country. There has also been a consistent focus on disease prevention in the Kassena Nankana Districts, with high immunization coverage rates and active disease surveillance. This has contributed to lower incidences of communicable diseases, a key factor in improving life expectancy. Finally, the influence of ongoing research by NHRC has ensured that health policies and interventions are evidence-based and tailored to the community's needs, enhancing their effectiveness in reducing mortality rates and improving life expectancy. These combined factors create a more favourable health environment in Kassena Nankana East and West Districts, and that could be responsible for the higher life expectancy compared to the national average in Ghana in 2016.

Table 7.1 Overall life table showing general mortality

Age group	ALL Deaths	Pop	$_nm_x$	$_nq_x$	$_nP_x$	$_nd_x$	l_x	$_nL_x$	T_x	e_x
0-4	78	19,573	0.0040	0.0158	0.9842	1577	100000	395742	6782182	67.82
5-9	29	19,353	0.0015	0.0075	0.9925	735	98423	487935	6386440	64.89
10-14	8	19,283	0.0004	0.0021	0.9979	202	97688	486745	5898505	60.38
15-19	10	17,779	0.0006	0.0028	0.9972	274	97486	484925	5411760	55.51
20-24	14	14,948	0.0009	0.0047	0.9953	454	97212	481221	4926835	50.68
25-29	25	11,710	0.0021	0.0106	0.9894	1027	96758	475824	4445614	45.95
30-34	23	9,674	0.0024	0.0118	0.9882	1131	95731	469712	3969790	41.47
35-39	22	7,866	0.0028	0.0139	0.9861	1314	94599	460630	3500078	37.00
40-44	33	6,555	0.0050	0.0249	0.9751	2319	93286	448906	3039448	32.58
45-49	36	6,817	0.0053	0.0261	0.9739	2371	90967	435283	2590541	28.48
50-54	49	6,928	0.0071	0.0347	0.9653	3079	88596	417933	2155258	24.33
55-59	55	5,953	0.0092	0.0452	0.9548	3861	85517	398372	1737325	20.32
60-64	50	5,026	0.0099	0.0485	0.9515	3963	81656	372721	1338953	16.40
65-69	70	4,143	0.0169	0.0811	0.9189	6297	77693	332887	966232	12.44
70-74	97	3,351	0.0289	0.1350	0.8650	9636	71395	277918	633345	8.87
75-79	78	1,755	0.0444	0.2000	0.8000	12352	61759	123519	355428	5.76
80+	92	1,651	0.0557	1.0000	0.0000	49408	49408	231909	231909	4.69
Total	769	162,365	0.0047	-	-	-	-	-	-	-

Source: Navrongo HDSS (2012-2018).

7.3 Impact of Communicable Causes of Death on Longevity

Table 7.2 shows the multiple decrement life table for the population in the study districts. The results indicated that the crude mortality rate due to communicable diseases was about 1.4 deaths per 1,000. Assuming a cohort of 100,000 newborns in 2016 in the study area, it was estimated that 18,171 of them would eventually die from communicable disease-related causes by the time they reached age 80 and above. In other words, about 18.2 percent of that cohort would eventually die from communicable causes by age 80.

Table 7.2 A multiple decrement life table for the KNE & KNW, 2016

Age group	ALL Deaths	Pop	CD Deaths	$_nm_x$	$_nq_x$	$_np_x$	$_nd_x$	l_x	$_nL_x$	T_x	e_x	$_nq_x^{CD}$	$_nd_x^{CD}$	l_x^{CD}	$_nM_x^{CD}$
0-4	78	19,573	55	0.0040	0.0158	0.9842	1577	100000	395742	6782182	67.82	0.0028	280	18171	0.0028
5-9	29	19,353	12	0.0015	0.0075	0.9925	735	98423	487935	6386440	64.89	0.0025	244	17890	0.0006
10-14	8	19,283	4	0.0004	0.0021	0.9979	202	97688	486745	5898505	60.38	0.0010	101	17646	0.0002
15-19	10	17,779	2	0.0006	0.0028	0.9972	274	97486	484925	5411760	55.51	0.0006	55	17545	0.0001
20-24	14	14,948	2	0.0009	0.0047	0.9953	454	97212	481221	4926835	50.68	0.0007	65	17490	0.0001
25-29	25	11,710	3	0.0021	0.0106	0.9894	1027	96758	475824	4445614	45.95	0.0013	124	17425	0.0003
30-34	23	9,674	9	0.0024	0.0118	0.9882	1131	95731	469712	3969790	41.47	0.0046	444	17301	0.0009
35-39	22	7,866	6	0.0028	0.0139	0.9861	1314	94599	460630	3500078	37.00	0.0038	360	16857	0.0008
40-44	33	6,555	9	0.0050	0.0249	0.9751	2319	93286	448906	3039448	32.58	0.0068	638	16497	0.0014
45-49	36	6,817	11	0.0053	0.0261	0.9739	2371	90967	435283	2590541	28.48	0.0080	731	15859	0.0016
50-54	49	6,928	14	0.0071	0.0347	0.9653	3079	88596	417933	2155258	24.33	0.0101	891	15128	0.0020
55-59	55	5,953	12	0.0092	0.0452	0.9548	3861	85517	398372	1737325	20.32	0.0100	858	14237	0.0020
60-64	50	5,026	9	0.0099	0.0485	0.9515	3963	81656	372721	1338953	16.40	0.0089	728	13380	0.0018
65-69	70	4,143	16	0.0169	0.0811	0.9189	6297	77693	332887	966232	12.44	0.0191	1486	12652	0.0039
70-74	97	3,351	30	0.0289	0.1350	0.8650	9636	71395	277918	633345	8.87	0.0438	3126	11166	0.0090
75-79	78	1,755	27	0.0444	0.2000	0.8000	12352	61759	123519	355428	5.76	0.0741	4575	8040	0.0154
80+	92	1,651	24	0.0557	1.0000	0.0000	49408	49408	231909	231909	4.69	0.0701	3465	3465	0.0145
Total	769	162,365	245	0.0047	-	-	-	-	-	-	-	-	18171	-	-

Source: Navrongo HDSS (2012-2018).

CD = Communicable causes of death

$_{Pop}$ = Population.

$_nm_x$ = Mortality rate for people in age group x to x + n.

$_nq_x$ = Probability of dying between ages x and x + n.

$_np_x$ = Probability of surviving between ages x and x + n.

l_x = Number surviving at each age.

${}_nd_x$ = Number of deaths between ages x and x + n.

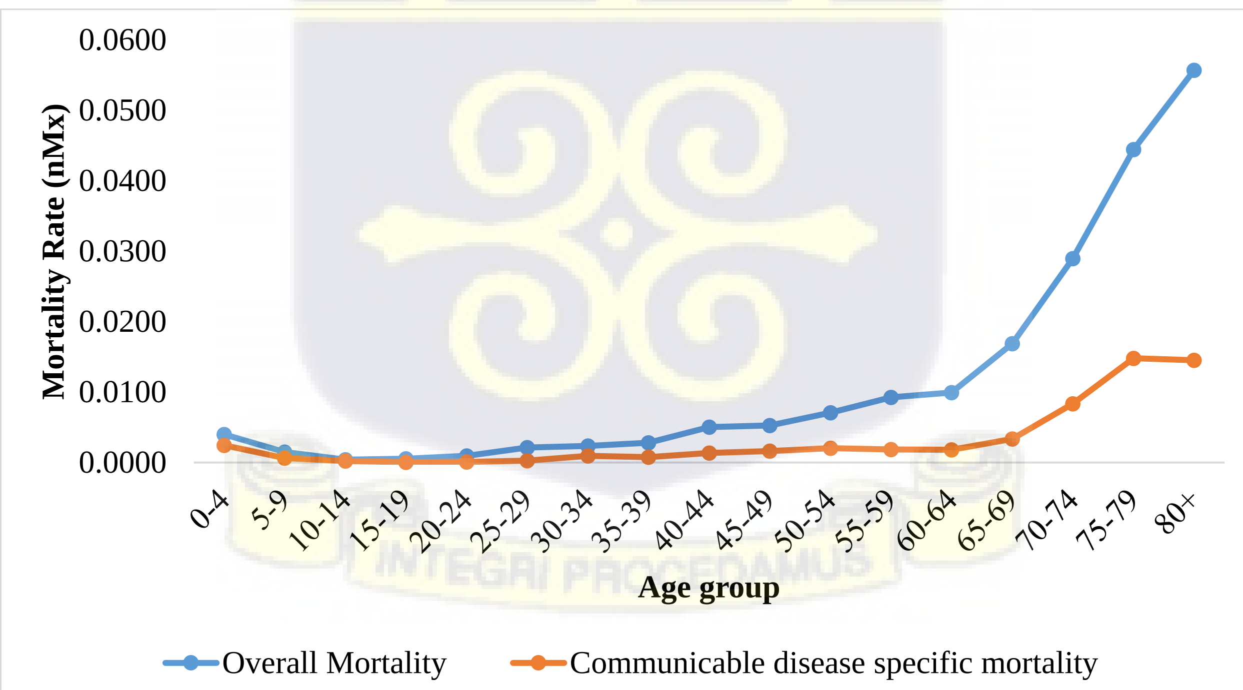
${}_nL_x$ = Person-years lived between ages x and x + n.

T_x = Person-years lived beyond age x.

e_x = Life expectancy at age x

Figure 7.1 presents the age patterns of mortality for overall causes and communicable causes of death. The results showed that communicable causes of mortality tended to mimic the overall mortality pattern. Generally, mortality was higher at younger and older ages, a characteristic seen in many developing countries where poor environmental conditions and infections tend to increase mortality in these age groups. It was observed that at early ages between 0-4, both all-cause mortality and communicable disease mortality were high but declined steadily after ages 5-9 years. This trend remained stable until after ages 20-24 years when all-cause mortality began to diverge from the communicable disease mortality curve. Both mortality curves peaked after ages 60-64 years; however, the all-cause mortality curve continued to shift away from the communicable disease mortality curve. This implied that causes other than communicable diseases also contributed significantly to the burden of mortality in the study area during the period.

Figure 7.1 Age-specific cause mortality pattern, KNE & KNW, 2016



Source: Navrongo HDSS (2012-2018).

After understanding the age-specific mortality patterns by communicable and overall mortality, the next goal was to estimate the impact of communicable causes of death. Cause-deleted life tables, also known as cause-elimination life tables, are demographic techniques often used to estimate the impact of eliminating a specific cause of death on life expectancy. This method provided an understanding of the contribution that a particular cause of death made to the overall mortality in the study area. Table 7.3 presented the potential gains in life expectancy for KNEM and KNW if epidemics of infectious diseases such as tuberculosis, malaria, hepatitis, and other infection-related diseases were reduced to non-public health significance or eliminated from the area. The results showed that if communicable diseases were eliminated in this population, life expectancy would have increased by 5.2 years, from 67.8 to 73.0 years.

Table 7.3 Associated single-decrement life table for causes of death other than infectious causes of death

Age group	l_x	$_nP_x$	R^{-CD}	P_{-}^{CD}	l_x^{-CD}	$_nq_{x-}^{CD}$	$_nd_x^{-CD}$	$_nq_x / _nq_x^{-CD}$	$_nm_x^{-CD}$	$_nL_x^{-CD}$	T_x^{-CD}	e_x^{-CD}
0-4	100000	0.9842	0.2949	0.9870	100000	0.0130	1297	1.184	0.0012	397407	7303099	73.0
5-9	98423	0.9925	0.5862	0.9950	98703	0.0050	492	1.496	0.0009	492286	6905693	70.0
10-14	97688	0.9979	0.5000	0.9990	98211	0.0010	102	2.001	0.0002	490801	6413407	65.3
15-19	97486	0.9972	0.8000	0.9978	98109	0.0022	220	1.111	0.0005	489996	5922606	60.4
20-24	97212	0.9953	0.8571	0.9960	97889	0.0040	392	1.077	0.0010	488465	5432610	55.5
25-29	96758	0.9894	0.8800	0.9907	97497	0.0093	910	1.137	0.0023	485209	4944145	50.7
30-34	95731	0.9882	0.6087	0.9928	96587	0.0072	693	1.647	0.0018	481201	4458936	46.2
35-39	94599	0.9861	0.7273	0.9899	95894	0.0101	967	1.378	0.0024	477051	3977735	41.5
40-44	93286	0.9751	0.7273	0.9820	94927	0.0180	1710	1.380	0.0035	470359	3500684	36.9
45-49	90967	0.9739	0.6944	0.9820	93217	0.0180	1680	1.446	0.0036	461882	3030325	32.5
50-54	88596	0.9653	0.7143	0.9753	91536	0.0247	2261	1.407	0.0059	452030	2568443	28.1
55-59	85517	0.9548	0.7818	0.9649	89276	0.0351	3136	1.256	0.0086	438539	2116413	23.7
60-64	81656	0.9515	0.8200	0.9604	86140	0.0396	3413	1.225	0.0099	422168	1677874	19.5
65-69	77693	0.9189	0.7714	0.9381	82727	0.0619	5123	1.261	0.0161	400827	1255706	15.2
70-74	71395	0.8650	0.6907	0.9088	77604	0.0912	7076	1.435	0.0382	370328	854879	11.0
75-79	61759	0.8000	0.6538	0.8741	70528	0.1259	8881	1.556	0.0309	330435	484551	6.9
80+	49408	0.0000	0.7391	0.0701	61646	0.9299	57323	1.000	0.0004	154116	154116	2.5

R^{-CD} = the proportion of death due to all causes other than communicable causes.

${}_{n}m_{x}$ = Mortality rate for people in age group x to x + n.

${}_{n}q_{x}$ = Probability of dying between ages x and x + n.

${}_{n}p_{x}$ = Probability of surviving between ages x and x + n.

l_{x} = Number surviving at each age.

${}_{n}d_{x}$ = Number of deaths between ages x and x + n.

${}_{n}L_{x}$ = Person-years lived between ages x and x + n.

T_{x} = Person-years lived beyond age x.

e_{x} = Life expectancy at age x.

Figure 7.2 shows the comparison of estimated life expectancy for various age groups for all-cause mortality and without communicable causes for the Kassena-Nankana East and West Districts, Ghana. The life expectancy for the combined causes of mortality was compared with the corresponding life expectancy after isolating deaths related to communicable causes. The results showed higher gains in life expectancy among the younger ages when communicable diseases were eliminated, compared to their counterparts in the older ages. This was likely not coincidental. Generally, averting infectious diseases increases the probability of surviving through the young ages, where infections contribute significantly to childhood mortality, particularly in low-income settings.

Figure 7.2 Estimated life expectancy for various age groups for all-cause mortality and without communicable disease for the Kassena-Nankana East and West District, Ghana

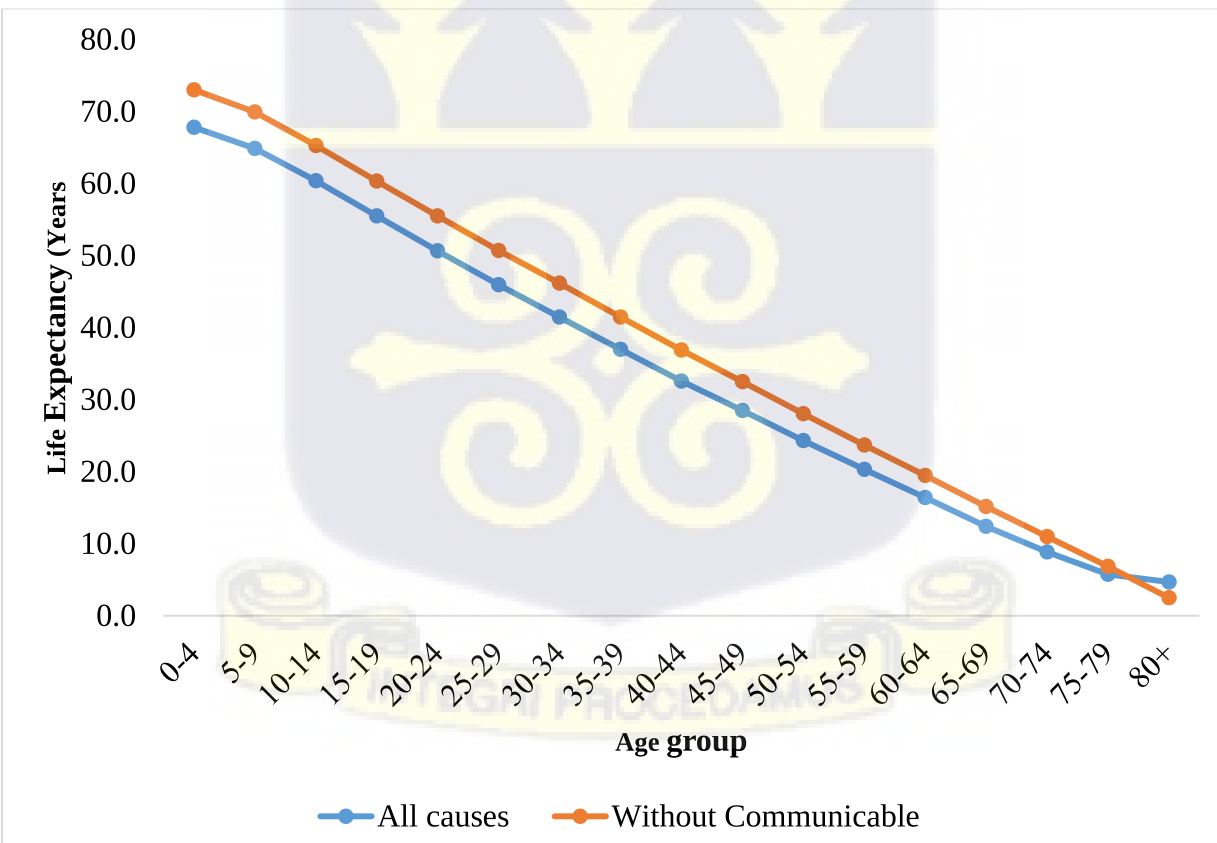
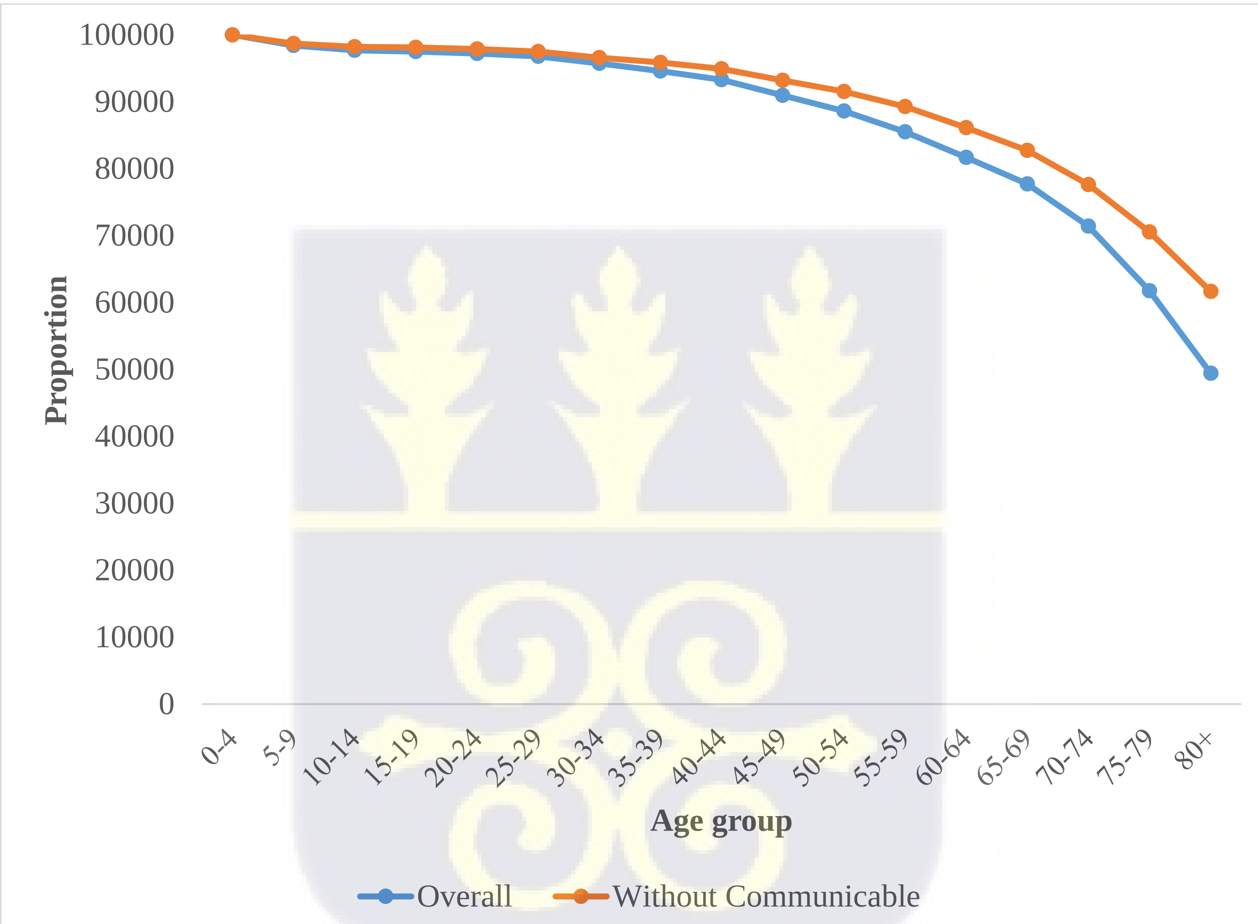


Figure 7.3 shows the number of individuals surviving to each age (l_x) for both all-cause mortality and without communicable diseases in the Kassena-Nankana East and West Districts, Ghana. The results indicated that if communicable diseases were eliminated as causes of death due to a major intervention, survival would have increased at almost every age (see also Table 7.3).

Figure 7.3 Estimated proportion of individuals surviving to each age with and without communicable diseases



Source: Navrongo HDSS (2012-2018).

7.4 Impact of non-communicable causes of death on longevity

As observed in Chapter Five, about forty-six percent of the deaths recorded in the KNE and KNW between 2012-2018 were attributable to non-communicable causes. It was therefore necessary to understand how many years would be added to life expectancy in the absence of NCDs in the study area. In 2016, out of the 769 deaths recorded, about forty-two percent were attributable to NCD causes.

