Socioeconomic inequality in the distribution of non-communicable diseases in Mexico

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Abstract

Introduction: Over the years the burden of non-communicable diseases (NCDs) increased globally, as well as the prevalence of multimorbidity. The burden is especially high in low-and middle-income countries (LMIC) such as Mexico where NCD mortality rates are highest. Further, Mexico stands out with high obesity prevalence (a major risk factor for NCDs) as well as high socioeconomic inequality. This study aims to assess the socioeconomic distribution of NCDs and multimorbidity in Mexico and how this has developed over time.

Methods: Longitudinal data from the WHO SAGE study, Wave 1 (2009/2010) and Wave 2 (2014), were used to assess changes and socioeconomic inequalities in prevalence of NCDs. The NCDs analysed were: cardiovascular diseases (CVD), respiratory diseases, and diabetes. Respondents were included in the study if they were over 50 years old and had full item response on the variables of interest. The Erreygers index and the standard CI were used to assess the socioeconomic distribution of NCDs. The standard CI was decomposed in order to assess which factors contributed to the inequality in NCD prevalence.

Results: A total of 1275 older adults (50+) were included in this study, with an average age of 66 at baseline. An increase in prevalence was found for CVD (+9%), diabetes (+8%), and multimorbidity (+7%). Respiratory diseases decreased slightly (-0.4%). CVD, multimorbidity, and respiratory diseases were concentrated among the wealthier quintiles in both Waves. Over time inequality decreased for CVD and multimorbidity (CVD: 0.104 vs 0.071, multimorbidity: 0.048 vs 0.018) while increasing for respiratory diseases (0.009 vs 0.013). The results for diabetes were not significant. Largest contributor to inequality in prevalence was wealth. Other contributors were living area, insurance, age, and gender.

Conclusion: Overall, the prevalence of NCDs and multimorbidity increased over time, with especially large increases in the poorer quintiles. This results in decreasing inequality (less pro-rich), but overall, the burden of NCDs on the healthcare system increased. Wealth was the main contributor to inequality in NCD prevalence.

Keywords: non-communicable diseases, multimorbidity, Mexico, socioeconomic inequality

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1. Introduction

Non-communicable diseases (NCDs) are increasing in prevalence and cause of death globally. In 2008, 36 million people died as a result of NCDs (63% of all deaths) (WHO, 2011). In more recent times, NCDs cause 41 million deaths globally, each year (71% of all deaths) (WHO, 2021). While in the past the rise of NCDs was mostly a public health concern in Western countries, data now shows that NCDs greatly impact low-and-middle-income countries (LMIC), where most NCD-related deaths (31.4 million, 77%) occur (WHO, 2021). The negative impact of NCDs is clear: they negatively affect social development and reduce productivity and economic growth (WHO & UNDP, 2015). NCDs may lead to individuals being unable to work and losing household income. Moreover, a large part of the healthcare costs related to NCD treatment tends to fall on patients themselves, leading to high household costs. This combination is detrimental to many and leads to increasing poverty rates (WHO, 2021). Accordingly, NCDs are high on the global agenda: one of the UN's Sustainable Development Goals for 2030 is to reduce NCDs by 30% globally (Bennet et al., 2020). In order to achieve this goal, it is important to understand the underlying mechanisms of NCD prevalence. This includes both physiological and behavioural risk factors (e.g., overweight, unhealthy diets), as well as underlying drivers such as socioeconomic inequality and social determinants of health (e.g., living area) (WHO & UNDP, 2015; Marmot, 2017).

The most common causes of NCD-related deaths are cardiovascular diseases (CVD, 17.9 million), cancer (9.0 million), respiratory diseases (3.9 million), and diabetes (1.6 million). Together they account for over 80% of premature NCD-related deaths (deaths before the age of 70) (WHO, 2021). Common risk factors for these NCDs include: obesity, unhealthy diets, physical inactivity, and tobacco use (Wu et al., 2015). These risk factors can help to analyse the differences in NCD prevalence between countries by looking at differences in exposure to these risk factors; higher NCD prevalence in certain countries may be explained by higher prevalence of these risk factors (Dieteren & Bonfer, 2021). Additionally, socioeconomic factors (e.g., wealth) should be considered when discussing NCDs; exposure to the risk factors mentioned above is often higher among disadvantaged population groups, including those in LMIC (WHO, 2021).

Multimorbidity is another growing issue worldwide, notably in LMIC. Multimorbidity is the presence of two or more NCDs in one individual at the same time (Eyowas et al., 2019). For example, an individual could be suffering from both diabetes and asthma simultaneously. There is increasing evidence of rising rates of multimorbidity in lower socioeconomic population groups in LMIC (Niessen et al., 2018). Studies show that less affluent populations develop multimorbidity earlier in life. This is associated with increased risk of premature death, impaired social functioning, mental health issues, and lower quality of life. Furthermore, it is more difficult to manage individuals with multimorbidity than it is to manage patients with a single NCD (Eyowas et al., 2019). Correspondingly, multimorbidity is associated with increasing healthcare costs for both patients as well as the healthcare system, and a large economic burden (Wang, 2018). This puts additional pressure on healthcare systems in LMIC who often already have to deal with a double or triple disease burden: communicable diseases, non-communicable diseases, and reproductive health issues (Eyowas et al., 2019). In addition, LMICs' healthcare systems often struggle to provide the integrated care needed for NCDs due to issues with capacity and quality (Xu et al., 2017).

In Mexico, the number of NCD-related deaths have steeply increased over time: from 323,000 deaths in 2000 to 512,800 in 2016, which accounts for 70% of all deaths (WHO, n.d., A). Moreover, a recent study found that on average 34.5% of the Mexican population suffered from multimorbidity (Rivera-Almaraz et al., 2018). Overweight is a major risk factor for NCDs, and the overweight rate in Mexico is extremely high with 75.2% (OECD, n.d.). While multiple studies have focused on the prevalence of risk factors such as overweight among different socioeconomic groups in Mexico (e.g., Esposito et al., 2020), fewer studies focus on how socioeconomic factors may contribute directly to the prevalence of NCDs and multimorbidity. However, there is evidence that shows that NCDs are more common in lower socioeconomic groups in LMICs (Niessen et al., 2018). In Mexico, this direct link between socioeconomic factors and NCD prevalence is under researched.

Regarding Mexican policies about NCDs it is apparent that they tend to focus on nutrition and less on other relevant factors linked to NCD development, such as socioeconomic aspects (Aceves et

al., 2020). However, these factors are particularly relevant in Mexico, which has high inequality levels. Income inequality is especially high. While economic growth in the past few decades has stagnated, which has led to minimal growth in average wages, the wealth of the top percentile grew fivefold, whilst millions remained in poverty (Hernandez, 2015). Therefore, understanding the role of socioeconomic status on the development of NCDs could help Mexican policy makers to develop more effective strategies to tackle this issue.

1.1. Objective and research questions

This research sets out to analyse the socioeconomic distribution of NCD prevalence and multimorbidity within the Mexican older adult population over the period of 2009-2014, and to assess potential drivers for this. Special attention will be given to socio-demographic and socioeconomic characteristics (e.g., living area, wealth).

The central research question is: To what extent is there socioeconomic inequality in the distribution of non-communicable diseases in Mexico and how has this evolved over time?

- What is the prevalence of non-communicable diseases and multimorbidity in Mexico in 2009 and 2014, and how has this evolved over time?
- What is the socioeconomic distribution of non-communicable diseases and multimorbidity in Mexico in 2009 and 2014?
- How has the socioeconomic distribution of non-communicable diseases and multimorbidity evolved over time?
- What contributes to the socioeconomic inequalities in the distributions of non-communicable diseases and multimorbidity?

To answer these questions Chapter 2 discusses the theoretical background that forms the basis of this study. Here, the conceptual framework and other relevant concepts are defined and discussed. Next, Chapter 3 explains the methodology of the study; study design, study population, data cleaning, the (in)dependent variables, and the data analysis. The results are analysed in Chapter 4 where the most important findings are presented. Last, the discussion in Chapter 5 answers the research questions based on the findings and a critical approach is taken to interpret the meaning

of these results and compare them to existing literature. Additionally, the strengths and limitations will be discussed, and recommendations for future research will be given as part of the conclusion.

2. Background

Due to the high burden of NCDs and increasing mortality rates, NCDs have been analysed extensively over the years. Various studies have researched risk factors and underlying drivers that are related to the development of NCDs and multimorbidity. Figure 1 shows these factors as part of the conceptual model used in this study and is adapted from a figure presented by the WHO (WHO & UNDP, 2015). First, the metabolic/physiological factors directly affect the development of NCDs. Secondly, the behavioural factors affect the development of both the physiological risk factors and NCDs. Lastly, the underlying drivers, which include the socioeconomic (e.g., wealth) and socio-demographic (e.g., age, sex) factors as social determinants of health (WHO & UNDP, 2015). In addition, the concept of socioeconomic health inequality was added to the model. All concepts are discussed below.

