Aus dem Institut für Medizinische Biometrie, Epidemiologie und Informatik
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Modelling the Burden of Noncommunicable Diseases among Hospitalized Patients in Ghana

Modellierung der Krankheitslast nicht übertragbarer Krankheiten bei stationären Patienten in Ghana

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Dedication

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Abbreviations

Abbreviation	Meaning
95% CI	95% Confidence Interval
AIDS	Acquired Immune Deficiency Syndrome
ASCR	Age-Standardized Cancer Rate
ASCRDR	Age-Standardized Cancer Rate
ASCVDR	Age-Standardized Cancer Rate
ASDR	Age-Standardized Cancer Rate
ASR	Age-Standardized Rate
ASSCDR	Age-Standardized Cancer Rate
CHIM	Centre for Health Information and Management
CHPS	Community-based Health Planning and Services
CIF	Cumulative Incidence Function
CRD	Chronic Respiratory Disease
CVD	Cardiovascular Disease
DAAD	Deutscher Akademischer Austauschdienst
DALYs	Disability-adjusted Life Years
DHIMS	District Health Information Management System
GBD	Global Burden of Disease
GHS	Ghana Health Service
GSS	Ghana Statistical Service
ICD-10	10th revision of the International Statistical Classification of Diseases and Related Health Problems
IMBEI	Institute of Medical Biostatistics, Epidemiology and Informatics
LMICs	Low-Middle-Income Countries
NCDs	Noncommunicable Diseases
QoL	Quality of Life
RR	Relative Rate
SAP	Statistical Analysis Plan
SCD	Sickle Cell Disease
SHR	Subdistribution Hazard Ratio
UN	United Nations
WHO	World Health Organization
YLDs	Years Lived with Disability

1. Introduction

1.1 Background

Living in the age of big data, these huge routine health service datasets generated for administrative purposes have not been used to the maximum extent. With regards to public health data, health systems have developed different approaches and data collection platforms for their patient data. Irrespective of the data quality issues that these datasets may pose, it is very important that they are proactively used in the care of patients and policy direction. Currently, the Global Burden of Disease (GBD) study (1, 2) has made enormous progress from their previous studies as they set out to understand the burden of diseases by integrating available health datasets for morbidity and mortality estimation at the global, regional and national levels. The estimates at the national level are usually insufficient. Hence, the countries are encouraged to perform a detailed analysis at the country levels.

Noncommunicable diseases (NCDs) are chronic diseases that affect persons of all age groups. According to the World Health Organization (WHO), there are four main types of NCDs: cardiovascular diseases, cancers, diabetes, and chronic respiratory diseases. There is increasing recognition of NCDs as a global health issue as children, adults and the elderly are all considered vulnerable to the risk factors contributing to NCDs. However, NCDs disproportionately affect low- and middle-income countries. The WHO estimates that NCDs were the leading cause of death globally, responsible for 38 million (68%) of the world's 56 million deaths in 2012. More than 40% of them (16 million) were premature deaths under age 70 years (3).

The United Nations (UN) High-level meeting on NCD Prevention and Control in September 2011 was only the second time that a disease has been highlighted in this way, the first being acquired immune deficiency syndrome (AIDS) a decade earlier (4). According to the WHO, almost three-quarters of all NCD deaths (28 million), and the majority of premature deaths (82%) occur in low- and middle-income countries (3).

Aikins et al. (2010) reported that the challenge is to find a good model that fits a specific context and the specificities of Sub-Saharan Africa and focus on achieving outcomes (5). Read and Doku recommended research into understanding what happens to

stroke patients after discharge and to estimate the indirect costs of NCDs on households, according to the UN Political Declaration in 2012 (4, 6).

According to the WHO constitution, governments are responsible for the health of their population. Nevertheless, the unavailability of accurate health data could result in societies recognizing the importance of health threats too late. The resulting effect will be a failure to allocate resources to important causes of morbidity and mortality. Diseases that lack advocacy and are under-appreciated are due to health systems lacking comprehensive measurements (7).

The Global Burden of Disease (GBD) study as part of its aim is the aligning of the health system's priorities to the populations they serve. The GBD is an international study that measures mortality and disability from over 300 diseases and injuries in more than 100 countries around the world including Ghana. The GBD study thrives on its ability to have a common estimator for all diseases. Other outputs include epidemiologic, spatial and temporal comprehensive findings. There is also a transparency with its biases estimation processes and uncertainty as well as reporting the gaps in current knowledge (7, 8).

1.2 Aims of the thesis

The overall aim of this study was to quantify and predict the burden of the five major NCDs: cardiovascular diseases (CVDs), diabetes, cancers, chronic respiratory diseases and sickle cell disease hospitalizations and mortality in Ghana. This project examined spatial and temporal trends in NCD hospitalizations and mortality. The study also identified explanatory factors that are associated with hospitalization and mortality for these NCDs (CVDs, diabetes, cancers, chronic respiratory diseases, and sickle cell disease).

1.2.1 Objectives of the thesis

1. To estimate spatial and temporal patterns in hospital admission rates and mortality in Ghana from 2012 to 2017 in major NCDs (cardiovascular, diabetes, cancers, chronic respiratory, and sickle cell disease).
2. To estimate how socio-demographic and health factors (including age, sex, location, occupation, education, health insurance status, surgical procedure and presence of comorbidity) affect the hospitalization duration for cardiovascular, diabetes, cancers, chronic respiratory, and sickle cell diseases with mortality as a competing risk.
3. To fit a Poisson regression model for hospitalization rate for cardiovascular, diabetes, cancers, chronic respiratory and sickle cell diseases, considering several covariates, allowing predictions from 2018 – 2032 among hospitalized patients in Ghana.

1.2.2 Research questions

1. What is/are the spatial and temporal pattern(s) in hospital admission rates and mortality in Ghana from 2012 to 2017 for all CVDs, diabetes, cancers, CRDs, and SCD?
2. What are the socio-demographic and health factors (including age, sex, location, occupation, education, health insurance status, surgical procedure and presence of comorbidity) of the population that are associated with hospitalization duration for the five NCDs (CVDs, diabetes, cancers, CRDs, and SCD)?
3. Which factors are associated with hospitalization rates for all five main NCDs (CVDs, diabetes, cancers, CRDs, and SCD) from 2012-2017 and what are the predictions for the future 2018-2032?

2. Literature review

2.1 Introduction

The literature review focuses on the global burden of Noncommunicable diseases (NCDs) and the five major NCDs in Ghana. This chapter also has sections on the big data, population-based registers or surveillance, cancer registry, and routine administrative databases.

2.2 The global burden of NCDs

Currently, NCDs morbidity and mortality are responsible for half of the healthy years (disability-adjusted life years—DALYs) lost globally. From 1990 to date, there has been a larger proportion of health loss from fatal and non-fatal conditions combined (7, 9). Noncommunicable Diseases (NCDs) are a threat to a nation's development, especially low-and-middle-income countries (LMICs). More than 70% of the world's poorest population live in LMICs where it is estimated that 80% of the world's 38 million NCDs deaths occur (8, 10-13). As a result of this surge in the morbidity and mortality of NCDs, these groups of diseases have caught the attention of global leaders (14, 15).

The largest mortality from the global increase in NCDs is expected on the African continent. According to the project by Dalal et al. 2011 and WHO 2014, by 2030, 46% of all mortality in Africa will be attributed to NCDs (16, 17). As a result of the large increase in NCD mortalities on the African continent, Nyaaba et al. 2017 sets out to answer the research question "what is Africa's policy progress in implementing the WHO NCD recommendations toward achieving the NCDs Global Action Plan 2013-2020?" The findings from this study suggested that the African continent is not on track in achieving the NCD indicators by the set deadlines (10).

It is required that effective and efficient public health policies and systems are created to meet the needs of people with NCDs (13, 18). These policies and systems could only be successful and achieve the intended goal when it's backed by data that are locally generated from within the health system. Although CVDs and cancer deaths have shown an overall reduction in the high-income countries from the age-standardized rates, there has been an increase in the number of life-years lost globally due to population growth and ageing (7, 19).

Sub-Saharan Africa countries such as Nigeria, Ghana, and South Africa are no exception as these countries continue to experience an increase in the incidence of NCDs (20-24). Marquez & Farrington in 2013 reported that respiratory tract infections are expected to be the leading killer of children from ages 5-15 years in Africa. They also alluded to the fact that the past 20 years have seen shifts in risks for communicable diseases in children to NCDs risks in adults in sub-Saharan Africa in terms of the attributable burden of disease (25).

According to the GHS 2016 annual report, the contributions from NCDs to illness, disability, and deaths in Ghana are significant. The major NCDs in Ghana according to the 2016 annual report and previous reports are CVDs, cancer, and diabetes of all types, CRDs and SCD. This study focused on these five NCDs identified by the GHS as a threat to the population, the health system, and the economy (26).

2.3 Cardiovascular diseases

Goal number three of the UN's Sustainable Development Goals (SDGs) sought to reduce one-third of premature NCDS deaths as a result of CVDs (2, 27). With the exception of sub-Saharan Africa, where infectious diseases continue to lead the cause of death; deaths from CVDs lead in every region of the world (7). The 2015 GBD reported 71.3% prevalence prior to the year 1998 compared to all causes of years lived with disability (YLDs). The prevalence was 76.6% from 1998-2005 and 69.1% from 2006-2013. The total estimate for these periods was 86.2% higher than any specific period estimate. The specific CVDs that were reported on were rheumatic heart disease, ischaemic heart disease, cerebrovascular diseases (ischemic stroke, hemorrhagic stroke, hypertensive heart disease, cardiomyopathy, and myocarditis, etc.) and other cardiovascular and circulatory diseases.

The increasing incidence and prevalence in the morbidities and mortalities due to CVDs on the African continent and Ghana cannot be overlooked. According to the WHO NCD Factsheet information about Ghana, an estimated annual death of 78,000 is due NCDs (17). For instance, the prevalence of hypertension in 2010 was reported to be between 24% and 48% in adult Ghanaians (28).

A recent retrospective study conducted by Appiah and his colleagues in the Komfo Anokye teaching hospital showed about a doubled increase in admissions for CVDs

from 4.6% in 2004 to 8.2% in 2014. The three major CVDs reported responsible for these increases were heart failure (HF; 88.3%), ischaemic heart disease (IHD; 7.2%), and dysrhythmias (1.9%), (29). In 2016 hypertension was the 4th top cause of hospital admissions and the 7th cause of death among the top ten causes of hospital admissions and mortalities respectively. Cerebrovascular Accident was the leading cause of inpatient deaths, congestive cardiac failure was the 6th cause of death among admitted in the same period (26).

2.4 Diabetes

According to the 2016 global report on diabetes, about 422 million adults lived with diabetes in the year 2014. It was estimated that the age-standardized global prevalence of diabetes in 2014 was 8.5%, which is twice the prevalence of 4.7% since 1980. An estimated 1.5 million mortality due to diabetes was reported in 2012 (30).

In the year 2009, the International Diabetes Foundation estimated the prevalence of Type 2 diabetes in Africa to be about 2.8% according to Gill and colleagues. In the report, the estimated prevalence of Type 2 diabetes in Ghana was over 3%, a little higher than the prevalence in Africa (20, 31). In 2010, a 6% - 9% prevalence of diabetes was estimated for major cities in Ghana (32-34). In 2016, the GHS reported a 9% prevalence of diabetes and 9th among the top ten causes of inpatient deaths in Ghana (26).

2.5 Neoplasms

The World Health Organization (WHO) defines cancer to be “a generic term for a large group of diseases characterized by the growth of abnormal cells beyond their usual boundaries that can then invade adjoining parts of the body and/or spread to other organs. Other common terms used are malignant tumours and neoplasms” (35). In the modules flyers developed by WHO for cancer control, the flyer captures 7.6 million deaths from cancer in 2005 (36), while in 2012, it was the leading cause of morbidity and mortality globally (15, 37). Seventy percent of these deaths occurred in LMICs. The GBD study reported that 8.8 million deaths globally are due to cancer. The report also projected the number of new cases to rise to 70% in the next 20 years. In terms

of treatment services, availability is 90% in high-income countries compared to 30% in low-income countries (15, 38, 39).

The WHO and partners believed that 40% of cancer cases can be prevented; as a result, six practical guides for program managers were proposed. The six steps are planning, prevention, early detection, diagnosis, palliative care, and policy and advocacy (36). Of importance to our study is the first step which is planning. Efficient planning could only be achieved based on scientific predictions which are essential for policy and decision-makers at all levels (40).

In Ghana, there is an increasing prevalence and incidence of cancer. Liver cancers were the 8th cause of inpatient deaths among the top ten causes of death in 2016 (26).

2.6 Chronic respiratory diseases

Chronic respiratory diseases were one of the main major cause groups responsible for increases in the YLDs rates per person according to the GBD 2015 report. The CRDs were 38.3% (before 1998), 64.9% (1998-2005), 32.4% (2006-2013) and a total of 68.6% for the period compared to all causes. These chronic respiratory diseases include obstructive pulmonary respiratory disease, pneumoconiosis, asthma, interstitial lung disease, and pulmonary sarcoidosis and other CRDs (8). Chronic respiratory diseases are gradually purging up in Sub-Saharan Africa. Several studies reported that although infectious and poverty-related diseases, including but not limited to malaria, infant mortality, cholera and malnutrition are still responsible for the population morbidities and mortalities diseases (20-24).

In the global asthma prevalence in adults study of in 2012, the study reported the prevalence of doctor-diagnosed, clinical asthma and wheezing symptoms in Ghana as 3.7%, 3.8% and 4.9% respectively (41).

2.7 Sickle cell disease (SCD)

Several reports and studies globally estimated that 300,000 annual births have SCD which is prevalent in the malaria-endemic parts of the world (primarily in Africa). It's believed that about 10% - 40% of the African population are carriers of the SCD gene resulting in a 2% prevalence of SCD on the continent (42, 43). Scott and the team in 2011 reported a daily delivery of 1,000 SCD children in Africa with about half of these children dying before age 5 years (43, 44). Other studies reported 50% - 90% SCD associated mortalities among African children (44-50). Twenty-six (26%) of all maternal deaths in 2016 were due to SCD (26).

2.8 Cancer registry/ administrative/ routine databases

Although population-based cancer registers are on the increase for cancers (51) and other NCDs, Ghana and other LMICs still have ideas of establishing theirs on the drawing board. Both the WHO and the Global Initiative for Cancer Registry Development through the International Agency for Research on Cancer reports that the needed registries to drive cancer policy could only be found in one out of five LMICs (15, 52).

Nevertheless, data on NCDs such as CVDs and cancers are being generated in the hospitals or in a country's routine administrative database (53). In the case of Ghana, the country does not have a national population-based cancer register; however, the two leading teaching hospitals (Korle Bu and Komfo Anokye Teaching Hospitals) have established a hospital-based register and the latter a population-based register (54, 55). Although the Komfo Anokye Teaching Hospital is described as a population-based registry, Laryea and his colleagues in their study indicated that the registry does not even cover all departments that could or diagnose cancer in the hospital (55).

Owing to the fact that these two hospitals are referral hospitals and could be considered as attending to patients with NCDs in their late stages, the most preferred sources of NCDs incidence data will be the District Health Information Management System II database. The database provides countrywide diagnoses from the district level to the national level.

2.9 Rationale

Several community-based studies conducted on NCDs in Ghana (32, 56-58) were focused on the risk factors of NCDs without considering the capacities of the hospitals where these patients are hospitalized for treatment. The District Health Information Management System (DHIMS) I database of the Ghana Health Service (GHS) serves as routine surveillance and monitoring system for the patients reporting to the hospitals, but this dataset has not been analysed to the benefit of the health system and people using and working in the hospitals. However, due to some challenges in the DHIMS I to efficiently capture patient health records during hospital visits, an improved version called DHIMS II was created in 2012 (59).

With NCDs requiring long stays in the hospitals, it is vital that health authorities and hospital managers use their internally generated data to make predictions about the future of these diseases. These predictions will go a long way to achieve the following: planning based on data and prediction, proper resource allocations, prevention, diagnosis and treatment of diseases. The other usefulness of prediction is measuring the particular outcome of a targeted program (40).

Based on the usefulness of prediction and the availability of the DHIMS data that serves as the national database for the GHS, this study modelled the burden of Noncommunicable Diseases (NCDs) among hospitalized patients in Ghana. This is the first time that NCDs morbidity and mortality resulting in hospital admissions is analysed in detail from the regional, and national levels.

The study will further offer governments, stakeholders, health administrators, public health experts among others a readily available scientific evidence of which NCDs to focus on in order to mitigate the projected high deaths due to NCDs in the sub-Sahara African region by the year 2030 (16, 33, 60, 61).

It is believed that assessing the prevailing trends of the NCDs in this study and extrapolating them into the future is the simplest way to make predictions (40). Following the guidance on the use of simple models makes interpretations easier guarantees a higher precision for prediction (40, 62).

It is against this backdrop that this study predicted the burden of NCDs among hospitalized patients in Ghana applying the requisite statistical models to DHIMS II of the GHS available from 2012 – 2017.

3. Materials and Methods

3.1 Introduction

This chapter describes the structure of the Ghana Health Service (GHS), study design, sources of data for my thesis and the process of data extraction and cleaning. The later part of this chapter focuses on the statistical tools and methods used for data analysis.

3.2 Overview of the Ghana Health Service

The health system in Ghana could be described as predominantly public and private. Health facilities and services are provided by both stakeholders. The health systems are overseen by the Ministry of Health, Ghana. The GHS is a non-political body that implements and supervises the activities of health facilities and their activities. There are regional and district health management teams in each region and districts for administrative purposes. The Regional Health Administration supervises and provides management support to the districts and sub-districts within each region. Similarly, supervision and management support is provided by the District Health Administration to the sub-districts.

The delivery of health services is structured into regional and district levels. Regional and district hospitals provide curative and public services. Health centres at the sub-district level also provide some curative services. The public health services at the sub-district level are provided by the District Health Management Team (DHMT) and the public health units within the district hospitals. The Community-based Health Planning and Services (CHPS) in the sub-districts deliver basic preventive and curative services for minor ailments in the community and at household levels.

Functionally, there are five (5) levels at which the health facilities are distributed according to the GHS 2016 annual report. These are teaching, regional and district hospitals. The rest are health centres or polyclinics, and CHPS compounds.

There are five levels of health facilities in Ghana. These are:

1. Teaching or Tertiary hospitals (there are four of these hospitals at the time data collection, but one regional hospital was upgraded to teaching hospital in 2019 make them 5 currently)
2. Regional hospitals (there are 10, one in each regional capital)
3. District hospitals (they're about 216, one in each district capital)
4. Health centres/ Polyclinics (there are averagely 2 per district, totalling 540 health centres or polyclinics)
5. Community-based Health Planning and Services

Of these five levels of health facilities in Ghana, all facilities contribute both inpatient and outpatient data to the DHIMS except for the Korle Bu and Komfo Anokye teaching hospitals and health facilities which do not admit patients. Hospitalization of patients is mainly restricted to the regional and district hospitals as they have the required capacities. There are some health centres/Polyclinics that have been allowed to admit patients in exceptional situations as they have demonstrated their capability (26).

3.3 Study area and location

Ghana is one of the West African middle-income countries which can be described as tropical. It is bordered to the East by Togo, West by Cote D'Ivoire, North by Burkina Faso and to the south by the Gulf of Guinea. Ghana currently has an estimated population of about 29 million people based on the Ghana Statistical Service, 2010 census figure of 24.2 million people. This 29 million population is about 0.4% of the world's current population. Its population per kilometre square is 127 people (thus 328 people per mi^2). The male population is about 50.9% and the female population of 49.1% with a population growth rate of about 2.2% (63). The total land area is 227,540 Km2 (87,854 sq. miles) with an approximate urban population of 15,533,945 (53.9%) people in 2017. The median age in Ghana is about 20.5 years (64-67). Total fertility (live births per woman) projected for 2010 – 2015 was 4.18 and that of 2015 – 2020 is 3.89. Projections of life expectancy at birth are 61.7 years from 2010 – 2015 and 63.2 years for 2015 – 2020 (64-67).

Ghana's capital city is Accra, which is also the seat of government. Ghana has 10 and 216 administrative regions and districts respectively, during my data collection and analysis. However, six more regions were created in a referendum held on 27th December 2018 (68). There are several ethnic groups in Ghana, however, the major ethnic groups are Akan (47.5%), Dagbani (17.0%), Ewe (14.0%), Ga-Dangme (7.0%), Gurma (6.0%), Guan (4.0%), Gurunsi (2.5%) and Bissa (1.0%). The majority of Ghanaians are Christians (71.0%) followed by Muslims (17.0%), (63).

This study was conducted in Ghana with study sites being the hospitals with inpatient data from 1st January 2012 to 31st December 2017 on the DHIMS platform in Ghana.

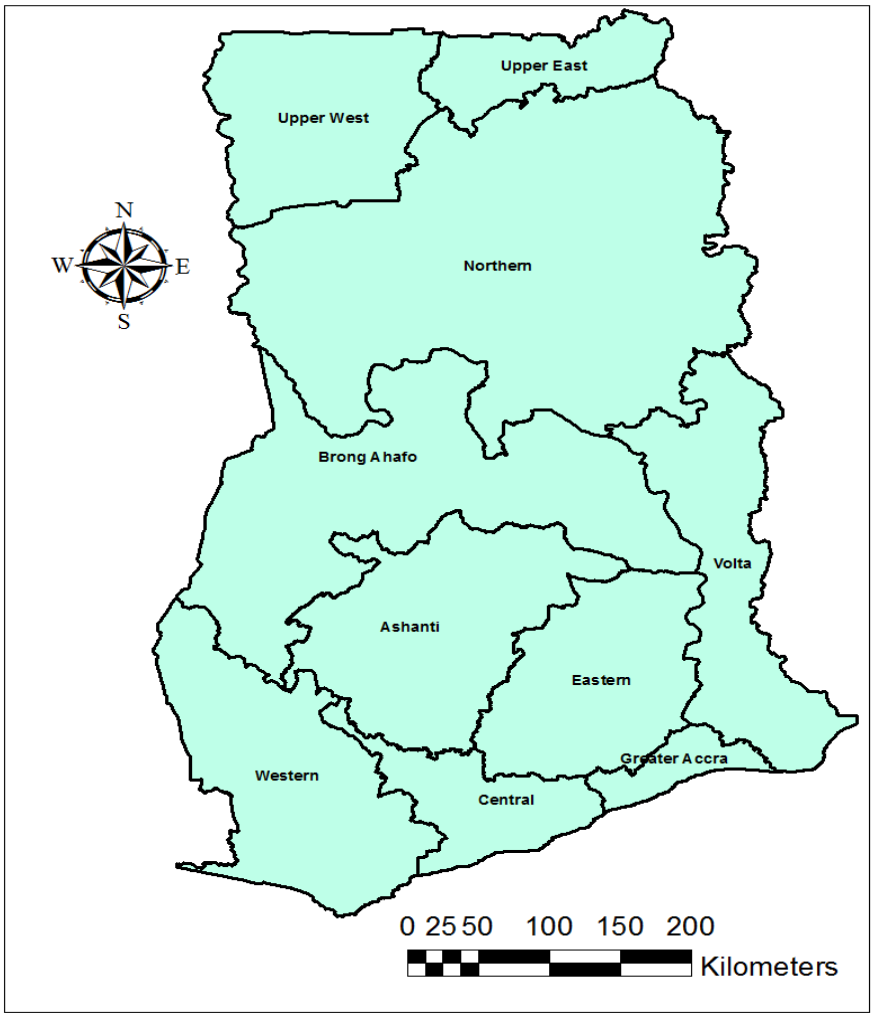


Figure 1: Administrative map of Ghana

3.4 Study design

3.4.1 Data sources and extraction plan for my thesis

For my thesis, data was extracted from two sources in Microsoft Excel format; (1) the GHS DHIMS platform for inpatient data and the (2) Ghana Statistical Service (GSS) for the country's population after my proposal received ethics approval from the Ghana Health Service Ethics Review Committee. The parameters extracted from each of the two databases are described in the following sections below.

3.4.1.1 District health information management system database

The policy implications of the growing NCD burden which forms the basis of the GBD suggests that, should there be available data to governmental and non-governmental organizations, policies would have been prioritized to extend healthful years for their respective populations. Additionally, inequality in health and access to quality health care and prevention could have been eliminated. Unlike the GBD study that combines data from different countries and sources for global, regional, and national estimations, the DHIMS is useful resource for similar estimations. The District Health Information Management System (DHIMS) database of the GHS is the country's data bank on health delivery in the country since it was introduced in 2008 (59). The data are managed by the Center for Health Information Management (CHIM) within the GHS.

The DHIMS platform was set up as a collaboration between the GHS and the University of Oslo (Department of informatics) based on the District Health Information System II (DHIS II). This is because of the challenge in obtaining the routine service data across the country from the health facilities. The GHS described this situation as a hindrance to their response and addressing of potential health emergencies, epidemics, and planning based on epidemics. The system has been designed with the aim of providing a comprehensive health management information system solution. The DHIMS II data has been in existence for the past 9 years. According to the GHS 2016 annual report, there are over 10,000 users currently on the DHIMS II platform with almost 300 hospitals in addition to the various health facilities (35).

The system was based on data warehousing principles with an easy to customize the modular structure in order to meet the needs of the different health systems from the

national, regional, district and health facility levels. DHIMS is a centralized online database that is easy to deploy and update. However, if you are connected to the server, you are able to save your data to your local server/computer in case your network becomes unstable and then later pushed to the server when the internet becomes more stable (69). The system automatically notifies you about the break-in connectivity and the need to save your data on the local computer. Also, the system sends you an automatic message if the saved data is successfully synchronized to the server (70).

The DHIMS database just like any other databases has both the front-end and backend. The data entry template has alternatives that can easily be customized for any new forms that need to be added. It also has a dashboard for health administrators in monitoring and evaluating health programs. There are inbuilt data quality analysis functions as well, however, these functions work with respect to the inpatient database. DHIMS is user-friendly, however, training and access are provided before one uses the system. The backend runs on tomcat and PostgreSQL database. The database uses 128-bit encryption from the Secure Sockets Layer (SSL) technology. Therefore, every user needs an SSL certificate authentication.

In terms of readily available analytical reports, DHIMS has several types of reports that users can generate from the system with ease depending on your level of access. Some of these outputs include raw or aggregated reports. These reports can be stratified by monthly, quarterly, yearly with the variable of interest. An interesting feature in the system is how data can be visualized using all the possible charts inbuilt in the system (69, 70).

Although the health facilities report to the GHS through DHIMS, the health facilities manage their patient records with different systems such as Health Administrators and Management System and Patient Health Information System among others (71, 72).

The DHIMS database captures the outpatient and inpatient data separately. The outpatient data are largely aggregated while the inpatient data is entered in the individual unit for some selected variables. The data captured at the individual unit allows for further statistical analysis with some flexibility as carried out in my thesis.

The DHIMS database is hosted in Accra, where the GHS head office is located. Due to a few challenges such as poor restrictions on the data fields, diseases not coded according to the ICD-10 among others, the system was updated in 2012 and named

DHIMS II. Although the system has been updated to include ICD-10 codes, this was poorly executed as these codes are attached to the diseases or some diseases are not coded at all. Analysts need to recode the data to conform to the ICD-10 codes for a complete list of diagnoses. The admissions data have age as a continuous variable while the outpatient captures age in categories and at an aggregated level. Every other variable in the admission's database is either categorical or text.

The data for my thesis was extracted from the national database of the DHIMS II system. The study facilities comprised the two teaching hospitals on the DHIMS, regional and district hospitals and the Polyclinics that also admit patients to their facilities. Also, the fact that the first phase of the system was a pilot project, the study only extracted data from the year 2012 to 2017.

There are 14 variables in the DHIMS II database shown in Table 1 below, however, only 13 variables were extracted as the data manager at DHIMS did not find the surgical procedure variable useful per this study objective:

Table 1: Ghana health service (GHS) DHIMS inpatient database variables extracted

No	Variable name	Variable type/format	Brief description of the variable	Extracted
1	Hospital Name	Text/string	Name of health facility from where care was sought	Yes
2	Patient Address	Text field	The address of patients' place of residence, preferably house number or landmark	Yes
3	Date of admission	Date	The date on which the patient was admitted into the hospital	Yes
4	Age of Patient	Numeric / continuous	Age of the patient	Yes
5	Gender of Patient	Text/string	Sex of the patient	Yes
6	Occupation of Patient	Categorical/string	Occupation of the patient	Yes
7	The educational level of Patient	Categorical/string	The highest educational level of the patient	Yes
8	Date of discharge	Date	The date on which the patient was discharged from the hospital	Yes
9	Speciality	Categorical / string	Refers to the ward in which the patient was admitted	No
10	Outcome	Categorical/string	This refers to the status of the patient after discharge; usually categorized as absconded, died, discharged, referred to another facility and missing.	Yes
11	Principal diagnosis	Categorical / string	This refers to what the doctor diagnosed as the main cause of hospitalization	Yes
12	An additional diagnosis	Categorical / string	This refers to any other diagnoses the doctor may diagnose as the additional conditions of the patient	Yes
13	Surgical procedure	Categorical / string	Indicates whether the patient has undergone any surgical procedure which has a "Yes" and "No" response	Yes
14	Health Insurance Status	Categorical / string	It shows whether the patient is registered with the National Health Insurance Scheme (NHIS)	Yes

3.4.1.1.1 Data quality assurance and missing data

The DHIMS database has an inbuilt data validation code for the users. In addition, users with an administrative level of access are also able to update these validation rules. These checks in the system are to ensure that the DHIMS database captures data of the highest quality. This notwithstanding, most of the fields are unrestrictive which could allow for wrongful entries. A question that one may ask is how often does the data entry staff validate their entered data? Data entry staff are expected to validate their entries immediately, it is entered. Similarly, how often have the health information officers also validated the data entered? Health Information Officers usually validate entered data on a monthly basis (70). This study dropped all patients with missing information for the year of admission, age, and sex as these were key variables in the study. The dropped numbers were very small compared to the size of the extracted data. The summary statistics on the number of variables extracted and missing values are shown in Figure 1 in the results section.

3.4.1.2 Ghana statistical service database/reports

The other important sources of data were from the Ghana Statistical Service (GSS) population database and essential available literature on NCDs in Ghana. The GSS is the official government agency responsible for the country's data generation and reporting on all sectors of the economy including health (73). The GSS is well-known for the successful conduct of five (5) national censuses in 1960, 1970, 1984, 2000 and 2010 in addition to other relevant national surveys (63). They have also conducted about six (6) Health and Demographic Surveys called Ghana Demographic and Health Survey with the most recent survey in 2014. They are also responsible for conducting the Multiple Indicator Cluster Surveys with partner institutions. Population estimates and projection including other indicators are the responsibility of the GSS (63, 64). The estimated population data on age, sex and region from 2012 – 2032 was provided by the GSS for this study.

3.5 Data cleaning and coding

The extracted data from DHIMS II was cleaned by writing the appropriate Stata codes using Stata version 12 (74). Non Communicable Diseases (NCDs) diagnosis for CVDs, diabetes, cancers, CRDs, and SCD were coded according to the WHO International Classification of Diseases and Injuries Tenth edition (ICD-10) codes (75, 76). The remaining NCD diagnoses were coded as others, whiles every other diagnosis was also coded as others. Both principal and additional diagnoses had six (6) categories. The subcategories of the five major NCDs used in the prediction were mapped according to ICD-10 codes.

Ages of patients were grouped according to a five (5) year period in order to be consistent with the population. There were 17 age groups of five (5) year period as follows 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, 80-100 years (63). These ages were more appropriate as it is same as the age groupings used by the GSS, the source of population and standard population for this study.

Additional variables necessary for the study were generated during the analysis, this included the duration of hospitalization which was based on the date of admission and discharge date.

The diagnoses from the DHIMS database was captured as free text, but to a large extent, these texts had some ICD10 codes attached to them as a prefix. Due to the poor coding of the diagnoses in the DHIMS, search terms and regular expressions (77, 78) were used in coding the five main NCDs (CVDs, diabetes, cancers, CRDs, and SCD). The search terms and respective regular expressions based on each NCD as used in Stata version 12 (74) with cross-tabulation tables are shown in appendix A1 (Search terms and regular expressions).

3.6 Statistical analysis plan (SAP)

We also conducted the data analysis in Stata version 12. Descriptive statistics and frequency graphs were used in describing the variables in the dataset. The rest of the statistical analysis plan followed the study objectives:

Objective 1: To estimate spatial and temporal patterns in hospital admission rates and mortality in Ghana from 2012 to 2017 in major NCDs (cardiovascular, diabetes, cancers, chronic respiratory, and sickle cell disease).

Spatial patterns were estimated using the age-standardized hospitalization rate for all CVDs, diabetes, cancers, CRDs, and SCD. The special patterns focused on the age-standardized hospitalization rate of these five main NCDs in Ghana without considering their subcategories. The age-standardized hospitalization rates for each of these NCDs were mapped onto the map of Ghana by sex and according to the ten administrative regions.

Time series plots were used to show the temporal trends for the number of hospitalizations and outcome of the five main NCDs in Ghana (CVDs, diabetes, cancers, CRDs, and SCD) at the country level in the results section by sex and geography (10 regions) as shown in Appendix A2. The age-standardized hospitalization rate maps were plotted for the empirical years (2012-2017) for each of the 5 NCDs above.

3.6.1 Age-standardized rates (ASR) per region

The ASR for hospitalization of these NCDs were estimated as described by previous studies (79) (27, 40, 79-82). The standardization was necessary for the comparison of several age groups and several populations because of its powerful influence on the mortality risk of the five NCDs (CVDs, diabetes, cancers, CRDs, and SCD) of interest. Weights from the standard population distribution were used in estimating the ASR which is the weighted mean of the age-specific rates.

The ASR was estimated as follows:

$$ASR = \sum crude\ rate(ij) * Gh_i \quad - - - equa\ (1)$$

Where:

$$Crude\ rate = \frac{x_i}{y_i} * 100{,}000 \quad - - - equa\ (2)$$

1. x_{ij} = the number of cases of CVDs, diabetes, cancers, CRDs or SCD in the i^{th} age group and the j^{th} region

2. y_i = the population in the i^{th} age group and the j^{th} region
3. Gh_i = age distribution of Ghana's standard population given by:

$$Gh_i = \frac{population\ in\ age\ group\ i}{Total\ standard\ population} \quad ---equa\ (3)$$

In addition to this standard estimation, this study applied the same formula above to an estimation of age-sex-specific weights. The use of age-sex-specific weights was very important as the age distributions may differ for males and females and the approach is rarely used. This is taking into account the different age distribution of males and females.

Objective 2: To estimate how socio-demographic and health factors (including age, sex, location, occupation, education, health insurance status, surgical procedure and presence of comorbidity) affect the hospitalization duration for cardiovascular, diabetes, cancers, chronic respiratory, and sickle cell diseases with mortality as a competing risk.

3.6.2 Fine-Gray regression model

We fitted a competing-risks regression model using the method of Fine and Gray (1999) which is referred to as the Cumulative Incidence Function (CIF). Fine and Gray posited a model for the hazard of the subdistribution for the failure of an event of interest, known as the Subhazard (83).

The competing risk regression model, in summary, assumes that:

The cause-specific intensities are given:

$$\lambda_1(t) \approx \text{Prob}(\text{state 1 time t} + \text{dt} \mid \text{state 0 time t})/\text{dt}$$

$$\lambda_2(t) \approx \text{Prob}(\text{state 2 time t} + \text{dt} \mid \text{state 0 time t})/\text{dt}$$

.

.

.

$$\lambda_k(t) \approx \text{Prob}(\text{state k time t} + \text{dt} \mid \text{state 0 time t})/\text{dt} \quad ---equa\ (4)$$

$$State\ occupation\ probabilities\ include\ the\ overall\ survival\ function:$$

$S(t) = P(alive\ time\ t)$:

$$and\ the\ cumulative\ incidences\ ("sub-distribution\ function")$$

$j = 1, \ldots, k$:

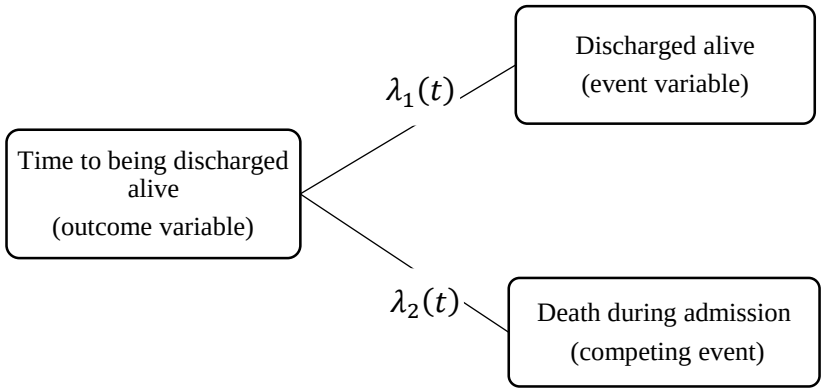
$$F_j(t) = P(dead\ from\ cause\ j\ before\ time\ t) \quad ---equa\ (5)$$

The CIF is the probability that the event of interest occurs before a given time, in this case, death before discharge from hospital admission. In our model, we used the duration of hospitalization as the potentially censored outcome variable where being discharged alive was the event. We considered mortality before discharge as a competing event.

In order to use the competing-risks regression model proposed by Fine and Gray (83), we made the following assumptions:

1. The covariates of interest were age group, sex, location, occupation, education, health insurance status, surgical procedure and presence of comorbidity

In the diagram,



In our competing risk model, we considered two options of hospital discharge (discharged alive or death during hospitalization).

$$Cause-specific\ hazards\ j = 1, 2\ (\text{“}transition\ intensities\text{”}):$$

$$\lambda_j(t) \approx \text{Prob(state j time t + dt | state 0 time t)/dt}$$

$$State\ occupation\ probabilities\ include\ the\ overall\ survival\ function:$$

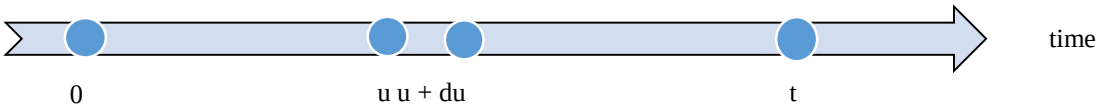
$$S(t) = P(hospitalized\ time\ t) = \exp[-(\Lambda_1(t) + (\Lambda_2(t))] - - - equa\ (6)$$

$$and\ the\ cumulative\ incidences\ ("sub - distribution\ function")$$

$$j = 1, 2$$

$$F_j(t) = P(discharged\ from\ cause\ j\ before\ time\ t) = \int_0^t S(u)\lambda_j(u)du \quad - - equa\ (7)$$

Illustratively, the integration function is given by:



Note:

$$S(t) + F_1(t) + F_2(t) = 1, for\ all\ t.$$

3.6.2.1 Fitting the competing-risks regression model

This model was fitted in Stata 12 using the $stcrreg$ command to perform the CIF analysis and then $stcurve$ command after the $stcrreg$ command to plot comparative CIFs. Prior to running the competing risk regression model in Stata, the dataset was first declared as a survival dataset using the Stata $stset$ command (74). The estimated subdistribution hazard ratios (SHR) and its associated 95% confidence intervals were reported in this study.

We assessed the proportional hazard assumption by assessing the Schoenfeld residuals for Fine-Gray model. The plot included the line of best fit and the Lowess fit for residual plot. The Schoenfeld residual plots were for the time variables and the covariates.