Table 7.4 presents the multiple decrement life table for the KNE and KNW districts in 2016. The results indicated that assuming a cohort of 100,000 newborns in 2016 in the study area, it was estimated that 29,972 of them would eventually die of NCD-related causes by the time they reached age 80 years and above. This meant that about 30 percent of that cohort would eventually die of non-communicable diseases by age 80

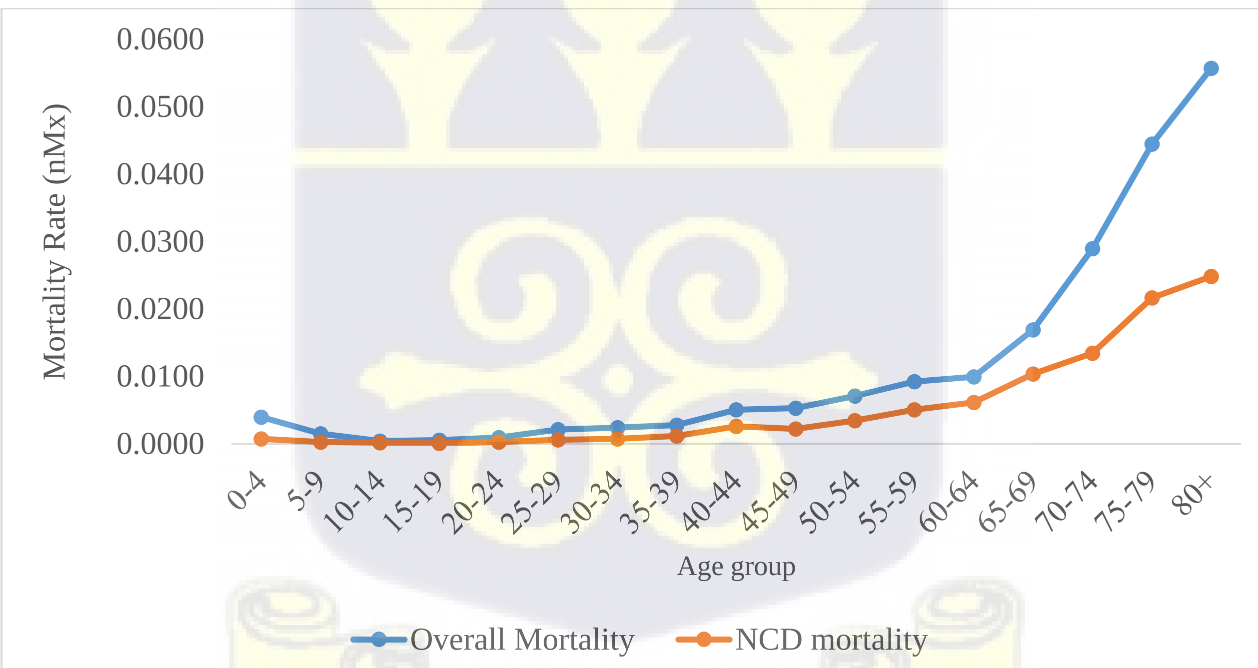
Table 7.4 A multiple decrement life table for the KNE & KNW, 2016

Age group	ALL Deaths	Pop	NCD^{Deaths}	${}_nm_x$	${}_nq_x$	${}_np_x$	${}_nd_x$	l_x	${}_nL_x$	T_x	e_x	${}_nq_x^{NCD}$	${}_nd_x^{NCD}$	l_x^{NCD}	${}_nm_x^{NCD}$
0-4	78	19,573	11	0.0040	0.0158	0.9842	1577	100000	395742	6782182	67.8	0.0006	56	29972	0.0006
5-9	29	19,353	5	0.0015	0.0075	0.9925	735	98423	487935	6386440	64.9	0.0010	102	29916	0.0003
10-14	8	19,283	3	0.0004	0.0021	0.9979	202	97688	486745	5898505	60.4	0.0008	76	29814	0.0002
15-19	10	17,779	1	0.0006	0.0028	0.9972	274	97486	484925	5411760	55.5	0.0003	27	29738	0.0001
20-24	14	14,948	4	0.0009	0.0047	0.9953	454	97212	481221	4926835	50.7	0.0013	130	29711	0.0003
25-29	25	11,710	7	0.0021	0.0106	0.9894	1027	96758	475824	4445614	45.9	0.0030	289	29581	0.0006
30-34	23	9,674	7	0.0024	0.0118	0.9882	1131	95731	469712	3969790	41.5	0.0036	346	29292	0.0007
35-39	22	7,866	9	0.0028	0.0139	0.9861	1314	94599	460630	3500078	37.0	0.0057	540	28946	0.0011
40-44	33	6,555	17	0.0050	0.0249	0.9751	2319	93286	448906	3039448	32.6	0.0129	1202	28407	0.0026
45-49	36	6,817	15	0.0053	0.0261	0.9739	2371	90967	435283	2590541	28.5	0.0109	995	27205	0.0022
50-54	49	6,928	24	0.0071	0.0347	0.9653	3079	88596	417933	2155258	24.3	0.0172	1521	26210	0.0035
55-59	55	5,953	29	0.0092	0.0452	0.9548	3861	85517	398372	1737325	20.3	0.0241	2058	24688	0.0049
60-64	50	5,026	31	0.0099	0.0485	0.9515	3963	81656	372721	1338953	16.4	0.0304	2480	22630	0.0062
65-69	70	4,143	41	0.0169	0.0811	0.9189	6297	77693	332887	966232	12.4	0.0483	3752	20150	0.0099
70-74	97	3,351	43	0.0289	0.1350	0.8650	9636	71395	277918	633345	8.9	0.0622	4438	16399	0.0128
75-79	78	1,755	37	0.0444	0.2000	0.8000	12352	61759	123519	355428	5.8	0.1001	6184	11960	0.0211
80+	92	1,651	41	0.0557	1.0000	0.0000	49408	49408	231909	231909	4.7	0.1169	5776	5776	0.0248
Total	769	162365	325	0.0047	-	-	-	-	-	-	-	-	29972		

Source: Navrongo HDSS (2012-2018). NCD = Non-communicable causes of death

Figure 7.4 presents the age patterns of mortality for overall and NCD causes of death. According to the results, NCD mortality tended to mimic the pattern of overall mortality. However, NCD mortality was lower at younger ages compared to older ages. This was expected because evidence suggests that older people suffer more from NCDs than younger age groups. It was observed that at the early age groups between 0-4 years, overall mortality and NCD mortality were low but began to peak after ages 60-64 years. It must be noted, however, that, similar to the behaviour of the communicable disease mortality curve noted earlier, the all-cause mortality curve continued to peak above the NCD mortality curve. Again, this suggested that causes other than NCDs were significant contributors to the mortality burden in the study area.

Figure 7.4 Age specific cause of mortality



Source: Navrongo HDSS (2012-2018).

Again, to understand the impact of the non-communicable disease burden on overall mortality in the study area, deaths attributable to NCD causes were isolated from all-cause mortality. The life expectancy for the area was then estimated under the assumption that NCDs were eliminated from the population. Table 7.5 presents the associated single-decrement life table for causes of death other than NCD causes. The results showed that if NCDs were to be reduced to non-public health importance in this population, life expectancy would have increased by 6.7 years, from 67.8 to 74.5 years.

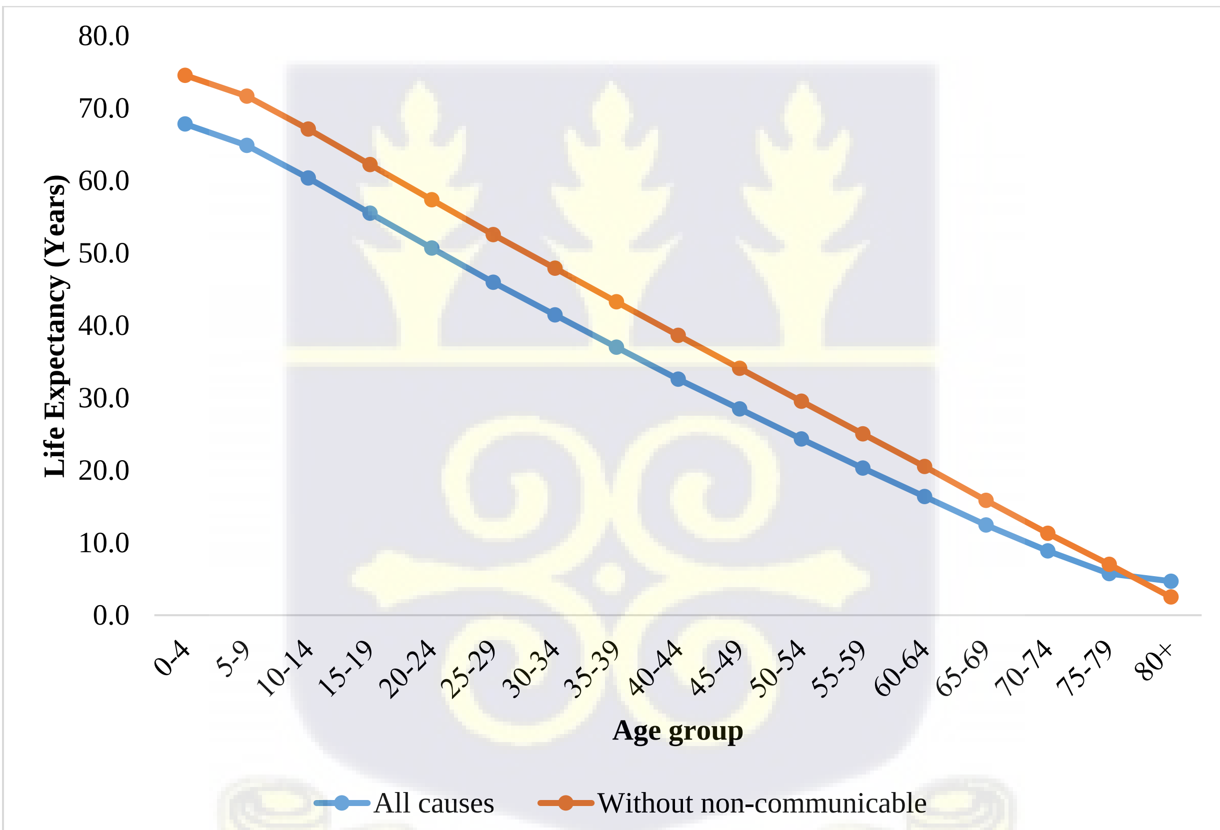
Table 7.5 Associated single-decrement life table for causes of death other than NCD causes of death

Age group	l_x	$_np_x$	R^{-NCD}	p^{-NCD}	l_x^{-NCD}	$_nq_x^{-NCD}$	$_nd_x^{-NCD}$	$_nq_x / {_nq_x^{-NCD}}$	$_nM_x^{-NCD}$	$_nL_x^{-NCD}$	T_x^{-NCD}	e_x^{-NCD}
0-4	100000	0.9842	0.8590	0.9848	100000	0.0152	1521	1.037	0.0034	396958	7454713	74.5
5-9	98423	0.9925	0.8276	0.9936	98479	0.0064	633	1.161	0.0012	490812	7057755	71.7
10-14	97688	0.9979	0.6250	0.9987	97846	0.0013	127	1.601	0.0003	488912	6566943	67.1
15-19	97486	0.9972	0.9000	0.9975	97719	0.0025	247	1.111	0.0005	487978	6078031	62.2
20-24	97212	0.9953	0.7143	0.9967	97472	0.0033	325	1.401	0.0007	486548	5590053	57.4
25-29	96758	0.9894	0.7200	0.9924	97147	0.0076	742	1.391	0.0015	483881	5103505	52.5
30-34	95731	0.9882	0.6957	0.9918	96405	0.0082	791	1.440	0.0017	480050	4619624	47.9
35-39	94599	0.9861	0.5909	0.9918	95614	0.0082	782	1.697	0.0017	476116	4139574	43.3
40-44	93286	0.9751	0.4848	0.9880	94832	0.0120	1136	2.076	0.0024	471321	3663458	38.6
45-49	90967	0.9739	0.5833	0.9849	93696	0.0151	1417	1.724	0.0031	464940	3192137	34.1
50-54	88596	0.9653	0.5102	0.9824	92280	0.0176	1622	1.977	0.0036	457344	2727197	29.6
55-59	85517	0.9548	0.4727	0.9789	90658	0.0211	1912	2.141	0.0044	448510	2269853	25.0
60-64	81656	0.9515	0.3800	0.9818	88746	0.0182	1612	2.672	0.0038	439700	1821343	20.5
65-69	77693	0.9189	0.4143	0.9672	87134	0.0328	2855	2.474	0.0070	428532	1381643	15.9
70-74	71395	0.8650	0.5567	0.9272	84279	0.0728	6136	1.854	0.0161	406055	953111	11.3
75-79	61759	0.8000	0.5256	0.9001	78143	0.0999	7804	2.003	0.0234	371207	547056	7.0
80+	49408	0.0000	0.5543	0.0000	70340	1.0000	70340	1.000	0.0309	175849	175849	2.5

Source: Navrongo HDSS (2012-2018). R^{-NCD} = the proportion of death due to all causes other than non-communicable disease causes of death

Figure 7.5 displays the estimated life expectancy for overall mortality and the corresponding life expectancy without NCDs for each age group. The life expectancy for the combined causes of mortality was compared with the corresponding life expectancy after isolating deaths related to NCD causes. The results also showed an increase in life expectancy at every age if NCDs were eliminated as a result of a major health intervention.

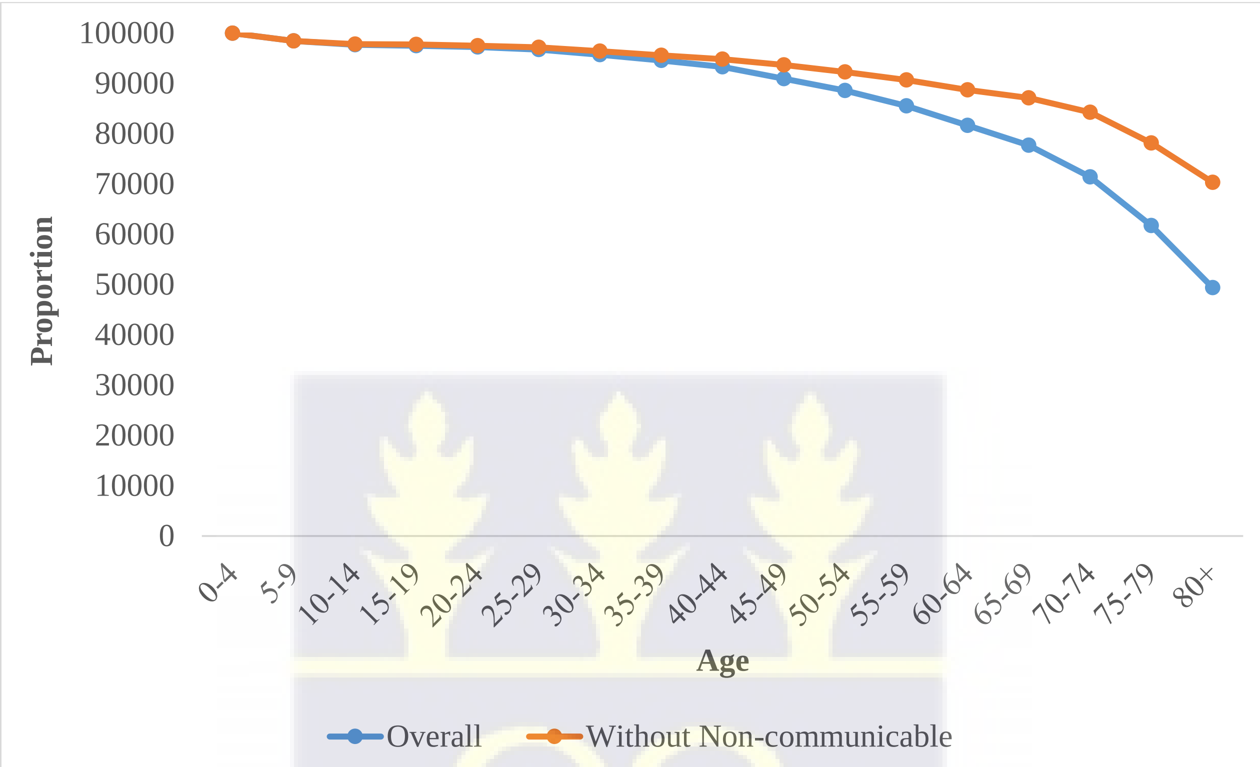
Figure 7.5 Comparison of estimated life expectancy for each age group without non-communicable diseases, Kassena-Nankana East and West District, Ghana



Source: Navrongo HDSS (2012-2018).

Figure 7.6 shows the number of individuals who survived to each age (l_x) with and without non-communicable causes of mortality in the study area. Again, the results indicated that if non-communicable diseases were eliminated or reduced as a major cause of death due to major public health interventions, survival would have increased at almost every age (see also Table 7.5).

Figure 7.6 Estimated proportion of individuals surviving to each age with and without non-communicable diseases



Source: Navrongo HDSS (2012-2018).

7.5 Impact of External Causes of Death on Longevity

Apart from communicable and non-communicable causes, some external causes, such as transport accidents, self-harm, assault, the spirit child phenomenon, and other factors, were major contributors to mortality in the KNE and KNW, as noted in the earlier chapter. Therefore, I modelled the impact of external causes of death on longevity in the study area.

These deaths were represented by age in a life table, as displayed in Table 7.6. The results indicated that assuming a cohort of 100,000 newborns in 2016 in the study area, it was estimated that 9,673 of them might eventually die from other external-related causes by the time they reached age 80 years and above. This meant that about 10 percent of that cohort might eventually die from external causes by age 80.

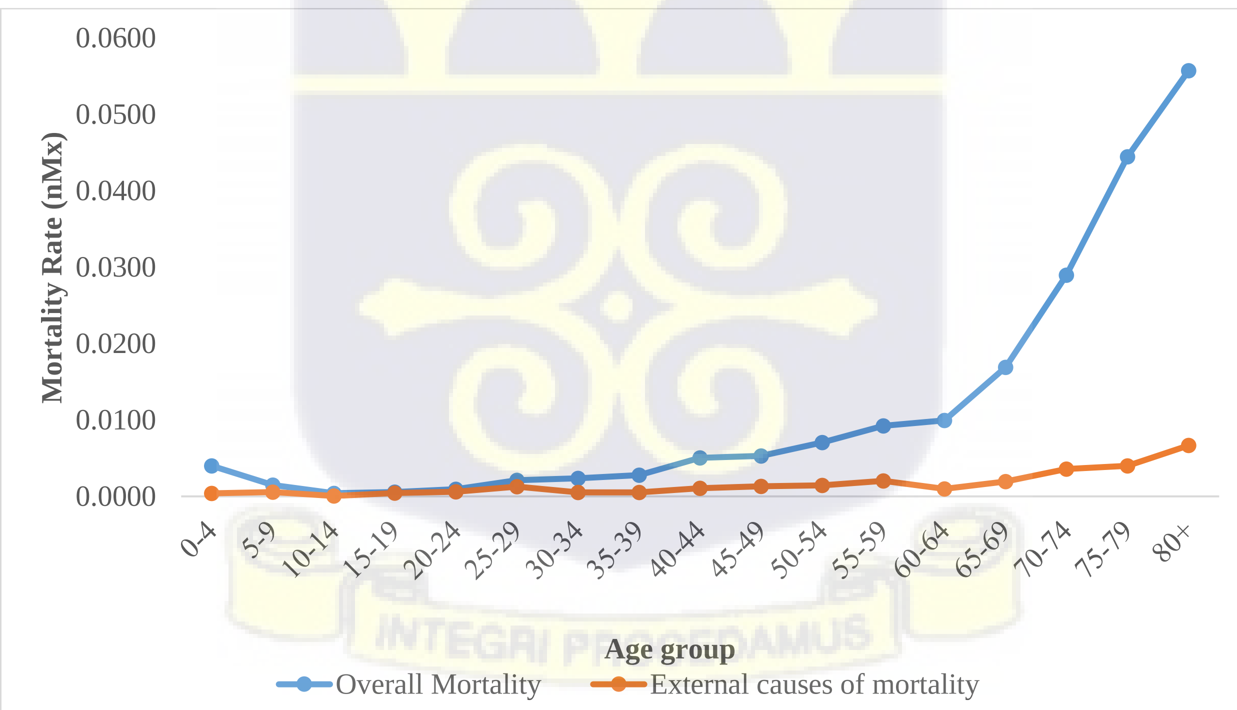
Table 7.6 A multiple decrement life table for the KNE & KNW, 2016

Age group	ALL Deaths	Pop	External causes	$_nm_x$	$_nq_x$	$_np_x$	$_nd_x$	l_x	$_nL_x$	T_x	e_x	$_nq_x^{Ex}$	$_nd_x^{Ex}$	l_x^{Ex}	$_nm_x^{Ex}$
0-4	78	19,573	4	0.0040	0.0158	0.9842	1577	100000	395742	6782182	67.82	0.0002	20	9673	0.0002
5-9	29	19,353	11	0.0015	0.0075	0.9925	735	98423	487935	6386440	64.89	0.0023	223	9652	0.0006
10-14	8	19,283	1	0.0004	0.0021	0.9979	202	97688	486745	5898505	60.38	0.0003	25	9429	0.0001
15-19	10	17,779	7	0.0006	0.0028	0.9972	274	97486	484925	5411760	55.51	0.0020	192	9404	0.0004
20-24	14	14,948	8	0.0009	0.0047	0.9953	454	97212	481221	4926835	50.68	0.0027	260	9212	0.0005
25-29	25	11,710	15	0.0021	0.0106	0.9894	1027	96758	475824	4445614	45.95	0.0064	618	8952	0.0013
30-34	23	9,674	5	0.0024	0.0118	0.9882	1131	95731	469712	3969790	41.47	0.0026	247	8334	0.0005
35-39	22	7,866	4	0.0028	0.0139	0.9861	1314	94599	460630	3500078	37.00	0.0025	240	8087	0.0005
40-44	33	6,555	7	0.0050	0.0249	0.9751	2319	93286	448906	3039448	32.58	0.0053	497	7847	0.0011
45-49	36	6,817	9	0.0053	0.0261	0.9739	2371	90967	435283	2590541	28.48	0.0066	599	7350	0.0013
50-54	49	6,928	10	0.0071	0.0347	0.9653	3079	88596	417933	2155258	24.33	0.0072	637	6752	0.0014
55-59	55	5,953	12	0.0092	0.0452	0.9548	3861	85517	398372	1737325	20.32	0.0100	858	6115	0.0020
60-64	50	5,026	5	0.0099	0.0485	0.9515	3963	81656	372721	1338953	16.40	0.0050	405	5257	0.0010
65-69	70	4,143	8	0.0169	0.0811	0.9189	6297	77693	332887	966232	12.44	0.0096	747	4852	0.0019
70-74	97	3,351	12	0.0289	0.1350	0.8650	9636	71395	277918	633345	8.87	0.0177	1267	4105	0.0036
75-79	78	1,755	7	0.0444	0.2000	0.8000	12352	61759	123519	355428	5.76	0.0197	1220	2838	0.0040
80+	92	1,651	11	0.0557	1.0000	0.0000	49408	49408	231909	231909	4.69	0.0328	1619	1619	0.0067
Total	769	162365	136	0.0047	-	-	-	-	-	-	-	-	9673	-	-

Source: Navrongo HDSS (2012-2018). Ex = External causes of death

Figure 7.5 displays the age patterns of mortality for the overall causes and external causes of death. The external cause of the mortality curve deviated from that of the overall mortality curve. At the initial stage (childhood), overall mortality was high while external cause mortality was lower. After five years, overall mortality began to decline and remained stable, similar to the case of the external cause of death curve. Both curves remained the same until after age 35 years when the overall mortality curve peaked and became higher than the external cause of mortality curve. It could be observed that external cause mortality was low in the younger age groups but began to peak after the age group of 30-34 years. Again, the all-cause mortality curve continued to peak above the external cause mortality curve, indicating the contribution of other causes of mortality beyond external causes.

