

Master Thesis

**The Evolution of Inequality in Mortality between
Diseases over Time. “A Case Study of Ghana”**

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Foreword

This thesis is in partial fulfillment for the completion of my master in Health Economics at Erasmus University Rotterdam. This enhanced my analytical, writing and reporting skills. It further broadened my scope in the health economics field and heightened my interest in this sector.

First of all, I would like to thank the almighty God for bringing me this far in this program. I would like to thank my supervisor, Raf Van Gestel for providing me with prompt feedback and supporting me throughout the writing process. Also, would like to thank my co-evaluator Arthur E. Attema for his feedback.

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Abstract

Introduction

Health Inequalities are a global issue which affect all countries both wealthy and less wealthy alike. Efforts to address disparities in health often poses a challenge as this is one of the most relevant issues faced in population health. Mortality which is one of the measurable aspects of health often differs across diseases as some are more difficult to treat. In Ghana, out of 246 diseases, 3 diseases namely malaria, LRI, and ischemic heart diseases accounted for 27% of total deaths in 2015. The aim of this study is to investigate inequality in mortality between diseases which can provide an insight into the likelihood of having access to treatment depending on disease severity.

Methods

Data was obtained from the Institute of Health Metrics and Evaluation's Global Health data exchange. Data was on Ghana for the years 1990, 2000 and 2015. This was to identify how the inequality has changed over time. It included information on 246 diseases in relation to their mortality and DALYs. Mortality and DALYs were used to rank disease severity. Diseases that accounted for less than 0.001% of total deaths were not used in the analysis. The Gini and Erreygers index and corresponding Lorenz and concentration curves were used to measure and display the level of inequality. The change in the Gini index over the years was decomposed with the Jenkins and Van Kerm decomposition to analyze whether it was due to progressivity or re-ranking.

Results

When disease severity is ranked by mortality, a decline is observed in inequality in mortality between diseases over the years. The decomposition of the change showed that major part is due to concentration of mortality towards relatively less severe diseases .i.e. increases in mortality were more substantial among less severe diseases. However, when diseases are ranked by DALYs, an increase was observed in the mortality between diseases over time. Splitting the samples, the direction of change differs by gender and age categories.

Conclusion

In sum, the choice of variable used to quantify disease severity produces different conclusions. Ranking disease severity by mortality, we may conclude that there is an increased likelihood of having access to treatment especially for severe diseases. On the contrary when DALYs are used, widening inequalities are observed. The implication is that diseases that have high disabling effect may have been neglected compared to those that have high mortality effect. Additionally, differences in mortality across diseases have become smaller.

Keywords: Ghana, inequality, mortality, diseases, DALYs

1 Introduction

In sub-Saharan countries, the strong presence of both rural and urban areas lead to a double burden of disease; i.e. a high disease burden for both communicable (CDs) and non-communicable diseases (NCDs) (Dalal et. al, 2011; Jamison et.al, 2006). In the year 2004, the 3 most severe diseases (Malaria, HIV/AIDS resulting in other diseases and Diarrheal diseases), all CDs accounted for 32% of all deaths in sub-Saharan Africa (GBD Compare Data Visualization, 2018). What we observe is that only these 3 diseases account for almost one-third of deaths. Next to CDs, also NCDs lead to sizeable burden of disease, .i.e. 4 out of the top 10 leading causes of Disability Adjusted Life Years (DALYs) were due to NCDs. Barrenho et. al (2017) found that in developing countries, drug innovation was concentrated in diseases with relatively low burden (severity) in the neonatal disorders , neglected tropical diseases and malaria subcategory. This means that for individuals afflicted with relatively less severe diseases in these subcategories, drugs may be available to cure them whereas for those afflicted with more severe diseases in these subcategories, the availability of curative medicines may be lacking or limited. If treatment options are readily available for less severe diseases they may have higher improvement in mortality leading to widening inequalities between diseases. Diseases that are more severe will have an even increasing share of mortality, as treatment options available may not be adequate. This will cause disparities between individuals. As those that experience these severe diseases or those who have increased risk of getting these diseases may have less chances of having access to novel treatments.

Health inequalities can be defined as differences in any measurable aspect of health in individuals or groups (Arcaya et. al, 2015). These inequalities are a global issue which affect all countries both wealthy and less wealthy alike. Efforts to address disparities in health often poses a challenge as this is one of the most relevant issues faced in population health. Over time, health systems have been established to reduce the disparities in health. Nonetheless, large health disparities are still existent with poor and developing countries such as those in sub-Saharan Africa often being plagued with these inequalities (Barreto, ML., 2017). Differences in mortality varies across diseases, as this is unavoidable. As mentioned early on, only 3 diseases account for one-thirds of all deaths in sub-Saharan Africa. This implies that if these diseases continually account for a significant proportion of deaths, then health disparities will widen. Since the survival probability of those afflicted with these diseases or have an increased risk of contracting these diseases may worsen.

Ghana is a developing country in sub-Saharan Africa which achieved the lower-middle income status in November 2010 (Atta Sakyi, 2011). In its latest Population and Housing Census conducted in 2010, it

estimated the crude death rate to be 6.6 deaths per 1000 for the total population. Additionally, the overall male mortality was found to be higher in the younger (about 41 deaths per 1000) and older ages (about 60 deaths per 1000). On the contrary, mortality for females is highest between the age range 15-39 (about 7 deaths per 1000) and declines till age 60 (about 8 deaths per 1000). A reasonable explanation for the high female mortality in this range was mainly due to pregnancy related deaths since this is the productive age (*Ghana Statistical Service, 2014*). The Global Burden of Disease (GBD) study divided causes of death into 3 groups, these are group 1 which constitutes CDs, maternal and neonatal diseases, group 2 which are NCDs, and group 3 which are injuries. As of 2015, mortality due to group 1 and group 2 causes accounted for 92.8% of total mortality in the country (*GBD Compare Data Visualization, 2018*).

In 2015, Malaria, Lower respiratory infections (LRI), and Ischemic heart disease which were the leading causes of mortality accounted for about 27% of all deaths from 246 diseases. In 1990 however, these 3 diseases accounted for about 22% of deaths (*GBD Compare Data Visualization, 2018*). Adams et. al (2004) found that malaria was the leading cause of in-hospital mortality with a proportional mortality rate of about 17%. In addition, the average number of productive days lost due to an episode on malaria was estimated to be 10.79 days (*Kirigia et. al, 2011*) indicating that not only does the severity of the disease have an impact on the individual but also on the economy. Hence, efforts should be made in improving the cure rates of these severe diseases as these have an impact on the economy as a whole.

The major role of diseases in increasing mortality has prompted the government and non-governmental organizations (NGOs) to set up several health improving measures. Measures such as the roll back malaria initiative was set up under the national malaria control to reduce the effect of malaria by a significant proportion (*Ghana Health Service, 2014*). This is to improve population health, as low mortality rate in a country is a positive health indicator. It could be expected that with the passing of time, the mortality and morbidity effect of some highly ranking disease may be minimized. On the contrary, a significant proportion of these diseases still remain in the ranks a decade later. The effect of some seasonal diseases such as cholera has been underestimated. Cholera, whose incidence rises during the rainy season has a large mortality and morbidity effect on Ghanaians. The major causes of cholera outbreak are poor water sanitation, open defecation, and unsafe hygiene practices among others. In 2014, the country recorded its worst ever cholera outbreak since 1982, it recorded about 17,000 cases with about 150 deaths (*Myjoyonline, 2014*). Kwasi Amenuvor, an official interviewed by The African Report stated how sad it is that Ghana is still grappling with cholera due to filth in the 21st century

(Laary,D; 2014). As a result of the seasonality of cholera, the campaign against it is not as massive as diseases that are not seasonal thus making it effect more dangerous over time. Ghana tried to reduce the disparities in access to health care with the introduction of the National Health Insurance Scheme (NHIS) in 2003. It made significant effort to improve access with low premium payments, however, the active membership of the scheme was 38% of the total population in 2013 (*National Health Insurance Authority, 2013*). Although there seem to be an improvement, widening inequalities were still observed in under-five mortalities, maternal mortalities and other health indicators. Some diseases seem to cause more deaths than proportional based on it severity, because of the existence of both rural and urban areas in Ghana, This is because of low access to healthcare, unsafe health practices and lack of basic amenities in rural areas.

This research is relevant to millennium development goal (MDG) 6: to “combat HIV/AIDS, malaria and other diseases” (*United Nations, 2000*). This is because HIV/AIDS, and malaria are amongst the leading severe diseases in the country. Hence, if inequality in mortality between diseases have decreased over time, this could be an indication that mortality share of these severe diseases have been minimized.

Considering these issues, this study aims to identify how inequalities in mortality between diseases have evolved over time. This can give an insight into the likelihood of having access to treatment depending on disease severity. It can provide further indication on how mortality between diseases have evolved i.e. whether they are diverging or converging. Therefore the following research question and related sub questions are formulated;

How has the Inequality in mortality between diseases in Ghana evolved over time?

Sub questions;

- Is the change in inequality due to re-ranking of diseases or due to mortality progressivity?
- How does the change in Inequality in mortality between diseases differ by gender and age groups?

The rest of the report is structured as follows, chapter 2 provides the background to the study and explains the concepts that are used. Chapter 3 describes the data and methods that are employed in

answering the research question. Chapter 4 gives a summary of the relevant results and interpretations. Finally, chapter 5 provides a summary and conclusions.

2 Background

In this section, we analyze and explain the basic concepts and previous studies that used in this research. The outcome of interest is to examine the change in inequality in mortality between diseases with respect to time.

2.1 Terms Definitions

Mortality as defined by the Marriam-Webster dictionary is the number of deaths in a given time or place. Usually, a disease is classified as severe if it has a high mortality. In this research there are 2 ways of quantifying disease severity and it is as follows (i) if the disease has a high mortality or (ii) if the disease has a high burden of disease (DALYs).

Burden of disease gives an idea of the impact of ill-health on the individual and the society as a whole. There are 2 common approaches of understanding and measuring burden of diseases (BoD) these are (i) Biomedical BoD (ii) Economic BoD.

Biomedical BoD in public health is focused on measuring the impact of illnesses and disabilities on an individual and its related outcomes .i.e. either death, recovery or further disabilities (*National Collaboration Centre for Infectious Diseases, 2016*). According to the World Health Organization (WHO), disability is used broadly in BoD analyses to refer to departures from good or ideal health in any of the important domains of health. It can also be defined as a measurement of the gap between current health status and an ideal situation, in which everyone lives to old age free of disease and disability (*Neuberger H., 2005*). Disabilities are not necessarily confined to long term illness but can also be short term. As an illustration, if someone develops a cough for two days, those two days that the person's current health status is not the ideal health is identified as a disability. For the purpose of this research, BoD may be labelled as the biomedical BoD. There are 3 main categories of diseases that constitute the BoD. These are NCDs, communicable, maternal, neonatal and nutritional diseases, and injuries.

However, BoD due to injuries will not be considered in this analysis since we are only focused on finding inequality in mortality between diseases. Globally, NCDs are the major contributors to the BoD. On the contrary, CDs are the major contributors to BoD in sub-Saharan Africa.