Objective 3: To fit a Poisson regression model to a retrospective data for cardiovascular, diabetes, cancers, chronic respiratory and sickle cell diseases considering several covariates among hospitalized patients in Ghana and to use the GSS data as input for the fitted prediction model to extrapolate into future time (2018 – 2032).

3.6.3 Poisson regression model

The Poisson regression model was fitted for all five main NCDs (CVDs, diabetes, cancers, CRDs, or SCD) from 2012-2017 using the Generalized Linear Model (GLM) as described by (27, 40, 79-82). In this analysis we used the log of the projected GSS population as an offset variable. An offset variable is one that is treated like a regression covariate whose parameter is fixed to be 1.0. In this analysis, we used $\log(\text{projected GSS population})$ since one would expect that the number of events is proportional to the number projected GSS population.

The analysis was based on the following assumptions that were met:

1. Extrapolating future (2018-2032) five main NCDs hospitalization trends based on the historic (2012-2017) trends can be modelled.
2. The duration (2012-2017) of the DHIMS II dataset time series allows for the estimation of models that adjust for age, sex, and regional trends.
3. The number of five main NCDs (CVDs, diabetes, cancers, CRDs, or SCD) in each of the age, sex, and regional stratum were assumed to be Poisson distributed.
4. Our fourth assumption dealt with two hypothetical situations: firstly, the employment of a linear model in order to avoid explosive growth which was the case of this data. Secondly, in the case of an observed decreasing trend, a log-linear model was the appropriate estimator employed. These two situations were based on the historic hospitalization trend.

We considered the following formulae for the Poisson model:

$$Ec_{it} = n_{it}\,(\alpha_i + \beta_i t) \quad ---------equa\,(8)$$

and

$$Ec_{it} = n_{it}\,\alpha_i(1 + \beta t) \quad ---------equa\,(9)$$

Where;

1. c_{it} is the number of cases (CVDs, diabetes, cancers, CRDs, or SCD) in age group i in year t,
2. n_{it} is the natural log of the population in the same stratum,
3. $\alpha_i, \beta_i, and\ \beta$are the model parameters,
4. E represents the expectation symbol according to the model.

Equation (8) postulates a simple linear trend for the hospitalization $\frac{c_{it}}{n_{it}}$ according to time t. Equation (8) is based on the simple assumption that the slope is (α_i, β_i), proportional to the intercept α_i in the linear trend (27, 40, 52, 79-82).

The parameter explanations in the equations $(8\ \&\ 9)$ also apply to equations . The log-likelihood was the basis for the choice of this model. The model implemented in Stata allowed this because it uses a sandwich estimator for the covariance matrix. The 95% CI level prediction intervals were calculated in the log-linear model using the following covariates (40, 79-81, 84). The prediction of the five main NCDs (CVDs, diabetes, cancers, CRDs, or SCD) in Ghana employed two different indices. The first indices were the proportion of years with the observed number of patients hospitalized falling within the prediction interval. The beta coefficients of variation were also assessed for the predictions to compare the lengths of the prediction interval (40). These two indices were calculated for each combination of the following variables:

1. Sex
2. Age group
3. Year of admission
4. Location (10 regions)

3.6.3.1 Prediction of future hospitalization rates

In order to predict the future (2018-2032) hospitalization rates based on the 2012-2017 Poisson regression model estimates, we made the following assumptions:

1. We assumed that the effect of calendar-year from 2012-2017 would remain constant for future years (2018-2032).
2. Since records from 2017 may still be incomplete, we fixed the calendar-year at 2016 for making predictions.

We only considered changes in the following variables: population count, age distribution, and sex distribution as taken from the GSS projections. Independent projections for other potential covariates such as lifestyle, quality of life (QoL), risk factors for any of these five main NCDs were not available for inclusion in the model.

3. We assumed that these are constant within the projected population.

The Stata version 12 $predict$ command was used in making the estimation of future (2018-2032) hospitalization rates after running the Poisson regression model (Appendix A2) with the $robust$ option (85) on the empirical (2012-2017) data considering: year, age and sex.

To assess how well Poisson regression model fits our data, we plotted the Pearson residuals against the fitted values. The plot was visually inspected for overdispersion.

3.7 Ethical approval

The study obtained ethical approval from the Ghana Health Service Ethics Review Committee (GHS-ERC: 002/12/17) and permission from the Director Generals of the Ghana Health Service and Ghana Statistical Service respectively.

3.7.1 Informed consent and confidentiality

This study employed the use of inpatient secondary data from the Ghana Health Service District Health Information System II (DHIMS II) database. As a result, the study did not have any direct contact with human participants that would warrant information sheet and informed consent forms.

However, after ethical approval was received, a permission letter with the synopsis of the proposal and the ethical approval letter was sent to the respective authorities within the GHS for data extraction and GSS for the population data.

The inpatient DHIMS II database did not have patient names, however, it contained patient hospital unique IDs. These patient hospital unique IDs were anonymized and new IDs generated by the Health Officer who signed off the data to be used for the study. All necessary confidentiality statements and documentation procedures available at the GHS were signed and complied with.

4. Results

4.1 Characteristics of extracted DHIMS data

Nearly 3 million (2,915,936) inpatient data were extracted from the GHS DHIMS database spanning six years of admissions. CVDs were the most frequent diagnoses (161,647, 5.5%) out of the five main NCDs of interest. The number of the patients hospitalized for the remaining four NCDs were diabetes 43,360 (1.4%), cancer 28,772 (1.0%), CRDs 27,733 (1.0%), and SCD 29,824 (1.0%). These five main NCDs represented 291,336 (9.9%) of all hospital admissions from 2012-2017 in Ghana.

After excluding inpatients with missing data for age, sex, date of admission and duplicate records, we analysed a complete dataset of 265,490 with the following distribution: CVDs 151,272; diabetes 40,202; cancer 26,627; CRDs 24,709 and SCD 22,680 records (Figure 2 & 3).

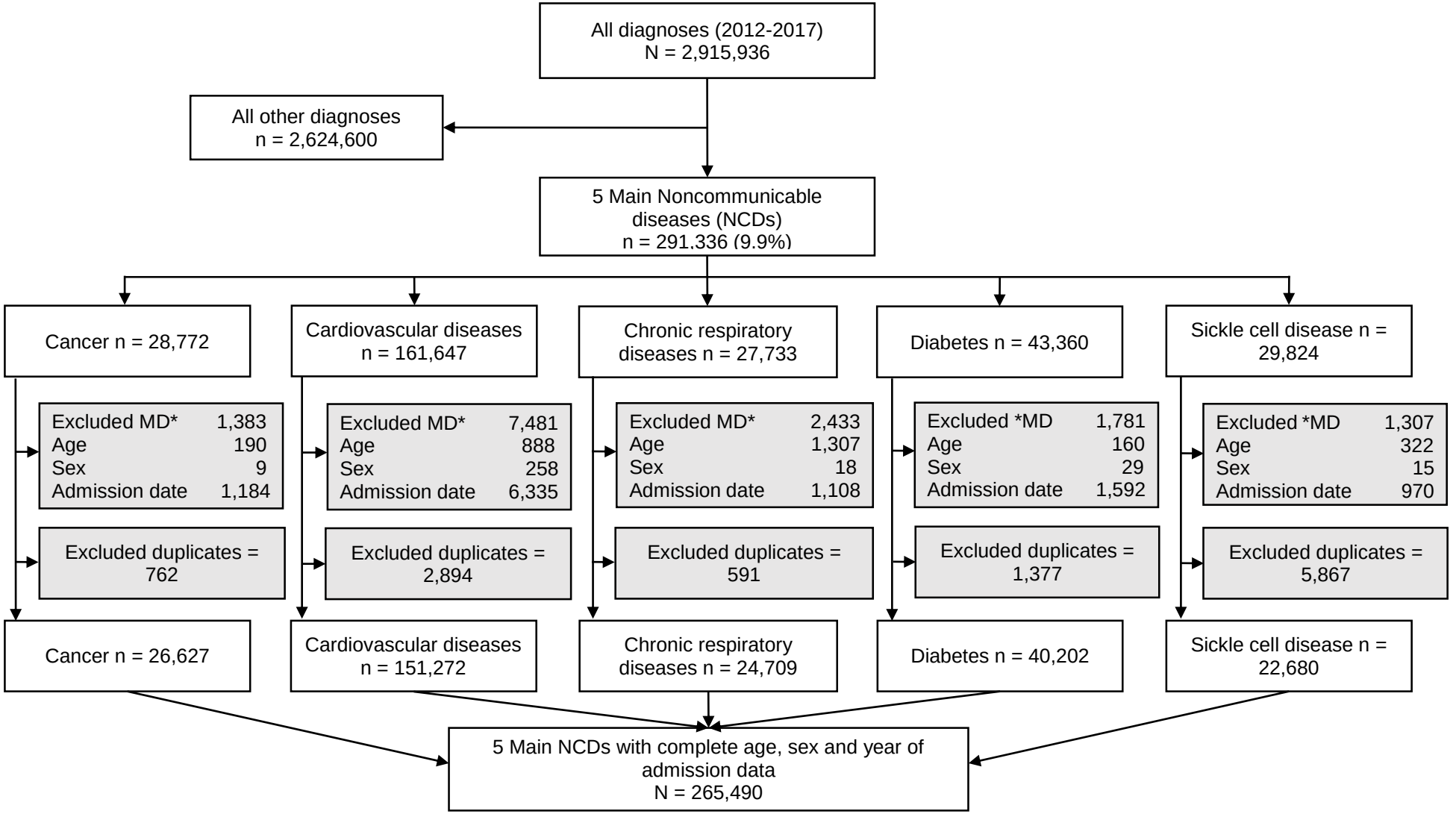


Figure 2: Flowchart of DHIMS data extraction [*MD = missing data]

Figure 3 shows the overall number of records extracted from the GHS District Health Information Management System II database (Figure 3).

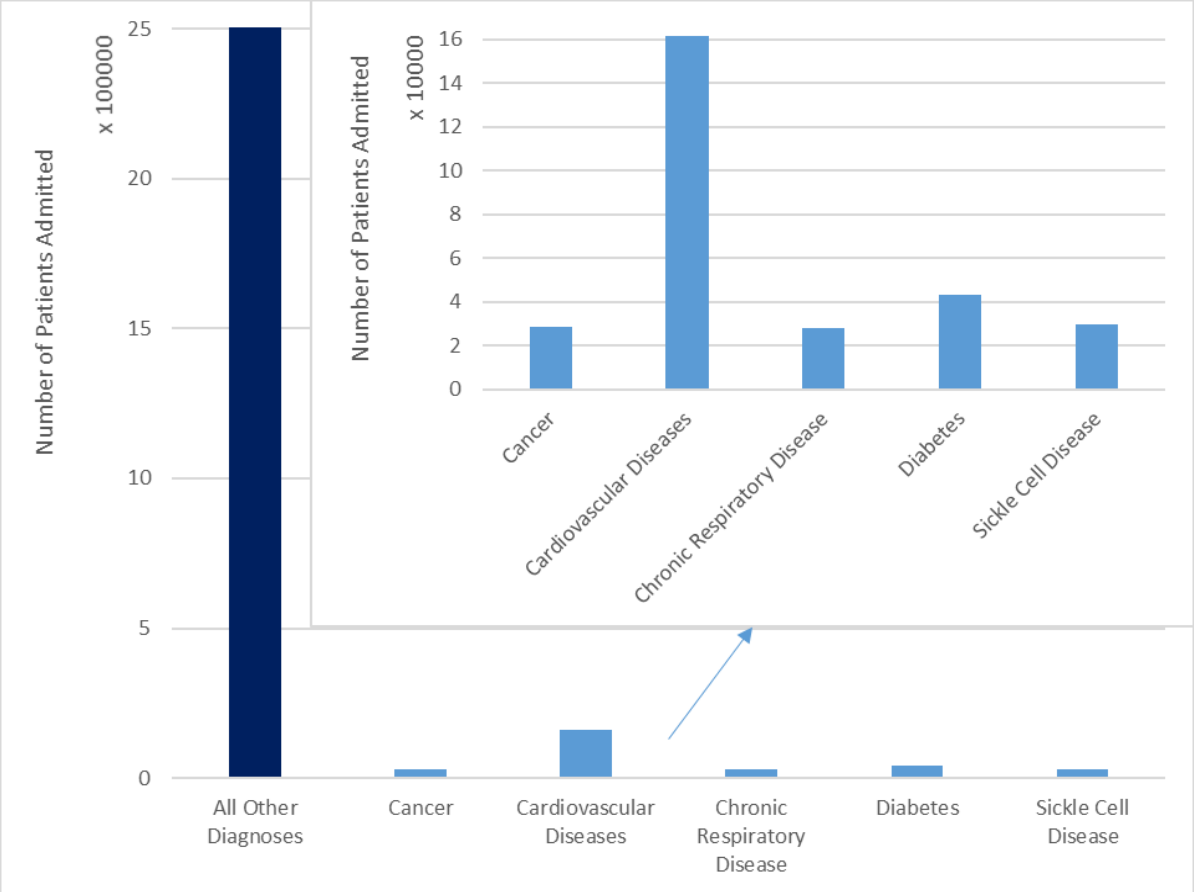


Figure 3: Distribution of cardiovascular, diabetes, cancer, chronic respiratory and sickle cell diseases and all other diagnoses from 2012 – 2017 as extracted from the DHIMS II database of the GHS

Figure 4 shows the sex distribution of patients for each of the five main NCDs from 2012-2017. The number of females was slightly higher in each disease group. Females were about three times higher than their male counterparts for cancer and about the same proportion of SCD inpatients (Figure 4).

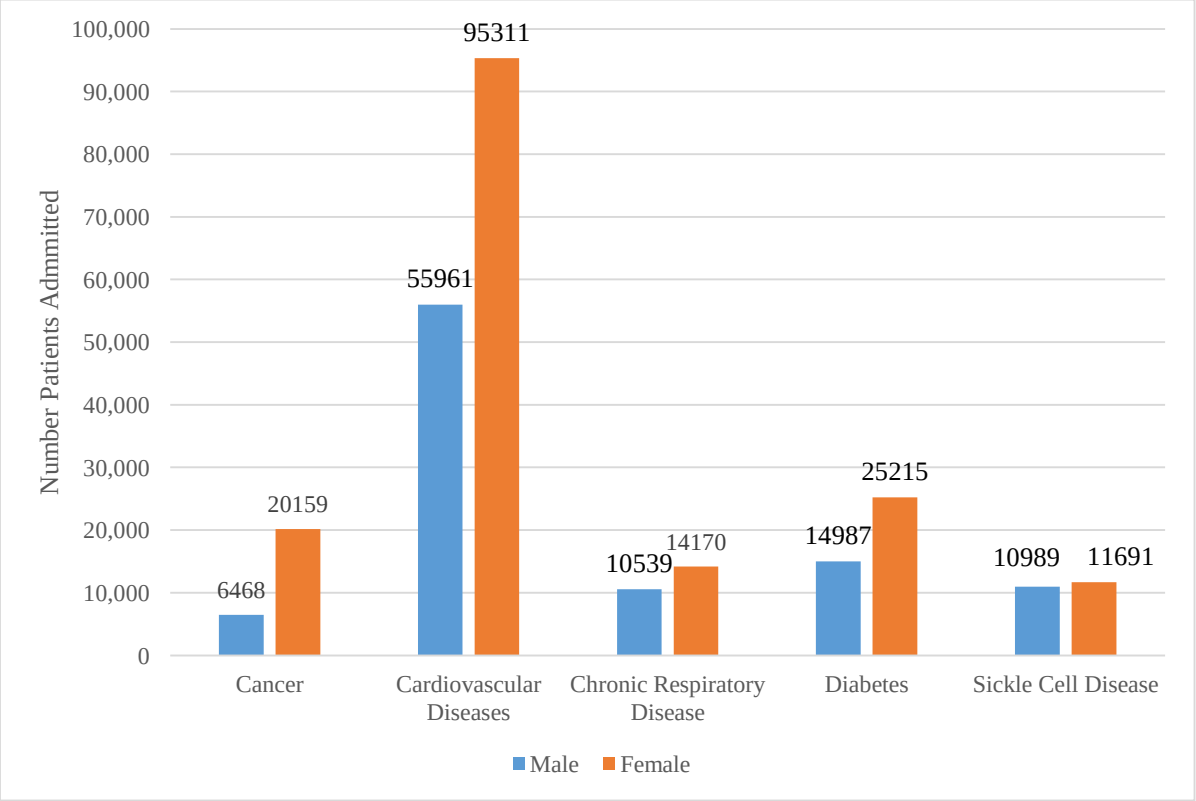


Figure 4: Sex distribution of cardiovascular, diabetes, cancer, chronic respiratory and sickle cell diseases

The extracted estimated population of Ghana from 2012 – 2032 by sex and the ten regions of Ghana showed a steady population growth. The Greater Accra and Ashanti regions which are the two major cities in Ghana had the highest projected populations from over 4 million in 2012 to almost 75 million in 2032 as shown in Figure 5. The Upper West and East regions in the northern part of Ghana had the smallest populations and predicted growth (Figure 5).

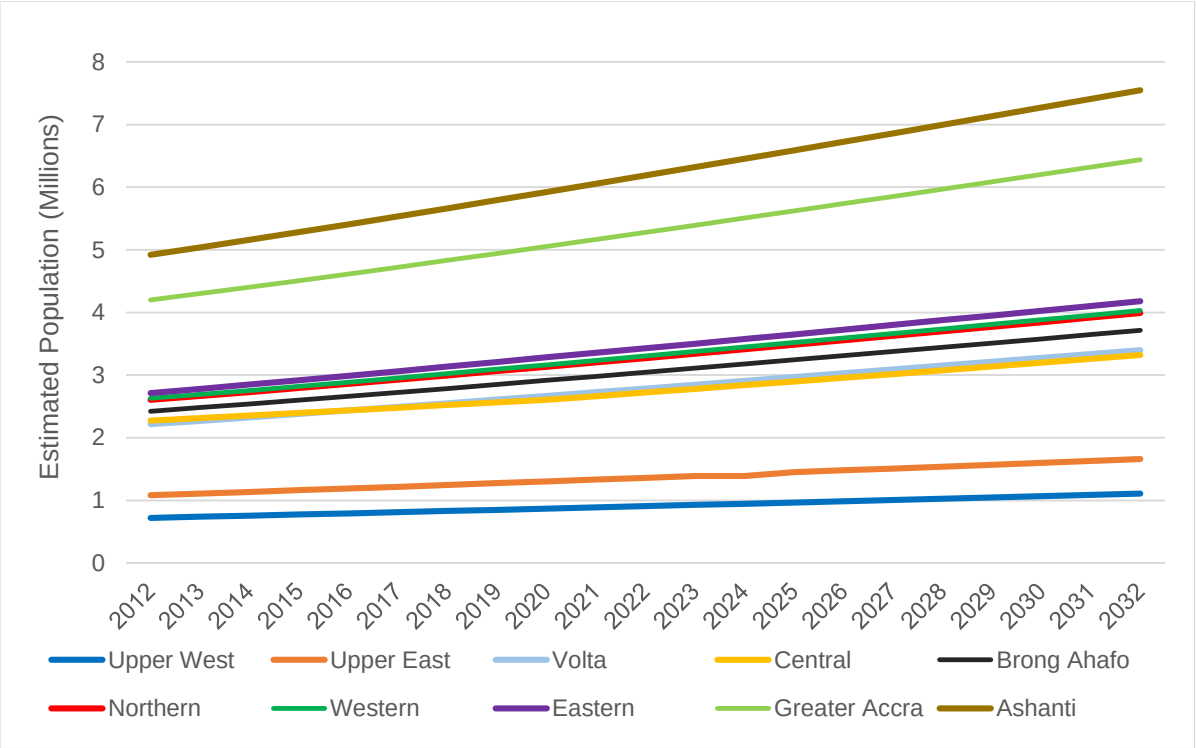


Figure 5: Estimated population of Ghana from 2012 – 2032 based on the 2010 housing and population census from the GSS distributed by the ten regions

Table 2 shows the Ghana standard population proportions based on the 2010 population and housing census conducted by the GSS (63).

Table 2: Ghana standard population proportions based on the 2010 population and housing census

Age group	Standard population
0-4years	0.138
5-9years	0.127
10-14years	0.118
15-19years	0.106
20-24years	0.094
25-29years	0.083
30-34years	0.068
35-39years	0.058
40-44years	0.048
45-49years	0.038
50-54years	0.034
55-59years	0.021
60-64years	0.019
65-69years	0.012
70-74years	0.014
75-79years	0.008
80+years	0.014

4.2 Patients and disease characteristics

The mean age of CVDs inpatients was 56 years (Standard Deviation [SD= 18.5]; Min, Max [1, 100]). Male CVDs inpatients were slightly older 58 years (SD= 17.9], Min, Max [1, 100]) than their female counterparts 55 years (SD= 18.9], Min, Max [1, 100]). The median duration of CVD hospitalization was 3 days (25^{th} and 75^{th} percentile = 1 and 5). Most of these CVD inpatients were either discharged by the 2^{nd} or 5^{th} day. However, most females stay in the hospital until the 4^{th} day and were discharged (Table 3).

The mean age of diabetic inpatients was 54 years (SD= 16.7; Min, Max [1, 100]). The age across both sexes was nearly the same. The median duration of diabetes hospitalization was 4 days (25^{th} and 75^{th} percentile = 2 and 6). Most of these diabetic inpatients were either discharged from the 2^{nd} or 6^{th} day. However, diabetic males could stay in the hospital until the 7^{th} day before being discharged (Table 3).

The mean age of cancer inpatients was 43 years (SD= 17.4], Min, Max [1, 100]). Male cancer inpatients were slightly older than their female counterparts; 49 years (SD= 23.7; Min, Max [1, 100]) and 41 years (SD= 14.4; Min, Max [1, 100]) respectively. The median duration of cancer hospitalization was 4 days (25^{th} and 75^{th} percentile = 2 and 6). Most of these cancer inpatients were either discharged from the 2^{nd} or 6^{th} day. However, males with cancer could stay in the hospital until the 7^{th} day before being discharged (Table 3).

The mean age of CRDs inpatients was 32 years (SD= 25.5; Min, Max [1, 100]). Female CRDs inpatients were slightly older 34 years (SD= 24.0], Min, Max [1, 100]) than their male counterparts 29 years (SD= 27.2; Min, Max [1, 100]). The median duration of CRD hospitalization was 2 days (25^{th} and 75^{th} percentile = 1 and 3). Most of these CRD inpatients were either discharged from the 1^{st} or 3^{rd} day. There was almost no difference in the duration of hospitalization before discharge by sex (Table 3).

The median age of SCD inpatients was 16 years (25^{th} and 75^{th} percentile = 8 and 24). Female SCD inpatients were slightly older 18 years (25^{th} and 75^{th} percentile = 10 and 26) than their male counterparts 14 years (25^{th} and 75^{th} percentile = 7 and 22). We found a few SCD patients, who were aged about 100 years, although not verified. These older ages of SCD inpatients have not yet been reported in literature per our review of the most existing literature. The median duration of SCD hospitalization was 3 days (25^{th} and 75^{th} percentile = 2 and 4). Most of these SCD inpatients were either

discharged from the 1st or 3rd day. There was almost no difference in the duration of hospitalization before discharge by sex (Table 3).

Table 3: Summary distribution of mean and median age and hospitalization duration of disease and sex

	Hospitalization duration							
					Quantiles			
Variable	**n**	**Mean**	**SD**	**Min**	**0.25**	**Median**	**0.75**	**Max**
Cardiovascular diseases								
Age (male)	55961	57.6	17.9	1	46	59	71	100
Age (female)	95311	54.8	18.9	1	40	55	70	100
Age (both sexes)	151272	55.8	18.5	1	42	56	71	100
Hospitalization duration (male)	53888	4.5	12.2	0	2	3	5	457
Hospitalization duration (female)	91768	3.9	10.5	0	1	2	4	383
Hospitalization duration (both sexes)	145656	4.1	11.2	0	1	3	5	457
Diabetes								
Age (male)	14987	53.7	16.7	1	42	55	65	100
Age (female)	25215	53.9	16.8	1	43	55	66	100
Age (both sexes)	40202	53.8	16.7	1	43	55	65	100
Hospitalization duration (male)	14431	5.8	12.8	0	2	4	7	382
Hospitalization duration (female)	24253	5.3	12.1	0	2	4	6	381
Hospitalization duration (both sexes)	38684	5.5	12.4	0	2	4	6	382
Cancer								
Age (male)	6468	48.5	23.7	1	31	51	69	100
Age (female)	20159	40.7	14.4	1	32	40	47	100
Age (both sexes)	26627	42.6	17.4	1	32	41	52	100
Hospitalization duration (male)	6214	6.5	16.2	0	2	4	7	439
Hospitalization duration (female)	19381	5.5	12.1	0	2	4	6	376
Hospitalization duration (both sexes)	25595	5.7	13.2	0	2	4	6	439
Chronic respiratory disease								
Age (male)	10539	28.9	27.2	1	4	20	52	100
Age (female)	14170	33.6	24.0	1	16	29	50	100
Age (both sexes)	24709	31.6	25.5	1	8	27	50	100
Hospitalization duration (male)	10130	3.2	11.2	0	1	2	3	372
Hospitalization duration (female)	13699	3.0	10.0	0	1	2	3	370
Hospitalization duration (both sexes)	23829	3.1	10.5	0	1	2	3	372
Sickle cell disease								
Age (male)	10989	16.0	12.3	1	7	14	22	100
Age (female)	11691	19.7	13.3	1	10	18	26	100
Age (both sexes)	22680	17.9	13.0	1	8	16	24	100
Hospitalization duration (male)	10588	4.0	9.9	0	2	3	4	371
Hospitalization duration (female)	11257	3.9	10.4	0	2	3	4	370
Hospitalization duration (both sexes)	21845	3.9	10.2	0	2	3	4	371

Cardiovascular disease inpatients discharged alive have a median hospitalization duration of 3 (25^{th} and 75^{th} percentile = 2 and 4). While those who died had a shorter median duration of 2 days (25^{th} and 75^{th} percentile = 2 and 5). There was a difference in the male vs. female CVDs inpatients discharged alive or who died.

Diabetics discharged alive had a median hospitalization duration of 4 days (25^{th} and 75^{th} percentile = 2 and 6). While those who died had a shorter median duration of 2 days (25^{th} and 75^{th} percentile = 1 and 6). There was a difference in the male vs. female diabetic inpatients discharged alive or who died.

The median hospitalization duration of cancer inpatients who were discharged home alive or who died was 4 days, however, their 25^{th} and 75^{th} percentiles vary, thus the 25^{th} and 75^{th} percentile for those discharged alive was 2 and 6, while those who died were 2 and 9. However, males could stay a day longer than females.

The median hospitalization duration for CRD inpatients who were discharged home alive or who died was 2 days, however, their 25^{th} and 75^{th} percentiles vary, thus the 25^{th} and 75^{th} percentile for those discharged alive was 1 and 3, while those who died were 1 and 5.

Sickle cell disease inpatients discharged alive had a median hospitalization duration of 3 days (25^{th} and 75^{th} percentile = 2 and 4). While those who died had a shorter median duration of 1 (25^{th} and 75^{th} percentile = 1 and 3). There was a difference in the male vs. female SCDs inpatients discharged alive or who died (Table 4).

Table 4: Summary distribution of mean and median hospitalization duration of disease and hospitalization outcome

	Hospitalization duration							
					Quantiles			
Variable	**n**	**Mean**	**SD**	**Min**	**0.25**	**Median**	**0.75**	**Max**
Cardiovascular diseases								
Alive (male)	48990	4.5	12.3	0	2	3	5	457
Alive (female)	86833	3.9	10.2	0	1	2	4	383
Alive (both sexes)	135823	4.1	11.0	0	2	3	4	457
Died (male)	4831	4.3	11.5	0	1	2	5	380
Died (female)	4814	5.0	15.5	0	1	2	6	369
Died (both sexes)	9645	4.6	13.6	0	1	2	5	380
Missing (male)	67	2.9	4.6	0	1	2	3	33
Missing (female)	121	2.5	6.2	0	0	1	3	63
Missing (both sexes)	188	2.6	5.7	0	0	1	3	63
Diabetes								
Alive (male)	13696	5.7	12.1	0	2	4	7	382
Alive (female)	23268	5.3	11.9	0	2	4	6	381
Alive (both sexes)	36964	5.4	12.0	0	2	4	6	382
Died (male)	712	6.4	23.1	0	1	2	6	368
Died (female)	943	5.6	17.3	0	1	2	6	340
Died (both sexes)	1655	5.9	20.0	0	1	2	6	368
Missing (male)	23	6.0	15.2	0	0	2	4	71
Missing (female)	42	2.5	3.4	0	0	1	3	13
Missing (both sexes)	65	3.8	9.5	0	0	2	3	71
Cancer								
Alive (male)	5593	6.4	16.7	0	2	3	7	439
Alive (female)	18881	5.4	12.2	0	2	4	6	376
Alive (both sexes)	24474	5.6	13.3	0	2	4	6	439
Died (male)	606	7.2	10.9	0	2	4	9	157
Died (female)	489	6.9	8.4	0	2	4	8	57
Died (both sexes)	1095	7.1	9.8	0	2	4	9	157
Missing (male)	15	4.5	8.6	0	1	2	4	34
Missing (female)	11	1.9	3.2	0	0	0	4	8
Missing (both sexes)	26	3.4	6.9	0	0	1	4	34
Chronic respiratory disease								
Alive (male)	9705	3.1	9.4	0	1	2	3	372
Alive (female)	13379	3.0	10.1	0	1	2	3	370
Alive (both sexes)	23084	3.0	9.8	0	1	2	3	372
Died (male)	411	6.2	31.4	0	1	2	5	370
Died (female)	313	4.0	8.4	0	1	2	5	95
Died (both sexes)	724	5.2	24.3	0	1	2	5	370
Missing (male)	14	1.1	1.2	0	0	1	2	4
Missing (female)	7	1.4	1.6	0	1	1	1	5
Missing (both sexes)	21	1.2	1.3	0	0	1	2	5
Sickle cell disease								
Alive (male)	10371	4.0	10.0	0	2	3	4	371
Alive (female)	11063	3.9	10.5	0	2	3	4	370
Alive (both sexes)	21434	4.0	10.3	0	2	3	4	371
Died (male)	202	2.4	3.3	0	1	1	3	24
Died (female)	185	3.1	5.6	0	1	2	4	60
Died (both sexes)	387	2.7	4.5	0	1	1	3	60

Table 4: Summary distribution of mean and median hospitalization duration of disease and hospitalization outcome

	Hospitalization duration							
					Quantiles			
Variable	n	Mean	SD	Min	0.25	Median	0.75	Max
Missing (male)	15	2.8	1.7	0	2	3	4	5
Missing (female)	9	2.7	3.2	0	0	1	6	7
Missing (both sexes)	24	2.8	2.3	0	0.5	2.5	4	7

There was a yearly increase in the number of CVD cases from 11,965 in 2012 to 36,168 in 2016 with a drop to 30,504 in 2017. These increases and drop were similar across both sexes. Out of the 151,272 CVD inpatients, the Eastern region had most of the cases 27,073 (17.9%). Most of these inpatients 15,309 (10.1%) were aged 50-54 years. The majority of CVD inpatients had no formal education 73,216 (48.4%), while farming or fishing was their main occupation. Eighty-one percent (122,017) of the CVD inpatients were insured under the Ghana National Health Insurance Scheme. About 2% (2,634) had some form of surgical procedure during hospitalization (Table 5).

There was a yearly increase in the number of diabetic cases from 3,164 in 2012 to 8,914 in 2016 with a drop to 8,706 in 2017. These increases and drop were similar across both sexes. Out of the 40,202 diabetic inpatients, the Eastern region had most cases 9,778 (24.3%). Most of these inpatients 4,945 (12.3%) were aged 50-54 years. The majority of diabetic inpatients had no formal education 17,510 (43.6%), while farming or fishing was their main occupation. Eighty-four percent (33,942/40,202) of the diabetic inpatients were insured under the Ghana National Health Insurance Scheme. Two percent (958/40,202) had some form of surgical procedure during hospitalization (Table 5).

There was a yearly increase in the number of cancer cases from 994 in 2012 to 7,653 in 2016 with a drop to 5,724 in 2017. These increases and drop were similar across both sexes. Out of the 26,627 cancer inpatients, the Volta region had most cases 5,244 (19.7%). Most of these inpatients 3,027 (11.4%) were aged 45-49 years. The majority of cancer inpatients had no formal education 11,656 (43.8%), while trading or engaging in some form of business was their main occupation. Eighty-seven percent (23,139) of the cancer inpatients were insured under the Ghana National Health Insurance Scheme. Thirty-seven percent (9,807) had some form of surgical procedure during hospitalization (Table 5).

There was a yearly increase in the number of CRD cases from 2,530 in 2012 to 5,686 in 2016 with a drop to 4,397 in 2017. These increases and drop were similar across both sexes. Out of the 24,709 CRD inpatients, the Volta region had most of the cases 4,005 (16.2%). Most of these inpatients 1,830 (7.4%) were aged 5-9 years. The majority of CRD inpatients had no formal education 13,172 (48.4%), and mostly either child/pupil 7,190 (29.1%). Eighty-four percent (20,853) of the CRD inpatients were registered under the Ghana National Health Insurance Scheme. About 1% (242) had some form of surgical procedure during hospitalization (Table 5).

There was a yearly increase in the number of SCD cases from 1,660 in 2012 to 5,327 in 2016 with a drop to 4,451 in 2017. These increases and drop were similar across both sexes. Out of the 22,680 SCD inpatients, the Eastern region had most of the cases 4,695 (20.7%). Most of these inpatients 4,106 (18.1%) were aged 15-19 years. The majority of SCD inpatients had no formal education 7,608 (33.5%), and mostly either child/pupil 9,318 (41.1%). Eighty-six percent (19,527) of the SCD inpatients were insured under the Ghana National Health Insurance Scheme. One percent (274) had some form of surgical procedure during hospitalization (Table 5).

