The Social Cost of Childhood Overweight and Obesity

Results on Health Care Usage, Well-Being, Education, and Labor Market Outcomes Until the Age of 21

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Preface

Among 7-year-old children in Denmark, 12% are overweight or obese. At age 14, 19% are overweight or obese. Previous literature indicates that overweight and obesity have negative consequences for the individual, not only for their health but also for their everyday life, their behavior, and their choices. From a societal perspective, it is important that all children have equal possibilities to realize their potential. In this report we investigate the short-run effects of being overweight and obese at age 7 and at age 14, respectively, in Denmark on health care usage, well-being, education results and choices, and labor market attachment.

This report was conducted by senior researcher Tine M. Eriksen, professor with special responsibilities (MSO) Jane Greve, research analyst Matvei Andersen, and researcher Mette T. Jensen. We thank Johannes Rosendal and Anders Barstad for excellent student assistance. We further thank Professor Jakob Kjellberg, and Professor John Cawley, as well as participants at the 3rd Meeting on Quantitative Educational Research in Denmark for their highly valuable comments. The report has been reviewed by two external reviewers relevant for the subject and method. We thank the reviewers for their highly valuable and constructive comments.

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Table of Contents

Key Findings

Introduction

In most Western countries, overweight among children, adolescents, and adults has increased significantly in recent decades and is considered a major societal challenge. Despite a broad consensus in the current relevant literature that overweight and obesity increase social costs, i.e., has a negative impact on well-being, schooling, health care, and employment, estimates vary substantially among studies due to different study populations, differences in measurements of overweight and social cost, and different estimation methods. Furthermore, most studies estimate the impact of overweight or obesity in adulthood on outcomes later in life. These estimates, however, do not necessarily mirror the relevant behavior and choices that occurred earlier in life – behavior and choices that are crucial for future health and labor market opportunities.

Aim

In this report, we investigate the consequences of being overweight and obese in elementary school (average age 7) and lower secondary school (average age 14). We exploit a unique data set using population-based measurements of height and weight, and investigate the consequences on a long list of outcomes related to well-being, health care usage, education, and the labor market.

Definition

The measure of overweight and obesity is based on the body mass index (BMI). BMI is weight in kilograms divided by height in meters squared. In this report we use the school nurses' measurements of height and weight, calculate BMI, and classify weight status according to The International Obesity Task Force classification scheme, which takes into account the child's age at the time of measurement, and gender.

Results

Overall, we find that being overweight and obese during childhood adversely affects well-being and school absence as well as school performance measured in elementary and lower secondary school. We further find that having excess weight in lower secondary school affects enrollment patterns in upper secondary education. In particular, children with overweight and obesity are less likely to enroll in high school. Instead, they are more likely to enroll in vocational education and more likely to not enroll in any upper secondary education by the age of 18. Furthermore, overweight and obese children have a higher probability of receiving social income transfers at age 21.

Data and methods

The results in this report are based on Danish population data on 340,425 lower secondary school children and 317,246 elementary school children with height and weight data obtained from health visits at the school from 2011 through 2017. Sample attrition analyses indicate that both the elementary school and lower secondary school sample is positively selected (e.g., includes children with fewer diagnoses of a mental or behavioral disorder and children from higher socioeconomic backgrounds compared to the general population). Still, we expect the selection to be of minor importance for the estimated average effects.

We compare children who are overweight or obese to children who are of normal weight, and investigate multiple outcomes of education, mental health, health usage, and social assistance across gender and socioeconomic background. Besides calculating the raw differences in the outcomes, we apply two different econometric methods. First, we estimate an ordinary least square (OLS) model, where we include a long list on control variables (all measured before outcome) including information pertaining to early health of the child, e.g., birth weight, as well as rich background information on the parents, e.g., education and income. Second, to investigate the role of unobserved characteristics related to family background we estimate a sibling fixed-effects model. While the results from these two models inform us about the robustness of the results, both methods have limitations, and we cannot rule out that unobserved characteristics related to overweight and obesity might bias the results.