2.1. NCDs and multimorbidity

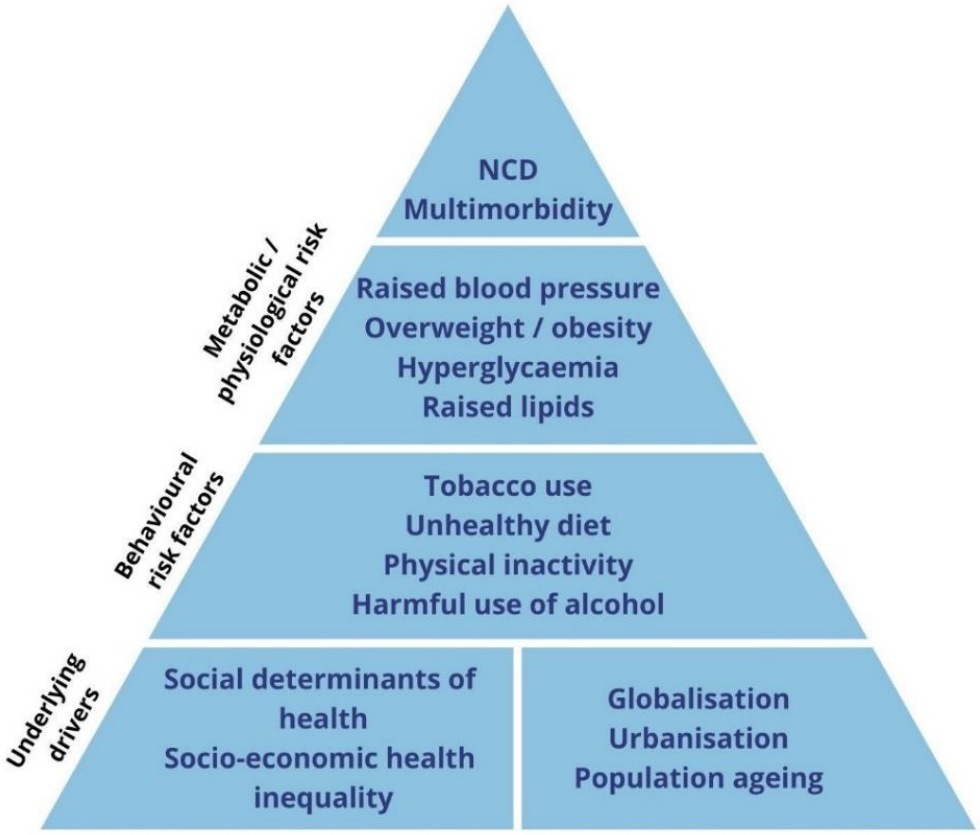
NCDs are chronic diseases which require medical attention for over a year (CDC, n.d., A). Cardiovascular diseases, chronic respiratory diseases, and diabetes are three of the major NCDs which account for over half of the NCD-related deaths (WHO, 2021). These three NCDs are the focus of this study. Furthermore, we will look at the multimorbidity of these diseases, defined as the presence of more than one NCD in a given individual (Eyowas et al., 2019).

2.2. Risk factors

While this study does not focus on the prevalence of physiological and behavioural risk factors itself, it is important to discuss them as they are linked to the underlying drivers, an important focal point in this study.

First, physiological risk factors have direct effects on the development of NCDs. The physiological factors included from the conceptual model are: raised blood pressure, hyperglycaemia, raised lipids, and overweight/obesity. Various studies show how these factors are linked to the development of NCDs. For example, all four physiological factors contribute to the development of CVDs (WHO, 2016; Dokken 2008; Mansour, 2019; Carbone et al., 2019). Notably, from the four physiological risk factors discussed, only overweight/obesity is associated with the three major NCDs discussed in this research (WHO, 2020, A; Murugan & Sharma, 2008; Barnes, 2011;

Figure 1. Conceptual framework. Adjusted from: WHO & UNDP, 2015, p.11



Carbone et al., 2019). These findings are especially relevant for Mexico considering their high rate of overweight (OECD, n.d.).

Behavioural risk factors include tobacco use, harmful alcohol consumption, physical inactivity, and an unhealthy diet. The relation between these factors with both NCDs and the physiological risk factors has been elaborated on extensively in previous literature. For instance, excessive alcohol consumption, physical inactivity, and unhealthy diets all contribute to hypertension and overweight (WHO, 2014; Fock & Khoo, 2013; Traversy & Chaput, 2015). Further, unhealthy diets may result in hyperglycaemia and raised blood lipids (Russel et al., 2016; Mansour, 2019). Additionally, evidence suggests a link between tobacco use and CVD and respiratory diseases (Virdis et al., 2010; Sturke, 2016). Moreover, excessive alcohol consumption increases the risk of developing CVD (Parry, Patra & Rehm, 2011).

Last, there are the underlying drivers which may influence the exposure to the risk factors mentioned above. First, social determinants of health (SDH) are "the non-medical factors that influence health outcomes" (WHO, n.d., B). In this study, the following factors are included as SDH: living area (rural versus urban), insurance, age, gender, and wealth. The link between these determinants and health has been established in various studies. First, there is an increasing movement of people from rural to urban areas. This is a process called urbanisation and is often associated with an increased exposure to risk factors due to sedentary lifestyles (Wu et al., 2015). For example, Oyebode et al. (2015) compared the exposure of risk factors between individuals living in urban and rural areas in various LMIC, including Mexico. They found that smoking was significantly higher among individuals in urban areas. Further, in poorer countries, obesity tends to be concentrated among individuals living in urban areas (Ameye & Swinnen, 2019). Second, another aspect which can affect the exposure to risk factors is insurance. One example is the study of Malta et al. (2020) who analysed the presence of NCD risk factors in the Brazilian population, comparing individuals with and without insurance. They found that insurance was associated with a decrease in risk factors such as smoking. Current literature however tends to stay focused on these differences in risk factors, or differences in NCD mortality, and less on prevalence (e.g., Sommer et al., 2015; Keetile et al., 2019). Third, the socio-demographic factors age and gender are often analysed as underlying drivers which affect the health of individuals. While individuals of all ages can be affected by NCDs, NCDs are mostly associated with individuals of older age. Individuals who die of NCDs before the age of 70, are classified as premature deaths (WHO, 2021). This study only focuses on individuals aged 50+ and does not analyse deaths due to NCDs, but age will be taken as a possible explanatory factor for the presence of NCDs, to see how age contributes to NCD prevalence. Further, gender itself is often associated with health inequality. Due to discrimination, lack of information and autonomy, women often have a more difficult time accessing necessary healthcare than men, which can negatively impact their health and well-being (WHO, n.d., C). Additionally, gender can impact the risk of individuals for developing certain NCDs. For example, Ameye & Swinnen (2019) found that in LMICs, women have a higher rate of obesity than men. On the other hand, men tend to smoke more than women (Peters et al., 2014). Furthermore, some studies suggest multimorbidity affects men and women differently (Eyowas et

al., 2019). Overall, gender is thought to influence the presence of risk factors and the development of NCDs, although this may very per country (WHO, n.d., D).

While multiple studies have linked the above-mentioned underlying drivers to risk factors of NCDs, the question remains if these differences translate to higher NCD prevalence in these groups, and higher socioeconomic inequality.

2.3. Socioeconomic inequalities in health

Inequality can be defined as "the state of not being equal, especially in status, rights, and opportunities" (UN, 2015, p.1). One form of inequality that is frequently discussed is economic inequality concerning income and living conditions (UN, 2015). While inequality is oftentimes conceptualised using such a socioeconomic framework with income inequality at its base, Warwick-Booth (2019) discusses the importance of including other relevant aspects to analyse social inequality: social class, gender, ethnicity, age, and health inequality. Health inequality can be defined as "unfair differences in health outcomes that can be observed between populations, between social groups within the same population or as a gradient across a population ranked by social position." (McCartney et al., 2019, p.9).

It is important to combine dimensions of inequality in analyses as they are often interrelated and linking them is crucial to develop a good understanding of the underlying processes of inequality (McKay, 2002). A good example is the importance of combining the discussion of economic inequality and health inequality. Income inequality is strongly associated with inequality in health and well-being worldwide (Pickett & Wilkinson, 2015). Lower social classes generally spend a larger proportion of their life in ill-health, and often die younger than individuals in higher social classes (Warwick-Booth, 2019). This shows the importance of taking socioeconomic factors into account when analysing health inequality (Marmot, 2017).

Similar inequality is discussed in studies concerning NCDs which show that prevalence for risk factors is higher among individuals with lower socioeconomic status (SES) (Hosseinpoor et al., 2012), where SES is usually measured as a combination of occupation, education, and income (Saegert et al., 2007). Increased exposure among lower SES groups may lead to increasing unhealthy behaviour and even loss of income. The situation is worsened if it results in these individuals developing NCDs, which is linked to further loss of income, as well as premature

deaths. Moreover, individuals in LMIC may struggle with accessing necessary or affordable care (WHO & UNDP, 2015). This is a vicious cycle that can push already disadvantaged population groups further into poverty: "poverty contributes to NCDs and NCDs contribute to poverty" (WHO & UNDP, 2015, p.10). Further, socioeconomic inequality is also found in the prevalence of multimorbidity, where multimorbidity develops earlier in individuals who are less wealthy. This difference in onset of multimorbidity can be as large as 15 years (Eyowas et al., 2019).

To summarise, current literature mainly focuses on the prevalence of NCD risk factors, especially the behavioural and physiological risk factors as presented in Figure 1. However, socioeconomic factors also play an important role when it comes to NCDs. This study aims to understand the distribution of the NCDs by assessing the relationship between NCDs and potential underlying drivers (e.g., wealth, insurance).

3. Methods

3.1. WHO SAGE data

This study quantitatively analyses socioeconomic inequality using data collected by the WHO study on global ageing and adult health (SAGE). SAGE is a longitudinal, cross-national study aimed at collecting information about the health and well-being of older adults in LMICs. The study took place in six countries: Mexico, China, Ghana, India, Russian Federation, and South Africa (INSP, 2014). The overarching goal of SAGE is to "examine changes in the health state of adults and to determine trends and patterns over time." (INSP, 2014, p.110). Thus far, the data of three Waves have been published, Wave 0-2 (INSP, 2014). This study focuses on the data made available for Mexico Waves 1 and 2.

3.2. Study population

The study population of SAGE includes a sample of individuals aged 50+ and a comparison sample of individuals aged 18-49. Participants were selected to participate in the SAGE study based on living area (rural, urban) to ensure the study population was representative of the general population of Mexico (based on location). 31 out of 32 Mexican states were included in the study (INSP, 2014). While all respondents who originally participated in both Wave 1 and Wave 2 were included in the study, some adjustments were made during data cleaning. These adjustments included removing respondents who were below the age of 50 at baseline (Wave 1), individuals for who no wealth index could be calculated due to missing information, and those who did not partake in both Waves. The steps in the data cleaning process are presented in more detail below (3.4.).

3.3. Study design

This study used the data collected in Wave 1 and 2 of the WHO SAGE study. Data collection for SAGE took place in 2009-2010 for Wave 1. This data was collected through questionnaires carried out using the CAPI programme which was developed specifically for SAGE Mexico. Questionnaires included were: the household questionnaire and the individual questionnaire (INSP, 2014). Wave 2 data was collected using a very similar approach in 2014, with some minor adjustments (Rodriguez & Espinoza, 2016). Using the available data from both waves allowed us

to analyse the data over time. The household questionnaire was essential for the construction of the wealth index, while the individual questionnaire includes questions regarding diagnoses of NCDs.

