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Master Thesis Health Economics

Socio-Economic Patterns in Overweight from Adolescence through Adulthood in the United States: a decomposition analysis

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ABSTRACT

Overweight among adolescents is a growing health problem in many countries, especially in the United States. The current study examines socioeconomic-related inequality in overweight and obesity over time among young Americans using the methodology of the Erreygers adjusted concentration index. The changes in the concentration index of obesity are decomposed into obesity-related income mobility (M^R) and income-related obesity mobility (M^H). The analyses from adolescence through adulthood are examined based on surveys from the National Longitudinal Study of Adolescent Health (Add Health). The descriptive results show a significant increase in both overweight (10.5 p.p.) and obesity (27 p.p.) prevalence from adolescence (11-22 y) to adulthood (24-34 y). The results of the Erreygers index show that socioeconomic-related inequality in overweight is not statistically significant in this study, except for males. For obesity, there is a statistically significant negative Erreygers index found, except for males in the last period (adulthood). Overall, individuals show a stronger negative degree of socioeconomic inequality in obesity at adult ages compared to younger ages, referring to a larger concentration of obesity among low-income groups during adulthood. In addition, the change in the Erreygers index of obesity can rather be attributed to income-related obesity mobility (M^H) than to obesity-related income mobility (M^R). This suggests that the increase in the Erreygers adjusted concentration index is more likely caused by transitions into obesity among the initial poor (M^H) than to reranking of incomes (M^R). Despite the lower contribution of M^R, the results still show a significant contribution, where obesity is associated with downward income mobility. Overall, both mobility components were harmful for low-SES groups, referring to an increase in obesity over time among the poor.

Key words: United States; Concentration index; Overweight; Obesity; Socioeconomic-related inequality; SES; Income mobility; Obesity mobility

1. INTRODUCTION

One of the highest proportions of overweight and obese people aged 18 and above is observed in the United States (US). As a result, the American population is considered the global leaders in adult overweight prevalence including obesity with 62.9% for women and 72.8% for men (WHO, 2014). The number of overweight people in the US is still increasing and it has become the recent struggle of the American population as well as for the worldwide population to overcome obesity. Overweight and obesity are associated with serious health disorders (Troiano et al., 1995; Hojjat & Hojjat, 2017). Demonstrated harmful health effects of being overweight include the risk of non-communicable diseases such as diabetes, cardiovascular diseases, musculoskeletal disorders and some cancers (WHO, 2015).

Overweight is often already developed at younger ages. The percentage of children with overweight or obesity has been increasing at a concerning rate during the last decades. Almost one in three children in the United States are overweight or obese (Hedley et al., 2004). In addition to the direct negative consequences of childhood overweight, it is even a bigger concern in the long term. Studies have shown that early development of overweight during childhood involves a great risk of obesity during adulthood (Serdula et al., 1993; Srinivasan et al., 1996; Power et al., 1997; Gordon-Larsen et al., 2004). Obesity involves even worse adverse health effects and is hard to treat (Troiano et al., 1995; Müller et al., 2001). Therefore, this study focuses also on overweight among adolescents in the United States since primary prevention of overweight is important to avoid the escalation of overweight during adulthood (Troiano et al., 1995).

Studies often attribute the high prevalence of overweight to socioeconomic status (SES) due to increased economic inequalities over time (Zhang & Wang, 2006). The relationship suggests that the socioeconomic status of an individual can have an effect on the chances of being overweight or obese. The study of Sobel & Stunkard (1989), a meta-analysis of 144 published studies on the association between SES and obesity, shows that there is no consistent relationship in developed countries. An inverse relationship between obesity and SES is found among women in developed countries, referring to a higher likelihood of obesity among low SES groups, while an inconsistent relationship is found for men and children. Furthermore, the study of Gordon-Larsen et al. (2003) shows also no dominant relationship between overweight and SES among young Americans. Overall, the relationship is complex when it comes to young

individuals and there is still lack of understanding in the literature. The current study contributes through observing whether socioeconomic inequality in overweight and/or obesity exists during adolescence and how it develops during adulthood. This is done by assessing the degree of inequality with respect to overweight and obesity through the methodology of the Erreygers adjusted concentration index and decomposing the changes of this index into mobility components (Wagstaff et al., 1991; Allanson et al., 2010).

This study uses data from the Add Health longitudinal study which is quite unique as it provides data from the same US adolescents over time from adolescence through adulthood. Therefore, this study applies the below described analysis on three time periods: 1994/1995, 2001/2002 and 2007/2008. The approach is inspired by the study of Madden (2016) for Ireland and consists of three parts. The first part of the analysis consists of descriptive analysis. This section provides overweight and obesity trends from adolescence through adulthood, by gender and income quintile. In addition, transitions from overweight into obesity are provided to observe whether there is an escalation of overweight from adolescence to adulthood. The second part examines changes in SES-related inequality of both overweight and obesity from 1994/1995 to 2007/2008, using the methodology of the Erreygers adjusted concentration index. This standard methodology provides a summary measure of socioeconomic inequality (Wagstaff & Van Doorslaer, 2008). In addition to the summary measure of inequality, changes in the Erreygers adjusted concentration index of obesity over time are observed by looking at two mobility components. The decomposition method of Allanson et al. (2010) provides a comprehensive way to disentangle whether changes in the concentration index are associated with changes of an individual's position in the income distribution or through changes in the individual's obesity status.

The remainder of this paper is structured as follows. Section two discusses the existing literature about the association between overweight/obesity and SES in the United States. Section three describes the methods of this study. Section four describes the results which consists of three parts. The first part consists of descriptive analysis. The second part examines SES-related inequality in overweight and obesity based on the methodology of the Erreygers adjusted concentration index. The third part observes the change in the inequality index from adolescence through adulthood by decomposing changes in the Erreygers adjusted concentration index of obesity into two mobility components. The final sections reflect on the study by providing concluding comments and discussion points.

2. THE US ASSOCIATION BETWEEN SES AND OVERWEIGHT

The overweight and obesity problem has reached a concerning level and, currently, overweight is considered as a major public health issue in the United States (Gordon-Larsen et al., 2004). Wang et al. (2002) already identified the concern with respect to overweight/obesity among American children using the NHANES data of two periods in the 20th century. A more recent study of Ogden et al. (2006) shows an overweight prevalence of 17.1 percent in 2003-2004 among children aged 2 to 19 years based on the NHANES data. In addition, the study found even more dramatic results among adults of 20 years or older, where 32.2 percent of the adults were obese. Overall, the results from the NHANES data show a significant increase in overweight prevalence among children between 1999 and 2004.

On the other hand, more recent data from the study of Ogden et al. (2014) shows that the prevalence of childhood obesity shows no significant differences between periods in the United States. Some other studies suggest that growth rates will be limited in the long run and predict a more hopeful future (Flegal et al., 2012). This stabilization evidence in both obesity and overweight is also found for other countries including Ireland (Madden, 2016), France (Salanave et al., 2009) and Switzerland (Schneider et al., 2010; Olds et al., 2011). However, these stabilization results are expected for future outcomes but do not reduce the harmful effects on the individuals that are currently already overweight. Even if policymakers do experience less challenges with respect to the increase of overweight prevalence, improvements are needed regarding the current high rates of overweight. The overweight struggle is now decades long, but the amount of successful policies is limited. In addition, Schwartz and Brownell (2007) emphasize the urgency of combatting the weight gain problem among individuals aged below 18.

