Erasmus School of Health Policy & Management

Socioeconomic inequalities in obesity among Mexican adults between 2009 and 2015

Master Thesis Health Economics, Policy & Law
Erasmus University Rotterdam

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Preface

This thesis was written for the master Health Economics, Policy and Law at the Erasmus School of Health Policy & Management. During this master, I became interested in the topic of socioeconomic inequalities and global health, and I am grateful that I have been able to do further research on this topic. Even though this study year was different than expected due to the corona pandemic, I have thoroughly enjoyed the program and the thesis writing process. I have learned a lot, and I am looking forward to putting the learned knowledge into practice.

Writing this thesis would not have been possible without the guidance and feedback of my supervisor Igna Bonfrer. Although we had to adapt to the online environment, she was able to give me all the tools I needed to make this research a success. Her extensive knowledge of socioeconomic inequalities and her expertise with STATA helped me a lot. I would therefore like to thank her very much for her assistance in completing this thesis successfully and on time.

I have enjoyed working on this topic for the past five months and I hope it will bring you just as much reading pleasure.

Amsterdam, 16 June 2021

Sophie Roberti

Abstract

Background

The obesity prevalence in Mexico has increased over the last decades, with currently 36.1 percent of the adult population being obese. One reason for this increase is the economic growth in Mexico over the last decades. The increasing obesity prevalence has consequences for the health of the Mexicans since obesity is a risk factor for non-communicable diseases (NCDs). Moreover, the costs associated with NCDs challenge the sustainability of the Mexican healthcare system. In addition, a transition of the concentration of obesity prevalence from the wealthier to the lower socioeconomic groups is observed with rising wealth, leading to increasing socioeconomic inequalities in health. From a policy perspective, it is important to develop interventions to stop the rise in obesity. This study contributes to the gap in literature by estimating and quantifying the size of the socioeconomic inequalities in obesity in Mexico. The aim is to provide a better understanding of the socioeconomic inequalities and its underlying drivers. This can help policymakers develop policies to prevent a further rise in obesity.

Methods

Data of the longitudinal World Health Organization (WHO) Study on global AGEing and adult health (SAGE) for 2009 and 2015 were used to estimate and quantify socioeconomic inequalities in the dependent variable *obesity (BMI 30+)*, and to estimate its underlying drivers. The number of respondents in the 2009 data was 2,333, and 3,797 for the 2015 data. Twenty independent variables, identified in literature as determinants for high *obesity (BMI 30+)* rates, were included. A *wealth index* was constructed to identify five wealth quintiles. To get a first understanding of how the independent variables related to *obesity (BMI 30+)*, an ordinary least squares (OLS) regression was estimated. The mean *obesity (BMI 30+)* prevalence for each quintile was estimated to gain insight into the distribution of *obesity (BMI 30+)*. The socioeconomic inequalities in *obesity (BMI 30+)* were presented and quantified with a concentration curve and standard concentration index. A Wagstaff-type decomposition analysis of the standard concentration index of *obesity (BMI 30+)* was used to identify the contribution of each independent variable to the total inequality in *obesity (BMI 30+).*

Results

The concentration indices for *obesity (BMI 30+)* in 2009 and 2015 were respectively 0.090 and 0.081, reflecting a pro-rich distribution. However, the socioeconomic inequalities in *obesity (BMI 30+)* decreased over time and became less pro-rich. The mean prevalence of *obesity (BMI 30+)* in the *richest quintile* declined with 0.8 percentage point, while an increase was observed in the other quintiles. The largest increase in the share of people facing *obesity (BMI 30+)* occurred in the *middle quintile,* were the mean obesity prevalence increased with 3.7 percentage point. The Wagstaff-type decomposition results show that the different levels of wealth had the highest contribution to the total inequality in *obesity (BMI 30+).* Being in the *poor, rich* and *richest quintile* were identified as the main underlying drivers for the existing inequality in *obesity (BMI 30+)* in 2009 and 2015. The role of the other independent variables in explaining the socioeconomic inequalities was small and considered less relevant.

Conclusions

Socioeconomic inequalities in *obesity (BMI 30+)* exist in Mexico, although they decreased between 2009 and 2015. The main reason for this decrease was the declining mean *obesity (BMI 30+)* prevalence in the *richest quintile,* while simultaneously an increase was observed in the *rich, middle, poor* and *poorest quintile.* This indicates a shift in the concentration of the *obesity (BMI 30+)* prevalence from the better-off to lower socioeconomic groups in Mexico. The different levels of wealth also appear to explain the largest share of the existing socioeconomic inequalities in *obesity (BMI 30+).* Policymakers should therefore focus on implementing policies which mainly try to halt the rising obesity rates in the four lowest quintiles.

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1 Introduction

1.1 Problem analysis

Mexico faces an acute obesity crisis, with currently 36.1 percent of the adult population being obese. The obesity prevalence has risen with 42.2 percent from 2000 to 2018 (Barquera & Rivera, 2020; Salas-Ortiz, 2020), with an especially large increase from 2000 to 2006 (OECD, 2010). After the United States, Mexico ranks second highest in the world in terms of obesity (OECD/European Observatory on Health Systems and Policies, 2017; Salas-Ortiz, 2020). If this trend continues, the expectation is that almost all Mexican men and women face overweight or obesity by 2050 (Salas-Ortiz, 2020).

The global prevalence of obesity for 2014 is presented in figure 1. Over the last 40 years, an increase has been observed in the global prevalence of obesity (Jaacks et al., 2019). These global trends of increasing obesity rates are affecting population health (Shah & Braverman, 2012). Contrasting patterns in obesity exist between high-income countries and low-income countries. In high-income countries, obesity is more prevalent among lower socioeconomic groups (Adams, 2020), while in low income countries, obesity is more prevalent among the better-off and considered a symbol of high social status and wealth; a condition of the elite (Dieteren & Bonfrer, 2021; Jiwani et al., 2019). However, in the last couple of decades the obesity rates have increased among lower socioeconomic groups in several low- and middle income countries, such as Colombia, Brazil and Mexico (Jiwani et al., 2019). Templin et al. (2019) studied this transition of obesity from wealthier to poorer segments of the population in 103 low- and middle-income countries (LMIC) and found substantial increases in obesity prevalence among the poorest between 1995 and 2016. They showed that when the GDP per capita in a country increases from US$10,000 to US$50,000, the concentration of obesity shifts from the wealthier elite to all other income deciles as well. This flattening and then reversing pattern in obesity prevalence with increasing GDP per capita, was also described by Adams (2020). Monteiro et al. (2004) found that with increasing income, the poor still experience more difficulties in obtaining low-calorie nutrition, such as fruit and vegetables. Furthermore, these groups often have constraints in obtaining a healthy and active life-style, due to limited free time as well as limitations in access to educational nutrition programmes (Levasseur, 2015). Consequently, the rapid transition of obesity from the elite towards the socioeconomic disadvantaged groups in LMIC leads to increasing socioeconomic inequalities in health (Jiwani et al., 2019). Another reason for increasing socioeconomic inequalities in health could be that the poor often have lower access to good quality healthcare, due to limited abilities to cover out-of-pocket expenditures (Templin et al., 2019).

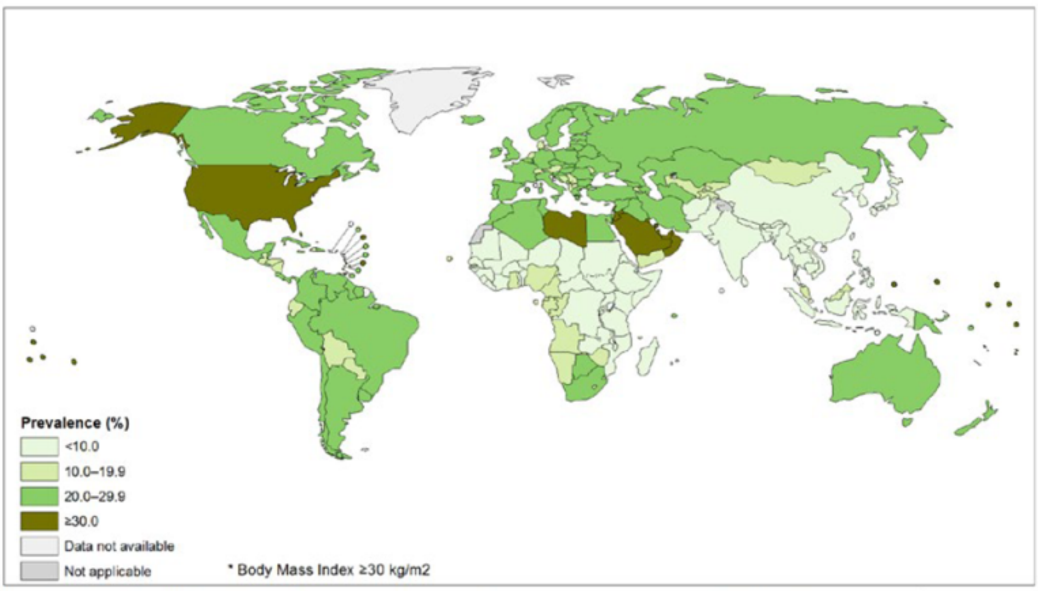


***Figure 1:** "Age-standardized prevalence of obesity in adults aged 18+ (BMI 30+), 2014" (World Health Organization , 2016).*

In Latin American countries, the burden of obesity expanded considerably between the period of 1998 and 2017 as well, with distinctive inequality patterns observed by wealth and education (Jiwani et al., 2019). Ferrer et al. (2014) studied these obesity inequalities by educational level in Mexico from 1988 to 2012. They found that the increase in obesity mainly affects women with lower levels of education in urban areas. The underlying reason is that the transition of low-cost nutrition and high-calorie drink production is lagging behind in rural areas. Salas-Ortiz (2020) also studied inequality in BMI for Mexican adults. This study found that in some Mexican areas the consumption of sweetened beverages such as Coca-Cola is higher than the consumption of bottled drinking water since these drinks are often cheaper. This reflects the limited opportunities of less wealthy citizens to obtain a healthy lifestyle.

The growth in obesity prevalence is -among others- a consequence of the increasing economic wealth that Mexico has experienced over the past decades (Jiwani et al., 2019; Rtveladze et al., 2014). Due to increased availability of low-priced high energy food, resulting from rising wealth, changes in diet have occurred. These changes have major consequences for the health of the Mexicans since they induce a rise in obesity and consequently form a risk factor for obesity-related non-communicable diseases (NCDs) (Rtveladze et al., 2014) such as diabetes, hypertension and various types of cancer (Salas-Ortiz, 2020; World Health Organization, 2016). The costs associated with these poor health outcomes and NCDs challenge the financial sustainability of the Mexican healthcare system and forces Mexican policymakers to develop public health interventions to stop the rise in obesity (OECD, 2010; Rtveladze et al., 2014). Other important drivers for the rising obesity prevalence are the changes in lifestyle towards less physical activity, lack of adequate prevention programmes and lack of information about the consequences of weight gain (Barquera et al., 2009; Salas-Ortiz, 2020). However, relatively little is known about the socioeconomic inequalities and potential shifts of the obesity prevalence from the wealthier to lower socioeconomic groups specifically in Mexico. To effectively inform Mexican policy makers, it is important to provide insight in these socioeconomic inequalities and into its underlying drivers. This study contributes to that gap by estimating the size of socioeconomic inequalities in obesity and changes therein over time between 2009 and 2015 in Mexico. Quantifying existing socioeconomic inequalities in obesity and understanding its underlying drivers can help policymakers develop policies to prevent a further rise in obesity.

1.2 Objective and research question

This research aims to estimate socioeconomic inequalities in the distribution of obesity prevalence and changes therein over time between 2009 and 2015 in the Mexican adult population. The main research question is:

What is the size of the socioeconomic inequalities in obesity in the Mexican adult population and how did these change between 2009 and 2015?

To get a better understanding of changes in socioeconomic inequalities in obesity over time, this study addresses the following sub questions:

- *How is obesity prevalence distributed across different socioeconomic groups in Mexico?*
- *How did this distribution in obesity prevalence change between 2009 and 2015?*
- *Which factors drive the socioeconomic inequalities in obesity in Mexico?*

1.3 Hypothesis

The expectation is that socioeconomic inequalities in obesity did exist in the Mexican adult population and changed in the period between 2009 and 2015. It is expected that the distribution of obesity prevalence shifted from the better-off to lower socioeconomic groups in the Mexican adult society.

1.4 Overview of chapters

Chapter 2 reviews the literature on socioeconomic inequalities in obesity. The measure of BMI, the concept of socioeconomic inequalities and an existing framework for the transition of obesity prevalence are explained. Chapter 2 ends with a conceptual model describing the important variables identified as determinants for obesity. The study population and data collection, the different datasets, the independent and dependent variables, and the different analyses are described in chapter 3. Chapter 4 comprises the results obtained with the different analyses. These results, as well as the strengths and limitations, are discussed in chapter 5. This chapter will end with several policy recommendations. The conclusion of this research is described in chapter 6.

2 Theoretical background

2.1 Body Mass Index

Obesity is defined as "the result of prolonged positive energy balance where energy intake is greater than energy expenditure" (Salas-Ortiz, 2020, p.2). The metric used to determine obesity is the Body Mass Index (BMI), reflecting the height and weight of an individual and is calculated with the formula: weight/(height*height) (Shah & Braverman, 2012). BMI is classified into categories with "overweight" reflecting a BMI between 25 and 30 and "obesity" reflecting a BMI exceeding 30 (Nuttall, 2015). The measure BMI was developed by the mathematical Quetelet for actuarial statistical considerations and not with the aim to measure overweight and obesity in populations (Eknoyan, 2008; Nuttall, 2015). This makes that BMI is criticized and has considerable limitations. BMI in itself is not a measure for health, but a measure of an individual's size (Gutin, 2018). A person can have a very low-fat mass but still have a high BMI, because the measure does not differentiate between fat mass and lean muscle mass (Nuttall, 2015). However, since the rising obesity rates are associated with poor health outcomes and higher incidences of NCDs (Salas-Ortiz, 2020; World Health Organization, 2016), it is a meaningful measure for this study.