DALYs are used to quantify the BoD. DALYs as defined by WHO is the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability. In terms of an indicator that combines mortality and morbidity into one estimate, DALYs are the most used worldwide (*Prüss-Üstün A et. al, 2003*). DALYs are a function of time, this implies that the longer the time spent in a

disabling condition, the greater the BoD is perceived to be. Measurement of DALYs considers mortality with age at death, incidence of various types of adverse health conditions with age at onset, prevalence of morbidities with severity, duration and sequelae, and remission rates (*Neuberger H., 2005*). Years of life lost due to premature mortality is determined if death happens before the highest life expectancy. In the calculation of DALYs, more weight is given to life years that are lost during productive age relative to those in childhood or old ages. In terms of quantifying the severity of a disease, DALYs will be used as a determining factor meaning that the disease that has the highest number of DALYs will be deemed the most severe and vice versa. In theory, one lost DALY is equivalent to losing one year in good health either because of premature death or disability (*Murray et. al, 2015*). For example, in 2010, 144,422 years were lost in good health because of premature deaths or disabilities associated with diabetes in Ghana. Additionally, there were 601,828 Ghanaians living with diabetes and deaths recorded were 4,424 (*GBD Compare Data Visualization, 2018*). The use of DALYs helps policy makers to identify diseases that are less fatal but disabling.

Progressivity is the advancement toward better conditions or methods according to the Thesaurus dictionary. This is a term that is often used in taxation literature as a measure of the nature of a tax. In taxation literature, tax progressivity is a tax rate that increases as income gets higher which means it advances the poor towards better conditions. In this research we borrow this concept as used by Jenkins & Van Kerm (2006) in their article “Trends in Income Inequality, pro-poor Income growth, and Income Mobility”. They define progressivity/pro-poor (of) income growth as one in which if aggregate income growth is positive, the income growth is concentrated among poorer individuals than richer individuals. Whereas if aggregate income growth is negative, then income growth is pro-poor if losses in income are concentrated among richer individuals than poorer individuals. Relating this to our study, if aggregate mortality declines over time, then progressive mortality decline is one in which, the decline in mortality is concentrated among severe diseases than less severe diseases. On the other hand, if aggregate mortality increases, then mortality decline is pro-severe if the increases in mortality are concentrated among less severe diseases than severe diseases. For instance, assume there is an aggregate decline in mortality of about 5%, then this decline is pro-severe if this decline was experienced more among severe diseases. Progressive and pro-severe can be used interchangeably during this study.

Re-ranking simply means the changes in ranking. Jenkins and Van Kerm tracked mobility of income by analyzing the changes in income ranks. We use the same concept in this study by tracking mobility of mortality by analyzing changes in mortality. It identifies how much of re-ranking of diseases is related

changes in mortality. As disease severity is ranked by mortality, it is important to know how the ranks of diseases have evolved. If mortality of severe diseases have changed, do other less severe diseases change in ranks? Or the severe diseases maintain their ranks, but their mortality effect is changed significantly? If mortality effect of all diseases changed proportionally then ranks of the diseases will remain unchanged all other things equal.

Inequality of opportunity occurs when people living in a society do not have access to the same opportunities (*European Bank for Reconstruction and Development, 2016*). Some authors (*Garcia-Gomez et. al, 2014; Bricard et. al, 2013*) have stated that inequality of opportunity is concerned about distinguishing between outcomes for which the individual is responsible for and the part for which they are not responsible for. The part for which individuals are not responsible is termed as circumstances whereas those they are responsible for are efforts. In addition, society is concerned about inequalities that arise because of differences in circumstances (*Garcia-Gomez et. al, 2014*). In this study, distinction is not made between efforts and circumstances. Linking this concept with the goal of this study means that the availability of a treatment opportunity given that you contract a disease will depend on the severity of the disease. For instance, if treatment options are readily available for relatively less severe diseases compared to more severe diseases and vice versa then it means there is an inequality in opportunity of treatment for a disease, assuming people are not responsible for their disease. Hence the former may lead to widening inequality in mortality between diseases whereas the latter may lead to narrowing inequalities.

When the concept of inequality in mortality is mentioned, people tend to associate it with socio-economic related inequality. Studies have been conducted to establish this relationship (*Kitigawa & Hause, 1973*). Currie and Schwandt (*2016*) state in a recent report that three common approaches have been laid out in the operationalization of inequality in mortality. These are differences in mortality of a population across (i) County-level economic measures (*Curie & Schwandt, 2016; Wilmoth et. al, 2011; Wang et. al, 2013; Murray et. al, 2006*), (ii) Educational attainment (*Pappas et. al, 1993; Olshanky et. al, 2012; Meara et.al, 2008; Cutler et. al, 2011*), (iii) Income level (*Pappas et. al, 1993; Waldron, 2007; Waldron, 2013, Bossworth and Burke, 2014*). In this study however, none of the approaches mentioned above are used in the operationalization of inequality in mortality. Differences in mortality of the population is studied across diseases. This will give an insight into how mortality differs across diseases over time. This can also indicate if diseases that were severe are getting less difficult to treat over time.

2.2 Previous empirical research

Currently, no extensive research has been conducted to identify inequalities in mortality between diseases at a country level. Nonetheless, a couple of related studies are discussed more in-depth below.

Murray et. al (2012), provided some information on the evolution of mortality of some key diseases. In 2010, there were about 52.8 million deaths globally. Out of this, CDs, maternal, neonatal & nutritional causes accounted for 24.9% which is equivalent to 15.9 million deaths. This was an improvement to the 46.5 million deaths recorded in 1990. The sources of the improvement can be attributed to large decreases in infectious diseases such as diarrhea, neonatal diseases, measles, and tetanus which altogether reduced from 9.9 million deaths worldwide to 6.59 million in 1990 and 2010 respectively. However, for HIV/AIDS & malaria, high increases were observed in the mortality they accounted between 1990 and 2010. In terms of NCDs, the deaths they accounted for rose from about 8 million to 34.5 million in 1990 and 2010 respectively. The decomposition shows that this increase was mainly due to the rise in incidence in deaths of diseases such as cancer, trachea, bronchus, ischemic heart disease, stroke, and diabetes which rose by more than 19%. In Sub-Saharan Africa, CDs, maternal, neonatal and nutritional diseases accounted for about 76% of premature mortality. These shows that globally, severity of diseases have evolved changing the mortality between diseases.

In the evolution of disease mortality burden in Cuba, Seuc & Dominguez (2010) grouped the major causes of mortality and YLL into clusters. They found that heart diseases and cancers were the main causes of these 2 indicators. The results highlighted that cancers were likely to surpass heart diseases as the leading cause in the near future. Additional analyses, also showed that mortality and YLL rates of influenza, pneumonia and neuropsychiatric conditions were likely to increase. Whereas cerebrovascular diseases and sepsis have remained unchanged and showed a higher probability of decreasing. These results show how the mortality of some diseases will change.

Based on mortality levels and population trends in 1990, Murray & Lopez (1997) made projections on the mortality trend of major disease categories. In all scenarios used (baseline, optimistic, pessimistic) a decline was projected in worldwide mortality due to communicable, maternal, neonatal and nutritional disorder by 2020. Particularly deaths due to diarrheal diseases, perinatal, measles and malaria were all projected to reduce significantly. On the other hand, diseases such as lung, stomach, liver cancer and HIV were all projected to increase substantially by 2020. Additionally, projections were also made on the changes in the leading cause of DALYs by 2020. With ischemic heart disease, unipolar major depression, cerebrovascular diseases, chronic obstructive pulmonary disorder, road accidents, LRI, diarrheal diseases

and HIV being the leading causes of DALYs. They attributed these changes in population structure and lifestyle. These projections indicate that mortality trends are not going to remain unchanged.

Barrenho et al (2017) conducted research on the misalignment between drug innovation and disease burden. The methodology employed in their research is the closest reference to this study. They ranked disease burden by DALYs against the cumulative share of R&D activity from pharmaceutical companies. The finding was that inequalities in health in developing countries may widen because pharmaceutical industries were not making any effort to initiate innovations that will target CDs prevalent in these countries. However, individuals suffering from NCDs were likely to benefit because of increased innovations targeted at diseases in this category. This may cause inequality in opportunity of treatment for diseases in this category. Meaning that those affected with diseases in the CDs category may get less access to novel treatments thus increasing their share of mortality.

Research undertaken by Isaakidis et al (2002) investigated randomized clinical research in addressing the health needs of sub-Saharan Africa. The authors concluded that randomized clinical research available was not evenly distributed in addressing the health needs of the region. The authors also stated that over time, the ratio of DALYs per amount of randomized evidence were much worse for some disease categories than others. Diseases that had worst ratios from the research include respiratory infections and congenital anomalies. These diseases that have worst ratios may cause inequalities in mortality between diseases to widen because the probability of not having access to treatment options may rise.

The aim of the study by Mejia et al (2014) was to investigate whether socio-economic status inequalities were greater in dental disease experience or its treatment in Australia. The finding was that oral health inequalities were more obvious in disease treatment than disease experience. In other words, both the poor and rich alike were likely to experience dental diseases, however a higher concentration of dental treatment towards the rich was observed. Although this is not entirely related to the aim of our study, it can be linked to it in one way or the other. Assuming there is a disease that is concentrated among the poor (example nutritional deficiencies, neglected tropical diseases), given that there are also inequalities in the disease treatment, inequality in mortality between diseases may widen because there may be a high mortality for the disease even if it is not very severe.

Agyei-Mensah and De-graft Aikins (2007) indicated that prior to 1990, the major causes of morbidity and mortality reported at health facilities in the capital of Ghana (Accra) were mainly CDs. These were

mainly malaria, parasitic infections, diarrhea, and respiratory infections among others. However, in the early 1990's circulatory diseases were gradually becoming the major causes of deaths in the nation's capital possibly because of the introduction of immunization services to combat CDs during this period. Also, there was some evidence to support the claim that infectious diseases can cause some chronic conditions whereas some chronic conditions increase the risk of infectious diseases.

Hence, using these concepts and previous studies, we intend to identify the inequality in mortality between diseases in Ghana over time.

2.3 Disease Profile in Ghana

Ghana is a lower-middle income country in sub-Saharan Africa with a current population of about 27.5 million. It has a youthful population with more than half (57.7%) of its population being between the ages of 15-64 years and a median age of 21.1 years with a life expectancy at birth of 67 years (*The World Factbook, 2018*). The mortality rate due to diseases was 643 deaths per 100,000 inhabitants in 2015 (*GBD Data Compare Visualization, 2018*).

Malaria continues to be the leading cause of high morbidity in the country. Ghana performs poorly in malaria, HIV/AIDS and LRI in comparison with other countries with similar economic indicators. Whereas the morbidity and mortality effect of some diseases are almost the same, this is not the case for all diseases. In Ghana most diseases that are in the top ranking causes of death are usually those that equally have high morbidities as well as mortalities. This is shown in table 1 that displays the top 10 causes of deaths and DALYs in Ghana.