The worldwide overweight issue does not affect all populations equally. In other words, overweight rates are not homogeneous for all individuals and depend on various factors such as; gender, education, socio-economic states, race, and cultural background (McLaren, 2007; Ogden et al., 2010). For instance, the literature shows that a lower socioeconomic status is often associated with higher chance of being overweight in one country whereas the relationship is not the same in another country. Therefore, in the case of socioeconomic inequality, which is the focus of this paper, it is important for policymakers to get more insight regarding the relationship between overweight and SES in the United States. There is still a need to unravel

the contribution of SES to the overweight problem, especially from younger ages to adult ages. Therefore, the provision of more insight about the importance of SES over time is one step closer to understanding the overweight issue.

However, socioeconomic differences in overweight populations can still be a challenge since the relationship is complex among different groups. For instance, the study of Zhang & Wang (2004) shows that the degree of socioeconomic inequality in overweight and obesity varies by gender and age in the United States. The socioeconomic inequality in overweight was especially present for female age-groups, where negative concentration indices were observed. In addition, the socioeconomic inequality in obesity was present among all age-groups for both genders, except for one male age-group. Overall, all age-groups provided negative concentration indices, but the severity of inequality varied by age-groups. The greatest degree of inequality was present among individuals from the ages of 40 to 49 years. However, the result is based on comparisons of different age groups involving different individuals. The current study will observe the differences between age-periods by gender based on the analysis of the same individuals over time.

Furthermore, the findings of Zhang & Wang (2004) show a stronger negative relationship between SES and obesity among women than men. In addition, contrary results between males and females were found with respect to inequality in overweight based on the methodology of the concentration index (CI). Among men, high SES-groups are more likely to be overweight than low SES-groups (positive CI), where the opposite holds for women (negative CI). The study of Sobel & Stunkard (1989) explains this inconsistent relationship among men through their different attitudes against overweight compared to women. Men experience less negative attitudes against overweight or obesity compared to women. These attitudes are already apparent at younger ages. For instance, the study of Hawkins et al. (1983) shows that teenage girls pay more attention to eating less compared to teenage boys.

There are many factors that explain the reason that overweight affects individuals differently. However, this paper focuses only on socio-economic status as a main factor to affect the overweight and obesity issue. The study of Goodman et al. (1999) shows evidence of SES gradients with respect to obesity among US adolescents, using the first period (1994/1995) of the Add Health data. It emphasizes the importance of considering SES factors in health studies such as overweight examinations. Although it is complex, understanding the role of

socioeconomic status helps to comprehend the health differences among adolescents over time. A comparable study of Friestad et al. (2003) also shows a negative association between overweight and SES during the first period (1994/1995) of the Add health study when using income and education as socioeconomic indicators. However, these results are based on a cross-sectional study and do not provide information over time.

The study of Wang & Zhang (2006) sheds more light on the dynamics of the relationship between overweight and SES over time covering the period from 1971 to 2002. It examines this relationship carefully by considering race, sex and age differences. Overall, results show that socioeconomic disparities weakened over time. In addition, the study of Gordon-Larsen et al. (2004) finds that girls are more likely to have a higher BMI compared to boys. This finding is in line with the results of other studies (Harris et al., 2009; Madden, 2016). Th results of Gordon-Larsen (2004) confirm that the BMI of young adults is higher than the BMI of adolescents, suggesting an enormous increase between youth and adulthood. This increase in BMI cannot be attributed to the 5 year difference in age. Therefore, the increase in body weight exceeds what one would expect during a five year increase in age.

It is necessary to discuss the criticism on using the BMI as a measure to define overweight or obesity. In particular, self-reported height and weight is often criticized as a source of measurement error. However, self-reported data is only used in the first period of the Add Health data and is not considered as problematic based on the study of Goodman et al. (1999). However, there is a tendency observed among females to underreport their weight (Swallen et al., 2005). This self-report bias among females is minimized due to the consistency of underreporting of weight among adolescent girls over time (Goodman, 2000). The remainder of the anthropometric data in later periods is measured by non-medic field interviewers (FI's) during an in-home interview. According to the study of Hussey et al. (2014), the in-home measures are reliable to use for the observation of weight and height. In addition, the accuracy of BMI in diagnosing overweight is often questioned in literature, but there is no other proven superior measure available in the current datasets (Romero-Corral et al., 2008 ; Ernsberger, 2012). Therefore, due to data limitation the majority of the studies use the BMI measure as a proxy for the estimation of overweight or obesity prevalence (Cole et al., 2000; Wang et al., 2002; Ogden et al., 2006; Madden, 2016). In addition, the age and gender specific cut-off points of Cole et al. (2000) are used for the analyses in this paper to determine overweight and obesity

among non-adults. The specific cut-off points take into account the systematic differences that occur with age and gender during adolescence. The definition of overweight and obesity is further explained in the methods section.

The aim of this study is to provide insights into the socioeconomic-related inequality in overweight and obesity in the United States. Therefore, no analysis will be provided about the developments in BMI below the overweight threshold. The longitudinal nature of the data used in this study provides the chance to observe developments of inequality with respect to overweight and obesity from adolescence through adulthood. Overall, these insights can help policy makers to be more effective in tackling the overweight and obesity issue at younger ages to avoid future escalation trends in overweight and obesity. We make several important and unique contributions to the existing literature: (i) observing the SES-related inequality in overweight and obesity from adolescence to adulthood of the same individuals through the use of the Erreygers adjusted concentration index and unique data (ii) decomposing the changes in the Erreygers adjusted concentration index of obesity into income-related obesity mobility and obesity-related income mobility based on the study of Allanson et al. (2010).

Given the existing literature, the current study provides more insights regarding the following proposed hypotheses. First, the concentration index is negative, suggesting a greater concentration of overweight and obesity among the low-SES groups compared to high-SES groups. Secondly, the degree of SES-related inequality is greater among females than males. The first two hypotheses are based on the described literature earlier in this section. Thirdly, socioeconomic-related inequality in overweight/obesity will increase from adolescence to adulthood. This is especially expected for obesity, since the Hojjat & Hojjat (2017) express their concern regarding the overweight issue among youth, since overweight adolescents are likely to become obese during adulthood. Therefore, more overweight adolescents, who are likely to be the initial poor based on the first hypothesis, will become obese. In addition, overweight/obese adults are also more likely to end up across the low-SES quintiles during adulthood than their non-fat counterparts. This limited upward income mobility among overweight and obese adolescents can be explained by the lower chance to complete a good education and the higher chance to end up at the poorest quintiles during adulthood (Hojjat & Hojjat, 2017). Consequently, more overweight/obesity among the poor causes a more unequal distribution of overweight/obesity. Therefore, an increase in the degree of socioeconomic-related inequality in overweight/obesity is expected during adulthood.

The last hypothesis includes expectations with respect to the decomposition of the change in the concentration index of obesity into two mobility components. Based on literature, this study proposes the following hypothesis: the change in the concentration index of obesity is mostly caused by transitions into obesity over time. The importance of obesity mobility to the change in the concentration index is based on the concern of many studies that overweight adolescents are likely to become obese during adulthood (Gordon-Larsen et al., 2014; Hojjat & Hojjat, 2017). The income mobility is expected to be a less important contributor. To illustrate, Chetty (2016) shows that the United States is not necessary the country of the great opportunities for each type of individual as is often claimed. Recent empirical studies have shown that US income mobility lags far behind other countries such as; Canada and Denmark (Corak 2013; Boserup et al., 2013). For instance, US children of the lowest income quintile have a chance of 7.5 percent to reach to highest income quintile, where the same chance is 13.5 percent in Canada (Chetty, 2016).