3.4. Data cleaning

Data cleaning was performed in Stata version 16.0. We started with four original datasets from the SAGE study: two individual datasets (one for each Wave), and two household datasets (one for each Wave). These datasets contained the data that was collected through the questionnaires. Using the data from these questionnaires, a new dataset was constructed through data cleaning. This new dataset was used to perform our analyses.

The first step of data cleaning was to remove all incomplete observations from the individual and household datasets. Individuals were removed based on a response variable included in the datasets. Next, wealth indices were created from the household datasets based on a set of household assets. Third, the individual datasets were merged with the household datasets for both Waves separately, after which non-matched observations were deleted. Observations that were not matched were those that had only completed either the individual questionnaire or the household questionnaire, but not both. This step resulted in two new datasets: one for Wave 1, and one for Wave 2. Further, these datasets were appended, matched on id number. This created one large longitudinal dataset where all relevant information from both Waves and both questionnaires was matched for each individual. This allowed us to analyse which individuals took part in both Waves, and which only took part in either Wave 1 or Wave 2. Based on this, observations of individuals who only took part in one of the Waves were removed. Finally, observations without a wealth index or age below 50 at baseline were removed. The result was the final dataset which was used to perform the analyses.

3.5. Variables

After data cleaning the relevant variables were constructed in Stata version 16.0. The dependent variables are the prevalence of NCDs and multimorbidity. We focus on three NCDs in this study: CVD, respiratory diseases, and diabetes. The presence of these NCDs was established using data from the individual questionnaires for both Wave 1 and Wave 2 where data from various questions

was combined to create new binary variables. To find the relevant variables the codebooks for both Wave 1 and Wave 2 were searched using keywords related to the NCDs. Further, as we focus on how NCDs and multimorbidity are distributed among the Mexican population based on wealth, the wealth index is one of our independent variables. Other independent variables included are: age, sex, living area, and insurance.

Dependent variables

First, three relevant questions from the datasets were included to create the variable *CVD*. These were if an individual had been diagnosed with either angina, a stroke, or hypertension by a medical professional. The CVD variable consisted of these three variables and was coded as 1 if an individual had received a diagnosis for at least one of the three separate categories. If this was not the case it was coded as 0.

Next, the variable for *respiratory diseases* consists of two separate questions; whether an individual had been diagnosed with asthma or chronic lung disease by a medical professional. In the SAGE study, chronic lung disease includes the following diseases; emphysema, bronchitis, or chronic obstructive pulmonary disease (COPD). Again, if an individual had received a diagnosis for at least one of these two elements, the new variable for respiratory diseases was coded as 1, and 0 if this was not the case.

Last, *diabetes* was based on the single question whether or not an individual had been diagnosed with diabetes by a health professional (1=yes, 0=no).

It should be noted that for Wave 1, eleven observations had incomplete information on the responses to the questions regarding NCD diagnoses. However, these observations did have complete information for Wave 2. Therefore, as eleven observations equalled less than 1% of the total study population, these observations were not excluded, but the researchers assumed that no response was equal to no diagnosis.

From these newly created NCD variables, the other dependent variable could also be created, namely *multimorbidity*. Multimorbidity was defined as the presence of more than one of the three NCDs (CVD, respiratory disease, diabetes). Thus, the variable multimorbidity was coded as 1 if an individual had received a diagnosis for two or more out of the three NCD variables. In order to do so three subcategories were created for multimorbidity: individuals with both a CVD and a

respiratory disease diagnosis, individuals with both a CVD and diabetes diagnosis, and last individuals with both diabetes and a respiratory disease. These variables were coded 1 if it was applicable to an individual, 0 if it was not. To create the final multimorbidity variable, we looked at the observations for these three sub-variables and multimorbidity was coded 1 if at least one of these three subcategories of multimorbidity was present.

Independent variables

The wealth index was not readily available in the SAGE database but was constructed using data from the household questionnaires for both Wave 1 and 2. All relevant variables were incorporated to create the best possible estimation of wealth. These elements include housing characteristics (e.g., value, availability, and type of water facilities) and other assets (e.g., televisions, cars, livestock). Using this data, a principal component analysis was performed to rank the households based on wealth. This ranking was used to separate the study population into quintiles which allows us to compare population groups (Filmer & Pritchett, 2001). The quintiles go from poorest (Q1) to richest (Q5).

Other variables that were collected from the data set include the following: age, sex, health insurance, and living area. Age is a continuous variable while the other three are binary. For gender, the variable *female* was created, coded as 1 for female and 0 for male. For location we looked at whether individuals lived in an urban (=0) or rural (=1) areas which created the variable *rural*. Last, for *insured* no distinction is made between types of insurance. Hence, any type of insurance whether private or public is coded as 1, and no insurance at all as 0. However, it should be pointed out that for Wave 1, 119 observations (9%) had missing information on the variable for insurance, and for Wave 2 this was 177 (14%) missing observations. Nevertheless, insurance was deemed as a relevant variable which may partly explain any socioeconomic inequality in the prevalence of NCDs. Therefore, these missing observations were included in the analysis as individuals who had no insurance, which allowed insurance to be included in the decomposition analysis.

3.6. Data analysis

The first step in the analysis was to analyse the baseline characteristics of the total study population as well as the separate wealth quintiles. Differences between the quintiles at baseline were tested using a chi-square test for categorical variables, and an ANOVA-analysis for the continuous variables age and wealth. Next, the prevalence of NCDs and multimorbidity in both Waves was analysed, as well as the differences between the two Waves. The differences between the two Waves was tested for significance using a chi-square test. This provided information on any changes in the prevalence of NCDs in the study population over time.

Concentration indices

The second part of the analysis consisted of calculating concentration indices. Concentration indices are widely used in health economics to analyse socioeconomic inequalities in the health of a population (Kjellson & Gerdthma, 2011). These indices show whether the dependent variables are concentrated among those with more or less wealth, according to the wealth ranking. Generally, concentration indices range between -1 and 1, with an equal distribution being an index of 0. The further away from 0, the greater the inequality (Morris et al., 2012). A positive index indicates that the disease is more concentrated among those with more wealth (a pro-rich distribution), while a negative index would suggest the disease is more concentrated among the poor (a pro-poor distribution). The standard concentration index (CI) can be calculated as:

$$CI = \frac{2*cov(y_i\, r_i)}{\mu}$$

where μ represents the mean health of the study population, y_i represents the health of individual i, and r_i the wealth ranking of individual i (Najafi et al., 2018).

In addition to the standard CI, this analysis uses an adjusted index. Because the dependent variables are dichotomous (a disease is either present or not), the boundaries of the standard CI change from -1 to +1, to μ – 1 to 1 – μ. Therefore, the values that the standard CI can take depends on μ, the mean health of a society (Kjellsson & Gerdtham, 2011). To take this into account, literature suggests various adjusted indices, such as the Wagstaff index and the Erreygers index. While there is discussion about which, if any, of the adjusted indices is superior to others (Kjellsson & Gerdtham, 2011), this analysis uses the Erreygers index. According to Erreygers (2009), a concentration index for binary health variables is best when it fulfils four properties: transfer,

mirror, cardinal invariance, and level independence. Transfer entails that "any mean-preserving change of the distribution which favours the better-off is translated into a pro-rich change of the index" and vice versa (p.510). This means that if one individual loses the exact amount of health another individual gains, the index is responsive to this change depending on the wealth ranking of these individuals. Next, the mirror property ensures that the indices for health and ill-health are equal in absolute value but have opposing signs (negative/positive) (Erreygers, 2009). Third, cardinal invariance relates to the measure of a health variable, where the inequality measured should not be responsive to different ways in which health can be measured (e.g., weight measured in kilograms versus pounds) (Kjellson & Gerdtham, 2011). Last, the property specific to the Erreygers index is level independence, where the index does not change if the population as a whole experience the same change in health (Erreygers, 2009). This level dependence shows that the Erreygers index does not dependent on the prevalence of diseases and thus measures absolute inequality. Therefore, using the Erreygers index, we can answer the question about "how far the society is from a state where the upper 50% of the distribution are healthy independently on the prevalence." (Kjellson & Gerdtham, 2011, p.22).

Decomposition of the concentration index

After the concentration indices were analysed, the standard CIs which proved to be significant were decomposed to isolate the effects of variables of interest on the socioeconomic inequality. Decompositions are generally performed on large datasets (e.g., Najafi et al., 2018; Almasi-Hashiani et al., 2017). To ensure the results are as valid and reliable as possible, the decompositions of this study were only performed if the group of individuals diagnosed with a certain disease was over a hundred. In this case, a decomposition analysis was performed using the following variables: sex (*female*), age, insurance (*insured*), living area (*rural*), and the wealth quintiles. This allowed us to analyse if and how much influence these variables have on the socioeconomic inequality of NCDs and multimorbidity.

The decomposition of a concentration index consists of various steps. First, a regression model is composed for the health outcomes and the explanatory variables, after which the elasticities of the explanatory variables are calculated. Next, the concentration indices are calculated for each explanatory variable separately, which shows if these variables themselves are concentrated

among individuals with more or less wealth. The calculated elasticity and CI are then multiplied for each variable which results in the contribution of these variables. Last, from the absolute contribution, the percentage contribution is calculated as the contribution of the explanatory variable divided by the CI of the dependent variable. Additionally, the residual was calculated as the total inequality (CI) – the explained inequality (sum of the explanatory variables). This residual shows how much of the socioeconomic inequality remains unexplained. All analyses were conducted in Stata version 16.0.

4. Results

4.1. The dataset

Figure 2 shows a flowchart of the steps that were taken to construct the dataset which was used to perform the data analyses. The first steps show the original datasets provided by SAGE and how many individuals were removed due to incomplete questionnaires. After merging the individual and household dataset for each Wave and excluding non-matched observations (i.e., individuals who only completed either the individual or household questionnaire but not both) we were left with 2680 observations for Wave 1 and 4417 observations for Wave 2. Next, 2854 individuals only took part in Wave 2, and 1117 only in Wave 1. Because this is a longitudinal study, these individuals were removed. Further, 54 individuals were removed due to missing information on the wealth index, and 234 respondents were below the age of 50 at baseline. The whole process resulted in a final dataset which included 1275 individuals for which all relevant data was available to perform the analyses with.