Figure 7.7 Age Patterns of Mortality



Source: Navrongo HDSS (2012-2018).

Again, to estimate the impact that external causes had on longevity in the study area, all deaths attributable to external causes were isolated from all-cause mortality. The life expectancy for the area was then estimated under the assumption that a major public health intervention was implemented and external causes were eliminated as a significant cause of death from this population. Table 7.7 presents the associated single-decrement life table for causes of death other than external causes. The results showed that if external causes had been eliminated in this population, life expectancy would have increased by 2.1 years, from 67.8 to 69.9 years.

Table 7.7 Associated single-decrement life table for causes of death other than external causes of death

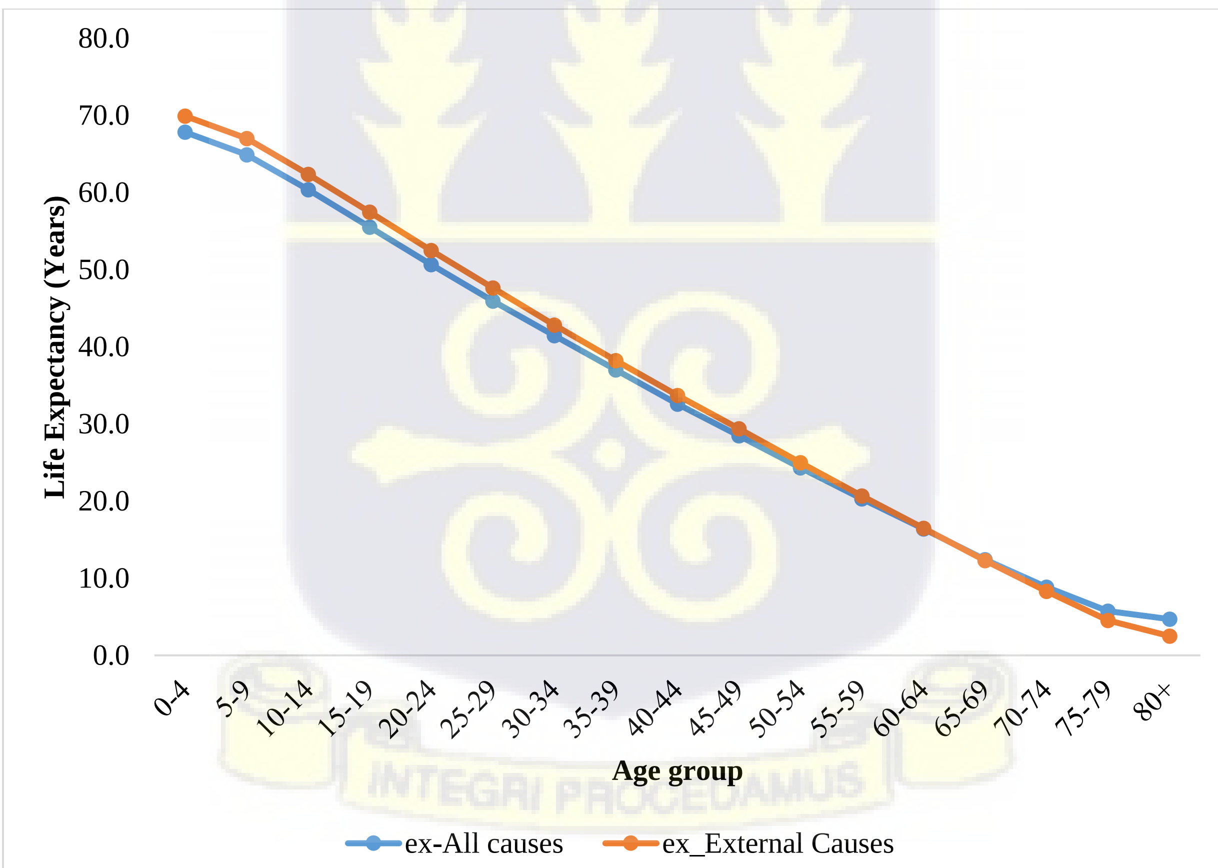
Age group	l_x	$_np_x$	R^{-Ex}	p^{-Ex}	l_x^{-Ex}	$_nq_x^{-Ex}$	$_nd_x^{-Ex}$	$_nq_x$ / $_nq_x^{-Ex}$	$_nm_x^{-Ex}$	$_nL_x^{-Ex}$	T_x^{-Ex}	e_x^{-Ex}
0-4	100000	0.9842	0.8974	0.9844	100000	0.0156	1557	1.027	0.0038	395864	6991930	69.9
5-9	98423	0.9925	0.6207	0.9948	98443	0.0052	511	1.437	0.0009	490495	6596066	67.0
10-14	97688	0.9979	0.8750	0.9982	97932	0.0018	178	1.143	0.0004	489011	6105571	62.3
15-19	97486	0.9972	0.2000	0.9992	97754	0.0008	82	5.006	0.0002	488078	5616561	57.5
20-24	97212	0.9953	0.3571	0.9980	97672	0.0020	195	2.804	0.0004	486841	5128482	52.5
25-29	96758	0.9894	0.4000	0.9958	97477	0.0042	413	2.508	0.0009	484111	4641641	47.6
30-34	95731	0.9882	0.7826	0.9908	97064	0.0092	897	1.279	0.0019	480352	4157530	42.8
35-39	94599	0.9861	0.8182	0.9887	96168	0.0113	1091	1.224	0.0023	473467	3677178	38.2
40-44	93286	0.9751	0.7879	0.9805	95076	0.0195	1857	1.273	0.0040	466199	3203711	33.7
45-49	90967	0.9739	0.7500	0.9805	93219	0.0195	1816	1.338	0.0040	455259	2737512	29.4
50-54	88596	0.9653	0.7959	0.9724	91403	0.0276	2519	1.261	0.0056	442914	2282253	25.0
55-59	85517	0.9548	0.7818	0.9649	88884	0.0351	3122	1.286	0.0072	427274	1839339	20.7
60-64	81656	0.9515	0.9000	0.9564	85762	0.0436	3737	1.114	0.0090	404818	1412065	16.5
65-69	77693	0.9189	0.8857	0.9286	82025	0.0714	5861	1.134	0.0150	373156	1007247	12.3
70-74	71395	0.8650	0.8763	0.8828	76165	0.1172	8928	1.151	0.0254	328205	634091	8.3
75-79	61759	0.8000	0.9103	0.8197	67237	0.1803	12120	1.110	0.0405	168092	305885	4.5
80+	49408	0.0000	0.8804	0.0000	55117	1.0000	55117	1.000	0.0491	137793	137793	2.5

Source: Navrongo HDSS (2012-2018).

R^{-Ex} = the proportion of death due to all causes other than external causes.

Figure 7.8 displays the estimated life expectancy for overall mortality and the corresponding life expectancy without external causes for each age group. The life expectancy for the combined causes of mortality was compared with the corresponding life expectancy after separating deaths related to external causes. The results showed probable gains in life expectancy, particularly among the younger and middle age groups, when external causes of death were hypothetically eliminated. Generally, averting external causes of death had marginal gains in life expectancy and improved the probability of surviving.

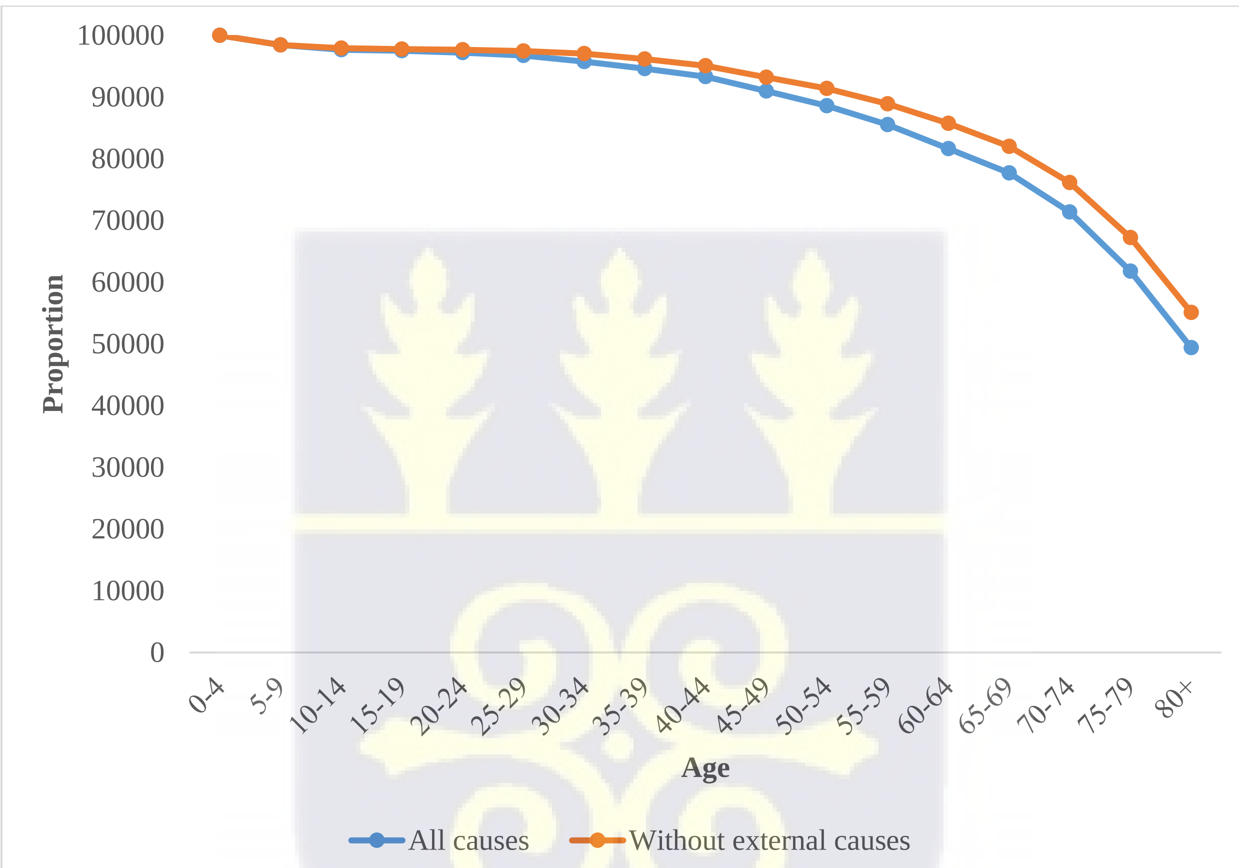
Figure 7.8 Comparison of estimated life expectancy for each age group without external causes, Kassena-Nankana East and West District, Ghana



Source: Navrongo HDSS (2012-2018).

Figure 7.9 displays the estimated number of survivors to each age (l_x) with and without external causes of mortality in the study area. The result showed that if external causes were hypothetically eliminated as causes of death due to a major intervention, survival would have increased at almost every age (see also Table 7.7).

Figure 7.9 Estimated proportion of individuals surviving to each age with and without external causes of mortality



Source: Navrongo HDSS (2012-2018).

7.6 Discussion

This chapter demonstrated the impact and burden of the diseases that caused mortality in the Kassena-Nankana East and West Districts in the Upper East Region of Ghana. One of the critical goals of the United Nations Sustainable Development Goals was Goal 3, which aimed to ensure healthy lives and promote well-being for all at all ages. Some of the targets of this goal included fighting communicable diseases, reducing NCD mortalities, and reducing global deaths and injuries from road traffic accidents. This chapter adopted three main assumptions and scenarios to examine their impact on achieving the SDG targets.

The first scenario assumed that if infectious or communicable diseases such as malaria, tuberculosis, hepatitis, HIV/AIDS, and other communicable diseases were hypothetically eliminated from the population in line with target 3.3 of the SDGs, how would it translate into improved longevity? Based on this assumption, I modelled the effect of eliminating or reducing deaths attributable to communicable diseases in the study area in 2016 and then estimated the resultant effect on life expectancy. In the second scenario, it was assumed that a major public health intervention was put in place and NCDs were reduced to a non-public health significance or eradicated from this population, as targeted in SDG target 3.4. Thus, all deaths attributable to NCDs were modelled to be eliminated, and the life expectancy for this population was estimated. Finally, it was assumed that SDG target 3.6 was achieved and all deaths attributable to injuries, self-harm, accidents, and other external causes were reduced to the point of non-public health significance. Again, I modelled their impact using the associated single-decrement life table procedure, estimating life expectancy in the absence of external causes of death.

Generally, the results showed that the different causes of death posed varying intensities of burden to households in the study area. It was also noted that the burden posed by the diseases varied among demographic age groups. It was observed that NCD mortality presented the greatest burden to households compared to other causes of death. It was observed that eliminating the different causes of death contributed to potential gains in life expectancy. However, the magnitude of gains in life expectancy in the absence of a particular cause of death varied from one cause to another. Additionally, the gains in life expectancy varied among the age groups assuming the causes of death were reduced to non-public health importance. These findings were consistent with earlier studies that observed similar age variations in mortality (Aksan & Chakraborty, 2023). The authors noted that changes in life expectancy did not lead to the same magnitude of change in mortality rates across all ages. The results of my study mirrored the third stage of the Epidemiological Transition Theory (ETT), where NCDs emerged as the leading cause of mortality as a result of ageing and changing lifestyle factors (Omran, 1971).

It is important to point out here that while the ETT indicated that communicable diseases are usually increasingly replaced by NCDs at this stage of the transition, the epidemiological transition in the study area depicted a semblance of a polarized model where both communicable and non-communicable diseases represented a double burden of disease.

The findings in my study were consistent with earlier studies (Bawah & Binka, 2007; Canudas-romo et al., 2014) conducted to estimate the impact of diseases on life expectancy. Bawah and Binka, for example, estimated that the elimination of malaria in northern Ghana would result in an additional six years of population life expectancy. This was to be expected because eliminating malaria implied that more lives would be saved and premature mortality due to malaria would significantly decline. In my study, it was observed that the proportion of people surviving at each age increased as the causes of death were modelled to be eliminated from the population. My study found that if NCDs were to be hypothetically eliminated from the study area as a result of a major public health intervention, it would translate to an additional 6.7 years of life expectancy. On the other hand, if some public health interventions were put in place and communicable diseases and external-related deaths became of non-public health significance, life expectancy in this population would increase by an additional 5.1 and 2.1 years, respectively. This implied that the most significant impact on disease mortality in the study area had been the growth of NCDs, which was responsible for 46.0 percent of the deaths during my study period. Therefore, it was important for policymakers and stakeholders in the health sector to prioritize and address these disease conditions, as well as communicable diseases, in order to reduce the burden they posed to households living in the study area.

The next chapter explored the age group-specific contributions to the improvement in life expectancy if the different causes of mortality in the study area were eliminated through public health intervention. The decomposition analysis technique was used.

CHAPTER EIGHT

DECOMPOSITION ANALYSIS OF THE BURDEN OF COMMUNICABLE AND NON-COMMUNICABLE DISEASES

8.1 Introduction

The decomposition analysis in this chapter provides insights into the age group-specific contributions to the improvement in longevity if different causes of mortality in the study area were eliminated through public health interventions. It follows the previous chapter, which established that life expectancy in the study area would improve if the major causes of mortality were modelled to be eliminated. While that information was useful for health intervention, it did not provide complete details on the age-specific contribution to life expectancy when a certain cause of death is reduced in this population. It was largely anticipated that eliminating different causes of death would reduce mortality across various age groups, thereby increasing overall life expectancy. However, some age groups might still have recorded high mortality rates that could offset the potential gains in life expectancy. This is because eradicating a disease that causes death does not have the same impact on survival across all age groups. Thus, this chapter goes a step further to examine the contribution to the overall change in life expectancy by the various age groups in the absence of each of the causes of mortality.

8.2 Decomposition of estimated change in life expectancy without communicable diseases

Table 8.1 presents the decomposition of the estimated changes in life expectancy for Kassena-Nankana East (KNE) and Kassena-Nankana West (KNW) in 2016 if communicable diseases had been hypothetically eliminated as causes of death from the study area. The results indicated that the overall improvement in life expectancy if communicable causes of death were eradicated, would have been 5.2 years. Decomposing these changes by age groups revealed that the contribution to life expectancy varied across the different groups. Generally, the gains in life expectancy from the elimination of communicable causes increased with age until after age 79 (as shown in Figure 8.1). It was observed that individuals aged 75-79 years contributed the most (34.0 percent) to life expectancy in the absence of communicable diseases, while those aged 80 years and above contributed the least proportion. This suggests that causes other than communicable diseases remained significant contributors to mortality in this age group. This implied that, while the overall life expectancy improves due to larger improvements in other age groups, the mortality rate in this specific age group increases, thus contributing negatively to the overall change in life expectancy. The combined contribution of early childhood to life expectancy without communicable diseases was 7.7 percent. Those aged 15 to 64 years collectively accounted for about half (50.2 percent) of the gains in life expectancy in the absence of infectious causes.

Table 8.1 Decomposition of the estimated changes in life expectancy at birth without communicable disease as a cause of death, by age group, KNE and KNW 2016

Age group	l_x	${}_nL_x$	T_x	l_x^{-CD}	${}_nL_x^{-CD}$	T_x^{-CD}	Change	Percent

0-4	100000	395742	6782182	100000	397407	7303099	0.213	4.1
5-9	98423	487935	6386440	98703	492286	6905693	0.189	3.6
10-14	97688	486745	5898505	98211	490801	6413407	0.076	1.5
15-19	97486	484925	5411760	98109	489996	5922606	0.050	1.0
20-24	97212	481221	4926835	97889	488465	5432610	0.072	1.4
25-29	96758	475824	4445614	97497	485209	4944145	0.114	2.2
30-34	95731	469712	3969790	96587	481201	4458936	0.257	4.9
35-39	94599	460630	3500078	95894	477051	3977735	0.233	4.5
40-44	93286	448906	3039448	94927	470359	3500684	0.341	6.5
45-49	90967	435283	2590541	93217	461882	3030325	0.360	6.9
50-54	88596	417933	2155258	91536	452030	2568443	0.407	7.8
55-59	85517	398372	1737325	89276	438539	2116413	0.384	7.4
60-64	81656	372721	1338953	86140	422168	1677874	0.385	7.4
65-69	77693	332887	966232	82727	400827	1255706	0.599	11.5
70-74	71395	277918	633345	77604	370328	854879	0.843	16.2
75-79	61759	123519	355428	70528	330435	484551	1.773	34.0
80+	49408	231909	231909	61646	154116	154116	-1.084	-20.8
Total	-	-	-	-	-	-	5.209	100.0

CD = Communicable causes of death

lx = Number surviving at each age.

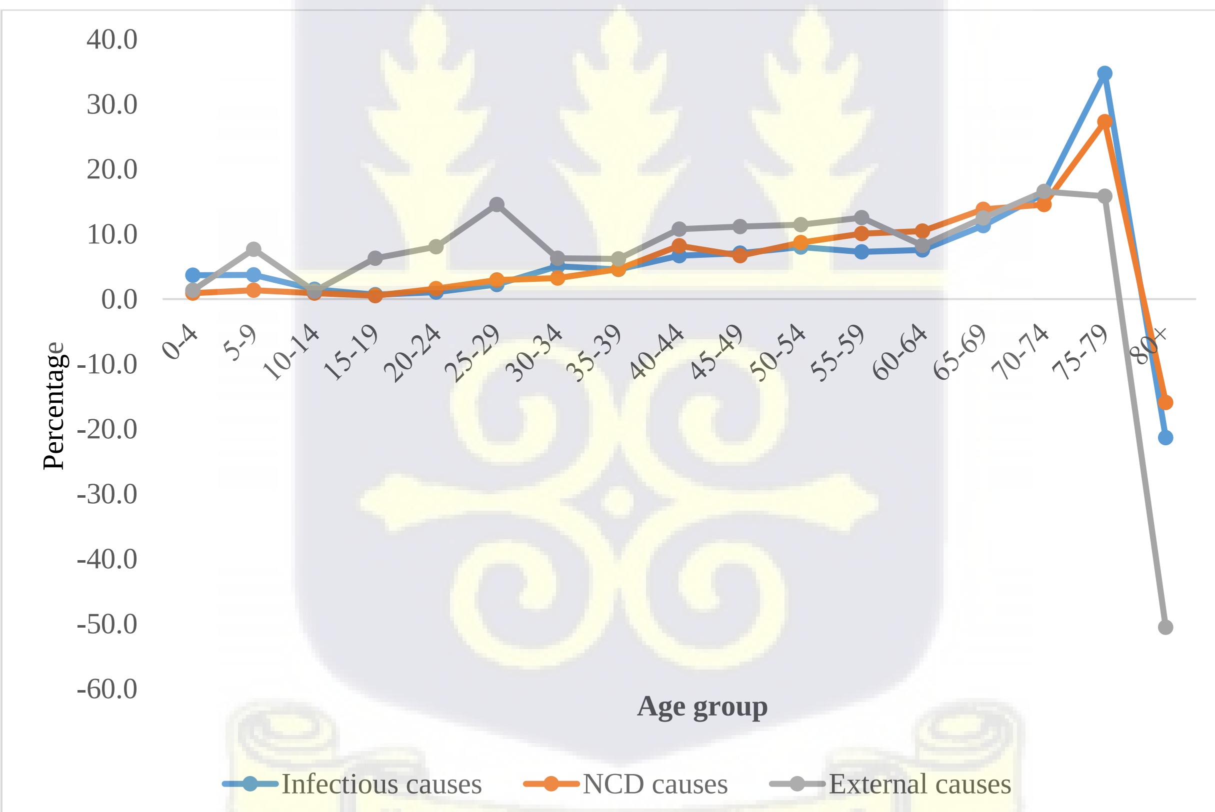
${}_nL_x$ = Person-years lived between ages x and x + n.

T_x = Person-years lived beyond age x.

Figure 8.1 depicts the comparison of the change in life expectancy at birth by age group and causes of death in KNE and KNW. Generally, the results indicated gains in life expectancy through the elimination of major epidemics that caused mortality. Additionally, the results showed that, except for external causes of death, the gains in life expectancy increased with age. However, the contribution to life expectancy gradually became negative when individuals survived beyond the age of 79 years. This implied that increases in mortality rates within these age groups contribute to a decrease in overall life expectancy. Therefore, any health intervention aimed at improving health status was inconsequential to longevity for those who had reached the age of 79 years. In other words, any policy intervention targeting the elimination of causes of mortality would not yield benefits for this age group. Therefore, targeted intervention for this age group should be focused on improving quality of life and not longevity.

Comparatively, the total change in life expectancy without an external cause curve appeared zig-zag and undulating until after age 79 years, when it took a downward negative trend. On the other hand, the other cause curves appeared linear, indicating positive gains in life expectancy as age increased.