In addition, Hojjat & Hojjat (2017) show that, based on existing empirical evidence, US children from low-SES families have limited possibilities to climb up to another quintile compared to children from high-SES families. Therefore this study expects reranking within the income distribution to be a less important mobility component to the change of the concentration index. Since youth from low-income households have a small chance to end up at a higher relative rank position. In addition, as mentioned earlier, Hojjat & Hojjat express their concern regarding income mobility among fat adolescents. According to Hojjat & Hojjat (2017), fat adolescents deal with several psychological problems (i.e. depression, isolation and anxiety) at younger and adult ages. Moreover, fat children are likely to isolate themselves and are less successful in developing themselves properly during adulthood as their non-fat counterparts. Therefore, overweight children are less likely to complete a good education and have a higher chance to end up at the poorest quintiles.

3. METHODOLOGY

This study assesses the degree of socioeconomic-related inequality with respect to overweight and obesity in the United States through the use of the concentration index (O'Donnell & Wagstaff, 2008; Wagstaff & Van Doorslaer, 2008). Furthermore, the method of Allanson et al. (2010) is used to decompose the change of the concentration index of obesity from adolescence through adulthood into mobility components. This section describes the data and methods more in detail.

3.1 Data

Sample

The data collected from Add Health is a school-based longitudinal study of American adolescents. The sample consists of 80 high schools and 52 middle schools in the United States (Chantala & Tabor, 1999). The original Add Health sample consists of 6,504 individuals and this cohort has been followed from 1994-95 until 2007-08. The collected data used in this study is derived from adolescents and parents. This study will use the data of three periods where American adolescents have been followed repeatedly into their young adult years. The data stems from 1994/1995, 2001/2002 and 2007/2008, referred to as first age-period (11-22 y), second age-period (18-28 y) and third age-period (24-34 y) respectively. These periods are recommended to use when doing a longitudinal analysis (Chen & Chantala, 2014).

Attrition

This study uses a balanced panel. Observations which appear in all three periods were kept and those observations with missing data for weight and height were dropped. This reduces the final sample size to 3822, where 54 percent consists of females and 46 percent of males. There is a sizable sample loss due to the previous mentioned adjustments, and as a result the issue of non-random attrition arises. This can be a potential threat if it affects the accuracy of estimates obtained from the sample surveys which can be hard to avoid in longitudinal studies. However, the availability to observe the same individuals over time is more important in this study due to the application of mobility measures on the change in the Erreygers adjusted concentration index. In addition, the studies of Chantala et al. (2004) and Brownstein et al. (2011) investigated the non-response and the potential bias in estimates and showed less concern regarding attrition

and the risk of biased results. Overall, all three periods remained representative when sample weights are used (Chen & Chantala, 2014). In summary, this study assumes that the samples adequately represent the same population over time and are able to provide results with minimum bias.

Measurement vs. Self-reporting

The weight and height are the main variable used to generate the health variable of interest. The Add Health data provides these variables in the first period from self-reporting data, which is already considered as reliable in the previous section (Hussey et al., 2014). On the other hand, measured data is used during the second and third period which is obtained by non-medical field interviewers. The weight of the respondents was measured to the nearest 0.1 kilogram. The non-medical interviewers were instructed to make sure the respondents stand with their weight equally distributed on the bathroom scale. Furthermore, the height for each respondents was measured to the nearest 0.1 centimetre.

3.2 Variable definitions

Binary outcome variable

The variables of interest in this study are overweight and obesity, which take a value of 1 if overweight (obese) and 0 otherwise. The most used method to measure overweight and obesity is derived from the body mass index (BMI) which is calculated as weight in kilograms divided by height in meters squared (kg/m^2). The calculation of the BMI is performed with both self-reported and direct measured anthropometric data. The World Health Organization defines overweight among adults as a BMI greater than or equal to 25 and obesity as a BMI greater than or equal to 30 (WHO, 2016).

Definition of overweight and obesity (<18)

This study deals with a sample of adolescents originally from 11 to 22 years which causes the BMI thresholds to differ by gender and age. The age and gender specific cut-off points [1]of Cole

[1] The specific cut-off points take into account the systematic differences that occur with age and gender during adolescence. The aim of these cut-off points is to develop an internationally comparable definition of overweight and obesity among children based on data from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore and the United States. For example, a boy of 6 years old is considered as obese if his BMI is greater than or equal to 19.78, while a boy of 16 years old is considered as obese if his BMI is greater than or equal to 28.88 .

et al. (2000) are used for the analyses in this study to determine overweight/obesity prevalence among adolescents (Table A1). These cut-off points have already been used in other studies (Wang et al., 2002 ; Madden, 2016). The cut-off points of Cole et al. (2000) are provided at exact half year ages. The age-related variables in the Add Health data are used to calculate the age in years, rounded to three decimal places. Therefore, the proper cut-off point is decided by choosing the age that is the nearest to the observed unrounded age of the individual in the sample. The cut-off points are only used for non-adults during the first period, since ages ranged from 11 years until 22 years old. The general threshold of the World Health organisation for adults (>18) is used for the other periods.

Normalized BMI

A comparison of BMI can be unreliable due to the changes in overweight/obesity thresholds over time. To avoid this, the BMI will be transformed into the normalized BMI to facilitate comparisons between different periods. It is defined as the BMI divided by the proper overweight or obesity threshold at that age and gender. A normalized BMI value of 1.1 means that a child has a BMI which is 10% higher than the appropriate threshold for their age and gender (Madden, 2016). In other words, a normalized BMI less than 1 refers a lower BMI than the threshold and a normalized BMI above 1 refers to a higher BMI than the threshold.

Income rank variable

Income is used as a rank variable during the computation of the Erreygers adjusted concentration indices. The types of income measures differ between periods due to the different phases of life observed in this study. The first age-period contains data about the total income before taxes and deductions of everyone who lives in one household. The second age-period consists of personal income and earnings and the third age-period of personal income and household income. This study only needs income to rank individuals. In case of household income, adjustments are needed for household size to enhance the consistency between the measures for comparative goals. The OECD-modified equivalence scale is used to adjust the household incomes, taking into account the size of the household and the age of its members. This OECD-modified scale uses a value of 1 for the household head, a value of 0.5 for each additional adult and a value of 0.3 for each child (Hagenaars et al., 1994). This study assumes that the rankings of different income variables are not problematic for comparison of concentration indices between periods. The next section presents the results of the Erreygers adjusted concentration indices when using the equivalent household income as a rank variable

to enhance consistency between periods. The results of other income rank variables are included in the appendix (Table A4 until A6).

Sample weights

When calculating the Erreygers index for each age-period and both sexes, sample weights are used. The sample weights correct for the unequal probability of selection of several schools in the sample, where the absolute value of the sample weight of an individual refers to the degree of representativeness. The higher the absolute value of the sample weight of the respondent, the more individuals the respondent represents in the population of interest. The appropriate sample weight is based on the guidelines provided by Add Health (Chen & Chantala, 2014). This study uses the sample weights recommended for cross-sectional analysis, since the Erreygers adjusted concentration index is calculated for each period separately. For further explanation of the use of weights during analysis, I refer to the guidelines for Add Health data provided by Chen & Chantala (2014).