4.2. Baseline characteristics

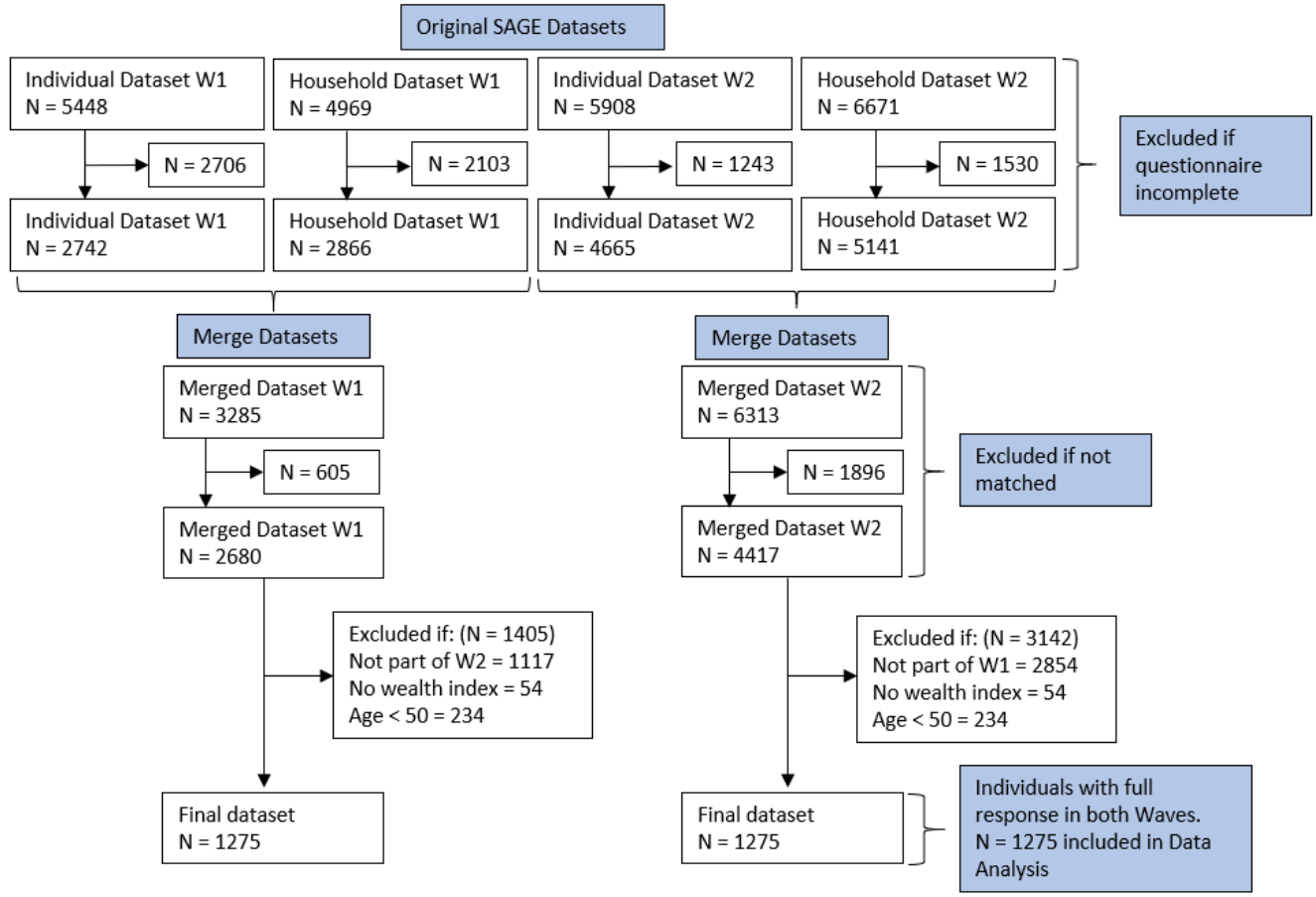
Table 1 presents the baseline characteristics (Wave 1) of the study population. Additionally, it shows the baseline characteristics for each wealth quintile separately, allowing for a comparison between these groups.

Background characteristics

Of the total study population 61% was female. This varies slightly between the quintiles, but this difference was not found to be significant. Further, the mean age of the study population was 66 years old, with slight differences between the quintiles (2.13 years between the oldest and youngest quintile). Although small, these differences proved to be significant: the poorest quintile (Q1) is the oldest, and the ages slowly decrease to where the wealthiest quintile (Q5) is the youngest.

In total, 30% of the total study population lives in rural areas. There are significant differences between the quintiles; from poorest (Q1) to richest (Q5), the number of individuals living in rural areas decrease, while those living in urban areas increase. A similar and significant trend is observed when looking at insurance. 67% of the total study population is insured, but the lower two quintiles show lower numbers of insured respondents than the three upper quintiles.

Figure 2. Flowchart: constructing the dataset



Non-communicable diseases

At baseline, 38% of the total study population was diagnosed with at least one CVD. Analysing the differences between the quintiles it can be observed that the percentage is lower in the poorest two quintiles but increases in the upper three quintiles. This difference between the quintiles was significant when performing a chi-square test.

Respiratory diseases does not show a similar trend and does not show a significant relationship between a diagnosis for this disease group and the quintiles. Overall, 7% of the total population was diagnosed with at least one respiratory disease, and this varies between the quintiles with Q2, Q3, and Q5 having the highest numbers of diagnoses.

Further, 19% of the total study population was diagnosed with diabetes. The table again shows that the number of diagnoses was the lowest for the poorest two quintiles, while these numbers increase in the wealthier quintiles. Especially quintile 3 stands out for the high number of diabetes

diagnoses, with 24% having received a diagnosis. Here, the chi-square showed that this difference between the quintiles was significant.

Finally, 12% of the total study population suffers from two or more NCDs at the same time. The trend for multimorbidity is similar to that of diabetes where the lower two quintiles show a lower number of multimorbidity, while these numbers increase in quintile 3-5. Additionally, Q3 again shows the highest percentage of individuals (16%) who fit the multimorbidity criteria. However, unlike diabetes no significant relationship was found between multimorbidity and the wealth quintiles.

Table 1. Baseline characteristics (Wave 1)

	Total N (%)	**Poorest (Q1) N (%)**	**Poor (Q2) N (%)**	**Middle (Q3) N (%)**	**Rich (Q4) N (%)**	**Richest (Q5) N (%)**
Observations	1275	255	255	255	255	255
Background characteristics						
Female	780 (61.2)	156 (61.2)	151 (59.2)	157 (61.6)	156 (61.2)	160 (62.8)
Age, mean (SD) *	66.42 (±8.1)	67.42	67.09	66.38	65.90	65.29
Location (*rural*) *						
Urban	898 (70.4)	100 (39.2)	168 (65.9)	186 (72.9)	215 (84.3)	229 (89.8)
Rural	377 (29.6)	155 (60.8)	87 (32.1)	69 (27.1)	40 (15.7)	26 (10.2)
Insurance (*insured*) *						
Insured	849 (66.6)	150 (58.8)	144 (56.5)	183 (71.8)	188 (73.7)	184 (72.2)
Uninsured	426 (33.4)	105 (41.2)	111 (43.5)	72 (28.2)	67 (26.3)	71 (27.8)
Non-communicable diseases						
CVD *						
Diagnosed	489 (38.4)	79 (31.0)	90 (35.3)	108 (42.4)	98 (38.4)	114 (44.7)
No diagnosis	786 (61.6)	176 (69.0)	165 (64.7)	147 (57.6)	157 (61.6)	141 (55.3)
Respiratory diseases						
Diagnosed	93 (7.3)	13 (5.1)	23 (9.0)	22 (8.6)	15 (5.8)	20 (7.8)
No diagnosis	1182 (92.7)	242 (94.9)	232 (91.0)	233 (91.4)	240 (94.1)	235 (9.2)
Diabetes *						
Diagnosed	236 (18.5)	39 (15.3)	38 (14.9)	61 (23.9)	45 (17.6)	53 (20.8)
No diagnosis	1039 (81.5)	216 (84.7)	217 (85.1)	194 (76.1)	210 (82.4)	202 (79.2)
Multimorbidity						
≥ 2 NCDs	158 (12.4)	24 (9.4)	24 (9.4)	41 (16.1)	30 (11.8)	39 (15.3)
≤ 1 NCD	1117 (87.6)	231 (90.6)	231 (90.6)	214 (83.9)	225 (88.2)	216 (84.7)

* $p \leq 0.05$ | ** $p \leq 0.01$ |*** $p \leq 0.001$

4.3. NCDs over time

Table 2 shows an overview of the absolute numbers of individuals diagnosed with NCDs in the total study population for both Waves, as well as the differences between the Waves. Starting with CVD, it shows an increase of almost 9%. This increase is mostly due to an increase of individuals who received a diagnosis of hypertension, which increased with 10% between the two waves. The number of diagnoses for angina and stroke also increased, but these increases were small (1% and 0,1% respectively). Furthermore, the number of diabetes diagnoses increased with 8% between Waves 1 and 2.

Notably, unlike CVD and diabetes, respiratory diseases overall decreased between the two Waves. This is the result of an increase in asthma diagnoses, and a simultaneous decrease in chronic lung disease diagnoses. Nevertheless, these changes are all relatively small, with decreases/increases of less than 1%.

Additionally, there was in increase in the number of individuals suffering from multimorbidity; 7%. Dividing this into subcategories, it shows that the increase is almost completely due to an increase in the number of individuals suffering from diabetes and CVD at the same time.

Table 2. NCDs diagnoses over time (total study population)

		Wave 1 **N (%)**	**Wave 2** **N (%)**	**Δ Waves [1]** **N (%)**
CVD	Total	489 (38.4)	602 (47.2)	+113 (8.9) ***
	Angina	26 (2.0)	39 (3.1)	+13 (1.0)
	Stroke	52 (4.0)	53 (4.2)	+1 (0.1)
	Hypertension	450 (35.3)	583 (45.7)	+133 (10.4) ***
Respiratory diseases	Total	93 (7.3)	88 (6.9)	-5 (0.4)
	Asthma	38 (3.0)	44 (3.5)	+6 (0.5)
	Chronic lung disease	64 (5.0)	52 (4.1)	-14 (0.9)
Diabetes		236 (18.5)	327 (25.7)	+91 (8.1) ***
Multimorbidity	Total	158 (12.4)	246 (19.3)	+88 (6.9) ***
	Diabetes & CVD	116 (9.1)	202 (15.8)	+86 (6.7) ***
	Diabetes & RD	20 (1.6)	23 (1.8)	+3 (0.2)
	CVD & RD	48 (3.8)	51 (4.0)	+3 (0.2)
N (total dataset)		1,275	1,275	

* $p \leq 0.05$ | ** $p \leq 0.01$ |*** $p \leq 0.001$

[1] Difference between the two Waves (W2 – W1)

4.4. Concentration indices

The Erreygers indices as well as the standard CI for the dependent variables for both Waves are presented in Table 3. Before going into the interpretation of the indices themselves, it is helpful to compare the Erreygers indices and standard CIs for both Waves.