2.2 Socioeconomic inequalities

Socioeconomic status (SES) is a measure reflecting social and economic status and is composed of three indicators: education, income and occupation. If there is no information available on these indicators, SES can also be defined in terms of wealth, ownership and subjective SES (Baker, 2014). Inequalities that relate to differences in SES are defined as socio-economic inequalities (McGill, 2014). A correlation exist between the SES and health status of an individual and this relationship have been extensively researched in literature (Wang & Geng, 2019). Therefore, studying socioeconomic characteristics is of importance when analyzing health inequalities (Marmot, 2017).

2.3 Four-stage framework for obesity transition

Jaacks et al. (2019) describe a four-stage framework to explain the transition in the global epidemic of obesity from higher to lower socioeconomic groups across four stages of economic development. The first stage reflects an increase in the obesity prevalence among the higher socioeconomic groups, with a prevalence of obesity between 5 and 20 percent among women (Jaacks et al., 2019). The main reason for only identifying obesity among women in this stage is the existing higher obesity rates (OECD/European Observatory on Health Systems and Policies, 2017; Wells et al., 2012). In the second stage, an increase of the obesity prevalence is observed among women, men and children, where the obesity prevalence is increasing to 20 percent for men and vary between 25 and 40 percent for women. Moreover, the socioeconomic gap between the elite and disadvantaged groups in the society is narrowing, especially among women. During the third stage, the observed gap in obesity prevalence between sexes is closing, while continuing to increase among children. In addition, a faster increase of the average BMI in lower socioeconomic groups is observed. As a response to the observed increase in obesity worldwide, the World Health Organisation (WHO) set a Global Action Plan target to halt this rise of obesity prevalence before 2025 (Menezes et al., 2016; World Health Organization, 2016). If effective, the fourth stage of the obesity transition model by Jaacks et al. (2019) is expected to be a decline in prevalence, reversing earlier patterns. However, this goal has not yet been achieved.

Jaacks et al. (2019) report that Mexico is currently in stage 2 of the obesity transition. Over the last 40 years, the obesity prevalence increased among the lower socioeconomic groups (Jiwani et al., 2019). Simultaneously, a reduction was observed in the socioeconomic differences in obesity, indicating that the socioeconomic gap is narrowing (Jaacks et al., 2019; Meisel et al., 2020). These events are typical characteristics of the second stage of the transition model.

2.4 Drivers for obesity

Earlier literature indicates several variables as drivers for rising obesity rates. The conceptual model presented in figure 2 describes some of these variables. The most straight-forward determinant to develop obesity in a population is increasing wealth (Ford et al., 2017; Swinburn et al., 2011). In LMIC, obesity also appears to be higher among *women*, those living in *urban areas* and people with a higher *age* (Chooi et al., 2019). Other positively contributing determinants indicated in literature are suffering from a *depression* (Luppino et al., 2010), *marriage* (Wilson, 2012), declining levels of *physical activity and* changes in *dietary intake* (Ford et al., 2017; Wright & Aronne, 2012). *Alcohol consumption* seems to be positively related with higher obesity rates as well, although evidence for this is less clear (Traversy & Chaput, 2015). Christakis & Fowler (2007) indicate that there might also be a role for the *social network* in the increasing obesity rates and that when someone in the *social network* is obese, the individual risk of obesity increases. A behavioural factor that is expected to have a negative influence on obesity is *tobacco use* (Dare et al., 2015), just as a *higher level of education* is likely to negatively influence obesity (Ferrer et al., 2014). Other drivers for obesity -understudied in current literature- might be experiencing *difficulties in daily activities* and whether someone *ever worked* in both the informal and formal sector. In contrast, a *(very) good current health status* might negatively influence obesity. This study uses these earlier identified determinants for obesity as variables to explore which can be defined as underlying drivers for the socioeconomic inequalities in Mexico.

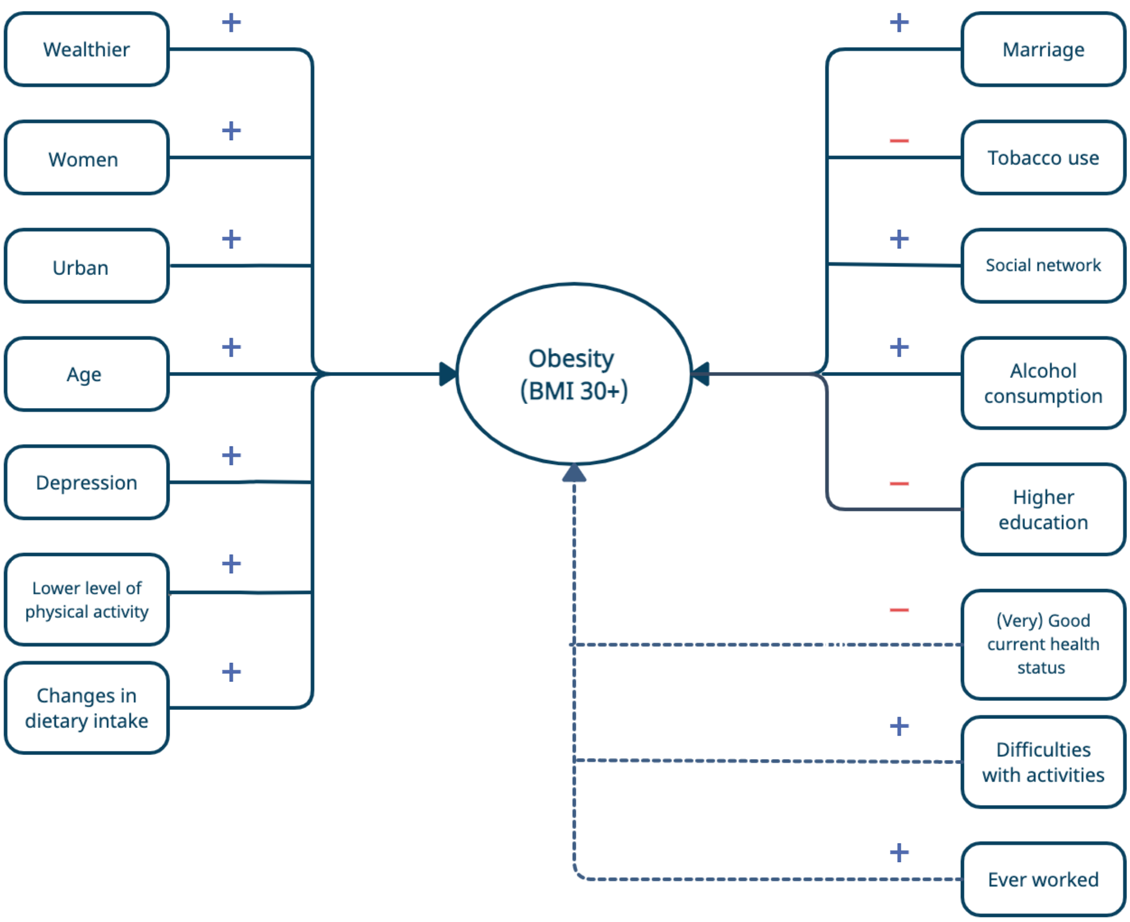


Figure 2: *Conceptual model describing determinants for rising obesity rates. The bold lines indicate variables that contribute to rising obesity rates based on findings in earlier literature. The dashed lines indicate understudied potential determinants in current literature that might contribute to the increasing obesity rates.*

3 Research methods

3.1 General design

This study takes a quantitative approach and aims to explain socioeconomic inequalities in obesity and changes therein over time between 2009 and 2015 in Mexico.

3.2 Study population and data collection

This study used data from two waves (2009 and 2015) of the longitudinal WHO Study on global AGEing and adult health (SAGE) (Biritwum et al., 2013; Kowal et al., 2012; World Health Organization, 2016). SAGE was designed to measure health and well-being, and to follow the ageing process of adults in six countries (Biritwum et al., 2013). In 2009, households were selected in 31 Mexican states. In each state, three visits for data collection were conducted. During the first visit, household level data and data on individual characteristics were collected. On the second visit, anthropometrics, biomarkers, function information and cognitive data were obtained. The third visit consisted of retests by the supervisors (Biritwum et al., 2013). To account for losses in follow-up, replacement and supplementary samples were included (Kowal et al., 2012). Most of the households were living in urban areas. Overall, 48 percent of the household members were male. There was an oversampling of the target population aged 50-plus, since the aim was to measure the health and wellbeing, and the ageing process of adults. A smaller target population with the age between 18 and 49 was included too. The approach in 2015 was similar (Biritwum et al., 2013).

To determine how socio-economic inequalities in obesity changed in Mexico, both changes over time in the entire study sample of 2009 and 2015 (cross-sectional data) and changes in individuals who participated in both 2009 and 2015 (panel data) can be examined. An argument to use the cross-sectional sample is the representativity for the Mexican adult population. Studying this sample will give information about changes in the average BMI and changes in the socioeconomic distribution of BMI in Mexico between 2009 and 2015. At the same time, studying the changes in BMI in individual respondents participating in both 2009 and 2015 can provide relevant information about the changes at the individual level. This study used the cross-sectional sample to examine obesity and changes in its socioeconomic distribution. The panel sample was used for a sensitivity analysis as a validity check. In this sensitivity analysis, the same analyses as in the cross-sectional sample were performed. All the analyses were conducted with the statistical programme STATA16.

3.3 Cross-sectional data and panel data

A household dataset (HH) and individual dataset (IND), with information on asset ownership and individual characteristics respectively, were merged for both 2009 and 2015. The asset ownership data were used to construct wealth indices for each household with a principal component analysis (PCA), which will be explained in section 3.4. Respondents who only had information for either the household dataset or the individual dataset were removed after the datasets were merged. With these merged datasets, steps were taken to construct three final datasets: (1) a cross-sectional dataset for 2009, (2) a cross-sectional dataset for 2015 and (3) a panel dataset containing information for both 2009 and 2015. The different steps taken to construct the three final datasets are described in a flowchart (figure 3). The final cross-sectional datasets for 2009 and 2015 consisted respectively of 2,333 and 3,797 respondents, while the final panel dataset consisted of 1,244 respondents.

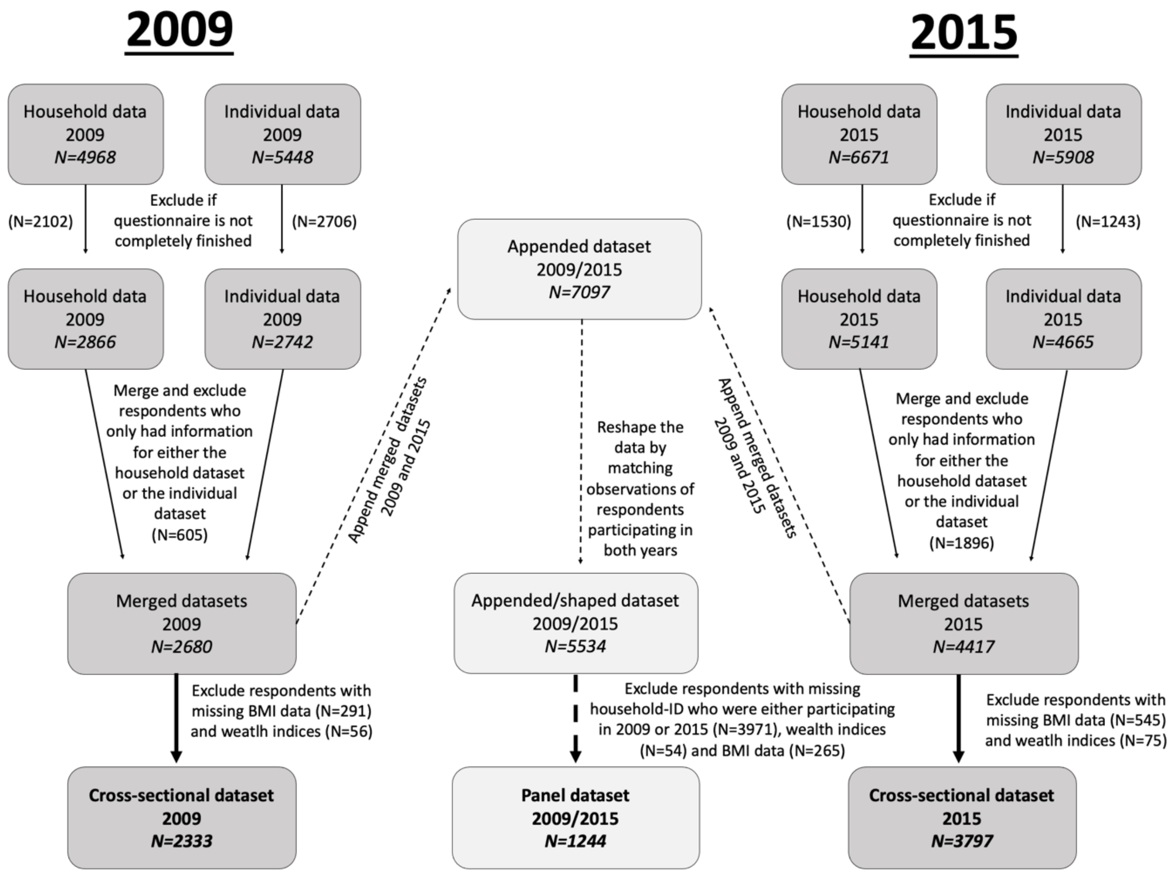


Figure 3: *Flowchart describing the construction process of the 3 datasets for final use.*

3.4 Dependent and independent variables

The dependent variable was *obesity (BMI 30+)* defined as a respondent having a BMI of 30 or higher, based on *weight* (in kilograms) and *height* (in centimetres). These anthropometrics were measured during the second visit of data collection (Biritwum et al., 2013). The following independent variables were included based on the conceptual model in figure 2: *women*, *age in years, education - more than primary, living together or married, health status today - good and very good, depression, difficulties with activities, ever used alcohol, ever used tobacco, walk or use bike for small distances, vigorous fitness for at least ten minutes, moderate fitness for at least ten minutes, sitting more than eight hours a day, every worked, friends coming over at least once a year, gotten out of the house at least once a year, daily fruit intake – more than two pieces a day, daily vegetable intake – more than two pieces a day* and a *wealth index.*

The independent variables *walk or use bike for small distances, vigorous fitness for at least ten minutes, moderate fitness for at least ten minutes* and *sitting more than eight hours a day* were included as a proxy for *physical activity* as described in the conceptual model*. Walk or use bike for small distances, vigorous fitness for at least ten minutes* and *moderate fitness for at least ten minutes* were used as proxies for *physical activity* which were likely to negatively influence *obesity (BMI 30+)*, while the proxy *sitting more than eight hours a day* was likely to increase the risk of *obesity (BMI 30+).* The independent variables *friends coming over at least once a year* and *gotten out of the house at least once a year* were used as proxies for the role of the *social network.* The variables *daily fruit intake – more than two pieces a day* and *daily vegetable intake – more than two pieces a day* were included as a proxy for *changes in dietary intake.*

The *wealth index* was used to identify five quintiles of respondents based on their socioeconomic status and were named: *poorest quintile, poor quintile, middle quintile, rich quintile* and *richest quintile*. The *wealth index* was constructed with a principal component analysis (PCA), based on information about ownership of 29 household assets (Filmer & Pritchett, 2001). An PCA "seeks to describe the variation of a set of variables as a set of linear combinations of the original variables, in which each consecutive linear combination is derived so as to explain as much as possible of the variation in the original data, while being uncorrelated with other linear combinations" (O'Donnell et al., 2007, p.72). The aim of the technique is to minimize information loss, while at the same time the interpretability is increased (Jollife & Cadima, 2016).