Table 1: Leading Causes of Death & DALYs 1990, 2015

Rank	Leading Causes of Deaths (1990)	Leading Causes of DALYs (1990)	Leading Causes of Deaths (2015)	Leading Causes of DALYs (2015)
1	Measles	Measles	Malaria	Malaria
2	LRI	Malaria	LRI	HIV/AIDS
3	Malaria	Diarrheal diseases	HIV/AIDS	Neonatal Encephalopathy

4	Diarrheal diseases	LRI	<i>Ischemic Heart Disease</i>	LRI
5	<i>Tuberculosis (TB)</i>	Neonatal Encephalopathy	<i>Stroke</i>	<i>Congenital Defect</i>
6	Neonatal Encephalopathy	Neonatal Preterm Birth	Neonatal Encephalopathy	Neonatal Sepsis
7	<i>Stroke</i>	<i>Tuberculosis (TB)</i>	<i>Tuberculosis (TB)</i>	Neonatal Preterm Birth
8	<i>Ischemic Heart Disease</i>	Protein-energy malnutrition	Meningitis	<i>Stroke</i>
9	Neonatal Preterm Birth	Neonatal Sepsis	<i>Congenital Defect</i>	<i>Ischemic Heart Disease</i>
10	HIV/AIDS	Meningitis	<i>Diabetes</i>	Meningitis

Source: GBD Data Compare Visualization, 2018

As shown in the table, most of the causes of deaths and DALYs are characterized by communicable diseases. There are about a maximum of 4 NCDs (diseases in italics) in the respective causes. We observe substantial re-ranking of some infectious diseases such as measles and HIV/AIDS in the top ranking causes of deaths and DALYs. Some NCDs such as Ischemic heart diseases have become higher in rank (from 8 to 4) and diabetes which was previously not in the top 10 (from 23 to 10) have become increasingly severe. The difference between causes of DALYs and deaths is that, the former emphasizes on conditions that cut lives short whereas the latter tend to be biased by conditions that kill people later in life (*Institute of Health Metrics and Evaluation, 2015*). What we observe is that malaria, is the leading cause of both death and DALYs. A plausible explanation for this is that this disease usually affects all age categories, but for children the mortality effect is usually instantaneous. However, for adults the parasite can manifest later in life leading to death. Additionally, most of the diseases are in both the leading causes of deaths and DALYs in Ghana. Because DALYs emphasize conditions that cut lives short, it is not surprising that 3 neonatal diseases are in the top 10 causes. This is because these are diseases that affect infants who are very delicate thus any disease affecting them usually cut their lives short.

2.4 Expected Outcome

Based on the previous empirical studies and the disease profile of Ghana, we can build some expectations on the evolution of inequality in mortality between diseases in Ghana.

The finding from the study by Barrenho et. al (2017) concluded that drug innovation was targeted more in NCDs. From table 1, about three-fifths of the leading causes of deaths and DALYs were due to CDs. It is expected that when diseases are ranked by DALYs, inequality will widen over time. This is because drug innovation between 1990 and 2010, were concentrated in disease with low burden prevalent in the country. This means mortality of the high burden diseases will remain unaddressed.

Similarly, this prediction can be backed by the research of Isaakidis et. al. They concluded that over time, clinical research to address health needs of sub-Saharan Africa have a fairly good correlation but may have disregarded some diseases (worst ratios). This implies that mortality for those with worst ratios may arise leading to widening of inequalities. This is because, clinical evidence available is not sufficient to explain the mechanisms of these disregarded diseases thus leading to higher mortalities.

Finally, based on the literature by Murray et.al (1997; 2012) and Agyei-Mensah, De-graft Aikins (2007) we expect inequality to have narrowed over time when diseases are ranked by mortality. This is because the findings from their study highlighted how mortality for most diseases in the CDs category have been reduced whereas those of others have risen. Given that these diseases are prevalent in Ghana, we expect that the share of mortality of this diseases may have decreased over time leading to a decline in inequality.

3 Data and Methodology

This section provides information on the sources of data and the justification of methods that are used to answer the research question.

3.1 Data and Study Population.

We use data obtained from the Institute for Health and Metrics Evaluation's Global health data exchange (GHDx). The Institute for Health and Metrics Evaluation (IHME) is a recognized institution that makes readily available information on population health. The organization collects data on mortality using available sources including surveys, vital registration, hospital records, verbal autopsies, censuses, sample registration systems, and disease surveillance (*IHME, 2018*). The organization assigns a single cause to one death and use statistical models to correct for any biases.

Data is obtained on country-specific mortality and DALYs in Ghana for the years 1990, 2000 and 2015. These years are being used because over the years substantial changes have been observed in the contribution of some diseases to the leading causes of death and DALYs. Hence, using this period will allow us to identify how inequality in mortality between diseases have evolved. The data includes information on death and DALYs associated with individual diseases and separately for subcategory of diseases. Add-on options include distinction between age categories and gender. The age categorization were as follows; under 5 years, 5-14 years, 15-49 years, 50-69 years, and 70+ years.

3.2 Variables

The variables that are used in this analysis are disease indicators, DALYs and mortality. Mortality and DALYs are the measures used to determine severity of diseases. Since the purpose of the research is to identify the inequality in mortality between diseases, diseases that cause no mortality are excluded. Diseases that are included in the analysis are those that accounted for at least 0.001% of total deaths in the 3 years under consideration. As such, the number of diseases used were not equal throughout the years. On average a total of 127 diseases are used. For example in a particular year, if a disease has less than 0.001% of deaths, it will not be used in that year. However, if it has more than this proportion in the other year then it will be used in the analysis. The reason for this is to make it possible to compare across different age categories and gender. For instance, maternal disorders only affect females whereas neonatal disorders only affect children under 5 years. Hence, if making conclusions regarding the results where no data are excluded, it will lead to biased conclusions. Furthermore, it also makes the analysis when using DALYs comparable to mortality. Also, some diseases may be rare which only

occurred in a certain year, therefore it should not be included in the analysis of that year where it did not account for any deaths. This however, has an implication for the decomposition, because the decomposition only uses diseases that are present all throughout the years. Therefore, it is possible that the conclusion from the decomposition may differ from the level effect.

As a reliability check, mortality levels and DALYs of disease subcategories were used and none of the subcategories are dropped because all the categories accounted for more than 0.001% of deaths. Similar conclusions were derived from when individual diseases are used with some dropped observations.

Additionally, analyses are done separately for different age groups and these are under 5 years, 5-14 years, 15-49 years, 50-69 years, and 70+ years. This categorization is followed because it is probable that inequality in mortality and direction of the change may vary for certain age groups (*Curie & Schwandt, 2016; Kidd, 2003*).

3.3 Methodology

We perform a quantitative analysis in this study because we want to quantify the inequality in mortality between diseases and this approach is more objective which will allow us to assess the impact better.

To begin with, a descriptive analysis is carried out to explore the nature of the data on the mortality in the various subcategory of diseases. This shows if changes in mortality are monotonous for the respective years that are considered in this research. The analysis also provides an insight on whether mortality decline is progressive and gives a representation of how the severity ranks of the various subcategory of diseases have evolved.

Analyses are performed to assess the inequality in mortality between diseases over the years. In addition, this inequality is decomposed to examine the source of the changes in the inequality i.e., is this change due to the progressivity of mortality or due to the effect of re-ranking in diseases. Similarly, inequality in mortality between diseases over the years is done for separate age groups and gender.

Concentration (Lorenz) Curves and Indices

Concentration and Lorenz curves provide a means to visually assess the degree of inequality in mortality between diseases using data from the global burden of diseases. Concentration curves are generated by plotting the cumulative distribution of mortality (y-axis) against the cumulative share of diseases ranked by DALYs in ascending order (x-axis). Similarly, the Lorenz curve is generated by plotting the cumulative distribution of mortality against the cumulative share of diseases ranked by mortality i.e. diseases that have the lowest mortality are ranked as least severe and vice versa. A 45⁰ line that runs through the plot represents the line of equality, this is when every disease irrespective of its severity has the same mortality. However, if the curve lies above (below) the line of equality, this implies that mortality is concentrated toward diseases that are less (more) severe. It is expected that the concentration curve will lie below the equality line, because mortality is incorporated into DALYs. The Lorenz curve can never lie above the 45⁰ line because we are plotting the cumulative distribution of mortality against its own rank of increasing mortality. The further the curve is from the line the greater the concentration (*World Bank, n.d*). The major difference between the two curves is that, the concentration curve uses two different variables for the x- axis and y-axis whereas the Lorenz curve uses one variable for both the x and y- axis.

In terms of quantifying the concentration curve, the Erreygers index (Erreygers, 2009) is used to calculate the concentration indices. The formula of the Erreygers index can be written as;

$$E(m) = \frac{8}{n^2(b_m - a_m)} \sum_{i=1}^n z_i m_i, \quad z_i = \frac{n+1}{2} - \lambda_i$$

Where n is the number of diseases, a_m and b_m denotes the minimum and maximum number of mortality (m_i), $\sum_{i=1}^n z_i m_i$ is weighted sum of all diseases mortality levels. The mortality m_i of disease i is weighted by a factor (DALYs) determined by the severity rank λ_i of this disease (*Erreygers, 2009*). The value of the Erreygers index ranges between -1 and +1. The closer the value is to 0, the lower the inequality, and a positive value of $E(m)$ indicates that mortality is concentrated towards severe diseases and vice versa.

The Erreygers Index is a more reliable measure of inequality because it satisfies all desirable properties of an index which are mirroring, transferability, Cardinal Invariance and level independence (*Erreygers, 2009*). The mirror property states that indices should give mirror images of the degree of inequality whether you are concentrating on ill health or health. Transferability means that transfers of DALYs from

a severe disease to a less severe disease decreases the measured level of inequality and vice versa. Cardinal invariance simply means that the degree of inequality should remain the same irrespective of the scale of the variable used, i.e. for a ratio-scale variable such as DALYs the index should be invariant to any positive proportional transformation of the DALYs. Finally, level independence states that if there is an equal increment/decrement in DALYs for all diseases, the value of the index should remain unchanged. Arguably, the Erreygers index is not the only way to quantify inequality however it is the only index that satisfies all four properties of a desirable index.

The Gini index is the ratio of the area between the Lorenz curve and the 45^o line to the area under the 45^o line (*Garswith, 1972*). In general, the Gini index quantifies the inequality from the Lorenz curve and is a measure of univariate inequality. The difference between the concentration (Erreygers) index and the Gini index is that the former measures the inequality in one variable over the distribution of another whereas the latter measures the inequality in a variable over the distribution of the same variable (*O'Donnell et. al, 2016.*) The formula for the Gini index can be written as:

$$G(v) = \int_0^1 k(s; v)(s - L(s))ds, \quad v > 1 \quad (\text{Jenkins \& Van Kerm, 2006}) \quad (1)$$

Where $k(s; v) = v(v-1)(1-s)^{v-2}$, v is the inequality aversion parameter, for the purpose of this research we use $v=2$ because this applies equal weights to both severe and less severe diseases in the analysis. The conclusions may differ according to the value of v , if the concentration curve of using the initial year rankings does not entirely lie above or below the Lorenz curve of using the final year rankings. This is because $v>2$ gives greater weight to severe diseases whereas $v<2$ gives greater weight to less severe diseases. s is $F(x)$, where $F(x)$ is the cumulative distribution function of mortality, $L(s)$ is the Lorenz curve of mortality distribution. Inserting $v=2$ in the equation, it can be rewritten as follows:

$$G(v) = \int_0^1 2(s - L(s))ds \quad (2)$$

The value of this index ranges between 0 and 1, the closer (farther) the value is to 1 the greater (lesser) the inequality.

The change in Gini is further decomposed to identify the source of the change which follows from the decomposition done by Jenkins & Van Kerm (*2006*). The change is the difference between the Gini index of the initial year (i) and the index of the final year (j) which is as follows:

$$\Delta G(v) \equiv G_j(v) - G_i(v) = \int_0^1 k(s; v) (L_i(s) - L_j(s)) ds \quad (3)$$

$G_i(v)$ and $G_j(v)$ are the Gini index of initial year i and final year j respectively. The components of the decomposition are progressivity and re-ranking of inequality changes, thus the change can be rewritten as:

$$\Delta G(v) = R(v) - P(v) \quad (4)$$

$$\begin{aligned} P(v) &= \int_0^1 k(s; v) (C_j^{(i)}(s) - L_i(s)) ds \\ &= G_i(v) - G_j^{(i)}(v) \end{aligned} \quad (5)$$

$$\begin{aligned} R(v) &= \int_0^1 k(s; v) (C_j^{(i)}(s) - L_j(s)) ds \\ &= G_j(v) - G_j^{(i)}(v) \end{aligned} \quad (6)$$

Where $C_j^{(i)}$ is the concentration curve of mortality in the final year where diseases are ranked by the mortality levels of the initial year. $G_j^{(i)}(v)$ is the generalized concentration coefficient for year j mortality calculated using year i rankings.