In general, health care cost is low for children, both in elementary school and lower secondary school, and there is little difference in the health care cost between normal-weight children, and overweight and obese children. Almost all of the health care costs are related to hospital admission.

To summarize, the results in this report point to negative consequences for both overweight and obese children. However, compared to children of normal weight, the effects sizes for children with obesity are higher than for children with overweight in most cases. The distinction between overweight and obese children is important because children who are overweight are more likely to be of normal weight later, e.g., due to an increase in height. Children with obesity do not have the same likelihood of being of normal weight later and their weight trajectory is often established at an early age.

Though much of the reviewed literature finds that girls appear to be more affected than boys on several outcomes, we find little evidence of systematic gender differences. An exception is that boys seem to be less likely to sit the exams if they are obese compared to normal weight, which does not seem to be the case for girls. Girls seem to be more likely to use health care when obese compared to of normal weight, which does not seem to be the case for boys.

Finally, overweight and obese children with disadvantaged backgrounds are not systematically more negatively affected than those coming from advantaged backgrounds. This result is in contrast to some other studies pointing at various negative consequences of childhood health problems for disadvantaged children.

We use two empirical models to estimate the results; ordinary least square models with a long list of controls, and sibling fixed-effects models, which take unobserved characteristics in the family into account. In most cases, the parameter estimates become smaller and statistically insignificant when using the fixed effects model, indicating that family characteristics, such as norms, lifestyle, and economic and social resources related to the children's body weight are also related to their outcomes. This is particularly the case in the models on school outcomes in elementary school and health care usage (in general and related to mental health) and social income transfers at ages 18 and 21. The estimated impact of overweight and obesity on school outcomes at age 18 and well-being measures, such as bullying and loneliness, in elementary school all show adverse and significant results, irrespective of the choice of model.

Conclusion

Overall, we find that being overweight and obese during childhood adversely affects social well-being, school performance, and school choices. In particular, we find that being overweight and obese negatively affects the grades in the final 9th grade exam and increases the probability of not being enrolled in an upper secondary education by age 18. While these outcomes are relevant in themselves, they are also expected to have an impact on long-term social costs, such as completed education, employment, income, and health.

Most previous literature points to significant health care costs of overweight and obesity. While we find significant effects on health care usage, the total health care costs are relatively small at ages 10 and 18. However, as most diseases related to overweight and obesity occur in adulthood, these costs might have been larger if we were able to estimate the cost at older ages. Previous literature has pointed to a significant increase in health care usage of overweight and obese people. Thus, it is relevant to re-estimate these effects at older ages, when these data become available.

While our results on mental health care usage are less clear in terms of adverse effects, we find strong evidence of negative effects on well-being of being overweight and, in particular, of being obese. Further research into initiatives that can improve well-being and school performance among children with overweight or obesity already in elementary school is warranted, as such initiatives may send them onto a better life track. Our results point to interventions that help maintain a high level of well-being and decrease school absence, as these are likely to have a positive impact on the children's school results and choices.

Box 1 Highlights of the results

Below we summarize the main consequences of childhood overweight and obesity. We estimate both an OLS model and a sibling fixed effects model, which we believe provides an upper and lower bound of the estimates of the consequences of overweight and obesity. Relative to normal-weight children:

- Children with overweight or obesity are 18-28% and 27-55%, respectively, more likely to be bullied in 4th grade. Among normal-weight children, 12% experience bullying in 4th grade.
- Children with overweight or obesity, when attending the exam, received a 0.1-0.2 and 0.2-0.5 standard deviation lower GPA in the grade 9th exit exam.
- Children with overweight or obesity have 4-15% and 19-42%, respectively, more school absence during 9th grade. Normal-weight children have an absence rate of 6%, equivalent to 12 days, during 9th grade on average.
- The probability of not being enrolled in an upper secondary education, i.e., neither high school nor vocational education, by age 18 is between 18-34% and 44-117% higher for children with overweight or obesity, respectively. Among normal-weight children, 6% are not enrolled in an upper secondary education by age 18.
- Overweight or obese children are 21-38% and 54-85%, respectively, more likely to receive social income transfers at age 21. Among normal-weight children, 10% receive a social income transfer at age 21.