All variables, both dependent and independent, are dichotomized with 1 indicating the situation where the related variable is true for a respondent, and 0 representing otherwise. *Age in years* is an exception and is included as a continuous variable. These independent variables were used to estimate if the determinants for *obesity (BMI 30+)* were consistent with earlier findings in literature, and to examine underlying drivers for socioeconomic inequalities in *obesity (BMI 30+)*. All other irrelevant variables in the datasets were excluded.

3.5 Missing data

A t-test for the cross-sectional sample was performed to examine whether respondents with missing data on *height* and *weight*, used to measure BMI, were significantly different from respondents with available data on these variables. The aim of the t-test was to become aware of potential data limitations.

3.6 Study design

3.6.1 Linear regression

To get a first understanding of how the independent variables are related to *obesity (BMI 30+)*, an ordinary least squares (OLS) regression was estimated. An OLS-regression allows to indicate existing correlations between the dependent variables and the independent variables and can help to determine if these correlations are consistent with earlier literature. Another potential regression option to estimate correlations between the dependent and independent variables would have been a probit regression model. A probit regression model is a common regression when the dependent variable is binary (Noreen, 1988). However, given that the interpretation of OLS-coefficients is more straight-forward, this research estimated an OLS-regression. The probit model was estimated as a sensitivity check. The regression is presented in equation 1.

$$Obesity_i\ (BMI\ 30+) = \beta_0 + \gamma X_i + \delta Z_j + \varepsilon_i \qquad (1)$$

where X_i reflects the variables regarding characteristics of individual i, and Z_j reflects the variables capturing characteristics of household *j*. γ indicates the change in probability of *obesity (BMI 30+)* for individual i, with respect to a change in the independent X variable. δ reflects the change in probability of *obesity (BMI 30+)* for individual i, with respect to a change in the independent Z variable. The variation in the dependent variable -not explained by the independent variables- is captured in the error term ε_i. β_0 is a constant and reflects the mean *obesity (BMI 30+)* if all the independent variables in the model are set to 0.

3.6.2 Concentration curve and standard concentration index

The mean *obesity (BMI 30+)* prevalence in the different wealth quintiles was estimated to gain insight into the distribution of obesity among the Mexican adult population. To measure if inequality in the distribution of the obesity prevalence among the Mexican quintiles existed, concentration curves and standard concentration indices were computed. The concentration curve consists of two underlying key variables: the variable of interest, *obesity (BMI 30+),* and the variable capturing the living condition, *wealth index* (O'Donnell et al., 2007). A concentration curve plots the cumulative proportion of households ordered by wealth against the cumulative proportion of obesity in the Mexican adult population and illustrates socioeconomic inequality in obesity (Kakwani et al., 1997). If all the Mexican adults, regardless of their wealth index, would have the same outcome for *obesity (BMI 30+)*, the concentration curve would be a 45-degree diagonal moving from the bottom-left corner to the upper-right corner. This would be a situation where no inequality exists with respect to the dependent variable *obesity (BMI 30+).* In contrast, if *obesity (BMI 30+)* would occur more among the poor (pro-poor), the concentration curve will be above the 45-degree diagonal. If *obesity (BMI 30+)* would be more concentrated among the rich (pro-rich), the concentration curve will be below the 45-degree diagonal. The further the concentration curve is from the 45-degree diagonal, the more inequality exists. A standard concentration index is directly linked to the concentration curve and quantifies the degree of socioeconomic inequality in obesity (O'Donnell et al., 2007). The standard concentration index is twice the area between the 45-degree diagonal and the concentration curve and can range between -1 and 1 (Kakwani et al., 1997). When obesity is more prevalent among the poor, the standard concentration index will be negative. Whereas, if the standard concentration index is positive, obesity will be more prevalent among the rich. If no inequality would exists with respect to *obesity (BMI 30+)*, the standard concentration index would be equal to zero (Kakwani et al., 1997; O'Donnell et al., 2007). This study computed a standard concentration index for both 2009 and 2015. The equation for the standard concentration index is (Najafi et al., 2018):

$$CI = \frac{2}{\mu} cov\,(h_i, r_i) \quad (2)$$

where μ reflects the mean of the dependent variable *obesity (BMI 30+)* in the sample, h_i represents the value for the variable *obesity (BMI 30+)* for individual i, and r_i represents the fractional position of individual i in the socioeconomic ranking of the sample (Najafi et al., 2018). The covariance between *obesity (BMI 30+)* and the fractional rank is multiplied with two and divided by the mean of *obesity (BMI 30+)* for all the individuals in the sample, which reflects that the standard concentration index is twice the area between the concentration curve for *obesity (BMI 30+)* and the 45-degree diagonal of equality (O'Donnell et al., 2007).

3.6.3 Decomposition of the standard concentration index

The concentration indices for *obesity (BMI 30)*, estimated for 2009 and 2015 in the cross-sectional sample, were decomposed to see what might explain the observed inequality. A Wagstaff-type decomposition analysis was used to estimate the underlying drivers for the socioeconomic inequalities (Wagstaff et al., 2003). This technique consists of four stages and allows to compute contributions for each of the independent variables to the total inequality. In the first stage, an OLS-regression model for *obesity (BMI 30+)* is performed for all independent variables to estimate the marginal effects of each variable on the dependent variable *obesity (BMI 30+)*. The second stage calculates the elasticity for each independent variable with respect to the dependent variable. The elasticity indicates the responsiveness of the dependent variable to the corresponding independent variable and is defined as the change in *obesity (BMI 30+)* in response to a one percent change in the independent variable (Wagstaff et al., 2003). The third stage computes the standard concentration index for each independent variable in the total cross-sectional sample. The most relevant stage is the fourth stage, wherein the contribution of each independent variable to the total inequality is calculated by multiplying the elasticity of each independent variable with its standard concentration index (Najafi et al., 2018). Equation 3 presents the formula to calculate the contribution of each independent variable *x* to the total estimated standard concentration indices for *obesity (BMI 30+)* in 2009 and 2015.

$$Contribution\ x\ total\ CI_{obesity} = Elasticity_{obesity/x} * CI_x \quad (3)$$

3.6.4 Sensitivity analyses

Several sensitivity analyses were performed. In addition to the described probit sensitivity analysis and the sensitivity analysis for the panel sample, a last sensitivity check was done for the variable *overweight (BMI 25-30)*. The focus in this study is on individuals with an unhealthy BMI and therefore, focussing on *obesity (BMI 30+)* is most interesting. However, a BMI between 25 and 30 is also classified as too high (Nuttall, 2015), and this group should not be neglected. To check if patterns for *overweight (BMI 25-30)* are comparable with observed patterns in *obesity (30+)*, all the analyses done for the dependent variable *obesity (BMI 30+)* were performed as a sensitivity check for *overweight (BMI 25-30)* as well.

4 Results

4.1 Summary statistics

Table 1 indicates characteristics concerning the independent and dependent variables for this study. Women are slightly overrepresented in both 2009 and 2015, as compared to male. The summary statistics concerning BMI show first information about the changes in BMI between 2009 and 2015 and indicate that average BMI slightly increased from 28.4 to 28.6. The share of people in the category of *overweight BMI (25-30)* increased with 0.2 percentage point. In 2009, the percentage of people with *overweight BMI (25-30)* was 40.4 percent, while this percentage was 40.6 in 2015. A larger increase of 1.3 percentage point was observed in the share of people with *obesity (BMI 30+)*. In 2009, the percentage of people with a BMI of 30+ was 32.8, whereas this was 34.1 percent in 2015.

Table 1 shows an increase for the independent variables *walk or use bike for small distances* and *moderate fitness for at least ten minutes* of respectively 3.8 percentage point and 4.0 percentage point, suggesting that people had higher levels of *physical activity* in 2015 compared to 2009. An increase of 19.7 percentage point was also observed in the share of people *going out of the house once or twice a year*, which could reflect a possible role for the *social network* in the rising obesity rates. The *fruit intake – two or more pieces a day* and the *daily vegetable intake – two or more pieces a day* both decreased with respectively 6.5 percentage point and 3.3 percentage point between 2009 and 2015, what could indicate a change in dietary intake towards less healthy food patterns. *Alcohol use* has increased with 7.9 percentage point, while a decrease of 13.2 percentage point is observed in the *tobacco use.* Finally, a considerable rise of 21.6 percentage point is observed in the share of people who *ever worked* in the informal or formal sector between 2009 and 2015.

Table 1: Summary statistics – Independent and dependent variables - 2009 and 2015

	2009 N=2333	2015 N=3797
Independent variables		
Woman (%)	62.1	59.7
Age in years (mean)	62.7	61.6
Education – more than primary school (%)	45.0	56.2
Living together or married (%)	63.1	62.5
Urban area (%)	72.9	72.8
Health today – good and very good (%)	39.7	46.5
Depression (%)	44.7	43.4
Difficulties with activities (%)	27.0	19.3
Tobacco use (%)	37.2	24.0
Alcohol use (%)	48.0	55.9
Walk or use bike for small distances (%)	59.6	63.4
Vigorous fitness for at least ten minutes (%)	3.7	3.6
Moderate fitness for at least ten minutes (%)	6.00	10.0
Sitting more than eight hours a day (%)	6.6	6.4
Ever worked (%)	55.4	77.0
Friends coming over once a year (%)	52.2	52.6
Going out of the house once or twice a year (%)	53.5	73.2
Daily fruit intake – two or more pieces a day (%)	45.1	38.6
Daily vegetable intake – two or more pieces a day (%)	46.1	42.8
Wealth Quintiles (mean)	3.0	3.0
Dependent variables		
BMI (mean)	28.4	28.6
Overweight – BMI: 25-30 (%)	40.4	40.6
Obesity – BMI: 30+ (%)	32.8	34.1
True height (cm)	156.1	155.9
True weight (kg)	69.3	69.4
Waist circumference (cm)	101.9	106.3
Hip circumference (cm)	110.5	109.4

Table 2 presents the t-test results to check whether respondents with missing data on *height* and/or *weight*, which had to be dropped, were not significantly different from respondents with available data on these variables. Significant differences between respondents with and without data on *height* and/or *weight* did exist on 16 out of the 20 independent variables in 2009, and on 11 of the 20 independent variables in 2015. All the variables for which differences did exists were highly significant at a 1%-level. These existing differences between the dropped respondents and the respondents with information on *height* and/or *weight* are a limitation of this study and limit generalisability.

Table 2: Two sample t-test for group with and without BMI data - 2009 and 2015

	2009			**2015**		
	Mean BMI missing (N= 291)	**Mean BMI observed (N=2333)**	**p-value**	**Mean BMI missing (N= 545)**	**Mean BMI observed (N=3797)**	**p-value**
Woman	.588	.621		.646	.597	***
Age in years	68.216	62.724	***	63.046	61.643	***
Education – more than primary school	.361	.450	***	.578	.562	
Living together or married	.444	.631	***	.545	.625	***
Urban area	.794	.729	***	.740	.728	
Health today – good and very good	.309	.397	***	.453	.465	
Depression	.413	.448		.455	.434	
Difficulties with activities	.337	.270	***	.352	.193	***
Tobacco use	.258	.372	***	.228	.240	
Alcohol use	.395	.480	***	.475	.558	***
Walk or use bike for small distances	.364	.596	***	.459	.634	***
Vigorous fitness for at least ten minutes	.024	.037		.042	.036	
Moderate fitness for at least ten minutes	.028	.060	***	.059	.100	***
Sitting more than eight hours a day	.378	.067	***	.181	.065	***
Ever worked	.419	.554	***	.712	.770	***
Friends coming over once a year	.367	.521	***	.521	.526	
Going out of the house once or twice a year	.334	.535	***	.692	.732	***
Daily fruit intake – two or more pieces a day	.389	.452	***	.439	.386	***
Daily vegetable intake – two or more pieces a day	.364	.461	***	.436	.428	
Wealth index	2.89	2.96		3.01	3.00	

***** p<.01, ** p<.05, * p<.10*

4.2 OLS-regression

Table 3 shows the OLS-regression results for 2009 and 2015. The results for 2009 show that *woman, living together or married*, *walk or use bike for small distances* and being in the *middle, rich* and *richest quintile* are significantly correlated with obesity at a 1%-level. *Woman, living together or married* and being in the *middle, rich* and *richest quintile* are positively correlated with *obesity (BMI 30+)*, while *walk or use bike for small distances* is negatively correlated. This is consistent with the described conceptual model. The indicated correlations for *age in years, difficulties with activities* and being in the *poor quintile* are significant at a 5%-level. *Age in years* seems to be negatively correlated with *obesity (BMI 30+),* which is in contrast with earlier described literature as presented in the conceptual model. *Difficulties with activities* and being in the *poor quintile* seem to have positive correlations with *obesity (BMI 30+),* which is in line with expectations. In 2015, *woman, age in years, living together or married, walk or use bike for small distances, sitting more than eight hours a day* and being in *poor, middle, rich* and *richest quintiles* are significantly correlated with *obesity (BMI 30+)* at a 1%-level. Similar as for 2009, *woman, living together other married* and being in *poor, middle, rich* and *richest quintiles* are positively correlated with *obesity (BMI 30+)*. *Sitting more than eight hours a day* is also positively correlated, which is as expected. Just as in 2009, *age in years* and *walk or use bike for small distances* are again negatively correlated with *obesity (BMI 30+). Tobacco use* is negatively and significant correlated at a 5%-level, which is consistent with earlier findings as well.