$P(v)$ is the progressivity index which measures the change in mortality, more specifically it determines the average rate at which relative mortality levels have changed for the several diseases in the years considered while maintaining the initial ranks that were used. This is also the difference between the Lorenz curve of the initial year and concentration curve of the final year when the initial year rankings are used. If there is an equi-proportional change in mortality for all the diseases and relative mortality is unchanged then $P(v)=0$. If the average mortality (u_i) for the years under consideration is not the same. Then

$$P(v) = \frac{r}{1+r} K(v)$$

Where $r = \frac{(u_1 - u_0)}{u_0}$ is the proportionate change in the average mortality of all diseases. $K(v)$ is the generalized Kakwani-type index of progressivity. If $r > 0$, then it means aggregate mortality decline is negative, this means mortality has increased. Hence, $P(v) > 0$ implies that the increase in mortality is

concentrated among less severe diseases than relatively severe diseases. On the other hand, if $r < 0$, this implies that aggregate mortality decline is positive, i.e. mortality

$R(v)$ is the re-ranking index, which measures the mobility of mortality based on how ranks have changed. This identifies, average change in the relative weights (ranks) of the diseases considered. This is also the difference between the Lorenz curve of the final year and the concentration curve of the final year with the different rankings. Thus, if none of the ranks of the diseases have changed over the years $R(v) = 0$, and $R(v) > 0$ otherwise.

All other things equal, if $R(v) > P(v)$ this translates to an increase in inequality in mortality between diseases over time and vice versa.

3.4 Validity and Reliability

According to Babbie (2008), reliability refers to identifying whether a particular technique applied repeatedly to the same object yields the same result each time whereas validity is a term describing a measure that reflects the concept it is intended to measure.

The Erreygers index which will be the measure of inequality is a well-founded index because it meets all important criterion (Erreygers, 2009) and has been widely used by a lot of researchers in quantifying inequalities.

For the validity of our results, we will represent disease severity separately by DALYs and mortality. This will ensure that we are actually representing disease severity correctly.

4 Results

In this section, a summary of the results are provided and interpreted.

4.1 Descriptive Statistics

We begin with some descriptive statistics of the subcategories of diseases.

Table 2: Deaths in each disease subcategory

Diseases (Subcategory)	Number of Diseases	1990 Number of deaths	2000 Number of deaths	2015 Number of deaths
HIV/AIDS & Tuberculosis	8 (3.3%)	12890 (9.45%)	27385 (16.83%)	21596 (12.14%)
Diarrhea, LRI & other common infectious diseases	17 (6.9%)	47776 (35.01%)	35799 (22.00%)	28091 (15.80%)
Neglected Tropical diseases & Malaria	23 (9.3%)	14076 (10.31%)	20926 (12.86%)	21345 (12.00%)
Maternal disorders	9 (3.7%)	1529 (1.12%)	1535 (0.94%)	1286 (0.72%)
Neonatal disorders	5 (2.0%)	15823 (11.59%)	16750 (10.29%)	18715 (10.52%)
Nutritional deficiencies	5 (2.0%)	3681 (2.70%)	3382 (2.08%)	3128 (1.76%)
Other CDs, maternal, neonatal & nutritional diseases	11 (4.5%)	1883 (1.38%)	1491 (0.92%)	1159 (0.65%)
Neoplasms	37 (15%)	6944 (5.09%)	10068 (6.19%)	15017 (8.44%)
Cardiovascular diseases	13 (5.3%)	16300 (11.94%)	24369 (14.97%)	34111 (19.18%)
Chronic respiratory diseases	8 (3.3%)	1993 (1.46%)	2518 (1.55%)	3942 (2.22%)

Cirrhosis & other chronic liver diseases	4 (1.6%)	2609 (1.91%)	3613 (2.22%)	5988 (3.37%)
Digestive diseases	10 (4.1%)	2435 (1.78%)	2905 (1.78%)	3857 (2.17%)
Neurological disorders	8 (3.3%)	862 (0.63%)	1341 (0.82%)	2661 (1.50%)
Mental & Substance use disorders	19 (7.7%)	128 (0.09%)	186 (0.11%)	502 (0.28%)
Diabetes, Urogenital & Endocrine diseases	26(10.6%)	4474 (3.28%)	6387 (3.92%)	10743 (6.04%)
Musculoskeletal disorders	6 (2.4%)	60 (0.04%)	92 (0.06%)	155 (0.09%)
Other NCD's	37(15.0%)	3001 (2.20%)	4003 (2.46%)	5528 (3.11%)
Total	246	136464	162750	177824
Population Size		14628260	18938762	27582821
Relative proportion of Deaths		0.933%	0.859%	0.645%

Table 3: Total DALYs in each disease subcategory

Diseases (Subcategory)	1990 Number of DALYs	2000 Number of DALYs	2015 Number of DALYs
HIV/AIDS & Tuberculosis	541392 (5.21%)	1319367 (12.23%)	1031456 (10.65%)
Diarrhea, LRI & other common infectious diseases	3449168 (33.20%)	2283094 (21.17%)	1440964 (14.87%)
Neglected Tropical diseases & Malaria	1713046 (16.48%)	1620731 (15.03%)	1216626 (12.56%)
Maternal disorders	92113 (0.89%)	80527 (0.75%)	94234 (0.97%)
Neonatal disorders	1394886 (13.43%)	1683762 (15.61%)	1484612 (15.32%)
Nutritional deficiencies	462521 (4.45%)	496390 (4.60%)	464558 (4.80%)
Other CDs, maternal, neonatal & nutritional diseases	155036 (1.49%)	95501 (0.89%)	121060 (1.25%)
Neoplasms	471298 (4.54%)	236000 (2.19%)	333385 (3.44%)
Cardiovascular diseases	464698 (4.47%)	675320 (6.26%)	872653 (9.01%)
Chronic respiratory diseases	89094 (0.86%)	110725 (1.03%)	163517 (1.69%)
Cirrhosis & other chronic liver diseases	132712 (1.28%)	97940 (0.91%)	222031(2.29%)
Digestive diseases	113297 (1.09%)	101574 (0.94%)	143432 (1.48%)

Neurological disorders	170445 (1.64%)	126279 (1.17%)	273278 (2.82%)
Mental & Substance use disorders	231174 (2.22%)	307014 (2.85%)	472937 (4.88%)
Diabetes, Urogenital & Endocrine diseases	299674 (2.88%)	385711 (3.58%)	561275 (5.79%)
Musculoskeletal disorders	145287 (1.40%)	305638 (2.83%)	186624 (1.93%)
Other NCD's	464256 (4.47%)	860543 (7.98%)	605033 (6.25%)
Total	10390096	10786117	9687674

Table 4: Ranks of diseases subcategory by mortality & DALYs

Diseases (Subcategory)	1990		2000		2015	
	Mortality	DALYs	Mortality	DALYs	Mortality	DALYs
HIV/AIDS & Tuberculosis	5	4	2	4	3	4
Diarrhea, LRI and other common infectious diseases	1	1	1	1	2	2
Neglected Tropical diseases & Malaria	4	2	4	3	4	3
Maternal Disorders	14	16	13	17	14	17
Neonatal disorders	3	3	5	2	5	1
Nutritional deficiencies	8	8	10	7	12	9
Other CDs, maternal, neonatal & nutritional diseases	13	12	14	16	15	16
Neoplasms	6	5	6	11	6	10

Cardiovascular diseases	2	6	3	6	1	5
Chronic respiratory diseases	12	17	12	13	10	14
Cirrhosis & other chronic liver diseases	10	14	9	15	8	12
Digestive diseases	11	15	11	14	11	14
Neurological disorders	15	11	15	12	13	11
Mental & Substance use disorders	16	10	16	9	16	8
Diabetes, Urogenital & Endocrine diseases	7	9	7	8	7	7
Musculoskeletal disorders	17	13	17	10	17	13
Other NCD's	9	6	8	5	9	6

Table 2, 3 & 4 provide descriptive statistics of the various subcategories of diseases. Individual diseases have been grouped under a larger subcategory with diseases that have similar characteristics. This categorization of diseases follows the global burden of disease classification. In total there are 17 major subcategories with 246 individual diseases. However, these individual diseases do not all cause mortality some only cause morbidity.

The subcategories that have the highest number of diseases are the neoplasms & other NCDs where each accounts for 15% of the total number of diseases. Neoplasms are diseases that affect the cells, these include the several cancer diseases. This explains why there are a lot of diseases under neoplasms because there are several types of cancers. On the contrary, these subcategories are not the ones that accounts for the highest proportion of deaths (8.44% and 3.11% respectively in 2015). The most striking

results in table 2 is the significant reduction in the proportion of deaths associated with Diarrhea, LRI & other common infectious diseases subcategory. The fatality in this subcategory was reduced by more than a half over the respective years (from 35.01% in 1990 to 15.80% in 2015). In addition, a reduction is seen in other subcategories such as the neonatal (11.59% to 10.52%) and maternal (1.12% to 0.72%) disorders, though these are not as substantial as the former. Between 2000 and 2015, there was a 4.69 percentage point reduction in mortality associated with HIV/ AIDS & Tuberculosis subcategory. Thus it is observed that there are sizeable improvements in mortality in these severe diseases. This could mean that over time, these diseases have become less difficult to treat. However, further analyses are needed to confirm this.

On the other hand, proportion of deaths in other subcategories such as cardiovascular diseases and neoplasms have been on the rise with an increase of 7.24% and 3.35% respectively in the period 1990-2015. This signals that some diseases have experienced re-ranking. That is diseases that were not considered to be very severe have become high ranking. In general, the good news is though the total number of deaths has increased over the years, the total number relative to the population size has reduced over time from 0.933% in 1990 to 0.645% in 2015. This indicates that the absolute number of deaths have increased due to population size but in relative terms, there is a decrease.

In table 3, the number and proportion of DALYs associated with each disease subcategory are presented. As expected the most significant reduction in the number of DALYs is associated with the diarrhea, LRI & other common infectious diseases subcategory. It reduced from about 33% in 1990 to about 15% of total DALYs in 2015. There are increases in the total number of DALYs associated with most of the NCDs subcategories. Also, there seem to be a disproportionate mortality in some of the subcategories given the total number of DALYs they account for. Cardiovascular diseases and neoplasms which accounted for 6.26% and 2.19% of total DALYs accounted for 14.97% and 6.19% of total deaths respectively whereas maternal disorders and chronic respiratory diseases which accounted for 0.75% and 1.03% of total DALYs accounted for 0.94% and 1.55% of total deaths respectively in 2000. This hints at an apparent misalignment between disease severity (DALYs) and mortality.

Table 4 gives details on the ranks, by both mortality levels and DALYs, of the various subcategories. Less than a half (i.e. 6 out of 17) of the subcategories maintained their rank in the 3 respective years when ranked by mortality. Nonetheless, ranks of subcategories that changed were not notable. For instance,

the number of deaths due to diarrhea, LRI & other common infections reduced from 47,776 (35.01%) to 35,799(22.00%) to 28,091(15.80%) in 1990, 2000 and 2015 respectively. This a significant reduction in both absolute and relative number of deaths, however the rank only dropped from 1 to 2. The fatality of other diseases in this subcategory may have increased or remained unchanged, indicating why the changes in ranks may not be notable. It is expected that there would have been more re-ranking in individual diseases compared to the subcategories. For example, measles which belongs to diarrhea, LRI & other infectious diseases subcategory was the leading cause of death in 1990 but, in 2015 it rank was 93. Hence, considering measles individually, its rank dropped significantly.