First, while the Erreygers indices and standard CI are not identical, they do present similar results; when the Erreygers index is positive, the standard CI is positive and vice versa. In addition, the table shows that the standard CI tends to be higher than the Erreygers index when positive, and lower when negative: the standard CI is usually further away from the zero, indicating greater inequality. Exceptions are the indices for total CVD and hypertension for both Waves, as well as the indices for diabetes in Wave 2, where the Erreygers indices suggests a more unequal distribution than the standard CI. However, for diabetes the Erreygers index and standard CI are almost identical.

When interpreting the indices, it is noticeable that apart from asthma all NCDs as well as multimorbidity have positive indices for both the Erreygers index and standard CI at baseline (W1). The negative indices for asthma indicate that this was the only disease more concentrated among the disadvantaged groups at the start of the study while the other diseases are more concentrated among those with higher wealth. Additionally, in Wave 2, the indices for angina show that this disease had a pro-poor distribution in 2014.

Moreover, analysing the significance of the indices we see that some results are more significant than others. Only the significant results will be discussed. Most significant results were found for CVD. Total CVD was concentrated among the wealthier groups for both Waves. Moreover, looking at the subcategories of CVD the table shows that stroke, as well as hypertension were more concentrated among richer individuals in Wave 1. This is no longer the case for stroke in Wave 2, but the results for hypertension remain significant with hypertension showing a pro-rich distribution.

In addition, multimorbidity is also concentrated among those with higher wealth for Wave 1, but the results are less clear in Wave 2. Looking at the subcategories, the results show that especially multimorbidity of diabetes and CVD is significantly distributed among the wealthier individuals, but only for Wave 1.

Table 3. Concentration indices

		Wave 1		Wave 2		Δ indices	
		EI [1]	Standard CI	EI	Standard CI	Δ EI	Δ Standard CI
CVD	Total	0.104 (0.031) ***	0.068 (0.020) ***	0.071 (0.032) *	0.038 (0.017) *	-0.033	-0.030
	Angina	0.009 (0.009)	0.109 (0.103)	-0.003 (0.011)	-0.023 (0.097)	-0.012	-0.132
	Stroke	0.034 (0.013) **	0.208 (0.073) **	0.012 (0.013)	0.070 (0.070)	-0.022	-0.138
	Hypertension	0.079 (0.031) **	0.056 (0.022) **	0.067 (0.032) *	0.037 (0.018) *	-0.012	-0.019
Respiratory diseases	Total	0.009 (0.017)	0.032 (0.054)	0.013 (0.016)	0.049 (0.063)	+0.004	+0.017
	Asthma	-0.011 (0.011)	-0.093 (0.082)	-0.013 (0.011)	-0.098 (0.088)	-0.002	-0.005
	Chronic lung disease	0.014 (0.014)	0.069 (0.066)	0.031 (0.014) *	0.177 (0.078) *	+0.017	+0.108
Diabetes		0.048 (0.025)	0.065 (0.033)	0.052 (0.028)	0.051 (0.027)	+0.004	-0.014
Multimorbidity	Total	0.048 (0.021) *	0.098 (0.042) *	0.018 (0.026)	0.024 (0.033)	-0.030	-0.074
	Diabetes & CVD	0.049 (0.019) **	0.134 (0.050) *	0.012 (0.023)	0.019 (0.036)	-0.037	-0.115
	Diabetes & RD	0.003 (0.008)	0.050 (0.097)	0.003 (0.008)	0.044 (0.107)	+0.000	-0.006
	CVD & RD	0.003 (0.012)	0.024 (0.073)	0.008 (0.013)	0.052 (0.080)	+0.005	+0.028

* $p \leq 0.05$ | ** $p \leq 0.01$ |*** $p \leq 0.001$

[1] Erreygers concentration index

Changes in socioeconomic inequality

The next question is how the concentration indices have changed over time, between the two Waves. Table 3 shows these changes, and therefore if socioeconomic inequality has increased or decreased according to the Erreygers indices and standard CI. Note that the positive or negative signs in the last two columns representing the changes cannot simply be interpreted as a decrease or increase. Rather, this depends on the distribution at baseline, and if an index changed from a negative to a positive value or vice versa. Therefore, as asthma was concentrated among the poor at baseline (Wave 1), a negative change indicates an increase in socioeconomic inequality where the disease has become even more concentrated among the poor. Further, Table 3 shows that angina was concentrated among the rich at baseline (a positive index), but among the poor in Wave 2 (a negative index). Nevertheless, inequality has decreased as the indices in Wave 2 lie closer to 0 than for Wave 1. For the other diseases, a decrease in the concentration index can be seen as a

decrease in socioeconomic inequality and vice versa. Keeping this in mind, this section will now discuss the results for the diseases for which at least one index was significant, or diseases for which the results stand out against the rest.

Focussing on the change as presented by the Erreygers index there are only two diseases for which the indices of both Waves are significant: total CVD and hypertension. Both show a decrease in socioeconomic inequality where the diseases have become less concentrated among the wealthier individuals with a decrease of 0.033 for CVD and a decrease of 0.012 for hypertension. Similar decreases are found for stroke, total multimorbidity, and more specifically multimorbidity of individuals suffering from both diabetes and CVD, which showed a decrease of -0.022, -0.030 and -0.037 respectively. Noticeably, respiratory diseases show an increase in inequality, where the total, and chronic lung diseases specifically, became more concentrated among the rich (+0.017 and +0.004 respectively), while asthma got more concentrated among poor (-0.002).

When analysing the changes as presented by the standard CI we see similar results. There are only two changes for which the indices are significant at both timepoints: total CVD (-0.132) and hypertension (-0.019) for which the distributions have become less pro-rich. Additionally, similar results can be seen for the other diseases as discussed above; stroke, total multimorbidity, multimorbidity of diabetes and CVD, and the respiratory diseases. Last, some changes in the standard CI stand out when it comes to the size of these changes. Angina, stroke, chronic lung disease and multimorbidity of diabetes and CVD show larger changes in the standard CI (-0.132, -0.138, +0.108, -0.115 respectively) than any other disease.

Differences in the changes of concentration indices (EI and CI)

While results show that the Erreygers index and standard CI always show similar results regarding where diseases are concentrated (i.e., if the Erreygers index is positive so is the standard CI, and vice versa), there are some differences in how the indices have changed over time. Therefore, differences in whether socioeconomic inequality has increased or decreased. These differences are apparent for diabetes and multimorbidity of diabetes and respiratory diseases. While the Erreygers index indicates an increase in socioeconomic inequality for diabetes, the standard CI suggests the opposite; a decrease in socioeconomic inequality where diabetes is more equally distributed among the study population. Further, according to the Erreygers index there is no change in the

socioeconomic inequality for multimorbidity of diabetes and respiratory diseases. However, the standard CI shows a slight decrease in inequality for this variable. All other diseases show similar changes when it comes to whether socioeconomic inequality has increased or decreased.

Moreover, there are differences in how large the estimated change in socioeconomic inequality is, even when the change is in the same direction. Overall, it appears that the changes in the standard CI are larger than the changes in the Erreygers indices. This indicates that on average, the standard CI implies there is a larger increase or decrease in socioeconomic inequality than the Erreygers index does. Exceptions are the changes estimated for total CVD where the change in standard CI is smaller than the change as indicated by the Erreygers index.

4.5. Distribution of NCDs between quintiles

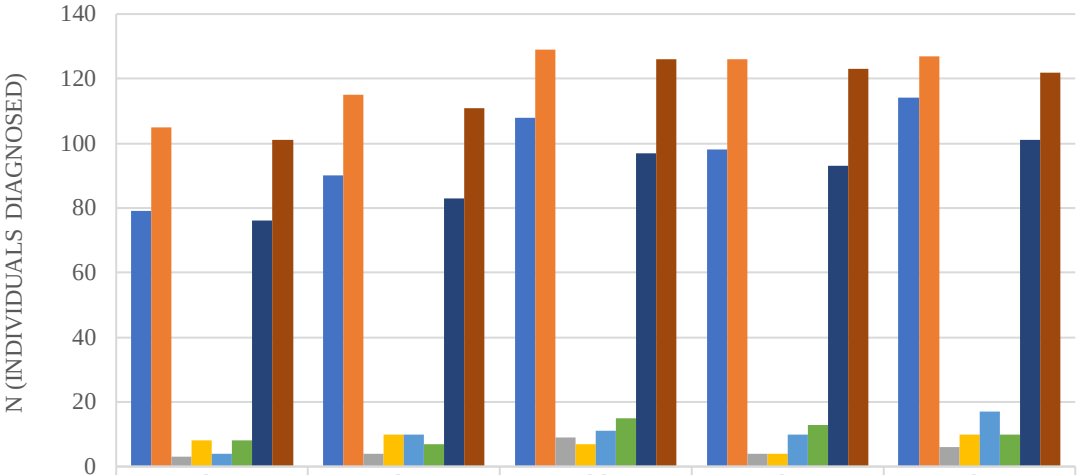
While the Erreygers indices and standard CIs calculate a single number to show whether a disease is more concentrated among the poorer or the wealthier individuals, it does not tell the whole story. Therefore, it is of interest to see how the prevalence of diseases varies among the wealth quintiles. Hence, Figure 3 (CVD), 4 (respiratory diseases), 5 (diabetes) and 6 (multimorbidity) present the distribution of these diseases among wealth quintiles for both waves. While all changes can be seen in the Figures, a few trends are worth noting here.