Table 5: Socio-demographic characteristics of patients of CVD, diabetes, cancer, CRD and SCD and by sex

	Cardiovascular disease			Diabetes			Cancer			Chronic respiratory diseases			Sickle cell disease		
Variables	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**
Year															
2012	1089 (43.0)	1441 (57.0)	2530 (100.0)	1317 (41.6)	1847 (58.4)	3164 (100.0)	437 (44.0)	557 (56.0)	994 (100.0)	4516 (37.7)	7449 (62.3)	11965 (100.0)	804 (48.4)	856 (51.6)	1660 (100.0)
2013	1327 (40.5)	1952 (59.5)	3279 (100.0)	1982 (37.9)	3252 (62.1)	5234 (100.0)	793 (42.2)	1086 (57.8)	1879 (100.0)	6561 (33.7)	12881 (66.3)	19442 (100.0)	1373 (48.7)	1449 (51.3)	2822 (100.0)
2014	1743 (42.2)	2392 (57.8)	4135 (100.0)	2613 (37.3)	4392 (62.7)	7005 (100.0)	1158 (27.6)	3043 (72.4)	4201 (100.0)	9438 (36.7)	16261 (63.3)	25699 (100.0)	2068 (49.7)	2096 (50.3)	4164 (100.0)
2015	1996 (42.6)	2686 (57.4)	4682 (100.0)	2771 (38.6)	4408 (61.4)	7179 (100.0)	1382 (22.4)	4794 (77.6)	6176 (100.0)	10583 (38.5)	16911 (61.5)	27494 (100.0)	2024 (47.6)	2232 (52.4)	4256 (100.0)
2016	2528 (44.5)	3158 (55.5)	5686 (100.0)	3258 (36.5)	5656 (63.5)	8914 (100.0)	1580 (20.6)	6073 (79.4)	7653 (100.0)	13519 (37.4)	22649 (62.6)	36168 (100.0)	2599 (48.8)	2728 (51.2)	5327 (100.0)
2017	1856 (42.2)	2541 (57.8)	4397 (100.0)	3046 (35.0)	5660 (65.0)	8706 (100.0)	1118 (19.5)	4606 (80.5)	5724 (100.0)	11344 (37.2)	19160 (62.8)	30504 (100.0)	2121 (47.7)	2330 (52.3)	4451 (100.0)
Region															
Ashanti	1044 (43.3)	1366 (56.7)	2410 (100.0)	1408 (36.6)	2437 (63.4)	3845 (100.0)	387 (27.3)	1033 (72.7)	1420 (100.0)	5331 (36.1)	9439 (63.9)	14770 (100.0)	100.02 (48.4)	1069 (51.6)	2071 (100.0)
Brong Ahafo	1488 (44.0)	1895 (56.0)	3383 (100.0)	2515 (39.3)	3877 (60.7)	6392 (100.0)	1130 (32.0)	2405 (68.0)	3535 (100.0)	7216 (40.2)	10720 (59.8)	17936 (100.0)	1676 (48.2)	1803 (51.8)	3479 (100.0)
Central	467 (42.2)	640 (57.8)	1107 (100.0)	946 (36.8)	1623 (63.2)	2569 (100.0)	393 (19.5)	1625 (80.5)	2018 (100.0)	3589 (33.6)	7093 (66.4)	10682 (100.0)	616 (44.4)	770 (55.6)	1386 (100.0)
Eastern	1443 (42.9)	1920 (57.1)	3363 (100.0)	3530 (36.1)	6248 (63.9)	9778 (100.0)	913 (23.3)	3000 (76.7)	3913 (100.0)	100.060 (36.3)	17680 (63.7)	27740 (100.0)	2280 (48.6)	2415 (51.4)	4695 (100.0)
Greater Accra	935 (47.6)	1031 (52.4)	1966 (100.0)	1787 (37.1)	3029 (62.9)	4816 (100.0)	861 (21.1)	3223 (78.9)	4084 (100.0)	6720 (36.1)	11920 (63.9)	18640 (100.0)	1605 (51.6)	1503 (48.4)	3108 (100.0)

Table 5: Socio-demographic characteristics of patients of CVD, diabetes, cancer, CRD and SCD and by sex

	Cardiovascular disease			Diabetes			Cancer			Chronic respiratory diseases			Sickle cell disease		
Variables	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**
Northern	1049 (41.9)	1457 (58.1)	2506 (100.0)	426 (40.8)	617 (59.2)	1043 (100.0)	845 (40.1)	1262 (59.9)	2107 (100.0)	3023 (34.7)	5700 (65.3)	8723 (100.0)	327 (45.6)	390 (54.4)	717 (100.0)
Upper East	486 (45.0)	593 (55.0)	1079 (100.0)	113 (34.8)	212 (65.2)	325 (100.0)	261 (31.9)	556 (68.1)	817 (100.0)	1200 (38.7)	1902 (61.3)	3102 (100.0)	183 (44.0)	233 (56.0)	416 (100.0)
Upper West	491 (35.4)	895 (64.6)	1386 (100.0)	157 (41.9)	218 (58.1)	375 (100.0)	167 (29.0)	408 (71.0)	575 (100.0)	1501 (40.5)	2202 (59.5)	3703 (100.0)	153 (47.5)	169 (52.5)	322 (100.0)
Volta	1639 (40.9)	2366 (59.1)	4005 (100.0)	1890 (37.3)	3180 (62.7)	5070 (100.0)	1030 (19.6)	4214 (80.4)	5244 (100.0)	9812 (36.2)	17261 (63.8)	27073 (100.0)	1922 (48.4)	2052 (51.6)	3974 (100.0)
Western	1497 (42.7)	2007 (57.3)	3504 (100.0)	2215 (37)	3774 (63)	5989 (100.0)	481 (16.5)	2433 (83.5)	2914 (100.0)	7509 (39.7)	11394 (60.3)	18903 (100.0)	1225 (48.8)	1287 (51.2)	2512 (100.0)
Age group															
0-4years	2932 (60.1)	1944 (39.9)	4876 (100.0)	40 (49.4)	41 (50.6)	81 (100.0)	330 (58.0)	239 (42.0)	569 (100.0)	589 (52.3)	537 (47.7)	1126 (100.0)	1832 (58.8)	1284 (41.2)	3116 (100.0)
5-9years	1154 (63.1)	676 (36.9)	1830 (100.0)	38 (45.2)	46 (54.8)	84 (100.0)	192 (54.1)	163 (45.9)	355 (100.0)	246 (53.6)	213 (46.4)	459 (100.0)	1928 (55.5)	1544 (44.5)	3472 (100.0)
10-14years	667 (56.9)	506 (43.1)	1173 (100)	86 (37.6)	143 (62.4)	229 (100)	162 (49.5)	165 (50.5)	327 (100)	253 (48.5)	269 (51.5)	522 (100)	1829 (55.2)	1483 (44.8)	3312 (100)
15-19years	515 (26.9)	1396 (73.1)	1911 (100.0)	298 (45.3)	360 (54.7)	658 (100.0)	223 (36.1)	394 (63.9)	617 (100.0)	505 (32.2)	1062 (67.8)	1567 (100.0)	1982 (48.3)	2124 (51.7)	4106 (100.0)
20-24years	406 (23.2)	1346 (76.8)	1752 (100.0)	365 (35.9)	652 (64.1)	1017 (100.0)	269 (26.0)	765 (74.0)	1034 (100.0)	766 (24.0)	2422 (76.0)	3188 (100.0)	1435 (43.5)	1863 (56.5)	3298 (100.0)
25-29years	407 (23.8)	1301 (76.2)	1708 (100.0)	399 (29.9)	934 (70.1)	1333 (100.0)	347 (15.8)	1846 (84.2)	2193 (100.0)	1228 (21.7)	4431 (78.3)	5659 (100.0)	801 (38.0)	1305 (62.0)	2106 (100.0)

Table 5: Socio-demographic characteristics of patients of CVD, diabetes, cancer, CRD and SCD and by sex

Variables	Cardiovascular disease			Diabetes			Cancer			Chronic respiratory diseases			Sickle cell disease		
	Male n(%)	Female n(%)	Total N(%)	Male n(%)	Female n(%)	Total N(%)	Male n(%)	Female n(%)	Total N(%)	Male n(%)	Female n(%)	Total N(%)	Male n(%)	Female n(%)	Total N(%)
30-34years	425 (28.3)	1078 (71.7)	1503 (100.0)	705 (34.8)	1322 (65.2)	2027 (100.0)	370 (10.9)	3011 (89.1)	3381 (100.0)	1911 (23.4)	6258 (76.6)	8169 (100.0)	409 (35.6)	739 (64.4)	1148 (100.0)
35-39years	398 (29.8)	939 (70.2)	1337 (100.0)	1015 (39.8)	1537 (60.2)	2552 (100.0)	371 (10.0)	3356 (90.0)	3727 (100.0)	2911 (29.1)	7088 (70.9)	9999 (100.0)	245 (35.5)	445 (64.5)	690 (100.0)
40-44years	401 (34.9)	748 (65.1)	1149 (100.0)	1302 (42.3)	1775 (57.7)	3077 (100.0)	403 (10.4)	3480 (89.6)	3883 (100.0)	3901 (34.4)	7452 (65.6)	11353 (100.0)	161 (35.5)	292 (64.5)	453 (100.0)
45-49years	403 (39.9)	607 (60.1)	1010 (100.0)	1398 (35.6)	2533 (64.4)	3931 (100.0)	437 (14.4)	2590 (85.6)	3027 (100.0)	4586 (37.4)	7688 (62.6)	12274 (100.0)	106 (35.2)	195 (64.8)	301 (100.0)
50-54years	420 (41.7)	586 (58.3)	100.06 (100.0)	1690 (34.2)	3255 (65.8)	4945 (100.0)	418 (22.4)	1448 (77.6)	1866 (100.0)	5835 (38.1)	9474 (61.9)	15309 (100.0)	82 (37.3)	138 (62.7)	220 (100.0)
55-59years	365 (39.9)	549 (60.1)	914 (100.0)	1779 (36.9)	3038 (63.1)	4817 (100.0)	418 (34.5)	793 (65.5)	1211 (100.0)	5924 (41.4)	8378 (58.6)	14302 (100.0)	55 (33.7)	108 (66.3)	163 (100.0)
60-64years	409 (47.6)	451 (52.4)	860 (100.0)	1812 (40.7)	2636 (59.3)	4448 (100.0)	511 (47.8)	558 (52.2)	1069 (100.0)	6102 (43.6)	7885 (56.4)	13987 (100.0)	48 (41.4)	68 (58.6)	116 (100.0)
65-69years	349 (49.5)	356 (50.5)	705 (100.0)	1287 (40.1)	1920 (59.9)	3207 (100.0)	445 (59.0)	309 (41.0)	754 (100.0)	4919 (45.3)	5945 (54.7)	10864 (100.0)	22 (40.7)	32 (59.3)	54 (100.0)
70-74years	403 (45.0)	493 (55.0)	896 (100.0)	1135 (38.3)	1827 (61.7)	2962 (100.0)	579 (58.5)	411 (41.5)	990 (100.0)	5646 (41.0)	8120 (59.0)	13766 (100.0)	21 (42.9)	28 (57.1)	49 (100.0)
75-79years	437 (43.6)	566 (56.4)	1003 (100.0)	917 (34.3)	1753 (65.7)	2670 (100.0)	556 (62.8)	330 (37.2)	886 (100.0)	5176 (37.5)	8618 (62.5)	13794 (100.0)	15 (38.5)	24 (61.5)	39 (100.0)
80-100years	448 (41.6)	628 (58.4)	1076 (100.0)	721 (33.3)	1443 (66.7)	2164 (100.0)	437 (59.2)	301 (40.8)	738 (100.0)	5463 (36.6)	9471 (63.4)	14934 (100.0)	18 (48.6)	19 (51.4)	37 (100.0)

Table 5: Socio-demographic characteristics of patients of CVD, diabetes, cancer, CRD and SCD and by sex

	Cardiovascular disease			Diabetes			Cancer			Chronic respiratory diseases			Sickle cell disease		
Variables	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**
Educational level															
JHS/Middle school	1639 (35.0)	3042 (65.0)	4681 (100.0)	4254 (35.9)	7585 (64.1)	11839 (100.0)	1209 (17.7)	5618 (82.3)	6827 (100.0)	14486 (35.8)	26017 (64.2)	40503 (100.0)	1932 (42.6)	2598 (57.4)	4530 (100.0)
None	5951 (45.2)	7221 (54.8)	13172 (100.0)	5930 (33.9)	11580 (66.1)	17510 (100.0)	3253 (27.9)	8403 (72.1)	11656 (100.0)	25146 (34.3)	48070 (65.7)	73216 (100.0)	3820 (50.2)	3788 (49.8)	7608 (100.0)
Primary	1707 (50.7)	1657 (49.3)	3364 (100.0)	1400 (33.9)	2731 (66.1)	4131 (100.0)	646 (24.3)	2017 (75.7)	2663 (100.0)	4652 (32.9)	9486 (67.1)	14138 (100.0)	2855 (52.9)	2538 (47.1)	5393 (100.0)
Senior high secondary (SHS)/vocational	741 (32.4)	1548 (67.6)	2289 (100.0)	1795 (45.4)	2162 (54.6)	3957 (100.0)	750 (24.8)	2272 (75.2)	3022 (100.0)	6265 (45.5)	7501 (54.5)	13766 (100.0)	1711 (46.1)	1998 (53.9)	3709 (100.0)
Tertiary	490 (41.2)	699 (58.8)	1189 (100.0)	1608 (58.2)	1156 (41.8)	2764 (100.0)	610 (24.8)	1846 (75.2)	2456 (100.0)	5406 (56.1)	4229 (43.9)	9635 (100.0)	670 (46.6)	768 (53.4)	1438 (100.0)
Occupation															
Child/pupil	4308 (59.9)	2882 (40.1)	7190 (100.0)	177 (41.5)	249 (58.5)	426 (100.0)	638 (54.8)	526 (45.2)	1164 (100.0)	1081 (49.4)	1109 (50.6)	2190 (100.0)	5295 (56.8)	4023 (43.2)	9318 (100.0)
Trader/business	551 (17.4)	2622 (82.6)	3173 (100.0)	1875 (18.8)	8108 (81.2)	9983 (100.0)	700 (8.6)	7418 (91.4)	8118 (100.0)	6355 (18.9)	27260 (81.1)	33615 (100.0)	451 (23.0)	1514 (77.0)	1965 (100.0)
Farmer/ fisherman	1735 (45.9)	2042 (54.1)	3777 (100.0)	4357 (43.1)	5755 (56.9)	10112 (100.0)	1652 (38.9)	2597 (61.1)	4249 (100.0)	15724 (43.8)	20144 (56.2)	35868 (100.0)	500 (43.2)	657 (56.8)	1157 (100.0)
Housewife	3 (0.5)	560 (99.5)	563 (100.0)	6 (1.1)	558 (98.9)	564 (100.0)	9 (1.2)	770 (98.8)	779 (100.0)	51 (1.5)	3262 (98.5)	3313 (100.0)	6 (4.4)	129 (95.6)	135 (100.0)
Para professional	217 (43.3)	284 (56.7)	501 (100.0)	857 (57.4)	637 (42.6)	1494 (100.0)	188 (17.4)	893 (82.6)	1081 (100.0)	2612 (53.9)	2234 (46.1)	4846 (100.0)	197 (41.4)	279 (58.6)	476 (100.0)
Professional	283 (40.9)	409 (59.1)	692 (100.0)	1012 (58.4)	721 (41.6)	1733 (100.0)	329 (19.6)	1351 (80.4)	1680 (100.0)	3176 (54.2)	2682 (45.8)	5858 (100.0)	231 (39.6)	352 (60.4)	583 (100.0)

Table 5: Socio-demographic characteristics of patients of CVD, diabetes, cancer, CRD and SCD and by sex

	Cardiovascular disease			Diabetes			Cancer			Chronic respiratory diseases			Sickle cell disease		
Variables	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**
Retired	344 (50.4)	339 (49.6)	683 (100.0)	1389 (50.4)	1367 (49.6)	2756 (100.0)	642 (67.2)	313 (32.8)	955 (100.0)	6219 (48.9)	6497 (51.1)	12716 (100.0)	26 (49.1)	27 (50.9)	53 (100.0)
Student	776 (32.3)	1626 (67.7)	2402 (100.0)	425 (46.8)	484 (53.2)	909 (100.0)	351 (34.0)	681 (66.0)	1032 (100.0)	933 (40.7)	1358 (59.3)	2291 (100.0)	2763 (50.3)	2733 (49.7)	5496 (100.0)
Unemployed	322 (35.0)	597 (65.0)	919 (100.0)	831 (28.7)	2066 (71.3)	2897 (100.0)	231 (22.9)	777 (77.1)	100.08 (100.0)	3724 (31.1)	8234 (68.9)	11958 (100.0)	237 (37.1)	402 (62.9)	639 (100.0)
Unspecified	728 (38.1)	1181 (61.9)	1909 (100.0)	1098 (36.8)	1884 (63.2)	2982 (100.0)	421 (28.1)	1078 (71.9)	1499 (100.0)	4526 (34.3)	8656 (65.7)	13182 (100.0)	446 (47.1)	500 (52.9)	946 (100.0)
Others	1270 (43.9)	1622 (56.1)	2892 (100.0)	2960 (46.7)	3381 (53.3)	6341 (100.0)	1306 (26.0)	3718 (74.0)	5024 (100.0)	11558 (45.5)	13850 (54.5)	25408 (100.0)	837 (43.8)	1073 (56.2)	1910 (100.0)
Health insurance															
No	1841 (50.3)	1819 (49.7)	3660 (100.0)	2604 (44.7)	3223 (55.3)	5827 (100.0)	1137 (37.4)	1906 (62.6)	3043 (100.0)	13405 (47.7)	14724 (52.3)	28129 (100.0)	1649 (54.7)	1367 (45.3)	3016 (100.0)
Yes	8615 (41.3)	12238 (58.7)	20853 (100.0)	12219 (36.0)	21723 (64.0)	33942 (100.0)	5260 (22.7)	17879 (77.3)	23139 (100.0)	42140 (34.5)	79877 (65.5)	122017 (100.0)	9280 (47.5)	10247 (52.5)	19527 (100.0)
Surgical procedure															
No	100.062 (42.7)	13515 (57.3)	23577 (100.0)	13962 (37.1)	23622 (62.9)	37584 (100.0)	4077 (25.6)	11875 (74.4)	15952 (100.0)	52739 (36.8)	90666 (63.2)	143405 (100.0)	10478 (48.4)	11165 (51.6)	21643 (100.0)
Yes	105 (43.4)	137 (56.6)	242 (100.0)	404 (42.2)	554 (57.8)	958 (100.0)	2176 (22.2)	7631 (77.8)	9807 (100.0)	1288 (48.9)	1346 (51.1)	2634 (100.0)	138 (50.4)	136 (49.6)	274 (100.0)

Table 5: Socio-demographic characteristics of patients of CVD, diabetes, cancer, CRD and SCD and by sex

	Cardiovascular disease			Diabetes			Cancer			Chronic respiratory diseases			Sickle cell disease		
Variables	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**
Additional diagnoses															
No	6755 (41.9)	9355 (58.1)	16110 (100.0)	7156 (40.2)	10659 (59.8)	17815 (100.0)	4868 (23.2)	16084 (76.8)	20952 (100.0)	30592 (36.3)	53644 (63.7)	84236 (100.0)	6367 (47.6)	7016 (52.4)	13383 (100.0)
Yes	3784 (44.0)	4815 (56.0)	8599 (100.0)	7826 (35.0)	14561 (65.0)	22387 (100.0)	1491 (26.3)	4184 (73.7)	5675 (100.0)	25369 (37.8)	41667 (62.2)	67036 (100.0)	4622 (49.7)	4675 (50.3)	9297 (100.0)
Hospitalization duration															
Same day	593 (41.8)	825 (58.2)	1418 (100.0)	496 (37.5)	825 (62.5)	1321 (100.0)	324 (25.9)	925 (74.1)	1249 (100.0)	2816 (41.2)	4014 (58.8)	6830 (100.0)	290 (46.5)	334 (53.5)	624 (100.0)
1Day	2785 (40.9)	4022 (59.1)	6807 (100.0)	1916 (37.9)	3140 (62.1)	5056 (100.0)	998 (30.1)	2319 (69.9)	3317 (100.0)	10552 (34.6)	19987 (65.4)	30539 (100.0)	1770 (47.4)	1963 (52.6)	3733 (100.0)
2Days	2939 (42.5)	3970 (57.5)	6909 (100.0)	2354 (34.7)	4423 (65.3)	6777 (100.0)	100.04 (28.7)	2491 (71.3)	3495 (100.0)	11433 (33.1)	23148 (66.9)	34581 (100.0)	2712 (47.8)	2956 (52.2)	5668 (100.0)
3Days	1538 (42.2)	2108 (57.8)	3646 (100.0)	2005 (35.0)	3725 (65.0)	5730 (100.0)	767 (23.1)	2559 (76.9)	3326 (100.0)	7985 (36.0)	14172 (64.0)	22157 (100.0)	2025 (48.5)	2152 (51.5)	4177 (100.0)
4Days	863 (43.9)	1103 (56.1)	1966 (100.0)	1644 (36.4)	2871 (63.6)	4515 (100.0)	553 (13.9)	3428 (86.1)	3981 (100.0)	5679 (38.3)	9144 (61.7)	14823 (100.0)	1284 (48.5)	1365 (51.5)	2649 (100.0)
5Days	445 (44.6)	553 (55.4)	998 (100.0)	1335 (38.1)	2172 (61.9)	3507 (100.0)	441 (16.0)	2319 (84.0)	2760 (100.0)	3716 (38.9)	5848 (61.1)	9564 (100.0)	794 (50.1)	791 (49.9)	1585 (100.0)
6Days	300 (46.9)	340 (53.1)	640 (100.0)	991 (35.3)	1813 (64.7)	2804 (100.0)	364 (21.7)	1314 (78.3)	1678 (100.0)	2972 (41.5)	4184 (58.5)	7156 (100.0)	509 (49.3)	524 (50.7)	1033 (100.0)
7Days	173 (43.5)	225 (56.5)	398 (100.0)	859 (38.5)	1372 (61.5)	2231 (100.0)	327 (25.1)	975 (74.9)	1302 (100.0)	2118 (41.8)	2945 (58.2)	5063 (100.0)	363 (52.4)	330 (47.6)	693 (100.0)
1-2weeks	350 (46.5)	402 (53.5)	752 (100.0)	2095 (41.9)	2910 (58.1)	5005 (100.0)	955 (31.3)	2095 (68.7)	3050 (100.0)	5058 (44.9)	6214 (55.1)	11272 (100.0)	643 (49.5)	655 (50.5)	1298 (100.0)

Table 5: Socio-demographic characteristics of patients of CVD, diabetes, cancer, CRD and SCD and by sex

	Cardiovascular disease			Diabetes			Cancer			Chronic respiratory diseases			Sickle cell disease		
Variables	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**	**Male n(%)**	**Female n(%)**	**Total N(%)**
2-3weeks	65 (58.0)	47 (42.0)	112 (100.0)	412 (43.9)	526 (56.1)	938 (100.0)	239 (30.7)	540 (69.3)	779 (100.0)	813 (43.3)	1066 (56.7)	1879 (100.0)	91 (51.1)	87 (48.9)	178 (100.0)
3-4weeks	14 (40.0)	21 (60.0)	35 (100.0)	119 (39.5)	182 (60.5)	301 (100.0)	87 (35.5)	158 (64.5)	245 (100.0)	236 (40.1)	353 (59.9)	589 (100.0)	25 (46.3)	29 (53.7)	54 (100.0)
1month-2years	65 (43.9)	83 (56.1)	148 (100.0)	205 (41.1)	294 (58.9)	499 (100.0)	155 (37.5)	258 (62.5)	413 (100.0)	510 (42.4)	693 (57.6)	1203 (100.0)	82 (53.6)	71 (46.4)	153 (100.0)

For all the five NCDs, male inpatients had higher proportions of additional diagnoses compared with females (Table 5).

Figure 6 shows the top ten different cardiovascular diseases from a list of 60 diagnosed CVDs. Essential (primary) hypertension (ICD10 code: I10) was the main diagnosis among both male and female inpatients accounting for more than 50% of the top ten CVDs. This was followed by congestive heart failure (ICD10 code: I50.0) and stroke not specified as haemorrhage or infarction (ICD10 code: I64) with similar proportions in males and females.

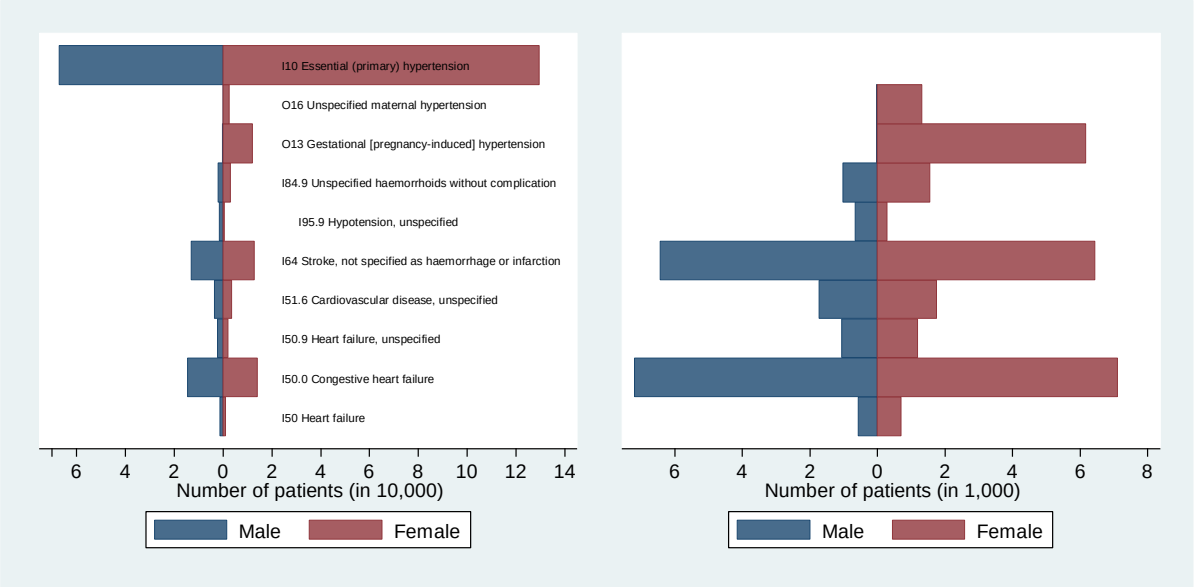


Figure 6: Distribution of overall top ten CVDs by sex

A total of six different types of diabetes were diagnosed over the period. Of these six, unspecified diabetes mellitus (ICD10 code: E14) was the highest to be diagnosed in both males and females accounting for over 95% of the cases. This was followed by unspecified diabetes mellitus with renal complications (ICD10 code: E14.2), (Figure 7).

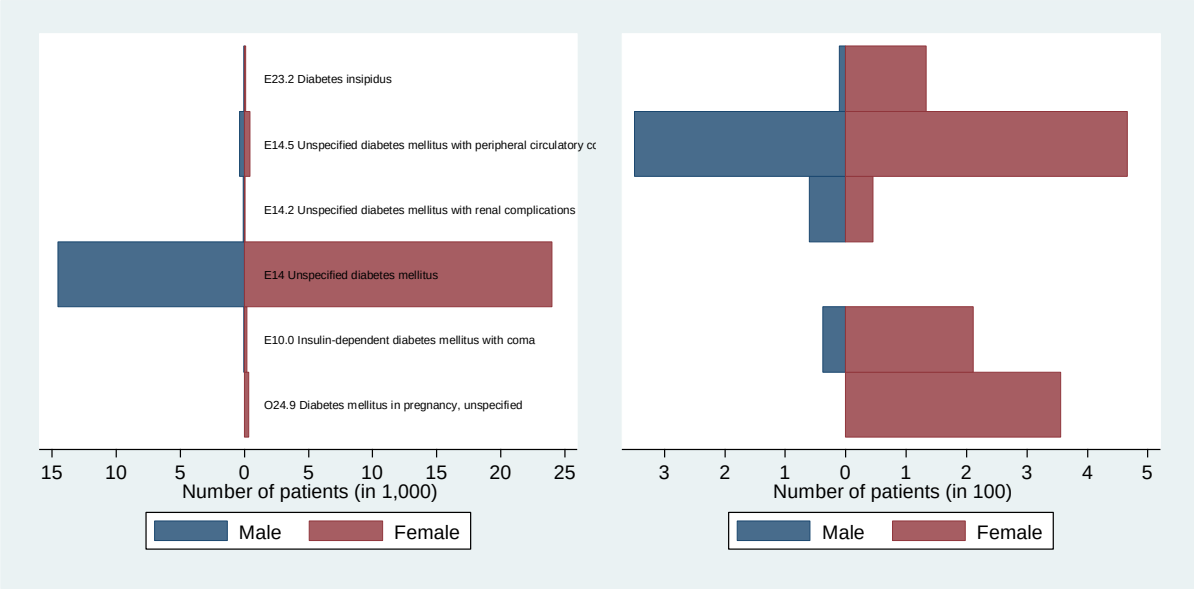


Figure 7: Distribution of eight diabetic types by sex

Figure 8 shows the top ten different cancer sites/types from a list of 77 diagnosed cancers. The predominantly diagnosed cancer within the top ten cases was unspecified Leiomyoma of the uterus (ICD10 code: D25.9). Female unspecified malignant neoplasm of the breast (ICD10 code: C50.9) and malignant neoplasm of the prostate (ICD10 code: C61) were the 2nd and 3rd leading cancer cases among the inpatients.

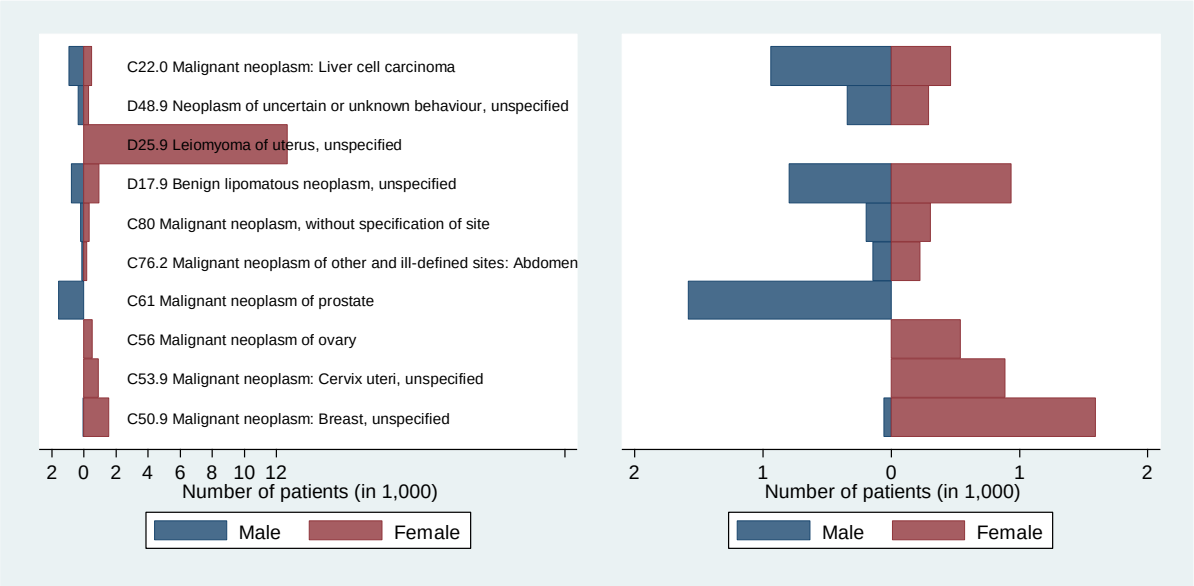


Figure 8: Distribution of overall top ten cancer sites by sex

Asthma (ICD10 code: J45) in general and asthma unspecified (ICD10 code: J45.9) were the main NCDs diagnosed under CRDs in the top ten lists of 17 asthma and Chronic Obstructive Pulmonary diseases (COPD) in the DHIMS II database. These two formed over 80% of the top ten CRDs. Bronchitis, not specified as acute or chronic (ICD10 code: J40) and pneumonia due to food and vomit (ICD10 code: J69.0) were the 3rd and 4th highest among the top ten CRD diagnoses (Figure 9).

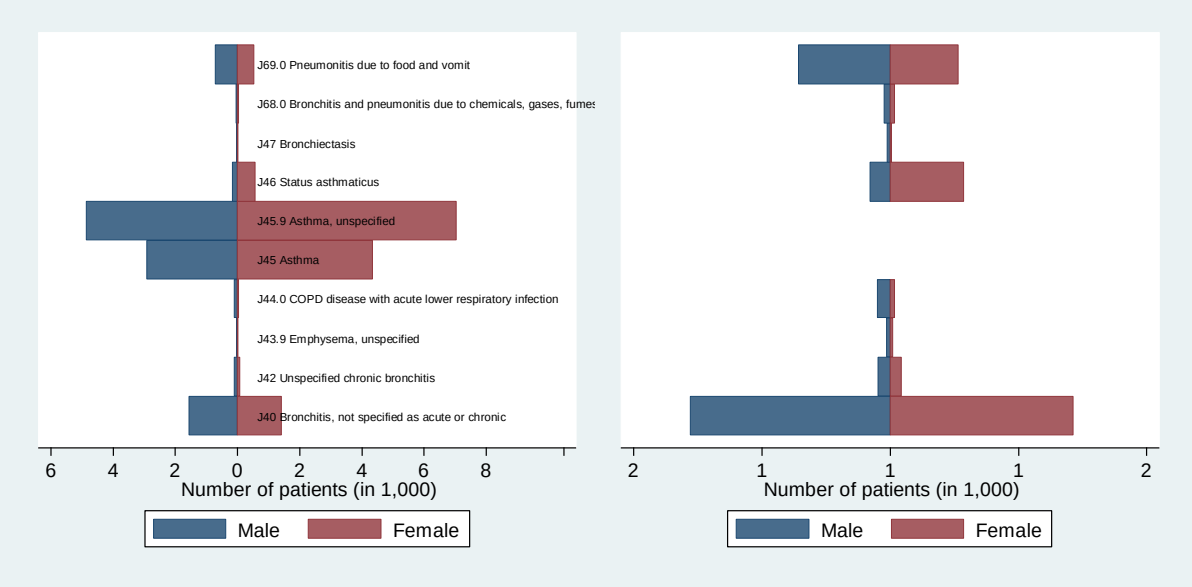


Figure 9: Distribution of overall top ten CRDs by sex

Figure 10 shows an even distribution of sickle cell anaemia with (ICD10 code: D57.0) and without (ICD10 code: D57.1) crisis among the inpatients and by sex.

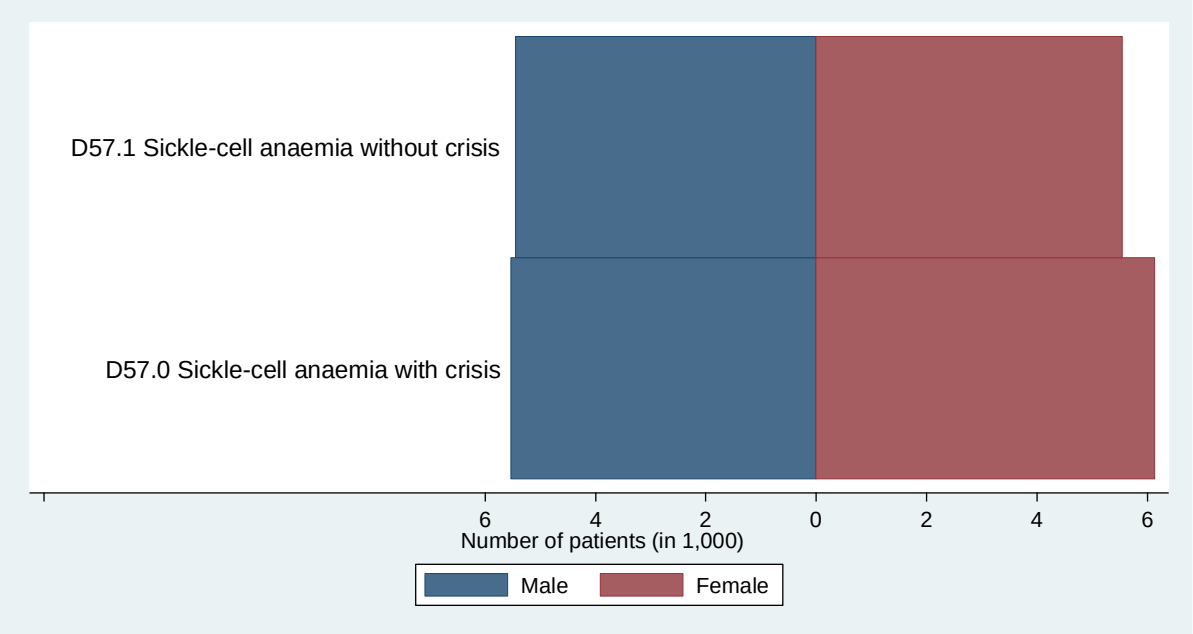


Figure 10: Distribution of two SCD types by sex

4.3 Objective 1: To estimate spatial and temporal patterns in hospital admission rates and mortality in Ghana from 2012 – 2017 in NCDs.

The Age-standardized cardiovascular disease rate (ASCVDR) from 2012 – 2017 was 93.7 (95%CI: 93.2,94.2) cases per 100,000 inpatients compared to a crude rate of 92.4 cases. The ASCVDR in females was 33.8 more cases per 100,000 inpatients compared to males (Table 6).

The Age-standardized diabetes rate (ASDR) from 2012 – 2017 was 24.0 (95%CI: 23.7,24.2) cases per 100,000 inpatients compared to a crude rate of 24.5 cases. The ASDR in females was nine more cases per 100,000 inpatients compared to males (Table 6).

At the country level, the Age-standardized cancer rate (ASCR) from 2012 – 2017 was 16.0 (95%CI: 15.8, 16.2) cases per 100,000 inpatients compared to a crude rate of 16.4 cases. The ASCR in females was 14.1 more cases per 100,000 inpatients compared to males (Table 6).

The Age-standardized chronic respiratory disease rate (ASCRDR) from 2012 – 2017 was similar between the crude and ASCRDR; 15.2 (95%CI: 15.0,15.4) cases per 100,000 inpatients compared to a crude rate of 15.1 cases. The ASCRDR in females was 3.3 more cases per 100,000 inpatients compared to males (Table 6).

The Age-standardized SCD rate (ASSCDR) from 2012 – 2017 was 14.0 (95%CI: 13.8,14.2) cases per 100,000 inpatients compared to a crude rate of 16.4 cases. The ASSCDR in females was 0.6 more cases per 100,000 inpatients compared to males (Table 6).

Table 6: Age-standardized rates and 95% confidence interval (95%CI) for all patients admitted for CVDs, diabetes, cancer, CRDs or SCD and by sex

Variables	Person-years	Admitted cases	Crude rate	Adj. rate (95% CI)
Cancer Cases	164016931	26829	16.4	16.0 (15.8,16.2)
CVD Cases	164016931	151630	92.4	93.7 (93.2,94.2)
CRD Cases	164016931	24709	15.1	15.2 (15.0,15.4)
Diabetes	164016931	40202	24.5	24.0 (23.7,24.2)
SCD Cases	164016931	22680	13.8	14.0 (13.8,14.2)
Sex distribution of CVD cases				
Male	80382354	56115	69.8	75.8 (75.2,76.5)
Female	83634577	95515	114.2	109.6 (108.9,110.3)
Sex distribution of diabetes cases				
Male	80382354	14987	18.6	19.2 (18.8,19.5)
Female	83634577	25215	30.1	28.2 (27.8,28.5)
Sex distribution of cancer cases				
Male	80382354	6545	8.1	8.7 (8.5,8.9)
Female	83634577	20284	24.3	22.8 (22.5,23.1)
Sex distribution of CRD cases				
Male	80382354	10539	13.1	13.5 (13.2,13.8)
Female	83634577	14170	16.9	16.8 (16.5,17.1)
Sex distribution of SCD cases				
Male	80382354	10989	13.7	13.7 (13.4,13.9)
Female	83634577	11691	14.0	14.3 (14.0,14.5)

The highest ASR for females diagnosed with CVD was recorded in the Volta region 191.9 (95% CI: 189.0,194.8) and the lowest in the Upper East Region 48.2 (95% CI: 46.0,50.5). Similarly, the highest male ASR for CVD was diagnosed in the Volta region 134.7 (95% CI: 132.0,137.4) and the lowest also in the Upper East Region 35.5 (95% CI: 33.5,37.6). Rates were higher among the females for all the five diseases.

The highest ASR for both males 35.8 (95% CI: 34.3,37.2) and females 49.3 (95% CI: 47.8,50.9) diagnosed with diabetes was recorded in the Brong Ahafo region. The Upper East region also recorded the lowest rates for both males 3.4 (95% CI: 2.8,4.1) and females 5.6 (95% CI: 4.8,6.4) diabetic cases.

The highest ASR for females diagnosed with cancer was recorded in the Volta region 54.3 (95% CI: 52.7,56.0) and the lowest in the Ashanti region 6.2 (95% CI: 5.9,6.6). For males, the highest ASR for cancer was diagnosed in the Brong Ahafo region 16.3 (95% CI: 15.4,17.3) and the lowest in the Ashanti region 2.9 (95% CI: 2.6,3.2), (Table 7).

The highest ASR for females diagnosed with CRD was recorded in the Upper West region 38.3 (95% CI: 35.8,41.0) and the lowest in the Ashanti region 8.1 (95% CI: 7.6,8.6). For males, the highest ASR for CRD was diagnosed in the Volta Region 23.0 (95% CI: 21.9,24.2) and the lowest in the Central region 6.8 (95% CI: 6.2,7.5).

The Volta region recorded the highest ASRs for both male and female SCD inpatients [males 28.4 (95% CI: 27.2,29.7) and females 31.0 (95% CI: 29.6,32.3)], while the Northern region recorded the lowest of ASRs [males 3.9 (95% CI: 3.5,4.4) and females 4.7 (95% CI: 4.3,5.2)], (Table 7).