The estimated results for the probit regression were comparable with the OLS-regression results for both 2009 and 2015. The results of the probit models are presented in table 7 (Appendix 8.1).

Table 3: OLS-regression results for *obesity BMI (30+)* - 2009 and 2015

	2009 (N=2333)			2015 (N=3797)		
Obesity (BMI 30+)	**Coef.**	**p-value**	**Sig**	**Coef.**	**p-value**	**Sig**
Woman	.169	.000	***	.151	.000	***
Age in years	-.002	.012	**	-.002	.000	***
Education – more than primary school	.009	.709		.005	.783	
Living together or married	.064	.003	***	.060	.000	***
Urban area	.017	.486		.020	.281	
Health today – good or very good	-.013	.522		-.024	.139	
Depression	-.017	.420		-.011	.499	
Difficulties with activities	.055	.017	**	.019	.354	
Tobacco use	-.013	.544		-.041	.028	**
Alcohol use	.004	.851		.033	.062	*
Walk or use bike for small distances	-.057	.006	***	-.043	.009	***
Vigorous fitness for at least ten minutes	-.098	.061	*	-.044	.298	
Moderate fitness	-.002	.956		.007	.778	
Sitting more than eight hours a day	.029	.476		.124	.000	***
Ever worked	.006	.782		.004	.835	
Friends coming over once a year	.032	.139		.003	.839	
Going out of the house once or twice a year	.022	.298		.021	.227	
Daily fruit intake – two or more pieces a day	.006	.778		.015	.361	
Daily vegetable intake – two or more pieces a day	.015	.488		.022	.182	
Poorest quintile	(omitted)	.		(omitted)	.	
Poor quintile	.071	.022	**	.068	.006	***
Middle quintile	.117	.000	***	.121	.000	***
Rich quintile	.114	.001	***	.113	.000	***
Richest quintile	.123	.000	***	.091	.001	***
Constant	.197	.005	***	.233	.000	***

****** p<.01, ** p<.05, * p<.10*

4.3 Concentration curves and standard concentration indices

The concentration curves for 2009 and 2015 are presented in figure 4. Both the concentration curves are below the 45-degree diagonal, indicating that obesity is unequally and pro-rich distributed in the Mexican adult population. However, the concentration curve is slightly closer to the 45-degree diagonal in 2015, compared to 2009. This reflects that the socioeconomic inequality in *obesity (BMI 30+)* declined between the period of 2009 and 2015 and became less pro-rich.

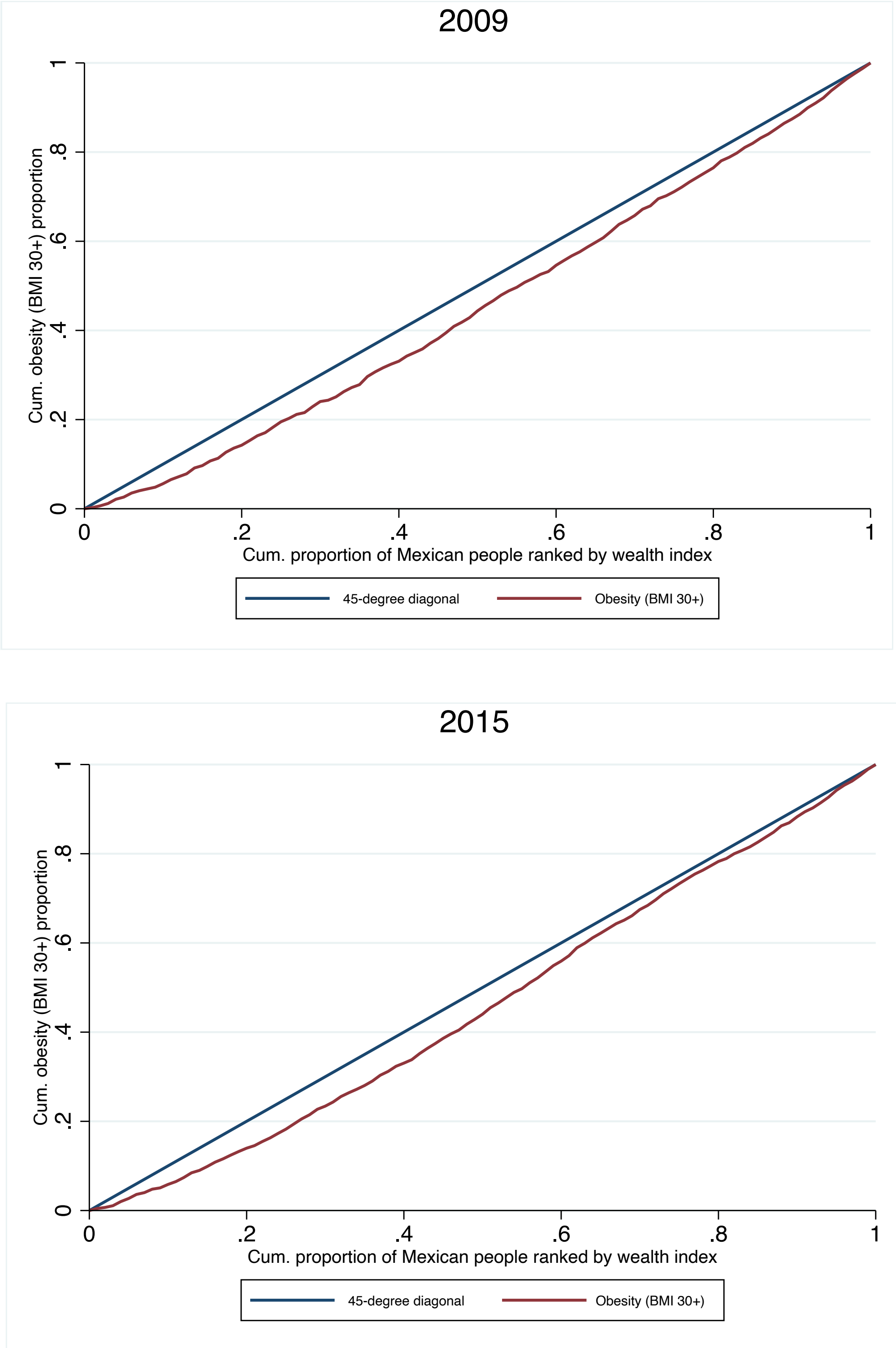


Figure 4: *Concentration curves obesity (BMI 30+) for 2009 and 2015. The red line represents the concentration curve for obesity (BMI 30+) and the blue line reflects the 45-degree diagonal for equality.*

The prevalence of obesity in each of the five wealth quintiles, and the standard concentration index for both 2009 and 2015, are presented in table 4. The p-values of 0.000 indicate that *obesity* (*BMI 30+)* is significantly unequally distributed at a 1%-level in both 2009 and 2015. The *obesity* (*BMI 30+)* standard concentration indices are 0.090 and 0.081 for respectively 2009 and 2015. Just as with the concentration curve, these values indicate that obesity is pro-rich distributed and more prevalent among the richer quintiles in the Mexican society, although this decreased a bit over time.

The pro-rich distribution of *obesity (BMI 30+)* is also reflected in the mean obesity prevalence for each quintile. In 2009, the *obesity (BMI 30+)* prevalence increases as people become richer and the highest prevalence of obesity is observed in the *richest quintile.* In 2015, an increase in the share of people facing *obesity (BMI 30+)* in each quintile is observed up until the *middle quintile,* where the mean prevalence for *obesity (BMI 30+)* is also the highest. After this quintile, the mean prevalence decreases in the *rich quintile* and decreases even further in the *richest* quintile. This indicates a shift of the obesity prevalence from the richer quintiles to lower socioeconomic groups in the Mexican adult society between 2009 and 2015 and explains why the standard concentration index for *obesity (BMI 30+)* decreased from 0.090 to 0.081. Except from the *richest quintile,* an increase in the mean *obesity (BMI 30+)* prevalence is observed in all the quintiles. The highest rise in *obesity (BMI 30+)* prevalence between 2009 and 2015 occurred in the *middle quintile,* where an increase of 3.7 percentage point was observed.

Table 4: Standard concentration index *obesity (BMI 30+)* - 2009 and 2015

Year	N	Standard CI	SE	Mean Poorest Quintile	Mean Poor Quintile	Mean Middle Quintile	Mean Rich Quintile	Mean Richest Quintile	p-value
2009	2333	0.090	.017	23.3%	31.0%	35.3%	36.5%	37.9%	.000
2015	2797	0.081	.013	23.8%	32.7%	39.0%	38.0%	37.1%	.000
Δ		*-0.009*		*+0.5%*	*+1.7%*	*+3.7%*	*+1.5%*	*-0.8%*	

4.4 Decomposition of the standard concentration index

The decomposition results for the standard concentration indices are presented in table 5 and table 6. The contribution in percentages of each independent variable to the total pro-rich standard concentration index are visualised in the last column. Being in the *poor, rich* and *richest quintiles* seem to explain most of the existing socioeconomic inequality in *obesity (BMI 30+)* in 2009. Especially being ranked in the *richest quintile* seems important and accounts for 65.7 percent of the observed socioeconomic inequality in *obesity (BMI 30+)*. The standard concentration index for the *richest quintile* is 0.806, which is as expected given that people are ranked based on their wealth index. The elasticity indicates that if the average wealth index for the *richest quintile* increases with 1 percent, an increase of 0.073 percent of the *obesity (BMI 30+)* prevalence is observed in this quintile. The contribution of 0.056 to the total socioeconomic inequality in *obesity (BMI 30+)* is calculated by multiplying the standard concentration index of the *richest quintile* with its elasticity. The *rich quintile* contributes to the total socioeconomic inequality in *obesity (BMI 30+)* for a less extensive extent of 32.2 percent and is determined by multiplying the standard concentration index of 0.406 with its elasticity of 0.071. This result in a contribution of 0.029 to the observed socioeconomic inequality in *obesity (BMI 30+)*. The *poor quintile* contributes for -0.017 to the total inequality of 0.090, which is equal to -19.4 percent. This contribution is obtained by multiplying the standard concentration index of -0.399 for the *poor quintile* with its elasticity of 0.044. Because being in the *poor quintile* is concentrated among the poor, as expected, the contribution of this independent variable to the total concentration index of 0.090 is negative. All the other independent variables only explain a small share of the pro-rich concentration index of 0.090. Of all the variables that have a small marginal contribution to the total observed inequality in *obesity (BMI 30+), age in years, urban area* and *difficulties with activities* seem to have the largest role in explaining the socioeconomic inequalities.

Table 5: Decomposition of the standard concentration index *obesity (BMI 30+)* - 2009

Obesity (BMI 30+) - 2009	Beta	Elasticity	CI	Contribution	Perc. contribution
Woman	.169	.320	-.005	-.002	-1.9
Age in years	-.002	-.366	-.015	.005	6.0
Education – more than primary school	.009	.012	.255	.003	3.3
Living together or married	.064	.122	.026	.003	3.5
Urban area	.017	.038	.146	.001	6.2
Health today – good or very good	-.013	-.018	.059	-.001	-1.0
Depression	-.017	-.023	-.079	.002	2.0
Difficulties with activities	.055	.045	-.120	-.005	-6.1
Tobacco use	-.013	-.015	.029	.000	-0.5
Alcohol use	.004	.006	.052	.000	0.4
Walk or use bike for small distances	-.057	-.103	-.020	.002	2.4
Vigorous fitness for at least ten minutes	-.098	-.011	.265	-.003	-3.3
Moderate fitness	-.002	-.000	.196	-.000	-0.1
Sitting more than eight hours a day	.029	.006	.134	.001	0.8
Ever worked	.006	.010	.041	.000	0.4
Friends coming over once a year	.032	.050	.011	.001	0.6
Going out of the house once or twice a year	.022	.036	.048	.002	1.9
Daily fruit intake – two or more pieces a day	.006	.008	.056	.000	0.5
Daily vegetable intake – two or more pieces a day	.015	.021	.081	.002	1.9
Poorest quintile	(omitted)	-	-.800	-	-
Poor quintile	.071	.044	-.399	-.017	-19.4
Middle quintile	.117	.071	.001	.000	0.1
Rich quintile	.114	.071	.406	.029	32.2
Richest quintile	.123	.073	.806	.056	65.7
Total of CI explained				*.086*	*95.5*
Residual				*004*	*4.5*
Total CI				*.090*	*100*

The results are comparable for the decomposition of 2015. Just as in 2009, the *poor, rich* and *richest quintile* are the most import underlying drivers for the existing inequality in *obesity (BMI 30+).* However, the elasticity for the *richest quintile* declined in comparison to 2009. This results in a smaller percentage contribution (52.8 percent instead of 65.7 percent) to the total standard concentration index of 0.081. The contribution of the *rich quintile* in comparison with 2009 increased with 1 percentage point. For this quintile, a decline of 0.004 in its elasticity and of 0.005 in the standard concentration index was observed. This resulted together in a contribution of 0.027 (33.2 percent) to the total socioeconomic inequality in *obesity (BMI 30+).* The declines in elasticities for the *rich* and *richest quintile* indicate that the rising obesity rates slowed down in the two richest part of the Mexican adult population, which was also reflected in the mean *obesity (BMI 30+)* prevalence. The *poor quintile* still negatively contributes to the total inequality in *obesity (BMI 30+)* in 2015 and accounts for -0.016, which is equal to -19.8 percent. This indicates a small increase of 0.4 percentage point for the negative role of the *poor quintile* in explaining socioeconomic inequalities in *obesity (BMI 30+).* The other independent variables only contribute for a very small share to the pro-rich standard concentration index of 0.081. Of all the independent variables with a small marginal contribution to the total observed inequality in *obesity (BMI 30+)*, *urban area* and *sitting more than eight hours a day* seem to play the largest part. The role of some of the variables seems to have increased or decreased a bit compared to 2009. An example is the contribution the variable *age in years*, which declined with 3.3 percentage point from 6 percent to 2.7 percent. Nevertheless, this is still a very small share of the total existing inequality in *obesity (BMI 30+)*.