3.3 Analysis

Erreygers adjusted concentration index

This study observes socioeconomic-related inequality in overweight and obesity, using the methodology of the Erreygers adjusted concentration index. Wagstaff et al. (1991) argue that the concentration index is the most appropriate technique to show a complete representation of total health inequality, since it fulfils some basic requirements:

> (i) that it reflect the socioeconomic dimension to inequalities in health; (ii) that it reflect the experiences of the entire population (rather than just, say, social classes I and V); and (iii) that it is sensitive to changes in the distribution of the population across socioeconomic groups. (p. 550)

This method has already been used in various studies to examine socioeconomic-related inequality of several health conditions or to observe the association between a particular health variable and a measure of socioeconomic status (Kakwani et al., 1997; Madden, 2016). According to the study of Kakwani et al. (1997), the concentration index can be computed by the following formula:

$$C = \frac{2 * cov(\mathrm{hi}, \mathrm{ri})}{\mu h} .$$

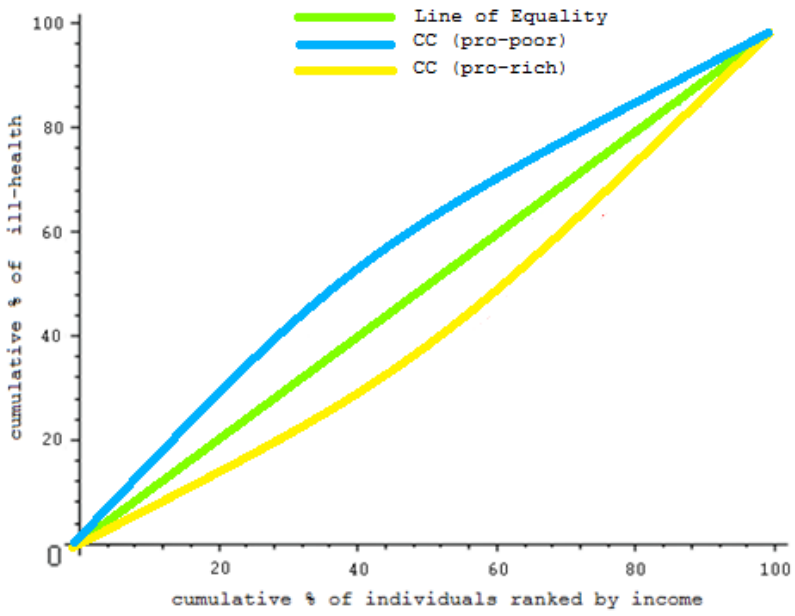
The calculation of the concentration index requires a health variable, the distribution of the health outcome of interest, and a variable that measures the living standards of an individual. The computation can be easily done in this study since it is based on micro data. The h_i is the health variable which provides the health value for individual $_i$, r_i is the relative rank of individual $_i$ in the income distribution and μ_h the mean value of the health variable (Kakwani et al., 1997). Several indicators can be used to provide information about the relative position of an individual in a social structure based on their access to social and economic resources (Marks et al., 2000). Socioeconomic status (SES) is usually measured by several direct measures (i.e. income) and indirect measures (i.e. education or occupation), each measure has its own weaknesses and strengths when studying the relationship between SES and health outcomes (Goodman, 1999). In the present study, income is chosen to observe the living standards of individuals over time.

In addition, it is important to note that this study uses the Erreygers adjusted version of the original concentration index, the so-called Erreygers index (Ei). The reason is that the health variable of interest needs to be on the same scale as the income variable during the computation of the original concentration index (Erreygers & Van Ourti, 2011; Kjellson & Gerdtham, 2013). This refers to a health variable with an infinite upper bound which is not always the case in health related studies. Many studies also deal with health outcomes such as categorical variables (i.e. self-assessed health) or binary outcomes (i.e. obese=1 and non-obese=0). The health outcome of this study is a binary variable (overweight/obesity) which is not on the same scale as the income rank variable. Therefore, the original formula of the concentration index cannot be applied in the current study and an adjusted version of the concentration index is recommended (Kjellson & Gerdtham, 2013).

The studies of Wagstaff (2005) and Erreygers (2009) proposed a normalization of the concentration index when using binary health outcomes. Wagstaff (2005) recommends normalization of $Cn = C / (1- \mu_h)$. On the other hand, a more recent study of Erreygers (2009) proposes the following normalization: $Ce= 4* \mu_h C$, when using a binary health outcome. Madden (2016) applied the Erreygers normalization to the concentration index in his study. Therefore, this study only presents the Erreygers indices in the results. The appendix provides the results of all types of concentration indices (Table A4 until A6). Overall, both normalized

concentration indices provided the same conclusions. Further information regarding the normalization of the concentration index is provided in the study of O'Donnell et al. (2016).

Figure 1: Graphical representation of the concentration index



A graphical representation of the Erreygers adjusted concentration index, the concentration curve (CC), provides a complete picture of whether socioeconomic-related inequality in the health variable of interest exists and whether the inequality is more present at one year than another. The diagonal represents the line of equality. The area between the concentration curve and the line of equality shows the degree of inequality which represents the distribution of overweight/obesity prevalence across income groups. The greater the area between the diagonal and the concentration curve, the greater the degree of inequality. The concentration index is mathematically defined as twice the area between the concentration curve and the diagonal and ranges from -1 to +1.

The adjusted concentration index takes a negative (positive) value if the concentration curve lies above (below) the diagonal, indicating that the health variable is concentrated among the relatively poor (rich). Therefore, the association between income and health variable is negative (positive). In this study, the health variable is overweight/obesity which indicates an ill-health. Therefore, a negative value of the adjusted concentration index reflects a situation where the rich are better-off since they are suffering less from overweight/obesity. In other words, the SES-related inequality is in favour of the rich. The opposite situation with a positive concentration index reflects SES-related inequality in favour of the poor.

Decomposing the change in inequality into mobility components

The study of Madden (2016) explains a way to exploit the panel nature of the dataset by decomposing the change in the Erreygers index into mobility components, based on the study of Allanson et al. (2010).The technique consists of a simple decomposition of the change in the Erreygers index, which is expressed by the following:

$$E^f - E^s = (E^f - E^{fs}) + (E^{fs} - E^s) = M^R - M^H .$$

First of all, one must define which two periods will be used to decompose the change in the Erreygers index into mobility components. The E^f reflects the Erreygers index of the last age-period, while the E^s is the Erreygers index of the initial age-period. In addition, the E^{fs} refers to the Erreygers Index of the last age-period when using the income of initial age-period as a rank variable (Allanson et al. 2010; Madden, 2016).

Health-related income mobiliy

The M^R (E^f - E^{fs}) represents the index of health-related income mobility. This index captures the change in the Erreygers Index caused by reranking individuals within the income distribution while holding the final period overweight constant. More specifically, the index assesses the effect of changes in the income rank between the initial and final periods. Furthermore, the index takes a value of zero if the overweight of the final period is uncorrelated with changes in the income rank. The zero value of the M^R occurs irrespective of the degree of the present income mobility. On the other hand, the M^R can be negative if the concentration index of the final period overweight ranked by initial income exceeds the concentration index of the final period overweight ranked by final period income (Allanson et al. 2010; Madden, 2016).

Income-related health mobility

The M^H (E^s - E^{fs}) reflects the income-related health mobility index. This term captures the health change between the initial and final period while holding the initial income rank constant. According to Allanson (2010), income-related health mobility index is positive (negative) if the overweight changes are progressive (regressive). This indicates that the poorest individuals in the initial period are more likely to experience an increase in overweight compared to the richer individuals. Again, the index equals zero if the relative overweight changes are uncorrelated with income or/and if there are no changes in weight status (Allanson et al. 2010; Madden, 2016).