Table 7: Number of cases, crude rates and ASR, and 95% confidence interval (95% CI) for admitted CVD, diabetes, cancer, CRDs, and SCD patients by sex and region

Variable			CVD			Diabetes			Cancer			CRD			SCD		
Sex	Region	Population	Number of cases	Crude rate	Adj. rate (95% CI)	Number of cases	Crude rate	Adj. rate (95% CI)	Number of cases	Crude rate	Adj. rate (95% CI)	Number of cases	Crude rate	Adj. rate (95% CI)	Number of cases	Crude rate	Adj. rate (95% CI)
Male	Ashanti	15368800	5362	34.9	40.3 (39.1,41.4)	1408	9.2	9.8 (9.3,10.4)	395	2.6	2.9 (2.6,3.2)	1044	6.8	7.2 (6.8,7.7)	1002	6.5	6.5 (6.1,6.9)
Female	Ashanti	15971360	9482	59.4	58.9 (57.7,60.1)	2437	15.3	14.9 (14.3,15.5)	1058	6.6	6.2 (5.9,6.6)	1366	8.6	8.5 (8.1,9.0)	1069	6.7	6.8 (6.4,7.2)
Male	Brong Ahafo	7563690	7225	95.5	109.0 (106.4,111.6)	2515	33.3	35.8 (34.3,37.2)	1142	15.1	16.3 (15.4,17.3)	1488	19.7	20.8 (19.7,21.9)	1676	22.2	21.8 (20.7,22.8)
Female	Brong Ahafo	7860260	10744	136.7	137.9 (135.3,140.5)	3877	49.3	49.3 (47.8,50.9)	2407	30.6	30.3 (29.1,31.5)	1895	24.1	24.2 (23.1,25.3)	1803	22.9	23.1 (22.0,24.2)
Male	Central	6913025	3598	52.0	55.4 (53.6,57.3)	946	13.7	14.0 (13.1,15.0)	399	5.8	6.2 (5.6,6.8)	467	6.8	6.8 (6.2,7.5)	616	8.9	8.9 (8.2,9.6)
Female	Central	7344623	7101	96.7	84.4 (82.5,86.4)	1623	22.1	19.3 (18.3,20.2)	1627	22.2	21.3 (20.3,22.4)	640	8.7	8.4 (7.7,9.1)	770	10.5	11.0 (10.3,11.8)
Male	Eastern	8521328	8971	105.3	90.4 (88.5,92.3)	3347	39.3	34.0 (32.8,35.2)	868	10.2	9.4 (8.7,10)	1365	16.0	15.9 (15.1,16.8)	2276	26.7	27.5 (26.3,28.6)
Female	Eastern	8790627	15600	177.5	143.1 (140.8,145.4)	5836	66.4	52.3 (50.9,53.7)	2954	33.6	30.1 (29,31.2)	1802	20.5	19.7 (18.8,20.7)	2410	27.4	29.1 (27.9,30.2)
Male	Greater Accra	13115733	6735	51.4	57.6 (56.1,59.2)	1787	13.6	14.4 (13.7,15.2)	872	6.6	7.6 (7.1,8.2)	935	7.1	8.2 (7.6,8.7)	1605	12.2	13.5 (12.8,14.2)
Female	Greater Accra	13629962	11937	87.6	87.9 (86.3,89.6)	3029	22.2	22.0 (21.2,22.9)	3252	23.9	20.4 (19.7,21.2)	1031	7.6	8.1 (7.6,8.6)	1503	11.0	11.7 (11.1,12.3)
Male	Northern	8126962	3027	37.2	42.7 (41.2,44.3)	426	5.2	6.0 (5.4,6.6)	843	10.4	11.5 (10.8,12.3)	1049	12.9	12.8 (12.0,13.6)	327	4.0	3.9 (3.5,4.4)
Female	Northern	8445599	5707	67.6	75.7 (73.7,77.7)	617	7.3	8.2 (7.6,8.9)	1264	15.0	16.1 (15.3,17.1)	1457	17.3	18.0 (17.1,18.9)	390	4.6	4.7 (4.3,5.2)
Male	Upper East	3379532	1204	35.6	35.5 (33.5,37.6)	113	3.3	3.4 (2.8,4.1)	277	8.2	8.2 (7.3,9.3)	486	14.4	13.7 (12.4,14.9)	183	5.4	5.3 (4.5,6.1)

Table 7: Number of cases, crude rates and ASR, and 95% confidence interval (95% CI) for admitted CVD, diabetes, cancer, CRDs, and SCD patients by sex and region

Variable			CVD			Diabetes			Cancer			CRD			SCD		
Sex	Region	Population	Number of cases	Crude rate	Adj. rate (95% CI)	Number of cases	Crude rate	Adj. rate (95% CI)	Number of cases	Crude rate	Adj. rate (95% CI)	Number of cases	Crude rate	Adj. rate (95% CI)	Number of cases	Crude rate	Adj. rate (95% CI)
Female	Upper East	3512020	1906	54.3	48.2 (46.0,50.5)	212	6.0	5.6 (4.8,6.4)	546	15.5	15.2 (13.9,16.5)	593	16.9	16.7 (15.3,18.1)	233	6.6	7.1 (6.2,8.1)
Male	Upper West	2253026	1505	66.8	70.0 (66.5,73.7)	157	7.0	7.4 (6.3,8.7)	168	7.5	7.9 (6.8,9.2)	491	21.8	21.2 (19.3,23.2)	153	6.8	6.7 (5.7,7.9)
Female	Upper West	2341348	2212	94.5	84.9 (81.4,88.6)	218	9.3	8.5 (7.4,9.8)	413	17.6	17.1 (15.4,18.8)	895	38.2	38.3 (35.8,41.0)	169	7.2	7.7 (6.5,8.9)
Male	Volta	6919971	9835	142.1	134.7 (132,137.4)	1890	27.3	25.5 (24.3,26.7)	1045	15.1	14.6 (13.8,15.6)	1639	23.7	23.0 (21.9,24.2)	1922	27.8	28.4 (27.2,29.7)
Female	Volta	7191293	17282	240.3	191.9 (189.0,194.8)	3180	44.2	35.2 (34.0,36.5)	4266	59.3	54.3 (52.7,56.0)	2366	32.9	31.9 (30.6,33.3)	2052	28.5	31.0 (29.6,32.3)
Male	Western	8207405	7540	91.9	102.6 (100.2,105.1)	2215	27.0	29.1 (27.8,30.4)	487	5.9	6.4 (5.8,7.0)	1497	18.2	18.9 (18.0,20.0)	1225	14.9	15.0 (14.2,15.9)
Female	Western	8529201	11428	134.0	141.7 (139.0,144.3)	3774	44.2	45.7 (44.3,47.2)	2445	28.7	27.7 (26.6,28.8)	2007	23.5	23.8 (22.8,24.9)	1287	15.1	15.1 (14.3,16.0)

Figures 11 – 13 show the spatial distribution of the number of patients, crude and ASR of cardiovascular, diabetes, cancer, chronic respiratory, and sickle cell diseases by sex and region using the map of Ghana. The spatial distribution classified the number of cases, crude rates, and adjusted rates into four equal groups for each of these five NCDs.

Cardiovascular diseases (CVDs)

The highest group for the number of CVD cases for both males (7540,10084) and females (11937,17716) was recorded in the Volta and Eastern regions. The lowest group for the number of CVD cases for both males (1204,3027) and females (1906,5707) were recorded in the Northern, Upper East and West regions (Figure 11). The Volta, Brong Ahafo and Eastern regions had the highest group of crude rates for male (95.5,142.1) CVD inpatients while the females (136.7,240.3) was in the Volta and Eastern regions. The smallest group of the CVD crude rates was recorded in Ashanti, Northern and Upper East regions for males (34.9,37.2) and in the Ashanti and Upper East regions for females (54.3,67.6), (Figure 12). The highest group of ASR for CVD cases for both males (109.0,210.1) and females (141.7,303.1) were recorded in the Volta and Eastern regions. The lowest group of ASR for CVD cases for males (35.5,42.7) was in the Ashanti and Upper East regions, whereas that of females (48.2,75.7) was recorded in the Ashanti, Northern, and Upper East regions (Figure 13).

Diabetes

The highest group for the number of diabetic cases for both males (2215,3530) and females (3774,6248) were recorded in the Brong Ahafo and Eastern regions. The lowest group for the number of diabetic cases for both males (113,426) and females (212,617) were recorded in the Northern, Upper East and West regions (Figure 11). The Brong Ahafo and Eastern Regions had the highest group of crude rates for male (27.3,41.4) diabetes inpatients while the females (44.2,70.9) was in the Brong Ahafo, Western and Eastern regions. The smallest group of the diabetes crude rates was recorded in Northern, Upper East and West regions for both males (3.3,7.0) and females (6.0,9.3), (Figure 12). The highest group of ASR for diabetic cases for both males (29.1,53.4) and females (45.7,83.1) were recorded in the Brong Ahafo and Eastern regions. The lowest group of ASR for diabetic cases for both males (3.4,7.4) and females (5.6,8.5) were recorded in the Northern, Upper East and West regions (Figure 13).

Cancer

Males in the Volta and Brong Ahafo regions were in the largest group (917, 1142) for count cancer cases, while the smallest group (168,395) was in the Ashanti, Upper East, and Upper West regions. For female cancer inpatients, Volta and Greater Accra regions were both in the largest group (3006, 4266) and the regions in the smallest group (413, 1058) which is the same as the males (Figure 11). Similarly, these same Volta, Brong Ahafo regions, and the Eastern region were the regions in the highest group from the crude rates for males (10.7, 15.1) and female (30.6, 59.3) cancer inpatients. However, for the lowest group for males (2.6, 5.9), it was in the Ashanti, Central and Western regions, while that of females (6.6, 15.5) was in Ashanti, Northern, and Upper East regions (Figure 12). The Volta, Brong Ahafo and Eastern regions had the highest group (14.5, 16.3) of the ASR for male cancer inpatients. While the Volta and Eastern regions recorded the highest ASR group (30.3, 54.3) of female cancer inpatients. The smallest ASR group for males (2.9,6.4), was recorded in the Ashanti, Western and Central regions, while that of females (6.2,16.1) was recorded in the Ashanti and Upper East regions (Figure 13).

Chronic respiratory diseases (CRDs)

The highest group for the number of CRD cases for both males (1488,1639) and females (1920,2366) were recorded in the Volta and Western regions. The lowest group for the number of CRD cases for both males (467,491) and females (593,895) were recorded in the Central, Upper East and West regions (Figure 11). The Volta and Brong Ahafo regions had the highest group of crude rates for male (19.7,23.7) CRD inpatients while the females (24.1,38.2) were in the Volta and Upper West regions. The smallest group of the CRD crude rates was recorded in Ashanti and Central regions for males (6.8,7.1) and in the Ashanti and Greater Accra regions for females (7.6,8.7), (Figure 12). The Volta, Upper West, and Eastern regions had a higher group (21.2,24.2) of the ASR for male cancer inpatients. While the Volta and Upper West regions recorded the highest group (28.5,38.3) of female cancer inpatients. In terms of the smallest ASR group for males (6.8,8.2), it was recorded in the Ashanti, Greater Accra, and Central regions, that of females (8.1,8.5) was recorded in the Greater Accra and Central regions, (Figure 13).

Sickle cell disease (SCD)

The highest group for the number of SCD cases for both males (1676,2280) and females (1803,2415) were recorded in the Volta and Eastern regions. The lowest group for the number of SCD cases for both males (153,327) and females (169,390) were recorded in the Northern, Upper East and West regions (Figure 11). The Volta and Eastern regions had the highest group of crude rates for male (22.2,27.8) SCD inpatients as well as that of females (22.9,28.5). The smallest group of the SCD crude rates was recorded in Ashanti, Northern and Upper East regions for both males (4.0,6.5) and females (4.6,6.7), (Figure 12). The highest group of ASR for CVD cases for both males (21.8,28.4) and females (23.1,31.0) were recorded in the Volta, Brong Ahafo and Eastern regions. The lowest group of ASR for SCD cases for males (3.9,6.5) was in the Northern and Upper East regions, whereas that of females (4.7,7.1) was recorded in the Ashanti and Northern regions (Figure 13).

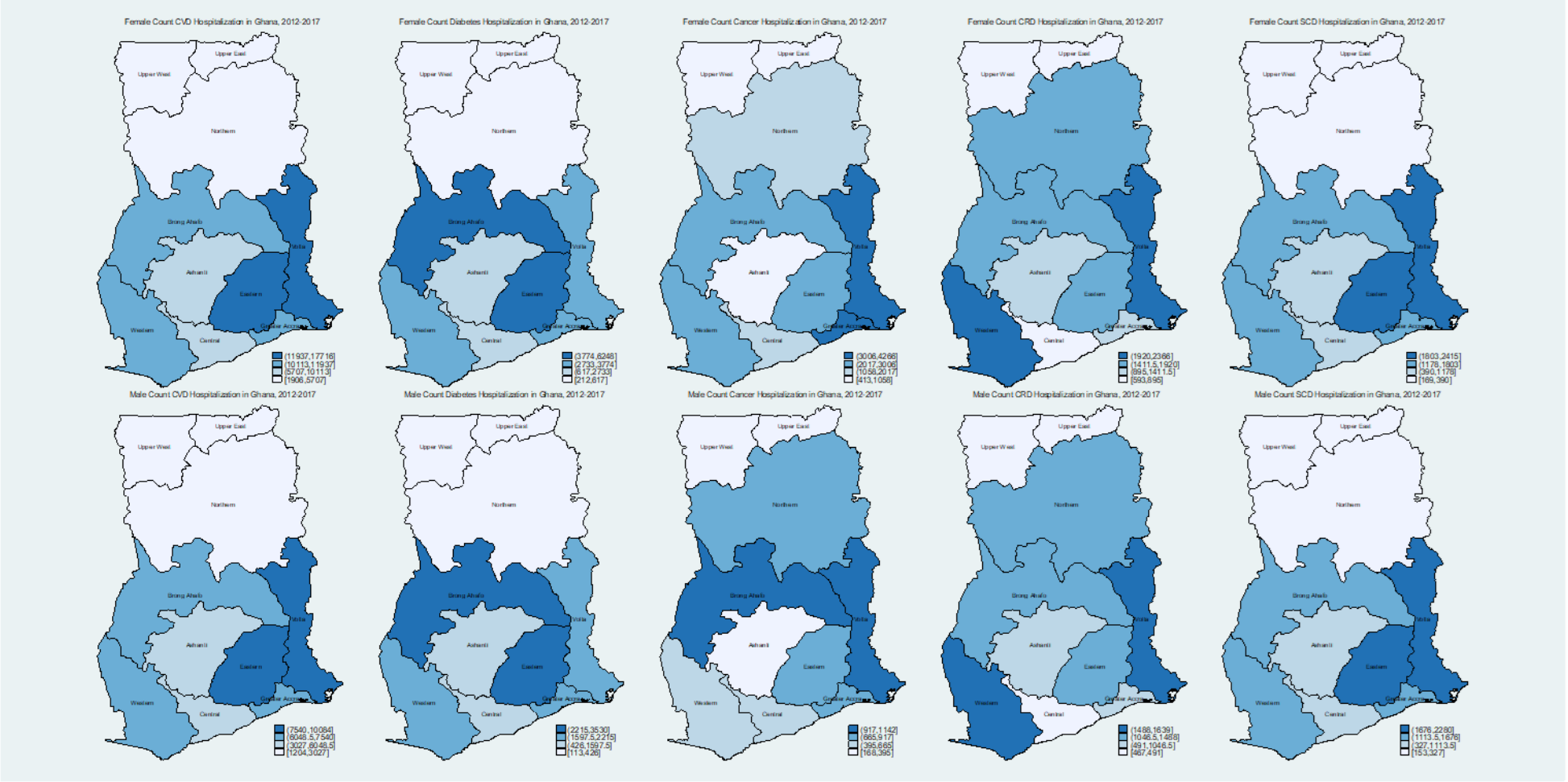


Figure 11: Spatial distribution of the number of hospitalized patients for cardiovascular, diabetes, cancer, chronic respiratory, and sickle cell diseases by sex and region

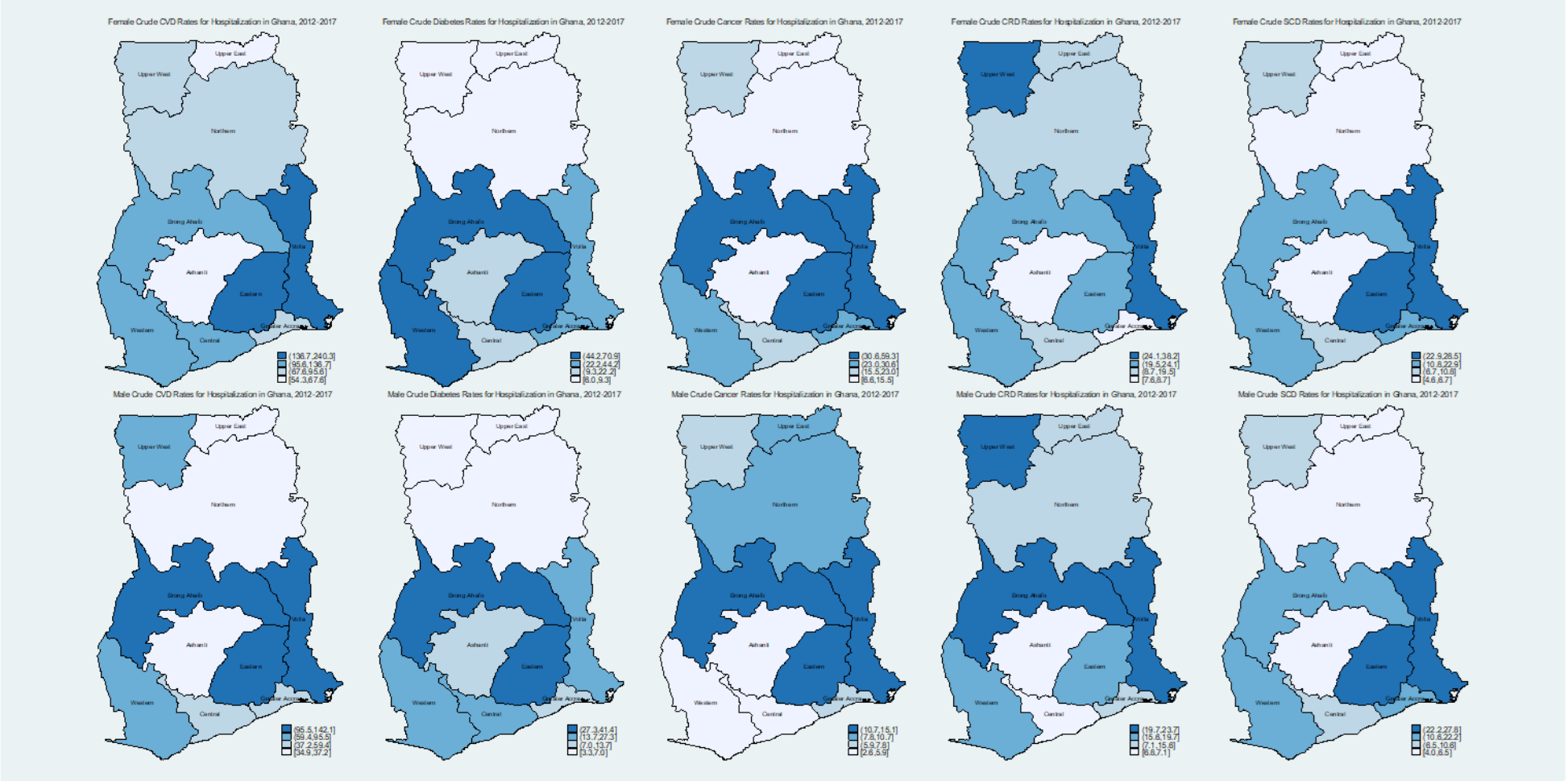


Figure 12: Spatial distribution of crude rates of patients hospitalized for cardiovascular, diabetes, cancer, chronic respiratory, and sickle cell diseases by sex and region

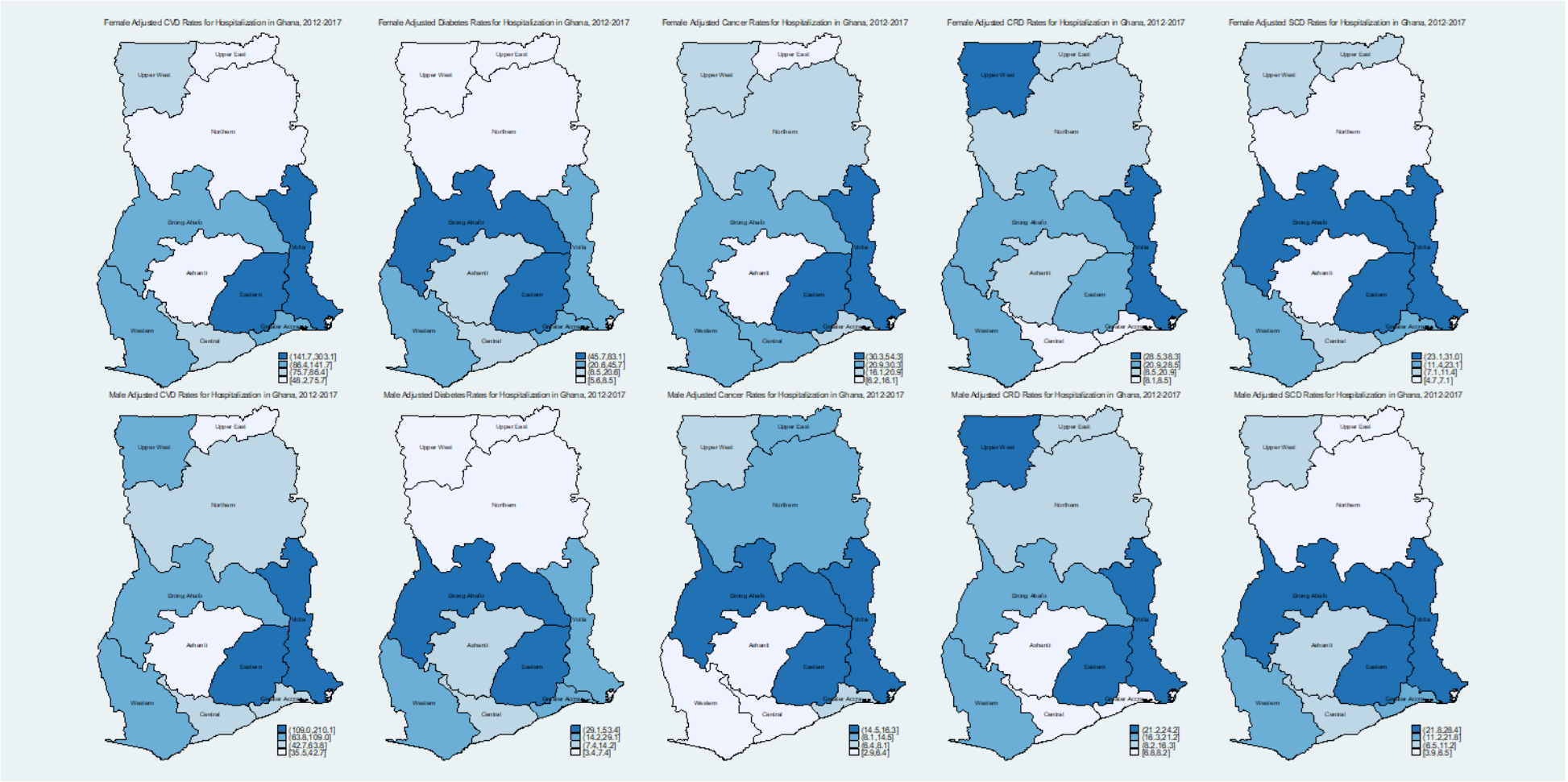


Figure 13: Spatial distribution of adjusted ASR of patients hospitalized for cardiovascular, diabetes, cancer, chronic respiratory, and sickle cell diseases by sex and region

4.4 Objective 2: Estimate how socio-demographic factors (including age, sex, location, occupation, education, health insurance status and presence of comorbidity) affect the hospitalization duration for CVDs, diabetes, cancers, chronic respiratory, and sickle cell diseases with mortality as a competing risk.

Table 9 shows the Subdistribution hazard ratio (SHR) and 95% confidence interval (CI) for hospital discharge for each of the five NCDs. The estimates were obtained from the Fine and Gray competing risk regression model with death as a competing risk. Visual inspection of plots of Schoenfeld residuals was used to verify the proportional hazard assumptions of the Competing-risks regression. We found out that only for covariate calender-year the brown line doesn't agree with the red line quite well. This suggests a nonproportional hazard function in calendar-year. The remaining covariates satisfied the proportional hazard assumption.

Cardiovascular diseases (CVDs)

For CVD inpatients, the estimated SHR for calendar-year and associated 95% confidence intervals was not statistically significant (SHR: 1.00; 95% CI: 1.00,1.01; p-value =0.188). The estimated SHR for females was 1.13 (95% CI: 1.07,1.20; p-value <0.001) compared to males. The difference between the SH for men and women changed depending on age group, although these changes were quite similar among certain age groups. There was a statistically significant difference in the estimated SHR of discharge for inpatients aged 50 years and above compared to the age group 25-29 years. The main effect between men and women was more pronounced in inpatients above 15 years old, except for the age group 30-34 years.

Except for the Volta region, which had a significantly lower SH for discharge (SHR: 0.97; 95% CI: 0.95,0.99; p-value =0.003), the rest of the regions had significantly higher SH compared to the Greater Accra region. Some of the regions included the Ashanti region with the highest SH of 52% for discharge compared to the Greater Accra region. In terms of occupation, housewives (SHR: 1.02; 95% CI: 0.98,1.06; p-value =0.412), para-professionals (SHR: 0.97; 95% CI: 0.94,1.00; p-value =0.065), professionals (SHR: 1.02; 95% CI: 0.99,1.06; p-value =0.230), and students (SHR: 1.05; 95% CI: 1.00,1.11; p-value =0.053) did not show any significant difference for SH of discharge compared to unemployed inpatients.

The primary school education level category of education showed no significant difference in the SH (SHR: 1.00; 95% CI: 0.98,1.01; p-value =0.640) for discharge compared to those who had no formal education. The SH for the discharge of patients insured was 12% higher than uninsured and statistically significant (SHR: 1.12; 95% CI: 1.10,1.13; p-value <0.001). There was a significant 18% lower SH for discharge for inpatients who had a surgical procedure (SHR: 0.82; 95% CI: 0.80,0.85; p-value <0.001) compared to those who had no surgical procedure while on admission. For patients with an additional diagnosis, the SH for discharge was also 18% significantly lower (SHR: 0.82; 95% CI: 0.81,0.83; p-value <0.001) compared to patients without additional diagnoses (Table 9).

Diabetes

For diabetic inpatients, the estimated SHR and associated 95% confidence intervals of discharge were 1.03 (95% CI: 1.02,1.03; p-value <0.001) for the calendar-year. The estimated SHR for females was 1.09 (95% CI: 0.98,1.21; p-value =0.102) compared to males. The difference between the SH for men and women changed only in age groups 5-9, 20-24, 40-44, 55-59, and 75-79 years although not statistically significant. Diabetic inpatients aged 0-4 years had a 44% higher SH to discharge compared to inpatients aged 25-29 years. The remaining age groups had lower SH compared to age group 25-29 years, however, only inpatients aged 75 years and more showed a statistical significance.

Four out of the ten regions had significantly higher SH for discharge between 11% (SHR: 1.11; 95% CI: 1.06,1.15; p-value <0.001) and 47% (SHR: 1.47; 95% CI: 1.31,1.65; p-value <0.001) compared to the Greater Accra region. In terms of occupation, farmer/fishermen and housewives had a significantly higher SH of discharge between 10% (SHR: 1.10; 95% CI: 1.06,1.15; p-value <0.001) and 12% (SHR: 1.12; 95% CI: 1.02,1.24; p-value=0.014) compared to unemployed inpatients. While pensioners/retirees showed a significantly lower SH for discharge (SHR: 0.92; 95% CI: 0.87,0.98; p-value =0.008) compared to unemployed inpatients.

The Junior High (SHR: 1.05; 95% CI: 1.02,1.07; p-value <0.001), and Senior Secondary (SHR: 1.07; 95% CI: 1.07,1.11; p-value <0.001) Schools and Tertiary (SHR: 1.12; 95% CI: 1.06,1.18; p-value <0.001) categories of education showed a significant difference in the SH for discharge compared to those who had no formal education.

Similarly, the SH for discharge of patients insured was 10% higher than uninsured and significant (SHR: 1.10; 95% CI: 1.06,1.13; p-value <0.001). There was a 40% significantly lower difference in the SH for discharge for inpatients who had a surgical procedure (SHR: 0.60; 95% CI: 0.57,0.63; p-value <0.001) compared to those who had no surgical procedure. For patients with an additional diagnosis, the SH for discharge was 6% significantly lower (SHR: 0.94; 95% CI: 0.92,0.96; p-value <0.001) compared to patients without additional diagnoses time to (Table 9).

Cancer

On average, there was an annual SHR of 1.05 (95% CI: 1.04,1.06; p-value <0.001) for calendar-year for cancer inpatients. The estimated SHR to discharge for females was 1.53 (95% CI: 1.34,1.75; p-value <0.001) compared to males. The difference between the SH for men and women changed depending on the age group. The estimated SH for inpatients under the age of 25 years was higher and statistically significant compared to the age group 25-29 years except for the age group 10-14 years; while there was no statistically significant difference in the SH of inpatients 30 or older years compared to those aged 25-29 years. The sex difference was less pronounced in all the ages. Six out of the ten regions had significantly lower SH for discharge between 13% (SHR: 0.87; 95% CI: 0.83,0.92; p-value <0.001) and 45% (SHR: 0.55; 95% CI: 0.52,0.58; p-value <0.001) compared to the Greater Accra region.

In terms of occupation, traders/business, farmer/fishermen, housewives, para-professionals, and all other categories of occupation had SH of discharge between 9% (SHR: 1.09; 95% CI: 1.02,1.17; p-value =0.009) and 19% (SHR: 1.19; 95% CI: 1.08,1.31; p-value=0.001) higher compared to unemployed inpatients. None of the categories of educational level showed a statistically significant difference in the SH for discharge compared to those who had no formal education. The SH for discharge of patients insured and uninsured were not significantly different. There was an 8% lower SH for discharge for inpatients who had a surgical procedure (SHR: 0.92; 95% CI: 0.90,0.95; p-value <0.001) compared to those who had no surgical procedure. For patients with an additional diagnosis, the SH for discharge was 17% lower (SHR: 0.83; 95% CI: 0.81,0.86; p-value <0.001) compared to patients without additional diagnoses (Table 9).

Chronic respiratory diseases (CRDs)

For CRD inpatients, the estimated SHR and associated 95% confidence intervals of discharge was 0.97 (95% CI: 0.96,0.97; p-value <0.001) for calendar-year. The estimated SHR for females was 1.07 (95% CI: 0.96,1.19; p-value =0.196) compared to males. The difference between the SH for men and women changed depending on age, especially from age 40 years. There was no statistically significant difference in the estimated SHR of discharge for inpatients under the age of 45 years, except for ages 15-19 years compared to the age group 25-29 years; while there was statistically significant lower SH for inpatients 45 or older years compared to those aged 25-29 years. The sex difference was more pronounced in ages 45 years and above, except for age 75-79 years. Six out of the ten regions had significantly higher SH for discharge between 9% (SHR: 1.09; 95% CI: 1.01,1.17; p-value =0.012) and 30% (SHR: 1.30; 95% CI: 1.21,1.38; p-value <0.001) compared to the Greater Accra region.

Although housewives, professionals and pensioners'/retirees' categories of occupation had SH of discharge between 2% (SHR: 1.02; 95% CI: 0.93,1.13; p-value =0.649) and 9% (SHR: 1.09; 95% CI: 0.99,1.21; p-value=0.089) higher compared to unemployed inpatients, they were not statistically significant; while the remaining categories showed statistical significance compared to unemployed inpatients. The Junior High, Senior Secondary and Tertiary levels of education showed a significantly higher SH between 5% (SHR: 1.05; 95% CI: 1.01,1.09; p-value =0.008) and 13% (SHR: 1.13; 95% CI: 1.05,1.21; p-value =0.002) for discharge compared to those who had no formal education. Similarly, the SH for discharge of patients insured was 3% higher than uninsured, but not statistically significant (SHR: 1.03; 95% CI: 0.99,1.07; p-value =0.122). There was a statistically significant 14% lower SH for discharge for inpatients who had a surgical procedure (SHR: 0.86; 95% CI: 0.77,0.96; p-value =0.007) compared to those who had no surgical procedure while on admission. For patients with an additional diagnosis, the SH for discharge was 12%, significantly lower (SHR: 0.88; 95% CI: 0.86,0.90; p-value <0.001) compared to patients without additional diagnoses (Table 9).

Sickle cell disease (SCD)

For SCD inpatients, the estimated SHR and associated 95% confidence intervals of discharge was 1.00 (95% CI: 0.99,1.00; p-value =0.394) for calendar-year. The estimated SHR for females was 0.98 (95% CI: 0.90,1.07; p-value =0.682) compared to males. The main effect between men and women did not show any pattern in age and sex interaction, although pronounced in women compared to men. Almost all age groups had lower SH for discharge compared to age group 25-29 years except for age group 80-100 years. Of these age groups, only age groups 35-39 years (SHR: 0.80; 95% CI: 0.68,0.94; p-value =0.007) and 60-64 years (SHR: 0.71; 95% CI: 0.54,0.94; p-value =0.016) were statistically significant.

Three out of the ten regions had significantly higher SH for discharge between 7% (SHR: 1.07; 95% CI: 1.01,1.12; p-value =0.017) and 17% (SHR: 1.17; 95% CI: 1.17,1.23; p-value <0.001) compared to the Greater Accra region. While three out of the ten regions also had significantly lower SHR for discharge between 7% (SHR: 0.93; 95% CI: 0.89,0.97; p-value =0.002) and 10% (SHR: 0.90; 95% CI: 0.83,0.97; p-value =0.006) compared to the Greater Accra region. In terms of occupation, all categories showed a higher SH of discharge, however, only farmers/fishermen, students and other categories of occupation were statistically significant compared to unemployed inpatients. Pensioners/retirees showed a non-significant SH of 27% (SHR: 0.73; 95% CI: 0.52,1.03; p-value=0.073) for discharge compared to unemployed patients.

Inpatients who had primary education showed a 4% significantly lower SH for discharge compared to those who had no formal education. While those educated to the secondary level had 6% significantly higher SH compared those who had no formal education. Similarly, the SHR for the discharge of patients insured and uninsured were not significantly different. There was also a statistically significant difference in the SH for discharge for inpatients who had a surgical procedure (SHR: 0.81; 95% CI: 0.73,0.90; p-value <0.001) compared to those who had no surgical procedure while on admission. For patients with an additional diagnosis, the SH for discharge was 13% lower (SHR: 0.87; 95% CI: 0.85,0.90; p-value <0.001) compared to patients without additional diagnoses (Table 9).

Table 8: Subdistribution hazard ratio (SHR) and 95% confidence interval (95% CI) from Fine-Gray regression models for hospital discharge and death as a competing risk for CVDs, diabetes, cancer, CRDs, and SCD inpatients

	CVD		Diabetes		Cancer		CRD		SCD	
Coefficients	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**
Year										
Year	1.00 (1.00,1.01)	0.188	1.03 (1.02,1.03)	<0.001	1.05 (1.04,1.06)	<0.001	0.97 (0.96,0.97)	<0.001	1.00 (0.99,1.00)	0.394
Age group										
0-4years	1.00 (0.90,1.11)	0.957	1.44 (0.90,2.32)	0.130	1.69 (1.37,2.10)	<0.001	0.96 (0.85,1.07)	0.459	0.92 (0.84,1.02)	0.100
5-9years	1.01 (0.89,1.15)	0.839	0.80 (0.58,1.09)	0.153	1.58 (1.24,2.00)	<0.001	1.10 (0.98,1.24)	0.104	0.94 (0.85,1.03)	0.192
10-14years	0.88 (0.78,1.00)	0.051	0.91 (0.73,1.13)	0.378	1.21 (0.96,1.53)	0.101	1.14 (1.00,1.29)	0.049	0.99 (0.9,1.08)	0.777
15-19years	0.93 (0.84,1.04)	0.215	0.94 (0.82,1.08)	0.412	1.35 (1.09,1.67)	0.006	1.15 (1.01,1.30)	0.038	0.98 (0.90,1.07)	0.629
20-24years	0.99 (0.90,1.08)	0.784	0.96 (0.85,1.08)	0.509	1.38 (1.14,1.67)	0.001	1.01 (0.88,1.16)	0.877	0.96 (0.88,1.04)	0.316
25-29years	ref		ref		ref		ref		ref	
30-34years	0.98 (0.92,1.05)	0.613	0.96 (0.86,1.08)	0.508	1.07 (0.88,1.29)	0.498	1.12 (0.98,1.28)	0.087	0.95 (0.84,1.08)	0.451
35-39years	0.99 (0.93,1.06)	0.839	0.97 (0.87,1.08)	0.556	0.94 (0.78,1.13)	0.499	0.92 (0.81,1.05)	0.234	0.80 (0.68,0.94)	0.007
40-44years	0.96 (0.90,1.02)	0.179	0.94 (0.85,1.04)	0.265	0.95 (0.79,1.13)	0.551	0.88 (0.76,1.01)	0.061	0.84 (0.69,1.03)	0.092
45-49years	0.94 (0.88,1.00)	0.048	0.99 (0.89,1.09)	0.816	0.99 (0.82,1.18)	0.88	0.76 (0.66,0.87)	<0.001	0.97 (0.78,1.22)	0.825
50-54years	0.89 (0.84,0.95)	<0.001	0.97 (0.88,1.07)	0.563	0.87 (0.73,1.04)	0.138	0.76 (0.66,0.87)	<0.001	0.93 (0.72,1.21)	0.607
55-59years	0.87 (0.82,0.93)	<0.001	0.94 (0.85,1.03)	0.186	0.92 (0.78,1.09)	0.346	0.68 (0.59,0.78)	<0.001	0.84 (0.64,1.12)	0.245
60-64years	0.89 (0.84,0.95)	<0.001	0.95 (0.86,1.05)	0.293	0.93 (0.79,1.1)	0.391	0.58 (0.50,0.67)	<0.001	0.71 (0.54,0.94)	0.016
65-69years	0.86 (0.81,0.91)	<0.001	0.97 (0.87,1.08)	0.544	0.88 (0.75,1.04)	0.146	0.67 (0.58,0.76)	<0.001	0.88 (0.61,1.27)	0.485
70-74years	0.84 (0.79,0.89)	<0.001	0.94 (0.84,1.05)	0.263	1 (0.85,1.17)	0.986	0.62 (0.55,0.71)	<0.001	0.73 (0.44,1.22)	0.235

Table 8: Subdistribution hazard ratio (SHR) and 95% confidence interval (95% CI) from Fine-Gray regression models for hospital discharge and death as a competing risk for CVDs, diabetes, cancer, CRDs, and SCD inpatients

	CVD		Diabetes		Cancer		CRD		SCD	
Coefficients	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**
75-79years	0.81 (0.76,0.86)	<0.001	0.86 (0.77,0.96)	0.009	1.01 (0.86,1.19)	0.901	0.65 (0.57,0.74)	<0.001	0.79 (0.44,1.43)	0.443
80-100years	0.80 (0.76,0.85)	<0.001	0.87 (0.77,0.99)	0.03	0.97 (0.82,1.15)	0.703	0.57 (0.50,0.66)	<0.001	1.08 (0.71,1.64)	0.706
Sex										
Male	ref		ref		ref		ref		ref	
Female	1.13 (1.07,1.20)	<0.001	1.09 (0.98,1.21)	0.102	1.50 (1.31,1.72)	<0.001	1.07 (0.96,1.19)	0.196	0.98 (0.90,1.07)	0.682
Region										
Ashanti	1.52 (1.49,1.56)	<0.001	1.39 (1.33,1.46)	<0.001	1.06 (1.00,1.13)	0.058	1.26 (1.19,1.33)	<0.001	1.17 (1.11,1.23)	<0.001
Brong Ahafo	1.07 (1.05,1.10)	<0.001	1.02 (0.98,1.06)	0.385	0.86 (0.82,0.91)	<0.001	0.99 (0.94,1.05)	0.738	0.98 (0.93,1.02)	0.294
Central	1.12 (1.09,1.14)	<0.001	1.02 (0.96,1.07)	0.565	0.87 (0.83,0.92)	<0.001	1.09 (1.02,1.17)	0.012	0.98 (0.92,1.04)	0.459
Eastern	1.09 (1.06,1.11)	<0.001	1.11 (1.06,1.15)	<0.001	0.80 (0.76,0.84)	<0.001	1.02 (0.97,1.08)	0.373	0.93 (0.89,0.97)	0.002
Greater Accra	ref		ref		ref		ref		ref	
Northern	1.07 (1.04,1.10)	<0.001	0.76 (0.71,0.81)	<0.001	0.55 (0.52,0.58)	<0.001	1.18 (1.11,1.25)	<0.001	0.90 (0.83,0.97)	0.006
Upper East	1.14 (1.09,1.18)	<0.001	1.01 (0.91,1.13)	0.813	1.05 (0.97,1.14)	0.212	1.24 (1.15,1.33)	<0.001	1.16 (1.05,1.29)	0.003
Upper West	1.33 (1.28,1.38)	<0.001	1.47 (1.31,1.65)	<0.001	1.21 (1.09,1.35)	<0.001	1.30 (1.21,1.38)	<0.001	1.06 (0.94,1.19)	0.351
Volta	0.97 (0.95,0.99)	0.003	0.9 (0.86,0.94)	<0.001	0.75 (0.71,0.78)	<0.001	0.95 (0.9,1.00)	0.054	0.91 (0.87,0.95)	<0.001
Western	1.27 (1.24,1.29)	<0.001	1.17 (1.12,1.22)	<0.001	0.73 (0.69,0.76)	<0.001	1.28 (1.21,1.35)	<0.001	1.07 (1.01,1.12)	0.017
Occupation										
Child/pupil	0.92 (0.86,0.98)	0.012	1.05 (0.91,1.20)	0.535	0.97 (0.84,1.13)	0.726	1.12 (1.03,1.21)	0.007	1.07 (0.98,1.17)	0.141
Trader/business	1.05 (1.03,1.07)	<0.001	1.04 (1.00,1.09)	0.068	1.09 (1.02,1.17)	0.009	1.08 (1.01,1.16)	0.031	1.06 (0.97,1.16)	0.165