Ranking the subcategories by DALYs, there seem to be apparent differences in diseases that are considered as severe. In 2015, cardiovascular diseases were considered as most severe by mortality whereas neonatal disorders were considered as most severe by DALYs. As statedint the causes of DALYs is biased toward diseases that cut lives short, this is why neonatal disorders are considered as most severe when ranked by DALYs. This provides a hint that there may be differences in conclusions that are drawn by using two different variables to rank disease severity.

Further analyses are needed to assess the source, magnitude and significance of these signals.

4.2 Lorenz (Concentration) Curves and Gini (Erreygers) Indices

Figure 1a: Lorenz curve for inequality in mortality between individual diseases
 Figure 1b: Concentration curve for inequality in mortality between individual diseases

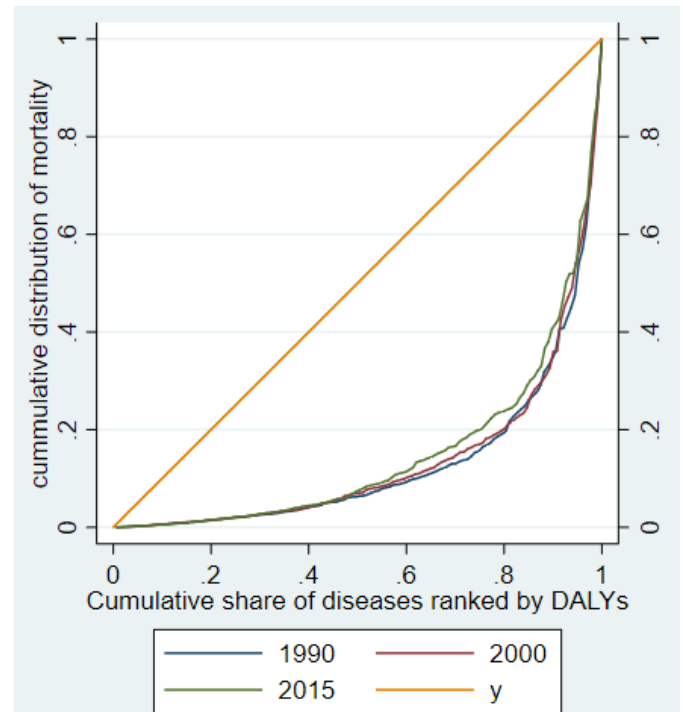
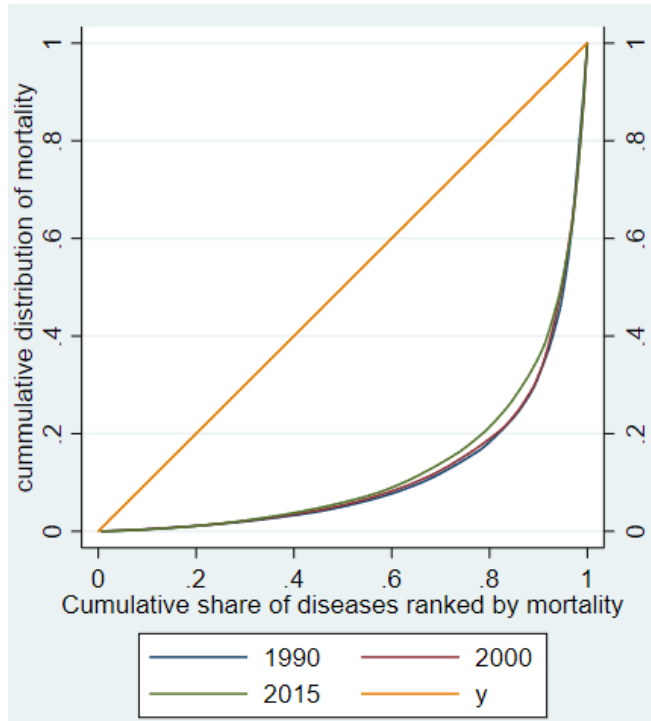


Table 5: Gini & Erreygers Indices for Individual diseases

Individual Diseases	1990		2000		2015		P-value H ₀ : differences = 0 ^b
	Index	SE	Index	SE	Index	SE	
Gini Indices	0.762*** (0.0993)		0.756*** (0.0973)		0.739*** (0.0934)		0.9843
Erreygers Indices	0.079*** (0.0108)		0.090*** (0.0122)		0.091*** (0.0123)		0.7306

* $p < 0.001$ ** $p < 0.05$ *** $p < 0.10$, ^b H₀: at least one of the difference $\neq 0$

Table 6: Decomposition of inequality (Gini) change for individual diseases

Initial Year	Final Year	Initial Gini	Final Gini	Change in Gini	Re-ranking Index	Progressivity Index
1990	2000	0.761	0.750 ^a	-0.011	0.020	0.031
2000	2015	0.753 ^a	0.726	-0.027	0.018	0.045
1990	2015	0.760	0.721	-0.040	0.048	0.088

Notes: $r > 0$ for each decomposition. ^a The initial Gini estimate may differ a bit from the final Gini estimate for the same year because it uses different samples i.e. data is unbalanced. Decomposition uses a panel data.

Figure 1a & 1b depict the cumulative distribution of mortality against the cumulative share of diseases ranked by mortality and DALYs respectively. The results from the Lorenz curves and Gini indices from table 6 suggest that there is a concentration of mortality among severe diseases when diseases are ranked by mortality. However, this concentration (inequality) has reduced over time. The decline in inequality could be an indication that individuals who contract severe diseases may have had increased likelihood of receiving treatment or these diseases may have become less difficult to treat. This is because these diseases have decreased their share of mortality over time. The value of the Gini indices are highly significant therefore, the claim that mortality is unequally distributed according to disease severity is supported. However, statistical analyses show that changes in inequality in mortality between diseases over the years is not significantly different from zero. This is confirmed in table 5 with a p-value of 0.9483, which shows that none of the changes are statistically different from zero at all the relevant significance levels (0.01, 0.05, and 0.10) used.

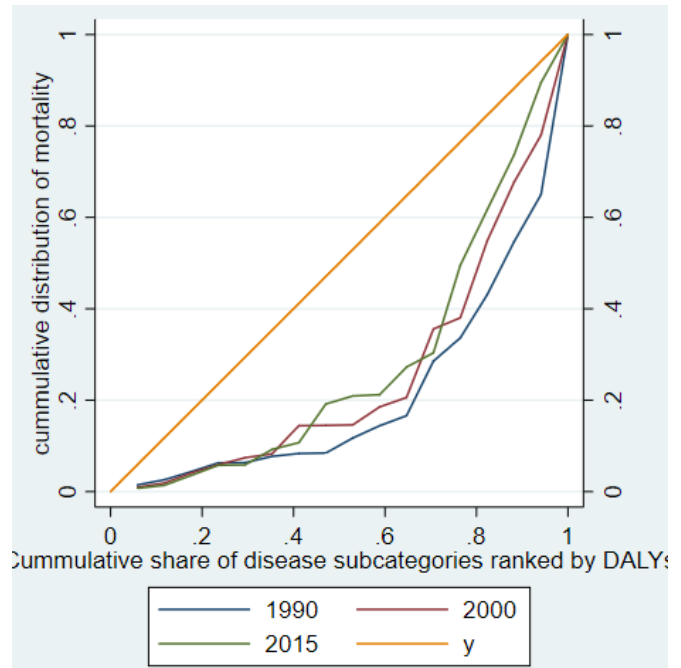
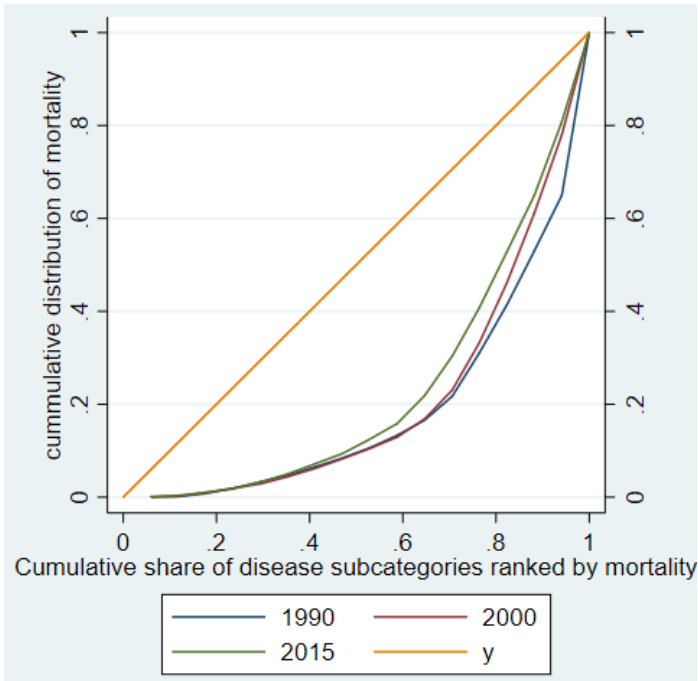
The decomposition of the change in table 6 shows that mortality change was progressive (pro-severe) in the 3 time periods 1990-2000, 1990-2015, & 2000-2015. The aggregate mortality change is positive, this means that average mortality has increased over the years. And the positive values of $P(v)$ means that the increases in mortality are concentrated more among less severe diseases. Thus, the increase in mortality favors severe diseases. It is evident from table 3, which shows how mortality has increased especially for NCDs which were considered to be less severe in the early 90's. Inequality declined by more than one percentage point for the periods considered. From 1990-2015, the Gini coefficient

reduced by 4 percentage points reducing from 0.760 to 0.721. In addition, it shows that the changes in ranking (re-ranking index) of diseases was not large enough to be offset by the equalizing effect of progressive mortality change. This means that though the mortality of some diseases have increased, the effect of the ranks of diseases that changed did not surpass the effect of the progressive mortality growth. The significance of the change in the decomposition can be taken from table 6 as this is also the change in the Gini indices.

Nevertheless, when diseases are ranked by DALYs, a contrary result is observed with the passage of time. The Erreygers Indices which are 0.0791, 0.0903, and 0.0910 in 1990, 2000 and 2015 respectively from table 6 confirm that mortality is concentrated among severe diseases. These values are significant indicating that we can reject the hypothesis that they are not statistically different from zero. However, this inequality has widened over time which is contradictory to when diseases are ranked by mortality. This is because over the period, diseases that are considered severe by DALYs have experienced an increasing share of mortality. Neglected tropical diseases & malaria, which is among the top 3 causes of DALYs, increased its share of mortality from 10.3% in 1990 to 12% in 2015. This implies that, treatment availability may be higher for diseases that have higher mortalities relative to those that cause higher disabling effects. It could also mean that these diseases have become more difficult to treat or may have been neglected. All other things equal, with a p-value of 0.7306, we cannot reject the hypothesis that the change in inequality in mortality between the diseases over the years is significantly different from zero at all the relevant significance levels.

Figure 2a: Lorenz curve for inequality in mortality between diseases subcategory

Figure 2b: Concentration curve for inequality in mortality between diseases subcategory



Note: These curves do not start from zero because there are only 17 major subcategory of diseases considered thus the rank of the first disease relative to the total number of subcategories is not close to zero.

Table 7: Gini & Erreygers Indices for Subcategory of diseases

Subcategory of Diseases	1990		2000		2015		P-values H_0 : differences =0
	Index	SE	Index	SE	Index	SE	
Gini Indices	0.613***	(0.1379)	0.580***	(0.0764)	0.532***	(0.0535)	0.8332
Erreygers Indices ^c	0.193***	(0.0501)	0.196***	(0.0446)	0.190***	(0.0418)	0.9967

Note: ^c Erreygers indices are larger here compared to the curves. This is because the weighted mortality levels are higher due to the fact that there are only 17 observations in each year.