Figure 8.1 Comparison of the change in life expectancy at birth by age group and causes of death in the KNE and KNW



8.3 Decomposition of estimated change in life expectancy without NCDs

Table 8.2 shows the decomposition of the estimated changes in life expectancy at birth if NCDs were eliminated in the KNE and KNW districts. The results showed that if NCDs were eliminated as a cause of death in this population due to public health intervention, the total change in life expectancy at birth would increase by 6.7 years. People aged 75-79 years contributed the most (27.3 percent) to the increase in life expectancy, while those aged 80 years and above contributed the least. Children under five and those aged between 5 to 14 years contributed less than five percent (3.2 percent) to the total change in life expectancy at birth if NCDs were eliminated as a result of a public health intervention. Adults aged between 55 to 79 years contributed slightly above three-quarters (76.2 percent) to the total change in life expectancy at birth without NCD causes. This result was expected because 46.0 percent of the total deaths recorded from 2012 to 2018 in the districts were due to NCD-related causes, with most of these deaths occurring among the older age groups (as depicted in Figure 5.1 in Chapter 5).

Table 8.2 Decomposition of the estimated changes in life expectancy at birth if NCDs were to be eliminated in the KNE and KNW districts

Age group	l_x	$_nL_x$	T_x	l_x^{-NCD}	$_nL_x^{-NCD}$	T_x^{-NCD}	Change	Percent
0-4	100000	395742	6782182	100000	396958	7454713	0.052	0.8
5-9	98423	487935	6386440	98479	490812	7057755	0.094	1.4
10-14	97688	486745	5898505	97846	488912	6566943	0.061	0.9
15-19	97486	484925	5411760	97719	487978	6078031	0.035	0.5
20-24	97212	481221	4926835	97472	486548	5590053	0.109	1.6
25-29	96758	475824	4445614	97147	483881	5103505	0.200	3.0
30-34	95731	469712	3969790	96405	480050	4619624	0.219	3.3
35-39	94599	460630	3500078	95614	476116	4139574	0.313	4.7
40-44	93286	448906	3039448	94832	471321	3663458	0.557	8.3
45-49	90967	435283	2590541	93696	464940	3192137	0.455	6.8
50-54	88596	417933	2155258	92280	457344	2727197	0.592	8.8
55-59	85517	398372	1737325	90658	448510	2269853	0.669	10.0
60-64	81656	372721	1338953	88746	439700	1821343	0.712	10.6
65-69	77693	332887	966232	87134	428532	1381643	0.916	13.6
70-74	71395	277918	633345	84279	406055	953111	0.971	14.4
75-79	61759	123519	355428	78143	371207	547056	1.853	27.6
80+	49408	231909	231909	70340	175849	175849	-1.084	-16.1
Total	-	-	-	-	-	-	6.725	100.0

NCD = NCD causes of death

lx = Number surviving at each age.

$_nL_x$ = Person-years lived between ages x and x + n.

T_x = Person-years lived beyond age x.

8.4 Decomposition of estimated change in life expectancy without external causes of death

Elsewhere in Chapter Five, it was reported that 10.9 percent of the deaths recorded in the KNE and KNW districts between 2012 and 2018 were due to external causes. In 2016, deaths attributable to external causes constituted 18 percent of the reported deaths in that year. To understand which age group contributed the most to the gains in life expectancy at birth if external causes of mortality were eliminated from this population, the total change in life expectancy at birth without external causes (2.1 years) was decomposed by age. The results showed that the age group 70-74 years was likely to contribute the most to the gains in life expectancy at birth if external causes of death were eliminated as major causes of death. The contribution of under-five mortality to the total change in life expectancy at birth was 0.7 percent. Additionally, those aged 80 years and above were likely to contribute negatively to the improvement of life expectancy at birth if external causes of death were eliminated. This implied that, besides external causes of death, other conditions significantly impacted the health of persons within this age group.

Table 8.3 Decomposition of the estimated changes in life expectancy at birth if external causes of mortality were to be eliminated in the KNE and KNW districts

Age group	l_x	$_nL_x$	T_x	l_x^{-Ex}	$_nL_x^{-Ex}$	T_x^{-Ex}	Change	Percent
0-4	100000	395742	6782182	100000	395864	6991930	0.015	0.7
5-9	98423	487935	6386440	98443	490495	6596066	0.164	7.8
10-14	97688	486745	5898505	97932	489011	6105571	0.025	1.2
15-19	97486	484925	5411760	97754	488078	5616561	0.119	5.7
20-24	97212	481221	4926835	97672	486841	5128482	0.157	7.5
25-29	96758	475824	4445614	97477	484111	4641641	0.312	14.9
30-34	95731	469712	3969790	97064	480352	4157530	0.135	6.4
35-39	94599	460630	3500078	96168	473467	3677178	0.132	6.3
40-44	93286	448906	3039448	95076	466199	3203711	0.231	11.0
45-49	90967	435283	2590541	93219	455259	2737512	0.239	11.4
50-54	88596	417933	2155258	91403	442914	2282253	0.246	11.7
55-59	85517	398372	1737325	88884	427274	1839339	0.268	12.8
60-64	81656	372721	1338953	85762	404818	1412065	0.177	8.4
65-69	77693	332887	966232	82025	373156	1007247	0.268	12.8
70-74	71395	277918	633345	76165	328205	634091	0.355	16.9
75-79	61759	123519	355428	67237	168092	305885	0.339	16.2
80+	49408	231909	231909	55117	137793	137793	-1.084	-51.7
Total	-	-	-	-	-	-	2.097	100.0

Ex = External causes of death

lx = Number surviving at each age.

${}_{n}L_{x}$ = Person-years lived between ages x and x + n.

T_x = Person-years lived beyond age x.

8.5 Discussion

The overall attainment of SDG 3 depended on policy interventions that focused on eliminating communicable and non-communicable diseases, as well as targeted reductions of external causes of mortality. In this chapter, the decomposition analyses provided clarity on which age groups were likely to contribute more to the total change in life expectancy at birth, assuming communicable, non-communicable, and external causes of mortality were separately eliminated as major causes of death from the population.

The decomposition analysis results provided a detailed examination of how different age groups contributed to changes in life expectancy at birth if communicable diseases (CDs), non-communicable diseases (NCDs), and external causes of mortality were eliminated. These findings were instrumental in highlighting the age-specific impact of these causes on overall longevity, offering insights into targeted public health interventions.

The decomposition analysis revealed that the gains in life expectancy were not uniform across all age groups; rather, they varied significantly depending on the age group and the specific cause of mortality eliminated. This indicated that interventions targeting the elimination of certain causes of death would have age-specific effects, with some age groups benefiting more than others.

If CDs were eliminated, the overall improvement in life expectancy in the Kassena-Nankana East (KNE) and West (KNW) districts was estimated at 5.2 years. The results showed that older age groups, particularly those aged 75-79 years, contributed the most to the gains in life expectancy (34.0 percent). In contrast, individuals aged 80 years and above contributed negatively, implying that other health conditions still posed significant threats to this age group. Early childhood (0-9 years) contributed a combined 7.7 percent, underscoring the importance of reducing CDs in these younger populations to enhance longevity.

When NCDs were removed as a cause of death, life expectancy increased by 6.7 years. Notably, the greatest contribution came from adults aged 75-79 years (27.3 percent), reflecting the high burden of NCDs among older adults. Children under five and those aged 5-14 years contributed a modest 3.2 percent, which was expected given the lower incidence of NCDs in younger populations. The results emphasized that interventions targeting NCDs would yield substantial longevity benefits, particularly for older adults, as NCD-related mortality predominantly affects this demographic.

The elimination of external causes of death, which constituted 18 percent of deaths in 2016, led to an increase in life expectancy of 2.1 years. The analysis revealed that individuals aged 70-74 years were likely to gain the most in life expectancy. Conversely, those aged 80 years and above were projected to contribute negatively to longevity gains, suggesting that other significant health challenges persist in this age group beyond external causes of mortality. This highlights the need for comprehensive health interventions beyond the elimination of external causes for these older populations.

The decomposition analysis also highlighted that the contributions to life expectancy varied not just by age but also by cause of mortality. For instance, gains in life expectancy from eliminating external causes were most pronounced among younger adults (25-29 years), contributing 14.9

percent, compared to just 2.2 percent and 3.0 percent for CDs and NCDs, respectively. This indicates that while external causes impact younger age groups more significantly, CDs and NCDs disproportionately affect older populations.

These findings have implications health interventions. First, the findings underscore the importance of age-specific and cause-specific public health interventions. For example, focusing on reducing CDs would have a notable impact on younger and older adults, whereas targeting NCDs would significantly benefit older age groups. Tailoring interventions to address the specific needs of each age group could maximize the overall gains in life expectancy. Secondly, understanding the contributions of different age groups to life expectancy gains can inform more efficient allocation of resources. Public health strategies can prioritize interventions that target high-impact age groups to achieve maximum longevity benefits with the same level of investment.

Thirdly, the negative contributions of those aged 80 years and above, even with the elimination of CDs, NCDs, and external causes, suggest that other health challenges, such as chronic conditions and general frailty, remain significant. This points to the need for comprehensive health approaches that go beyond disease elimination to include preventive care, management of chronic conditions, and quality end-of-life care for older adults. Fourthly, the decomposition analysis demonstrated that proactive health interventions targeting specific causes of death could lead to substantial improvements in life expectancy. However, these interventions must be tailored to address the unique health needs of each age group to be most effective. Overall, the decomposition analysis provided valuable insights into the age-specific impacts of various mortality causes on life expectancy, highlighting the potential for targeted public health interventions to significantly enhance longevity in the study population.

CHAPTER NINE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

9.1 Introduction

This section synthesizes the key findings of the study, drawing comprehensive conclusions from the analysis and offers actionable recommendations to guide public health policy and interventions in the Kassena-Nankana East (KNE) and Kassena-Nankana West (KNW) districts. The study aimed to evaluate the impact of eliminating communicable diseases (CDs), non-communicable diseases (NCDs), and external causes of mortality on life expectancy at birth in the study population. Through decomposition analysis, the research identified the age-specific contributions to changes in life expectancy when these causes of mortality were removed, highlighting the most and least affected demographic groups.

The results revealed significant variations in life expectancy gains across different age groups, depending on the type of mortality cause eliminated. This understanding provides a critical foundation for designing targeted public health interventions that can maximize longevity benefits. The findings underscore the importance of prioritizing interventions that address the specific health burdens faced by distinct age groups, thereby optimizing resource allocation and enhancing overall life expectancy.

This chapter summarizes the key insights gained from the study, presents the conclusions drawn from the findings, and offers practical recommendations for policymakers, healthcare providers, and stakeholders. The recommendations aim to inform future strategies for improving population health and achieving sustainable gains in life expectancy in the KNE and KNW districts.

9.2 Summary of Key Findings

The quest to understand the causes of death within a population has remained a major interest to demographers, epidemiologists, and public health researchers due to the importance of identifying major diseases that cause mortality in specific geographic areas. However, research on this issue has been limited in many sub-Saharan African countries due to a lack of high-quality vital registration data to analyze causes of mortality. In light of this, my study estimated the impact of communicable and non-communicable causes of death among households in the Kassena-Nankana East and West districts in the Upper East Region of Northern Ghana. The study also explored factors associated with broad causes of mortality in the study area and estimated the gains in population life expectancy assuming these causes of mortality were hypothetically removed. Data were sourced from the Navrongo HDSS, specifically using verbal autopsy data from the NDSS, spanning from 2012 to 2018. Data quality evaluation techniques were employed to assess the accuracy and reliability of age reporting. Three levels of analysis were conducted: univariate, bivariate, and multivariate.

At the univariate level, the prevalence of specific and broad causes of mortality was assessed. The bivariate analysis examined the relationship between sociodemographic characteristics and causes of mortality. In the multivariate analysis, multinomial logistic regression models were used to examine the determinants of the causes of mortality in the study area. Additionally, multiple and single decrement life table techniques were employed to estimate the effect on population life expectancy if communicable, non-communicable, and external causes were distinctly removed. Finally, age decomposition analysis was conducted separately for communicable, non-communicable, and external causes of death.

Regarding the mortality data quality and plausibility, the results showed minimal age heaping and misreporting, consistent with earlier studies (Chandramohan et al., 2008; Lankoandé et al., 2022; Lyons-Amos & Stones, 2017). The Whipple's Index indicated that the data were highly accurate and reliable, contrary to most studies on age data in sub-Saharan Africa (Elo et al., 2013; Fayehun et al., 2019; Randall & Coast, 2016; Womack et al., 2020).

The results showed that most of the deceased were aged 75 years and above (36.3%), male (57.1%), married (42.8%), farmers (67.3%), from the least poor households (37.3%), had no education (77.8%), and were affiliated with the Christian religion (56.7%). A high proportion of deaths occurred in 2012, 2013, and 2015, with more than half (59.1%) occurring in the dry season and almost two-thirds (65.5%) occurring at home.

Cerebrovascular and cardiovascular diseases, infectious and parasitic diseases, transport accidents and injuries, and intestinal infectious and diarrheal diseases were the leading specific causes of death. The study found a coexistence of both communicable and non-communicable diseases, posing a double burden on households, as documented by Agyei-Mensah & De-Graft Aikins (2010). NCDs were the leading cause of mortality from 2012-2018, contributing sixty-four (46.0) percent of premature deaths, followed by CDs (37.4%) and road traffic accidents and injuries (10.9 percent). Almost six (6) percent of deaths were attributed to unknown causes. The total disease burden in the study area generally declined over the period, with deaths from NCDs falling from 55.7 percent in 2012 to 35.7 percent in 2018. Deaths from CDs, on the other hand, fluctuated from 36.1 percent in 2012, increased to 40.8 percent in 2014, declined to less than forty percent between 2015 and 2017 and rose to 44.8 percent in 2018. The results also showed that external causes were declining. However, deaths from unknown causes increased from less than two per cent in 2012 to 10.4 percent and 8.0 per cent in 2017 and 2018, respectively. The decline in general mortality could be attributed to health interventions, including the Navrongo Community Health and Family Planning Project (CHFP) (Debpuur et al., 2002), the implementation of the Community Health Planning and Service (CHPS) (Sakeah et al., 2018), and health operation research and communication activities that improved health service access and utilization.

At the bivariate analysis level, age, sex, educational attainment, religion, marital status, socio-economic status, place of death, occupation, and year of death were significantly related to the causes of death, while no significant relationship was found between the season of death and causes of death. Across the sexes, there were marked differentials in the risk of dying from various causes. The majority of deaths due to NCDs and transport accidents were among men, while the proportion of deaths from CDs was higher in females (40.3%) than in males (35.1%). SES was also significant, with a higher proportion of deaths from CDs reported among the least poor category (30.3%).

The multinomial logistic regression results indicated that age, sex, marital status, socioeconomic status (wealth status), education, religion of affiliation and place of death were the significant determinants of the causes of mortality in the study area, while occupation, year of death and season of death were not significantly associated with causes of mortality.

The study comprehensively assessed the impact of eliminating communicable diseases (CDs), non-communicable diseases (NCDs), and external causes of mortality on life expectancy at birth in the Kassena-Nankana East (KNE) and West (KNW) districts. The key findings from the decomposition analysis revealed significant variations in the contribution of different age groups to life expectancy gains when these major causes of death were hypothetically removed. The summary of the key findings is as follows:

First, the analysis showed that the removal of CDs would lead to an overall increase in life expectancy by 5.2 years. Individuals aged 75-79 years contributed the most (34.0 percent) to the gains in life expectancy, while those aged 80 years and above contributed the least (-21 percent), highlighting a diminishing return on life expectancy improvements among the oldest age groups. The combined contribution of early childhood (ages 0-9 years) to life expectancy gains without CDs was 7.7 percent, reflecting the significant impact of communicable diseases on young children in this population.

Secondly, if NCDs were eliminated, the total change in life expectancy at birth would increase by 6.7 years. The highest contributors were individuals aged 75-79 years, accounting for 27.3 percent of the total gains in life expectancy, demonstrating that NCDs disproportionately affect older adults. Children under five years and those aged 5-14 years had a combined contribution of only 3.2 percent to the total gains, indicating that NCDs are predominantly a concern for older populations. Adults aged 55-79 years contributed over three-quarters (76.2 percent) to the overall increase in life expectancy, emphasizing the need for targeted NCD interventions among middle-aged and elderly individuals.

Thirdly, the removal of external causes of mortality, such as accidents and injuries, was associated with a total increase of 2.1 years in life expectancy at birth. The age group 70-74 years contributed the most to the gains in life expectancy from eliminating external causes. Individuals aged 25-29 years saw higher gains in longevity (14.9 percent) without external causes compared to those seen with the elimination of CDs (2.2 percent) and NCDs (3.0 percent). Those aged 80 years and above contributed negatively to improvements in life expectancy without external causes, suggesting that other health conditions significantly impact this age group. Although primary health care has focused on maternal and child health, there is a need for more attention to adult chronic disease management.

Again, the study found that the benefits of eliminating different causes of death were not uniform across age groups, with older age groups (particularly those aged 75-79 years) consistently contributing the most to gains in life expectancy when CDs and NCDs were removed. Younger age groups, particularly those under five years, had relatively lower contributions to life expectancy gains from the elimination of NCDs and external causes, underscoring the need for more age-appropriate health interventions. The results highlighted that targeted interventions focusing on the most affected age groups could yield substantial improvements in overall life expectancy.

These findings provide critical insights into the demographic-specific impacts of major causes of mortality in the KNE and KNW districts, informing the development of targeted public health policies and resource allocation strategies to maximize gains in life expectancy. While the hypothetical elimination of CDs and NCDs presents a promising scenario, achieving this is complex. CDs like malaria and TB are influenced by environmental and socioeconomic factors, requiring substantial improvements in healthcare, infrastructure, and living conditions. NCD prevention necessitates public health interventions, lifestyle changes, early detection, and improved access to healthcare services. Thus, the elimination of CDs and NCDs in Ghana could result in significant life expectancy gains, possibly adding 8 to 12 years. However, this would require massive investments in healthcare, public health infrastructure, and socioeconomic development, emphasizing the importance of addressing both disease types simultaneously to improve overall health outcomes and life expectancy in the country.

9.3 Conclusion

This study comprehensively assessed the impact of different causes of mortality on longevity in the Kassena-Nankana East and West Districts of the Upper East Region of Ghana. The study results revealed that communicable causes of death accounted for a higher proportion of under-five mortality among households in the study area, while non-communicable causes were responsible for high adult mortality. In the context of scarce resources, these are key areas that health practitioners should target to reduce mortality in these population groups. The study also found that most deaths among young adults were due to external causes, including transport accidents and injuries. However, there is clear evidence that NCD mortality is now rising in many parts of sub-Saharan Africa. This finding contrasts with many studies in the sub-region, which suggest that CDs remain the leading cause of death in many SSA countries.

By employing multiple decrements and associated single-decrement life table techniques, the study highlighted how various diseases, including communicable diseases (CDs), non-communicable diseases (NCDs), and external causes, contribute differently to the overall mortality burden and life expectancy in the study area. The findings underscored the critical role that CDs, NCDs, and external causes play in shaping the mortality landscape, with NCDs emerging as the leading cause of death, particularly among older age groups. It was evident that eliminating or significantly reducing these causes of death could lead to substantial gains in life expectancy, though the magnitude of these gains varied across different age groups and causes.

The study revealed a polarized epidemiological transition, where both CDs and NCDs continue to coexist, contributing to a double burden of disease. This duality poses significant challenges for public health planning and resource allocation, necessitating tailored interventions to address both infectious and chronic disease burdens simultaneously. The findings align with global health targets such as the Sustainable Development Goals (SDGs), particularly Goal 3, which aims to ensure healthy lives and promote well-being for all ages. By modelling the hypothetical elimination of CDs, NCDs, and external causes, the study highlighted the potential for improved longevity and emphasized the need for strategic health interventions to achieve these outcomes.

9.4 Recommendations

Based on the findings, the following recommendations are made for policy and future research.

9.4.1 Policy Recommendations

The evidence from the study showed that households in the study area faced a triple burden of communicable, non-communicable, and external causes of mortality, with non-communicable diseases being the leading cause of death among broad causes. It was evident that reducing NCDs as the major cause of death would have the most significant impact in reducing mortality in the study area and contribute more to additional years of life gained compared to eliminating other causes of death. However, health attention at regional, national, and local levels largely focused on communicable diseases. Given that NCDs contributed the most significant burden to mortality in the study area, efforts should be intensified to prevent and manage chronic diseases such as hypertension, diabetes, and cancers. This includes increasing access to early diagnosis, enhancing primary healthcare services, promoting healthy lifestyles, and implementing targeted public awareness campaigns on the risk factors of NCDs.

Secondly, despite the prominence of NCDs, communicable diseases remain a significant cause of death, especially among younger populations. There is a need to strengthen disease surveillance, improve vaccination coverage, and enhance vector control programs, particularly for malaria and tuberculosis. Public health education on preventive measures such as hygiene, sanitation, and safe sexual practices should also be prioritized.

Thirdly, to address the burden of external causes, including road traffic accidents and other injuries, the government should enforce stricter road safety regulations, improve road infrastructure, and promote the use of protective gear such as helmets and seatbelts. Additionally, mental health support and awareness programs are needed to address self-harm and assault-related deaths

Fourthly, the coexistence of CDs and NCDs highlights the need for an integrated approach to healthcare. Health services should be restructured to provide comprehensive care that addresses both infectious and chronic diseases, ensuring that individuals receive holistic treatment and management across the life course

Fifthly, efforts aimed at reducing the health burden of diseases should extend beyond hospital settings to include home care, particularly for the aged and chronically sick patients, to improve their health status. Admittedly, resource constraints could be a major barrier to implementing this recommendation. Therefore, the Ghana Health Service could leverage its existing community outreach programs and CHPS models to incorporate a home-based care component for the aged and chronically ill patients to reduce mortality in the community. The aged bore the greatest burden of NCDs, which was found to be the leading broad cause of mortality in the study districts. The data suggested that most NCD-related deaths occurred outside hospital facilities. Therefore, introducing home-based treatment for NCDs could potentially avert more deaths in the study area.

Additionally, the workplace environment could serve as a conducive setting for screening and treating diseases while instituting policies that promote healthy lifestyle behaviours. The Ghana Health Service should encourage and promote health screenings at workplaces as a mechanism for early detection and treatment. Identifying potentially high-risk occupations could also shift health providers' focus towards providing education and promoting positive behaviours to reduce risks. Moreover, introducing award packages and incentives for employees to achieve specific health goals could serve as a strategy to reduce the burden of CDs and NCDs through workplace interventions.

Finally, health stakeholders needed to explore churches, schools, and workplace environments as potential avenues for health intervention programs, including health screenings and education, to improve health outcomes. Evidence from other studies indicated that members of religious sects that prescribed and proscribed health behaviours and practices strongly influenced health outcomes.

9.4.2 Recommendations for future research

The present study was largely quantitative in its approach. In many African countries and settings, sociocultural theories provide explanations for causes of death that may not align with the International Disease Classifications. This study found that about six percent of the deaths were categorized as unknown. Qualitative interviews could have highlighted some of the cultural aspects of the causes of death, which this study could not explore due to data limitations. Therefore, further studies should employ qualitative approaches to explore socio-cultural theories of causes of death.