4. RESULTS

This section describes the results in three parts. The first part consists of descriptive analysis. The second part examines socioeconomic-related inequality in overweight and obesity based on the methodology of the Erreygers adjusted concentration index. The third observes the change in the concentration from adolescence to adulthood by decomposing changes in the Erreygers index of obesity into mobility components.

4.1 Descriptive analysis

The total overweight rate in table 1 shows a significant increase of 13.4 (7.3) percentage points over time for males (females). This growth rate is even more concerning with respect to obesity, where a significant increase of about 27 percentage points is observed for both males and females. Furthermore, significant gender differences with respect to overweight are found. The overweight differences between men and women increase from adolescence to adulthood, where men show a significant higher overweight prevalence than women. However, the normalized overweight (1.15) during the last period shows that, on average, both males and females exceed their appropriate overweight threshold with 15 percent. Therefore, despite the higher prevalence of men, overweight women suffer on average from the same intensity of overweight as overweight men. The complete data regarding the overweight and obesity incidence is included in table A2 in the appendix.

Table 1: Normalized BMI and prevalence rates, by age-period and gender

	Males (N=1745)			Females (N=2077)		
Age-period	11-22 y	18-28 y	24-34 y	11-22 y	18-28 y	24-34 y
Normalized overweight	0.95	1.06*	1.15*	0.93	1.07*	1.15*
Normalized obesity	0.78	0.88*	0.96*	0.78	0.89*	0.96*
Overweight rate	21.6	30.7*	35.0***	17.7	24.2*	25.0
Obesity rate	8.5	22.7*	36.0*	9.6	24.5*	36.0*

*Notes to Table 1: Data, Add Health (period 1-3). Sample size: 3822. *,**,** indicates significant increases at 1%, 5% and 10 % in prevalence rates compared to the period before based on the paired t-test.*

Transitions from overweight into obesity

Table 2 and 3 provide data concerning the transitions from overweight into obesity. Several studies, which are mentioned in the literature review section, showed their concern regarding

the risk of escalation of overweight from adolescence to adulthood. The transitions from overweight into obesity are for both genders enormous, since at least 66 percent of the overweight adolescents in period 1 becomes obese during adulthood. Therefore, it can be confirmed that overweight adolescents are indeed likely to become obesity at adult ages. In addition, it shows that overweight individuals are quite mobile over time. It is interesting to observe whether these overweight individuals who became obese are from relative low SES-groups or high SES-groups. Further explanation regarding mobility will be observed in the last part of this section, where the change of the Erreygers index with respect to obesity will be decomposed into mobility components.

Table 2: Transitions from overweight into obesity, males

Males			
Age-period: 11-22 y	Age period: 24-34 y		
	Non-obese	**Obese**	Total
Non-overweight	72.8%	27.2 %	N=1370
Overweight	33.6%	66.4%	N=375
Total	N=1124	N=621	N=1745

Notes to Table 2: Data, Add Health (period 1 & 3). Sample size: 3822.

Table 3: Transitions from overweight into obesity, females

Females			
Age-period: 11-22 y	Age period: 24-34 y		
	Non-obese	**Obese**	Total
Non-overweight	70.2%	29.8%	N=1722
Overweight	28.5%	71.5%	N=355
Total	N=1309	N=768	N=2077

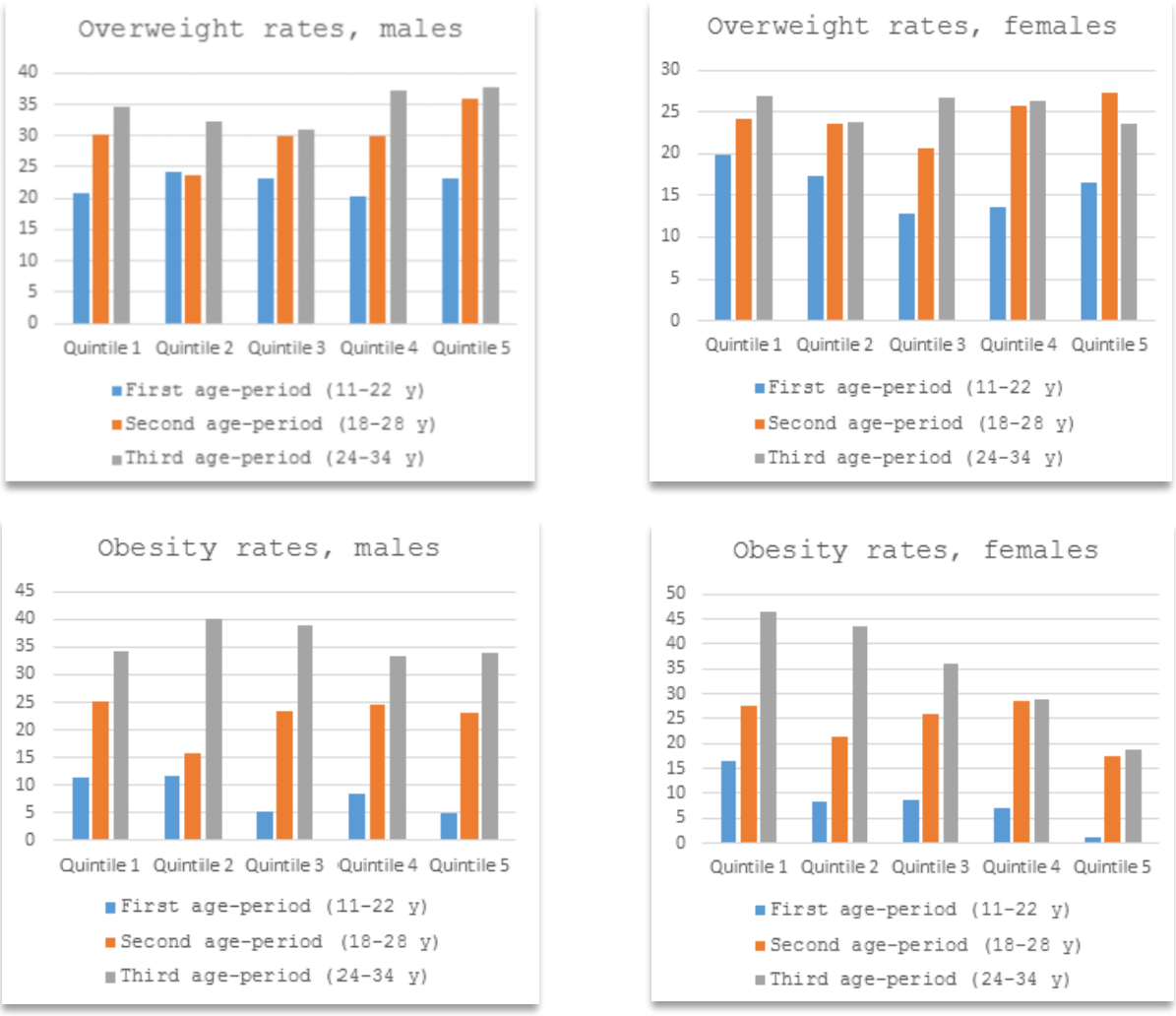
Notes to Table 3: Data, Add Health (period 1 & 3). Sample size: 3822.