The Lorenz curves in figure 2a and corresponding significant Gini indices in table 7 show that when considering subcategory of diseases without analyzing diseases individually, there is concentration of mortality among severe diseases and this inequality has reduced over time. It is clearly seen from the

Lorenz graph as the latest year (2015) is the closest to the equality line. The indices were 0.613, 0.580 and 0.532 in 1990, 2000 and 2015 respectively. These conclusions are similar to the analyses for individual diseases.

In figure 2b, the differences in the concentration curves are not monotonous, however a clear difference can be seen between 1990 and 2015, showing that the inequality in mortality between diseases is greater in 1990 than in 2015. However, the curve for 2000 had sections lying above or below the 2015. The Erreygers indices from table 7 is consistent with these observations and show that inequality was highest in 2000. This could be attributed to the rise in mortality of some major subcategories in 2000 as seen from table 2. 3 of the top 4 severe subcategories ranked in terms of DALYs experienced increases in the total number of deaths from 1990 to 2000. Out of the top 4, there was about a 112% and 49% increase in mortality associated with HIV/AIDS & Tuberculosis and Neglected Tropical diseases & Malaria respectively over the period. In 2015, this reduced although not to the level in 1990. Results of the statistical analysis show that both the Gini and Erreygers indices are statistically different from the equality line and thus we reject the hypothesis that mortality is equally distributed according to disease severity.

With p-values of 0.8332 and 0.9967 for the changes in the Gini and Erreygers indices respectively, we do not have sufficient evidence to reject the hypothesis that the inequality in mortality between diseases are not significantly different over the years, all other things being equal.

Figure 3a: Lorenz curve for inequality

Figure 3b: Lorenz curve for inequality in mortality

in mortality between individual diseases (Males) between individual diseases (Females)

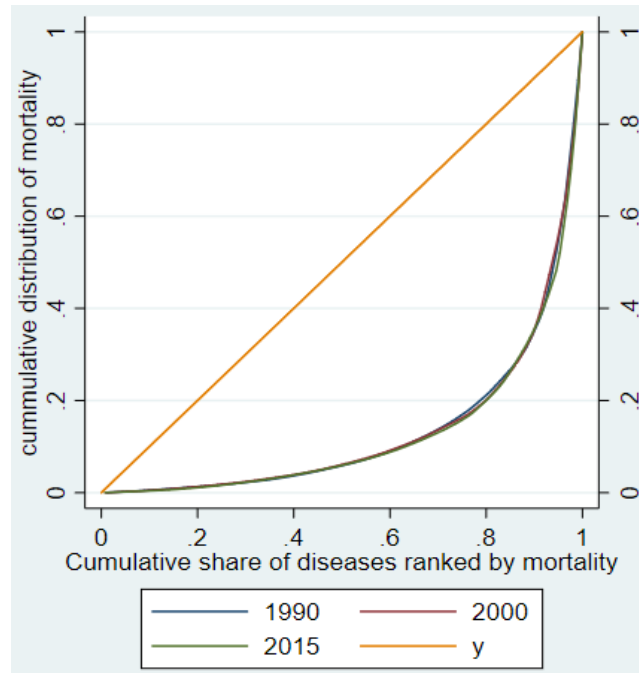
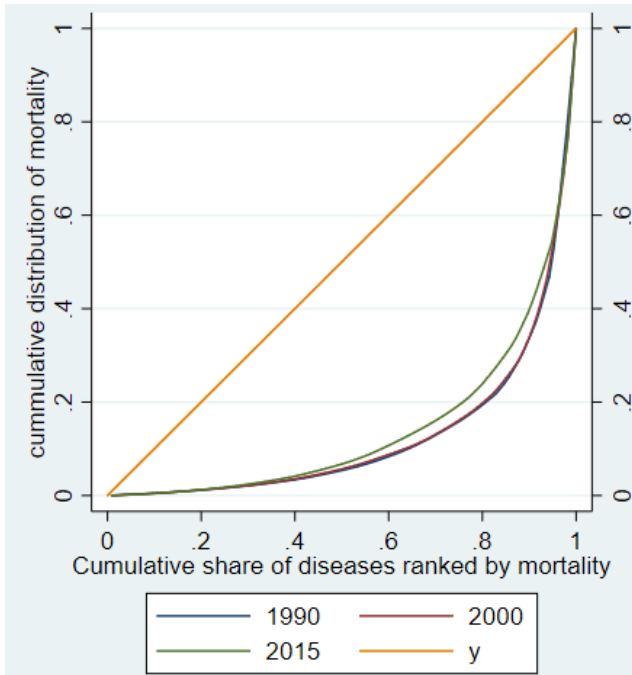


Table 8: Gini & Erreygers Indices for Individual diseases by gender

Individual Diseases (Indices)	1990		2000		2015		P-values H_0 : differences =0
	Index	SE	Index	SE	Index	SE	
Gini Male	0.764***	(0.1187)	0.761***	(0.1150)	0.729***	(0.1134)	0.9724
Female	0.759***	(0.1072)	0.765***	(0.1074)	0.767***	(0.1140)	0.9983

Table 9: Decomposition of inequality change for individual diseases (Male)

Initial Year	Final Year	Initial Gini	Final Gini	Change in Gini	Re-ranking Index	Progressivity Index
1990	2000	0.761	0.749	-0.012	0.022	0.034
2000	2015	0.757	0.725	-0.033	0.023	0.056
1990	2015	0.760	0.712	-0.048	0.058	0.106

$r > 0$

Table 10: Decomposition of inequality change for individual diseases (Female)

Initial Year	Final Year	Initial Gini	Final Gini	Change in Gini	Re-ranking Index	Progressivity Index
1990	2000	0.759	0.753	-0.006	0.038	0.045
2000	2015	0.763	0.759	-0.004	0.019	0.023
1990	2015	0.757	0.747	-0.010	0.072	0.082

$r > 0$

Figure 3a & 3b suggest that there is a concentration of mortality among severe diseases for both males and females where disease severity is ranked by mortality levels. This inequality has reduced over time, which is consistent with the significant Gini indices in table 8. The inequality is greater among males than females, and the change in inequality for females is almost indistinguishable from the Lorenz graph. The direction of the change is different by gender and this conforms to the Gini indices in table 8. Inequality widened by less than 1 percentage points for females while it decreased by about 3.5 percentage points for males for the 25 year period. The widening in inequality for females could be attributed to changes in lifestyles for females which also makes them susceptible to smoking and alcohol related diseases. P-values close to 1 indicates that the change in the Gini indices over the years is not significantly different from zero at all the relevant significance levels. This implies that we can reject the claim that inequality in mortality between diseases have changed over time.

Table 9 & 10 provide detailed information on the decomposition of the change in inequality in males and females respectively. In table 9, the largest decline in inequality is 4.8 percentage points between 1990 and 2015. This is expected because this is a longer period compared to the other periods. The

positive progressivity indicates that increases in mortality is concentrated among less severe diseases. This usage of the panel data signals that mortality between diseases may be converging. As it is for the individual diseases, increases in mortality among less severe diseases is more than proportional to the effect of the changes in ranks of the diseases. This is why a decline is observed in inequality.

Table 10 provides a more interesting result. This is because when finding the level effect of inequalities in diseases for females, it indicates that this has increased over time. However, the decomposition indicates that for all the time periods considered, inequality has declined, albeit by a small amount. This means considering only diseases that are present in both periods of the decompositions, disparities in mortalities between diseases are narrowing. The inference drawn from this contradictory result is that, the share of mortality of diseases that women are now prone to may be rising compared to those that are already present. The decline in inequality from 1990 to 2015 is 1 percentage point compared to the 0.8 percentage point increase in the level effect. The progressivity effect to the re-ranking effect under the female category is small relative to that under the male category. For all the years, increases in mortality is concentrated among less severe diseases. The changes in ranking as a result of increases in mortality of some diseases did not offset the effect that the increase is concentrated among less severe diseases.

Figure 4: Inequality in Mortality between diseases for different Age categories

Figure 4a: Lorenz curve for Inequality in mortality

Figure 4b: Lorenz curve for Inequality in mortality

between individual diseases (under 5 years)

between individual diseases (5-14 years)

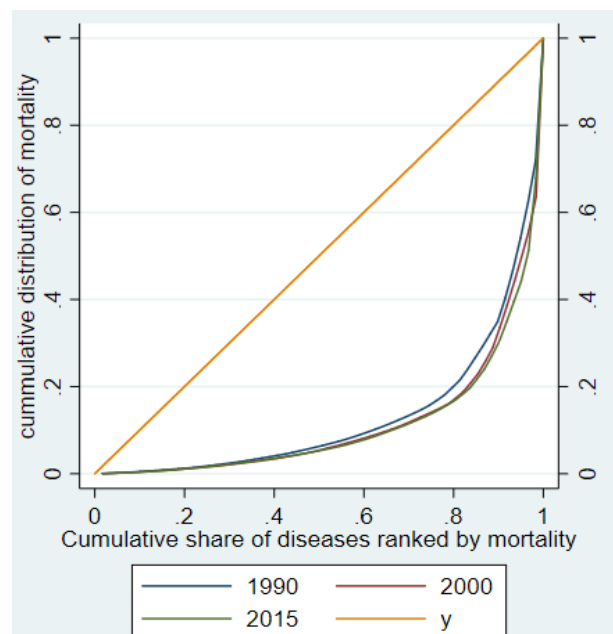
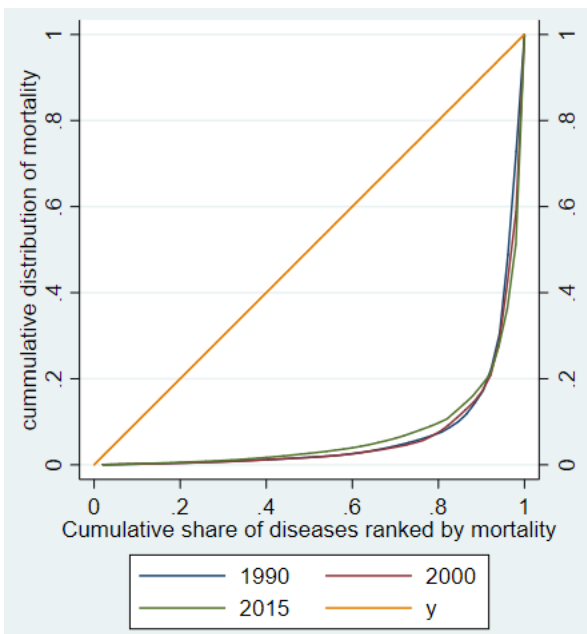


Figure 4c: Lorenz curve for Inequality in mortality between individual diseases (15-49 years)