Table 6: Decomposition of the standard concentration index *obesity (BMI 30+)* - 2015

Obesity (BMI 30+) - 2015	Beta	Elasticity	CI	Contribution	Perc. contribution
Woman	.151	.265	-.005	-.001	-1.5
Age in years	-.002	-.379	-.006	.002	2.7
Education – more than primary school	.005	.008	.185	.001	1.9
Living together or married	.060	.111	.023	.002	3.1
Urban area	.020	.044	.133	.006	7.2
Health today – good or very good	-.024	-.032	.016	-.001	-0.7
Depression	-.011	-.014	-.049	.001	0.9
Difficulties with activities	.019	.011	-.096	-.001	-1.3
Tobacco use	-.041	-.029	.043	-.001	-1.5
Alcohol use	.033	.054	.052	.003	3.5
Walk or use bike for small distances	-.043	-.079	-.018	.001	1.8
Vigorous fitness for at least ten minutes	-.044	-.005	.242	-.001	-1.4
Moderate fitness	.007	.002	.244	.001	0.6
Sitting more than eight hours a day	.124	.023	.207	.005	6.0
Ever worked	.004	.010	.041	.000	0.5
Friends coming over once a year	.003	.050	.021	.001	0.1
Going out of the house once or twice a year	.021	.046	.030	.001	1.7
Daily fruit intake – two or more pieces a day	.015	.018	.124	.002	2.7
Daily vegetable intake – two or more pieces a day	.022	.028	.059	.002	2.0
Poorest quintile	(omitted)	-	-.800	-	-
Poor quintile	.068	.040	-.398	-.016	-19.8
Middle quintile	.121	.070	.003	.000	0.2
Rich quintile	.113	.067	.401	.027	33.2
Richest quintile	.091	.053	.801	.043	52.8
Total of CI explained				*.076*	*94.7*
Residual				*.005*	*5.3*
Total CI				*.081*	*100*

4.5 Sensitivity analyses

The results for the sensitivity analyses on both the panel dataset and for the variable *overweight (BMI 25-30)* can be found in respectively appendix 8.2 and 8.3.

4.5.1 Panel sensitivity analysis

The results for the panel sample are comparable to the findings in the cross-sectional sample. The t-test results for this sample reveal less significant differences between the respondents which had to be dropped due to missing data on *height* and *weight*, and respondents with available data on these variables. Significant differences only did exist on 5 of the 20 variables in 2009, and on 9 of the 20 variables in 2015. The standard concentration indices for *obesity (BMI 30+)* are 0.087 in 2009 and 0.072 in 2015. Both standard concentration indices are significant at a 1%-level and declined over time, which is comparable to the decline in the socioeconomic inequality in *obesity (BMI 30+)* in the cross-sectional sample, although it decreased a bit more. Just as in the cross-sectional sample, obesity is pro-rich distributed and more prevalent among richer adults in the Mexican society. Nevertheless, a decline in the mean *obesity (BMI 30+)* prevalence was observed in the *poorest, middle*, *rich* and *richest quintile* in the panel sample*,* while in the cross-sectional sample a decline was only observed in the *richest quintile*. The prevalence for the *poor quintile* seems to have increased with 0.8 percentage point between 2009 and 2015.

The decomposition results to understand which variables are underlying drivers for the observed socioeconomic inequalities in 2009 and 2015 are presented in tables 11 and 12 in appendix 8.2.4. These results are mostly in line with the findings for the cross-sectional sample. Being in the *poor, rich* and *richest quintiles* also seem to explain most of the existing inequality in *obesity (BMI 30+)* in 2009 and 2015. However, some of the findings are in contrast with the cross-sectional sample. *Education – more than primary school* seem to play a larger role in explaining the socioeconomic inequalities in 2009, compared to the cross-sectional sample, and contributes positively with 11.8 percent. Another finding which is not observed in the cross-sectional sample, is the considerable role for *age in years* in explaining the socioeconomic inequalities in *obesity (BMI 30+)* in 2015*.* This variable explains 11.7

percent of the observed inequalities, while this is only 2.7 percent in the cross-sectional sample. A last observation which is in contrast with the findings in the cross-sectional sample, is the contribution of the variable living in an *urban area. Urban area* has a negative contribution of -16.6 percent to the total inequality in *obesity (BMI 30+)* in 2015, while it contributes for considerable smaller share of -1.6 percent in 2009. Moreover, this variable contributes positively to the pro-rich concentration indices for 2009 and 2015 in the cross-sectional sample. The role for the other independent variables is small and seem to be not very relevant in explaining the existing socioeconomic inequalities in *obesity (BMI 30+)*.

4.5.2 Overweight sensitivity analysis

The results for the sensitivity analysis for *overweight (BMI 25-30)* are presented in Appendix 8.3. The p-values for the estimated standard concentration indices were not significant at a 5%-level in both 2009 and 2015, indicating that significant socioeconomic inequalities in *overweight (BMI 25-30)* did not exist. This was also reflected in the concentration curves, which were close to the 45-degree diagonal, and the small standard concentration indices of 0.011 for 2009 and 0.022 for 2015. The pro-rich standard concentration indices indicate that the socioeconomic inequalities in *overweight (BMI 25-30)* have slightly increased over time. This is in contrast with the observed decline in socioeconomic inequalities in *obesity (BMI 30+).*

5 Discussion

This cross-sectional study contributes to the existing gap in literature by estimating if socioeconomic inequalities in obesity exists and changed over time between 2009 and 2015 in Mexico. Quantifying and estimating these socioeconomic inequalities in *obesity (BMI 30+)* and its underlying drivers can help policymakers to prevent a further rise in obesity in the future. The most important results will be discussed in this chapter.

5.1 Discussion of main findings

This study shows that in both 2009 and 2015, the standard concentration indices for *obesity (BMI 30+)* are pro-rich (respectively 0.091 and 0.080), indicating that obesity is more concentrated among the richer quintiles in the Mexican adult population. This is also reflected in the computed concentration curves. However, the pro-rich standard concentration indices are relatively small for both years, given that a standard concentration index can range between -1 and 1. In addition, the standard concentration index for *obesity (BMI 30+)* seems to have decreased over time, which is also reflected by the changes in the mean *obesity (BMI 30+)* prevalence in each quintile. While in 2009 the highest *obesity (BMI 30+)* prevalence was observed in the *richest quintile* (37.9 percent), this shifted towards the *middle quintile* in 2015 (39.0 percent). The highest increase of 3.7 percentage point in the obesity prevalence between 2009 and 2015 was observed in the *middle quintile*, whereas a decline of 0.8 percentage point was observed in the *richest quintile.* These results indicate that the socioeconomic gap between the better-off and the disadvantaged groups is narrowing, which is consistent with stage 2 of the four-stage framework for obesity transition described by Jaacks et al. (2019). This framework explains that the socioeconomic gap between the better-off and disadvantaged groups becomes smaller as soon as countries experience an increase in economic wealth, just as Mexico has experienced over the past decades (Jiwani et al., 2019; Rtveladze et al., 2014).

The results for the decomposition of the standard concentration indices show that the most important drivers for the inequality in *obesity (30+)* are being in the *poor, rich* or *richest quintile* for both 2009 and 2015. Since the quintiles are composed based on the wealth indices for each respondent which reflect asset ownership, and because socioeconomic inequalities in *obesity (BMI 30+)* do exist, these results are in line with the expectations. The other independent variables suggested as determinants for *obesity (BMI 30+)* in earlier literature seem to have a limited role in explaining the socioeconomic inequality in *obesity (BMI 30+)*. However, striking is that the percentage contribution of *age in years* to the total inequality decreased with 3.3 percentage point, from 6.0 percent in 2009 to 2.7 percent in 2015. This suggests that the role for *age in years* in the existing socioeconomic inequalities declined over time and that *obesity (BMI 30+)* became more equally distributed among all age groups. Notable for the variable *age in years* is the negative elasticity with respect to *obesity (BMI 30+)*, whereas a reverse pattern was suggested by Chooi et al. (2019). In the contribution of the independent variable *urban*, an increase of 1.0 percentage point has been observed. This indicates that *obesity (BMI 30+)* became more prevalent in the *urban* areas rather than rural areas and based on its pro-rich standard concentration index, this is where most of the richer people live. This shows that the socioeconomic gap in *obesity (BMI 30+)* between *urban* and rural areas increased between 2009 and 2015, possibly because *urban* residents are more likely to have sedentary jobs, use motorized transport and consume more processed and high-calorie food (Neuman et al., 2013). A considerable decline was observed in the percentage contribution for *difficulties with activities* between 2009 and 2015. While this independent variable was negatively contributing for -6.1 percent to the total inequality in *obesity (BMI 30+)* in 2009, it was only explaining -1.3 percent of the total socioeconomic inequalities in 2015. This decline can be explained by the lower concentration index and lower elasticity in 2015, compared to 2009. This indicates that the influence of the independent variable *difficulties with activities* on the dependent variable *obesity (BMI 30+)* declined, while it simultaneously became more equally distributed and affected the poor less. Another independent variable that contributes negatively to the total socioeconomic inequality in *obesity (BMI 30+)* is *tobacco use*. The negative contribution seems to have increased with 1.0 percentage point over time, being the result of the increasing pro-rich standard concentration index from 0.023 to 0.043, as well as a higher negative elasticity. An explanation for the increasing pro-rich standard concentration index of *tobacco use* could be the rise of tobacco taxes in 2011 (Reynales-Shigematsu et al., 2019). This could have led into less *tobacco use* in the poorer segments of the Mexican adult population, and therefore, into an increase in the negative contribution to the total pro-rich standard concentration index of *obesity (BMI 30+).* The last noticeable variable with a substantial higher percentage contribution in 2015 compared to 2009 is *sitting more than eight hours a day.* An increase in the role of this variable in explaining existing socioeconomic inequalities in *obesity (BMI 30+)* of 5.2 percentage point had taken place. A potential explanation could be lower levels of physical activity due to more sedentary lifestyles (Salas-Ortiz, 2020), among the richer segments of the Mexican adult population. The standard concentration index for *sitting more than eight hours* was pro-rich distributed in 2009 (0.134) and became even more pro-rich over time (0.207), suggesting that limited levels of physical activity mostly occur among the rich. In addition, the elasticity for *sitting more than eight hours a day* increased with 0.017, indicating that this variable had a higher influence on *obesity (BMI 30+)* in 2015 than in 2009. Together, this resulted in a higher contribution of this independent variable to the total socioeconomic inequality in *obesity (BMI 30+).*

A sensitivity analysis showed that no socioeconomic inequalities were found for the variable *overweight (BMI 25-30)*. Both the standard concentration indices of 0.011 for 2009 and 0.022 for 2015 were not significant. This indicates that *overweight (BMI 25-30)* is not significant unequally distributed among the different quintiles, which is in contrast with the observed socioeconomic inequalities for *obesity (BMI 30+).* This suggest that the observed shift in *obesity (BMI 30+)* prevalence from richer segments to socioeconomic disadvantaged groups between 2009 and 2015 did not occur for *overweight (BMI 25-30)*. An explanation could be that the transition of the *overweight (BMI 25-30)* prevalence from richer to lower socioeconomic groups is lagging behind, compared to the transition of the *obesity (BMI 30+)* prevalence*.*

5.2 Methodological strengths and limitations

This study had several limitations that should be taken into account and can be considered a threat for the generalisability of this study. First, the t-test results show considerable significant differences at a 1%-level between the respondents with and without data on *height* and *weight*. These existing differences between the respondents that had to be dropped and the respondents with information on *height* and/or *weight* limit generalisability of this study.

Another limitation that is threatening the generalisability of this study is the high average *age in years* of the respondents. Since SAGE was designed to measure health and well-being, and to follow the ageing process of adults in six countries (Biritwum et al., 2013), this study had an oversampling of people above the age of 50. Therefore, the results of this study are mostly reflecting the older adult Mexican population which make the conclusions less valid. To study changes in the prevalence of *obesity (BMI 30+),* which are representative for the whole adult Mexican population, it is recommended to include more respondents below the age of 50. Moreover, the most recent data were collected in the period of 2015 and therefore might be potentially outdated. It could be that certain situations, which were likely to influence the *obesity (BMI 30+)* prevalence, did change over time. An example is the implementation of a tax-policy for sugar-sweetened beverages (Arantxa Cochero et al., 2017). This study was unable to estimate the effects of this policy, due to the short timespan between the implementation of the policy and the year that the most recent data were obtained. Further research with more up-to-date data is therefore recommended, since it is likely that the implementation of this policy had a considerable influence on the *obesity (BMI 30+)* prevalence.

There are also some remarkable findings in the summary statistics for the panel sample over time, although these only relate to a few respondents. An increase of 0.2 percentage point was observed in the percentage of females participating in both 2009 and 2015. However, the independent variable *woman* is expected to stay constant, given that the panel sample aims to follow respondents over time. An explanation for this increase is that some of the respondents had undergone a gender change between 2009 and 2015 or started identifying themselves as woman rather than man. Another noticeable change in the summary statistics of the panel sample is the decrease in average *height* between 2009 and 2015, possibly because people might lose height as they get older (Sorkin et al., 1999). However, in-depth analysis of the panel dataset revealed that the *height* of some respondents declined with unusual numbers. An explanation could be that respondents have been suffering from conditions which resulted into declines in their length, such as amputation of lower limbs. Nevertheless, it is unlikely that this explains all the unusual declines in *height*. Both the remarkable changes discussed throughout this section could indicate potential measurement error and should be considered when interpretating the results. This potential measurement error reduces the reliability of this study.