Box 2 Overview of the monetary costs of childhood overweight and obesity at ages 10, 18, and 21

Below we summarize the estimated monetary costs from health care usage at age 10 and age 18 and social income transfers at age 21. Overall, the cost of overweight or obesity on these outcomes, measured in childhood and adolescence, are small. However, as diseases related to excess body weight are likely to occur later, in adulthood, and the probability of receiving social income transfers already in early adulthood is significantly larger for overweight and obese children compared to normal-weight children, we might expect larger monetary costs in the future. The per-child cost is largest for obesity.

The aggregated monetary costs for an average cohort related to: (*all results are relative to normal-weight children)*

- Primary health care sector at age 10 are DKK 371,000-528,000 for overweight and DKK 201,000-257,000 for obese children.
- Secondary health care sector at age 10 are DKK 1.7-2.5 million for overweight and DKK 2-2.3 million for obese children.
- Primary sector figures at age 18 are not significantly different.
- Secondary health care sector figures at age 18 are DKK 98,000-2,096,000 for overweight and DKK 802,000 – 828,000 for obese children. The lower-bound estimates are not significantly different from 0.
- Social income transfers at age 21 are DKK 14-21 million for overweight and DKK 8-14 million for obese individuals. The lower-bound estimates are not significantly different from 0.

1 Introduction

Over the past decades, the prevalence of overweight and obesity has increased in many Western countries. Recent figures on measured height and weight across the OECD countries show that approximately 34% of adults are overweight, while 26% are obese (OECD, 2023),[1] and today overweight and obesity is considered a worldwide epidemic. Similarly, high prevalence rates of overweight and obesity are found among adolescents. According to the Health Behavior in School-Aged Children survey (HBSC), approximately 18% of 15-year-old children in Europe and Canada are overweight or obese, with a significantly higher prevalence for boys than for girls (World Health Organization, 2020). These figures are slightly lower for Danish children, with 12% of girls and 16% of boys self-reporting that they are overweight or obese (Madsen et al., 2023). Compared to the gender averages in 2008, this represents an increase of 50% and 60%, respectively (ibid.). In Denmark, obesity among 15-year-old children has been constant around 5% in the past 20 years (Bruun et al., 2021).

A vast literature shows that being overweight or obese is costly, both for the individual and for society. Individuals with overweight or obesity have a higher risk of experiencing serious illnesses, such as type-2 diabetes, heart disease, and many other health conditions (Bjerregaard et al., 2018; Schneider et al., 2020). Numerous studies also find that overweight and obesity is related to stigma, reduced self-esteem, and lower educational attainment (e.g. Moradi et al., 2021; Langford et al., 2022). These negative health consequences and lower educational attainments are known to have an adverse impact on labor market outcomes and the overall quality of life.

In this report, we estimate the consequences of being overweight and obese on well-being, healthcare usage, and education and labor market outcomes. We estimate the impact of overweight and obesity measured at elementary school (av. age 7) on outcomes in 2nd to 4th grade (approximately ages 8-10) and lower secondary school (av. age 14) on outcomes in 9th grade and at ages 18 and 21.