First, for CVD it can be seen that in Wave 1 the prevalence is often highest among the wealthiest quintile (Q5). This however changes in Wave 2 where Q3 often shows the highest prevalence. Further, it shows that the increase in prevalence in Q5 is lower when compared to all other quintiles (with the exception of angina). This confirms the changes in distribution as presented by the concentration indices, where the distribution as become less pro-rich, with angina as an exception.

Second, Figure 4 shows the changes in respiratory diseases. Here the largest decrease can be seen in Q3 while the prevalence increases in Q5, therefore increasing inequality as shown by the concentration indices. This is however not the case for asthma, where the prevalence also increased in the poorest quintile (Q1).

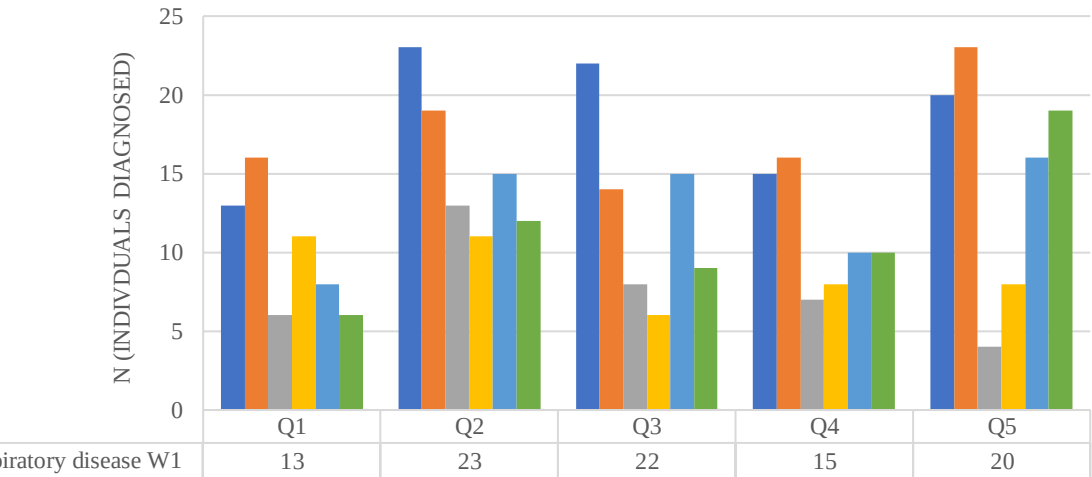
Third, Figure 6 shows that for total multimorbidity as well as its subcategory of diabetes and CVD, prevalence increased over time for all quintiles. However, the wealthiest quintile (Q5) shows a smaller increase than the other quintiles, which is in line with a less pro-rich distribution in Wave 2, as found by the concentration indices.

Figure 3. Distribution of CVD between quintiles (over time)



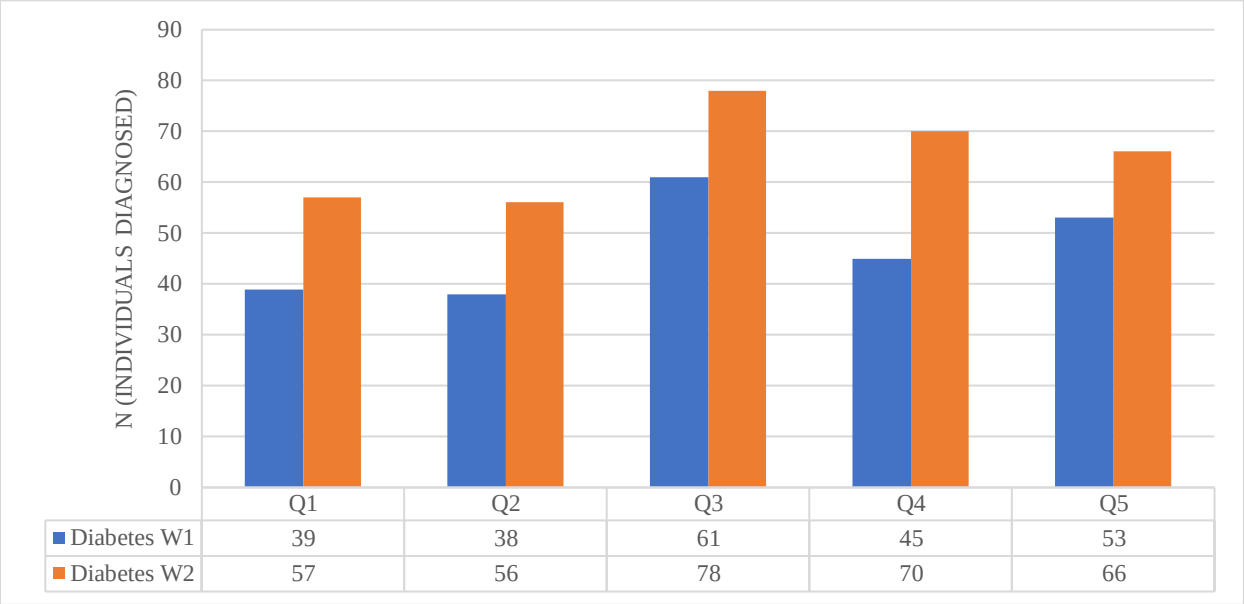
	Q1	Q2	Q3	Q4	Q5
CVD W1	79	90	108	98	114
CVD W2	105	115	129	126	127
Angina W1	3	4	9	4	6
Angina W2	8	10	7	4	10
Stroke W1	4	10	11	10	17
Stroke W2	8	7	15	13	10
Hypertension W1	76	83	97	93	101
Hypertension W2	101	111	126	123	122

Figure 4. Distribution of respiratory diseases between quintiles (over time)



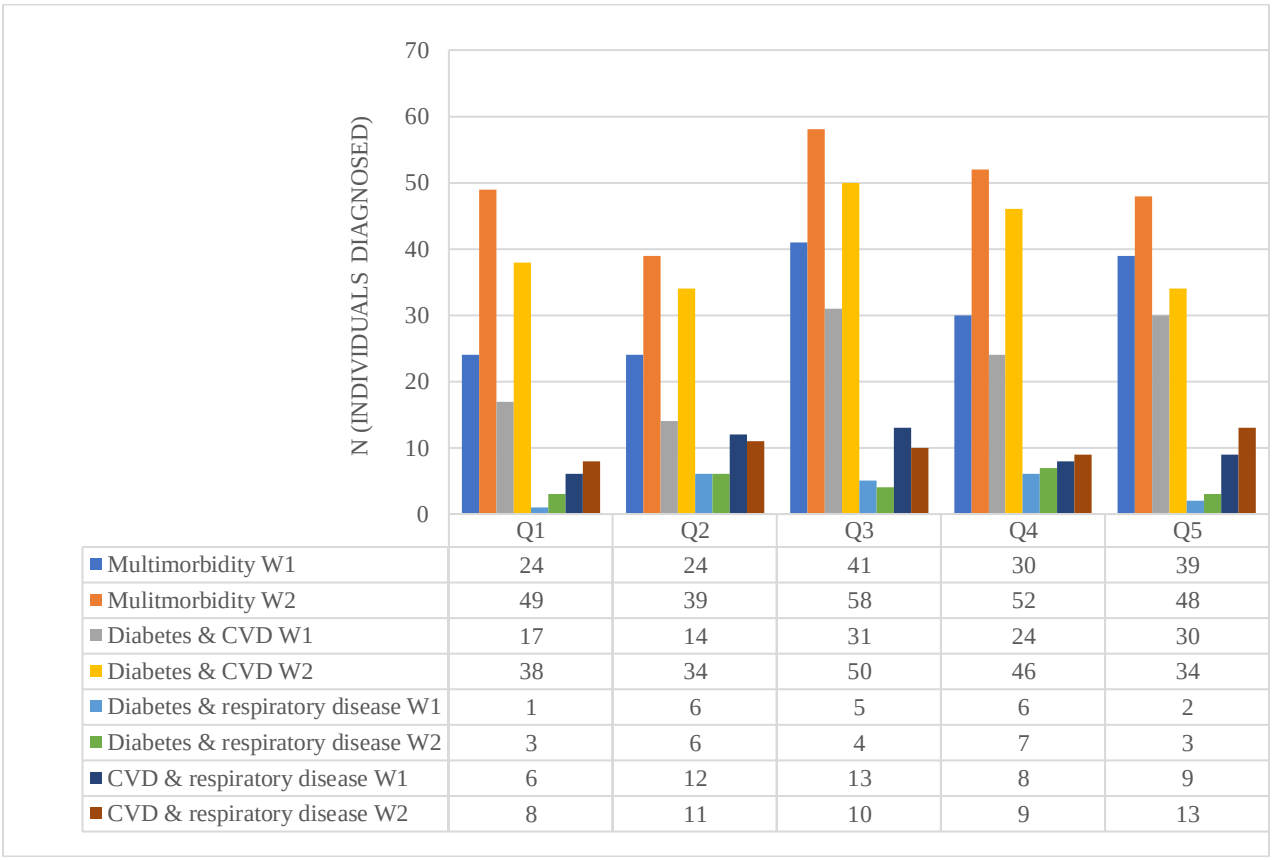
	Q1	Q2	Q3	Q4	Q5
Respiratory disease W1	13	23	22	15	20
Respiratory disease W2	16	19	14	16	23
Asthma W1	6	13	8	7	4
Asthma W2	11	11	6	8	8
Chronic lung disease W1	8	15	15	10	16
Chronic lung disease W2	6	12	9	10	19

Figure 5. Distribution of diabetes between quintiles (over time)



	Q1	Q2	Q3	Q4	Q5
Diabetes W1	39	38	61	45	53
Diabetes W2	57	56	78	70	66

Figure 6. Distribution of multimorbidity between quintiles (over time)



	Q1	Q2	Q3	Q4	Q5
Multimorbidity W1	24	24	41	30	39
Mulitmorbidity W2	49	39	58	52	48
Diabetes & CVD W1	17	14	31	24	30
Diabetes & CVD W2	38	34	50	46	34
Diabetes & respiratory disease W1	1	6	5	6	2
Diabetes & respiratory disease W2	3	6	4	7	3
CVD & respiratory disease W1	6	12	13	8	9
CVD & respiratory disease W2	8	11	10	9	13

4.6. Decomposition of the concentration index

Table 5 presents the results of the decomposition analysis of the standard CIs that were found to be significant. Note that while the concentration indices of stroke (Wave 1) and chronic lung disease (Wave 2) were significant, no decomposition was performed for these variables as less than a hundred individuals had been diagnosed with the disease.