4.2 SES-related inequality

Figure 2 presents the overweight and obesity rates per income quintile for each age-period. The first quintile presents the 20 percent lowest incomes, where the fifth quintile refers to the 20 percent highest incomes. The data of 1994/1995 where the individuals were aged from 11 until 22 years, suggests no clear negative association between overweight and SES as is observed for obesity. The rates of obesity are clearly higher for lower quintiles compared to higher quintiles.

The second age-period (2001/2002) provides the notion of some positive socioeconomic association between overweight and SES for both genders, indicating higher overweight rates among high income quintiles compared to low income quintiles. This positive association diminishes in the third age-period for males and changes into a more negative association between overweight and SES for females. The negative association between obesity and SES is less apparent in the second period compared to the first period. However, this negative association is visible again in the third age-period, especially among females. Overall, the prevalence rates by income quintile suggest clear significant differences between different income quintiles with respect to obesity. Table A3 in the appendix provides more details regarding figure 2. The evidence of a negative association between overweight and SES is less noticeable. The degree of SES-related inequality will be further investigated in the remainder of this section, using statistical techniques from health economics.

Figure 2: Overweight and obesity rates per income quintile, by age-period and gender.



Notes to Figure 2: Data, Add Health (period 1-3). Sample size: 3822.

The above described results between different income quintiles are based on different periods. Therefore, different types of incomes were used to describe the trends. The first age-period is based on equivalent household income, the second age-period is based on personal income of the individuals themselves and the third age-period is again based on equivalent household income. The income used in the second age-period is less reliable compared to the other periods due to the age range in this period. Individuals might not be settled yet into a secure job and some are still financially dependent on their families. Therefore, further analysis regarding the degree of socioeconomic inequality in overweight and obesity is focused on the first and third age-period, representing adolescence and adulthood.

As described in the methods section, the concentration index is calculated through the Erreygers method since this study deals with a binary outcome. Therefore, the concentration index is called the Erreygers index (Ei). The Erreygers index is calculated by using equivalent household income as a rank variable for both periods which is explained in the methods section. The computed Erreygers indices do not only provide information about the direction of the relationship between overweight/obesity and socioeconomic status, but the indices also show the degree of inequality. A larger absolute value of the Erreygers index refers to greater degree of socioeconomic-related inequality with respect to overweight or obesity.

Table 4: Erreygers index (Ei) for overweight and obesity, by age-period and gender

Gender	Overweight/Obesity	Age-group	N	Ei	Se	P-value
Males	Overweight	11-22 y	1390	-0.005	0.035	0.880
		24-34 y	1626	+0.055	0.033	0.095***
	Obesity	11-22 y	1390	-0.051	0.019	0.007*
		24-34 y	1626	-0.039	0.031	0.213
Females	Overweight	11-22 y	1587	-0.043	0.026	0.104
		24-34 y	1960	-0.012	0.028	0.657
	Obesity	11-22 y	1587	-0.099	0.015	0.000*
		24-34 y	1960	-0.218	0.026	0.000*

*Notes to Table 4: Data, Add Health (period 1 & 3). Sample size: 3822. *,**,*** indicates significance of Ei at 1%, 5% and 10% levels respectively. Robust standard errors are in parentheses.*

The data from the table above presents the Erreygers concentration indices by age-period and by gender. The computation of the Erreygers index is done by treating the two periods as simple cross-sections without using the longitudinal nature. The Erreygers indices of overweight show

that there is no significant SES-related inequality for the incidence of overweight over time, except for males in the third-age period. The Erreygers index of males is positive, indicating a concentration of overweight among the high-SES groups. As described in the literature review, it is possible to find an inconsistent association between SES and overweight for males. This finding is in line with the meta-analysis of Sobel & Stunkard (1989), showing men have other attitudes against overweight and obesity than women. Therefore, the relationship between SES and overweight can result in a positive direction. The other Erreygers indices are negative, indicating a concentration of overweight among the poor. However, these indices are overall not significant. Therefore, there is no clear evidence for SES-related inequality in overweight. This was not expected since studies such as Friestad et al. and Goodman et al. found contrasting results for the first age-period of the Add Health study. However, they used other methods to define inequality. Evidently, the overweight rates did not increase among specific income groups, but increases were rather equally distributed across income quintiles.

On the other hand, during adolescence, there is a statistically significant socioeconomic-related inequality in obesity observed for both genders. These Erreygers concentration indices of obesity are negative ($P<0.01$). This means that, during adolescence, individuals from low-SES households are more likely to be obese compared to individuals from high-SES households. Overall, the inequality index of obesity shows statistically significant gender differences by gender with a stronger degree of inequality among females. During adulthood, both genders show a negative value of the obesity Erreygers index with significant differences between men and women. However, the socioeconomic-related inequality of obesity is only statistically significant for women. Therefore, obesity is more concentrated among low-SES women compared to high-SES women. In addition, the degree of socioeconomic inequality in obesity among females increased over time. Adult men do not show a significant negative Erreygers index anymore, referring to a more equal male distribution of obesity across income quintiles during adulthood than adolescence. In sum, females show a higher degree of socioeconomic-related inequality in obesity than males, where gender differences increase even more during adulthood.

Overall, evidence of significant SES-related inequalities is only found for obesity. The negative value ($P<0.01$) of the Erreygers index indicates a concentration of obesity among low-SES groups. In general, a negative value of the concentration index indicates pro-poor inequality. However, obesity is an ill-health. Therefore, negative value of the Erreygers index reflects a

situation where the high-SES groups are better off since they suffer less from obesity compared to the low-SES groups. In other words, the inequality is in favour of the rich.

4.3 Obesity-related income mobility and Income-related obesity mobility

The remainder of this section aims to decompose the change in the Erreygers index of obesity into two mobility components; income-related health mobility (M^H) and health-related income mobility (M^R). These mobility components are of great interest since they indicate whether the change in the Erreygers index was mostly caused by transitions into or out of obesity (M^H) or by reranking within the income distribution (M^R). In addition, the sign of the M^H and M^R indicates whether the change was in favour of the low-SES groups or the high-SES groups. For instance, given that E^f is negative, the contribution of the M^R (E^f - E^{fs}) will have a positive sign if E^{fs} is a negative index and greater in absolute value than E^f . This indicates that the change is beneficial for the poor since the concentration of overweight/obesity during the last period is less concentrated among the poor when using the final income rank variable compared to the use of the initial income rank variable. The M^R will be negative in all other scenarios.

The data in table 6 provides information on how the Erreygers index of obesity changes from the first age-period to the third age-period. This is done through the Allanson et al. (2010) decomposition of the change in the Erreygers index with respect to income. The decomposition is done for obesity since the results of the Erreygers index show mostly evidence of SES-related inequalities with respect to obesity. Therefore, the M^H index refers to income-related obesity mobility and the M^R to obesity-related income mobility. Over time, and as we observed earlier in this section, a higher degree of socioeconomic inequality in obesity is observed in adulthood compared to adolescence, where a more negative Erreygers index refers to a greater concentration of obesity among the low-SES groups.