The biggest limitation of this study is the unavailability of data on unhealthy food patterns. SAGE only collected data about the fruit- and vegetable intake of the respondents, while information about unhealthy dietary intakes would have been more interesting and could have provide relevant information. *Changes in diets* is discussed in earlier literature as an important driver for the increased obesity prevalence in Mexico (Rtveladze et al., 2014) and further research with information on this variable is highly recommended. This study uses *fruit intake- more than two pieces a day* and *vegetable intake-more than two pieces a day* as proxies for these *changes in diet*, and it should be recognized that these proxies might be doubtful substitutes for this determinant. The use of this doubtful substitutes could impact the validity of the results.

A last point of critique which could threaten the validity of this research is the debate around the measure of BMI. It was briefly discussed in the theoretical concept that this measure is heavily criticized because it is a measure reflecting the size of an individual, rather than a measure of health (Gutin, 2018). Therefore, further research where obesity is measured in more sophisticated ways is recommended.

Despite these limitations, this study also had several strengths. A first strength was the usage of data collected by the WHO, ensuring the data to be extensive and strong. Moreover, the data were collected over several years, which made it possible to study changes over time. Another strength was the use of the standard concentration indices, which is considered a valid way to measure socioeconomic inequalities with respect to an outcome of health (O'Donnell et al., 2007). A last strength of this study was the already collected WHO SAGE data by the start of this research, which resulted in limited methodological challenges for data collection. These strengths imply that the findings of this study can be considered relevant.

5.3 Policy recommendations

The aim of this study was to get a clear understanding of socioeconomic inequalities in *obesity (BMI 30+)* and its underlying drivers to inform Mexican policymakers how to prevent a further rise in the obesity prevalence in the future. Several policy recommendations to tackle the rise in *obesity (BMI 30+)* can be made. First, an increase in the mean prevalence of *obesity (BMI 30+)* is observed in the *poorest, poor, middle* and *rich quintile,* while simultaneously a decrease in the mean *obesity (BMI 30+)* prevalence occurred in the *richest quintile.* This suggests that the rising obesity rates are dominating in the four lowest quintiles, and especially in the *middle quintile,* the 3.7 percentage point increase in *obesity (BMI 30+)* prevalence is alarming. Policymakers should therefore implement policies targeted at the four lowest quintiles, with special attention for the *middle quintile*. A recommended policy solution is to implement an educational program targeted at those quintiles, to create awareness around the health risks related to *obesity (BMI 30+)*. Another policy recommendation could be the introduction of taxes on processed nutrition with high levels of added sugar. A comparable policy of levying taxes on sugar-sweetened beverages was already implemented in Mexico by the start of 2014. It was found that the implementation of these taxes caused a 6 percent decline in consumption of the sugar-sweetened beverages (Arantxa Cochero et al., 2017). Given that the results for this similar policy were promising, the implementation of a similar tax-policy for processed nutrition with high levels of added sugar is encouraged. A last policy recommendation could be the introduction of campaigns to promote more active lifestyles. The discussed contributing role for *sitting for more than eight hours* in explaining the existing socioeconomic inequalities in *obesity (BMI 30+)* increased between 2009 and 2015. Encouraging higher levels of physical activity through public campaigns can help to reduce the socioeconomic inequalities. This recommended policy would probably reach all the quintiles and is therefore also likely to further decrease the *obesity (BMI 30+)* prevalence in the *richest quintile.*

6 Conclusion

Socioeconomic inequalities in *obesity (BMI 30+)* did exist in Mexico, although they have decreased in the period between 2009 and 2015. To ensure that socioeconomic inequalities in *obesity (BMI 30+)* do not increase, policymakers should focus on implementing policies which mostly try to halt the rise in *obesity (BMI 30+)* prevalence in the four lowest quintiles. The main reason for this is the observed decline in mean *obesity (BMI 30+)* prevalence in the *richest quintile*, while simultaneously a rise in the *obesity (BMI 30+)* prevalence has been observed in the other quintiles with an especially large increase in the *middle quintile.* Moreover, the highest mean prevalence of *obesity (BMI 30+)* has shifted from the *richest quintile* to the *middle quintile* in the period between 2009 and 2015. This indicates that the existing socioeconomic gap in *obesity (BMI 30+)* is narrowing. This is line with the characteristics of stage 2 of the transition model by Jaacks et al. (2019). The different levels of wealth seem to play the most important role in explaining the existing socioeconomic inequalities in *obesity (BMI 30+)* for both 2009 and 2015. The other independent variables, identified in earlier literature as determinants for the high *obesity (BMI 30+)* rates, did not play considerable roles in explaining the observed socioeconomic inequalities. However, further research with more recent data, a collected sample with a higher number of respondents below the age of 50 and usage of a more sophisticated measure of obesity is recommended. In addition, collecting data on unhealthy food patterns is recommended in follow-up studies.

7 References

Adams, J. (2020). Addressing socioeconomic inequalities in obesity: Democratising access to resources for achieving and maintaining a healthy weight. *PLoS Medicine*, *17*(7), 10–12. https://doi.org/10.1371/journal.pmed.1003243

Arantxa Cochero, M., Rivera-Dommarco, J., Popkin, B. M., & Ng, S. W. (2017). In Mexico, evidence of sustained consumer response two years after implementing a sugar-sweetened beverage tax. *Health Affairs*, *36*(3), 564–571. https://doi.org/10.1377/hlthaff.2016.1231

Baker, E. H. (2014). *Socioeconomic Status , Defi nition*.

Barquera, S., Campos-Nonato, I., Hernández-Barrera, L., Flores, M., Durazo-Arvizu, R., Kanter, R., & Rivera, J. A. (2009). Obesity and central adiposity in mexican adults: Results from the mexican national health and nutrition survey 2006. *Salud Publica de Mexico*, *51*(SUPPL.4). https://doi.org/10.1590/s0036-36342009001000014

Barquera, S., & Rivera, J. A. (2020). Obesity in Mexico: rapid epidemiological transition and food industry interference in health policies. *The Lancet Diabetes and Endocrinology*, *8*(9), 746–747. https://doi.org/10.1016/S2213-8587(20)30269-2

Biritwum, R., Mensah, G., Yawson, A., & Minicuci, N. (2013). Study on global AGEing and Adult Health (SAGE), Wave 1. *Who Sage*, 1–111.

Chooi, Y. C., Ding, C., & Magkos, F. (2019). The epidemiology of obesity. *Metabolism: Clinical and Experimental*, *92*, 6–10. https://doi.org/10.1016/j.metabol.2018.09.005

Christakis, N. A., & Fowler, J. H. (2007). The Spread of Obesity in a Large Social Network over 32 Years. *New England Journal of Medicine*, *357*(4), 370–379. https://doi.org/10.1056/nejmsa066082

Dare, S., Mackay, D. F., & Pell, J. P. (2015). Relationship between smoking and obesity: A cross-sectional study of 499,504 middle-aged adults in the UK general population. *PLoS ONE*, *10*(4). https://doi.org/10.1371/journal.pone.0123579

Dieteren, C., & Bonfrer, I. (2021). *Socioeconomic inequalities in lifestyle risk factors across low- and middle-income countries*. 1–12.

Eknoyan, G. (2008). Adolphe Quetelet (1796-1874) - The average man and indices of obesity. *Nephrology Dialysis Transplantation*, *23*(1), 47–51. https://doi.org/10.1093/ndt/gfm517

Ferrer, C. P., McMunn, A., Rivera Dommarco, J. A., & Brunner, E. J. (2014). Educational inequalities in obesity among Mexican women: Time-trends from 1988 to 2012. *PLoS ONE*, *9*(3), 1–8. https://doi.org/10.1371/journal.pone.0090195

Filmer, D., & Pritchett, L. H. (2001). Estimating wealth effects without expenditure data - Or tears: An application to educational enrollments in states of India. *Demography*, *38*(1), 115–132. https://doi.org/10.2307/3088292

Ford, N. D., Patel, S. A., & Narayan, K. M. V. (2017). Obesity in Low- and Middle-Income Countries: Burden, Drivers, and Emerging Challenges. *Annual Review of Public Health*, *38*, 145–164. https://doi.org/10.1146/annurev-publhealth-031816-044604

Gutin, I. (2018). In BMI we trust: Reframing the body mass index as a measure of health. *Social Theory and Health*, *16*(3), 256–271. https://doi.org/10.1057/s41285-017-0055-0

Jaacks, L. M., Vandevijvere, S., Pan, A., McGowan, C. J., Wallace, C., Imamura, F., Mozaffarian, D., Swinburn, B., & Ezzati, M. (2019). The obesity transition: stages of the global epidemic. *The Lancet Diabetes and Endocrinology*, *7*(3), 231–240. https://doi.org/10.1016/S2213-8587(19)30026-9

Jiwani, S. S., Carrillo-Larco, R. M., Hernández-Vásquez, A., Barrientos-Gutiérrez, T., Basto-Abreu, A., Gutierrez, L., Irazola, V., Nieto-Martínez, R., Nunes, B. P., Parra, D. C., & Miranda, J. J. (2019). The shift of obesity burden by socioeconomic status between 1998 and 2017 in Latin America and the Caribbean: a cross-sectional series study. *The Lancet Global Health*, *7*(12), e1644–e1654. https://doi.org/10.1016/S2214-109X(19)30421-8

Jollife, I. T., & Cadima, J. (2016). Principal component analysis: A review and recent developments. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *374*(2065). https://doi.org/10.1098/rsta.2015.0202

Kakwani, N., Wagstaff, A., & Van Doorslaer, E. (1997). Socioeconomic inequalities in health: Measurement, computation, and statistical inference. *Journal of Econometrics*, *77*(1), 87–103. https://doi.org/10.1016/S0304-4076(96)01807-6

Kowal, P., Chatterji, S., Naidoo, N., Biritwum, R., Fan, W., Ridaura, R. L., Maximova, T., Arokiasamy, P., Phaswana-Mafuya, N., Williams, S., Josh Snodgrass, J., Minicuci, N., D'Este, C., Peltzer, K., Ties Boerma, J., Yawson, A., Mensah, G., Yong, J., Guo, Y., … Newell, M. L. (2012). Data resource profile: The world health organization study on global ageing and adult health (SAGE). *International Journal of Epidemiology*, *41*(6), 1639–1649. https://doi.org/10.1093/ije/dys210

Levasseur, P. (2015). Causal effects of socioeconomic status on central adiposity risks: Evidence using panel data from urban Mexico. *Social Science and Medicine*, *136–137*, 165–174. https://doi.org/10.1016/j.socscimed.2015.05.018

Luppino, F. S., de Wit, L. M., Bouvy, P. F., Stijnen, T., Cuijpers, P., Penninx, B. W. J. H., & Zitman, F. G. (2010). Overweight, Obesity, and Depression. Archives of General Psychiatry, 67(3), 220. https://doi.org/10.1001/archgenpsychiatry.2010.2

Marmot, M. (2017). Closing the health gap. *Scandinavian Journal of Public Health*, *45*(7), 723–731. https://doi.org/10.1177/1403494817717433

McGill, P. (2014). Summary : Understanding Socio-Economic Inequalities. *Center for Aging Research and Development in Ireland*, 1–12.

Meisel, J. D., Ramirez, A. M., Esguerra, V., Montes, F., Stankov, I., Sarmiento, O. L., & Valdivia, J. A. (2020). Using a system dynamics model to study the obesity transition by socioeconomic status in Colombia at the country, regional and department levels. *BMJ Open*, *10*(6), e036534. https://doi.org/10.1136/bmjopen-2019-036534

Menezes, M. M., Lopes, C. T., & Nogueira, L. de S. (2016). Impacto de intervenções educativas na redução das complicações diabéticas: revisão sistemática. *Revista Brasileira de Enfermagem*, *69*(4), 773–784. https://doi.org/10.1590/0034-7167.2016690422i

Monteiro, C. A., Conde, W. L., Lu, B., & Popkin, B. M. (2004). Obesity and inequities in health in the developing world. *International Journal of Obesity*, *28*(9), 1181–1186. https://doi.org/10.1038/sj.ijo.0802716

Najafi, F., Pasdar, Y., Hamzeh, B., Rezaei, S., Nazar, M. M., & Soofi, M. (2018). Measuring and decomposing socioeconomic inequalities in adult obesity in western Iran. *Journal of Preventive Medicine and Public Health*, *51*(6), 289–297. https://doi.org/10.3961/jpmph.18.062

Neuman, M., Kawachi, I., Gortmaker, S., & Subramanian, S. V. (2013). Urban-rural differences in BMI in low- and middle-income countries: The role of socioeconomic status. *American Journal of Clinical Nutrition*, *97*(2), 428–436. https://doi.org/10.3945/ajcn.112.045997

Noreen, E. (1988). An Empirical Comparison of Probit and OLS Regression Hypothesis Tests University of Chicago Stable. *Journal of Accounting Research*, *26*(1), 119–133. https://www.jstor.org/stable/2491116

Nussbaumer, L. (2020). Anthropometrics. In *Human Factors in the Built Environment*. https://doi.org/10.5040/9781501320415.ch-002

Nuttall, F. Q. (2015). Body mass index: Obesity, BMI, and health: A critical review. *Nutrition Today*, *50*(3), 117–128. https://doi.org/10.1097/NT.0000000000000092

O'Donnell, O., Doorslaer, E., Wagstaff, A., & Lindelow, M. (2007). Analyzing Health Equity Using Household Survey Data (1ste ed.). World Bank Publications. https://doi.org/10.1596/978-0-8213-6933-3

OECD/European Observatory on Health Systems and Policies. (2017). Obesity Update 2017. *Diabetologe*, *13*(5), 331–341. www.oecd.org/health/obesity-update.htm

OECD. (2010). OECD Perspectives : Mexico Key Policies for Sustainable Development. *October*, *October*.