Additionally, there were limited studies that estimated the impact of CDs and NCDs on population longevity, especially using national-level data. More studies in this area are needed, particularly those with national coverage.

REFERENCES

Abubakari, S. W., Bawah, A. A., Nettey, E. O., Apraku, E. A., Zandoh, C., Amenga-etego, S., Asante, K. P., Owusu-agyei, S., & Badasu, D. M. (2019). Potential gains in reproductive-aged life expectancy if maternal mortality were eradicated from the Kintampo districts of Central Ghana. *BMC Pregnancy and Childbirth*, *19*(374), 1–8.

Addo-Yobo, E. (2023). Prevalence and control of intestinal infectious diseases in Northern Ghana. *Ghana Health Journal*, *12*(3), 45–56.

Adeyemi, R. A., Zewotir, T., & Ramroop, S. (2019). A Bayesian Hierarchical Analysis of Geographical Patterns for Child Mortality in Nigeria Abstract : *The Open Public Health Journal*, *12*(4), 247–262. https://doi.org/10.2174/1874944501912010247

Adjorlolo, S., Egbenya, D. L., & Adjorlolo, S. (2020). A twin disaster : Addressing the COVID-19 pandemic and a cerebrospinal meningitis outbreak simultaneously in a low-resource country meningitis outbreak simultaneously in a low-resource country. *Global Health Action*, *13*(1). https://doi.org/10.1080/16549716.2020.1795963

Africa Renewal. (2017). *Health care systems : time for a rethink Pain from crash in commodity prices Africa ' s hopes for new UN chielf*. *March*, 8–9. https://www.un.org/africarenewal/sites/www.un.org.africarenewal/files/Africa_Renewal_En_Dec2016_Mar2017_0.pdf

Agrawal, H., Das, N., Nathani, S., Saha, S., Saini, S., Kakar, S. S., & Roy, P. (2021). An Assessment on Impact of COVID-19 Infection in a Gender Specific Manner. *Stem Cell Reviews and Reports*, *17*, 94–112. https://doi.org/10.1007/s12015-020-10048-z

Agyei-Mensah, S., & De-Graft Aikins, A. (2010). Epidemiological transition and the double burden of disease in Accra, Ghana. *Journal of Urban Health*, *87*(5), 879–897. https://doi.org/10.1007/s11524-010-9492-y

Agyemang, C., Aikins, A. D., Edusei, A. K., Nkum, B. C., & Ogedegbe, G. (2012). Stroke in Ashanti Region of Ghana. *Ghana Medical Journal*, *46*(2), 12–17.

Agyemang, C., & Bhopal, R. S. (2013). The epidemiology of cardiovascular diseases in Ghana. *Cardiovascular Diagnosis and Therapy*, *3*(4), 255–267. https://doi.org/10.3978/j.issn.2223-3652.2013.09.02

Aiello, A. E., Coulborn, R. M., Perez, V., & Larson, E. L. (2008). Effect of hand hygiene on infectious disease risk in the community setting: a meta-analysis. *American Journal of Public Health*, *98*(8), 1372–1381.

Aksan, A.-M., & Chakraborty, S. (2023). Life expectancy across countries: Convergence, divergence and fluctuations. *World Development*, *168*, 106263.

Aku, F. Y., Lessa, F. C., Asiedu-Bekoe, F., Balagumyetime, P., Ofosu, W., Farrar, J., Ouattara, M., Vuong, J. T., Issah, K., Opare, J., Ohene, S.-A., Okot, C., Kenu, E., Ameme, D. K., Opare, D., & Abdul-Karim, A. (2017). Meningitis Outbreak Caused by Vaccine-Preventable Bacterial Pathogens — Northern Ghana, 2016. *Morbidity and Mortality Weekly Report*, *66*(30), 806–810. https://doi.org/10.15585/mmwr.mm6630a2

Akweongo, P., Dalaba, M. A., Hayden, M. H., Awine, T., Nyaaba, G. N., Anaseba, D., Hodgson, A., Forgor, A. A., & Pandya, R. (2013). The Economic Burden of Meningitis to Households in Kassena-Nankana District of Northern Ghana. *PLoS ONE*, *8*(11), 4–9. https://doi.org/10.1371/journal.pone.0079880

Al-Haddad, B. J. S., Jedy-Agba, E., Oga, E., & Adebamowo, C. (2013). *Age Heaping and Cancer Rate Estimation in Nigeria* (No. 2013–03). https://doi.org/10.18128/MPC2013-03

Allotey, P., & Reidpath, D. (2001). Establishing the causes of childhood mortality in Ghana: The "spirit child." *Social Science and Medicine*, *52*(7), 1007–1012. https://doi.org/10.1016/S0277-9536(00)00207-0

Amidu, N., Antuamwine, B. B., Addai-Mensah, O., Abdul-Karim, A., Stebleson, A., Abubakari, B. B., Abenyeri, J., Opoku, A. S., Nkukah, J. E., & Najibullah, A. S. (2019). Diagnosis of bacterial meningitis in Ghana: Polymerase chain reaction versus latex agglutination methods. *PLoS ONE*, *14*(1), 1–8. https://doi.org/10.1371/journal.pone.0210812

Amu, H., Darteh, E. K. M., Tarkang, E. E., & Kumi-Kyereme, A. (2021). Management of chronic non-communicable diseases in Ghana: a qualitative study using the chronic care model. *BMC Public Health*, *21*(1), 1–18. https://doi.org/10.1186/s12889-021-11170-4

Anteneh, A., Araya, T., & Misganaw, A. (2013). Factors associated with place of death in Addis Ababa, Ethiopia. *BMC Palliative Care, 12*(14). https://doi.org/10.1186/1472-684X-12-14

Arcury, T. A., Gesler, W. M., Preisser, J. S., Sherman, J., Spencer, J., & Perin, J. (2005). The Effects of Geography and Spatial Behavior on Health Care Utilization among the Residents of a Rural Region. *HSR: Health Services Research*, *40*(1), 135–156.

Arrow, K. J., Panosian, C., & Gelband, H. (2004). A Brief History of Malaria. In *Saving Lives, Buying Time: Economics of Malaria Drugs in an Age of Resistance* (pp. 125–135). Institute of Medicine (US) Committee on the Economics of Antimalarial Drugs. http://www.nap.edu/catalog/11017.html

Atiga, O., Walters, J., & Pisa, N. (2023). Challenges of medical commodity availability in public and private health care facilities in the Upper East Region of Ghana: a patient-centered perspective. *BMC Health Services Research*, *23*(1), 1–15. https://doi.org/10.1186/s12913-023-09717-9

Austad, S. (2006). Why women live longer than men: sex differences in longevity. *Gend Med*, *3*, 79– 92.

Avdic, D., Hägglund, P., Lindahl, B., & Johansson, P. (2019). Sex differences in sickness absence and the morbidity-mortality paradox: a longitudinal study using Swedish administrative registers. *BMJ Open*, *9*(8), e024098. https://doi.org/10.1136/bmjopen-2018-024098

Averett, S. L., Sikora, A., & Argys, L. M. (2008). For better or worse: relationship status and body mass index. *Economics and Human Biology*, *6*(3), 330–349. https://doi.org/10.1016/j.ehb.2008.07.003

Awini, E., Sarpong, D., Adjei, A., Manyeh, A. K., Amu, A., Akweongo, P., Adongo, P., Kukula, V., Odonkor, G., Narh, S., & Gyapong, M. (2014). Estimating cause of adult (15 + years) death using InterVA-4 in a rural district of southern Ghana. *Global Health Action*, *7*(1), 1–8. https://doi.org/10.3402/gha.v7.25543

Baiden, F., Bawah, A., Biai, S., Binka, F., Boerma, T., Byass, P., Chandramohan, D., Chatterji, S., Engmann, C., Greet, D., Jakob, R., Kahn, K., Kunii, O., Lopez, A. D., Murray, C. J. L., Nahlen, B., Rao, C., Sankoh, O., Setel, P. W., … Yang, G. (2007). Setting international standards for verbal autopsy. *Bulletin of the World Health Organization*, *85*(8), 570–571. https://doi.org/10.2471/BLT.07.043745

Baider, L., & Surbone, A. (2014). Religious and cultural factors in cancer care in South Africa. *Supportive Care in Cancer*, *22*(7), 1975–1980.

Baird, J., Jacob, C., Barker, M., Fall, C. H. D., Hanson, M., Harvey, N. C., Inskip, H. M., Kumaran, K., & Cooper, C. (2017). Developmental origins of health and disease: A lifecourse approach to the prevention of non-communicable diseases. *Healthcare (Switzerland)*, *5*(1). https://doi.org/10.3390/healthcare5010014

Bangha, M., Wak, G., Jasseh, M., Pison, G., Newton, R., Gomez-Olive, X. F., Sifuna, P., Otieno, W., Sankoh, O., Network, I., Hdss, A., Africa, S., & Hdss, K. (2017). Assessing levels and trends of adult mortality in Sub Saharan Africa using INDEPTH health and demographic surveillance systems. *International Journal for Population*, *August 2020*, 43.

Barclay, S., & Arthur, A. (2008). Place of death-how much does it matter? *British Journal of General Practice*, *58*(549), 228–229. https://doi.org/10.3399/bjgp08X279706

Barendregt, J. J. (2009). “Coping with multiple morbidity in a life table”. *Mathematical Population Studies*, *7*(1), 29–49. https://doi.org/10.1080/08898489809525445

Bärnighausen, T., Bloom, D. E., & Humair, S. (2017). Economics of antiretroviral treatment vs. circumcision for HIV prevention. *Proceedings of the National Academy of Sciences*, *114*(29), 7604–7609.

Barry, J. A. (2014). Caregiving men of Alzheimer ’ s disease sufferers in Nuevo León (Mexico): experiences and meanings. *Vulnerable Groups & Inclusion*, *5*(1). https://doi.org/10.3402/vgi.v5.24166

Basannar, D. R., Singh, S., Yadav, J., & Yadav, A. K. (2022). Quantifying Age Heaping and Age Misreporting in a Multicentric Survey. *Indian Journal of Community Medicine*, *42*(1), 147–

150. https://doi.org/10.4103/ijcm.IJCM

Bawah, A. A., & Binka, F. N. (2007). How Many Years of Life Could Be Saved If Malaria Were Eliminated from a Hyperendemic Area of Northern Ghana ? *American Journal of Tropical Medicine and Hygiene*, *77*(6), 145–152. https://doi.org/10.4269/ajtmh.2007.77.145

Bawah, A., Welaga, P., Azongo, D. K., Wak, G., Phillips, J. F., & Oduro, A. (2014). Road traffic fatalities - a neglected epidemic in rural northern Ghana : evidence from the Navrongo demographic surveillance system. *Injury Epidemiology*, *1*(22), 1–9. https://doi.org/10.1186/s40621-014-0022-3

Bayray, A., Assefa, M., & Bekele, A. (2017). Levels and Trends of Mortality : A Five Year Retrospective Hospital Record Review. *Research & Reviews : Journal of Computational Biology*, *6*(1), 11–24. https://www.researchgate.net/profile/Alemayehu_Bayray/publication/328214930_Levels_and_Trends_of_Mortality_A_Five_Year_Retrospective_Hospital_Record_Review/links/5bc97705299bf17a1c5f7d69/Levels-and-Trends-of-Mortality-A-Five-Year-Retrospective-Hospital-Re

Behera, S., & Pradhan, J. (2022). A combination of moderate and vigorous physical activities reduces the burden of multimorbidity: findings from Longitudinal Ageing Study in India. *Journal of Health, Population and Nutrition*, *41*(1), 1–11. https://doi.org/10.1186/s41043-022-00323-9

Beltrán-sánchez, H., & Andrade, F. C. D. (2016). Time trends in adult chronic disease inequalities by education in Brazil : 1998 – 2013. *International Journal for Equity in Health*, *15*, 139. https://doi.org/10.1186/s12939-016-0426-5

Beltran-Sanchez, H., & Preston, S. (2007). *A New Method for Attributing Changes in Life Expectancy to Various Causes of Death , with Application to the United States* (No. 07–01; PSC Working Paper Series).

Benchimol, E. I., Manuel, D. G., To, T., Griffiths, A. M., Rabeneck, L., & Guttmann, A. (2011). Development and use of reporting guidelines for assessing the quality of validation studies of health administrative data. *Journal of Clinical Epidemiology*, *64*(8), 821–829.

https://doi.org/10.1016/j.jclinepi.2010.10.006

Beng, K., Fong, W., & Shum, E. (2009). Where the Elderly Die: The Influence of Socio-Demographic Factors and Cause of Death on People Dying at Home. *Ann Acad Med Singapore*, *38*, 676–683.

Biritwum, R. B., Mensah, G., Minicuci, N., Yawson, A. E., Naidoo, N., Chatterji, S., Kowal, P., Biritwum, R. B., Mensah, G., Minicuci, N., Yawson, A. E., Biritwum, R. B., Mensah, G., Minicuci, N., Yawson, A. E., Naidoo, N., & Chatterji, S. (2013). Household characteristics for older adults and study background from SAGE Ghana Wave 1. *Global Health Action ISSN:*, *6*(1), 20096. https://doi.org/10.3402/gha.v6i0.20096

Bjørnstad, O., Finkenstädt, B., & Grenfell, B. (2002). Dynamics of measles epidemics: estimating scaling of transmission rates using a time series SIR model. *Ecol Monogr.*, *72*, 169–184.

Boah, M., Yeboah, D., Kpordoxah, M. R., Issah, A. N., & Adokiya, M. N. (2023). Temporal trend analysis of the HIV/AIDS burden before and after the implementation of antiretroviral therapy at the population level from 1990 to 2020 in Ghana. *BMC Public Health*, *23*, 1399. https://doi.org/10.1186/s12889-023-16321-3

Boakye, H., Atabila, A., Hinneh, T., Ackah, M., Ojo-Benys, F., & Bello, A. I. (2023). The prevalence and determinants of noncommunicable diseases among Ghanaian adults: A survey at a secondary healthcare level. *PLoS ONE*, *18*(2 February), 1–14. https://doi.org/10.1371/journal.pone.0281310

Bosu, W. (2010). Epidemic of hypertension in Ghana: a systematic review. *BMC Public Health*, *10*, 418.

Bosu, W. K. (2015). The Epidemiology of Hypertension and its Cardiovascular Implications in Ghana. *Cardiovascular Diagnosis and Therapy*, *5*(1), 30–38. https://doi.org/10.3978/j.issn.2223-3652.2014.09.05.

Brathwaite, R., Addo, J., Kunst, A. E., Agyemang, C., Owusu-Dabo, E., De-Graft Aikins, A., Beune, E., Meeks, K., Klipstein-Grobusch, K., Bahendeka, S., Mockenhaupt, F. P., Amoah, S., Galbete, C., Schulze, M. B., Danquah, I., & Smeeth, L. (2017). Smoking prevalence differs by location of residence among Ghanaians in Africa and Europe: The RODAM study. *PLoS ONE*, *12*(5), 1–15. https://doi.org/10.1371/journal.pone.0177291

Burkart, K., Khan, M. H., Krämer, A., Breitner, S., Schneider, A., & Endlicher, W. R. (2011). Seasonal variations of all-cause and cause-specific mortality by age , gender , and socioeconomic condition in urban and rural areas of Bangladesh. *International Journal for Equity in Health*, *10*, 32.

Cacciani, L., Bargagli, A. M., Cesaroni, G., Forastiere, F., Agabiti, N., & Davoli, M. (2015). Education and mortality in the Rome longitudinal study. *PLoS ONE*, *10*(9), 1–12. https://doi.org/10.1371/journal.pone.0137576

Canudas-romo, V., Liu, L., Zimmerman, L., Ahmed, S., & Tsui, A. (2014). Potential Gains in Reproductive-Aged Life Expectancy by Eliminating Maternal Mortality : A Demographic Bonus of Achieving MDG 5. *PLoS ONE*, *9*(2), 1–7. https://doi.org/10.1371/journal.pone.0086694

Caulkins, J., Grass, D., Feichtinger, G., Hartl, R., Kort, P. M., Prskawetz, A., Seidl, A., & Wrzaczek, S. (2020). How long should the COVID-19 lockdown continue? *PLoS ONE*, *15*(12 December), 1–19. https://doi.org/10.1371/journal.pone.0243413

Centers for Disease Control and Prevention (CDC). (2020). *HIV and injection drug use*.

Centers for Disease Control and Prevention (CDC. (2012). *Principles of Epidemiology in Public Health Practice*, (Third). https://doi.org/10.1201/9781315381848

Centre for Disease Control. (2022). *Ghana Fact Sheet 2022*. https://www.cdc.gov/globalhealth/countries/ghana/

Chandramohan, D., Shibuya, K., Setel, P., Cairncross, S., Lopez, A. D., Murray, C. J. L., Basia, Z., Snow, R. W., & Binka, F. (2008). Should Data from Demographic Surveillance Systems Be Made More Widely Available to Researchers ? *The PLoS Medicine Debate*, *5*(2), 169–173. https://doi.org/10.1371/journal.pmed.0050057

Chisumpa, V. H., Odimegwu, C. O., & Saikia, N. (2019). Mortality in Sub-Saharan Africa: What is Killing Adults Aged 15-59 Years in Zambia? In *Vienna Institute of Demography Working*

Papers (04/2019). https://doi.org/10.1553/0x003cb430

Citi Newsroom. (2020, April 7). *33 CSM deaths in Upper West: Rashid Pelpuo writes to Akufo-Addo on 'lack of expeditious action.'* https://citinewsroom.com/2020/04/33-deaths-from-csm-in-upper-west-dr-rashid-pelpuo-writes-to-president-akufo-addo-on-lack-of-expeditious-action/

Codjoe, S. N. A., Okutu, D., & Mumuni, A. (2016). Urban Household Characteristics and Dietary Diversity : An Analysis of Food Security in Accra , Ghana. *Food and Nutrition Bulletin*, *37*(2), 202–218. https://doi.org/10.1177/0379572116631882

Connolly, M. A., Gayer, M., Ryan, M. J., Salama, P., Spiegel, P., & Heymann, D. L. (2004). Communicable diseases in complex emergencies: Impact and challenges. *The Lancet*, *364*(944), 1974–1983. https://doi.org/10.1016/S0140-6736(04)17481-3

Cox, F. E. (2013). History of the discovery of the malaria parasites and their vectors. *Parasites & Vectors*, *3*(5), 1–8. https://doi.org/10.4018/jec.2013010101

Crimmins, E. M., Shim, H., Zhang, Y. S., & Kim, J. K. (2019). Differences between Men and Women in Mortality and the Health Dimensions of the Morbidity Process. *Clinical Chemistry*, *65*(1), 135–145. https://doi.org/10.1373/clinchem.2018.288332.Differences

Cuevas, L. E., Jeanne, I., Molesworth, A., Bell, M., Savory, E. C., Connor, S. J., & Thomson, M. C. (2007). Risk mapping and early warning systems for the control of meningitis in Africa. *Vaccine*, *25*(SUPPL. 1), A12–A17. https://doi.org/10.1016/j.vaccine.2007.04.034

Curtis, S. (2004). *Health and inequality: geographical perspectives.* Sage.

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

Dalstra, J. A. A., Kunst, A. E., Borrell, C., Breeze, E., Cambois, E., Costa, G., Geurts, J. J. M., Lahelma, E., Oyen, V. H., Rasmussen, N. K., Regidor, E., Spadea, T., & Mackenbach, J. P. (2005). Socioeconomic differences in the prevalence of common chronic diseases : an overview of eight European countries. *Int J Epidemiol* ., *34*(2), 316–326. https://doi.org/10.1093/ije/dyh386

de-Graft Aikins, A. (2007). Ghana's neglected chronic disease epidemic: a developmental challenge. *Ghana Medical Journal*, *41*(4), 154–159. http://www.ncbi.nlm.nih.gov/pubmed/18464903%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC2350116

http://www.ncbi.nlm.nih.gov/pubmed/18464903%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC2350116

de-Graft Aikins, A., Addo, J., Ofei, F., Bosu, W., & Agyemang, C. (2012). Ghana's burden of chronic non-communicable diseases: future directions in research, practice and policy. *Ghana Medical Journal*, *46*(2 Suppl), 1–3.

de-Graft Aikins, A., Addo, J., Offei, F., Bosu, W. ., & Agyemang, C. (2012). Ghana's burden of chronic non-communicable diseases: future directions in research, practice and policy. *Ghana Medical Journal*, *46*(2), 29–38. http://www.globalizationandhealth.com/series.%0Ahttps://www.ajol.info/index.php/gmj/article/view/88737

De-Graft Aikins, A., Anum, A., Agyemang, C., Addo, J., & Ogedegbe, O. (2012). Lay Representations of Chronic Diseases in Ghana: Implications for Primary Prevention. *Ghana Medical Journal*, *46*(2), 59–68.

de-Graft Aikins, A., Boynton, P., & Atanga, L. L. (2010). Developing effective chronic disease interventions in Africa: Insights from Ghana and Cameroon. *Globalization and Health*, *6*(6), 6–8. https://doi.org/10.1186/1744-8603-6-6

de-Graft Aikins, A., Kushitor, M., Koram, K., Gyamfi, S., & Ogedegbe, G. (2014). Chronic non-communicable diseases and the challenge of universal health coverage: insights from community-based cardiovascular disease research in urban poor communities in Accra, Ghana. *BMC Public Health*, *14*(Suppl 2), 1–9.

Dharmaratne, S. D., Jayasuriya, R. L., Perera, B. Y., Gunesekera, E., & Sathasivayyar, A. (2011).

Opportunities and challenges for verbal autopsy in the national Death Registration System in Sri Lanka: past and future. *Population Health Metrics*, *9*(21).

Duncan, B., Rumel, D., Zelmanowicz, A., Mengue, S., & dos Santos, S. (1995). Social inequality in mortality in Sao Paulo State, Brazil. *International Journal of Epidemiology*, *24*, 359–365.

Durkheim, E. (1951). *SuicideGlencoe, Ill, The Free Press.* (Glencoe, I). The Free Press.

Dye, C. (2014). After 2015: Infectious diseases in a new era of health and development. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1645). https://doi.org/10.1098/rstb.2013.0426

Egunsola, O., Raubenheimer, J., & Buckley, N. (2019). Variability in the burden of disease estimates with or without age weighting and discounting : a methodological study. *BMJ Open*, *9*(e027825), 10–15. https://doi.org/10.1136/bmjopen-2018-027825

Ehlers, V. J. (2006). Challenges and opportunities of health service delivery in the context of HIV/AIDS. *Curationis*, *29*(2), 1–9. https://doi.org/https://doi.org/10.4102/curationis.v29i2.1061

Elo, I. T., Mykyta, L., Sebastiani, P., Christensen, K., Glynn, N. W., & Perls, T. (2013). Age validation in the Long Life Family Study through a linkage to early-life census records. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*, *68*(4), 580–585. https://doi.org/10.1093/geronb/gbt033

Fantahun, M., Berhane, Y., Högberg, U., Wall, S., & Byass, P. (2008). Young adult and middle age mortality in Butajira demographic surveillance site, Ethiopia: Lifestyle, gender and household economy. *BMC Public Health*, *8*, 268. https://doi.org/10.1186/1471-2458-8-268

Fayehun, O., Ajayi, A. I., Onuegbu, C., & Egerson, D. (2019). Age heaping among adults in Nigeria: evidence from the Nigeria Demographic and Health Surveys 2003-2013. *Journal of Biosocial Science*, *52*(1), 132–139. https://doi.org/10.1017/S0021932019000348

Feinstein, C. A. (2002). Seasonality of Deaths in the U . S . by Age and Cause. *Demographic Research A*, *6*(17). https://doi.org/10.4054/DemRes.2002.6.17

Ferrari, M., Grais, R., & Bharti, N. (2008). The dynamics of measles in sub-Saharan Africa. *Nature*, *451*, 679.