Table 8: Subdistribution hazard ratio (SHR) and 95% confidence interval (95% CI) from Fine-Gray regression models for hospital discharge and death as a competing risk for CVDs, diabetes, cancer, CRDs, and SCD inpatients

	CVD		Diabetes		Cancer		CRD		SCD	
Coefficients	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**
Farmer/fisherman	1.08 (1.06,1.10)	<0.001	1.10 (1.06,1.15)	<0.001	1.14 (1.06,1.22)	<0.001	1.08 (1.01,1.15)	0.03	1.17 (1.06,1.29)	0.002
Housewife	1.02 (0.98,1.06)	0.412	1.12 (1.02,1.24)	0.014	1.19 (1.08,1.31)	0.001	1.02 (0.93,1.13)	0.649	1.13 (0.94,1.35)	0.200
Para professional	0.97 (0.94,1.00)	0.065	0.98 (0.92,1.04)	0.544	1.15 (1.06,1.25)	0.001	0.89 (0.80,1.00)	0.043	1.11 (1.00,1.25)	0.060
Professional	1.02 (0.99,1.06)	0.23	0.99 (0.92,1.06)	0.749	1.09 (1,1.19)	0.064	1.09 (0.99,1.21)	0.089	1.09 (0.97,1.23)	0.145
Pensioner/retired	0.96 (0.94,0.99)	0.005	0.92 (0.87,0.98)	0.008	0.95 (0.86,1.06)	0.372	1.07 (0.98,1.18)	0.139	0.73 (0.52,1.03)	0.073
Student	1.05 (1.00,1.11)	0.053	1.01 (0.92,1.10)	0.902	1.11 (0.99,1.23)	0.062	1.14 (1.05,1.24)	0.001	1.09 (1.01,1.19)	0.036
Unemployed	ref		ref		ref		ref		ref	
Unspecified	1.12 (1.09,1.15)	<0.001	1.04 (0.99,1.10)	0.154	0.96 (0.88,1.05)	0.348	1.25 (1.16,1.34)	<0.001	1.15 (1.04,1.27)	0.005
Others	1.05 (1.02,1.07)	<0.001	1.05 (1.00,1.10)	0.048	1.11 (1.03,1.18)	0.004	1.11 (1.03,1.19)	0.004	1.05 (0.97,1.15)	0.230
Education level										
None	ref		ref		ref		ref		ref	
JHS/Middle school	1.02 (1.01,1.03)	0.002	1.05 (1.02,1.07)	<0.001	1.03 (0.99,1.06)	0.109	1.05 (1.01,1.09)	0.008	1.01 (0.97,1.05)	0.732
Primary	1.00 (0.98,1.01)	0.64	1.03 (0.99,1.06)	0.133	1.02 (0.98,1.07)	0.343	1.00 (0.96,1.03)	0.821	0.96 (0.93,0.99)	0.023
SHS/vocational	1.04 (1.02,1.06)	<0.001	1.07 (1.03,1.11)	<0.001	0.99 (0.94,1.03)	0.528	1.06 (1.01,1.12)	0.018	1.06 (1.01,1.12)	0.025
Tertiary	1.08 (1.05,1.11)	<0.001	1.12 (1.06,1.18)	<0.001	1.03 (0.97,1.10)	0.351	1.13 (1.05,1.21)	0.002	1.08 (1.00,1.16)	0.053
Insurance status										
Yes	1.12 (1.10,1.13)	<0.001	1.10 (1.06,1.13)	<0.001	0.98 (0.94,1.03)	0.472	1.03 (0.99,1.07)	0.122	1 (0.97,1.04)	0.812
Surgical procedure										
Yes	0.82 (0.80,0.85)	<0.001	0.60 (0.57,0.63)	<0.001	0.92 (0.90,0.95)	<0.001	0.86 (0.77,0.96)	0.007	0.81 (0.73,0.90)	<0.001

Table 8: Subdistribution hazard ratio (SHR) and 95% confidence interval (95% CI) from Fine-Gray regression models for hospital discharge and death as a competing risk for CVDs, diabetes, cancer, CRDs, and SCD inpatients

	CVD		Diabetes		Cancer		CRD		SCD	
Coefficients	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**
Additional diagnoses										
Yes	0.82 (0.81,0.83)	<0.001	0.94 (0.92,0.96)	<0.001	0.83 (0.81,0.86)	<0.001	0.88 (0.86,0.90)	<0.001	0.87 (0.85,0.90)	<0.001
Age and sex interaction										
0-4years#Female	0.83 (0.74,0.94)	0.003	0.81 (0.48,1.39)	0.446	0.72 (0.57,0.92)	0.008	0.93 (0.83,1.05)	0.252	1.04 (0.94,1.16)	0.457
5-9years#Female	0.81 (0.69,0.96)	0.015	1.16 (0.74,1.83)	0.513	0.66 (0.51,0.85)	0.002	0.99 (0.86,1.13)	0.827	1.08 (0.97,1.19)	0.155
10-14years#Female	0.97 (0.83,1.14)	0.726	1.00 (0.78,1.30)	0.971	0.80 (0.61,1.05)	0.103	0.94 (0.81,1.09)	0.402	1.02 (0.91,1.13)	0.780
15-19years#Female	1.05 (0.94,1.19)	0.387	0.94 (0.79,1.10)	0.426	0.78 (0.62,1.00)	0.045	0.93 (0.81,1.08)	0.341	1.09 (0.98,1.21)	0.110
20-24years#Female	1.04 (0.94,1.15)	0.420	1.03 (0.88,1.19)	0.741	0.76 (0.61,0.93)	0.009	1.07 (0.92,1.24)	0.393	1.05 (0.94,1.17)	0.414
25-29years#Female	ref		ref		ref		ref		ref	
30-34years#Female	0.99 (0.92,1.07)	0.897	0.97 (0.85,1.11)	0.687	0.88 (0.72,1.06)	0.184	0.87 (0.75,1.02)	0.078	1.01 (0.87,1.17)	0.918
35-39years#Female	1.01 (0.94,1.09)	0.789	0.97 (0.85,1.10)	0.638	0.93 (0.77,1.12)	0.443	0.96 (0.82,1.12)	0.597	1.14 (0.94,1.37)	0.191
40-44years#Female	1.03 (0.96,1.10)	0.479	1.02 (0.90,1.16)	0.708	0.91 (0.76,1.10)	0.337	1.00 (0.86,1.17)	0.989	1.15 (0.91,1.45)	0.253
45-49years#Female	1.05 (0.98,1.12)	0.174	0.95 (0.84,1.07)	0.401	0.86 (0.71,1.04)	0.117	1.16 (0.99,1.36)	0.066	1.01 (0.77,1.34)	0.927
50-54years#Female	1.10 (1.03,1.18)	0.006	0.99 (0.87,1.11)	0.812	0.87 (0.72,1.05)	0.153	1.03 (0.88,1.22)	0.683	0.86 (0.64,1.17)	0.344
55-59years#Female	1.08 (1.01,1.16)	0.020	1.03 (0.91,1.16)	0.633	0.76 (0.63,0.92)	0.004	1.17 (1.00,1.37)	0.057	1.03 (0.73,1.47)	0.863
60-64years#Female	1.02 (0.95,1.09)	0.541	0.97 (0.86,1.10)	0.658	0.70 (0.57,0.84)	<0.001	1.29 (1.09,1.53)	0.003	1.30 (0.88,1.92)	0.182
65-69years#Female	1.05 (0.98,1.13)	0.165	0.99 (0.87,1.12)	0.868	0.81 (0.66,1.00)	0.045	0.99 (0.84,1.18)	0.926	0.85 (0.47,1.53)	0.583
70-74years#Female	1.06 (0.99,1.14)	0.083	0.99 (0.87,1.13)	0.883	0.74 (0.61,0.90)	0.002	1.10 (0.94,1.29)	0.216	1.24 (0.71,2.18)	0.445

Table 8: Subdistribution hazard ratio (SHR) and 95% confidence interval (95% CI) from Fine-Gray regression models for hospital discharge and death as a competing risk for CVDs, diabetes, cancer, CRDs, and SCD inpatients

	CVD		Diabetes		Cancer		CRD		SCD	
Coefficients	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**	**SHR(95%CI)**	**P-value**
75-79years#Female	1.05 (0.98,1.13)	0.162	1.06 (0.93,1.22)	0.375	0.71 (0.58,0.87)	0.001	0.98 (0.84,1.14)	0.753	0.68 (0.32,1.46)	0.323
80-100years#Female	1.00 (0.93,1.07)	0.933	0.97 (0.84,1.13)	0.705	0.74 (0.60,0.92)	0.006	1.06 (0.91,1.24)	0.441	0.45 (0.24,0.85)	0.014

Figure 14 shows the combined CIF Plot from the Fine-Gray regression model of cardiovascular, diabetes, cancer, chronic respiratory, and sickle cell diseases patients from hospitalization to discharge. By the 10th day of admission, nearly 90% of these patients got discharged home or died.

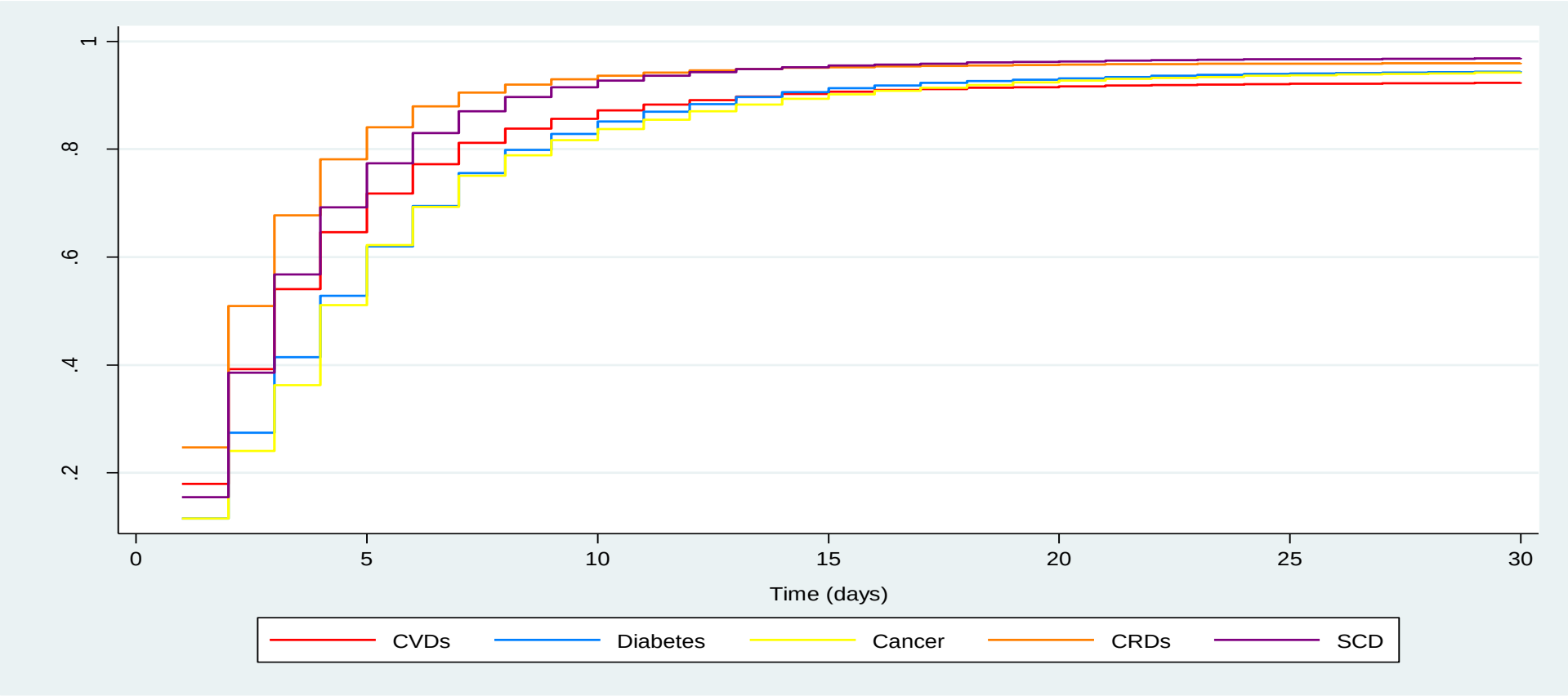


Figure 14: Cumulative incidence functions plot from the Fine-Gray regression model of cardiovascular, diabetes, cancer, chronic respiratory, and sickle cell diseases patients from hospitalization to discharge

4.5 Objective 3: To fit a Poisson regression model for cardiovascular, diabetes, cancers, chronic respiratory, sickle cell diseases and several covariates with predictions from 2018 – 2032 among hospitalized patients in Ghana.

4.5.1 Factors associated with hospitalization for cardiovascular, diabetes, cancers, chronic respiratory and sickle cell diseases

Cardiovascular diseases

The Poisson regression showed a statistically significant relative rate of CVD admissions (RR: 1.15; 95%CI:1.13,1.18; P<0.001) for calendar-year. The estimated relative rate of admission of CVD patients increased as age increased; age 5-9years (RR: 0.14; 95%CI:0.10,0.18; P<0.001) to 75-79years (RR: 48.23; 95%CI:36.87,63.11; P<0.001) compared with age 25-29 years. The estimated relative rate of admission of female patients was three times higher than male patients (RR: 3.43; 95%CI:2.55,4.62; P<0.001). The estimated relative rate of admission of CVD patients by region was statistically different from the Greater Accra region (reference region), except for the Northern and Western regions. The highest of the relative rates was in the Volta region (RR: 1.44; 95%CI:1.24,1.67; P<0.001) and the lowest relative rate in the Upper East region (RR: 0.16; 95%CI:014,0.20; P<0.001), (Table 10).

Diabetes

The Poisson regression showed a statistically significant relative rate of diabetes admissions (RR: 1.15; 95%CI:1.13,1.18; P<0.001) for calendar-year. The estimated relative rate of admission of diabetes patients increased as age increased; age 10-14years (RR: 0.16; 95%CI:0.11,0.22; P<0.001) to 75-79years (RR: 26.33; 95%CI:19.52,35.51; P<0.001) compared with age 25-29 years. The estimated relative rate of admission of female patients was twice as male patients (RR: 2.18; 95%CI:1.56,3.05; P<0.001). The estimated relative rate of admission of diabetes patients by region was statistically different from the Greater Accra region (reference region), except for the Volta region. The highest of the relative rates were in the Eastern region (RR: 1.92; 95%CI:1.69,2.18; P<0.001) and the lowest relative rate was in the Upper East region (RR: 0.07; 95%CI:0.05,0.08; P<0.001), (Table 10).

Cancer

The Poisson regression showed a statistically significant relative rate of cancer admissions (RR: 1.30; 95%CI:1.25,1.34; P<0.001) for calendar-year. The estimated relative rate of admission of cancer patients increased as age increased; age 0-4years (RR: 0.56; 95%CI:0.39,0.80; P<0.001) to 75-79 years (RR: 19.11; 95%CI:13.37,27.31; P<0.001) compared with age 25-29 years. The estimated relative rate of admission of female patients was five times higher than male patients (RR: 5.15; 95%CI:3.53,7.51; P<0.001). The estimated relative rate of admission of cancer patients by region was statistically different from the Greater Accra region (reference region), except for the Brong Ahafo, Eastern and Volta regions. The highest of the relative rate was in the Volta region (RR: 1.21; 95%CI:0.95,1.55; P<0.001) and the lowest relative rate was in the Upper East region (RR: 0.15; 95%CI:0.12,0.19; P<0.001), (Table 10).

Chronic respiratory diseases

The Poisson regression showed a statistically significant relative rate of CRD admissions (RR: 1.10; 95%CI:1.08,1.13; P<0.001) for calendar-year. The estimated relative rate of admission of CRD patients decreased as age increased; age 0-4years (RR: 4.04; 95%CI:3.09,5.28; P<0.001) to 20-24years (RR: 0.90; 95%CI:0.68,1.20; P=0.473) compared with age 25-29 years. It then began to increase again to age group 80-100years. The estimated relative rate of admission of female patients was three times higher than male patients (RR: 3.08; 95%CI:2.34,4.05; P<0.001). The estimated relative rate of admission of CRD patients by region was statistically different from the Greater Accra region (reference region). The highest of the relative rate was in the Volta region (RR: 2.06; 95%CI:1.69,2.51; P<0.001) and the lowest relative rate was in the Upper East region (RR: 0.51; 95%CI:0.40,0.66; P<0.001), (Table 10).

Sickle cell disease

The Poisson regression showed a statistically significant relative rate of SCD admissions (RR: 1.15; 95%CI:1.12,1.19; P<0.001) for calendar-year. The estimated relative rate of admission of SCD patients increased marginally as age increased; age 0-4years (RR: 1.32; 95%CI:0.97,1.81; P=0.081) to 15-19years (RR: 1.97; 95%CI:1.50,2.57; P<0.001) and dropped at age 20-24 years compared with age 25-29 years. The remaining relative rates were less than one compared to inpatients older than 25 years. The estimated relative rate of admission of female patients was almost 2 times higher than male patients (RR: 1.57; 95%CI:1.15,2.14; P=0.004). The estimated relative rate of admission of SCD patients by region was statistically different from the Greater Accra region (reference region), except for the Brong Ahafo and Western regions. The highest of the relative rates was in the Volta region (RR: 1.35; 95%CI:1.10,1.66; P=0.004) and the lowest relative rate was in the Upper West region (RR: 0.11; 95%CI:0.09,0.15; P<0.001), (Table 10).

Table 9: Relative rates (RR), 95% confidence interval (95% CI) and p-value from Poisson regression models for CVDs, diabetes, cancers, CRDs and SCD

	Cardiovascular disease		Diabetes		Cancer		Chronic respiratory disease		Sickle cell disease	
Coefficients	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**
Calendar-year										
Calendar-year	1.15 (1.13,1.18)	<0.001	1.15 (1.13,1.18)	<0.001	1.30 (1.25,1.34)	<0.001	1.10 (1.08,1.13)	<0.001	1.15 (1.12,1.19)	<0.001
Sex										
Male	ref		ref		ref		ref		ref	
Female	3.43 (2.55,4.62)	<0.001	2.18 (1.56,3.05)	<0.001	5.15 (3.53,7.51)	<0.001	3.08 (2.34,4.05)	<0.001	1.57 (1.15,2.14)	0.004
Age group										
0-4years	0.28 (0.22,0.37)	<0.001	0.06 (0.03,0.09)	<0.001	0.56 (0.39,0.80)	0.002	4.04 (3.09,5.28)	<0.001	1.32 (0.97,1.81)	0.081
5-9years	0.14 (0.10,0.18)	<0.001	0.06 (0.04,0.10)	<0.001	0.38 (0.25,0.57)	<0.001	1.85 (1.43,2.39)	<0.001	1.64 (1.27,2.10)	<0.001
10-14years	0.15 (0.11,0.19)	<0.001	0.15 (0.11,0.22)	<0.001	0.33 (0.21,0.50)	<0.001	1.13 (0.88,1.45)	0.321	1.62 (1.23,2.12)	<0.001
15-19years	0.32 (0.25,0.42)	<0.001	0.59 (0.42,0.83)	0.003	0.51 (0.34,0.74)	<0.001	1.01 (0.77,1.31)	0.962	1.97 (1.50,2.57)	<0.001
20-24years	0.56 (0.43,0.74)	<0.001	0.83 (0.59,1.16)	0.278	0.71 (0.49,1.04)	0.075	0.90 (0.68,1.20)	0.473	1.64 (1.23,2.19)	0.001
25-29years	ref		ref		ref		ref		ref	
30-34years	2.00 (1.50,2.65)	<0.001	2.39 (1.69,3.37)	<0.001	1.31 (0.88,1.94)	0.186	1.34 (0.97,1.83)	0.074	0.67 (0.49,0.93)	0.017
35-39years	3.41 (2.60,4.46)	<0.001	3.66 (2.65,5.06)	<0.001	1.51 (1.04,2.19)	0.032	1.37 (1.02,1.85)	0.040	0.45 (0.33,0.62)	<0.001
40-44years	5.77 (4.37,7.62)	<0.001	5.71 (4.14,7.89)	<0.001	2.18 (1.51,3.15)	<0.001	1.75 (1.31,2.34)	<0.001	0.37 (0.26,0.52)	<0.001
45-49years	7.33 (5.63,9.55)	<0.001	6.89 (4.95,9.60)	<0.001	2.46 (1.73,3.50)	<0.001	1.94 (1.48,2.55)	<0.001	0.26 (0.19,0.36)	<0.001
50-54years	11.86 (9.26,15.19)	<0.001	10.77 (8.04,14.43)	<0.001	3.08 (2.19,4.32)	<0.001	2.47 (1.91,3.19)	<0.001	0.26 (0.19,0.37)	<0.001

Table 9: Relative rates (RR), 95% confidence interval (95% CI) and p-value from Poisson regression models for CVDs, diabetes, cancers, CRDs and SCD

	Cardiovascular disease		Diabetes		Cancer		Chronic respiratory disease		Sickle cell disease	
Coefficients	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**
55-59years	14.64 (11.30,18.96)	<0.001	12.82 (9.36,17.55)	<0.001	3.88 (2.71,5.56)	<0.001	2.72 (2.07,3.57)	<0.001	0.21 (0.15,0.30)	<0.001
60-64years	21.02 (16.34,27.03)	<0.001	18.86 (13.87,25.65)	<0.001	6.4 (4.58,8.95)	<0.001	4.13 (3.15,5.41)	<0.001	0.26 (0.18,0.37)	<0.001
65-69years	21.93 (17.12,28.07)	<0.001	17.02 (12.58,23.03)	<0.001	7.14 (5.08,10.04)	<0.001	4.58 (3.47,6.04)	<0.001	0.15 (0.08,0.28)	<0.001
70-74years	35.4 (28.02,44.72)	<0.001	21.72 (16.11,29.28)	<0.001	13.08 (8.99,19.01)	<0.001	7.40 (5.79,9.45)	<0.001	0.2 (0.13,0.33)	<0.001
75-79years	48.23 (36.87,63.11)	<0.001	26.33 (19.52,35.51)	<0.001	19.11 (13.37,27.31)	<0.001	11.93 (8.94,15.91)	<0.001	0.22 (0.13,0.37)	<0.001
80-100years	47.23 (36.28,61.49)	<0.001	19.40 (14.32,26.28)	<0.001	14.10 (9.98,19.92)	<0.001	11.50 (8.52,15.53)	<0.001	0.24 (0.13,0.43)	<0.001
Region										
Ashanti	0.82 (0.70,0.96)	0.012	0.81 (0.71,0.94)	0.004	0.39 (0.30,0.50)	<0.001	1.24 (1.01,1.53)	0.042	0.72 (0.57,0.9)	0.004
Brong Ahafo	0.99 (0.85,1.15)	0.886	1.37 (1.20,1.56)	<0.001	0.97 (0.79,1.19)	0.756	1.58 (1.28,1.95)	<0.001	1.10 (0.88,1.38)	0.392
Central	0.58 (0.50,0.67)	<0.001	0.54 (0.47,0.62)	<0.001	0.50 (0.40,0.63)	<0.001	0.52 (0.42,0.65)	<0.001	0.42 (0.34,0.53)	<0.001
Eastern	1.44 (1.25,1.66)	<0.001	1.92 (1.69,2.18)	<0.001	0.95 (0.77,1.17)	0.641	1.64 (1.34,2.01)	<0.001	1.52 (1.23,1.87)	<0.001
Greater Accra	ref		ref		ref		ref		ref	
Northern	0.5 (0.43,0.58)	<0.001	0.23 (0.20,0.27)	<0.001	0.56 (0.44,0.72)	<0.001	1.29 (1.03,1.62)	0.029	0.24 (0.19,0.31)	<0.001
Upper East	0.16 (0.14,0.20)	<0.001	0.07 (0.05,0.08)	<0.001	0.21 (0.17,0.27)	<0.001	0.51 (0.40,0.66)	<0.001	0.13 (0.10,0.18)	<0.001
Upper West	0.2 (0.17,0.24)	<0.001	0.08 (0.07,0.10)	<0.001	0.15 (0.12,0.19)	<0.001	0.71 (0.56,0.90)	0.006	0.11 (0.09,0.15)	<0.001
Volta	1.44 (1.24,1.67)	<0.001	1.06 (0.92,1.22)	0.406	1.21 (0.95,1.55)	0.126	2.06 (1.69,2.51)	<0.001	1.35 (1.10,1.66)	0.004

Table 9: Relative rates (RR), 95% confidence interval (95% CI) and p-value from Poisson regression models for CVDs, diabetes, cancers, CRDs and SCD

	Cardiovascular disease		Diabetes		Cancer		Chronic respiratory disease		Sickle cell disease	
Coefficients	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**	**RR(95%CI)**	**P-value**
Western	1 (0.86,1.15)	0.963	1.21 (1.06,1.39)	0.006	0.73 (0.57,0.92)	0.007	1.74 (1.42,2.14)	<0.001	0.86 (0.69,1.07)	0.167
Sex and age Interaction										
Female#0-4years	0.27 (0.18,0.41)	<0.001	0.52 (0.28,0.95)	0.035	0.15 (0.09,0.24)	<0.001	0.23 (0.16,0.33)	<0.001	0.47 (0.31,0.72)	<0.001
Female#5-9years	0.24 (0.16,0.38)	<0.001	0.54 (0.29,1.02)	0.057	0.17 (0.10,0.28)	<0.001	0.19 (0.13,0.27)	<0.001	0.50 (0.34,0.72)	<0.001
Female#10-14years	0.31 (0.20,0.47)	<0.001	0.73 (0.44,1.22)	0.228	0.20 (0.11,0.36)	<0.001	0.25 (0.17,0.35)	<0.001	0.51 (0.34,0.75)	0.001
Female#15-19years	0.62 (0.42,0.92)	0.017	0.54 (0.34,0.85)	0.008	0.36 (0.22,0.6)	<0.001	0.88 (0.60,1.28)	0.491	0.69 (0.46,1.02)	0.060
Female#20-24years	0.89 (0.59,1.34)	0.574	0.79 (0.51,1.23)	0.289	0.55 (0.33,0.91)	0.020	1.03 (0.70,1.52)	0.879	0.80 (0.54,1.20)	0.280
Female#30-34years	0.78 (0.51,1.18)	0.234	0.69 (0.44,1.09)	0.113	1.39 (0.83,2.34)	0.213	0.67 (0.45,1.01)	0.055	0.93 (0.60,1.44)	0.740
Female#35-39years	0.62 (0.42,0.91)	0.015	0.64 (0.41,0.97)	0.037	1.59 (0.96,2.62)	0.070	0.68 (0.46,1.01)	0.056	1.01 (0.65,1.58)	0.962
Female#40-44years	0.45 (0.30,0.66)	<0.001	0.54 (0.35,0.82)	0.004	1.34 (0.83,2.16)	0.237	0.50 (0.34,0.72)	<0.001	0.94 (0.60,1.48)	0.795
Female#45-49years	0.44 (0.30,0.64)	<0.001	0.72 (0.47,1.11)	0.138	1.09 (0.68,1.77)	0.716	0.45 (0.30,0.65)	<0.001	1.04 (0.66,1.65)	0.852
Female#50-54years	0.42 (0.29,0.61)	<0.001	0.74 (0.50,1.11)	0.144	0.62 (0.39,0.98)	0.043	0.43 (0.30,0.61)	<0.001	0.92 (0.57,1.50)	0.741
Female#55-59years	0.39 (0.27,0.57)	<0.001	0.78 (0.51,1.19)	0.248	0.36 (0.22,0.58)	<0.001	0.46 (0.32,0.67)	<0.001	1.21 (0.73,2.02)	0.462
Female#60-64years	0.32 (0.23,0.46)	<0.001	0.59 (0.40,0.88)	0.010	0.19 (0.12,0.29)	<0.001	0.32 (0.22,0.46)	<0.001	0.77 (0.48,1.25)	0.293
Female#65-69years	0.32 (0.22,0.46)	<0.001	0.63 (0.42,0.95)	0.027	0.13 (0.08,0.20)	<0.001	0.31 (0.21,0.46)	<0.001	0.84 (0.40,1.77)	0.640
Female#70-74years	0.35 (0.25,0.50)	<0.001	0.62 (0.42,0.91)	0.015	0.12 (0.07,0.20)	<0.001	0.34 (0.24,0.48)	<0.001	0.71 (0.35,1.40)	0.321

Table 9: Relative rates (RR), 95% confidence interval (95% CI) and p-value from Poisson regression models for CVDs, diabetes, cancers, CRDs and SCD

	Cardiovascular disease		Diabetes		Cancer		Chronic respiratory disease		Sickle cell disease	
Coefficients	RR(95%CI)	P-value	RR(95%CI)	P-value	RR(95%CI)	P-value	RR(95%CI)	P-value	RR(95%CI)	P-value
Female#75-79years	0.37 (0.25,0.54)	<0.001	0.66 (0.44,1.00)	0.053	0.09 (0.06,0.15)	<0.001	0.33 (0.23,0.49)	<0.001	0.77 (0.38,1.57)	0.471
Female#80-100years	0.34 (0.23,0.50)	<0.001	0.63 (0.41,0.95)	0.029	0.09 (0.06,0.14)	<0.001	0.30 (0.20,0.46)	<0.001	0.46 (0.22,0.95)	0.036

Figure 15 shows the Poisson coefficient plot of rate ratios for CVDs, diabetes, cancer, CRDs and SCD.

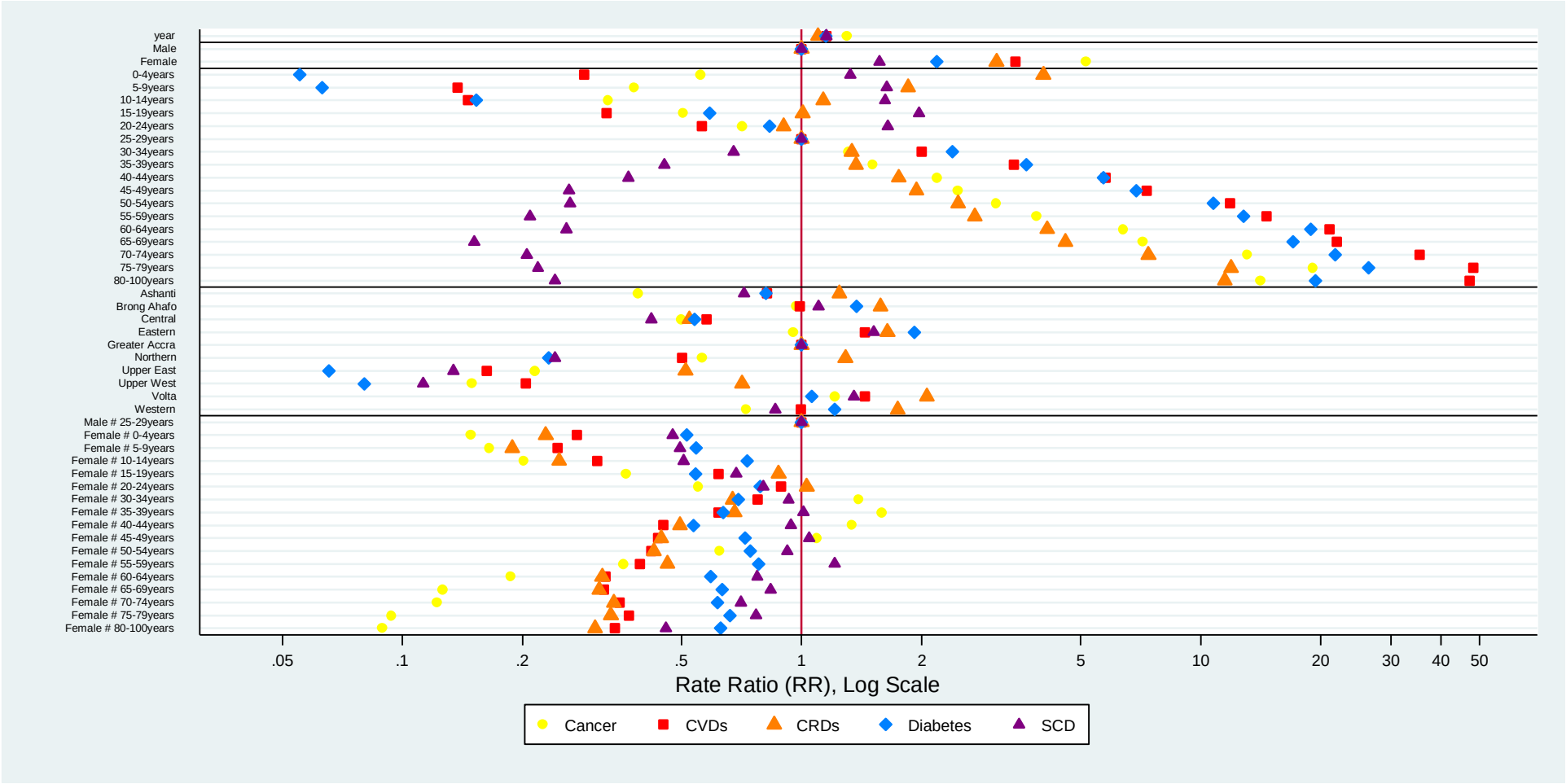


Figure 15: Coefficient plot from the Poisson regression model for cardiovascular, diabetes, cancer, chronic respiratory, and sickle cell diseases patients hospitalized

4.5.2 Predictions of future burden of cardiovascular, diabetes, cancers, chronic respiratory and sickle cell disease from 2018 – 2032

Based on the 6 years of historical data, we predicted the annual number of CVD cases from 2017 to 2032. The annual empirical cases were 4530 (95% CI: 4399, 4664) among hospitalized male patients verses 7449 (95% CI: 7281, 7620) females in the reference year (2012). In 2016, the number of males for CVD patients hospitalized was 13570 (13343, 13800) and females 22715 (22420, 23012). We predicted that the number of male CVD patients to be hospitalized in 2022 will be 34971 (34605, 35340) and 57839 (57368, 58312) for females. In 2027, the predicted number of male CVD patients to be hospitalized will be 79028 (78478, 79580) and 129969 (129263, 130677) for females. In 2032, which is the last year for the predictions, we expect the male CVD patients to be hospitalized to increase to 177155 (176331, 177981) and 289944 (288889, 291001) for females (Table 11 and Figure 16).

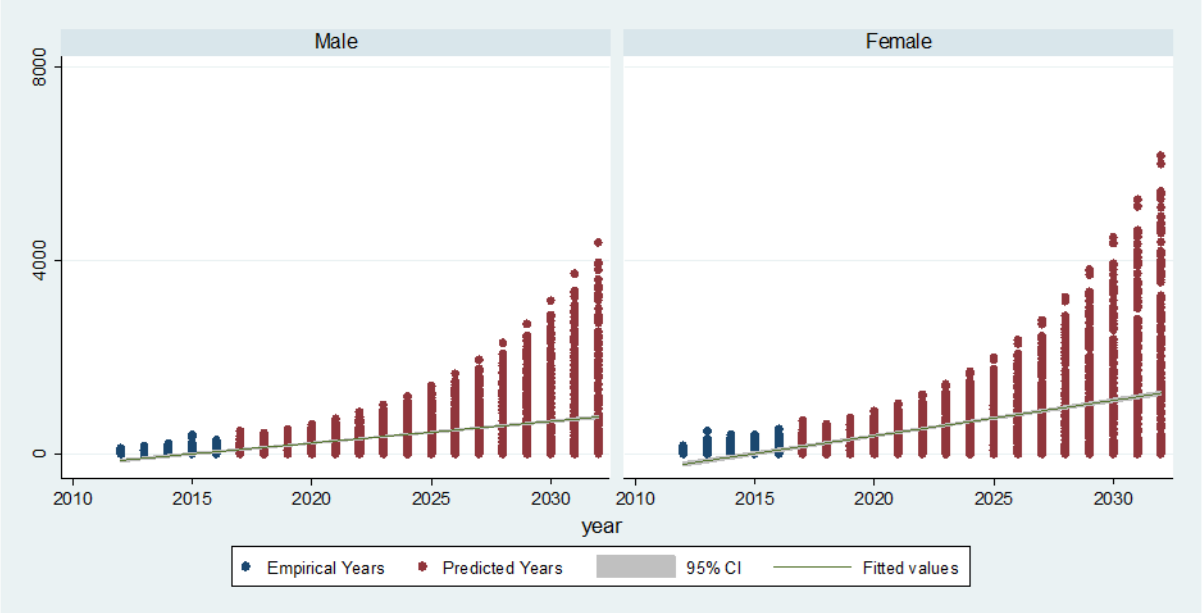


Figure 16: Poisson regression model plot empirical and predicted for cardiovascular disease cases by sex and year (2012-2032) with dots indicating age groups

Based on the 6 years of historical data, we predicted the annual number of diabetic cases from 2017 to 2032. The annual empirical cases were 1319 (95% CI: 1249, 1392) among hospitalized male patients versus 1847 (95% CI: 1764, 1933) females in the reference year (2012). In 2016, the number of male diabetic patients hospitalized was 3257 (3146, 3370) and females was 5657 (5510, 5806). We predicted that the number of male diabetic patients to be hospitalized in 2022 will be 9630 (9439, 9824) and 15769 (15524, 16017) for females. In 2027, the predicted number of male diabetic patients to be hospitalized will be 21634 (21347, 21924) and 35226 (34859, 35596) for females. In 2032, which is the last year for the predictions, we expect the male diabetic patients to be hospitalized to increase to 48211 (47782, 48643) and 78123 (77576, 78673) for females (Table 12 and Figure 17).

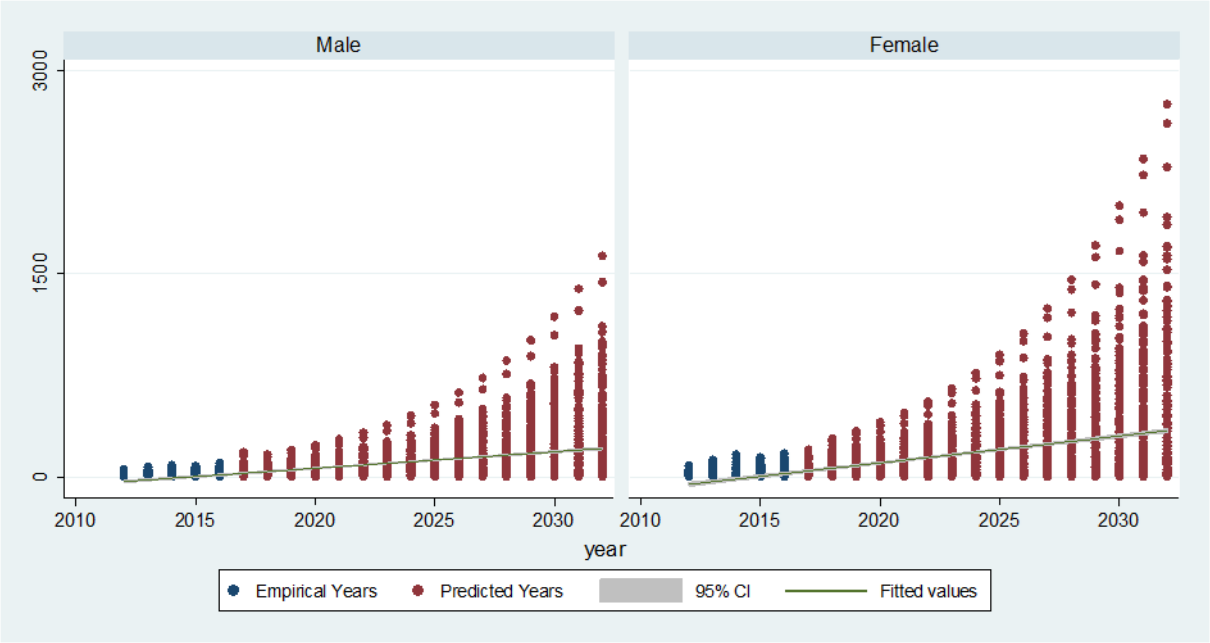


Figure 17: Poisson regression model plot empirical and predicted for diabetes cases by sex and year (2012-2032) with dots indicating age groups

Based on the 6 years of historical data, we predicted the annual number of cancer cases from 2017 to 2032. The annual empirical cases were 442 (95% CI: 402, 485) among hospitalized male patients versus 557 (95% CI: 512,605) females in the reference year (2012). In 2016, the number of male cancer patients hospitalized was 1566 (1489, 1646) and females was 6154 (6001, 6310). We predicted that the number of male cancer patients to be hospitalized in 2022 will be 1828 (1745, 1914) and 5781 (5633, 5932) for females. In 2027, the predicted number of male cancer patients to be hospitalized will be 2033 (1946, 2123) and 6391 (6235, 6550) for females. In 2032, which is the last year for the predictions, we expect the male cancer patients to be hospitalized to increase to 2242 (2150, 2337) and 7014 (6851, 7180) for females. There were few age groups within the females that recorded fairly large which translated into the predictions (Table 13 and Figure 18).