Reynales-Shigematsu, L. M., Wipfli, H., Samet, J., Regalado-Pineda, J., & Hernández-ávila, M. (2019). Tobacco control in Mexico: A decade of progress and challenges. *Salud Publica de Mexico*, *61*(3), 292–302. https://doi.org/10.21149/9360

Rtveladze, K., Marsh, T., Barquera, S., Sanchez Romero, L. M. ari., Levy, D., Melendez, G., Webber, L., Kilpi, F., McPherson, K., & Brown, M. (2014). Obesity prevalence in Mexico: impact on health and economic burden. *Public Health Nutrition*. https://doi.org/10.1017/S1368980013000086

Salas-Ortiz, A. (2020). *Understanding the role of inequality of opportunity in body mass index and waist circumference among Mexican adults*. http://www.york.ac.uk/economics/postgrad/herc/hedg/wps/

Shah, N. R., & Braverman, E. R. (2012). Measuring adiposity in patients: The utility of body mass index (BMI), percent body fat, and leptin. *PLoS ONE*, *7*(4). https://doi.org/10.1371/journal.pone.0033308

Sorkin, J. D., Muller, D. C., & Andres, R. (1999). Longitudinal change in the heights of men and women: Consequential effects on body mass index. *Epidemiologic Reviews*, *21*(2), 247–260. https://doi.org/10.1093/oxfordjournals.epirev.a018000

Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L., & Gortmaker, S. L. (2011). The global obesity pandemic: Shaped by global drivers and local environments. *The Lancet*, *378*(9793), 804–814. https://doi.org/10.1016/S0140-6736(11)60813-1

Templin, T., Hashiguchi, T. C. O., Thomson, B., Dieleman, J., & Bendavid, E. (2019). The overweight and obesity transition from the wealthy to the poor in low- And middleincome countries: A survey of household data from 103 countries. *PLoS Medicine*, *16*(11), 1–15. https://doi.org/10.1371/journal.pmed.1002968

Traversy, G., & Chaput, J. P. (2015). Alcohol Consumption and Obesity: An Update. *Current Obesity Reports*, *4*(1), 122–130. https://doi.org/10.1007/s13679-014-0129-4

Wagstaff, A., Van Doorslaer, E., & Watanabe, N. (2003). On decomposing the causes of health sector inequalities with an application to malnutrition inequalities in Vietnam. *Journal of Econometrics*, *112*(1), 207–223. https://doi.org/10.1016/S0304-4076(02)00161-6

Wang, J., & Geng, L. (2019). Effects of socioeconomic status on physical and psychological health: Lifestyle as a mediator. *International Journal of Environmental Research and Public Health*, *16*(2). https://doi.org/10.3390/ijerph16020281

Wells, J. C. K., Marphatia, A. A., Cole, T. J., & McCoy, D. (2012). Associations of economic and gender inequality with global obesity prevalence: Understanding the female excess. *Social Science and Medicine*, *75*(3), 482–490. https://doi.org/10.1016/j.socscimed.2012.03.029

Wilson, S. E. (2012). Marriage, gender and obesity in later life. *Economics and Human Biology*, *10*(4), 431–453. https://doi.org/10.1016/j.ehb.2012.04.012

World Health Organisation. (2016). Global Ncd Target. *Facts Sheet*, *16*(195), 2. http://www.who.int/beat-ncds/en/

World Health Organization. (2016). *Mexico - Study on Global Ageing and Adult Health -2014, Wave 2*. 1–4. http://apps.who.int/healthinfo/systems/surveydata/index.php/catalog/212#page=overview&tab=study-desc

Wright, S. M., & Aronne, L. J. (2012). Causes of obesity. *Abdominal Imaging*, *37*(5), 730–732. https://doi.org/10.1007/s00261-012-9862-x

8 Appendices

8.1 Probit regression

Table 7: Probit regression results for *obesity BMI (30+)* - 2009 and 2015

	2009 (N=2333)			2015 (N=3797)		
Obesity (BMI 30+)	**Coef.**	**p-value**	**Sig**	**Coef.**	**p-value**	**Sig**
Woman	0.499	0.000	***	0.429	0.000	***
Age in years	-0.005	0.012	**	-0.006	0.000	***
Education – more than primary school	0.025	0.701		0.018	0.718	
Living together or married	0.185	0.003	***	0.170	0.000	***
Urban area	0.049	0.486		0.061	0.262	
Health today – good or very good	-0.034	0.576		-0.067	0.140	
Depression	-0.047	0.436		-0.034	0.460	
Difficulties with activities	0.158	0.018	***	0.052	0.378	
Tobacco use	-0.041	0.533		-0.126	0.021	***
Alcohol use	0.013	0.841		0.090	0.075	*
Walk or use bike for small distances	-0.161	0.007	***	-0.123	0.008	***
Vigorous fitness for at least ten minutes	-0.276	0.075	**	-0.135	0.270	
Moderate fitness	-0.009	0.940		0.019	0.791	
Sitting more than eight hours a day	0.089	0.439		0.338	0.000	***
Ever worked	0.012	0.844		0.006	0.913	
Friends coming over once a year	0.087	0.160		0.010	0.828	
Going out of the house once or twice a year	0.069	0.267		0.065	0.201	
Daily fruit intake – two or more pieces a day	0.016	0.785		0.043	0.374	
Daily vegetable intake – two or more pieces a day	0.043	0.480		0.062	0.184	
Poorest quintile	(omitted)	-		(omitted)	.	
Poor quintile	0.227	0.015	***	0.212	0.003	***
Middle quintile	0.361	0.000	***	0.362	0.000	***
Rich quintile	0.353	0.000	***	0.341	0.000	***
Richest quintile	0.378	0.000	***	0.280	0.000	***
Constant	-0.882	0.000	***	-0.739	0.000	***

**** p<.01, ** p<.05, * p<.10*

8.2 Sensitivity analysis: panel sample

8.2.1 Summary statistics

Table 8 indicates characteristics concerning the independent and dependent variables in the panel sample. The average BMI of respondents included in this sample declined a bit from 28.627 to 28.508 over time, and a decline of 1.3 percentage point was observed in the number of with *obesity (BMI of 30+).* In 2009, the percentage of people with *obesity* (*BMI 30+)* was 34 percent, while this was 32.7 percent in 2015. This is in contrast with what is observed in the cross-sectional sample.

Table 8: Summary statistics – Independent and dependent variables - 2009 and 2015

	2009 N=1244	2015 N=1244
Independent variables		
Woman (%)	63.4	63.6
Age in years (mean)	61.7	66.4
Education – more than primary school (%)	46.7	49.6
Living together or married (%)	68.5	61.2
Urban area (%)	70.1	70.1
Health today – good and very good(%)	39.5	42.9
Depression (%)	44.4	44.5
Difficulties with activities (%)	25.6	25.6
Tobacco use (%)	36.8	23.4
Alcohol use (%)	49.4	44.9
Walk or use bike for small distances (%)	65.0	58.7
Vigorous fitness for at least ten minutes (%)	3.50	2.00
Moderate fitness for at least ten minutes (%)	5.70	8.40
Sitting more than eight hours a day (%)	3.50	7.20
Ever worked (%)	55.8	73.6
Friends coming over once a year (%)	53.3	53.7
Going out of the house once or twice a year (%)	55.9	71.9
Daily fruit intake – two or more pieces a day (%)	46.4	42.3
Daily vegetable intake – two or more pieces a day (%)	47.7	46.5
Wealth Quintiles (mean)	2.997	2.998
	2009	2015
Dependent variables		
BMI (mean)	28.627	28.508
Overweight – BMI: 25-30 (%)	41.0	41.8
Obesity – BMI: 30+ (%)	34.0	32.7
True height (cm)	156.1	154.4
True weight (kg)	69.8	68.1
Waist circumference (cm)	98.3	104.3
Hip circumference (cm)	107.6	111.4

The t-test results to check whether respondents with missing data on *height* and *weight*, which had to be dropped, were not significantly different from respondents with available data on these variables are presented in table 9. Significant differences between respondents with and without *height* and/or *weight* did exist on 5 out of the 20 independent variables in 2009, and on 9 of the 20 independent variables in 2015.

Table 9: Two sample t-test for group with and without BMI data - 2009 and 2015

	2009			2015		
	Mean BMI missing (N= 122)	Mean BMI observed (N=1387)	p-value	Mean BMI missing (N= 180)	Mean BMI observed (N=1329)	p-value
Woman	.557	.643		.683	.633	
Age in years	63.631	61.939		69.844	66.401	***
Education – more than primary school	.467	.46		.456	.503	
Living together or married	.582	.671	**	.533	.611	**
Urban area	.754	.702		.722	.705	
Health today – good and very good	.369	.395		.328	.432	***
Depression	.467	.452		.561	.441	***
Difficulties with activities	.352	.264	**	.400	.254	***
Tobacco use	.311	.362		.222	.229	
Alcohol use	.483	.488		.422	.446	
Walk or use bike for small distances	.533	.64	**	.339	.589	***
Vigorous fitness for at least ten minutes	.033	.038		.017	.019	
Moderate fitness for at least ten minutes	.041	.058		.017	.081	***
Sitting more than eight hours a day	.147	.037	***	.234	.070	***
Ever worked	.541	.551		.666	.738	***
Friends coming over once a year	.533	.533		.483	.543	
Going out of the house once or twice a year	.434	.561	***	.683	.720	
Daily fruit intake – two or more pieces a day	.492	.465		.450	.423	
Daily vegetable intake – two or more pieces a day	.483	.48		.467	.462	
Wealth index	2.81	2.92		2.96	2.96	

**** p<.01, ** p<.05, * p<.10*

8.2.2 OLS-regression

Table 10 shows the OLS-regression results for 2009 and 2015. The results for 2009 show that *woman* and being in the *middle* or *rich quintile* are significantly and positively correlated with *obesity (BMI 30+)* at a 1%-level. *Living together or married* and being in *the richest quintile* are positively correlated at a 5%-significance level. The results for 2015 indicate that *woman, age in years, walk or use bike for small distances* and being ranked in the *richest quintile* are significantly correlated with *obesity (BMI 30+)* at a 1%-level. *Age in years* and *walk or use bike for small distances* are negatively correlated, while *woman* and being in the *richest quintile* are positively correlated. *Depression, sitting more than eight hours a day* and being in the *poor, middle* or *rich quintile* are significant positively correlated with *obesity (BMI 30+)* at a 5%-level. *Difficulties with activities* is negatively correlated with *obesity (BMI 30+)*, also at 5%-level.

Table 10: OLS-regression results for *obesity BMI (30+)* - 2009 and 2015

	2009 (N=1244)			2015 (N=1244)		
Obesity (BMI 30+)	**Coef.**	**p-value**	**Sig**	**Coef.**	**p-value**	**Sig**
Woman	.193	.000	***	.186	.000	***
Age in years	.000	.692		-.005	.000	***
Education – more than primary school	.032	.290		.014	.630	
Living together or married	.079	.011	**	.009	.745	
Urban area	-.004	.894		-.043	.178	
Health today – good or very good	.028	.322		.003	.901	
Depression	-.021	.460		-.055	.041	**
Difficulties with activities	.063	.052	*	.065	.034	**
Tobacco use	-.020	.531		-.036	.277	
Alcohol use	-.002	.948		.006	.833	
Walk or use bike for small distances	-.051	.080	*	-.085	.002	***
Vigorous fitness for at least ten minutes	.042	.582		-.082	.386	
Moderate fitness	.029	.627		-.006	.907	
Sitting more than eight hours a day	.048	.508		.103	.011	**
Ever worked	.014	.650		.024	.479	
Friends coming over once a year	.039	.189		.008	.756	
Going out of the house once or twice a year	.040	.183		.035	.245	
Daily fruit intake – two or more pieces a day	.002	.936		-.016	.575	
Daily vegetable intake – two or more pieces a day	.017	.564		.038	.176	
Poorest quintile	(omitted)	-		(omitted)	-	
Poor quintile	.061	.154		.061	.146	
Middle quintile	.126	.004	***	.103	.017	**
Rich quintile	.130	.004	***	.103	.020	**
Richest quintile	.108	.024	**	.110	.020	**
Constant	.054	.620		.456	.000	***

**** p<.01, ** p<.05, * p<.10*

8.2.3 Concentration curves and standard concentration indices

The concentration curves for 2009 and 2015 are presented in figure 5. Both the concentration curves are below the 45-degree diagonal, indicating that obesity is unequally and pro-rich distributed in Mexico. The concentration curve for 2015 is closer to the 45-degree diagonal, compared to 2009. This indicates a decline in the socioeconomic inequality in *obesity (BMI 30+)* between the period of 2009 and 2015.