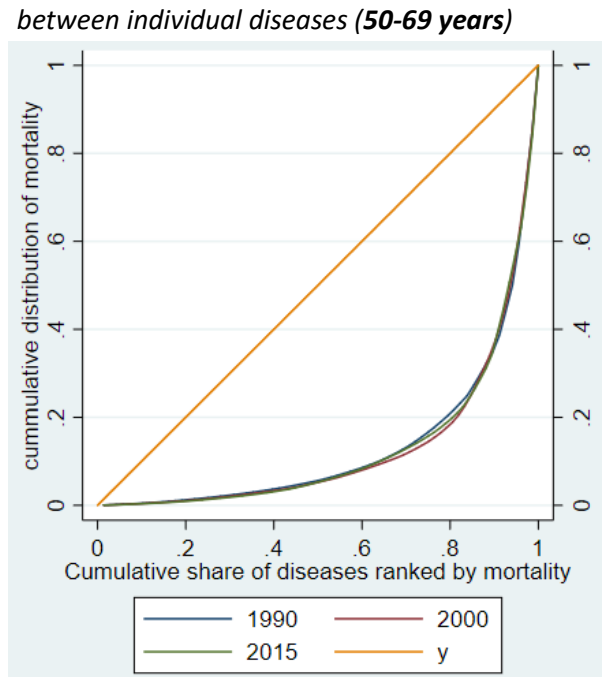
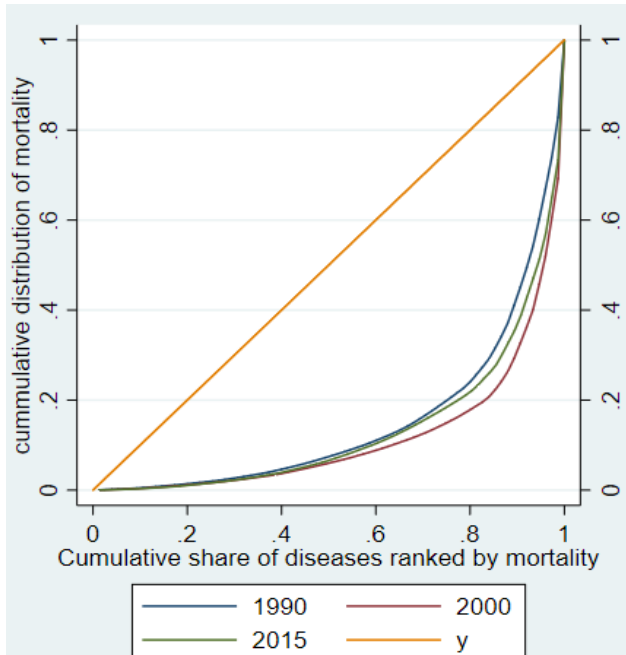


Figure 4e: Lorenz curve for inequality in mortality

Between individual diseases (70+ years)

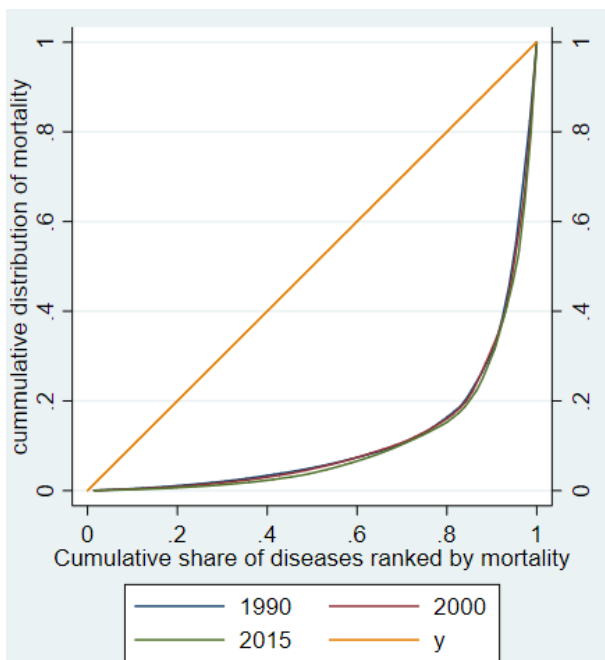


Table 9: Gini Indices for individual diseases by age categories

Individual Diseases (Gini Indices)	1990		2000		2015		p-values H ₀ : differences =0
	Index	SE	Index	SE	Index	SE	
Under 5 years	0.858***	(0.1995)	0.866***	(0.2368)	0.853***	(0.2704)	0.9993
5 -14 years	0.738***	(0.1530)	0.768***	(0.1967)	0.776***	(0.1868)	0.9878
15-49 years	0.697***	(0.1005)	0.765***	(0.1723)	0.731***	(0.1475)	0.9457
50-69 years	0.736***	(0.1148)	0.745***	(0.1075)	0.742***	(0.1072)	0.9983
70+ years	0.766***	(0.1291)	0.772***	(0.1338)	0.786***	(0.1389)	0.9940

Our final graphs are illustrations in inequality in mortality between diseases for different age categories. Generally, there is concentration of mortality among severe diseases and the direction of change over the years however differs across the age categories. The most striking result that is observed is that the concentration of mortality among severe diseases is far greater in children under 5 years, which is consistent with the Lorenz graph and Gini indices though this inequality has narrowed over time. For instance, neonatal disorders have been reduced from 11.59% to 10.52% whereas nutritional deficiencies which has damaging impact on children have reduced from 2.7% to 1.76% in 1990 and 2015 respectively. The change in the inequality is however not monotonous over time, between 1990 and 2000, there is a widening of inequality. Between 2000 and 2015, the inequality narrowed. The narrowing inequality can be interpreted as an increased likelihood for those affected with severe diseases to receive treatment. The changes in inequality as indicated in table 9 are not statistically different from zero at all the relevant significance levels used.

On the contrary for individuals between the ages 5-14 years, 50-69 years, 15-49 years, and 70+ years concentration of mortality among severe diseases have widened over time. Inequality widened by more than 0.6 percentage points for those between 50-69 years whereas the category with the largest increase were those between 5-14 years. Largest inequality change was about 3.8 percentage points.

The corresponding indices from table 9 confirm this. Similarly, the change in inequality over the years is not statistically different from zero as reported in table 9.

Given that the changes in inequality are small, a larger sample size may have helped to get significance for the power of comparisons in all the analyses.

Table 10: Decomposition of inequality change for individual diseases (under 5 years)

$r < 0$

Initial Year	Final Year	Initial Gini	Final Gini	Change in Gini	Re-ranking Index	Progressivity Index
1990	2000	0.851	0.862	0.011	0.010	-0.002
2000	2015	0.858	0.847	-0.011	0.008	0.019
1990	2015	0.845	0.846	0.001	0.017	0.016

In table 10, average mortality change (r) is negative for all the decompositions. This means that aggregate mortality has declined over time. Inequality increased by 1.1 percentage point between 1990 and 2000 whereas it decreased by the same amount between 2000 and 2015. For the 25- year period the decline was 0.1 percentage point. The negative progressivity index in the first period indicates that the decreases in mortality is concentrated among less severe diseases but by a very small amount. In this same period, the re-ranking effect was higher showing that much of the re-ranking was due to decreases in mortality. From 2000 to 2015, however progressivity effect was higher than the re-ranking effect. This decomposition indicates that inequality rose by 0.1 percentage point between 1990 and 2015.

Table 11: Decomposition of inequality change for individual diseases (between 5 and 14 years)

Initial Year	Final Year	Initial Gini	Final Gini	Change in Gini	Re-ranking Index	Progressivity Index
1990	2000	0.735	0.758	0.023	0.070	0.047
2000	2015	0.763	0.774	0.011	0.011	0.000
1990	2015	0.735	0.769	0.035	0.190	0.155

$r > 0$

The decomposition for those between 5 and 14 years produced similar conclusions to the change in levels. Inequality increased by more than 1.1 percentage points for the 3 periods. Mortality growth for each of the decomposition was progressive. Increases in mortality were proportionally larger for relatively less severe diseases than for the relatively severe. However the high re-ranking effect shows that changes in ranks of the diseases were mostly associated with increases in mortality for those diseases. Interestingly, increases in mortality were proportionally the same for both severe and less severe diseases between 2000 and 2015. Thus, the change in Gini for this period was mainly due to re-ranking effect.

Table 12: Decomposition of inequality change for individual diseases (between 15 and 49 years)

Initial Year	Final Year	Initial Gini	Final Gini	Change in Gini	Re-ranking Index	Progressivity Index
1990	2000	0.697	0.765	0.068	0.016	-0.052
2000	2015	0.760	0.721	-0.039	0.015	0.054
1990	2015	0.691	0.721	0.030	0.034	0.003

$r > 0$

Inequality change is much greater in those between ages 15 and 49 years. The highest change was between 1990 and 2000 where inequality increased by 6.8 percentage points. In this period, the negative progressivity index implies that increases in mortality is concentrated among severe diseases. The re-ranking index which also accounts for changing severity ranks of the diseases was much smaller than the progressive mortality change. In the other periods however, mortality growth was concentrated among less severe diseases.

Table 13: Decomposition of inequality change for individual diseases (between 50 and 69 years)

Initial Year	Final Year	Initial Gini	Final Gini	Change in Gini	Re-ranking Index	Progressivity Index
1990	2000	0.733	0.731	-0.001	0.019	0.020
2000	2015	0.745	0.732	-0.013	0.010	0.023
1990	2015	0.733	0.718	-0.015	0.029	0.043

$r > 0$

Progressive mortality growth was larger in all the time periods for those between 50 and 69 years compared the re-ranking effect. This also shows that mortality between diseases may be converging as increases were proportionally larger for relatively less severe diseases.

Table 14: Decomposition of inequality change for individual diseases (above 70 years)

Initial Year	Final Year	Initial Gini	Final Gini	Change in Gini	Re-ranking Index	Progressivity Index
1990	2000	0.766	0.759	-0.007	0.009	0.016
2000	2015	0.772	0.774	0.002	0.008	0.006
1990	2015	0.766	0.763	-0.004	0.017	0.021

$r > 0$

Similarly for those above 70 years, increases in mortality were more than proportionally larger in relatively less severe diseases compared to less severe diseases. The highest progressivity index from 1990 to 2015 was 0.155 for the age category 5-14 years whereas the lowest index was 0.03 for age category 15-49 years. This means that mortality growth was highly concentrated among severe diseases in those within the ages 5-14 years compared to other age categories. The similarities across all the age categories for the 25-year period is that mortality change favored severe diseases. Therefore, it is an indication that severe diseases over the years may becoming less difficult to combat.

5 Discussion

This research assessed the magnitude and significance of inequality in mortality between diseases in Ghana in 1990, 2000, and 2015. The aim of the study is to investigate how inequality in mortality between diseases have changed over time. This could provide an insight on how the mortality and morbidity effect of severe diseases have changed. In other words, are the strategies employed in controlling these diseases being manifested in the changes in the share of mortality observed in these diseases? Additionally, it could also indicate if there is an increased likelihood of receiving treatment depending on disease severity. Over the years, Ghana has tried to minimize mortality by targeting the key causes. This is because diseases are the major causes of death which account for more than 93% of all deaths with injuries accounting for the remaining 7%. This observation is not only peculiar to Ghana but also globally for which diseases account for about 91% of all deaths (*GBD compare visualization, 2018*).

The study focused mainly on diseases that cause mortality. Subsequently, diseases severity is classified by mortality and DALYs. The results confirm quantitatively that mortality is unequally distributed according to disease severity, i.e. mortality is concentrated among severe diseases in the years under consideration. Mortality is incorporated in severity, thus this will differ according to diseases and inequality is expected. The outcome of interest is to determine how this inequality has changed over time.