Table 5: Income-related obesity mobility (M^H) and obesity-related income mobility (M^R)

	Obesity		
	Total	Females	Males
Ei of first age-period	-0.077* (0.013)	-0.099* (0.015)	-0.052* (0.019)
Ei of last age-period	-0.129* (0.022)	-0.218* (0.026)	-0.039 (0.031)
Ei of last age period using rank variable of first age period	-0.111* (0.026)	-0.182* (0.034)	-0.044 (0.036)
Delta Ei	-0.053	-0.119	0.013
M^R	-0.018*	-0.036*	0.005
M^H	0.034***	0.083*	-0.008

*Notes to Table 5: Data, Add Health (period 1 & 3). Sample size: 3822. *,**,*** indicates significance of Ei at 1%, 5% and 10% levels respectively. Robust standard errors are in parentheses.*

The contribution of the M^H to the change in the significant Erreygers indices of obesity is in most cases larger than the M^R contribution, as is illustrated by table 6. Therefore, income-related obesity mobility (M^H) is more important for the change in socioeconomic inequality of obesity than obesity-related income mobility (M^R) in this phase of life (adolescence to adulthood). The income-related obesity mobility captures the change due to the change in the obesity status of the individual, where obesity-related income mobility index captures the change due to changing the position in the income distribution. The positive contribution of the significant M^H indices indicate that changes in the inequality of obesity are concentrated among the poor. This means that obesity is even more concentrated among the poor if the health levels during the last period are observed with the use of the initial income rank variable. More specifically, adolescents from lower initial household incomes suffer more from obesity during adulthood compared to adolescents from higher initial household incomes. The low-SES adolescents transit more often into obesity during adulthood than high-SES adolescents, which causes an increase in socioeconomic inequalities of obesity.

In addition, while the M^R (obesity-related income mobility) index is smaller than the M^H, it still shows a significant contribution to the change of the Erreygers index for obesity. The contribution of the M^R index is negative which is caused by the lower absolute value of the E^{fs}

index. This negative contribution means that there is less adult-obesity concentrated among low-SES adolescents than among low-SES adults, referring to a change in the Erreygers index in disfavour of the low-SES groups. Therefore, in the phase of adolescence to adulthood, obesity is rather associated with downward income mobility than with upward income mobility. This in line with the study of Hojjat & Hojjat (2016), who expressed their concern regarding the risk of limited upward mobility among fat adolescents. For instance, overweight adolescents deal with several psychological problems (i.e. depression, isolation and anxiety) at younger ages and adult ages as well. Moreover, fat children are more likely to isolate themselves and are less successful in developing themselves properly during adulthood as their non-fat counterparts. Therefore, fat adolescents are more likely to end up across the lower quintiles during adulthood than non-fat adolescents. Both income-related obesity mobility (M^H) and obesity-related income mobility (M^R) are detrimental for the low-SES groups, causing an increase in the degree of inequality for obesity from adolescence to adulthood. To conclude, both types of mobility contribute to the change in Erreygers index in disfavour of the poor and the largest contribution to the change in Ei can mostly be attributed to transitions into obesity among the initially poor.

CONCLUSION

This study examined the dynamics of socioeconomic inequality in overweight and obesity from adolescence to adulthood in the United States. This is done by assessing the degree of inequality with respect to overweight and obesity using the Erreygers corrected version of the concentration index and decomposing the changes of this index into two mobility components. First of all, this study showed the alarming trends for both overweight and obesity. Overall, the results showed a significant increase in both overweight (10.5 p.p.) and obesity (27 p.p.) prevalence from the first age-period (11-22 y) to the third age-period (24-34 y). In addition, the transitions from overweight into obesity over time were a reason for concern. This finding is in line with other studies, who already expressed their concerns regarding the escalation of overweight in the phase of adolescence to adulthood (Gordon-Larsen et al., 2004; Hojjat & Hojjat, 2017).

The first hypothesis in this study, suggesting a negative concentration index, is overall confirmed for the incidence of obesity. The negative Erreygers indices for overweight were not significant, suggesting a rather equally distribution of overweight across income quintiles. The Erreygers indices of obesity were overall negative, referring to a larger concentration of obesity among low-SES groups than high-SES groups. Therefore, the notion of SES-related inequality in this study was only found for obesity, where statistically significant concentration indices were found for both adolescence and adulthood. In addition, the socioeconomic inequality in obesity for females was greater than for males which confirms our second hypothesis based on existing literature. The third hypothesis stated that socioeconomic-related inequalities will increase from adolescence to adulthood, which is in line with results of this study. A higher degree of socioeconomic inequality in obesity was observed during adulthood, referring to an increase in SES-related inequalities from younger ages to adult ages. Also, the gender differences regarding the degree of SES-related inequality of obesity increased over time, where females showed an even higher degree of SES-related inequality than males during adulthood.

Lastly, the results of both mobility indices are in line with the fourth hypothesis. The study investigated the change in the Erreygers index of obesity by decomposing this change into two mobility components using the paper of Allanson (2010). The mobility components used in this study were income-related obesity and obesity-related income mobility. As expected, both types of mobility contribute to the change in Erreygers index in disfavour of the poor. In

addition, the largest contribution to the change in Ei can mostly be attributed to transitions into obesity among the initially poor. This is a concerning result since adolescents from low SES-families are more likely to be obese during adulthood compared to adolescents from high SES-families. Despite the smaller contribution of the income mobility component, it still contributed in a disfavourable way for the poor to the change in the Erreygers index. More specifically, in the phase of adolescence to adulthood, obesity is rather associated with downward income mobility than with upward income mobility.

DISCUSSION

This study contributes to the literature by providing insights regarding the relationship between SES and overweight/obesity from adolescence through adulthood. This is done by using longitudinal data combined with a new proposed method to decompose the change in the concentration index into mobility components. The socioeconomic-related inequality is especially found for obesity for both adolescence and adulthood, where obesity was more concentrated among the poor. Furthermore, the incidence of obesity is even more concentrated among the poor during adulthood. The change in the socioeconomic-related inequality of obesity is in disfavour of the poor people, which can be explained through the two mobility components that have been investigated in this study. Overall, the largest contribution is caused through the transitions into obesity among the initial poor. Therefore, this study showed that prevention of not only obesity, but also overweight during adolescence is crucial to avoid transitions into obesity during adulthood. In addition, obesity is associated with downward income mobility, indicating an increase of obesity among poor adults. The outcomes of this study show the need for policies to address the obesity issue at younger ages to overcome transitions into obesity and the risk of downward income mobility during adulthood.

For example, equal upward income mobility seems to be overestimated in the United States as Chetty (2016) already expressed her concern about. The association of obesity and downward income mobility might be caused by the reasons mentioned by Hojjat & Hojjat (2016) such as; anxiety, isolation and depression among obese adolescents. Therefore, it could be helpful to develop policies that can improve the environment of fat adolescents, which can lead to more happiness among obese adolescents and decrease the risk of psychological problems that lead to failure (i.e. low education level) on the long term. The previous mentioned policy could also help fat adolescents to be more secure and lower the risk of escalation of overweight into during adulthood when they face less psychological struggles.

Next to the interventions regarding improving conditions for fat adolescents, obesity-prevention policies should focus mainly on adolescents from low-SES households, especially females, since they are most likely to become obese during adulthood. However, in general, population-based interventions targeting all groups are crucial too since the United States is considered the global leader in adult overweight prevalence, where the overweight and obesity rates concerning at all ages.