Most previous studies focus on the consequences of overweight and obesity in adulthood. However, it is well-established that there is a high persistency in overweight and obesity (Singh et al., 2008). Complications identified in adulthood may therefore very well be a result of consequences already present during childhood. If children who experience overweight perform poorly in both elementary and lower secondary school, this might explain poorer labor market outcomes later in life. Therefore, understanding whether and how overweight and obesity in childhood affect individuals at school and their early

[1] Using self-reported height and weight measures the report show slightly lower prevalence rates. In general, there is a tendency to underreport overweight and obesity (Burkhauser & Cawley, 2008).

school choices is crucial for the design of effective and targeted interventions. As pointed out by Cunha & Heckman (2007), early-life interventions are likely to provide the highest return, which further highlights the importance of intervening as early as possible.

Inequality in health is an increasing concern among politicians and policy makers. Just as prevalence rates in type-2 diabetes and cancer exhibit large differences by socio-economic status (SES), prevalence rates in overweight and obesity differ significantly by SES. Woods et al. (2006) find that individuals suffering from cancer are more likely to die from the disease if they are of low SES. The general concern is whether observed differences by SES are caused by actual differences in the prevalence of disease, differences in diagnosis of disease, or differences in the consequences of disease due to differences in health literacy and utilization of the health care systems. Even in Denmark, where health care is free of charge – so that, theoretically, there are no initial differences in access to health care – the question is whether equal access to care in fact exacerbates inequality, as individuals of higher SES are better at navigating the system and to a greater extent seek health care assistance. During childhood, parents constitute the primary decision-makers with regard to children's health investments, and thus Parental SES plays an important role in the determination of the children's health. In this report, we estimate all consequences by parental socio-economic status.

We are not the first to investigate the consequences of overweight and obesity on well-being, health care, school, and labor market outcomes. However, the existing literature relies heavily on population studies that are primarily American. Especially the studies that take steps to account extensively for both observed and unobserved heterogeneity rely on a few American population surveys. In this report, we exploit access to administrative data on weight and height for the population of children enrolled in elementary and lower secondary schools in the school years 2011/12-2016/17, which we link to administrative registry data on education, health and well-being, and social income transfers. Using administrative data as opposed to survey data holds the advantage that it minimizes bias due to attrition and measurement errors. Typically, it also provides access to larger populations, making heterogeneity analyses more feasible.

The report is structured as follows: First, we review relevant literature pertaining the different outcomes. Second, we introduce the methodology and data used in this report. We apply two separate samples, one for children enrolled in elementary school and one for children enrolled in lower secondary school. Chapter 4 presents descriptive statistics and the results pertaining the lower-secondary school sample, while Chapter 5 presents descriptive statistics and the results pertaining to the elementary school sample. Finally, Chapter 6 presents the study's limitations, and Chapter 7 covers ethical considerations.

2 Literature

Poor health early in life may have far reaching consequences for the individual as it likely affects future health as well as education and labor market opportunities (Grossman, 1972). Because individuals with poor health may be constrained in their ability to invest in good health, e.g., by making changes to live a healthier lifestyle, this likely results in a downward spiral where poor health leads to lower educational achievement or labor market performance, which in turn may foster worse health (ibid.). It is therefore crucial to understand whether and how childhood overweight and obesity impact health, both physically and mentally, well-being, scholastic performance, education choices, and labor market involvement.

Below is an overview of the existing literature on the relationship between overweight and obesity and health care usage, mental health and well-being, and education and labor market outcomes. In general, the literature points to a number of negative consequences of being overweight and obese during childhood. However, many studies lack good data (i.e., based on surveys and self-reported height and weight), and the results often depends on the empirical method.

2.1 Health care usage

Overweight and obesity is a physical condition, which has been linked with poor physical health and increased health care usage (World Health Organization, 2021). Several studies on overweight and obesity have documented health consequences related to cardiovascular diseases, diabetes, cancers, and other major chronic health conditions (Anekwe et al., 2020).