Floyd, J. R. (2018). The impact of diabetes and cancer on life expectancy: Implications for public health policy. *Global Health Action*, *11*(1), 1501622. https://doi.org/10.1080/16549716.2018.1501622

Fottrell, E, & Byass, P. (2010). Verbal Autopsy: Methods in Transition. *Epidemiologic Reviews*, *32*, 38–55.

Fottrell, Edward. (2009). Dying to count: Mortality surveillance in resource-poor settings. *Global Health Action*, *2*(1), 1–7. https://doi.org/10.3402/gha.v2i0.1926

Gähler, M. (2006). “To divorce is to die a bit”: a longitudinal study of marital disruption and psychological distress among Swedish women and men. *The Family Journal*, *14*(4), 372–82.

Gallup, J. L., & Sachs, J. D. (2001). The Economic Burden of Malaria. *The American Journal of Tropical Medicine and Hygiene*, *64*(1), 85–96. https://doi.org/doi:10.4269/ajtmh.2001.64.85

García-pando, C. P., Thomson, M. C., Stanton, M. C., Diggle, P. J., Hopson, T., Pandya, R., Miller, R. L., & Hugonnet, S. (2014). *Meningitis and climate : from science to practice*. 1–15.

Gardner, G., & Halweil, B. (2000). Underfed and overfed: The global epidemic of malnutrition. In *Worldwatch Paper* (Issue 150).

GBD 2016 Meningitis Collaborators. (2018). Global , regional , and national burden of meningitis , 1990 – 2016 : a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet Neurology*, *17*(December). https://doi.org/10.1016/S1474-4422(18)30387-9

George, L. K., Ellison, C. G., & Larson, D. B. (2002). Explaining the Relationships between Religious Involvement and Health. *Psychological Inquiry*, *13*(3), 190–200.

Gesteiro, E., García-Carro, A., Aparicio-Ugarriza, R., & González-Gross, M. (2022). Eating out of Home: Influence on Nutrition, Health, and Policies: A Scoping Review. *Nutrients*, *14*, 1265. https://doi.org/10.3390/nu14061265

Ghana Health Service. (2016). *Ghana Health Service Annual Report*.

Ghana Health Service. (2018). *Ghana Health Services: The health sector in Ghana: Facts and Figures*. https://www.ghanahealthservice.org/downloads/Ghana_Health_Service_2018_Annual_Report.pdf

Ghana Health Service (GHS). (2022). *Annual Report on Communicable Diseases in Ghana*.

Ghana Statistical Service. (2010). *2010 Population and Housing Census Report: Mortality*.

Ghana Statistical Service. (2013). 2010 Population & Housing Census National Analytical Report. In *Ghana Statistical Service*.

Ghana Statistical Service. (2014a). *2010 Population and Housing Census: District Analytical Report Kassena Nankana West District*. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www2.statsghana.gov.gh/docfiles/2010_District_Report/Upper East/Kasena Nankana West.pdf

Ghana Statistical Service. (2014b). *Ghana Living Standards Survey (GLSS6)*. https://doi.org/10.4337/9781848446175.00006

Ghana Statistical Service. (2015). *Ghana Poverty Mapping Report*. http://marefateadyan.nashriyat.ir/node/150

Ghana Statistical Service. (2021a). *2021 Population and Housing Census: General Report Volume 3A*.

Ghana Statistical Service. (2021b). *Ghana 2021 Population and Housing Census General Report*.

Ghana Statistical Service. (2021c). *The Ghana 2021 Population and Housing Census (PHC) Volume 2: Proximity of Residential Structures to Essential Service Facilities*.

GhanaDistricts. (2023). *Ghana Districts: A repository of all Local Assemblies in Ghana*.

Gisquet, E., Julliard, S., & Geoffroy-Perez, B. (2016). Do social factors affect the place of death? Analysis of home versus institutional death over 20 years. *Journal of Public Health (United Kingdom)*, *38*(4), e472–e479. https://doi.org/10.1093/pubmed/fdv167

Glei, D. A., Barbieri, M., & Santamaría-Ulloa, C. (2019). Costa Rican mortality 1950-2013: An evaluation of data quality and trends compared with other countries. *Demographic Research*, *40*, 835–864. https://doi.org/10.4054/DemRes.2019.40.29

Gold, M. R., Stevenson, D., & Fryback, D. G. (2002). HALYs and QALYs and DALYs, oh my: Similarities and differences in summary measures of population health. *Annual Review of Public Health*, *23*, 115–134. https://doi.org/10.1146/annurev.publhealth.23.100901.140513

Gomes, B., & Higginson, I. J. (2006). Factors influencing death at home in terminally ill patients with cancer: Systematic review. *British Medical Journal*, *332*(7540), 515–518. https://doi.org/10.1136/bmj.38740.614954.55

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

Goudge, J., Gilson, L., Russell, S., Gumede, T., & Mills, A. (2009). Affordability, availability and acceptability barriers to health care for the chronically ill: Longitudinal case studies from South Africa. *BMC Health Services Research*, *9*(75), 1–18. https://doi.org/10.1186/1472-6963-9-75

Gouveia, N., & Fletcher, T. (2000). Time series analysis of air pollution and mortality : e V ects by cause , age and socioeconomic status. *Journal Epidemiol Community Health*, *54*, 750–755.

Grippo, F., Navarra, S., Orsi, C., Manno, V., Grande, E., Crialesi, R., Frova, L., Marchetti, S., Pappagallo, M., Simeoni, S., Di Pasquale, L., Carinci, A., Donfrancesco, C., Lo Noce, C., Palmieri, L., Onder, G., & Minelli, G. (2020). The Role of COVID-19 in the Death of SARS-CoV-2–Positive Patients: A Study Based on Death Certificates. *Journal of Clinical Medicine*, *9*(11), 3459. https://doi.org/10.3390/jcm9113459

GSS; GHS; ICF International. (2014). Ghana demographic health survey. In *Demographic and*

Health Survey 2014.

Gwatkin, D.R., & Heuveline, P. I. (1997). Improving Health Outcomes of the Poor. *British Medical Journal*, *515*(7107), 497–498.

Gwatkin, Davidson R, Guillot, M., & Heuveline, P. (1999). The burden of disease among the global poor. *Lancet*, *354*, 586–589.

Gyasi, R. M., Phillips, D. R., & Meeks, S. (2020). Aging and the Rising Burden of Noncommunicable Diseases in Sub-Saharan Africa and other Low- A nd Middle-Income Countries: A Call for Holistic Action. *Gerontologist*, *60*(5), 806–811. https://doi.org/10.1093/geront/gnz102

Habaasa, G. (2022). The contribution of social norms and religious practices towards low death registration in 3 HDSS sites of Uganda. *BMC Health Services Research*, *22*(1), 1–10. https://doi.org/10.1186/s12913-022-08589-9

Haileamlak, A. (2019). Physical Inactivity: The Major Risk Factor for Non-Communicable Diseases. *Ethiopian Journal of Health Sciences*, *29*(1), 810. https://doi.org/10.4314/ejhs.v29i1.1

Hansen, S., Tolle, S., & Martin, D. (2002). Factors Associated with Lower Rates of In-Hospital Death. *J Palliat Med*, *5*, 677–685.

Harris, C. R., Jenkins, M., & Glaser, D. (2006a). Gender Differences in Risk Assessment : Why do Women Take Fewer Risks than Men ? *American Psychological Association*, *1*(1), 48–63.

Harris, C. R., Jenkins, M., & Glaser, D. (2006b). Influence of peritoneal dialysis on factors affecting oxygen transport. *Judgment and Decision Making*, *1*(1), 48–63. https://doi.org/10.1159/000180527

Herbst, A. J., Mafojane, T., & Newell, M. L. (2011). Verbal autopsy-based cause-specific mortality trends in rural KwaZulu-Natal, South Africa, 2000-2009. *Population Health Metrics*, *9*, 1–13. https://doi.org/10.1186/1478-7954-9-47

Herrera, S., Enuameh, Y., Adjei, G., Ae-Ngibise, K. A., Asante, K. P., Sankoh, O., Owusu-Agyei, S., & Yé, Y. (2017). A systematic review and synthesis of the strengths and limitations of measuring malaria mortality through verbal autopsy. *Malaria Journal*, *16*(1), 1–8. https://doi.org/10.1186/s12936-017-2071-x

Heuschen, A. K., Abdul-Mumin, A., Adokiya, M., Lu, G., Jahn, A., Razum, O., Winkler, V., & Müller, O. (2022). Impact of the COVID-19 pandemic on malaria cases in health facilities in northern Ghana: a retrospective analysis of routine surveillance data. *Malaria Journal*, *21*(149), 1–8. https://doi.org/10.1186/s12936-022-04154-1

Hill, K., Lopez, A. D., Shibuya, K., & Jha, P. (2009). Interim measures for meeting needs for health sector data: birth and death registration and improved estimates of mortality. *The Lancet*, *373*(9681), 1343–1351.

Hill, T. D., Saenz, J. L., & Rote, S. M. (2020). Religious Participation and Mortality Risk in Mexico. *The Journals of Gerontology*, *75*(5), 1053–1061.

Hodgson, A., Smith, T., Gagneux, S., Adjuik, M., Pluschke, G., Mensah, N. K., Binka, F., & Genton, B. (2001). Risk factors for meningococcal meningitis in northern Ghana. *Transactions of The Royal Society of Tropical Medicine and Hygiene*, *95*(5), 447–480.

Holliman, R. E., Liddy, H., Johnson, J. D., & Adjei, O. (2007). Epidemiology of invasive pneumococcal disease in Kumasi, Ghana. *Transactions of The Royal Society of Tropical Medicine and Hygiene*, *101*(4), 405–413. https://doi.org/https://doi.org/10.1016/j.trstmh.2006.08.014

Horton, R. (2012). The Global Burden of Disease Study 2010 (GBD 2010. *The Lancet.*, *380*(9859), 2053–2054.

Houle, B., Clark, S. J., Kahn, K., Tollman, S., & Yamin, A. E. (2015). The impacts of maternal mortality and cause of death on children ’ s risk of dying in rural South Africa : evidence from a population based surveillance study (1992-2013). *Reproductive Health*, *2(Suppl 1)*(1 S7). https://doi.org/10.1186/1742-4755-12-S1-S7

Hurt, L., Ronsmans, C., & Saha, S. (2004). Effects of education and other socioeconomic factors on middle age mortality in rural Bangladesh. : *Journal of Epidemiology and Community*

Health, *58*, 315–320.

Huynen, M. M., Martens, P., Schram, D., Weijenberg, M. P., & Kunst, A. E. (2001). The impact of heat waves and cold spells on mortality rates in the Dutch population. *Environmental Health Perspectives*, *109*, 463–470.

Idler, E., Blevins, J., Kiser, M., & Hogue, C. (2017). Religion , a social determinant of mortality ? A 10-year follow-up of the Health and Retirement Study. *PLoS ONE*, *12*(12), e0189134.

Irma, E. T., & Preston, H. S. (1992). Effects of Early-Life Conditions on Adult Mortality: A Review. *Office of Population Research*, *58*(2), 186–212. http://www.jstor.org/stable/3644718 Accessed: 19-09-2016 14:46 UTC

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*(1). https://doi.org/10.1186/s12992-014-0081-9

Jacobsen, R., Oksuzyan, A., Engberg, H., Jeune, B., Vaupel, J. W., & Christensen, K. (2008). Sex differential in mortality trends of old-aged Danes: A nation wide study of age, period and cohort effects. *European Journal of Epidemiology*, *23*(11), 723–730. https://doi.org/10.1007/s10654-008-9288-5

Jamison, D. T., Summers, L. H., Alleyne, G., Arrow, K. J., Berkley, S., Binagwaho, A., & Yamey, G. (2013). Global health 2035: A world converging within a generation. *The Lancet*, *382*(9908), 1898–1955. https://doi.org/https://doi.org/10.1016/S0140-6736(13)62105-4

Jasseh, M., Howie, S. R. C., Gomez, P., Scott, S., Roca, A., Cham, M., Greenwood, B., Corrah, T., & D’Alessandro, U. (2014). Disease-specific mortality burdens in a rural Gambian population using verbal autopsy, 1998-2007. *Global Health Action*, *7*(1). https://doi.org/10.3402/gha.v7.25598

Jay, S., Carnesb, B. A., Rogersc, R. G., & Smifhd, L. (1998). Emerging infectious diseases : the Fifth stage of the epidemiologic transition ? *Wld Hlth Statist. Quatt*, *51*, 207–217.

Jha, P. (2012). Counting the dead is one of the world’s best investments to reduce premature mortality. *Hypothesis*, *10*(1), 1–6. https://doi.org/10.5779/hypothesis.v10i1.211

Jo, C. (2014). Cost-of-illness studies: concepts, scopes, and methods. *Clinical and Molecular Hepatology*, *20*(4), 327–337. https://doi.org/10.3350/cmh.2014.20.4.327

Joung, I. M. A., Van De Mheen, H. D. Stronks, K., & Van Poppel, F. W. A. Mackenbach, J. P. (1998). A longitudinal study of health selection in marital transitions. *Social Science & Medicine*, *46*(3), 425–435. https://doi.org/10.1016/S0277-9536(97)00186-X

Juma, K., A. Juma, P., Shumba, C., Otieno, P., & Asiki, G. (2020). Non-Communicable Diseases and Urbanization in African Cities: A Narrative Review. *In Public Health in Developing Countries - Challenges and Opportunities*, *November*. https://doi.org/10.5772/intechopen.89507

Kaburi, B. B., Kubio, C., Kenu, E., Ameme, D. K., Mahama, J. Y., Sackey, S. O., & Afari, E. A. (2017). Evaluation of bacterial meningitis surveillance data of the northern region, Ghana, 2010-2015. *Pan African Medical Journal*, *27*(164). https://doi.org/10.11604/pamj.2017.27.164.11036

Kaburi, B. B., Kubio, C., Kenu, E., Nyarko, K. M., Mahama, J. Y., Sackey, S. O., & Afari, E. A. (2017). Evaluation of the enhanced meningitis surveillance system, Yendi municipality, northern Ghana, 2010-2015. *BMC Infectious Diseases*, *17*(1), 1–11. https://doi.org/10.1186/s12879-017-2410-0

Kaplan, R. M., & Kronick, R. G. (2006). Marital status and longevity in the United States population. *Journal of Epidemiology and Community Health*, *60*(9), 760–765. https://doi.org/10.1136/jech.2005.037606

Karim, A., Saeed, B. I. I., Darkwah, K. F., & Musah, A. A. I. (2015). Analysis of Chronic Disease Conditions in Ghana Using Logistic Regression. *International Journal of Statistics and Applications*, *5*(4), 133–140. https://doi.org/10.5923/j.statistics.20150504.01

Kassena Nankana Municipal Assembly. (2021). *KNMA Ariculture, Education and Health*.

Kassena Nankana West District Assembly. (2021). *District Medium Term Development Plan Under Agenda for Jobs : Creating Prosperity and Equal Opportunity for All*.

Katzmarzyk, P. T., Friedenreich, C., Shiroma, E. J., & Lee, I. M. (2022). Physical inactivity and non-communicable disease burden in low-income, middle-income and high-income countries. *British Journal of Sports Medicine*, *56*(2), 101–106. https://doi.org/10.1136/bjsports-2020-103640

Kim, J., & Richardson, V. (2014). The Impact of Poverty, Chronic Illnesses, and Health Insurance Status on Out-of-Pocket Health Care Expenditures in Later Life. *Social Work in Health Care*, *53*(10), 932–949. https://doi.org/10.1080/00981389.2014.955940

Kim Streatfield, P., Khan, W. A., Bhuiya, A., Hanifi, S. M. A., Alam, N., Bagagnan, C. H., Sié, A., Zabré, P., Lankoandé, B., Rossier, C., Soura, A. B., Bonfoh, B., Kone, S., Ngoran, E. K., Utzinger, J., Haile, F., Melaku, Y. A., Weldearegawi, B., Gomez, P., … Byass, P. (2014). Adult non-communicable disease mortality in Africa and Asia: Evidence from INDEPTH Health and Demographic Surveillance System sites. *Global Health Action*, *7*(1). https://doi.org/10.3402/gha.v7.25365

Kleinman, A. (1981). Patients and Healers in the Context of Culture: An Exploration of the Borderland between Anthropology, Medicine, and Psychiatry. In *Patients and Healers in the Context of Culture* (Issue August 1981). University of California Press. https://doi.org/10.1525/9780520340848

Kootbodien, T., Wilson, K., Tlotleng, N., Ntlebi, V., Made, F., Rees, D., & Naicker, N. (2018). Tuberculosis mortality by occupation in South Africa, 2011–2015. *International Journal of Environmental Research and Public Health*, *15*(12). https://doi.org/10.3390/ijerph15122756

Kuupiel, D., Cheabu, B. S. N., Yeboah, P., Duah, J., Addae, J. K., Ako-Nnubeng, I. T., Osei, F. A., Ziblim, S. D., Mchunu, G. G., Pillay, J. D., & Bawontuo, V. (2023). Geographic availability of and physical accessibility to tuberculosis diagnostic tests in Ghana: a cross-sectional survey. *BMC Health Services Research*, *23*(755). https://doi.org/10.1186/s12913-023-09755-3

Kwabena, A. (2023). Impact of WASH interventions on diarrhoeal diseases in rural Ghana. *Journal of Public Health*, *15*(2), 112–123.

Kweku, M., Id, H. A., Awolu, A., Adjuik, M., Id, A. A., Manu, E., Tarkang, E. E., Komesuor, J., Asalu, G. A., Aku, F. Y., Id, N. K., Anumu, F., Boateng, L. A., Alornyo, J. S., Glover, R., Letsa, T., Bawah, A. A., Kanlisi, N. S., Awoonor-williams, J. K., … Gyapong, J. O. (2020). Community-Based Health Planning and Services Plus programme in Ghana : A qualitative study with stakeholders in two Systems Learning Districts on improving the implementation of primary health care. *PLoS ONE*, *15*(1), 1–24. https://doi.org/10.1371/journal.pone.0226808

Kynast-wolf, G., Hammer, G. P., Muller, O., Kouyate, B., & Becher, H. (2005). Season of death and birth predict patterns of mortality in Burkina Faso. *International Epidemiological Association*, *35*, 427–435. https://doi.org/10.1093/ije/dyi150

Lahana, E., Pappa, E., & Niakas, D. (2011). Do place of residence and ethnicity affect health services utilization? Evidence from Greece. *International Journal for Equity in Health*, *10*, 1–9. https://doi.org/10.1186/1475-9276-10-16

Lankoandé, Y. B., Masquelier, B., Zabre, P., Bangré, H., Duthé, G., Soura, A. B., Pison, G., & Ali, S. (2022). Estimating mortality from census data: A record-linkage study of the Nouna Health and Demographic Surveillance System in Burkina Faso. *Demographic Research*, *46*(April), 653–680. https://doi.org/10.4054/DEMRES.2022.46.22

Lee, I., Shiroma, E., Lobelo, F., Puska, P., Blair, S., & Katzmarzyk, P. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*, *219*, 219.

Lego, V., Lazarevič, P., & Luy, M. (2019). The Male-Female Health-Mortality Paradox. *Encyclopedia of Gerontology and Population Aging*, 1–8. https://link.springer.com/referenceworkentry/10.1007/978-3-319-69892-2_798-2

Liang, J., McCarthy, J., Jain, A., Krause, N., & Bennett, J. (2000). Socioeconomic gradient in old age mortality in Wuhan, China. *Journals of Gerontology Series B, Psychological Sciences and Social Sciences*, *55*, S222–233.

Lloyd-Sherlock, P., Minicuci, N., Corso, B., Beard, J., Chatterji, S., & Ebrahim, S. (2017). Diseases of the Rich? the Social Patterning of Hypertension in Six Low- and Middle-Income Countries. *Eur J Dev Res.*, *29*(4), 827–42.

Lozano, R., Naghavi, M., Foreman, K., Lim, S., Shibuya, K., Aboyans, V., Abraham, J., Adair, T., Aggarwal, R., Ahn, S. Y., AlMazroa, M. A., Alvarado, M., Anderson, H. R., Anderson, L. M., Andrews, K. G., Atkinson, C., Baddour, L. M., Barker-Collo, S., Bartels, D. H., … Murray, C. J. L. (2012). Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: A systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*, *380*(9859), 2095–2128. https://doi.org/10.1016/S0140-6736(12)61728-0

Lucyk, K. (2016). They are not my problem: A content and framing analysis of references to the social determinants of health within Canadian news media, 1993-2014. *Canadian Journal of Communication*, *41*(4), 631–654. https://doi.org/10.22230/cjc.2016v41n4a3034

Lyons-Amos, M., & Stones, T. (2017). Trends in Demographic and Health Survey data quality: An analysis of age heaping over time in 34 countries in Sub Saharan Africa between 1987 and 2015. *BMC Research Notes*, *10*(1), 1–7. https://doi.org/10.1186/s13104-017-3091-x

Macintyre, S., Hunt, K., & Sweeting, H. (1996). Gender differences in health: are things really as simple as they seem? *Soc Sci Med*, *42*, 617–24.

Mackie, E., Shears, P., Frimpong, E., & Mustafa-Kutana, S. (1992). A study of bacterial meningitis in Kumasi , Ghana. *Ann Trop Paediatr*, *12*(2), 143–148. https://doi.org/10.1080/02724936.1992.11747559

Maduekwe, N. I., Banjo, O. O., & Sangodapo, M. O. (2017). The Nigerian Civil Registration and Vital Statistics System: Contexts, Institutions, Operation. *Social Indicators Research*, *134*(2), 651–674. https://doi.org/10.1007/s11205-016-1448-5

Maman, S., Cathcart, R., Burkhardt, G., Omba, S., & Behets, F. (2009). The role of religion in HIV-positive women's disclosure experiences and coping strategies in Kinshasa, Democratic Republic of Congo. *Social Science & Medicine*, *68*(5), 965–970.

Marmot, M. (2005). Social determinants of health inequalities. *The Lancet*, *365*(9464), 1099–1104.