This study deals with some limitations too. Firstly, socioeconomic inequality patterns can vary across many groups such as ethnic groups. Therefore, future research is needed to understand the full mechanisms that are associated with socioeconomic-related inequality in obesity. Secondly, this study deals with a sample that has been followed from adolescence though adulthood. Therefore, the income variable is based on parental income in the first age-period and income from the individuals itself in the last age-period. The non-consistency of the income measure from adolescence through adulthood can lead to difficulties to observe SES-related inequalities correctly. Future studies could try to find a better way to minimize this inconsistency when measuring SES among adolescents. Thirdly, this study only provided insights regarding SES-related inequality in overweight and obesity. However, it did not provide any causal relationships between SES and overweight/obesity. Therefore, future studies could contribute by providing more causal empirical evidence regarding SES-related inequality in overweight and obesity. Fourthly, only BMI is used as a measure for the identification of overweight/obesity due to data limitation. In general, the BMI measure is prone to biasedness if it is not correctly measured. Therefore, other measures can be used to observe overweight/obesity if more measures are present in datasets. In addition, future studies could observe which factors are associated with the SES-related inequality in obesity by using the decomposition method of the Erreygers adjusted concentration index.

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APPENDIX

Table A1: Cut-off points of Cole et al. (2000) for overweight and obesity by gender and age

	Overweight		**Obesity**	
Age	**Males**	**Females**	**Males**	**Females**
11.0	20.55	20.74	25.10	25.42
11.5	20.89	21.20	25.58	26.05
12.0	21.22	21.68	26.02	26.67
12.5	21.56	22.14	26.43	27.24
13.0	21.91	22.58	26.84	27.76
13.5	22.27	22.98	27.25	28.20
14.0	22.62	23.34	27.63	28.57
14.5	22.96	23.66	27.98	28.87
15.0	23.29	23.94	28.30	29.11
15.5	23.60	24.17	28.60	29.29
16.0	23.90	24.37	28.88	29.43
16.5	24.19	24.54	29.14	29.56
17.0	24.46	24.70	29.41	29.69
17.5	24.73	24.85	29.70	29.84
>18.0	25	25	30	30

Table A2: BMI, Normalized BMI, prevalence rates by gender

	Males			**Females**			**Overall**		
Period (P)	P1	P2	P3	P1	P2	P3	P1	P2	P3
BMI	22.51	26.39	28.82	22.34	26.66	28.78	22.42	26.52	28.80
Normalized overweight	0.95	1.06	1.15	0.93	1.07	1.15	0.94	1.06	1.15
Normalized obesity	0.78	0.88	0.96	0.78	0.89	0.96	0.78	0.88	0.96
Overweight rate	0.216	0.307	0.35	0.177	0.242	0.25	0.195	0.275	0.30
Obesity rate	0.085	0.227	0.36	0.096	0.245	0.36	0.091	0.236	0.36

Notes to Table A2: Data, Add Health (period 1-3). Sample size: 3822.

Table A3: Overweight and obesity rates per income quintile, by age-period and gender.

	11-22 y (N=2977)	**18-28 y** (N=3604)	**24-34 y** (N=3586)	**11-22 y** (N=2977)	**18-28 y** (N=3604**)**	**24-34 y** (N=3586)
Quintile 1	20.7 (19.8)	30.1 (24.2)	34.5 (26.8)	11.5 (16.4)	25.2 (27.6)	34.3 (46.6)
Quintile 2	24.2 (17.4)	23.8 (23.5)	32.2 (23.8)	11.7 (8.4**)	15.9***(21.5***)	40.2 (43.4)
Quintile 3	23.1(12.9**)	29.9 (20.6)	31.1 (26.7)	5.3** (8.8*)	23.5 (25.8)	38.9 (36.0*)
Quintile 4	20.2(13.7**)	30.0 (25.8)	37.3 (26.4)	8.6 (7.0*)	24.7 (28.4)	33.4 (29.0*)
Quintile 5	23.1 (16.6)	36.0 (27.3)	37.7 (23.5)	4.9** (1.2*)	23.1 (17.6***)	34.0 (18.7*)

*Notes to Table A3: Data, Add Health (period 1-3). Sample size: 3822. *,**,** indicates significant increases at 1%, 5% and 10% in prevalence rates compared to the first quintile based on the paired t-test. Females data are in parentheses.*

Table A4: Concentration indices of overweight/obesity, first period

WAVE 1	**OVERWEIGHT**			**OBESITY**		
	Total	Females	Males	Total	Females	Males
Standard CI	-0.0326 (0.0304)	-0.0662 (0.0404)	-0.0059 (0.0389)	-0.2290* (0.0377)	-0.2973* (0.0460)	-0.1524* (0.0560)
Generalized CI	-0.0062 (0.0058)	-0.0106 (0.0065)	-0.0013 (0.0087)	-0.0192* (0.0032)	-0.0247* (0.0038)	-0.0129* (0.0047)
Erreygers index (E)	-0.0248 (0.0231)	-0.0425 (0.0260)	-0.0052 (0.0346)	-0.0766* (0.0126)	-0.0986* (0.0152)	-0.0515* (0.01893)
Wagstaff index (W)	-0.0403 (0.0375)	-0.0788 (0.0482)	-0.0076 (0.0501)	-0.2499* (0.0411)	-0.3242* (0.0502)	-0.1665* (0.0612)

*Notes to Table A4: Data, Add Health (period 1). Sample size: 3822. Standard errors are in parentheses. *,**,*** indicates significance of CI at 1%, 5% and 10% levels respectively. Robust standard errors are in parentheses. Equivalent household income is used as a rank variable.*

Table A5: Concentration indices of Overweight, third period

WAVE 4	**OVERWEIGHT**					
	Income rank: Household income			**Income rank: Personal income**		
	Total	Females	Males	Total	Female	Males
Standard CI	0.0248 (0.0197)	-0.0120 (0.0269)	0.0396*** (0.0235)	0.0271 (0.0177)	-0.0045 (0.0244)	0.0163 (0.0211)
Generalized CI	0.0075 (0.0059)	-0.0031 (0.0069)	0.0137*** (0.0081)	0.0082 (0.0054)	-0.0011 (0.0062)	0.0058 (0.0074)
Erreygers index (E)	0.0299 (0.0237)	-0.01228 (0.0276)	0.0548*** (0.0326)	0.0328 (0.0212)	-0.0045 (0.0248)	0.0231 (0.0298)
Wagstaff index (W)	0.0355 (0.0281)	-0.0161 (0.0362)	0.0606*** (0.0360)	0.0388 (0.0254)	-0.0060 (0.0327)	0.0253 (0.0326)

*Notes to Table A5: Data, Add Health (period 3). Sample size: 3822. *,**,*** indicates significance of CI at 1%, 5% and 10% levels respectively. Robust standard errors are in parentheses.*

Table A6: Concentration indices of Obesity, third period

WAVE 4	OBESITY					
	Income rank: Household income			Income rank: Personal income		
	Total	Females	Males	Total	Females	Males
Standard CI	-0.0896* (0.0153)	-0.1508* (0.0183)	-0.0269 (0.0215)	-0.0414** (0.0138)	-0.1112* (0.0159)	0.0255 (0.0192)
Generalized CI	-0.0324* (0.0055)	-0.0545* (0.0066)	-0.0097 (0.0078)	-0.0150* (0.0050)	-0.040* (0.0058)	0.0092 (0.0069)
Erreygers index (E)	-0.1294* (0.0221)	-0.2180* (0.0264)	-0.0389 (0.0310)	-0.0600* (0.0200)	-0.1615* (0.0230)	0.0367 (0.0278)
Wagstaff index (W)	-0.1403* (0.0240)	-0.2362* (0.0286)	-0.0421 (0.0336)	-0.0650* (0.0217)	-0.1746* (0.0249)	-0.0398 (0.0301)

*Notes to Table A6: Data, Add Health (period 3). Sample size: 3822. *,**,*** indicates significance of CI at 1%, 5% and 10% levels respectively. Robust standard errors are in parentheses.*