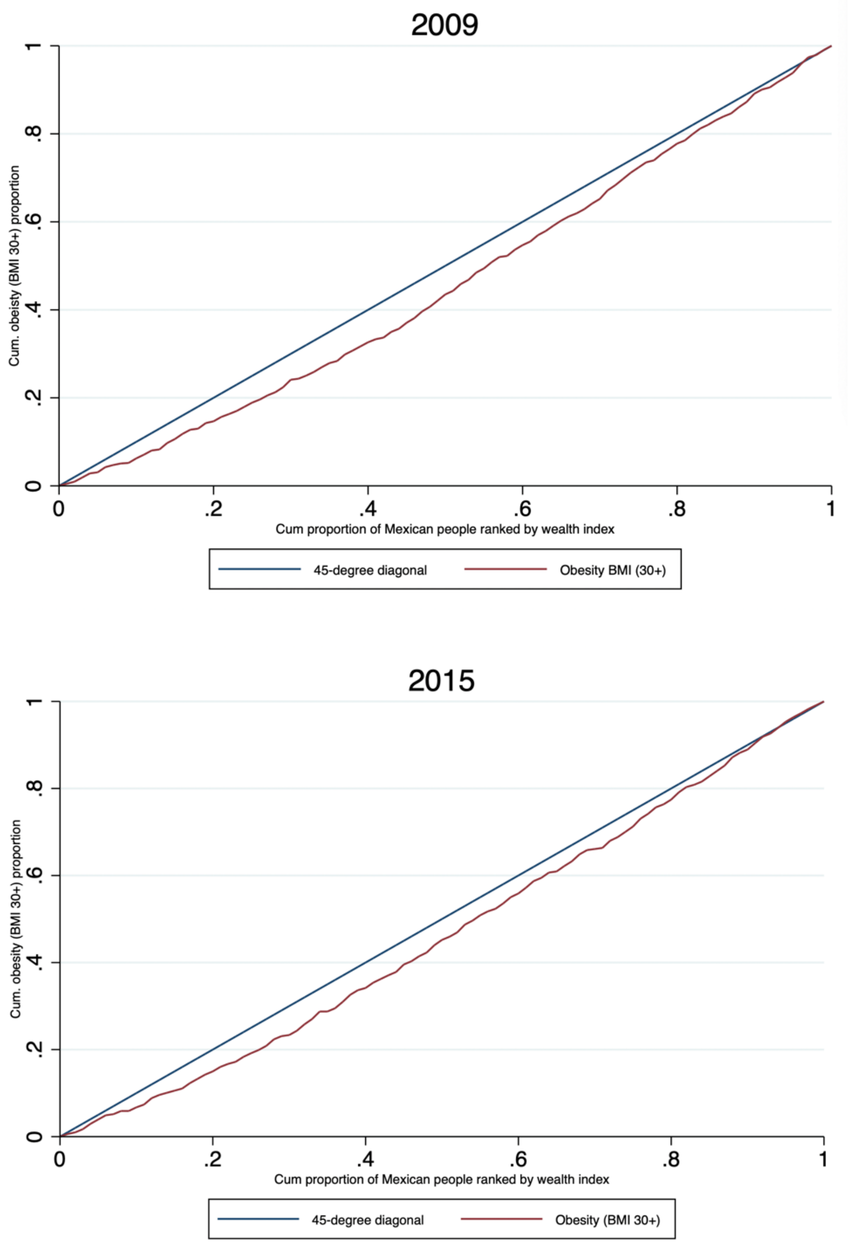


Figure 5: *Concentration curves obesity (BMI 30+) for 2009 and 2015. The red line represents the concentration curve for obesity (BMI 30+) and the blue line reflects the 45-degree diagonal for equality.*

The standard concentration indices for *obesity (BMI 30+)* of 0.087 and 0.072, for respectively 2009 and 2015, are presented in table 11. These standard concentration indices also reflect a pro-rich distribution of *obesity (BMI 30+)*, which declined slightly between 2009 and 2015. The mean *obesity (BMI 30+)* prevalence for each quintile declined between 2009 and 2015, except for the *poor quintile.* In the *poor quintile* an increase was observed in the share of people facing *obesity (BMI 30+)* of 0.8 percentage point.

Table 11: Standard concentration index *obesity (BMI 30+)* - 2009 and 2015

Year	N	Standard CI	SE	Mean Poorest Quintile	Mean Poor Quintile	Mean Middle Quintile	Mean Rich Quintile	Mean Richest Quintile	p-value
2009	1244	.087	.022	24.9	30.5	37.6	39.0	38.1	.000
2015	1244	.072	.023	24.5	31.3	35.7	35.3	36.7	.002
Δ				*-0.4%*	*+0.8%*	*-1.9%*	*-3.7%*	*-1.4%*	

8.2.4 Decomposition of the standard concentration index

The decomposition results for the standard concentration indices are presented in table 12 and table 13. Being in the *poor, rich* and *richest quintiles* seem to explain most of the existing socioeconomic inequality in *obesity (BMI 30+)* in 2009 and 2015. The role of the other independent variables in explaining the socioeconomic inequalities in *obesity (BMI 30+)* in this sample is considerably lower. The results are comparable with the results of the cross-sectional sample described in section 4.4.

Table 12: Decomposition of the standard concentration index *obesity (BMI 30+)* - 2009

Obesity (BMI 30+) - 2009	Beta	Elasticity	CI	Contribution	Perc. contribution
Woman	.193	.360	-.012	-.004	-5.2
Age in years	.000	-.084	-.006	.001	0.6
Education – more than primary school	.032	.044	.231	.010	11.8
Living together or married	.079	.159	.020	.003	3.6
Urban area	-.004	-.009	.152	-.001	-1.6
Health today – good or very good	.028	-.033	.035	.001	1.3
Depression	-.021	-.028	-.057	.002	1.8
Difficulties with activities	.063	.047	-.085	-.004	-4.6
Tobacco use	-.020	-.022	.037	-.001	-0.9
Alcohol use	-.002	-.003	.059	.000	-0.2
Walk or use bike for small distances	-.051	-.097	-.018	.002	2.0
Vigorous fitness for at least ten minutes	.042	.004	.214	.001	1.0
Moderate fitness	.029	.005	.217	.001	1.2
Sitting more than eight hours a day	.048	.005	.187	.001	1.2
Ever worked	.014	.023	.041	.001	1.2
Friends coming over once a year	.039	.061	-.010	-.001	-0.7
Going out of the house once or twice a year	.040	.066	.031	.002	2.3
Daily fruit intake – two or more pieces a day	.002	.003	.029	.000	0.1
Daily vegetable intake – two or more pieces a day	.017	.023	.080	.002	2.2
Poorest quintile	(omitted)	-	-.800	-	-
Poor quintile	.061	.036	-.400	-.014	-16.7
Middle quintile	.126	.075	.002	.000	0.1
Rich quintile	.130	.077	.403	.031	35.7
Richest quintile	.108	.063	.802	.051	58.7
Total of CI explained				*0.082*	*94.8*
Residual				*0.005*	*5.2*
Total CI				*0.087*	*100*

Table 13: Decomposition of the standard concentration index *obesity (BMI 30+)* - 2015

Obesity (BMI 30+) - 2015	Beta	Elasticity	CI	Contribution	Perc. contribution
Woman	.186	.361	-.015	-.006	-7.7
Age in years	-.005	-.944	--.009	.008	11.7
Education – more than primary school	.014	.022	.221	.005	6.7
Living together or married	.009	.018	.016	.000	0.4
Urban area	-.043	-.091	.132	-.012	-16.6
Health today – good or very good	.003	.004	-.015	-.000	-0.1
Depression	-.055	-.075	-.037	.003	3.9
Difficulties with activities	.065	.050	-.098	-.005	-6.9
Tobacco use	-.036	-.025	.079	-.002	-2.8
Alcohol use	.006	.009	.090	.001	1.1
Walk or use bike for small distances	-.085	-.152	-.027	.004	5.8
Vigorous fitness for at least ten minutes	-.082	-.005	.353	-.002	-2.4
Moderate fitness	-.006	-.001	.304	-.000	-0.6
Sitting more than eight hours a day	.103	.029	.111	.003	4.4
Ever worked	.024	.054	.059	.003	4.4
Friends coming over once a year	.008	.014	.050	.001	1.0
Going out of the house once or twice a year	.035	.076	.029	.002	3.1
Daily fruit intake – two or more pieces a day	-.016	-.021	.129	-.003	-3.7
Daily vegetable intake – two or more pieces a day	.038	.054	.069	.004	5.2
Poorest quintile	(omitted)	-	-.800	-	-
Poor quintile	.061	.038	-.400	- .015	-20.8
Middle quintile	.103	.063	.001	.000	0.01
Rich quintile	.103	.062	.401	.025	34.9
Richest quintile	.110	.067	.801	.054	74.5
Total of CI explained				*0.069*	*95.5*
Residual				*0.003*	*4.5*
Total CI				*0.072*	*100*

8.3 Sensitivity analysis: overweight (BMI 25-30)

8.3.1 OLS-regression

Table 14 shows the OLS-regression results for the independent variable *overweight (BMI 25-30)* for both 2009 and 2015. The results for 2009 show that *woman* and being in the *richest quintile* are significantly correlated with *overweight (BMI 25-30)* at a 1%-level significance level*. Woman* is negatively correlated, while being in the *richest quintile* shows a positive correlation. *Walk or use bike for small distances* is positively correlated at a 5%-significance level. The results for 2015 indicate that *woman* is still negative and significantly correlated at a 5%-level. *Sitting more than eight hours a day* is also negative and significantly correlated at a 5%-level.

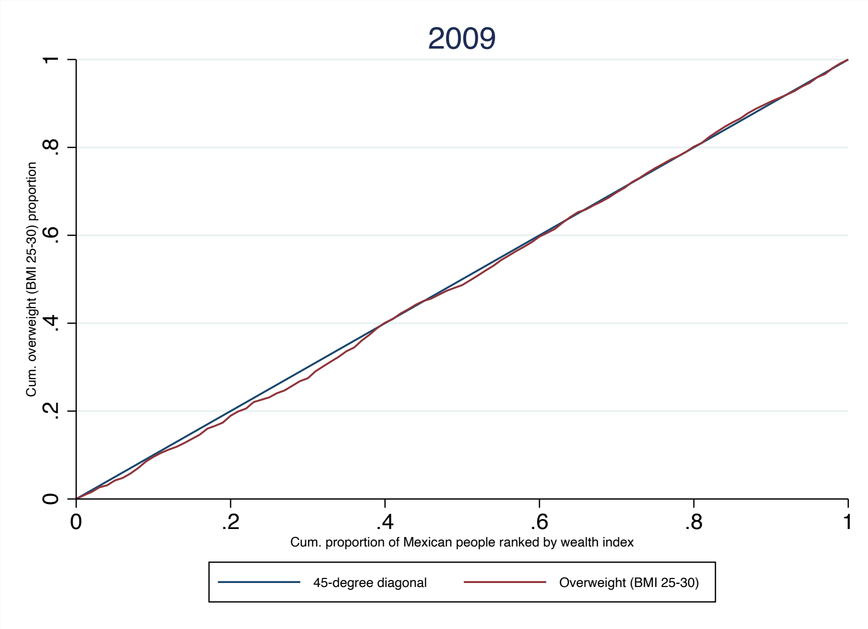
Table 14: OLS-regression results for *obesity BMI (30+)* - 2009 and 2015

	2009 (N=2333)			2015 (N=3797)		
Overweight (BMI 25-30)	**Coef.**	**p-value**	**Sig**	**Coef.**	**p-value**	**Sig**
Woman	-.098	.000	***	-.061	.004	***
Age in years	-.001	.319		0.00	.760	
Education – more than primary school	-.026	.274		-.016	.391	
Living together or married	.001	.974		.007	.689	
Urban area	.030	.241		.008	.702	
Health today – good or very good	-.021	.339		-.004	.804	
Depression	-.005	.821		.007	.691	
Difficulties with activities	-.035	.159		-.025	.249	
Tobacco use	.004	.879		.034	.091	*
Alcohol use	-.004	.853		-.016	.395	
Walk or use bike for small distances	.053	.016	**	-.001	.933	
Vigorous fitness for at least ten minutes	.051	.362		-.030	.503	
Moderate fitness	-.036	.406		-.007	.792	
Sitting more than eight hours a day	-.066	.122		-.122	.000	***
Ever worked	-.009	.712		-.009	.692	
Friends coming over once a year	-.032	.157		-.016	.328	
Going out of the house once or twice a year	.001	.967		-.001	.976	
Daily fruit intake – two or more pieces a day	.007	.748		.011	.533	
Daily vegetable intake – two or more pieces a day	.020	.371		-.025	.159	
Poorest quintile	(omitted)	-		(omitted)	-	
Poor quintile	.038	.254		.003	.895	
Middle quintile	-.003	.922		.003	.922	
Rich quintile	.017	.624		.033	.227	
Richest quintile	.012	.752	***	.056	.055	*
Constant	.495	.000	***	.447	.000	***

****** p<.01, ** p<.05, * p<.10*

8.3.2 Concentration curves and standard concentration indices

The concentration curves for *overweight (BMI 25-30)* are presented in figure 6. Both the concentration curves for 2009 and 2015 are very close to the 45-degree diagonal, indicating that there is almost no socioeconomic inequality in *overweight (BMI 25-30).* This is also reflected in the small standard concentration indices of 0.011 and 0.022 for respectively 2009 and 2015, presented in table 14. Both the standard concentration indices are not significant at a 5%-level.



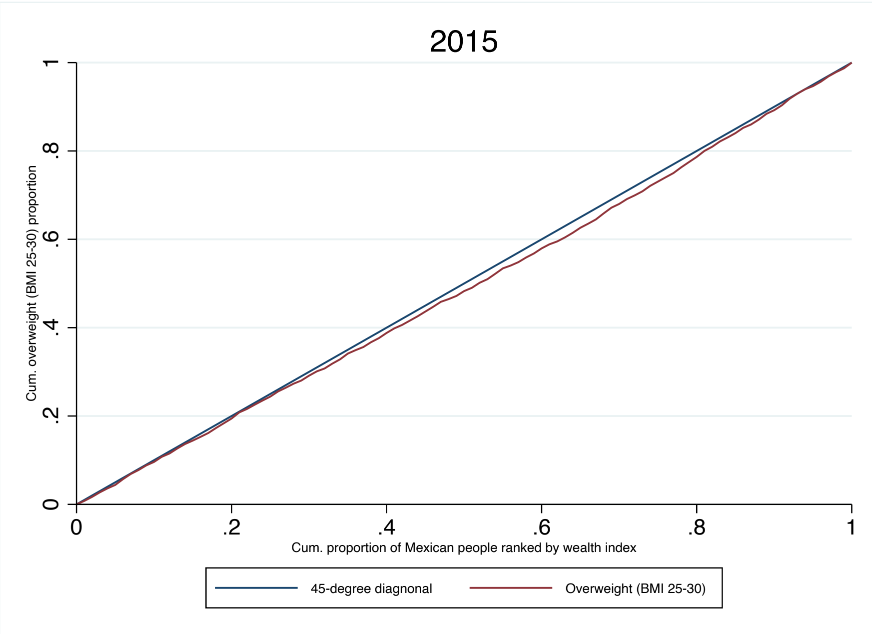


Figure 6: *Concentration curves overweight (BMI 25-30) for 2009 and 2015. The red line represents the concentration curve for obesity (BMI 30+) and the blue line reflects the 45-degree diagonal for equality.*

Table 15: Standard concentration index *obesity (BMI 30+)* - 2009 and 2015

Year	N	Standard CI	SE	Mean Poorest Quintile	Mean Poor Quintile	Mean Middle Quintile	Mean Rich Quintile	Mean Richest Quintile	p-value
2009	2333	.011	.014	38.3	42.9	39.4	41.1	40.3	.453
2015	3797	.022	.011	39.5	39.2	38.9	42.1	43.3	.050
Δ				*+1.2%*	*-3.7%*	*-0.5%*	*+1.0%*	*+3.0%*	