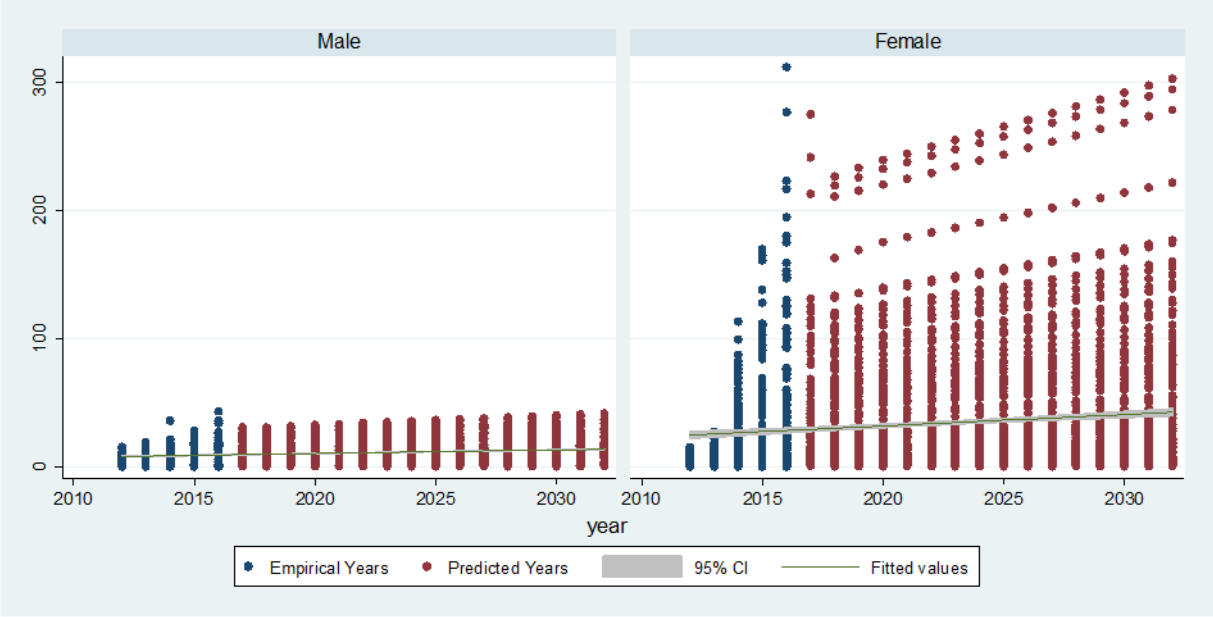


Figure 18: Poisson regression model plot of empirical and predicted cancer cases by sex and year (2012-2032) with dots indicating age groups

Based on the 6 years of historical data, we predicted the annual number of CRD cases from 2017 to 2032. The annual empirical cases were 1103 (95% CI: 1039, 1170) among hospitalized male patient verses 1441 (95% CI: 1368, 1517) females in the reference year (2012). In 2016, the number of male CRD patients hospitalized was 2528 (2430, 2629) and females was 3158 (3049, 3270). We predicted that the number of male CRD patients to be hospitalized in 2022 will be 4383 (4254, 4515) and 5841 (5692, 5993) for females. In 2027, the predicted number of male CRD patients to be hospitalized will be 7857 (7684, 8033) and 10412 (10213, 10614) for females. In 2032, which is the last year for the predictions, we expect the male CRD patients to be hospitalized to increase to 13973 (13742, 14207) and 18426 (18161, 18694) for females. A more extreme numbers were noticed among the males in certain age groups (Table 14 and Figure 19).

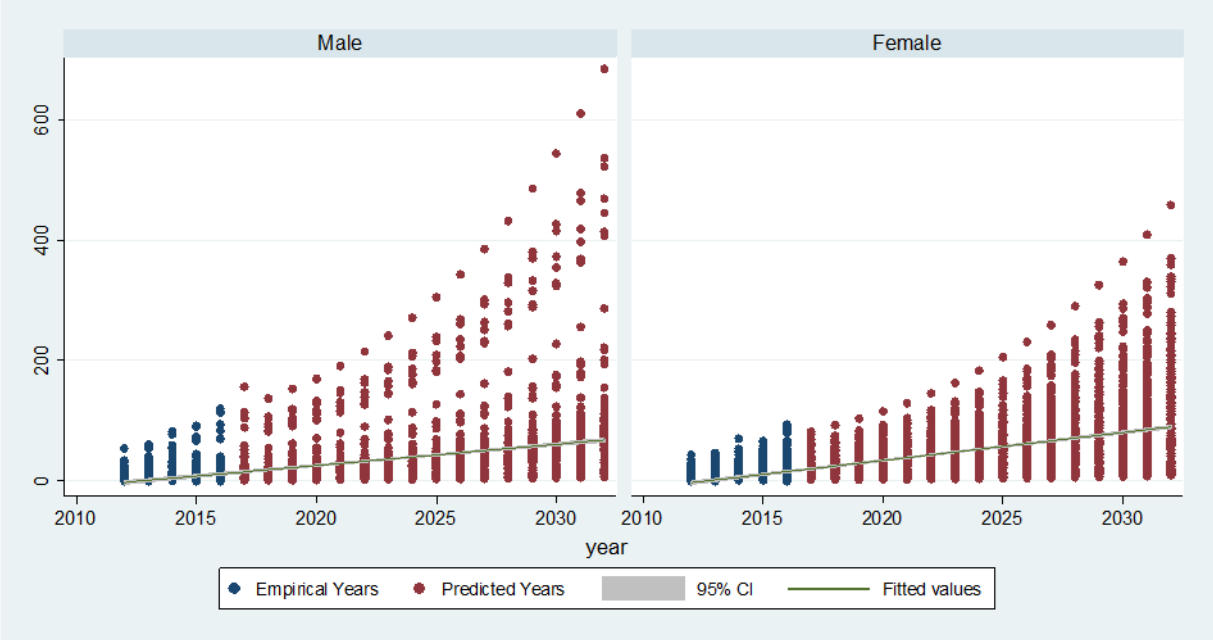


Figure 19: Poisson regression model plot empirical and predicted for chronic respiratory disease cases by sex and year (2012-2032) with dots indicating age groups

Based on the 6 years of historical data, we predicted the annual number of SCD cases from 2017 to 2032. The annual empirical cases were 808 (95% CI: 753, 866) among hospitalized male patients versus 856 (95% CI: 710,915) females in the reference year (2012). In 2016, the number of male SCD patients hospitalized was 2599 (2500, 2701) and females was 2728 (2627, 2832). We predicted that the number of male SCD patients to be hospitalized in 2022 will be 6774 (6614, 6937) and 7061 (6897, 7228) for females. In 2027, the predicted number of male SCD patients to be hospitalized will be 15396 (15154, 15641) and 15956 (15709, 16206) for females. In 2032, which is the last year for the predictions, we expect the male SCD patients to be hospitalized to increase to 34710 (34346, 35077) and 35799 (35429, 36172) for females. As the years of prediction increased, the burden of diabetes turn to be more pronounced in certain age groups of the females (Table 15 and Figure 20).

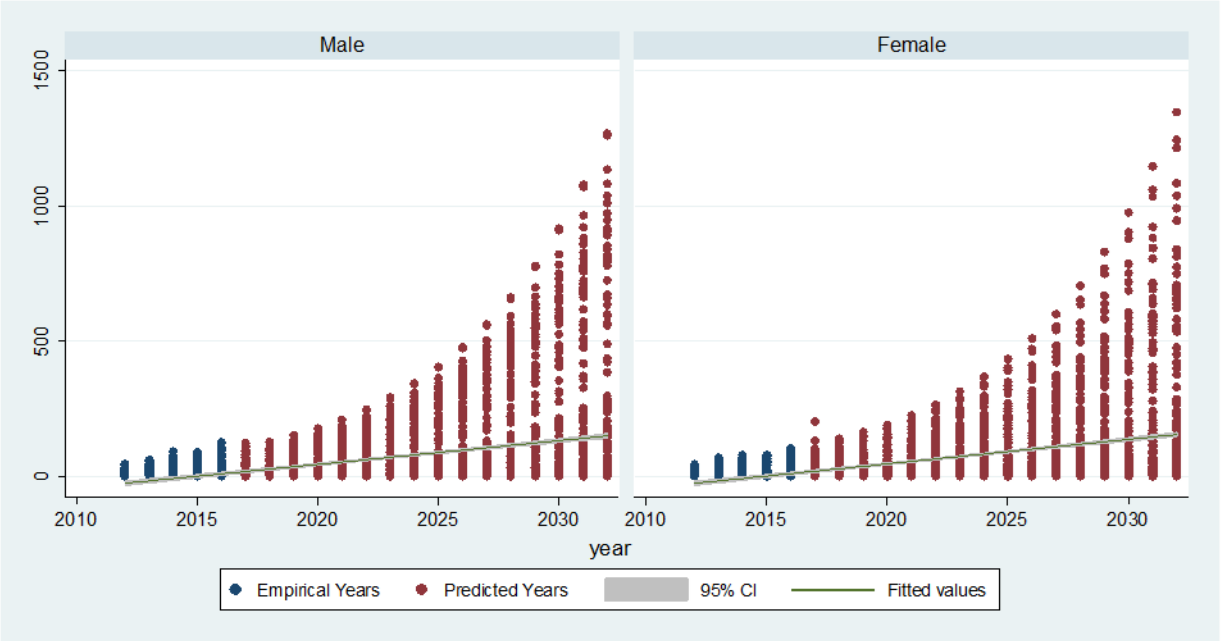


Figure 20: Poisson regression model plot empirical and predicted for sickle cell disease cases by sex and year (2012-2032) with dots indicating age groups

5. Discussion

The findings of this study are discussed under two broad headings: the methods used in this study and their applications to CVDs, diabetes, cancer, chronic respiratory and sickle cell diseases.

5.1 Methodology

This section discusses the data collection and quality, missingness, selection biases and how they were resolved. Additionally, we also addressed the assumptions and validity of the ASR, Fine-Gray, and Poisson regression model methods applied to the five NCDs.

5.1.1 Data collection and quality, missingness and selection biases

The availability of comprehensive, credible data for large epidemiological studies still remains a challenge in LMICs (86). However, most of these countries have huge routinely collected administrative data that are useful for modelling and prediction (53, 87). As planned, data on every hospital contributing data to the DHIMS II from 2012 – 2017 consisting of 13 variables extracted were automatically included in the study. All thirteen variables were sufficient enough for my thesis. These numbers were very few and their effect on our estimates should be minimal. In terms of selection biases, this was quite applicable to recommendations in the RECORD statement (87) for using secondary data as some important variables such as diagnostic tests, treatments, and patient medical history were not available in the extracted dataset.

5.1.2 Age-standardized rate (ASR) estimation method

All the assumptions required for estimating the ASR were met in each of the five NCDs. This included the stratification of each of were five NCDs by age group and sex in each region with a corresponding population and Ghana's standard population based on the 2010 population and housing census (63).

5.1.3 Fine and Gray regression model

In order to determine how long inpatients for these five NCDs stay in hospital before discharge and the associated risk factors, we chose to use the Fine-Gray regression approach because in circumstances where inpatients get discharged as a result of death would affect our endpoint. Hence, our definition of death before discharge as a competing event and the reporting of the Subhazard ratios (83). All our assumptions in section 3.6.2 were valid for the Fine-Gray model. We excluded inpatients without an exit date from the outcome before fitting the model and this did not affect the estimates.

The analysis of the Schoenfeld residuals showed no evidence that the assumption of proportional hazard has been violated.

5.1.4 Poisson regression model and predictions

Just like the two methods above, our Poisson regression also had some assumptions and limitations that were considered. The first assumption was that the DHIMS II database can be used to estimate the risk factors associated with hospitalization for the five NCDs while making predictions into the future. This assumption was met, however, it was limited with additional patient information as described in section 5.1.1. Although a six-year historical data was extracted, a linear trend was found in the first five-year as a result, set the model base year of prediction to 2016. Again the time series assumption of the data was met and also Poison distributed. We selected the log-linear option of the model in order to allow the dependence of the variance on the mean and modelling the log mean as a linear function of the covariates (79, 80).

The overall performance of the fitted Poisson model was measured by the Pearson residual which corrects for the unequal variance in the raw residuals by dividing by the standard deviation. After visually assessing the plots for each of the five NCDs, the plots appear to be good for a Poisson fit.

5.2 CVDs, diabetes, cancer, chronic respiratory and sickle cell disease

In this section, we discuss the findings and the implication of the above methods to these five diseases.

5.2.1 Cardiovascular diseases

The Eastern and Volta regions recorded both the highest ASR for female and male CVD inpatients from 2012 – 2017. This high CVD among inpatients in these two regions could be due to the fact that most of the people living there are older or retired from active service. Unlike the Eastern region, the Volta region's high ASR could also be attributed to the patronage of health services from residents in the neighbouring Republic of Togo. It was, however surprising that both the Greater Accra and Ashanti regions with the higher hospital density were not among the regions with the highest ASR. This could partially be explained by the presence of the first-two Teaching hospitals and the dominance of private hospitals in these regions. In addition to the above reasons, the non-contribution of data from these two large hospitals accounted for the regions' low ASR.

We found out that the duration of stay for CVD patients seems to be the same over the six-year period as the SH was one. However, for some reason, females got discharged earlier, assuming the discharge was not due to death. Just like other studies (2, 28, 88, 89) we similarly reported that CVD was high among inpatients especially inpatients above 35 years. For regional discharge of CVD inpatients, all the regions were quite similar with higher chances of early discharge from admission. However, the Volta region was an exception with a longer hospital stay. This could probably be the result of a high number of cases from this region. Unsurprisingly, inpatients who a surgical procedure while on admission or comorbidity tend to stay longer (89). This meant that without death as a competing risk event during hospitalization, these inpatients would stay for longer before discharge.

Based on the demographic and clinical characteristics included in the Poisson regression model, there was a 15% yearly increase in the number of CVD inpatients at the hospitals in Ghana. This effect could easily be explained by the changes in the population and data capture improvements over the years. Although several studies attributed future incidence of CVDs to lifestyle risk factors (20, 28, 90, 91), these were unfortunately not available for

inclusion in our model. Nevertheless, their effects cannot be overlooked. Cardiovascular diseases (CVDs) as diseases that affect older populations were evidenced in the study as well (28, 91, 92), but our relative rate of nearly 50% in the very older population has to be interpreted with caution. Again, our finding on females being 3 times at risk of hospitalization are consistent with smaller studies that reported higher CVDs among females compared to males (57, 93-95) and that of sub-Saharan Africa (89). The Eastern and Volta regions had a significantly higher relative rate for the number of CVDs hospitalized in Ghana. This significant association of region to inpatient CVD hospitalization has not been reported in the literature yet, hence our probable explanation could be due to the fact that these regions are quite populous with older retired people. Hence the onset of CVD might not necessarily be from these regions, especially the Volta region. Smaller and rural regions that are believed to have healthy lifestyles indeed had as low as 0.16 relative rates of CVD hospitalization.

Based on the fitted model and its assumptions, we predicted an 87.2% increase in CVD cases among females and 88.2% among males in 2022 from 2016. Similarly, our predictions for 2027 show a reduction of 76.8% and 77.3% for females and males respectively. Beyond the recommended short term predictions (27, 40), we extended our predictions to the year 2032 due to the availability of the population estimates. Hence, in 2032, we predict a marginal reduction of 76.2% in females and 76.6% in the males but with much higher uncertainty (40).

5.2.2 Diabetes

Diabetes was predominant in two of the regions in the middle zone of Ghana for both sexes. As expected, due to the underdeveloped nature of the northern belt of Ghana one would expect that regions in this zone should record the least of diabetic cases. Similarly, due to the large population and several hospitals in the two biggest regions, it was quite surprising that none of them was among the highest ASR regions for diabetes.

There was a 3% higher average yearly diabetic patient discharged from hospitals from 2012 – 2017. This presupposes that diabetic inpatients were being discharged earlier on average. For some reason, male diabetic inpatients were found to stay longer in the

hospitals compared to the females. In terms of the age of diabetic inpatients, the very young children were the most likely ones to be discharged early while the older you get, the longer your duration of admission. We also noticed that there was as high as 36% SH for discharge among the regions with higher SH. This clearly shows a significant difference in the duration of hospitalization among these regions. Another interesting finding of the diabetics was that they really stayed longer when they had to undergo a surgical procedure. A longer stay was also established for inpatients with comorbidities (89).

The average yearly relative rates of hospitalization for diabetic cases were estimated to be 15% higher over the 6 years and increased as age increases (32, 96). The double burden of the disease in females compared to males was earlier reported by Gouda et al and others (89, 97-99). The burden was quite different across the ten regions of Ghana and higher in the Eastern and Volta regions than expected. This unexpected increase could be probably due to the older population in these regions. However, the poorer and smaller regions had the least relative rates as one would expect (64).

For all diabetic cases, the WHO estimated 851,000 cases in 2030 from the 34,000 cases in 2000 for Ghana (100). This notwithstanding, we made predictions just for hospitalized diabetic cases. We extrapolate that all things being equal the 99% increase in male diabetic cases in 2022 from 2016 would reduce to 76% in 2017 and steady in 3032. This means that although numerically the number of cases in 2032 would be larger than 2027, the percentage increase would not be different from 2027 per the population growth. Although the percentage change is expected to be stable in 2032, we still believe this increase is higher and hospitals and stakeholders need pragmatic response plans.

5.2.3 Cancer

Cancer admissions were highest in the Volta, Eastern and Brong Ahafo regions for males while it was only highest in the Volta and Eastern regions for females. This burden cuts across the middle belt of Ghana from the west to east. The Ashanti region surprisingly had the lowest ASR for both males and female cancer inpatients, which could be due to a hospital-based cancer registry in the region (101). Again, this big hospital does not contribute data to DHIMS due to their autonomy (101). These reasons are also applicable

to the Greater Accra region with low numbers than expected. Nevertheless, the three northern regions showed a higher admission for cancer, especially among males. This could be attributed to the Tamale Teaching hospital, which is the biggest referral hospital in the north and also contributes data to the DHIMS.

There has been a 5% increase in the number of cancer hospitalizations. This increase could be attributed to the high burden of breast, cervical and prostate cancers. Previous studies reported the increasing burden of these cancers (54, 102-104). It was therefore not surprising that the proportion of cancers was elevated in the females compared to males. This elevation of cancer in females was also age-dependent (104) although Naku Ghartey et al (105) found otherwise. Younger cancer inpatients below the age of 25 years were more likely to be discharged earlier compared to those older. We noticed a regional variation in the distribution of cancer. However, what was unusual was the early discharge of cancer inpatients from regions that are classified as less developed. In the case of the Upper East and West regions, we believe discharge was likely due to referral to a higher hospital for better care. Although cancer inpatients who had some surgical procedure stayed longer during on admissions, those with an additional diagnosis stayed much longer.

Based on the demographic and clinical characteristics included in the Poisson regression model, there was a 30% yearly increase in the number of cancer inpatients to the hospitals in Ghana. This effect could easily be explained by the normal changes in the population and data capture improvements over the years. Additionally, several educational campaigns on prevention, early diagnosis among others might be a contributing factor (36, 91, 106-109), although several studies attributed future incidence of cancers to lifestyle risk factors (36, 90, 91, 107). A patient's susceptibility to cancer hospitalization increased with an increase in age. Our findings of females being 5% more at risk of hospitalization deserve interpretation with caution as females formed over 75% of cancer inpatients, smaller studies reported higher cancer among females compared to males (104, 110). Due to the disparities in the distribution of the health facilities in Ghana, it was surprising that some cancer inpatients stayed longer during hospitalization in rural regions as the urban regions.

Based on the fitted model and its assumptions, we predicted a 6.3% increase in CVD cases among females and 15.4% among males in 2022 from 2016. Similarly, our predictions for 2027 showed a reduction of 10.6% and 10.0% for females and males respectively. Beyond the recommended short term predictions (27, 40, 80, 84, 111), we extended our predictions to the year 2032 due to the availability of the population estimates. Hence, in 2032 we predicted a marginal reduction of 9.3% in females and 9.8% in the males but with much higher uncertainty. These uncertainties were also described in other studies (40, 80, 81).

5.2.4 Chronic respiratory diseases

Most chronic respiratory diseases admitted to hospitals in Ghana were among children. Therefore, it was not surprising to see the regions with younger populations (63) recording the highest ASR. For both males and females, the Upper West region recorded the highest cases of ASR in addition to the Volta region. There were more cases among males in the Eastern region compared to their female counterparts. The Greater Accra had small numbers for both males and females, which may suggest that chronic respiratory diseases were not the major health issues in the region just like the Ashanti region as well.

The annual burden of CRDs saw a 3% average decrease from 2012 – 2017 with more female cases compared to males. Asthmas and COPDs such as unspecified bronchitis (J40) and pneumonia due to food and vomit (J69.0) were the main CRDs among the older population and are consistent with other studies (26, 97, 107, 108). Most of the regions showed an early discharge of CRD patients compared to Greater Accra regions. However, the Volta region had CRD patients staying longer. This finding is difficult to explain as other regions such as the Upper East and West with similar development characteristics like the Volta region discharged inpatients much earlier. The SH for discharge for all categories of occupation showed an earlier discharge from hospitalization except for para-professionals. Although the remaining categories of occupation got discharged much earlier, inpatients engaged in farming/fishing and trading/business got discharged later. The admission for CRDs was earlier reported by (26, 112). Education seems to play a role in the discharge of CRD inpatients as higher education was associated with early

discharge. Similarly, insured inpatients also got discharged much earlier compared to uninsured inpatients. Nevertheless, inpatients who had a surgical procedure while on admission or those with comorbidities had longer hospital stays.

There was a yearly 10% increase in hospitalization for CRD inpatients from 2012 – 2017 in Ghana (107, 108). We found this increase to be driven by more females compared to males (113). We found the relative rate of hospitalization for CRD to be more pronounced in the very young (less than 25 years) and very old (80-100 years) populations (114, 115). There were very high and significant relative rates across the regions. This gives an indication of the regions where stakeholders could focus and channel their resources to improve the care for CRD inpatients.

Based on these findings, we predicted that there would be an annual increase of 53.7% male CRD cases from 2016 to 2022, while that of the females would be 59.6% for the same period. Our predictions for male CRD inpatients showed an increase of almost 56.0% for the years 2027 and 2032. However, there was a marginal drop from 56.3% in 2027 to 55.6% in 2032 for females. Realistically, these percentages seem to be the same, however, due to a large amount of data involved every little difference is important. Gouda and colleagues reported a 48.3% change from 1990 – 2017 for all-DALYs in sub-Saharan Africa (89).

5.2.5 Sickle cell disease

Male and female hospital admissions for SCD was predominant in the Volta, Eastern and Brong Ahafo regions. The case of the Volta region was consistent with Yawson et al 2016 (116) while the other two regions did not. The distribution of SCD across the regions by sex was nearly the same for both males and females except for the Ashanti and Upper East regions. In the case of the Ashanti region, there were more males than females and the reverse was true for the Upper East region.

Calendar-year did not show any influence on discharge over the six-year period. The SH for the discharge of SCD inpatients reporting to hospitals from 2012 to 2017 showed slightly higher female clients which was also obvious in the age-sex interaction. The SH for discharge was lower for almost all ages. This means that getting discharged early for

SCD was not dependent on a patient's age. However, the SH for discharge showed a regional variation with a surprisingly similar SH between some rural and urban regions. For instance, Ashanti (urban) and Upper East (rural) regions have nearly the same SHRs. It was very similar in the case of Western (urban) and Upper West (rural) regions. Apart from pensioners who stayed much longer during hospitalization, the remaining categories of occupation got discharged much earlier compared to unemployed SCD inpatients. The SH for discharge was dependent on education as the higher the educational level of the inpatient, the earlier discharge time. Inpatients who had a surgical procedure while on admission or those with comorbidities had longer hospital stays (89).

The average yearly relative rates of hospitalization for SCD cases were estimated to be 15% higher over the 6 years and increased marginally as age increased. This increase in the number of cases as the patient grew was not surprising because the WHO projects 20% to 30% prevalence in the general population (117) but could be due to the older inpatients that we found which were not updated in literature. The nearly double burden of the disease in females compared to males was earlier reported among pregnant women (118). The three Northern and Central regions had the lowest SH for discharge. This implies that inpatients in these four regions stayed relatively longer before discharge compared to others. A possible explanation could be due to their rural nature.

Based on the empirical trends we made predictions for the future burden of SCD among inpatients in Ghana. In all SCD cases, the WHO estimated a 20% - 30% prevalence in Ghana (117). This notwithstanding, we made predictions just for hospitalized SCD cases just like previously described predictions. We extrapolated that all things being equal the 89.0% and 88.5% increase in male and female SCD cases in 2022 from 2016 would reduce to 77.8% in 2027 and almost the same in 3032 for both sexes. This means that although numerically the number of SCD cases in 2032 would be greater than 2027, the percentage increase would not be that different from 2027 per the population growth, although the percentage change is expected to be stable in 2032.

5.3 Limitations and strengths

There were a few possible limitations and strengths of this study in addition to those that were specific to the statistical methods used. The first and foremost has to do with the normal limitations of secondary data usage. This notwithstanding, the remaining limitations and strengths of this study could be classified into two as follows:

5.3.1 Limitations

The inpatient data captured into DHIMS II lacks essential patient history, diagnostic tests performed, cancer diagnosis did not have their sites captured, and treatments administered. This information is, however, collected in the patient health record book, but are not captured by the DHIMS.

The diagnoses as contained in the DHIMS II database are not perfectly coded according to WHO ICD-10 codes which was a major limitation to the DHIMS database. A lot of efforts was invested to code all diagnoses for each of the five NCDs according the ICD-10 codes. These self-written Stata codes were validated as well as the validation of the list NCDs by two physicians in order to avoid misclassification.

Due to the large volume of data, we dropped all patients with missing information for the year of admission, age, and sex as these were key variables in the study. This could have possibly resulted in a small selection bias.

The unavailability of patient history information and risk factors in the models did not permit us see the effects these important variables (patient history, diagnostic tests performed, cancer diagnosis did not have their sites captured, and treatments administered) when modelled. This notwithstanding, the predictions of NCDs mortality and outcome are essential for the development and resourcing of health facilities among others.

5.3.2 Strengths

A greater understanding of the trends in NCDs in different areas of the country and a greater understanding of the factors that underlie the changes in NCD admissions and mortality have been reported. We also predicted the future burden of CVDs, diabetes, cancers, CRDs and SCD from 2018 – 2032. We have also demonstrated the usefulness of the GHS database in estimating the national burden of diseases. This understanding could then be used to inform service planning, or to direct public health interventions in Ghana. However, one should bear in mind that the data has some limitations as explained above and interpretation should be done with caution.

In conclusion, the DHIMS data was a useful big data source which was largely complete for this study. Also, this is the first time that such big routine administrative health service data has been used in Ghana to estimate national disease burden. Compared to previously available data, the data processing in this study has resulted in a much higher available quality data. Comparing the results of this to available scientific literature, this would advance and broaden the scope for the use of routine administrative health service data in LMICs.

6. Summary (Zusammenfassung)

6.1 Zusammenfassung

Hintergrund

Die Weltgesundheitsorganisation (WHO) berichtete, dass weltweit nichtübertragbare Krankheiten (NCDs) für 41 Millionen (71%) der 57 Millionen Todesfälle im Jahr 2016 verantwortlich waren. Mehr als 36% davon (15 Millionen) waren vorzeitige Todesfälle (30 - 70 Jahre). 78% aller NCD-Todesfälle und 85% der vorzeitigen Todesfälle treten wiederum in Ländern mit niedrigem und mittlerem Einkommen auf.

Die fünf wichtigsten NCDs in Ghana sind Herz-Kreislauf-Erkrankungen (CVDs), Diabetes, Krebs, chronische Atemwegserkrankungen (CRDs) und Sichelzellenkrankheiten. Die vorliegende Studie quantifizierte durch Häufigkeit und Dauer von durch diese NCDs verursachten Krankenhausaufenthalten in Ghana von 2012 bis 2017 in Abhängigkeit verschiedener Einflussfaktoren. Auf dieser Basis wurde die zukünftige (2018–2032) Belastung aufgrund von Krankenhausaufenthalten und dieser NCDs prognostiziert. Dabei wurden auch die räumlichen und zeitlichen Trends sowie Erklärungsfaktoren im Zusammenhang mit Krankenhausaufenthalten und Mortalität identifiziert.

Material und Methoden

Fast 3 Millionen Datensätze (bestehend aus 13 Variablen) über Krankenhausaufenthalte in Ghana von 2012 bis 2017 wurden aus der Datenbank des District Health Information Management System (DHIMS II) des Ghana Health Service (GHS) extrahiert. Die Bevölkerungsdaten und die Standardbevölkerung für diese Studie wurden vom Ghana Statistical Service zur Verfügung gestellt. Diese Datensätze wurden nach dem positiven Votum des Ghana Health Service Ethics Review extrahiert.

In dieser Studie wurden hauptsächlich drei statistische Methoden verwendet:

- Altersstandardisierte Raten (ASR) mit 95% Konfidenzintervallen (CI) wurden für jede der fünf NCDs pro Region stratifiziert nach Geschlecht berechnet.

- Für jede der fünf NCDs wurde ein Fine-Gray-Regressionsmodell für Ereigniszeiten mit konkurrierenden Risiken wurde zur Schätzung des Subdistribution Hazard Ratio (SHR)

mit 95% CI für die Zeit bis zur Entlassung aus dem Kranken angepasst. Dabei wurde auch die zugehörige Cumulative Incidence Function (CIF) berechnet.

- Die Auftretensrate für jede der fünf NCDs wurde durch ein Poisson-Regressionsmodell mit Geschlecht, Alter, Kalenderjahr und Region als Kovariablen unter Verwendung der empirischen Daten von 2012–2017 modelliert, wobei die Größe der Population als Offset diente. Für die Kovariaten wurden die relativen Raten mit 95% CI geschätzt. Auf Basis des Modells wurde dann die zukünftige Häufigkeit von Hospitalisierungen aufgrund dieser NCDs in Ghana in den Jahren 2018–2032 prognostiziert, wobei die geschätzte zukünftige Bevölkerungsgröße als Basis diente.

Ergebnisse

Der Datensatz mit 265.490 Beobachtungen zeigte folgende Verteilung: CVDs 151.272; Diabetes 40.202; Krebs 26.627; CRDs 24.709 und SCD 22.680 Beobachtungen. In jeder Krankheitsgruppe gab es mehr Frauen als Männer, insbesondere bei den CVDs, Diabetes und Krebspatienten. Patienten mit CRDs und SCDs waren deutlich jünger als Patienten mit den verbleibenden drei NCDs. Der Median (1. und 3. Quartil) für die Krankenhausaufenthaltsdauer waren 3 Tage (1, 5) für CVDs, 4 Tage (2, 6) für Diabetes, 4 Tage (2, 6) für Krebs, 2 Tage (1, 3) für CRDs und 3 Tage (2, 4) für SCD.

Die geschätzte ASR pro 100.000 Einwohner für die fünf NCDs betrug 93,7 für CVDs, 24,0 für Diabetes, 15,2 für CRDs und 14,0 für SCD. Das Geschlecht war eine der Kovariablen, die statistisch signifikant mit der Zeit bis zur Entlassung aus dem Krankenhaus assoziiert waren. Das SHR für Männer vs. Frauen für CVD betrug 1.13 (95% CI: 1.07, 1.20; p<0.001); für Diabetes 1.09 (95% CI: 0.98, 1.21; p=0.102); für Krebs 1.53 (95% CI: 1.34, 1.75; p <0.001); für CRD 1.07 (95% CI: 0.96, 1.19; p=0.196).

Die relative Rate

(RR) für die Hospitalisierung durch jede der NCDs nahm mit zunehmendem Alter zu. Frauen hatten für alle fünf NCDs eine höhere RR als Männer (CVD [RR: 3,43; 95%CI:2.55,4.62; P<0,001]; Diabetes [RR: 2.18; 95%CI:1.56,3.05; P<0.001]; Krebs [RR: 5.15; 95%CI:3.53,7.51; P<0.001]; CRD [RR: 3.08; 95%CI:2.34,4.05; P<0.001]; SCD [RR: 1.57; 95%CI:1.15,2.14; P=0.004]).

Basierend auf dem Poisson-Modell für jede der NCDs wurden die folgenden Vorhersagen gemacht: CVDs würden von 92.810 im Jahr 2022 auf 467.099 im Jahr 2032 steigen, Diabetes von 25.399 auf 126.334, Krebs von 7.609 auf 9.256, CRDs von 10.224 auf 32.399 und SCDs von 13.835 auf 70.509.

Diskussion und Schlussfolgerung

Insgesamt stellten wir eine höhere Krankheitslast im Sinne der Hospitalisierungen bei Frauen im Vergleich zu Männern fest. Dies lässt sich teilweise durch das Verhältnis von Frauen zu Männern in der Bevölkerung erklären, welches in der Volkszählung von Ghana 2010 gemeldet wurde. Der beobachtete Anteil von Hospitalisierungen war jedoch stärker ausgeprägt als das Geschlechterverhältnis in der Bevölkerung. Die Belastung durch CVDs, Diabetes und Krebs war eher auf Erwachsene zurückzuführen, während CRDs und SCDs in der jungen Bevölkerung höher waren. Darüber hinaus haben wir die zukünftige Belastung durch CVDs, Diabetes, Krebs, CRDs und SCD in den Jahren 2018–2032 prognostiziert. Diese Prognosen sollten mit Vorsicht interpretiert werden, da sie auf einer Extrapolation der Bevölkerungszahlen und der Hospitalisierungsraten beruhen. Durch die vorliegende Arbeit wurde der Nutzen der GHS-Datenbank bei der Schätzung der nationalen Krankheitslast gezeigt. Dieses Verständnis könnte genutzt werden, um die Planung von Gesundheitsleistungen zu unterstützen oder um Maßnahmen im Bereich der öffentlichen Gesundheit in Ghana zu lenken.

6.2 Abstract

Background

The World Health Organization (WHO) reported that Noncommunicable Diseases (NCDs) were responsible for 41 million (71%) of the world's 57 million deaths in 2016. More than 36% of them (15 million) were premature deaths (30–70 years); again, 78% of all NCD deaths and 85% of the premature deaths occur in low- and middle-income countries.

This study quantified and predicted the future (2018–2032) burden due to hospitalization and mortality of the five major NCDs in Ghana: cardiovascular diseases (CVDs), diabetes, cancers, chronic respiratory diseases (CRDs) and sickle cell disease (SCD). The spatial and temporal trends, and explanatory factors associated with hospitalization and mortality were also identified for these NCDs.

Materials and Methods

Nearly 3 million records (comprising 13 variables) on hospitalizations in Ghana from 2012 – 2017 were extracted from the District Health Information Management System (DHIMS II) database of the Ghana Health Service (GHS). The population data and standard population for this study were extracted from the Ghana Statistical Service. These datasets were extracted after the Ghana Health Service Ethics Review Committee approved the study.

Three main statistical methods were used in this study:

- Age-standardized rates (ASR) and 95% confidence intervals (95% CI) were computed for each of the five NCD per region and stratified by sex.
- The Fine-Gray competing-risks regression model was used in estimating the subdistribution hazard ratio (SHR) for the failure of an event of interest (hospital discharge) also known as the subhazard and the associated Cumulative Incidence Function (CIF). The model fit was using the Schoenfeld residuals.
- A Poisson regression model was fitted for each of the five NCDs with sex, age, calendar-year and region as covariates using the empirical from 2012 – 2017. The model assumed a log linearity and the population was used as the offset. We then

predicted the future burden of these NCDs among hospitalized patients in Ghana from 2018 – 2032. The model fit was using the Pearson residuals.

The 95% confidence intervals (95% CI) and p-values were reported for the Fine-Gray and Poisson models. Statistical significance was set at a p-value <0.05.

Results

We analysed a complete dataset of 265,490 with the following breakdown: CVDs 151,272; diabetes 40,202; cancer 26,627; CRDs 24,709 and SCD 22,680 records. There were more females than males in each disease category but higher among the CVDs, diabetes and cancer patients. In terms of age, the patients in the CRDs and SCD were much younger compared to the remaining three NCDs. The median with 25th and 75th percentiles for hospitalization durations were 3 days (1,5) for CVDs, 4 days (2,6) for diabetes, 4 days (2,6) for cancer, 2 days (1,3) for CRDs and 3 days (2,4) for SCD.

The estimated ASR per 100,000 population for each of five NCDs were 93.7 for CVDs, 24 for diabetes, 15.2 for CRDs, and 14 for SCD. Sex was one of the several covariates associated with hospitalization discharge. Males vs. females SHR for CVD (SHR:1.13; 95% CI: 1.07,1.20; p-value <0.001); diabetes (SHR:1.09; 95% CI: 0.98,1.21; p-value =0.102); cancer (1.53; 95% CI: 1.34,1.75; p-value <0.001); and CRD (SHR:1.07; 95% CI: 0.96,1.19; p-value =0.196).

The relative rate for all the NCDs increased as age increased. Similar trends for sex was seen for all the NCDs where females had a higher RR compared with males (CVD [RR: 3.43; 95%CI:2.55,4.62; P<0.001]; diabetes [RR: 2.18; 95%CI:1.56,3.05; P<0.001]; cancer [RR: 5.15; 95%CI:3.53,7.51; P<0.001]; CRD [RR: 3.08; 95%CI:2.34,4.05; P<0.001]; SCD [RR: 1.57; 95%CI:1.15,2.14; P=0.004]).

Based on a Poisson model for each of the NCDs, we made the following predictions; CVDs would increase from 92,810 in 2022 to 208,969 in 2027, diabetes would increase from 25,399 in 2022 to 58,860 in 2027, cancer would increase from 7,609 in 2022 to 8,424 in 2027, CRDs would increase from 10,224 in 2022 to 18,269 in 2027, and SCD would increase from 13,835 in 2022 to 31,352 in 2027.