With the passage of time, inequality in mortality between diseases have narrowed. This in line with literature (Agyei-Mensah & De-graft Aikins, 2007; Murray et. al, 2012; Boutayeb, 2005; Murray & Lopez 1997), which presented that significant reductions were observed in diseases which were severe in the early 90's due to increased immunization, vaccine availability, and development among others over time. Additionally, epidemiological transition has increased the mortality associated with some diseases especially those in the NCDs category. There are multiple channels through which inequality may have narrowed. A couple of them will be discussed here. To begin with, inequality may have narrowed because the government has made substantial progress in targeting severe diseases, reducing the mortality share of these diseases. This is evident through the several efforts the country made to achieve the MDG 6 which focused on combating severe diseases prevalent in sub-Saharan Africa. The government of Ghana set up a joint team with the United Nations to support the Ghana Aids commission and Ghana Health service to establish the national strategic plan for HIV and prevention of mother to child transmission of HIV respectively. In terms of malaria and tuberculosis, the country did

not only focus on treatment, but it pursued other aspects such as early diagnosis and prevention. These were not only theoretical establishments; significant reductions were observed in new HIV infections (20%), with a reduction in case fatality rate and parasite prevalence associated with malaria, and finally the country made progress in increasing cure rates of tuberculosis (*United Nations Ghana, 2014*). Subsequently, narrowing inequality may indicate more availability of treatment. In 2003, the national health insurance scheme was introduced to improve access to medical care for all (*National Insurance Authority, 2004*). This scheme covered a wide range of treatment with low premium rates hence making it affordable for those in rural areas. In addition, treatments have been made available for health conditions such as neglected tropical diseases that are prevalent in rural areas to reduce the burden associated with these diseases. Ghana has made strides in being one of the countries to have successfully eradicated guinea worm and trachoma which are all neglected tropical diseases (*Ghana Business news, 2017*). The narrowing inequalities can be a manifestation of these actions as these have made severe diseases decrease their share of mortality.

Furthermore, zero mortality was recorded in some epidemics that usually plagued the country. In 2014, the annual health report by the Ghana health service indicated that Ghana has maintained a polio-free status since 2008. In addition, maternal and neonatal tetanus, and measles mortality have remained at zero since 2003 and 2011 respectively (*Ghana Health Service Annual Report, 2015*). This means that with these diseases, their severity ranks have reduced significantly and do not account for mortality anymore. Finally, technological progress in health have helped improved mortality and morbidity rate associated with some subcategories. Most innovation in health in the country are being innovated through mobile phones because Ghana has a mobile phone subscription almost up to 100%. Therefore, through technology, this is the easiest way to reach a major part of the population. To help reduce maternal mortality especially in rural areas, a mobile health technology was launched called mobile midwife in July 2010. This technology is available on mobile phones which provides nursing and pregnant women with reminders either through voice messages or message alerts. The information includes reminders on antenatal visits, treatments, labor services and vaccination. This is tailored to the suit the profile of each woman and this technology has helped improved maternal mortality rate especially in the rural areas that have adopted this technology (*Julia Thomas, 2014; Imani Cheers, 2013*). This and other technological improvements in health have helped reduce mortality and morbidity effect of some diseases. These reasons lead to diseases decreasing their share of mortality over time. Therefore, these could explain why inequality between diseases have narrowed over time.

Splitting the samples by gender, mortality is concentrated among severe diseases for both males and females. However, the change in inequality over time differs by gender. Inequality in mortality between diseases have narrowed over time for males whereas for females, this has widened. Studies (Zere et. al, 2012; Oppong Asamoah & Agardh, 2016; Adamba, 2013) confirm that social and wealth-related inequalities are persistent in maternal mortality and factors that exacerbate it. Between 2008 and 2014, wealth-related inequality was particularly higher in the usage of skilled birth attendance (*Oppong Asamoah & Agardh, 2016*) whereas this inequality was also high in preventive treatment for malaria during pregnancy (*Zere et. al, 2012*). These cause diseases in the maternal disorders category to increase their share of mortality as the country has a strong presence of both rural and urban areas. This persistent inequalities in disease experience and treatment contribute to widening inequalities in mortality between diseases for this population group. Put differently, women with a low social class are more likely to get maternal related diseases while these same women are less likely to have access to treatment and preventive measures. The combination of these two factors implies that mortality for these type of diseases will increase compared to those diseases disparities are inexistent. Additionally, the rising incidence of breast cancer deaths in Ghanaian women and reporting at advanced stages of the disease has led to a poor prognosis thus increasing deaths associated with breast cancer (*Ohene-Yeboah & Adjei, 2012*). These could explain the widening inequalities.

Regarding inequality within different age categories, similar results are identified which shows that mortality is unequally distributed according to disease severity, with concentration among severe diseases. For children under-five years, inequality has narrowed over time whereas for those in other age categories (5-14, 15-49, 50-69, and above 70 years) the inequality has widened. Reasons for the narrowing inequality in children under 5 years could be attributed to the impact of *MDG 4* whose target was to reduce under-five mortality rate by two-thirds from 1990- 2015. Ghana has made significant improvement in the achievement of this target (although it faced stagnation in 2014) by conducting broad immunization and other preventive measures in children. Conversely, the widening inequality for those above 5 years may be explained by the reciprocal relationship between chronic diseases and infectious diseases (Agyei-Mensah & De-graft Aikins, 2007; Murray & Lopez 1997). The burden of infectious diseases which often afflict children make them prone to developing chronic conditions later in life which may explain the widening of inequalities.

Decomposition of the change in inequality indicated that although there was re-ranking of diseases, it was offset by progressive mortality decline. In other words, mortality increases over the years was more

concentrated among less severe diseases, and the average change in the ranks of the diseases that changed from being less severe to severe and vice versa was not high. Therefore, this latter effect was not high enough to overshadow the former effect of progressive mortality decline. The decomposition analysis showed that on average mortality has increased over the years. However, this does not necessarily imply low likelihood of treatment for all the diseases. This is because mortality depends on other factors such as population increase, demographic change which leads to changes in sex and age specific causes of death. This conforms to the literature by Murray et. al (2012) where the findings highlighted the drastic reductions in mortality associated with diarrheal diseases and other severe infectious diseases from 1990 to 2010 contrary to the increases observed in some major NCDs. Similarly Murray & Lopez (1997) projections showed that increases in mortality were going to be relatively larger for diseases that were less severe in the past. Decomposition results with the exception of those under 5 years shows that mortality has increased for all diseases but particularly for less severe diseases. This signals the converging of mortality between diseases.

Similarly, when disease severity is ranked by DALYs, mortality is unequally distributed according to disease severity, with the concentration of mortality among severe diseases. However, with respect to time, this inequality has persisted. This conforms to the literature (Barrenho et. al, 2017; Isaakidis et. al, 2002) that highlighted that a misalignment between drug innovation, randomized clinical research and diseases has persisted when DALYs are used to quantify disease burden. The widening of inequality between diseases when ranked by DALYs may be attributed to the changes in the decomposition of DALYs. DALYs comprises of years of life lost due to premature mortality (YLL) and years of life lived with disability (YLD). Murray & Lopez (2013) noted that the proportions of YLL & YLD that made up to DALYs have changed, with a greater proportion being attributed to YLD rather than YLL.

Put differently, this may imply that mortality of some severe diseases may have been minimized, however the disabling effect of diseases may have been neglected. With this in mind, findings of this study indicates that diseases that are considered severe by DALYs have increased their share of mortality. In table 4, ranking by DALYs, neonatal disorders were considered the third most severe disease subcategory in 1990, second most severe in 2000, and the most severe in 2015. The major conclusion that can be gathered by using different variables to quantify disease severity is that, more focus is on diseases that have high mortality and less focus on diseases that have relatively high disabling but low mortality effect. This is because when mortality is used to quantify disease severity, narrowing inequalities are observed indicating severe diseases have decreased their share of mortality.

However, when DALYs are used to quantify disease severity, widening inequalities are observed indicating a deterioration in mortality amongst diseases. The only difference between DALYs and mortality is the addition of YLD to the former. This therefore indicates that diseases that have high YLD have increased their share of mortality over time. Furthermore, this implies that those with diseases that have relatively higher YLD may have less likelihood of having access to treatment. This is in line with literature (Barrenho et. al, 2017) which presented that innovation for new medicines that are aimed at reducing neonatal disorders are unequally concentrated towards diseases in this category that have low DALYs.

The institute for Health Metrics and Evaluation provided a country report on BoD of Ghana in relation to other comparator countries. According to the report, the country performed bad in reducing the number of DALYs associated with some leading causes of DALYs including sickle cell disease, epilepsy, schistosomiasis, and a couple of others between 1990 and 2010. This is in line with the inference that was drawn earlier. The reason for using DALYs to quantify disease severity is that, it can help policy makers structure disease control programs and treatment that could reduce both mortality and disabilities proportionally.

5.1 Limitations

To begin with, one of the limitations associated with this study involves the errors that come with prospective data gathering. The global burden of disease of data is one of the most comprehensive data on descriptive epidemiology (Murray et.al, 2013). For countries with rural areas such as Ghana, sometimes data on diseases are insufficient or inexistent. Hence, data scientists provided estimates for these diseases by using sophisticated statistical modelling. Therefore, it is possible that the magnitude of the inequality in this study may be underestimated or overestimated. However, it is unlikely that the overall trend will change.

The institute of health metrics and evaluation indicated that when developing estimates for the causes of death, they only show the root cause of the death. Thus, for example if someone dies from a bacterial infection from a non-healing wound due to accident, but it is because of diabetes that this wound could not heal. The death is assigned to the accident and not to the diabetes or wound. This means that if we assume that the inequality has risen because of mortality increase of some diseases, it may lead to a biased conclusion. This could be because the death due to that cause may not necessarily be due to less

disease control programs or lack of treatment, but it may be because of the interaction with other diseases. However, the global burden of disease data is the only available data on epidemiology and the number of times people may die due to a single cause represents the major part of reality thus reducing the bias.

The Erreygers indices that were used for the calculation of the concentration index is bounded. With our mortality data, the lower bound was zero. However, for the upper bound twice the maximum number of deaths in the data was used and the choice of the bound influences the value of the index. As a robustness check, the generalized concentration index (unbounded) which is closer to Erreygers in the family of rank-dependent indicators produced similar conclusions (Erreygers, Guido, 2009).

Also, using mortality as a proxy for not receiving treatment may not necessarily be appropriate. As mortality due to diseases sometimes depends on factors such as lifestyle, choices and other factors. However, this is the closest proxy given the data produced by the global health data exchange.

5.2 Conclusions and Policy Implications

To my knowledge this study is a first step in understanding changes in inequality in mortality between diseases in Ghana. In sum, the direction of the change in inequality in mortality between diseases depends on the variable used to quantify severity. Inequalities have narrowed over time which signals an increased likelihood of having access to treatment especially for severe diseases, when mortality is used to quantify severity. The reverse is true when DALYs are used to quantify severity. However, reductions of inequalities alone do not indicate that disease control strategies or mortality effect of some diseases have been successful. This is because mortality decline is dependent on other factors.

Overall the decomposition results indicates that diseases that were considered less severe in the past years have experienced proportionally larger increases in mortality. If this trend persists, this implies that gradually mortality between diseases will converge. Therefore, diseases that are also considered less severe should be given some priority.

The government should not focus on only diseases that have high mortalities, but it should also place prominence on reducing diseases that have high disabling effect. In other words it should aim on reducing both mortality and disabling effect of disease. This is because when disease severity is

classified by DALYs or by mortality, contradictory results are observed. The use of DALYs to classify diseases severity indicates that inequality has widened over time. This means with diseases that have relatively high disabling effect, their share of mortality have increased over time. Therefore, this calls for government to place emphasis on these diseases.

Though the change in inequality over time is not significant, this study can provide insight on the overall trend of mortality between diseases. That is, it provides insight on whether mortality between diseases are converging. Further research can build on finding a closer proxy for treatment or interventions to investigate how these inequalities have changed.

The widening in inequalities between diseases for females strengthens the case for addressing social inequalities in maternal mortality and other aspects of health.

This research aimed to identify the likelihood of receiving treatment depending on disease severity and does not distinguish between socio economic statuses (SES). Further research can also be conducted to identify how this inequality differs by SES.

It would have been informational to find how the inequality in mortality between diseases differs by the 10 regions in Ghana. This is because some regions are highly urbanized thus it can be an indication of the likelihood of having access to treatment depending on the region. Data was not available by regions, however, when available, possible future studies should make determined effort to research into this area.

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