First, the CIs of each explanatory variables are given. *Female* and *insured* both have positive indices which shows that they are more concentrated among the wealthier groups. *Age* and *rural* on the other hand show negative CIs: older individuals and individuals living in rural areas are more concentrated in poorer population groups. The concentration indices for the quintiles are as expected; more concentrated among the poor for Q2, and more among the rich for Q4 and Q5, while Q3 is right in the middle.

Moreover, the table shows the elasticity, contribution, and percentage contribution to inequality of each explanatory variable. The higher the percentage contribution, the greater the contribution to socioeconomic inequality. The table shows that the wealth quintiles generally have a high contribution when it comes to inequality. This is especially noticeable for the two wealthiest quintiles; Q4 and Q5. Q2 also shows high contributions for CVD and hypertension in both Waves, but less for multimorbidity and its subcategory of diabetes and CVD. Overall, the wealth quintiles account for a large part of the socioeconomic inequality that was found.

Next, the other explanatory variables show varying contributions to the socioeconomic inequality. For CVD and hypertension, the highest contributor apart from wealth is age, varying from an 8.0 – 9.0 percentage contribution. The second largest contributor for these diseases is insurance, with a contribution ranging from 4.5 – 7.9%. Following this is gender (*female*) and living area (*rural*) (-1.5 – 2.7%). The decomposition for multimorbidity shows different results: rural is the highest contributor, followed by female, insured, and last age.

Additionally, we see that large parts of the socioeconomic inequality for all diseases in Table 4 could be explained by the explanatory variables included in the decomposition. The residual shows the percentage contribution of socioeconomic inequality that is left unexplained, which ranges from 1.1 – 6.8%

Table 4. Decomposition of the standard CI

		CVD W1		CVD W2		Hypertension W1		Hypertension W2		Multimorbidity W1		Diabetes & CVD W1	
	CI [1]	Elast [2]	Contri [3] (%)	Elast	Contri (%)	Elast	Contri (%)	Elast	Contri (%)	Elast	Contri (%)	Elast	Contri (%)
Female (ref: male)	0.008	0.208	0.002 (2.4)	0.187	0.001 (3.9)	0.266	0.002 (3.7)	0.208	0.002 (4.4)	0.383	0.003 (3.1)	0.410	0.003 (2.4)
Age	-0.006	0.867	-0.005 (-8.0)	0.554	-0.003 (-9.1)	0.886	-0.006 (-9.8)	0.548	-0.003 (-9.2)	0.125	-0.001 (-0.8)	0.277	-0.002 (-1.3)
Rural (ref: urban)	-0.338	0.003	-0.001 (-1.2)	-0.003	0.001 (2.7)	-0.002	0.001 (1.3)	0.002	-0.001 (-1.5)	-0.043	0.014 (14.6)	-0.015	0.005 (3.7)
Insured (ref: non-insured)	0.057	0.054	0.003 (4.5)	0.053	0.003 (7.9)	0.068	0.004 (6.9)	0.039	0.002 (6.0)	-0.037	-0.002 (-2.2)	-0.005	-0.002 (-1.7)
Poorest (Q1)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Poorer (Q2)	-0.400	0.026	-0.010 (-15.1)	0.018	-0.007 (-19.3)	0.018	-0.007 (-13.0)	0.020	-0.008 (-21.3)	-0.005	0.002 (2.2)	-0.026	0.010 (7.7)
Middle (Q3)	0.000	0.060	0.000 (0.0)	0.039	0.000 (0.0)	0.046	0.000 (0.0)	0.043	0.000 (0.0)	0.099	0.000 (0.0)	0.119	0.000 (0.0)
Richer (Q4)	0.400	0.041	0.016 (24.4)	0.034	0.014 (36.2)	0.038	0.015 (27.2)	0.039	0.016 (42.4)	0.027	0.011 (11.2)	0.059	0.024 (17.6)
Richest (Q5)	0.801	0.075	0.060 (88.5)	0.036	0.029 (98.9)	0.056	0.045 (80.6)	0.038	0.030 (81.5)	0.081	0.065 (66.2)	0.108	0.087 (64.7)
Total inequality explained			0.065 (95.4)		0.037 (98.9)		0.054 (96.9)		0.038 (102.2)		0.092 (94.4)		0.125 (93.2)
Residual			0.003 (4.5)		0.000 (1.1)		0.002 (3.1)		-0.001 (-2.2)		0.006 (5.6)		0.009 (6.8)
Total CI			0.068 (100) ***		0.038 (100) *		0.056 (100) **		0.037 (100) *		0.098 (100) *		0.134 (100) *

* $p \leq 0.05$ | ** $p \leq 0.01$ |*** $p \leq 0.001$

[1] Concentration index of the explanatory variables

[2] Elasticity

[3] Contribution

4.7. Comparing the decomposition and standard CI results

Having analysed the indices and the decomposition, the question follows: can this decomposition explain the results found by the indices? Starting with CVD it seems that the findings of the decomposition are in line with those of the standard CI. The standard CI showed that the prevalence of CVD became less concentrated among the wealthier quintiles. Accordingly, one may expect to see this in the contributions of the decomposition. This is indeed the case for CVD. Comparing the contributions of wealth between the two waves, Table 5 shows that the contribution of Q4 and Q5 decreased slightly, from a combined contribution of +112.9 in Wave 1, to a combined contribution of +112.7 in Wave 2. This combined with an increase in the contribution of the lower quintile Q2 could possibly explain the decrease in the pro-rich distribution.

For hypertension we might expect similar results as CVD based on the similarities in the standard CI. However, this is not the case as the contribution of the wealthier quintiles (Q4 and Q5) increased more than the contribution of Q2. Therefore, this does not fit the possible explanation as given for CVD. However, comparing the decomposition results for hypertension between the two Waves there is another notable factor: the percentage of the standard CI that can be explained by the explanatory variables. Here, Table 5 shows that while in Wave 1 only 96.9% of the socioeconomic inequality as found by the standard CI could be contributed to the explanatory factors, for Wave 2 this was a 102.2%. This may indicate an overestimation of one or more variables, which could explain some of the differences between the results of the decomposition and the results of the standard CI.

Because for multimorbidity and its subcategory of diabetes and CVD the decomposition was only performed for Wave 1, the results will be compared to that of the other decompositions and their standard CIs. Multimorbidity and the category diabetes and CVD had lower indices than CVD and hypertension, therefore indicating they were less concentrated among the rich. Table 5 does show a smaller contribution for Q4 and Q5. At the same time, Q2 also shows a smaller contribution when compared to CVD and hypertension.

5. Discussion

This longitudinal study quantitatively assessed socioeconomic inequality in the distribution of non-communicable diseases in Mexico and the changes over time. It provides information about the prevalence of three major NCDs: cardiovascular diseases (angina, stroke, hypertension), respiratory diseases (asthma, chronic lung diseases) and diabetes. Additionally, the prevalence of multimorbidity was analysed, defined as the presence of more than 1 NCD in a single individual. It provides insight on the prevalence of these diseases over time and differences between socioeconomic groups. Further, it analyses if socioeconomic inequality has increased or decreased over time. In addition, the study aimed to understand the underlying drivers behind the socioeconomic inequality. Overall, it was found that the prevalence of NCDs in Mexico increased between the years 2009 (Wave 1) and 2014 (Wave 2). The diseases were often more concentrated among wealthier individuals, although less so in Wave 2 when compared to Wave 1. Wealth seems to be the greatest contributor to this inequality in prevalence. The main findings are discussed in more detail below.

5.1. Prevalence of non-communicable diseases in Mexico

The prevalence of most NCDs included in this study increased over time. The biggest increase was seen in CVD (from 39 to 47%), especially hypertension (from 35 to 46%). These results are in line with Arredondo et al. (2018) who observed an increasing trend in hypertension and expects it to keep doing so. Campos-Nonato et al. (2013) on the other hand suggests a stabilisation of hypertension. They measured blood pressure of their study population using the recommended procedures of the American Heart Association and found that 40% of individuals with hypertension had not previously been diagnosed. Hence, they state that the diagnostics in Mexico may be lacking and should be improved. Should that be the case, this may have affected our findings which are based on if individuals had received a diagnosis at the time of the questionnaire. If so, our findings may be an underestimation and the number of individuals with hypertension may be even higher. To ensure this is not the case Mexican policymakers should analyse the current diagnostics and expertise of their healthcare workers. They might need to invest in the training for their healthcare workers (Arredondo et al., 2018). Further, it may be important to

encourage regular screening of common NCDs and to provide this opportunity to individuals to reduce the risk of NCDs and to timely diagnose and treat if needed (Mallawaarachchi et al., 2016). Further, the prevalence of diabetes showed an increase from 19% to 26% between the two Waves. This is consistent with Levaillant et al. (2019) who also saw an increase in diabetes diagnoses in Mexico; from 7% in 2006 to 10.4% in 2016. While these numbers may look quite different, it is important to remember that the numbers form this study are older adults only (50+), and that NCDs are generally concentrated in this age group (WHO, 2021), which differs from Levaillant et al. (2019) where the focus was adults in general.

The increase in diabetes and CVD patients may be due to various reasons. Medina et al. (2020) stated that the increase is largely due to a decrease in physical activity. Additionally, Soto-Estrada et al. (2018) linked the increase in diabetes to worsening eating patterns, including higher calorie consumptions and an increase in sugar. Furthermore, Davila-Cervantes (2020) established a link between CVD and an increase in various risk factors such as high BMI, dietary risks, and high LDL cholesterol.

In addition, as both CVD and diabetes diagnoses increased separately, so did the number of individuals suffering from both diseases at the same time. This is not the first study to find a link between diabetes and CVD. Hernández-Ávila et al. (2013) found that 47% of individuals with diabetes had also been diagnosed with hypertension and 4% with stroke. This link between CVD and diabetes has been researched in previous literature, which showed an important relation between the two. Diabetes patients often suffer from obesity and raised blood pressure, both of which are risk factors for CVD, therefore increasing diabetes patients' risks of developing CVD (Leon & Maddox, 2015).