Discussion and conclusion

Overall, we noticed a higher disease burden and risk factors among females compared to males. Although, this could be explained by the higher female to male ratio reported in the 2010 Ghana census, this proportion was more pronounced. The burden of CVDs, diabetes and cancers were more tailored towards adults, while CRDs and SCD were higher in the young population. Furthermore, we predicted the future burden of CVDs, diabetes, cancers, CRDs and SCD from 2018 – 2032. These forecasts should be interpreted with caution as they are based on extrapolation of population counts and hospitalisation rates. We have demonstrated the usefulness of the GHS database in estimating the national burden of diseases. This understanding could be used to inform service planning, or to direct public health interventions in Ghana.

7. References

1. Reddy KS. Global Burden of Disease Study 2015 provides GPS for global health 2030. The Lancet. 2016;388(10053):1448-9.
2. Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, et al. Global, Regional, and National Burden of Cardiovascular Diseases for 10 Causes, 1990 to 2015. Journal of the American College of Cardiology. 2017;70(1):1-25.
3. World Health Organization. Global status report on noncommunicable diseases 2014. Geneva: WHO; 2014 2016. Available from: http://apps.who.int/iris/bitstream/10665/148114/1/9789241564854_eng.pdf?ua=1.
4. Political declaration of the high-level meeting of the general assembly on the prevention and control of non-communicable diseases, (2012).
5. Aikins Ad-G, Unwin N, Agyemang C, Allotey P, Campbell C, Arhinful D. Tackling Africa's chronic disease burden: from the local to the global. Globalization and health. 2010;6(1):5.
6. Read UM, Doku V. Mental health research in Ghana: a literature review. Ghana medical journal. 2012;46(2):29-38.
7. Benziger CP, Roth GA, Moran AE. The Global Burden of Disease Study and the Preventable Burden of NCD. Glob Heart. 2016;11(4):393-7.
8. Naghavi M, Wang H, Lozano R, Davis A, Liang X, Zhou M. GBD 2013 Mortality and Causes of Death Collaborators. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2015;385(9963):117-71.
9. Murray CJ, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. The lancet. 2012;380(9859):2197-223.
10. Nyaaba GN, Stronks K, de-Graft Aikins A, Kengne AP, Agyemang C. Tracing Africa's progress towards implementing the Non-Communicable Diseases Global action plan 2013-2020: a synthesis of WHO country profile reports. BMC Public Health. 2017;17(1):297.
11. World Health Organization. Global brief on hypertension. World Health Organization. 2013.
12. World Health Organization. Preventing Chronic Diseases-A Vital Investment: WHO Global Report: World Health Organization; 2005. Available from: http://www.who.int/chp/chronic_disease_report/part1/en/.
13. World Health Organization. Media centre Noncommunicable diseases prematurely take 16 million lives annually, WHO urges more action News release 2017 [Available from: http://www.who.int/mediacentre/news/releases/2015/noncommunicable-diseases/en/.
14. Mendis S, Al Bashir I, Dissanayake L, Varghese C, Fadhil I, Marhe E, et al. Gaps in capacity in primary care in low-resource settings for implementation of essential noncommunicable disease interventions. International journal of hypertension. 2012;2012.
15. World Health Organization. Media centre noncommunicable diseases factsheet 2017 [Available from: http://www.who.int/mediacentre/factsheets/fs355/en/.
16. Dalal S, Beunza JJ, Volmink J, Adebamowo C, Bajunirwe F, Njelekela M, et al. Non-communicable diseases in sub-Saharan Africa: what we know now. International journal of epidemiology. 2011;40(4):885-901.
17. World Health Organization. Noncommunicable Diseases (NCD) Country Profiles , 2014. 2014 [Available from: http://www.who.int/nmh/countries/gha_en.pdf?ua=1.
18. World Health Organization. Noncommunicable diseases progress monitor 2015 2015. Available from: http://apps.who.int/iris/bitstream/10665/184688/1/9789241509459_eng.pdf.
19. Abubakar I, Tillmann T, Banerjee A. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2015;385(9963):117-71.

20. BeLue R, Okoror TA, Iwelunmor J, Taylor KD, Degboe AN, Agyemang C, et al. An overview of cardiovascular risk factor burden in sub-Saharan African countries: a socio-cultural perspective. Globalization and health. 2009;5:10.
21. Bonita R, Beaglehole R. Stroke prevention in poor countries: time for action. Stroke. 2007;38.
22. Kadiri S, Salako B. Cardiovascular risk factors in middle aged Nigerians. East African Medical Journal. 1997;74.
23. Kengne AP, Awah PK. Classical Cardiovascular risk factors and all-cause mortality in rural Camroon. QJM. 2009;102.
24. Yach D, Hawkes C, Gould C, Hofman K. The global burden of chronic diseases: overcoming impediments to prevention and control. Jama. 2004;291.
25. Marquez PV, Farrington JL. The challenge of non-communicable diseases and road traffic injuries in sub-Saharan Africa: an overview. 2013.
26. Ghana Health Service. 2016 Annual Report June 2017. Available from: http://www.ghanahealthservice.org/ghs-category.php?cid=5.
27. National Cancer Registry. Trends in Irish cancer incidence 1994-2002, with projections to 2020 2006 [Available from: http://www.ncri.ie/pubs/pubfiles/proj_2020.pdf.
28. Bosu WK. Epidemic of hypertension in Ghana: a systematic review. BMC Public Health. 2010;10(1):418.
29. Appiah LT, Sarfo FS, Agyemang C, Tweneboah HO, Appiah N, Bedu-Addo G, et al. Current trends in admissions and outcomes of cardiac diseases in Ghana. Clinical cardiology. 2017;40(10):783-8.
30. World Health Organization. Global report on diabetes: World Health Organization; 2016. Available from: http://www.who.int/gho/mortality_burden_disease/en/index.html.
31. Gill G, Mbanya JC, Ramaiya K, Tesfaye S. A sub-Saharan African perspective of diabetes. Diabetologia. 2009;52.
32. Amoah AG, Owusu SK, Adjei S. Diabetes in Ghana: a community based prevalence study in Greater Accra. Diabetes research and clinical practice. 2002;56(3):197-205.
33. Nyarko KM, Ameme DK, Ocansey D, Commeh E, Markwei MT, Ohene SA. Capacity assessment of selected health care facilities for the pilot implementation of Package for Essential Non-communicable Diseases (PEN) intervention in Ghana. The Pan African medical journal. 2016;25(Suppl 1):16.
34. Owiredu WKBA, Adamu MS, Amidu N, Woode E, Bam V, Plange-Rhule J, et al. Obesity and Cardiovascular Risk Factors in a Pentecostal Population in Kumasi-Ghana. J Med Sci. 2008;8.
35. World Health Organization. Programmes: Cancer 2017 [Available from: http://www.who.int/cancer/en/.
36. World Health Organization. Programmes: Cancer modules flyer: cancer control 2006 [Available from: http://www.who.int/cancer/modules/Modules%20Flyer.pdf?ua=1.
37. Ferlay J, Steliarova-Foucher E, Lortet-Tieulent J, Rosso S, Coebergh J, Comber H, et al. Cancer incidence and mortality patterns in Europe: estimates for 40 countries in 2012. European journal of cancer. 2013;49(6):1374-403.
38. Forouzanfar MH, Afshin A, Alexander LT, Aasvang GM, Bjertness E, Htet AS, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. 2016.
39. World Health Organization. Media centre: cancer factsheet 2017 [Available from: http://www.who.int/mediacentre/factsheets/fs297/en/.
40. Dyba T, Hakulinen T. Do cancer predictions work? Eur J Cancer. 2008;44(3):448-53.
41. To T, Stanojevic S, Moores G, Gershon AS, Bateman ED, Cruz AA, et al. Global asthma prevalence in adults: findings from the cross-sectional world health survey. BMC Public Health. 2012;12:204.

42. Piel FB, Hay SI, Gupta S, Weatherall DJ, Williams TN. Global burden of sickle cell anaemia in children under five, 2010-2050: modelling based on demographics, excess mortality, and interventions. PLoS Med. 2013;10(7):e1001484.
43. Hematology ASo. State of sickle cell disease 2016 report. Sickle cell disease coalition 2016.
44. Grosse SD, Odame I, Atrash HK, Amendah DD, Piel FB, Williams TN. Sickle cell disease in Africa: a neglected cause of early childhood mortality. American journal of preventive medicine. 2011;41(6 Suppl 4):S398-405.
45. Makani J, Cox SE, Soka D, Komba AN, Oruo J, Mwamtemi H, et al. Mortality in sickle cell anemia in Africa: a prospective cohort study in Tanzania. PloS one. 2011;6(2):e14699.
46. Makani J, Williams TN, Marsh K. Sickle cell disease in Africa: burden and research priorities. Annals of tropical medicine and parasitology. 2007;101(1):3-14.
47. Rees DC, Williams TN, Gladwin MT. Sickle-cell disease. Lancet. 2010;376(9757):2018-31.
48. Serjeant GR. Mortality from sickle cell disease in Africa. Bmj. 2005;330(7489):432-3.
49. Weatherall DJ, Clegg JB. Inherited haemoglobin disorders: an increasing global health problem. Bull World Health Organ. 2001;79(8):704-12.
50. Williams TN, Obaro SK. Sickle cell disease and malaria morbidity: a tale with two tails. Trends in parasitology. 2011;27(7):315-20.
51. Murray CJL, Fitzmaurice C, Naghavi M. Improving the quality and coverage of cancer registries globally – Authors' reply. The Lancet. 2015;386(9998):1036.
52. Bray F, Znaor A, Cueva P, Korir A, Swaminathan R, Ullrich A, et al. Planning and developing population-based cancer registration in low-and middle-income settings: IARC (International Agency for Research on Cancer); 2014.
53. Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, et al. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement. PLoS Med. 2015;12(10):e1001885.
54. Calys-Tagoe BN, Yarney J, Kenu E, Amanhyia NAKO, Enchill E, Obeng I. Profile of cancer patients' seen at Korle Bu teaching hospital in Ghana (A cancer registry review). BMC research notes. 2014;7(1):577.
55. Laryea DO, Awuah B, Amoako YA, Osei-Bonsu E, Dogbe J, Larsen-Reindorf R, et al. Cancer incidence in Ghana, 2012: evidence from a population-based cancer registry. BMC cancer. 2014;14(1):362.
56. Addo J, Amoah AG, Koram KA. The changing patterns of hypertension in Ghana: a study of four rural communities in the Ga District. Ethn Dis. 2006;16(4):894-9.
57. Amoah AGB. Hypertension in Ghana: A cross-sectional community prevalence study in Greater Accra. Ethn Dis. 2003;13.
58. Biritwum R, Gyapong J, Mensah G. The epidemiology of obesity in Ghana. Ghana medical journal. 2005;39(3):82.
59. Adaletey DL, Poppe O, Braa J, editors. Cloud computing for development—Improving the health information system in Ghana. IST-Africa Conference and Exhibition (IST-Africa), 2013; 2013: IEEE.
60. World Health Organization. Health statistics and information systems: projections of mortality and burden of disease to 2030 2002 [Available from: http://www.who.int/healthinfo/global_burden_disease/projections2002/en/.
61. World Health Organization. The global burden of disease: 2004 update. Geneva: WHO; 2008 2014. Available from: http://www.who.int/healthinfo/global_burden_disease/GBD_report_2004update_full.pdf.
62. Chatfield C. Prediction intervals for time-series forecasting. Principles of forecasting: Springer; 2001. p. 475-94.
63. Ghana Statistical Service. 2010 Population and Housing Census Summary Report of Final Results 2012. Available from:

http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf.
64. Ghana Statistical Service. Ghana Demographic and Health Survey 2014 2015. Available from: http://www.statsghana.gov.gh/publications.html.
65. Hakulinen T, Teppo L, Saxén E. Do the predictions for cancer incidence come true? Experience from Finland. Cancer. 1986;57(12):2454-8.
66. United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2017 Revision, DVD Edition. 2017 [Available from: https://esa.un.org/unpd/wpp/Download/Standard/Population/.
67. Worldometers. Countries in the world by population (2017). 2017.
68. Wikipedia. Regions in Ghana 2019 [Available from: https://en.wikipedia.org/wiki/Regions_of_Ghana.
69. Nyonator FK, Ofosu A, Osei D, Atweam D, Policy Planning Monitoring and Evaluation Division. District health information management system (DHIMS) II: The experience of Ghana Health Service N.D. [Available from: http://solutionscenter.nethope.org/../dhims2_crs_presentation.ppt.
70. Policy Planning Monitoring Evaluation Division Center for Health Information Management Ghana Health Service. DHIMS2 Facility User Manual. 2015.
71. Infotech Systems Ghana. Our clients 2013 [Available from: http://www.infotechsystemsonline.com/clients/.
72. Progsoft Solutions Limited Ghana. Our clients 2016 [Available from: http://progsoftgh.com/kbs/clients.html.
73. Ghana Statistical Service. Homepage: about us 2017 [Available from: http://www.statsghana.gov.gh/About_us.html.
74. StataCorp. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP. 2011.
75. World Health Organization. International Statistical Classifi cation of Diseases and Related Health Problems 10th Revision (ICD-10) Version for 2010 2010. Available from: http://apps.who.int/classifications/icd10/browse/2010/en#/X59.
76. World Health Organization ICD-10. Changes to volume 2 ICD-10 2010 to 2016 2017 [Available from: http://apps.who.int/classifications/icd10/files/ICD10Vol220162010Trackchanges.pdf?ua=1.
77. Belotti F, Depalo D. Translation from narrative text to standard codes variables with Stata. 2009.
78. Press S, Tool IQ. Stata: Data Analysis and Statistical Software.
79. Dyba T, Hakulinen T. Comparison of di!erent approaches to incidence prediction based on simple interpolation techniques. STATISTICS IN MEDICINE,. 2000;19, (13)(1741-1752).
80. Dyba T, Hakulinen T, Paivarinta L. A SIMPLE NON-LINEAR MODEL IN INCIDENCE PREDICTION. STATISTICS IN MEDICINE, . 1997;16, 2297–2309.
81. Godlewski D, Wojtys P, Antczak A. Predictions of cancer incidence in Wielkopolska in 2018. Contemp Oncol (Pozn). 2012;16(1):38-43.
82. World Health Organization. WHO methods and data sources for global burden of disease estimates 2000-2015 2017. Available from: http://www.who.int/gho/mortality_burden_disease/en/index.html.
83. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. Journal of the American statistical association. 1999;94(446):496-509.
84. Bray F, Moller B. Predicting the future burden of cancer. Nat Rev Cancer. 2006;6(1):63-74.
85. . !!! INVALID CITATION !!! .
86. Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease Study 2017, Seattle, WA: IHME. The Lancet. 2018.
87. Nicholls SG, Quach P, von Elm E, Guttmann A, Moher D, Petersen I, et al. The REporting of Studies Conducted Using Observational Routinely-Collected Health Data (RECORD)

Statement: Methods for Arriving at Consensus and Developing Reporting Guidelines. PLoS One. 2015;10(5):e0125620.
88. Mozaffarian D. Global Scourge of Cardiovascular Disease: Time for Health Care Systems Reform and Precision Population Health. Journal of the American College of Cardiology. 2017;70(1):26-8.
89. Gouda HN, Charlson F, Sorsdahl K, Ahmadzada S, Ferrari AJ, Erskine H, et al. Burden of non-communicable diseases in sub-Saharan Africa, 1990–2017: results from the Global Burden of Disease Study 2017. The Lancet Global Health. 2019;7(10):e1375-e87.
90. Wu F, Guo Y, Chatterji S, Zheng Y, Naidoo N, Jiang Y, et al. Common risk factors for chronic non-communicable diseases among older adults in China, Ghana, Mexico, India, Russia and South Africa: the study on global AGEing and adult health (SAGE) wave 1. BMC Public Health. 2015;15:88.
91. Nelson F, Nyarko KM, Binka FN. Prevalence of Risk Factors for Non-Communicable Diseases for New Patients Reporting to Korle-Bu Teaching Hospital. Ghana Medical Journal. 2015;49(1):12.
92. Agyemang CO. Rural and urban differences in blood pressure and hypertension in Ghana, West Africa. Public Health. 2006;120.
93. Sarfo FS, Akassi J, Awuah D, Adamu S, Nkyi C, Owolabi M, et al. Trends in stroke admission and mortality rates from 1983 to 2013 in central Ghana. J Neurol Sci. 2015;357(1-2):240-5.
94. Awuah RB, Anarfi JK, Agyemang C, Ogedegbe G, Aikins A. Prevalence, awareness, treatment and control of hypertension in urban poor communities in Accra, Ghana. J Hypertens. 2014;32(6):1203-10.
95. Agyemang C, Bruijnzeels MA, Owusu-Dabo E. Factors associated with hypertension awareness, treatment, and control in Ghana, West Africa. J Hum Hypertens. 2006;20.
96. Stevenson CR, Critchley JA, Forouhi NG, Roglic G, Williams BG, Dye C, et al. Diabetes and the risk of tuberculosis: a neglected threat to public health? Chronic illness. 2007;3(3):228-45.
97. Tagoe HA. HOUSEHOLD BURDEN OF CHRONIC DISEASES IN GHANA. GHANA MEDICAL JOURNAL. 2012;46, Number 2 Supplement.
98. de-Graft Aikins A, Boynton P, Atanga LL. Developing Effective Chronic Disease Prevention in Africa: insights from Ghana and Cameroon. Glob Heal. 2010;6.
99. Gatimu SM, Milimo BW, Sebastian MS. Prevalence and determinants of diabetes among older adults in Ghana. BMC Public Health. 2016;16(1):1174.
100. World health Organization. Country and Regional Data on Diabetes: WHO African Region: Diabetes in the WHO African Region: WHO; 2019 [Available from: https://www.who.int/diabetes/facts/world_figures/en/index1.html.
101. O'Brien KS, Soliman AS, Awuah B, Jiggae E, Osei-Bonsu E, Quayson S, et al. Establishing effective registration systems in resource-limited settings: cancer registration in kumasi, Ghana. J Regist Manag. 2013;40.
102. Yeboah E, Hsing A, Mante S, Mensah J, Kyei M, Yarney J, et al. MANAGEMENT OF PROSTATE CANCER IN ACCRA, GHANA. Journal of the West African College of Surgeons. 2016;6(4):31-65.
103. Wiredu EK, Armah HB. Cancer mortality patterns in Ghana: a 10-year review of autopsies and hospital mortality. BMC Public Health. 2006;6:159.
104. Nartey Y, Hill PC, Amo-Antwi K, Nyarko KM, Yarney J, Cox B. Cervical cancer in the Greater Accra and Ashanti regions of Ghana. Journal of global oncology. 2016;3(6):782-90.
105. Naku Ghartey Jnr F, Anyanful A, Eliason S, Mohammed Adamu S, Debrah S. Pattern of Breast Cancer Distribution in Ghana: A Survey to Enhance Early Detection, Diagnosis, and Treatment. International journal of breast cancer. 2016;2016:3645308.
106. WORLD HEALTH STATISTICS. COUNTRY SUCCESS STORIES. WORLD HEALTH ORGANIZATION 2017;PART 3.

107. Ministry of Health Ghana. National Policy for the Prevention and Control of Chronic Non-Communicable Diseases in Ghana 2012. Available from: http://www.pascar.org/uploads/files/Ghana_-_National_Policy-_Prevention_and_control_of_chronic_non-communicable_diseases.pdf.
108. Ministry of Health Ghana. Strategy for the Management, Prevention and Control of Chronic Non-Communicable Diseases in Ghana 2012-2016 2012. Available from: http://www.nationalplanningcycles.org/sites/default/files/country_docs/Ghana/ghana.pdf.
109. Hanna TP, Kangolle AC. Cancer control in developing countries: using health data and health services research to measure and improve access, quality and efficiency. BMC Int Heal Hum Rights. 2010;10.
110. Tenkorang EY, Kuuire VZ. Noncommunicable Diseases in Ghana: Does the Theory of Social Gradient in Health Hold? Health education & behavior : the official publication of the Society for Public Health Education. 2016;43(1 Suppl):25S-36S.
111. Poudel KK, Huang Z, Neupane PR, Steel R. Prediction of the Cancer Incidence in Nepal. Asian Pacific journal of cancer prevention : APJCP. 2017;18(1):165-8.
112. Ghana Health Service. 2011 Annual Final Report 2012. Available from: http://www.ghanahealthservice.org/ghs-category.php?cid=5.
113. Bosu WK. A comprehensive review of the policy and programmatic response to chronic non-communicable disease in Ghana. Ghana Med J. 2012;46.
114. Amoah AS, Forson AG, Boakye DA. A review of epidemiological studies of asthma in Ghana. Ghana medical journal. 2012;46(2):23-8.
115. Addo-Yobo EO, Custovic A, Taggart SC, Craven M, Bonnie B, Woodcock A. Risk factors for asthma in urban Ghana. Journal of allergy and clinical immunology. 2002;108(3):363-8.
116. Yawson AE, Abuosi AA, Badasu DM, Atobra D, Adzei FA, Anarfi JK. Non-communicable diseases among children in Ghana: health and social concerns of parent/caregivers. African health sciences. 2016;16(2):378-88.
117. World Health Organization. Sickle Cell Disease: Overview 2019 [Available from: https://www.afro.who.int/health-topics/sickle-cell-disease.
118. Engmann C, Adanu R, Lu T-S, Bose C, Lozoff B. Anemia and iron deficiency in pregnant Ghanaian women from urban areas. International Journal of Gynecology & Obstetrics. 2008;101(1):62-6.

8. Appendix

Appendix A1. Search terms and regular expressions

1. **CVDs search terms:** Hypertension, Heart, Cardiovascular, I00-I99, and P29.

Regex command:

gen cvd = "cvds" if regexm(p_diag, "[hH]ypertension|[hH]eart|[cC]ardiovascular|I[0 − 9][0 − 9]|(P29\. [0 − 4])|(P29\. [8 − 9])")

Cross-tabulation table : ta p_diag cvd

2. **Diabetes search terms:** Diabetes, Diabetic, N08.3, and G99.0.

Regex command:

gen diabetes = "diabetes" if regexm(p_diag, "[dD]iabetes|[dD]iabetic|(E0[8 − 9][0 − 9])|(E1[0 − 4])|N08.3|G99.0")

Cross-tabulation table : ta p_diag diabetes

3. **Cancer search terms:** Neoplasms, Benign, Cancer, Ulcer, Tumor, Kidney, ICD10 code C00-C97, D00-D09, D10-D36, and D37-D48.

Regex command:

gen Cancer
= "Cancer" if regexm(p_diag, "[nN]eoplasm|[bB]enign|[cC]ancer|[uU]lcer|[tT]umor|C[0 − 9][0 − 9]|(D[0 − 3][0 − 9]|D4[0 − 8])")

Cross-tabulation table : ta p_diag Cancer

4. **CRDs search terms:** Asthma, Respiratory, Bronchitis, J40-J47, and P22-P28.

Regex command:

gen crd = "crds" if regexm(p_diag, "[aA]sthma|[rR]espiratory|[bB]ronchitis|J4[0 − 7]|J([0 − 3]|[6 − 9])[0 − 9]|P22\. [0 − 1]|P22\. [8 − 9] |(P23\. [0 − 6])|(P23\. [8 − 9])|(P24\. [0 − 3])|(P24\. [8 − 9])|(P25\. [0 − 3])|(P25\.8)|(P26\. [0 − 1])|(P26\. [8 − 9])|P2[2 − 8]")

Cross-tabulation table: ta p_diag card

5. **SCD search terms:** Sickle, D57, and Z13.

Regex command: $\text{gen scd} = \text{"scd" if regexm(p\_diag, "[sS]ickle|(D5[7][0-8])|Z13")}$

Cross-tabulation table: ta p_diag scd

Appendix A2. Poisson Regression Model

$$noi\ glm\ can\ year\ i.sexxx\ ib6.agegrp\ ib5.region\ c.sexxx\#\#agegrp,///$$

$$offset(lngsspop)\ link(log)\ family(poisson)\ vce(robust)$$

Appendix A3. Study timelines

All Preparatory, Academic, and Research activities are expected to take three years as shown in Figure 2 below.

Activity / year / month	Year 1: 2017/2018						Year 2: 2018/2019						Year 3: 2019/2020					
	10-11	12-01	02-03	04-05	06-07	08-09	10-11	12-01	02-03	04-05	06-07	08-09	10-11	12-01	02-03	04-05	06-07	08-09
Academic Work (course auditing)																		
Literature Review (essential reading)																		
Normal reading																		
Research Proposal updates																		
Ethical clearance		Dec.	Jan.															
Data Collection: secondary data extraction & initial cleaning from the District Health Information Management System 2 (DHIMS II) Database at the GHS head office in Accra-Ghana																		
Data cleaning and coding																		
Seminar presentations	Nov.																	
Data analysis																		
Thesis writing																		
Thesis submission																		
Manuscripts Writing																		
Viva and graduation																		
Return to Ghana																		

Figure 21: Study timelines

Appendix A4. Budget

The PhD is a scholarship provided by the German Academic Exchange Service (DAAD) and the Government of Ghana for a study period of 3 years external into the fourth year.

Funding for this project is provided by the DAAD (international travel cost) and the researchers with support from the Institute for Medical Biostatistics, Epidemiology, and Informatics, University Medical Center of Johannes Gutenberg University Mainz, Germany.

The study estimated the overall amount of EUR€2,520 as shown in Table 2 with the breakdown was used in the study.

Table 10: Study budget

No.	Item	Description	Quantity	Amount (EUR€)	Total Amount (EUR€)
1	International travel	Travel from Mainz, Germany to Ghana and back	1	770	770
2	Domestic travel	in-Country travels	1	200.00	200
3	Ethics and regulatory review charges	GHS Ethical Administrative fees	1	100	100
4	Durable equipment	2TB External hard drives	2	100	200
5	Consumables	1. Printing and photocopies of Proposals, letters, etc., binding of documents 2. Communication (telephone and internet charges)	1	200	200
6	Honorarium for data extraction team	Refreshment during data extraction period	3	300	900
7	Contingency	Any other unplanned expenditures that may arise	1	150	150
	Total				**2520**

Appendix A5. The yearly number and 95% confidence interval (95% CI) of empirical and predicted CVD, diabetes, cancer, CRD, and SCD cases from Poisson regression model by sex

Table 11: Yearly number and 95% confidence interval (95% CI) of empirical and predicted cardiovascular cases from Poisson regression model by sex

	Empirical n(95% CI)		Predicted n(95% CI)	
Year	**Male**	**Female**	**Male**	**Female**
2012	4530 (4399,4664)	7449 (7281,7620)	5998 (5847,6152)	10018 (9823,10216)
2013	6562 (6404,6723)	12881 (12660,13105)	6905 (6743,7070)	11817 (11605,12032)
2014	9456 (9266,9649)	16293 (16044,16545)	8461 (8282,8643)	13801 (13572,14033)
2015	10621 (10420,10825)	16973 (16719,17230)	9732 (9540,9927)	16986 (16732,17243)
2016	13570 (13343,13800)	22715 (22421,23012)	11443 (11234,11655)	19761 (19486,20039)
2017	11389 (11181,11600)	19205 (18934,19479)	13591 (13364,13821)	23134 (22837,23434)
2018			17922 (17661,18186)	29877 (29539,30218)
2019			21235 (20950,21523)	35304 (34937,35674)
2020			25184 (24874,25497)	41759 (41359,42162)
2021			29681 (29344,30021)	49152 (48718,49589)
2022			34971 (34605,35340)	57839 (57369,58312)
2023			41192 (40795,41592)	68044 (67534,68557)
2024			48494 (48063,48928)	80014 (79461,80570)
2025			57091 (56624,57561)	94094 (93494,94697)
2026			67180 (66673,67690)	110601 (109950,111255)
2027			79028 (78478,79581)	129969 (129263,130678)
2028			92936 (92339,93536)	152685 (151920,153453)
2029			109255 (108608,109905)	179315 (178486,180147)
2030			128393 (127692,129097)	210523 (209625,211424)
2031			150836 (150076,151599)	247094 (246121,248070)
2032			177155 (176331,177982)	289944 (288890,291001)

Table 12: Yearly number and 95% confidence interval (95% CI) of empirical and predicted diabetes cases from Poisson regression model by sex

	Empirical n(95% CI)		Predicted n(95% CI)	
Year	Male	Female	Year	Male
2012	1319 (1249,1392)	1847 (1764,1933)	1600 (1523,1680)	2625 (2526,2727)
2013	1982 (1896,2071)	3252 (3141,3366)	1841 (1758,1927)	3106 (2998,3217)
2014	2612 (2513,2714)	4393 (4264,4525)	2244 (2152,2339)	3581 (3465,3700)
2015	2769 (2667,2874)	4410 (4281,4542)	2601 (2502,2703)	4574 (4442,4709)
2016	3257 (3146,3371)	5657 (5511,5806)	3076 (2968,3187)	5246 (5105,5390)
2017	3045 (2938,3155)	5661 (5514,5810)	3623 (3506,3743)	6089 (5937,6244)
2018			4942 (4805,5082)	8129 (7953,8308)
2019			5859 (5710,6011)	9628 (9437,9822)
2020			6951 (6789,7116)	11412 (11204,11623)
2021			8183 (8007,8362)	13416 (13190,13645)
2022			9630 (9439,9824)	15769 (15524,16017)
2023			11330 (11122,11541)	18529 (18263,18798)
2024			13324 (13099,13552)	21765 (21477,22056)
2025			15666 (15422,15913)	25563 (25251,25878)
2026			18412 (18147,18680)	30012 (29673,30354)
2027			21634 (21347,21924)	35226 (34859,35596)
2028			25411 (25100,25725)	41334 (40937,41734)
2029			29838 (29500,30179)	48486 (48055,48920)
2030			35024 (34658,35393)	56857 (56391,57326)
2031			41097 (40701,41496)	66656 (66151,67164)
2032			48211 (47782,48643)	78123 (77576,78673)

Table 13: Yearly number and 95% confidence interval (95% CI) of empirical and predicted cancer cases from a Poisson regression model by sex

	Empirical n(95% CI)		Predicted n(95% CI)	
Year	**Male**	**Female**	**Male**	**Female**
2012	442 (402,485)	557 (512,605)	1344 (1273,1418)	3986 (3863,4112)
2013	791 (737,848)	1088 (1024,1155)	1314 (1244,1387)	4146 (4021,4274)
2014	1158 (1092,1227)	3083 (2975,3194)	1402 (1330,1477)	4421 (4292,4553)
2015	1375 (1303,1450)	4854 (4718,4993)	1425 (1352,1501)	4588 (4456,4723)
2016	1566 (1489,1646)	6154 (6001,6310)	1466 (1392,1543)	4741 (4607,4878)
2017	1095 (1031,1162)	4671 (4538,4807)	1500 (1425,1578)	4761 (4627,4898)
2018			1659 (1580,1741)	5255 (5114,5399)
2019			1703 (1623,1786)	5398 (5255,5544)
2020			1749 (1668,1833)	5543 (5398,5691)
2021			1788 (1706,1873)	5661 (5515,5810)
2022			1828 (1745,1914)	5781 (5633,5932)
2023			1869 (1785,1956)	5901 (5751,6054)
2024			1909 (1824,1997)	6021 (5870,6175)
2025			1950 (1864,2039)	6145 (5992,6301)
2026			1991 (1905,2080)	6267 (6113,6424)
2027			2033 (1946,2123)	6391 (6235,6550)
2028			2074 (1986,2165)	6515 (6358,6675)
2029			2116 (2027,2208)	6639 (6480,6801)
2030			2158 (2068,2251)	6764 (6604,6927)
2031			2200 (2109,2294)	6889 (6727,7054)
2032			2242 (2150,2337)	7014 (6851,7180)

Table 14: Yearly number and 95% confidence interval (95% CI) of empirical and predicted chronic respiratory disease cases from a Poisson regression model by sex

	Empirical n(95% CI)		Predicted n(95% CI)	
Year	Male	Female	Male	Female
2012	1103 (1039,1170)	1441 (1368,1517)	1279 (1210,1351)	1688 (1608,1771)
2013	1327 (1257,1400)	1952 (1866,2041)	1399 (1327,1474)	1985 (1899,2074)
2014	1743 (1662,1827)	2392 (2297,2490)	1637 (1559,1718)	2206 (2115,2300)
2015	1996 (1909,2086)	2686 (2585,2790)	1799 (1717,1884)	2484 (2387,2584)
2016	2528 (2430,2629)	3158 (3049,3270)	2085 (1997,2177)	2736 (2634,2841)
2017	1856 (1773,1942)	2541 (2443,2642)	2354 (2260,2451)	3070 (2962,3181)
2018			2736 (2634,2841)	3664 (3546,3785)
2019			3078 (2970,3189)	4117 (3992,4245)
2020			3463 (3349,3580)	4626 (4494,4761)
2021			3896 (3775,4020)	5199 (5059,5342)
2022			4383 (4254,4515)	5841 (5692,5993)
2023			4929 (4792,5069)	6561 (6403,6722)
2024			5539 (5394,5687)	7364 (7197,7534)
2025			6227 (6073,6384)	8270 (8093,8450)
2026			6996 (6833,7162)	9280 (9092,9471)
2027			7857 (7684,8033)	10412 (10213,10614)
2028			8822 (8639,9008)	11678 (11467,11892)
2029			9902 (9708,10099)	13094 (12871,13320)
2030			11110 (10904,11319)	14677 (14441,14916)
2031			12461 (12243,12682)	16447 (16197,16700)
2032			13973 (13742,14207)	18426 (18161,18694)

Table 15: Yearly number and 95% confidence interval (95% CI) of empirical and predicted of SCD cases from Poisson regression model by sex

	Empirical n(95% CI)		Predicted n(95% CI)	
Year	Male	Female	Male	Female
2012	808 (753,866)	856 (800,915)	1175 (1109,1244)	1207 (1140,1277)
2013	1373 (1301,1448)	1449 (1375,1526)	1314 (1244,1387)	1559 (1483,1638)
2014	2068 (1980,2159)	2096 (2007,2188)	1637 (1559,1718)	1783 (1701,1868)
2015	2024 (1937,2114)	2232 (2140,2327)	1808 (1726,1893)	2026 (1939,2116)
2016	2599 (2500,2701)	2728 (2627,2832)	2384 (2289,2482)	2222 (2131,2316)
2017	2121 (2032,2213)	2330 (2236,2427)	2675 (2575,2778)	2893 (2789,3000)
2018			3510 (3395,3628)	3677 (3559,3798)
2019			4134 (4009,4262)	4325 (4197,4456)
2020			4867 (4731,5006)	5086 (4947,5228)
2021			5743 (5595,5894)	5993 (5842,6147)
2022			6774 (6614,6937)	7061 (6897,7228)
2023			7988 (7814,8165)	8316 (8138,8497)
2024			9416 (9227,9608)	9790 (9597,9986)
2025			11097 (10892,11305)	11526 (11317,11738)
2026			13073 (12850,13299)	13563 (13336,13793)
2027			15396 (15154,15641)	15956 (15709,16206)
2028			18126 (17863,18392)	18766 (18499,19036)
2029			21333 (21048,21621)	22064 (21774,22357)
2030			25099 (24789,25412)	25934 (25619,26252)
2031			29520 (29184,29859)	30474 (30133,30818)
2032			34710 (34346,35077)	35799 (35429,36172)

Appendix A6. Figure 22 – 26 shows the empirical (2012 – 2016) and predicted values (2017 – 2032) for each of the 5 NCDs by region and sex from the Poisson regression model.

Figure 22 shows the empirical (2012 – 2016) and predicted values (2017 – 2032) for cardiovascular disease by region and sex from the Poisson regression model.

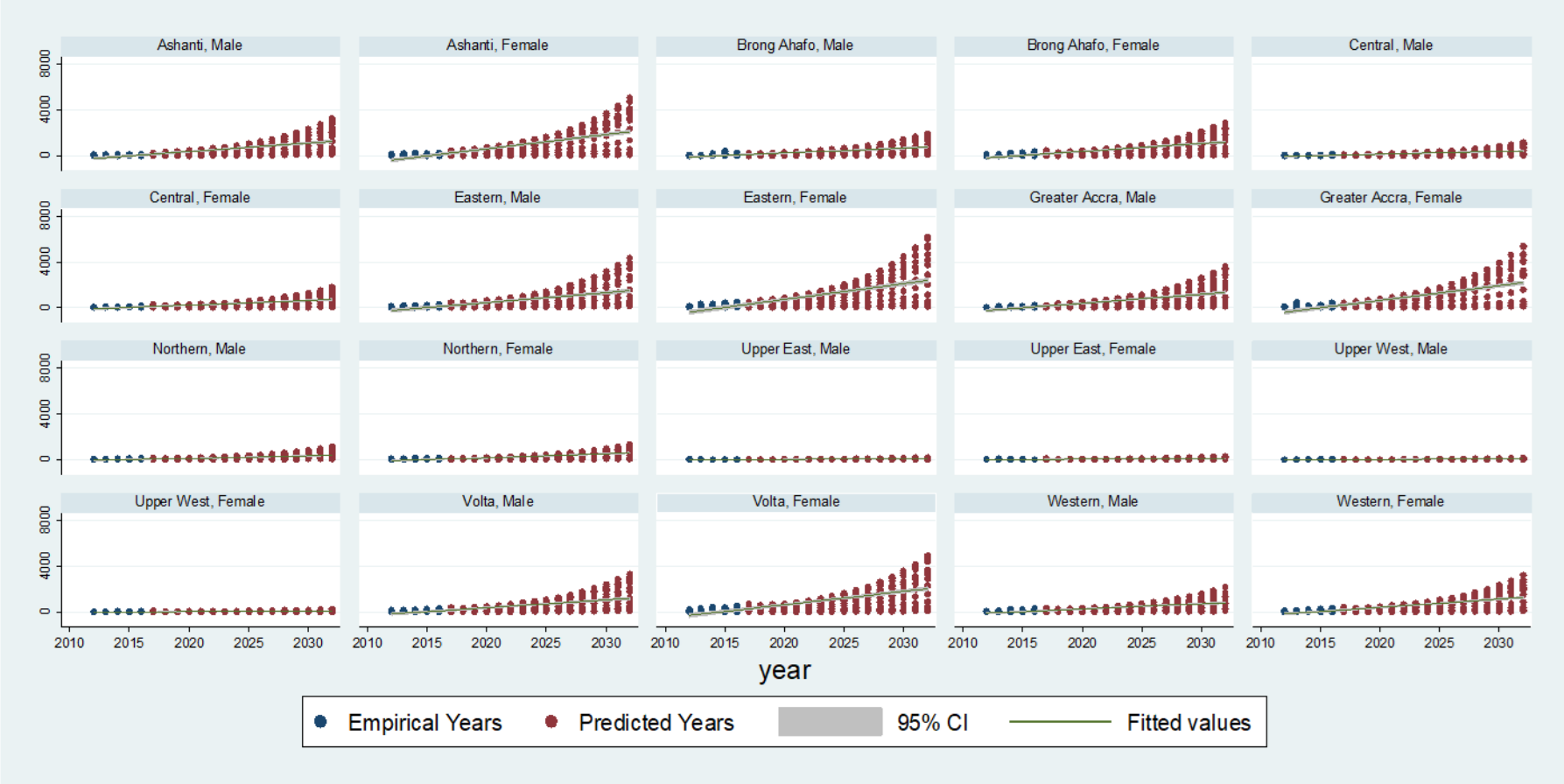


Figure 22: Poisson regression empirical and prediction plot for CVDS by region and sex with dots indicating age groups

Figure 23 shows the empirical (2012 – 2016) and predicted values (2017 – 2032) for diabetes by region and sex from the Poisson regression model.