Mathers, C. D., & Loncar, D. (2006). Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Medicine*, *3*(11), 2011–2030.

https://doi.org/10.1371/journal.pmed.0030442

Mathers, C., Sadana, R., Salomon, J., Murray, C., & Lopez, A. (1999). Healthy life expectancy in 191 countries. *The Lancet 2001*, *357*, 1685–1691.

Mazamay, S., Guégan, J. F., Diallo, N., Bompangue, D., Bokabo, E., Muyembe, J. J., Taty, N., Vita, T. P., & Broutin, H. (2021). An overview of bacterial meningitis epidemics in Africa from 1928 to 2018 with a focus on epidemics " outside - the - belt ." *BMC Infectious Diseases*, *21*(1027), 1–13. https://doi.org/10.1186/s12879-021-06724-1

McCullough, M. ., Hoyt, W. T., Larson, D. B., Koenig, H. G., & Thoresen, C. (2000). Religious Involvement and Mortality: a Meta-Analytic Review. *Health Psychology*, *29*(3), 211–222.

Melaku, Y. A., Sahle, B. W., Tesfay, F. H., Bezabih, A. M., Aregay, A., Abera, S. F., Abreha, L., & Zello, G. A. (2014). Causes of death among adults in northern Ethiopia: Evidence from verbal autopsy data in health and demographic surveillance system. *PLoS ONE*, *9*(9). https://doi.org/10.1371/journal.pone.0106781

Meles, G. G., Ayele, G., Gutema, B. T., Kondale, M., Zerdo, Z., Merdekios, B., Tsalla, T., Kote, M., Baharu, A., Bekele, A., Gebremeskel, F., Shegaze, M., & Gultie, T. (2023). Causes and trends of adult mortality in southern Ethiopia: an eight-year follow up database study. *BMC Infectious Diseases*, *23*(29), 1–9. https://doi.org/10.1186/s12879-023-07988-5

Mendis, S., Davis, S., & Norrving, B. (2015). Organizational Update:The World Health Organization Global Status Report on Noncommunicable Diseases 2014; One More Landmark Step in the Combat Against Stroke and Vascular Disease. *Stroke*, *46*(5), e123. https://doi.org/10.1161/STROKEAHA.115.008097

Mensah, F. (2023). Rabies control strategies and their impact in Ghana. *Tropical Medicine and Health*, *29*(1), 78–89.

Mete, C. (2005). Predictors of elderly mortality: Health status, socioeconomic characteristics and social determinants of health. *Health Economics*, *14*(2), 135–148. https://doi.org/10.1002/hec.892

Mikkelsen, L., Phillips, D. E., & AbouZahr, C. (2015). A global assessment of civil registration and vital statistics systems: monitoring data quality and progress. *The Lancet, 386*(10001), 1395–1406.

Miller, R., Ikram, S., Armelagos, G., Walker, R., Harer, W., Shiff, C., Baggett, D., Carrigan, M., & Maret, S. (1994). Diagnosis of Plasmodium falciparum infections in mummies using the rapid manual ParaSight-F test. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *8*(1), 31–32.

Mineau, G., Smith, K., & Bean, L. (2004). Adult mortality risks and religious affiliation : The role of social milieu in biodemographic studies. *ANNALES DE DÉMOGRAPHIE HISTORIQUE*, *2*(108), 85–104. https://doi.org/10.3917/adh.108.0085

Minicuci, N., Biritwum, R. B., Mensah, G., Yawson, A. E., Naidoo, N., Chatterji, S., & Kowal, P. (2014). Sociodemographic and socioeconomic patterns of chronic non-communicable disease among the older adult population in Ghana. *Global Health Action*, *7*(1). https://doi.org/10.3402/gha.v7.21292

Ministry of Health. (2012a). National Policy for the Prevention and Control of Chronic Non-Communicable Diseases in Ghana. In *Ministry of Health, Ghana* (Issue August, pp. 1–27). Ministry of Health. https://www.iccp-portal.org/sites/default/files/plans/national_policy_for_the_prevention_and_control_of_chronic_non-communicable_diseases_in_ghana(1).pdf

Ministry of Health. (2012b). *National Policy for the Prevention and Control of Chronic Non-Communicable Diseases in Ghana* (Issue August).

Ministry of Local Government and Rural Development (MLGRD). (2019). *Annual Progress Report, Republic of Ghana, 2019*. http://lgs.gov.gh/index.php/annual-report/

Mohan, V., & Muliyil, J. (2009). Mortality patterns and the effect of socioeconomic factors on mortality in rural Tamil Nadu, south India: a community-based cohort study. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *103*, 801–806.

Molesworth, A. M., Cuevas, L. E., Connor, S. J., Morse, A. P., & Thomson, M. C. (2003). *Environmental Risk and Meningitis Epidemics in Africa*. *9*(10), 1287–1293.

Montano, D. (2021). Socioeconomic status, well-being and mortality: a comprehensive life course analysis of panel data, Germany, 1984-2016. *Archives of Public Health*, *79*(1). https://doi.org/10.1186/s13690-021-00559-7

Morens, D. M., Folkers, G. K., & Anthony S. Fauci. (2004). The challenge of emerging and re-emerging infectious diseases. *Nature*, *430*(6996), 242–249. www.nature.com/nature

Moyer, C. A., Aborigo, R. A., Kaselitz, E. B., Gupta, M. L., Oduro, A., & Williams, J. (2016). PREventing Maternal and Neonatal Deaths (PREMAND): A study protocol for examining social and cultural factors contributing to infant and maternal deaths and near-misses in rural northern Ghana. *Reproductive Health*, *13*(1), 1–13. https://doi.org/10.1186/s12978-016-0142-z

Moyo, E., Moyo, P., Murewanhema, G., Mhango, M., Chitungo, I., & Dzinamarira, T. (2023). Key populations and Sub-Saharan Africa's HIV response. *Frontiers in Public Health*, *11*(1079990). https://doi.org/10.3389/fpubh.2023.1079990

Mubeta, N., Id, F., Lima, L., & Gomez, L. F. (2023). *The burden of mortality due to injury in Cabo*. 1–15. https://doi.org/10.1371/journal.pone.0278589

Murray, C. J. ., & Lopez, A. D. (1996). *The Global burden of disease : a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020*. World Health Organization, World Bank & Harvard School of Public Health. https://apps.who.int/iris/handle/10665/41864

Murray, C. J. L., Ezzati, M., Lopez, A. D., Rodgers, A., & Vander Hoorn, S. (2003). Comparative quantification of health risks: Conceptual framework and methodological issues. *Population Health Metrics*, *1*, 1–20. https://doi.org/10.1186/1478-7954-1-1

Murray, C. J. L., Lopez, A. D., Shibuya, K., & Lozano, R. (2011). Verbal autopsy: Advancing science, facilitating application. *Population Health Metrics*, *9*(August). https://doi.org/10.1186/1478-7954-9-18

Murray, C. J. L., Lozano, R., Flaxman, A. D., Serina, P., Phillips, D., Stewart, A., James, S. L., Vahdatpour, A., Atkinson, C., Freeman, M. K., Ohno, S. L., Black, R., Ali, S. M., Baqui, A.

H., Dandona, L., Dantzer, E., Darmstadt, G. L., Das, V., Dhingra, U., … Lopez, A. D. (2014). Using verbal autopsy to measure causes of death: The comparative performance of existing methods. *BMC Medicine*, *12*(1), 1–19. https://doi.org/10.1186/1741-7015-12-5

Murray, C. J., & Lopez, A. D. (1999). On the Comparable Quantification of Health Risks: Lessons from the Global Burden of Disease. *Epidemiology*, *10*, 594–605.

Nakaji, S., Parodi, S., Fontana, V., Umeda, T., Suzuki, K., Sakamoto, J., Fukuda, S., Wada, S., Sugawara, K., & Affiliations. (2004). Seasonal changes in mortality rates from main causes of death in Japan (1970--1999). *European Journal Epideniology*, *19*(10), 905–913. https://doi.org/10.1007/s10654-004-4695-8

Narh-Bana, S. A., Chirwa, T. F., Mwanyangala, M. A., & Nathan, R. (2012). Adult deaths and the future: A cause-specific analysis of adult deaths from a longitudinal study in rural Tanzania 2003-2007. *Tropical Medicine and International Health*, *17*(11), 1396–1404. https://doi.org/10.1111/j.1365-3156.2012.03080.x

Navrongo Health Research Centre. (2016). *The Navrongo Health and Demographic Surveillance System Biannual Report, 2015-2016*.

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*, *392*, 1072–1088.

NDPC. (2012). *Achieving the MDGs with equity in Ghana: Unmasking the issues behind the averages*.

Nimako, B. A., Baiden, F., Sackey, S. O., & Binka, F. (2013). Multimorbidity of chronic diseases among adult patients presenting to an inner-city clinic in Ghana. *Globalization and Health*, *9*(1), 1–7. https://doi.org/10.1186/1744-8603-9-61

Nugent, R. (2008). Chronic diseases in developing countries: health and economic burdens. *Ann N Y Acad Sci.*, *1136*(Nugent, R), 70–79. https://doi.org/10.1196/ annals.1425.027

Nyblade, L., Stangl, A., Weiss, E., & Ashburn, K. (2009). Combating HIV stigma in health care settings: what works? *Journal of the International AIDS Society*, *12*(1), 1–7.

Nyonator, F. K., Awoonor-williams, J. K., Phillips, J. F., Jones, T. C., & Miller, R. A. (2005). The Ghana Community-based Health Planning and Services Initiative for scaling up service delivery innovation. *Health Policy and Planning*, *20*(1), 25–34. https://doi.org/10.1093/heapol/czi003

O'Donnell, O. (2007). Access to health care in developing countries: breaking down demand side barriers Acesso aos cuidados de saúde nos países em desenvolvimento: rompendo barreiras contra a demanda. *Cadernos de Saude Publica*, *23*(12), 2820–2834.

O'Flaherty, M., & Capewell, S. (2018). Modelling the potential impact of population-wide cardiovascular disease prevention strategies on life expectancy. *European Journal of Preventive Cardiology*, *25*(4), 432–440. https://doi.org/10.1177/2047487317741860.

Obermeyer, Z., Rajaratnam, J. K., Park, C. H., Gakidou, E., Hogan, M. C., Lopez, A. D., & Murray, C. J. L. (2010). Measuring adult mortality using sibling survival: A new analytical method and new results for 44 countries, 1974-2006. *PLoS Medicine*, *7*(4). https://doi.org/10.1371/journal.pmed.1000260

ODPHP (US Department of Health and Human Services, O. of D. P. and H. P. (2017). *Foundation health measures: Determinants of health*. https://www.healthypeople.gov/2020/about /foundation-health-measures/Determinants-of-Health.

Oduro, A. R., Wak, G., Azongo, D., Debpuur, C., Wontuo, P., Kondayire, F., Welaga, P., Bawah, A., Nazzar, A., Williams, J., Hodgson, A., & Binka, F. (2012). Profile of the Navrongo health and demographic surveillance system. *International Journal of Epidemiology*, *41*(4), 968–976. https://doi.org/10.1093/ije/dys111

Ofori-Asenso, R., & Garcia, D. (2016). Cardiovascular diseases in Ghana within the context of globalization. *Cardio- Vasc Diagn Ther.*, *6*(1), 67. https://doi.org/10.3978/j.issn.2223-3652.2015.09.02

Ogunjuyigbe, P. O. (2004). Under-Five Mortality in Nigeria : Perception and Attitudes of the Yorubas towards the Existence of " Abiku ." *Demographic Research*, *11*(2). https://doi.org/10.4054/DemRes.2004.11.2

Ohene, S. A., Tettey, Y., & Kumoji, R. (2011). Cause of death among Ghanaian adolescents in Accra using autopsy data. *BMC Research Notes*, *4*, 2–7. https://doi.org/10.1186/1756-0500-4-353

Okonofua, F., Ntoimo, L., Ogu, R., Galadanci, H. Mohammed, G. Adetoye, D., & Abe, E. (2017). Association of the delay in seeking care with maternal mortality in Nigeria. *Obstetrics & Gynecology*, *131*(5), 100–107.

Olanrewaju, F. O., Ajayi, L. A., Loromeke, E., Olanrewaju, A., Allo, T., & Nwannebuife, O. (2019). Masculinity and men's health-seeking behaviour in Nigerian academia. *Cogent Social Sciences*, *5*(1), 1682111. https://doi.org/10.1080/23311886.2019.1682111

Olshansky, S. J., & Ault, A. B. (1988). The Fourth Stage of the Epidemiologic Transition : The Age of Delayed Degenerative Diseases. *The Milbank Quarterly*, *64*(3), 355–391.

Omer, S. B., Salmon, D. A., Orenstein, W. A., DeHart, M. P., & Halsey, N. (2009). Vaccine refusal, mandatory immunization, and the risks of vaccine-preventable diseases. *New England Journal of Medicine*, *360*(19), 1981–1988.

Omoregbe, J. (1993). Ethics, a Systematic and Historical Study. *Epicurian Ethics;, Lagos, Nigeria: Joja Educational Research and Publishers Limited*, 174–7.

Omran, A. R. (1971). The Epidemiologic Transition : A Theory of the Epidemiology of Population Change. *The Milbank Memorial Fund Quarterly*, *49*(4), 509–538. https://doi.org/https://www.jstor.org/stable/3349375 Accessed:24-11-2019:07:51

Oshio, T., & Kan, M. (2019). Educational level as a predictor of the incidences of non-communicable diseases among middle-aged Japanese: A hazards-model analysis. *BMC Public Health*, *19*, 852. https://doi.org/10.1186/s12889-019-7182-6

Outbreak News. (2023). *Ghana records 5.7 million malaria cases in 2021*. Ghana records 5.7 million malaria cases in 2021 - Outbreak News Today

Owusu, A. (2023). Epidemiology of viral hepatitis in Ghana: Challenges and opportunities. *Hepatology Reports*, *14*(4), 210-220.

Owusu, A. Y., Kushitor, S. B., Ofosu, A. A., Kushitor, M. K., Ayi, A., & Awoonor-Williams, J. K. (2021). Institutional mortality rate and cause of death at health facilities in Ghana between 2014 and 2018. *PLoS ONE*, *16*(9 September), 1–15. https://doi.org/10.1371/journal.pone.0256515

Owusu, M., Nguah, S. B., Boaitey, Y. A., Badu-Boateng, E., Abubakr, A. R., Lartey, R. A., & Adu-Sarkodie, Y. (2012). Aetiological agents of cerebrospinal meningitis: a retrospective study from a teaching hospital in Ghana. *Annals of Clinical Microbiology and Antimicrobials*, *11*(1), 1. https://doi.org/10.1186/1476-0711-11-28

Paglione, L., Angelici, L., Davoli, M., Agabiti, N., & Cesaroni, G. (2020). Mortality inequalities by occupational status and type of job in men and women: Results from the Rome Longitudinal Study. *BMJ Open*, *10*(6). https://doi.org/10.1136/bmjopen-2019-033776

Pan American Health Organization (PAHO). (2019). *Tobacco kills one person every 34 seconds in the Americas.* https://www3.paho.org/hq/index.php?option=com_content&view=article&id=15229:tobacco-kills-one-person-every-34-seconds-in-the-americas&Itemid=1926&lang=en

Pardeshi, G. S. (2010). Age heaping and accuracy of age data collected during a community survey in the Yavatmal District, Maharashtra. *Indian Journal of Community Medicine*, *35*(3), 391–395. https://doi.org/10.4103/0970-0218.69256

Pearce, J., Ben Wheeler, D. D., Barnett, R., & Rigby, J. (2006). Geographical inequalities in health in New Zealand, 1980-2001: the gap widens. *Aust N Z J Public Health*, *30*, 461–466.

Pearce, J., Mitchell, R., & Shortt, N. (2015). *Place , space , and health inequalities* (pp. 192–205).

Pison, G., Masquelier, B., Kante, A. M., Ndiaye, C. T., Douillot, L., Duthé, G., Sokhna, C., Delaunay, V., & Helleringer, S. (2018). Estimating mortality from external causes using data from retrospective surveys: A validation study in Niakhar (Senegal). *Demographic Research*, *38*(32), 879–896. https://doi.org/10.4054/DemRes.2018.38.32

Popa-Velea, O., & Purcarea, V. L. (2014). Psychological factors mediating health-related quality of life in COPD. *Journal of Medicine and Life*, *7*(1), 100–103.

Poston, D. L. J., & Bouvier, L. F. (2010). *Population and Society: An Introduction to Demography*. Cambridge University Press.

Prüss-Ustün, A., Wolf, J., Corvalán, C., Bos, R., & Neira, M. (2016). *Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks*.

Rabie, H., & Goussard, P. (2016). Tuberculosis and pneumonia in HIV-infected children: an overview. *Pneumonia*, *8*(1), 1–10. https://doi.org/10.1186/s41479-016-0021-y

Ram, B., & Thakur, R. (2022). Epidemiology and Economic Burden of Continuing Challenge of Infectious Diseases in India: Analysis of Socio-Demographic Differentials. *Frontiers in Public Health*, *10*(June), 901276. https://doi.org/10.3389/fpubh.2022.901276

Ramroth, H., Lorenz, E., Rankin, J. C., Fottrell, E., Yé, M., Neuhann, F., Ssennono, M., Sié, A., Byass, P., & Becher, H. (2012). Cause of death distribution with InterVA and physician coding in a rural area of Burkina Faso. *Tropical Medicine and International Health*, *17*(7), 904–913. https://doi.org/10.1111/j.1365-3156.2012.02998.x

Randall, S., & Coast, E. (2016). The quality of demographic data on older Africans. *Demographic Research*, *34*(1), 143–174. https://doi.org/10.4054/DemRes.2016.34.5

Rankin, J. C., Lorenz, E., Neuhann, F., Yé, M., Sié, A., Becher, H., & Ramroth, H. (2012). Exploring the role narrative free-text plays in discrepancies between physician coding and the InterVA regarding determination of malaria as cause of death, in a malaria holo-endemic region. *Malaria Journal*, *11*, 1–9. https://doi.org/10.1186/1475-2875-11-51

Raphael, D. (2009). *Social determinants of health: Canadian perspectives* (2nd ed.). Toronto: Canadian Scholars' Press.

Rau, R., Bohk-ewald, C., Muszyńska, M. M., & Vaupel, J. W. (2017). Seasonality of Causes of Death. In *Visualizing Mortality Dynamics in the Lexis Diagram* (pp. 99–122). Springer.

Rau, R., & Doblhammer, G. (2003). Seasonal mortality in Denmark : the role of sex and age. *Demographic Research*, *9*(9), 197–222. https://doi.org/10.4054/DemRes.2003.9.9

Robards, J., Evandrou, M., Falkingham, J., & Vlachantoni, A. (2012). Marital status, health and mortality. *Maturitas*, *73*(4), 295–299. https://doi.org/10.1016/j.maturitas.2012.08.007

Rosenwaike, I., & Stone, L. F. (2003). Verification of the ages of super- centenarians in the United States: Results of a matching study. *Demography*, *40*, 727–739.

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), 1–18. https://doi.org/10.1371/journal.pone.0113780

Rossum, C. T. M. Van, Shipley, M. J., Hemingway, H., & Grobbee, D. E. (2001). Seasonal variation in cause-specific mortality : Are there high-risk groups ? 25-year follow-up of civil servants from the first Whitehall study. *International Epidemiological Association*, *30*, 1109–1116.

Roura, L. C., & Arulkumaran, S. S. (2015). Facing the noncommunicable disease (NCD) global epidemic - The battle of prevention starts in utero - The FIGO challenge. *Best Practice and Research: Clinical Obstetrics and Gynaecology*, *29*(1), 5–14. https://doi.org/https://doi.org/10.1016/j.bpobgyn.2014.04.018

Rudman, J., Poku, Y. A., & Houben, R. (2020). *Cost-Benefit Analysis of Interventions To Reduce the Tuberculosis Burden in Ghana*.

Saeed, B. I. I., Abdul-Aziz, A. R., Nguah, S. B., & Zhao, X. (2013). The effect of socio-economic predictors of chronic diseases in Ghana: results of a nationwide survey. *Global Journal of Health Science*, *5*(5), 115–123. https://doi.org/10.5539/gjhs.v5n5p115

Samir, K., Mishra, R., Mishra, R., & Shukla, A. (2020). Working paper Community COVID-19 Vulnerability Index in India. *IIASA Workimg Paper*, *May*, 1–18.

Sankoh, O., & Byass, P. (2012). The INDEPTH network: Filling vital gaps in global epidemiology. *International Journal of Epidemiology*, *41*(3), 579–588. https://doi.org/10.1093/ije/dys081

Sanuade, Olutobi A., Anarfi, J. K., de-Graft Aikins, A., & Koram, K. A. (2014). Patterns of cardiovascular disease mortality in Ghana: A 5-year review of autopsy cases at Korle-Bu teaching hospital. *Ethnicity and Disease*, *24*(1), 55–59.

http://paa2013.princeton.edu/sessions/%0Ahttp://paa2013.princeton.edu/sessions/%0Ahttp://www.embase.com/search/results?subaction=viewrecord&from=export&id=L372294441%0Ahttp://www.ishib.org/ED/journal/24-1/ethn-24-01-55.pdf%0Ahttp://library.deakin.edu.au/r

Sanuade, Olutobi Adekunle. (2016). *Burden of Stroke in Ghana: Prevalence, Experience and Caregiving* (Issue July). University of Ghana, Legon.

Saydah, S. H., Imperatore, G., & Beckles, G. L. (2013). Socioeconomic status and mortality: Contribution of health care access and psychological distress among U.S. adults with diagnosed diabetes. *Diabetes Care*, *36*(1), 49–55. https://doi.org/10.2337/dc11-1864

Schneider, L. T. (2017). The ogbanje who wanted to stay : The occult , belonging , family and therapy in Sierra Leone. *Ethnography*, *18*(2), 133–152. https://doi.org/10.1177/1466138116673381

Schneider, S., Vibo, R., Taba, N., & Kõrv, J. (2020). Mortality in young adult patients with acute ischaemic stroke. *Acta Neurol Scand*, *141*(December 2019), 242–249. https://doi.org/10.1111/ane.13217

Setel, P. W. (2011). Verbal autopsy and global mortality statistics: if not now, then when? *Population Health Metrics*, *9*(20).

Setel, P. W., Sankoh, O., Rao, C., Velkoff, V. A., Mathers, C., Gonghuan, Y., Hemed, Y., Jha, P., & Lopez, A. D. (2005). Sample registration of vital events with verbal autopsy: a renewed commitment to measuring and monitoring vital statistics. *Bulletin of the World Health Organization*, *83*(8).

Sherman, I. (1998). A brief history of malaria and discovery of the parasite's life cycle. In I. Sherman (Ed.), *Malaria: Parasite Biology, Pathogenesis and Protection.*

Shoko, M. (2011). Is there a mortality differential by marital status among women in South Africa ? A study on a rural sub-district of Mpumalanga Province in the North-East South Africa. *African Population Studies*, *25*(1), 173–184.

Sidorchuk, A., Agardh, E., Aremu, O., Hallqvist, J., Allebeck, P., & Moradi, T. (2009).

Socioeconomic differences in lung cancer incidence: a systematic review and meta-analysis. *Cancer Causes Control*, *20*(4), 459–471.