Respiratory diseases showed a slight decrease in prevalence. This decrease was mainly due to a decrease of individuals diagnosed with a chronic lung disease, in this study: emphysema, bronchitis, or COPD. Interpreting this it is helpful to look at smoking prevalence, one of the main risk factors of respiratory diseases, especially chronic lung diseases (CDC, n.d., B). Zavala-Arciniega et al. (2020) found a 50% decrease in smoking prevalence of daily smokers between the years 2002-2016. This may have resulted in the decrease in prevalence of respiratory diseases found in this study, more specifically the decrease in chronic lung diseases.

5.2. The socioeconomic distribution of NCDs in Mexico over time

Results showed a significant pro-rich distribution for the following diseases: total CVD (both Waves), stroke (Wave 1), hypertension (both Waves), chronic lung disease (Wave 2), total multimorbidity (Wave 1), and multimorbidity of diabetes and CVD (Wave 1). This indicates that at these times, these diseases were concentrated among the wealthier individuals. Analysing the change in inequality over time showed that chronic lung disease is an exception compared to the others as it showed an increase in inequality (more pro-rich), whereas the others showed a decrease in inequality (less pro-rich). The increase in inequality for chronic lung disease was due to an increase in diagnosis for the upper two quintiles and a simultaneous decrease in the lower quintiles. The decrease in inequality for the other diseases may sound positive, but this is not necessarily the case. These diseases showed increases for the whole study population, but especially in the lower quintiles. Overall, this shows a shift where NCDs are becoming increasingly more prevalent in less advantaged groups, therefore increasing the burden of NCDs. The burden is especially high in Q3 for both Waves.

These findings are troubling for various reasons. First, the increase in disease burden for the population as a whole will only increase the burden on the healthcare system and may threaten the ability of the Mexican health system to perform sufficiently under such pressure (Allotey et al., 2014). Further, the increase in NCDs in lower socioeconomic groups can be especially troubling as these individuals are often already disadvantaged. A large part of the Mexican healthcare system is funded directly by its patients, leading to increasing economic gaps between the poor who may have difficulty affording healthcare, and the wealthy who do not. This in turn has shown to affect the overall health of the population (Thelwell, 2020). The increasing burden of NCDs in more disadvantaged groups would therefore likely increase this gap even further. To address this issue, it is important to ensure effective coverage for all citizens of Mexico, regardless of their economic status by ensuring financial protection (Arredondo et al., 2018)

As this is the first study in our knowledge to analyse changes in the socioeconomic inequality in the prevalence of NCDs in LMIC, we were unable to compare these results to existing literature. Current literature instead tends to focus on socioeconomic inequalities in mortality rates or risk factors (e.g., Sommer et al., 2015; Keetile et al., 2019), but not on the prevalence of NCDs in LMIC.

5.3. Contributors to the socioeconomic health inequality

This study showed that the greatest contributing factors to inequality in NCD prevalence is wealth. This is consistent with the common belief that wealth can have a large impact on health, and therefore the distribution of health within a population (Curran & Mahutga, 2018). The large contribution of wealth may partly be explained by inequality in risk factors. For example, more disadvantaged groups often show higher rates of smoking and alcohol abuse, as well as blood pressure and are therefore at increased risk (Allen et al., 2017; Di Cesare et al., 2013). More advantaged groups however are often less physically active and have unhealthier diets (Allen et al., 2017). Additionally, wealth has been more directly linked to the development of NCDs: socioeconomically disadvantaged individuals in LMIC are at higher risk of developing CVD, COPD, and diabetes according to Sommer et al. (2015). Williams et al. (2018) however found a different relationship where the more advantaged groups are more likely to develop diabetes. This seems to be more in line with our findings where most NCDs are concentrated among the wealthier groups. Overall, more research should be performed to fully understand the true impact wealth can have on the development of NCDs, as this relationship is complicated.

Other possible contributors included in this study were age, gender, living area, and insurance. Results showed that for CVD, age and insurance were the biggest contributors apart from wealth. The opposite is true for multimorbidity where living area and gender showed the highest contributions apart from wealth. All four factors have been previously shown to relate to inequalities in NCD. First, the effect of age could be expected and is often seen as justifiable because NCDs are associated with older age (WHO, 2021 & Rodgers et al., 2019). However, when it comes to multimorbidity the contribution is low, indicating that multimorbidity may affect individuals of any age similarly. Further, insurance was an important contributor to inequality in CVD prevalence. This is in line with previous research by Malta et al. (2016) who concluded that insurance may not only effect inequality in prevalence, but also severeness of NCDs. As for living area, our findings are consistent with Biswas et al. (2016) who found inequality in NCDs based on a comparison of urban and rural areas in Bangladesh, another LMIC. Last, this study's findings showed that gender can affect inequality. Recent evidence from WHO suggest that men may increase their risk of developing NCDs by partaking in risky behaviour (e.g., smoking, unhealthy diets) in all age groups. Women however have an increased biological risk where they are more

likely to suffer from overweight, raised blood pressure, and raised cholesterol solely due to their gender. This especially holds true the older women get (WHO, 2020, B). This may explain the higher contribution of the variable *female* in our decomposition for inequality.

5.4. Strengths and limitations

Multiple steps were taken to ensure reliability and validity of this study. First, the data that was used comes from a large longitudinal study from WHO (SAGE). Using longitudinal data allowed for a comparison over time to establish if any trends were apparent in the disease burden of NCDs. This may be more informative for policy makers than data from a single point in time, to allow them to make more informed choices in line with the current developments. However, a limitation of using this data is that it was collected in 2009/2010 for Wave 1 and in 2014 for Wave 2 (INSP, 2014; Rodriguez & Espinoza, 2016). While the data for Wave 3 has been collected, unfortunately this has not been made publicly available yet and could not be included in this study. Therefore, any developments after the year 2014 are not represented in this data.

Further, the study included a large sample of the Mexican population with participants from 31 out of the 32 Mexican states. To ensure a representative sample, the SAGE research team paid special attention to the living area (urban versus rural) of participants during the selection of the study population (INSP, 2014). After the data cleaning the final study sample was compared with the original to ensure a similar distribution of individuals living in the urban and rural areas, as intended by SAGE.

Additionally, the Erreygers index was used for the first part of the analysis as it satisfies all conditions necessary to produce accurate information in case of a dichotomous outcome variable (Erreygers, 2009). Unfortunately, it was not possible to perform a decomposition of the Erreygers index, which is why the standard CI was also added to the analysis, which was then decomposed. However, keeping the Erreygers index for the first part of the analysis allows for a comparison between the two approaches to allow for the best possible representation of the true socioeconomic inequalities in NCD prevalence.

Another limitation to this study is that it was not possible to include cancer with the available data collected from the SAGE study, even though this is one of the four major NCDs (WHO, 2021). Next, while education is often thought be a possible contributing factor to inequality (INSP, 2014)

there was too much missing information in the data which led to the exclusion of education as a variable, which may have affected the results of the decomposition. Additionally, while insurance was included in the analysis, one should keep in mind that this variable also included some missing data. Moreover, there may be other relevant variables for the decomposition which were not included (e.g., smoking, alcohol consumption, diet). Further, while this study included over a thousand respondents, some disease groups were relatively small which may have impacted which findings were significant, as well as the ability to perform a decomposition for stroke and chronic lung disease.

6. Conclusion

The central aim of this study was to analyse if there was socioeconomic inequality in the distribution of non-communicable diseases in Mexico and if so: to what extent, and has this evolved over time? Data showed an increase in all NCDs included in this study, except for respiratory diseases. Additionally, multimorbidity (individuals suffering from more than one NCD at the same time) increased over time, especially the combination of CVD and diabetes.

Socioeconomic inequality of the prevalence of these NCDs decreased between Wave 1 (2009) and Wave 2 (2014). For both points in time, NCDs were more concentrated among wealthier individuals, but less so in Wave 2. This is the result of greater increases in prevalence in the lower quintiles (Q1-Q3/4) than the wealthier quintiles (Q4/5). The biggest contributing factor to the inequality in NCDs prevalence in this study was wealth, explaining in part the pro-rich distribution of these diseases. Other contributors to the inequality were insurance, living area, gender, and age, although these varied in size of contribution.

The increasing prevalence of NCDs in Mexico is troubling due to the pressure it puts on the healthcare system (Allotey et al., 2014). The increase in multimorbidity makes this even more burdensome due to the challenging nature of treating and managing multimorbidity (Eyowas et al., 2019). Moreover, even though socioeconomic inequality has decreased this is not necessarily a positive. The overall disease burden still increased, and a larger share of the Mexican older adult population is now experiencing the negative effects of NCDs. Further, it is troubling that the prevalence is increasing more rapidly in individuals with lower wealth, who often already struggle with accessing affordable healthcare (Thelwell, 2020). This is an issue to take seriously, and steps should be taken to address the increasing prevalence of NCDs and multimorbidity in Mexico.

Based on these findings we recommend that policymakers increase prevention and health promotion programmes in order to timely address the increasing prevalence of NCDs and multimorbidity. Further, it is important to strengthen the healthcare system to ensure it can endure this increasing burden of NCDs and multimorbidity. One step in this direction would be to address the possible issues regarding diagnosis, to ensure individuals get regular check-ups of good quality. This allows for them to get treatment as soon as possible. To do so, it might be needed to (re)train healthcare staff as mentioned by Arredondo et al. (2018). Additionally, policymakers should

ensure accessible and affordable healthcare to all who need it. The increasing prevalence is especially high in groups with lower wealth, a group who is already disadvantaged. As Arredondo et al. (2018) mentions the growing prevalence of NCDs is likely to increase the economic gap between population groups even further. Therefore, steps should be taken to slow/stop increasing inequality where possible, for example through increasing financial protection.

Further research into the underlying drivers (e.g., insurance, living area) behind the socioeconomic inequality can support policymakers in reaching these goals. Moreover, when reviewing literature it was found that few numbers are available regarding prevalence in NCDs and multimorbidity in Mexico over time, as well as the socioeconomic inequalities present in this distribution. Instead, studies tend to focus on the prevalence of risk factors and mortality. While these are also important, numbers on prevalence may help tell a more complete story. Additionally, the relation between wealth and NCD prevalence is complex, and more research is needed in LMIC countries such as Mexico to understand the full extent of this relationship. Only then, when policymakers have all the necessary information, policy programmes can be developed which include all relevant aspects to tackle the issue appropriately.

7. References

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