Figure 23: Poisson regression empirical and prediction plot for diabetes by region and sex with dots indicating age groups

Figure 24 shows the Empirical (2012 – 2016) and predicted values (2017 – 2032) for cancer by region and sex from the Poisson regression model.

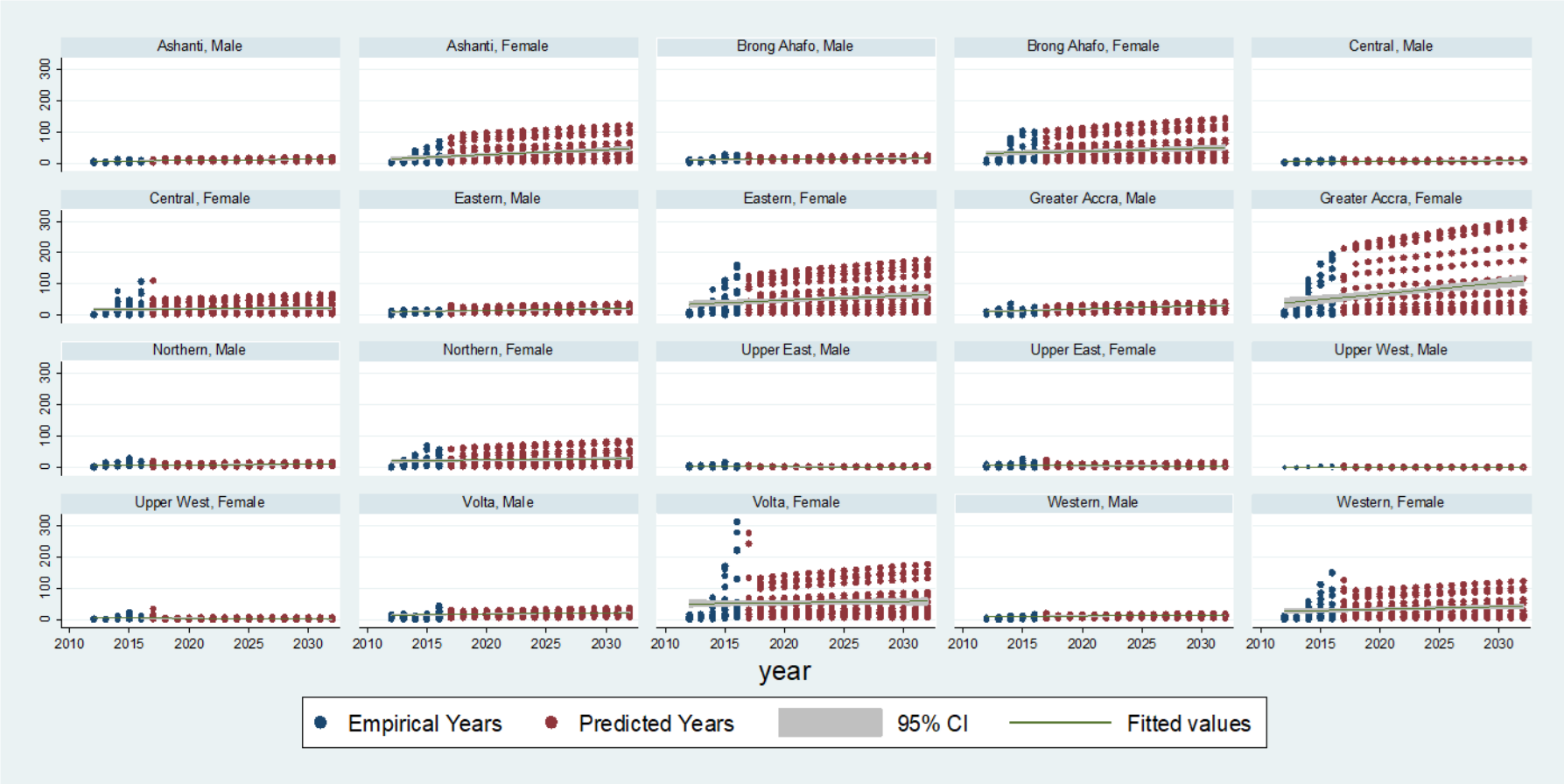


Figure 24: Poisson regression empirical and prediction plot for cancer by region and sex with dots indicating age groups

Figure 25 shows the Empirical (2012 – 2016) and predicted values (2017 – 2032) for chronic respiratory disease by region and sex from the Poisson regression model.

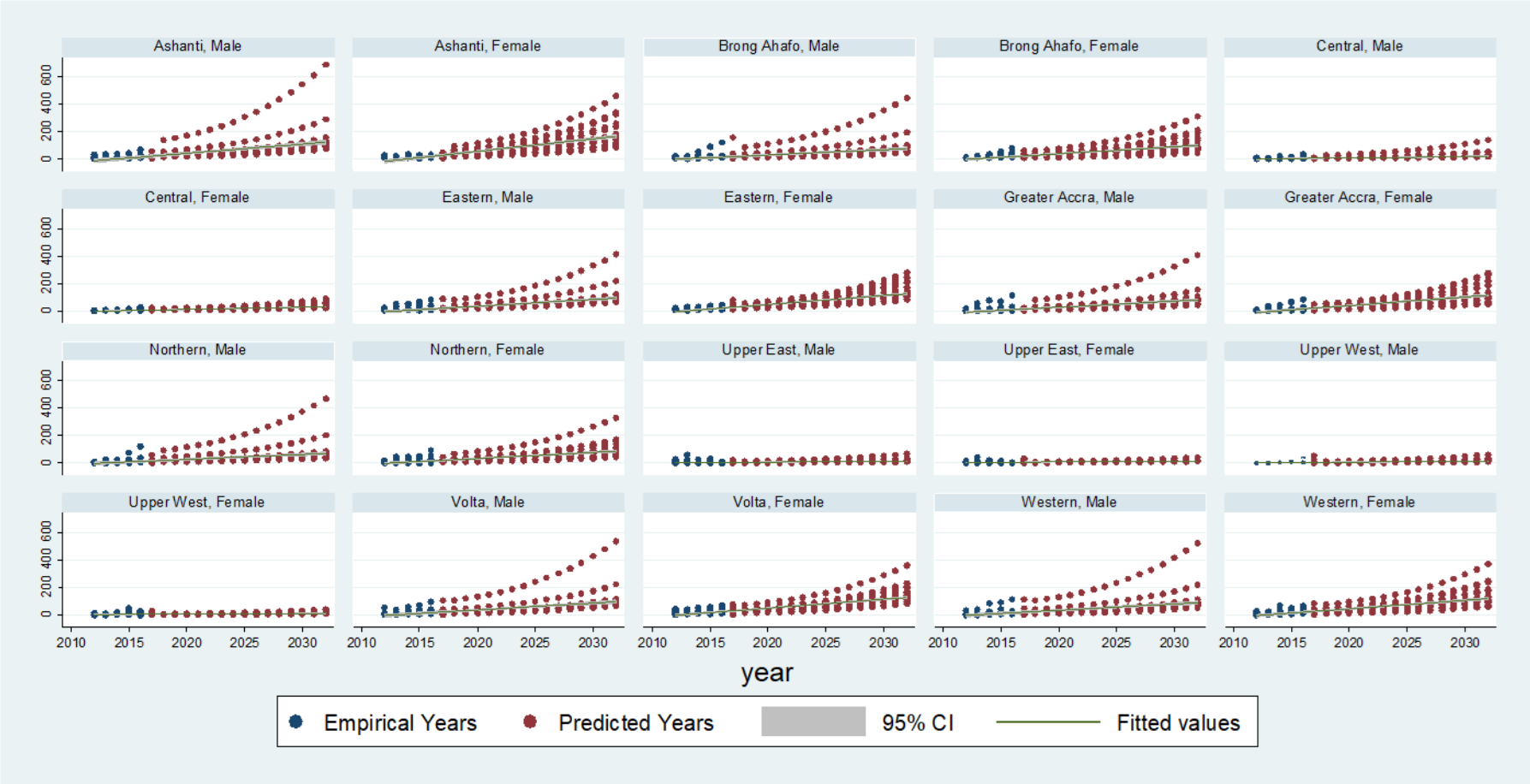


Figure 25: Poisson regression empirical and prediction plot for CRDS by region and sex with dots indicating age groups

Figure 26 shows the empirical (2012 – 2016) and predicted values (2017 – 2032) for SCD by region and sex from the Poisson regression model.

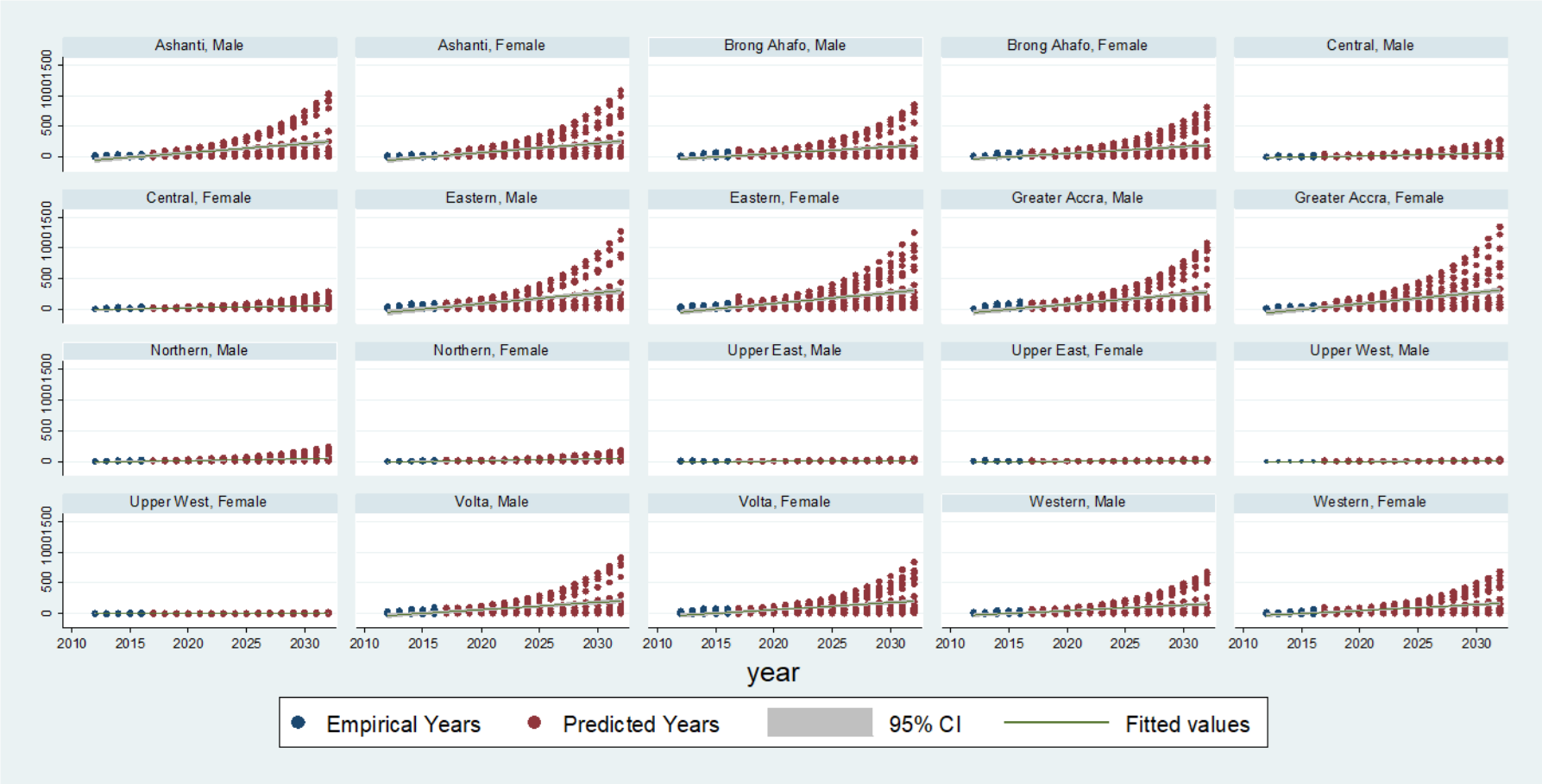


Figure 26: Poisson regression empirical and prediction plot for SCD by region and sex with dots indicating age groups

Appendix A5. Figures 25 to 29 show the disease-specific Poisson coefficient plot of rate ratios for CVDs, diabetes, cancer, CRDs and SCD with the 95% CI band.

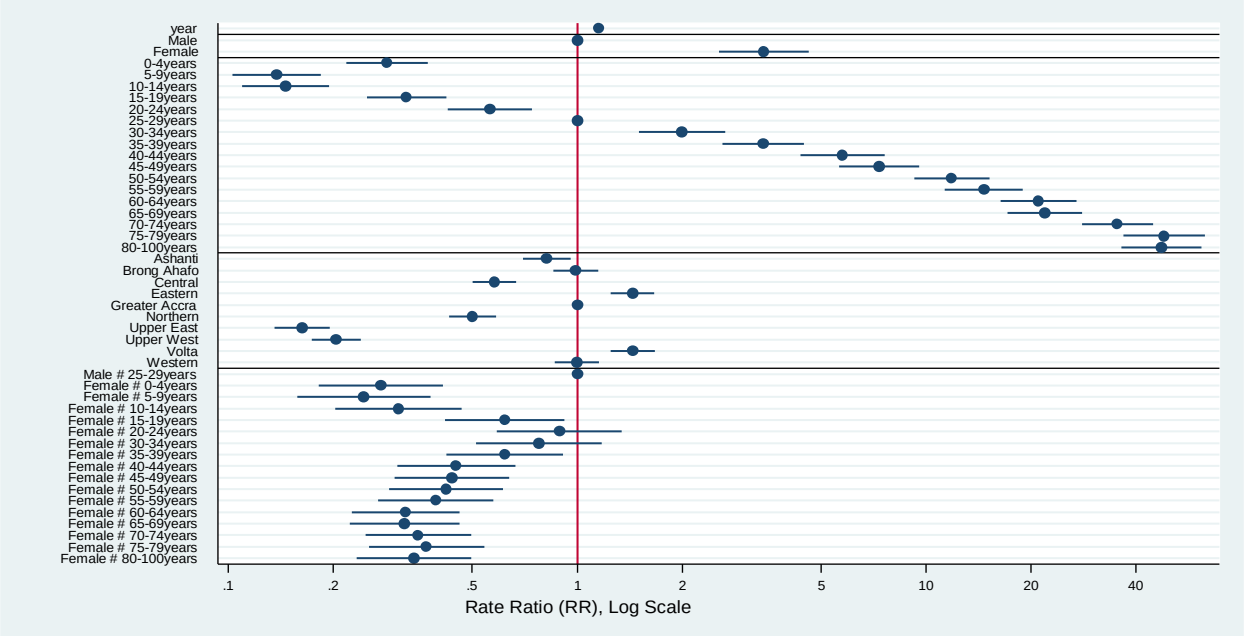


Figure 27: Coefficient and 95% CI plot from the Poisson regression model for CVDs patients hospitalized

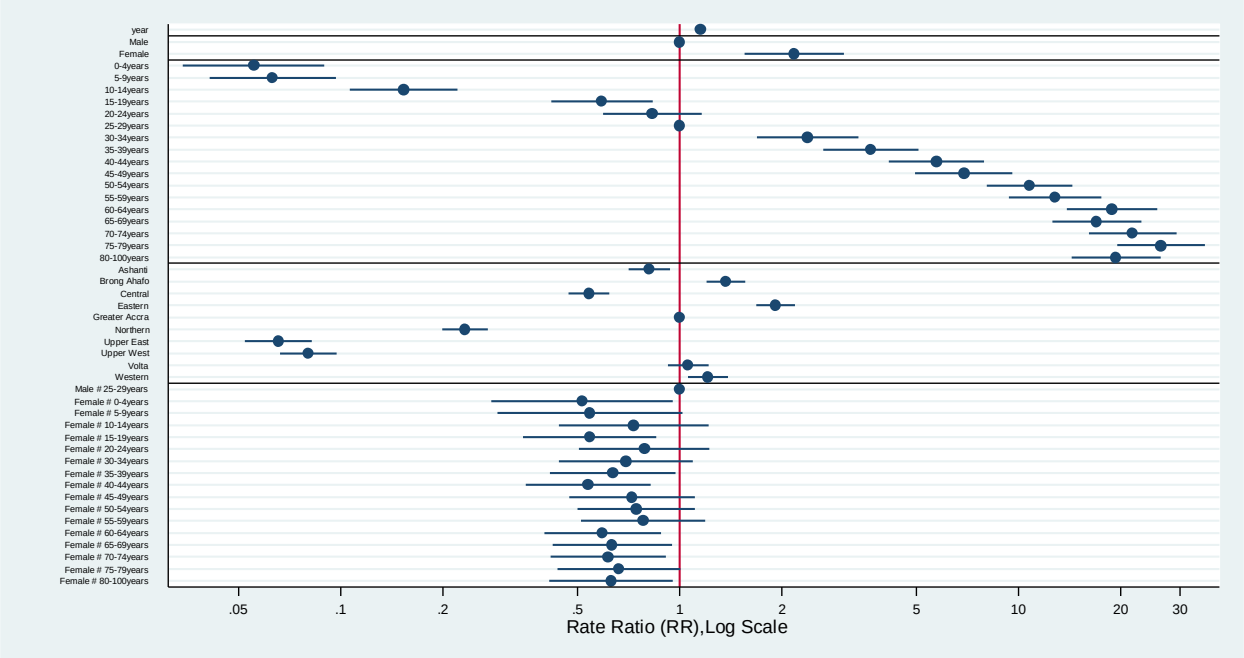


Figure 28: Coefficient and 95% CI plot from the Poisson regression model for diabetes patients hospitalized

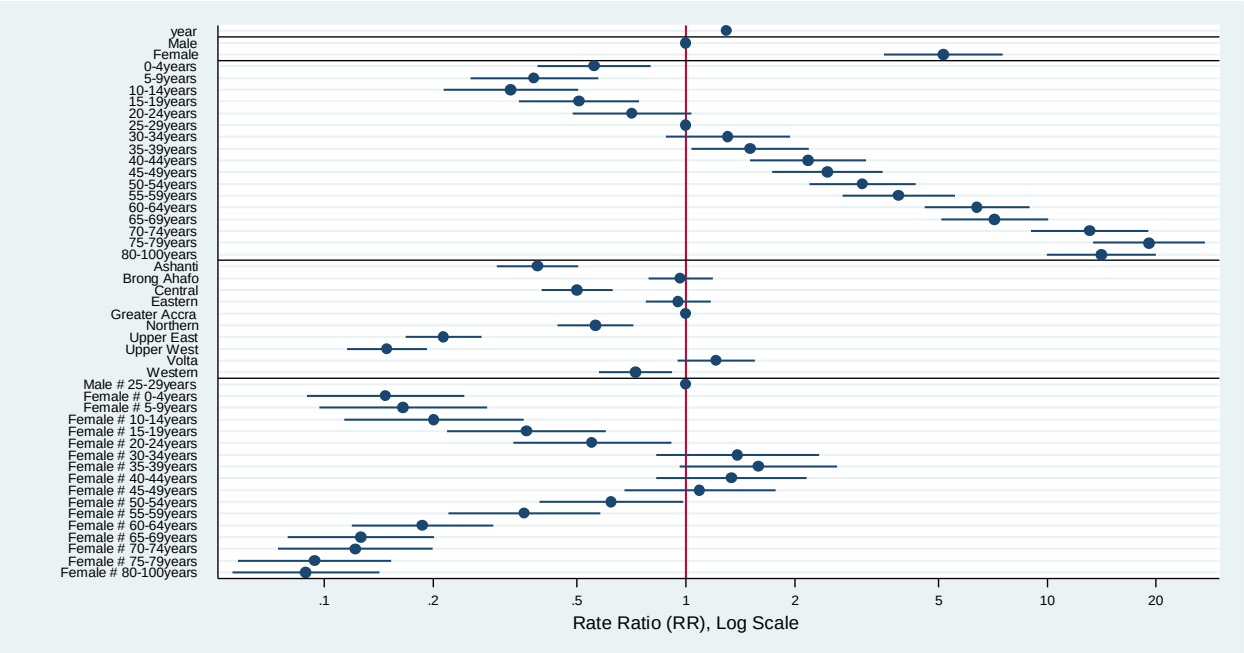


Figure 29: Coefficient and 95% CI plot from the Poisson regression model for cancer patients hospitalized

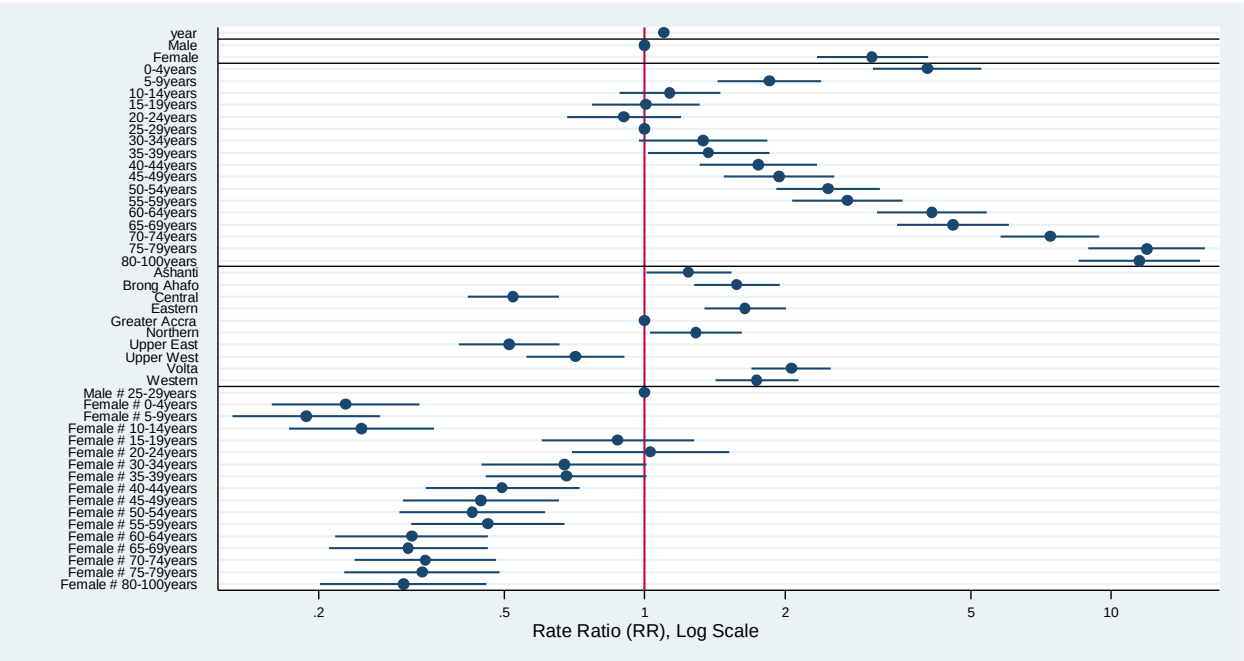


Figure 30: Coefficient and 95% CI plot from the Poisson regression model for chronic respiratory disease patients hospitalized

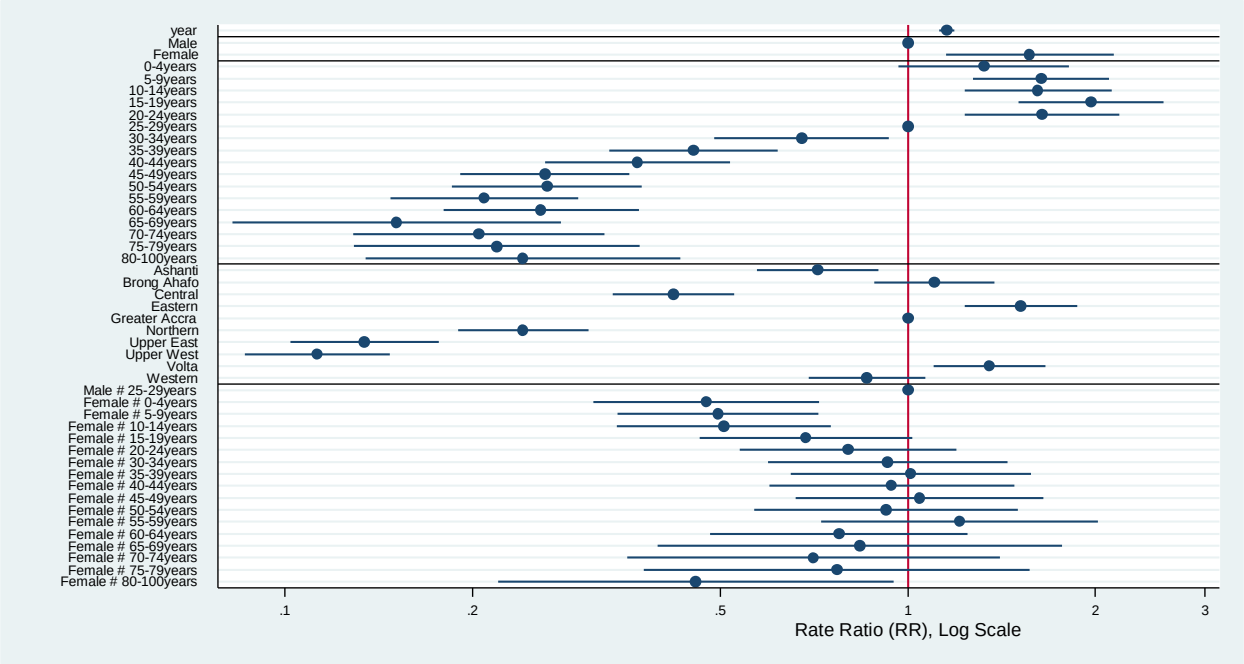


Figure 31: Coefficient and 95% CI plot from the Poisson regression model for SCD patients hospitalized

Acknowledgement

Tabular Curriculum Vitae

Curriculum Vitae

Personal information	
Name	Clement Tetteh Narh
Education	
2017-date	**PhD Candidate** (Biostatistics), Institute of Medical Biostatistics, Epidemiology and Informatics (IMBEI), University Medical Center, Johannes Gutenberg University Mainz Thesis title: “Modelling the Burden of Noncommunicable Diseases among Hospitalized Patients in Ghana” Planned submission: 20.12.2019
2011-2012	**Master of Science** (Clinical Trials), School of Public Health, University of Ghana-Legon, Accra
2008-2010	**Bachelor of Science** (Statistics), School of Physical Sciences, University of Cape Coast, Cape Coast.
2003-2006	**Higher National Diploma** (Statistics), Department of Mathematics and Statistics, Accra Polytechnic, Accra.
1999-2001	**Secondary School Certificate,** Osudoku Secondary Technical School, Asutsuare
Awards	
2017-2020	German Academic Exchange Service (DAAD) Scholar
2019	Larry J. Anderson Award for Outstanding Public Health Science
2019	2019 Charles C. Shepard Science Award Nominee
Work experience	
2018-date	**Statistical Consulting:** Dept. of Biostatistics, IMBEI, University Medical Center, JGU
2014-date	**Assistant Research Fellow:** Dept. of Epidemiology and Biostatistics, School of Public Health, University of Health and Allied Sciences, Hohoe, Volta Region
2013-date	**Data Manager/Statistician:** WHO Rotavirus Regional Reference Laboratory (RRL), Noguchi Memorial Institute for Medical Research (NMIMR), University of Ghana, Legon.

2015-date	**Statistical Consulting:** INESS Project, INDEPTH NETWORK, Accra, Ghana
2015-2017	**Statistical Consulting:** Volta Regional Health Directorate, Ho, Ghana
2015-2017	**Clinical Monitor:** The Use of a Multiple Micronutrient Supplement in Women of Reproductive Age, Komfo Anokye Teaching Hospital, Kumasi, Ghana
2014-2016	**Clinical Research Coordinator:** University of Health and Allied Sciences Research Center, Hohoe, School of Public Health, Hohoe, Volta Region
2015	**WHO Temporary Advisor:** WHO ROTAVIRUS REGIONAL REFERENCE LABORATORY South African MRC / Diarrhoeal Pathogens Research Unit Sefako Makgatho Health Sciences University PRETORIA, Republic of South Africa
2010-2014	**Senior Data Manager (quantitative and qualitative):** Dodowa Health Research Centre (DHRC), Dodowa, Ghana

Peer-reviewed publications

1. Adjei KK, Kikuchi K, Owusu-Agyei S, Enuameh Y, Shibanuma A, Ansah EK, Yasuoka J, Poku-Asante K, Okawa S, Gyapong M, Tawiah C. Women's overall satisfaction with health facility delivery services in Ghana: a mixed-methods study. Tropical medicine and health. 2019 Dec 1;47(1):41.
2. Lartey BL, Damanka S, Dennis FE, Enweronu-Laryea CC, Addo-Yobo E, Ansong D, Kwarteng-Owusu S, Sagoe KW, Mwenda JM, Diamenu SK, **Narh C.** Rotavirus strain distribution in Ghana pre-and post-rotavirus vaccine introduction. Vaccine. 2018 Nov 12;36(47):7238-42.
3. Nonvignon J, Atherly D, Pecenka C, Aikins M, Gazley L, Groman D, **Narh CT**, Armah G. Cost-effectiveness of rotavirus vaccination in Ghana: Examining impacts from 2012 to 2031. Vaccine. 2018 Nov 12;36(47):7215-21.
4. Shibanuma A, Yeji F, Okawa S, Mahama E, Kikuchi K, **Narh C,** Enuameh Y, Nanishi K, Oduro A, Owusu-Agyei S, Gyapong M. The coverage of continuum of care in maternal, newborn and child health: a cross-sectional study of woman-child pairs in Ghana. BMJ global health. 2018 Sep 1;3(4):e000786.
5. Tate JE, Mwenda JM, Armah G, Jani B, Omore R, Ademe A, Mujuru H, Mpabalwani E, Ngwira B, Cortese MM, Mihigo R. Evaluation of intussusception after monovalent rotavirus vaccination in Africa. New England Journal of Medicine. 2018 Apr 19;378(16):1521-8.
6. Tate JE, Mwenda JM, Armah G. African Intussusception Surveillance Network. Evaluation of intussusception after monovalent rotavirus vaccination in Africa. N Engl J Med. 2018;378(16):1521-8.
7. Agbozo F, Abubakari A, **Narh C,** Jahn A. Accuracy of glycosuria, random blood glucose and risk factors as selective screening tools for gestational diabetes mellitus in comparison with universal diagnosing. BMJ Open Diabetes Research and Care. 2018 Jun 1;6(1):e000493.

8. Escribano-Ferrer B, Gyapong M, Bruce J, Bana SA, **Narh CT,** Allotey NK, Glover R, Azantilow C, Bart-Plange C, Sagoe-Moses I, Webster J. Effectiveness of two community-based strategies on disease knowledge and health behaviour regarding malaria, diarrhoea and pneumonia in Ghana. BMC public health. 2017 Dec;17(1):948.

9. Kamiya Y, Akpalu B, Mahama E, Ayipah EK, Owusu-Agyei S, Hodgson A, Shibanuma A, Kikuchi K, Jimba M. The gender gap in relation to happiness and preferences in married couples after childbirth: evidence from a field experiment in rural Ghana. Journal of Health, Population and Nutrition. 2017 Dec;36(1):8.

10. Ferrer BE, Hansen KS, Gyapong M, Bruce J, Bana SA, **Narh CT,** Allotey NK, Glover R, Azantilow NC, Bart-Plange C, Sagoe-Moses I. Cost-effectiveness analysis of the national implementation of integrated community case management and community-based health planning and services in Ghana for the treatment of malaria, diarrhoea and pneumonia. Malaria journal. 2017 Dec;16(1):277.

11. Ferrer BE, Webster J, Bruce J, Narh-Bana SA, **Narh CT,** Allotey NK, Glover R, Bart-Plange C, Sagoe-Moses I, Malm K, Gyapong M. Integrated community case management and community-based health planning and services: a cross-sectional study on the effectiveness of the national implementation for the treatment of malaria, diarrhoea and pneumonia. Malaria journal. 2016 Dec;15(1):340.

12. Armah G, Pringle K, Enweronu-Laryea CC, Ansong D, Mwenda JM, Diamenu SK, **Narh C,** Lartey B, Binka F, Grytdal S, Patel M. Impact and effectiveness of monovalent rotavirus vaccine against severe rotavirus diarrhoea in Ghana. Clinical Infectious Diseases. 2016 Apr 7;62(suppl_2):S200-7.

13. Enuameh YA, Okawa S, Asante KP, Kikuchi K, Mahama E, Ansah E, Tawiah C, Adjei K, Shibanuma A, Nanishi K, Yeji F. Factors influencing health facility delivery in predominantly rural communities across the three ecological zones in Ghana: A cross-sectional study. PloS one. 2016 Mar 31;11(3):e0152235.

14. Yeji F, Shibanuma A, Oduro A, Debpuur C, Kikuchi K, Owusu-Agei S, Gyapong M, Okawa S, Ansah E, Asare GQ, Nanishi K. Continuum of care in a maternal, newborn and child health program in Ghana: Low completion rate and multiple obstacle factors. PloS one. 2015 Dec 9;10(12):e0142849.

15. Adjei KK, Laar AK, **Narh CT,** Abdulai MA, Newton S, Owusu-Agyei S, Adjei S. A comparative study on the availability of modern contraceptives in public and private health facilities in a peri-urban community in Ghana. Reproductive health. 2015 Dec;12(1):68.

16. Kikuchi K, Ansah EK, Okawa S, Enuameh Y, Yasuoka J, Nanishi K, Shibanuma A, Gyapong M, Owusu-Agyei S, Oduro AR, Asare GQ. Effective linkages of continuum of care for improving neonatal, perinatal, and maternal mortality: a systematic review and meta-analysis. PloS one. 2015 Sep 30;10(9):e0139288.

17. Okawa S, Ansah EK, Nanishi K, Enuameh Y, Shibanuma A, Kikuchi K, Yasuoka J, Gyapong M, Owusu-Agyei S, Oduro AR, Asare GQ. High incidence of neonatal danger signs and its implications for postnatal Care in Ghana: a cross-sectional study. PloS one. 2015 Jun 19;10(6):e0130712.

18. Streatfield PK, Khan WA, Bhuiya A, Hanifi SM, Alam N, Ouattara M, Sanou A, Sié A, Lankoandé B, Soura AB, Bonfoh B. Cause-specific childhood mortality in Africa and Asia: evidence from INDEPTH health and demographic surveillance system sites. Global health action. 2014 Dec 1;7(1):25363.

19. **Narh CT.** *Rotavirus Diarrhea Reinfection and its Outcome on Weight and Hospitalization-Duration Among Children in Ghana: A Randomized, Double-Blinded, Placebo-Controlled Trial* (Masters dissertation, University of Ghana).

20. Källander K, Kadobera D, Williams TN, Nielsen RT, Yevoo L, Mutebi A, Akpakli J, **Narh C,** Gyapong M, Amu A, Waiswa P. Social autopsy: INDEPTH Network experiences of utility, process, practices, and challenges in investigating causes and contributors to mortality. Population health metrics. 2011 Dec;9(1):44.

Conference abstracts

1. Der J, Grint D, **Narh CT,** Bonsu F, Grant AD. Finding the missing tuberculosis cases in Ghana: where are the gaps in the pathway to diagnosis? Presentation at 50th Union World Conference on Lung Health, 30th October-2nd November 2019, Hyderabad, India

2. Der J, Grint D, **Narh CT,** Bonsu F, Grant AD. Tuberculosis symptoms screening practices of healthcare workers in a district hospital in Ghana. Presentation at TBScience 2019 conference, 29-30th October 2019, Hyderabad, India

3. **Narh CT**, Der J, Ofosu A, Wollschlaeger D, Blettner M: Modelling the Burden of Cancer among Hospitalized Patients in Ghana. In: Proceedings of the 2nd UCT Mainz Science Day, September 18th-19th, 2019; Mainz, Germany. Abstract handbook

4. **Narh CT**, Ofosu A, Armah GE, Wollschlaeger D: Modelling the burden of gastroenteritis among hospitalized children under-five years of age in Ghana. In: Proceedings of the 12th African Rotavirus Symposium 2019, 30 July - 1 August 2019; Johannesburg, South Africa. Abstract handbook

5. Der J, Nyantakyi DO**, Narh CT**: Determinants of Tuberculosis Treatment Interruption in Ketu South District, Ghana-2016. Project: TB Treatment Interruption in Ketu South Municipality, Volta Region, Ghana. In: Proceedings of the 9th TEPHINET Global Scientific Conference August 7-11, 2018; Chiang Mai, Thailand. Available from: https://www.researchgate.net/publication/319234074_Determinants_of_Tuberculosis_Treatment_Interruption_in_Ketu_South_District_Ghana-2016

6. Agbozo F, Abubakari A, **Narh C,** Jahn A (2017). Are we missing pregnant women with gestational diabetes? Evidence from a diagnostic accuracy study comparing glycosuria, glycated haemoglobin, random and fasting glucose to oral glucose tolerance test. Tropical Medicine and International Health. Volume 22, Issue S1 pp 351-352. https://doi.org/10.1111/tmi.12984

Research experience

Current/ previous research areas	
2017-date	1. **PhD Candidate:** Modelling the Burden of Noncommunicable Diseases for hospitalized patients in Ghana.
2017	2. **Data Manager:** Cost-effectiveness of rotavirus vaccination in Ghana: Examining impacts from 2012 to 2031
2014-date	3. **Data Manager:** Intussusception following monovalent rotavirus vaccination in seven African countries

2014-2017	4. **Academic Supervisor:** Data Quality Assessment and Data Management of Malaria, Rotavirus of the District Health Information Management System (DHIMS) of the Ghana Health Service.
	5. **Local Safety Monitor:** Monitoring and Evaluation of clinical studies (M&E): The Use of a Multiple Micronutrient Supplement in Women of Reproductive Age, Komfo Anokye Teaching Hospital, Kumasi, Ghana.
2016	6. **Data Manager:** Impact and effectiveness of a monovalent rotavirus vaccine against severe rotavirus diarrhoea in Ghana
2015	**Clinical Research Coordinator (CRC):**
	7. A Phase 1 Study to Evaluate the Safety, Tolerability and Immunogenicity of Heterologous Prime-Boost Regimens Using MVA-BN®-Filo and Ad26.ZEBOV Administered in Different Sequences and Schedules in Healthy Adults
	8. 2. Safety and immunogenicity study of GSK Biologicals' investigational recombinant chimpanzee adenovirus Type 3-vectored Ebola Zaire vaccine (GSK3390107A) in adults in Africa
2014	9. **Data Manager:** Effectiveness of the monovalent Rotavirus Vaccine (RotarixTM) Against Severe Rotavirus Diarrhea in Ghana
2012-2014	10. **Data Manager:** Ghana EMBRACE Implementation Research Project
2012	11. **Data Manager:** Immunogenicity of the Human Rotavirus Vaccine (Rotarix™) at Varying Schedules and Ages in Rural Ghana
2012	12. **Data Manager:** Estimating the Economic Burden of Gastroenteritis in Ghanaian Children
2010-2011	13. **Data Manager and Interviewer:** Pilot Study to Assess the Feasibility of a Medicine in Pregnancy Registry in Ghana
2008-2011	14. **Data Manager:** Dodowa Health and Demographic Surveillance System (DHDSS)

Language proficiency

1. English: Fluent
2. German (level B1): Intermediate
3. Ghanaian languages (Twi, Ewe, Ga, Dangme, Fante, and Brono): Fluent

Referees