Siegel, J. S., & Swanson, D. A. (2004). *The Methods and Materials of Demography* (J. S. Siegel & A. Swanson, David (eds.); Second). Elsevier Academic Press.

Siegel, J., & Swanson, D. (2004). *The methods and Materials of Demography* (D. S. Siegel, Jacobs (ed.); 2nd ed.). Elsevier Academic Press 525 B Street, Suite 1900, San Diego, California 92101-4495, USA.

Snyder, J. J., & Muntner, P. (2020). The impact of reducing cardiovascular disease risk factors on life expectancy in the United States. *Circulation: Cardiovascular Quality and Outcomes*, *13*(2), e006462. https://doi.org/10.1161/CIRCOUTCOMES.119.006462.

Soloway, B. (2017). Socioeconomic Status Predicts Mortality More Strongly Than Some Globally Recognized Risk Factors. *General Medicine, Cardiology*.

Sommer, I., Griebler, U., Mahlknecht, P., Thaler, K., Bouskill, K., & Gartlehner, G. (2015). Socioeconomic inequalities in non-communicable diseases and their risk factors : an overview of systematic reviews. *BMC Public Health*, *15*, 914. https://doi.org/10.1186/s12889-015-2227-y

Spoorenberg, T. (2007). Quality of age reporting: Extension and application of the modified Whipple's index. *Population*, *62*(4), 729–741. https://doi.org/10.3917/pope.704.0729

Stringhini, S., Carmeli, C., Jokela, M., Avendaño, M., Muennig, P., Guida, F., Ricceri, F., D'Errico, A., Barros, H., Bochud, M., Chadeau-Hyam, M., Clavel-Chapelon, F., Costa, G., Delpierre, C., Fraga, S., Goldberg, M., Giles, G. G., Krogh, V., Kelly-Irving, M., … Tumino, R. (2017). Socioeconomic status and the 25 × 25 risk factors as determinants of premature mortality: a multicohort study and meta-analysis of 1·7 million men and women. *The Lancet*, *389*(10075), 1229–1237. https://doi.org/10.1016/S0140-6736(16)32380-7

Su, T., Kouyate, B., & (Flessa, S. (2006). *Catastrophic household expenditure for health care in a low-income society: a study from Nouna District, Burkina*. 618– 626.

Subedi, R., Greenberg, T. L., & Roshanafshar, S. (2019). Does geography matter in mortality ? An analysis of potentially avoidable mortality by remoteness index in Canada. *Health Reports*, *30*(82), 3–15.

Sulemana, A. (2017). *Relative Risk of Women Dying From Maternal, Infectious or Non-Communicable Causes in Kintampo, Ghana: A Competing Risks Analysis* (Issue July). University of Ghana.

Tan, W. S., Bajpai, R., Low, C. K., Ho, A. H. Y., Wu, H. Y., & Car, J. (2019). Individual, clinical and system factors associated with the place of death: A linked national database study. *PLoS ONE*, *14*(4), 1–13. https://doi.org/10.1371/journal.pone.0215566

Tatem, A. J., Rogers, D. J., & Hay, S. I. (2017). Global transport networks and infectious disease spread. *Advances in Parasitology*, *62*, 293–343.

Tenkorang, E. Y., & Kuuire, V. Z. (2015). Noncommunicable Diseases in Ghana: Does the Theory of Social Gradient in Health Hold? *Health Education and Behavior*, *43*, 25S-36S. https://doi.org/10.1177/1090198115602675

Teyssou, R., & Muros-Le Rouzic, E. (2007). Meningitis epidemics in Africa : A brief overview. *Science Direct*, *25s*, 7–11. https://doi.org/10.1016/j.vaccine.2007.04.032

Todd, J. E., Mancino, L., & Lin, B.-H. (2010). The Impact of Food Away from Home on Adult Diet Quality. *SSRN Electronic Journal*, *February*. https://doi.org/10.2139/ssrn.1557129

Tsey, K., Baffour, A., & Schneider, M. (2016). Spiritual beliefs and the delay in seeking healthcare: A qualitative study from Northern Ghana. *Journal of Health Psychology*, *21*(9), 1830–1840.

Tuoyire, D. A., & Ayetey, H. (2018). Gender differences in the association between marital status and hypertension in Ghana. In *Journal of Biosocial Science* (Vol. 51, Issue 3). https://doi.org/10.1017/S0021932018000147

UNICEF. (2022). *State of the World's Children: Water, Sanitation and Hygiene*.

United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development.*

United Nations Sustainable Development Goals. (2019). *Goal 3: Ensure healthy lives and promote* *well-being for all at all ages*. https://sdgs.un.org/goals/goal3

Valecha, N., Staedke, S., Filler, S., Mpimbaza, A., & Greenwood, B Chandramohan, D. (2011). Malaria-attributed death rates in India. *Lancet*, *377*, 992–993.

Verbrugge, L. (1979). Marital status and health. *Journal of Marriage and Family*, *41*(2), 267–85.

Waite, L. J., & Lehrer, E. L. (2003). The Benefits from Marriage and Religion in the United States: a Comparative Analysis. *Population and Development Review*, *29*(2), 255–275.

Wak, G., Bangha, M., Azongo, D., Oduro, A., & Kwankye, S. (2017). Data Reliability: Comparison between Census and Health and Demographic Surveillance System (HDSS) Outputs for Kassena-Nankana East and West Districts, Ghana. *Population Review*, *56*(1), 31–45.

Wang, H., Naghavi, M., Allen, C., Barber, R. M., Carter, A., & Casey, D. C. (2016). Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet*, *388*(10053), 1459–1544.

Whitson, J. (2005). Disease Research Report: Meningococcal Disease (Meningitis). *Biology 240.*, *8*(4), 1–6.

WHO. (2014). *Global status report on noncommunicable diseases 2014*. https://doi.org/ISBN 9789241564854

WHO. (2016). *Global health estimates 2015: deaths by cause, age, sex, by countryand by region, 2000-2015*.

WHO. (2019). *GHANA Annual Report*. https://www.afro.who.int/sites/default/files/2020-10/Ghana Annual report 2019.pdf

WHO. (2020a). *Health 2020 : Education and health through the life-course* (Issue July 2015).

WHO. (2020b). *World malaria report 2020: 20 years of global progress and challenges*. Licence: CC BY-NC-SA 3.0 IGO. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2020

WHO. (2021a). Physical Activity Fact Sheet. In *World Health Organization*.

WHO. (2021b). Word Malaria Report 2021. In *Word Malaria report Geneva: World Health Organization. (2021). Licence: CC BY-NC-SA 3.0 IGO*. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2021

WHO. (2022). *World Health Statistics 2022 :Monitoring Health for SDGs, Sustainable development goals*.

WHO. (2023a). Epidemiological Fact Sheet: HIV statistics, globally and by WHO region, 2023. *HIV Data and Statistics*, Last accessed 14/04/2024. https://cdn.who.int/media/docs/default-source/hq-hiv-hepatitis-and-stis-library/j0294-who-hiv-epi-factsheet-v7.pdf?sfvrsn=5cbb3393_7

WHO. (2023b). *HIV , Number of people dying from HIV-related causes*. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/number-of-deaths-due-to-hiv-aids#:~:text=Situation and trends%3A 650 000,dying f…

WHO. (2023c). *Malaria*. https://www.who.int/news-room/fact-sheets/detail/malaria#:~:text=Four African countries accounted for,%25) and Niger (3.9%25)

WHO. (2023d). *Non-communicable diseases*. https://doi.org/10.1016/b978-0-7020-5101-2.00062-5

WHO Africa. (2022). *Beating noncommunicable diseases in Ghana through primary healthcare*. https://www.afro.who.int/photo-story/beating-noncommunicable-diseases-ghana-through-primary-healthcare

WHO African Region. (2023a). *Africa's TB reduction rate falls short amid slowing global progress*. Who. https://www.afro.who.int/news/africas-tb-reduction-rate-falls-short-amid-slowing-global-progress

WHO African Region. (2023b). *Diabetes , a silent killer in Africa* (Issue March). chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://files.aho.afro.who.int/afahobckpcontainer/production/files/iAHO_Diabetes_Regional_Factsheet.pdf

Williams, J. (2022). "Burden of acute respiratory infections in children under five in West Africa. *BMC Infectious Diseases*, *22*(3), 234–242.

Williams, Julianne, 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). https://doi.org/10.7189/jogh.08.020409

Wolrd Health Organization. (2020). *Global health estimates 2020: Deaths by Cause, Age, Sex, by Country by Region 2000-2019*. https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-leading-causes-of-death

Womack, L. S., Alpren, C., Martineau, F., Jambai, A., Singh, T., Kaiser, R., & Redd, J. T. (2020). Quality of age data in the Sierra Leone Ebola database. *Pan African Medical Journal*, *35*, 1–10. https://doi.org/10.11604/pamj.2020.35.104.20348

World Bank. (1993). *World Development Report- Investing in Health*.

World Health Organisation. (2017a). *Health impact assessment (HIA), determinants of health*. http://www.who.int/hia/evidence/doh/en.

World Health Organisation. (2017b). *The Global Tuberculosis Report 2017*. https://doi.org/10.1002/9781119421542.ch7

World Health Organization. (1998). *Control of epidemic meningococcal disease : WHO practical guidelines* (2nd ed.). https://doi.org/10.34161/johta.2015.3.2.001

World Health Organization. (2000). *Health systems: improving performance*.

World Health Organization. (2009). *Global health risks: mortality and burden of disease attributable to selected major risks*.

World Health Organization. (2017). WHO report on the global tobacco epidemic, 2017: monitoring tobacco use and prevention policies. In *World Health Organization*. https://apps.who.int/iris/bitstream/handle/10665/255874/9789241512824-eng.pdf

World Health Organization. (2018a). *Antibiotic resistance*.

World Health Organization. (2018b). *Noncommunicable Diseases Country Profiles 2018*.

World Health Organization. (2018c). *World Health Statistics 2018: Monitoring Health for the SDGs, Sustainable Development Goals*. http://journals.sagepub.com/doi/10.1177/1120700020921110%0Ahttps://doi.org/10.1016/j.reuma.2018.06.001%0Ahttps://doi.org/10.1016/j.arth.2018.03.044%0Ahttps://reader.elsevier.com/reader/sd/pii/S1063458420300078?token=C039B8B13922A2079230DC9AF11A333E295FCD8

World Health Organization. (2020). *Climate change and health*.

World Health Organization. (2023). *Non-communicable diseases;Factsheet*. https://doi.org/10.1093/acprof:oso/9780199238934.003.15

World Health Organization (WHO). (2018). *Global Health Observatory data repository: Life expectancy at birth*. WHO. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/life-expectancy-at-birth-(years)

World Health Organization (WHO). (2019). *World Health Statistics Overview 2019: Monitoring Health for the SDGs*. https://reliefweb.int/report/world/world-health-statistics-2019-monitoring-health-sdgs

Yaka, P., Sultan, B., Broutin, H., Janicot, S., Philippon, S., & Fourquet, N. (2008). Relationships between climate and year-to-year variability in meningitis outbreaks : A case study in Burkina Faso and Niger. *International Journal of Health Geographics*, *7*(34), 1–13. https://doi.org/10.1186/1476-072X-7-34

Yawson, A. E., Abuosi, A. A., Badasu, D. M., Atobra, D., Adzei, F. A., & Anarfi, J. K. (2016). Non-communicable diseases among children in Ghana: Health and social concerns of parent/caregivers. *African Health Sciences*, *16*(2), 378–388. https://doi.org/10.4314/ahs.v16i2.6

Ye, Y., Wamukoya, M., Ezeh, A., Emina, J. B. O., & Sankoh, O. (2012). Health and demographic surveillance systems: A step towards full civil registration and vital statistics system in sub-Sahara Africa? *BMC Public Health*, *12*(1), 1. https://doi.org/10.1186/1471-2458-12-741

Young, T. K. (2004). *Population Health: Concepts and Methods*. Oxford Scholarship Online. https://doi.org/10.1093/acprof:oso/9780195158540.001.0001

Zhang, L., Narayanan, K., Suryadevara, V., Teodorescu, C., Reinier, K., Uy-Evanado, A., Chugh, H., Zheng, Z. J., Gunson, K., Jui, J., & Chugh, S. S. (2015). Occupation and risk of sudden death in a United States community: A case-control analysis. *BMJ Open*, *5*(12), 1–8. https://doi.org/10.1136/bmjopen-2015-009413

APPENDICES

Appendix I

A general life table for the Male Population NDSS (2016)

Age group	Male Deaths	Male Population	*nMx*	$_nq_x$	$_nP_x$	*ndx*	*lx*	*nLx*	*Tx*	*ex*
0-4	32	9806	0.0033	0.0129	0.9871	1294	100000	396506	6331110	63.31
5-9	18	9894	0.0018	0.0091	0.9909	894	98706	488326	5934604	60.12
10-14	6	9957	0.0006	0.0030	0.9970	294	97812	486790	5446278	55.68
15-19	6	9126	0.0007	0.0033	0.9967	320	97518	484166	4959488	50.86
20-24	11	7301	0.0015	0.0075	0.9925	729	97198	479089	4475322	46.04
25-29	16	5891	0.0027	0.0135	0.9865	1301	96468	471851	3996232	41.43
30-34	16	4736	0.0034	0.0168	0.9832	1594	95167	462888	3524381	37.03
35-39	17	3952	0.0043	0.0213	0.9787	1991	93573	447078	3061493	32.72
40-44	28	2889	0.0097	0.0473	0.9527	4333	91582	425047	2614415	28.55
45-49	29	2752	0.0105	0.0513	0.9487	4479	87249	402442	2189368	25.09
50-54	31	2734	0.0113	0.0551	0.9449	4563	82770	377745	1786927	21.59
55-59	31	2203	0.0141	0.0680	0.9320	5316	78207	349893	1409182	18.02
60-64	31	1862	0.0166	0.0799	0.9201	5825	72891	313321	1059289	14.53
65-69	44	1566	0.0281	0.1313	0.8687	8803	67066	268119	745967	11.12
70-74	40	1156	0.0346	0.1592	0.8408	9277	58263	215303	477848	8.20
75-79	41	745	0.0550	0.2419	0.7581	11849	48985	92840	262545	5.36
80+	48	721	0.0666	1.0000	0.0000	37136	37136	169705	169705	4.57
Total	445	77291	0.00576							

Appendix II
A general life table for the Female Population NDSS (2016)

Age group	Female Deaths	Female Population	*nMx*	*nqx*	*nPx*	*Ndx*	*lx*	*nLx*	*Tx*	*ex*
0-4	46	9767	0.0047	0.0047	0.9953	469	100000	398733	7256639	72.57
5-9	11	9459	0.0012	0.0058	0.9942	577	99531	494503	6857907	68.90
10-14	2	9326	0.0002	0.0011	0.9989	106	98954	493667	6363404	64.31
15-19	4	8653	0.0005	0.0023	0.9977	228	98847	492613	5869738	59.38
20-24	3	7647	0.0004	0.0020	0.9980	193	98619	490235	5377124	54.52
25-29	9	5819	0.0015	0.0077	0.9923	758	98426	486614	4886890	49.65
30-34	7	4938	0.0014	0.0071	0.9929	690	97668	483346	4400275	45.05
35-39	5	3914	0.0013	0.0064	0.9936	617	96978	480165	3916929	40.39
40-44	5	3666	0.0014	0.0068	0.9932	655	96361	476477	3436764	35.67
45-49	7	4065	0.0017	0.0086	0.9914	821	95706	469389	2960287	30.93
50-54	18	4194	0.0043	0.0212	0.9788	2015	94885	457040	2490898	26.25
55-59	24	3750	0.0064	0.0315	0.9685	2925	92871	443076	2033857	21.90
60-64	19	3164	0.0060	0.0296	0.9704	2661	89946	425687	1590782	17.69
65-69	26	2577	0.0101	0.0492	0.9508	4295	87285	389653	1165095	13.35
70-74	57	2195	0.0260	0.1219	0.8781	10119	82990	333787	775441	9.34
75-79	37	1010	0.0366	0.1678	0.8322	12228	72871	151609	441654	6.06
80+	44	930	0.0473	1.0000	0.0000	60644	60644	290045	290045	4.78
Total	324	85074	0.00381							

Appendix III

Estimation Procedure for Multiple Decrement and Associated Single Decrement Life Tables

In the analysis of causes of death, the force of the mortality function from different causes is additive because disentangling precisely the effects of other causes of death is difficult, especially in settings where precise measurement is not possible. Thus, the sum of the different causes is equal to all causes combined as represented in equation (1) thus:

$$\mu(x) = \sum_{i=1}^{I} \mu_i(x), \tag{1}$$

where $\mu(x)$ is the force of mortality from all causes combined and parameters $\mu i(x)$ refer to the death rate for the *i*th cause of death. This implies that the rates of decrements are also additive:

$$ {}_{n}m_x = \sum_{i=1}^{i} {}_{n}m_{xi}, \tag{2}$$

where ${}_{n}m_x$ is the rate of decrement from all causes and ${}_{n}m_{xi}$ in this case is the rate of decrement from CDs or NCDs or external causes of death.

Considering the basic relationship between mortality rates (${}_{n}m_x$) and the probability of dying (${}_{n}q_x$) as shown in the conventional life table, the transformation of the rates to probabilities of dying is shown in the following equation as:

$$ {}_{n}q_x = \frac{n\,{}_{n}m_x}{1 + (n - {}_{n}a_x)\,{}_{n}m_x}, \tag{3}$$

where $_na_x$ is defined as the average number of person-years lived in the interval x to $x + n$ by those who died in the interval. This relationship extends to multiple-decrement processes as follows:

$$_nq_{xi} = \frac{n_nm_{xi}}{1 + (n - {_na_x})({_nm_{xi}} + {_nm_{x,-1}})}, \tag{4}$$

where $_nm_{xi}$ and $_nm_{x,-i}$ represent decrement rates from CDs or NCDs or External and all other causes other than CDs or NCDs or External combined, respectively. Data concerning the causes of death by age and the corresponding number of person-years by the same sub-categories define the probabilities of dying at each age ($_nq_x$), by cause of death. However, obtaining the $_na_x$ values is often difficult. Therefore, different techniques are employed to estimate the $_na_x$ values. First, it is assumed that those who died in the interval on average lived halfway through the interval. Based on this assumption, an initial value of 2.5 is adopted for all age groups with an interval of 5 years. For the younger than 1-year and 1–4-year age groups, a procedure suggested by Coale and Demeny is adopted (Bawah and Binka, 2007).

Using the $_na_x$ values of 2.5 in the $_nm_x \rightarrow {_nq_x}$ conversion formula, $_nq_x$ values are estimated first and the values are used to obtain $_nd_x$ (the number of deaths between age x and $x + n$) in a life table. These $_nd_x$ estimates are plugged into the iteration formula below to obtain new sets of $_na_x$ values. These values are subsequently re-introduced into the $_nm_x \rightarrow {_nq_x}$ conversion formula to re-estimate new $_nd_x$ values, which are re-introduced in the iteration formula to obtain a new set of $_na_x$ values. This process is repeated until stable estimates of $_na_x$ are achieved (Bawah and Binka, 2007). The iteration equation used is specified as follows:

$$_na_x = \frac{-\frac{n}{24}{_nd_{x-n}} + \frac{n}{2}{_nd_x} + \frac{n}{24}{_nd_{x+n}}}{_nd_x}. \tag{5}$$

The stable ${}_na_x$ values then are used to generate a life table for the population in the study area through the basic ${}_nm_x \rightarrow {}_nq_x$ conversion formula. With the overall life table generated, the probability of dying from CDs or NCDs or External causes of death (${}_nq_{xi}$)

is estimated, by applying the proportion of deaths that are due to CDs or NCDs or External causes of death to the overall probabilities of dying for each age, ${}_nq_x$, as follows:

$$ {}_nq_{xi} = {}_nq_x \cdot \frac{{}_nD_{xi}}{{}_nD_x}, \tag{6} $$

where ${}_nq_{xi}$ and ${}_nD_{xi}$ represent the probability of dying from CDs or NCDs or External causes of death and the observed number of deaths from CDs or NCDs or External causes of death, respectively. The above relationship assumes that the observed death rates for CDs or NCDs or External causes of death (${}_nM_{xi}$) are equal to the life-table death rates for CDs or NCDs or External causes of death (${}_nm_{xi}$), that is, ${}_nM_{xi} = {}_nm_{xi}$.

Estimating the contribution of mortality from CDs or NCDs or External causes of death to overall mortality also allow to estimate the effect of eliminating CDs or NCDs or External causes of death through "cause- deleted" lifetable analysis (Bawah and Binka, 2007). If CDs or NCDs or External causes-related mortality were eliminated as a cause of death, survival at age interval x to $x + n$, will be represented as:

$$ {}_nP_{x,-i} = {}_np_x^{\left(\frac{{}_nD_{xi}}{{}_nD_x}\right)}. \tag{7} $$

The approach described above assumes that the force of mortality function from each cause is proportional to all causes combined in the interval x to $x + n$ and constant throughout the interval (Arriaga, 1984). The ${}_na_x$ values for the associated single decrement life table were obtained using the following formula for all age groups except the first two and the last:

$$ {}_n a_{x,-i} = n + R^i \frac{{}_n q_x}{{}_n q_{x,-i}} ({}_n a_x - n), \tag{8} $$

where ${}_n a_{x,} -i$ refers to the average number of person-years lived by those dying in the interval from all causes other than CDs NCDs or external causes, and *Ri* represents the proportion of deaths due to CDs, NCDs or external causes. For the other age groups, the iteration procedure used for estimating the *nax* values in the general life table is used.

Appendix IV

Estimation Procedure for Decomposition by Age

The estimation procedure for the decomposition analysis involve the following formula;.

$$ {}_n\Delta_x = \frac{l_x^{all}}{l_0^{all}} \cdot \left(\frac{{}_nL_x^{-COD}}{l_x^{-COD}} - \frac{{}_nL_x^{all}}{l_x^{all}} \right) + \frac{T_{x+n}^{-COD}}{l_0^{all}} \cdot \left(\frac{l_x^{all}}{l_x^{-COD}} - \frac{l_{x+n}^{all}}{l_{x+n}^{-COD}} \right), $$

where the superscripts *all* and *–COD* (CDs or NCDs or External) indicate, respectively, with and without CDs or NCDs or External causes of death. The right-hand side of the equation denotes to the direct effect of a change in mortality rates between ages x and $x + n$, whereas the second term refers to the sum of both the indirect and interaction effects of contributions resulting from the number of person-years to be added because of additional survivors at age $x + n$ exposed to the new mortality conditions. The equation used for the open-ended interval is as follows:

$$ {}_\infty\Delta_x = \frac{l_x^{all}}{l_0^{all}} \cdot \left(\frac{T_x^{-COD}}{l_x^{-COD}} - \frac{T_x^{all}}{l_x^{all}} \right). $$

Thus, the change in life expectancy ($l_0{}^{o(-COD)} - l_0{}^{o(all)} \sum x \; n\Delta x$) can be decomposed according to the contribution of the different age groups.