Excessive weight may commence in and follow children from a very young age. Ling et al. (2023) provide a meta-analysis of the economic burden of childhood overweight and obesity. The study covers health and medical costs from recent studies up until February 2022. Based on 48 studies that meet the selected criteria, they estimate that compared to normal weight, overweight and obesity increased annual total medical costs by $191 (DKK 1,318) per capita and $308 (DKK 2,125) per capita, respectively. They find that the higher health care costs are driven mainly by large hospitalization costs, whereas there are lower costs associated with nonhospital healthcare, outpatient costs, and prescribed medication. Investigating heterogeneity, the meta-analysis finds higher costs for boys than girls, and estimates that long-term indirect costs (labor productivity) are larger than direct costs (heath care treatments). Most of the included studies are conducted in an American context, and transferring the findings to a Danish context is not straightforward. Furthermore, the variation in the results of the included studies should also be emphasized. The effect sizes range from $2-$1,304 and are most likely sensitive to difference in the countries of study, empirical method, method of measuring of body weight, and sample composition.

One of the studies included in the meta-analysis above is Biener et al. (2020). While they find results of a similar magnitude as those in Ling et al. (2023) when estimating the costs of overweight and obesity using linear regression (ordinary least squares (OLS) regression), their estimates are four times larger when the apply the instrumental variables (IV) method. The instrumental variable method has been used extensively in the estimation of body weight on a range of outcomes, as unobserved factors related to body weight are also likely to be related to the outcome, leading to biased estimates (see Section 3.2 for a detailed discussion of the IV method). With a good instrument, the IV method can account for these unobserved factors. In Biener et al. (2020), they use mothers' BMI as an instrument for child weight class and estimate the total annual medical costs of obesity to be $907 (DKK 6,258) and of severe obesity to be $1,491 (DKK 10,288).

Overall, there is evidence of higher health care costs caused by childhood overweight and obesity. The context, sample, and method appear to matter for the results, which makes the exact cost estimate difficult to infer with any certainty.

2.2 Mental health and well-being

A number of studies have investigated how overweight and obesity are related to mental health and social well-being. For example, childhood obesity (and not overweight) has been associated with depression (Quek et al., 2017), although a recent study finds no association when considering obesity at ages 8 and 13 on depression 60 years later (Gibson-Smith et al., 2020). An Australian study finds increased risks of mood disorders, e.g., major depressive disorders (Sanderson et al., 2011), and a study by Palermo & Dowd (2012) concludes, using individual fixed effects analyses, that obesity had a negative association with behavioral outcomes.

In general children who are overweight or obese report a lower quality of life on several dimensions, e.g., physical, psychological, and social dimension, during childhood and adolescence (Buttitta et al., 2014). Sarrias & Blanco (2022) investigate whether childhood obesity affects social emotional development and find that obesity among Chilean children in elementary and middle school had a negative association with social emotional development for both boys and girls.

A large literature investigates the association between overweight and obesity and social exclusion. Children in Danish middle school and lower secondary school with excess weight experience higher levels of bullying (Brixval et al., 2012), and a meta-analysis concludes that higher weight status in middle school and lower secondary school is positively associated with bullying (Van Geel et al., 2014). Griffiths et al. (2005) find, conditioning on parental social class, that obesity at age 7.5 increased the probability of being bullied at age 8.5 for both boys and girls.

One study investigated whether SES affected the association between excess weight and well-being among children. Their findings suggest that the effects of overweight and obesity on quality of life did not differ by SES (Killedar et al., 2020).

Most of the studies, we identify, that investigate how overweight and obesity are associated with well-being and mental health are cross-sectional and adjust only for gender and age, so that they do not identify the causal effect of overweight and obesity. As the relation between mental health and body weight can also be interpreted as a reverse effect, i.e., that lower mental health can affect body weight, there is a need for more rigorous research investigating these relationships further.

2.3 Education

In general, studies find negative associations between overweight and obesity and school performance (He et al., 2019). A recent systematic review on the impact of childhood obesity on human capital in high income countries identifies 22 longitudinal studies that apply robust causal inference approaches (Segal et al., 2021). Due to high heterogeneity of the included studies, the authors do not conduct a meta-analysis, but conclude that the findings on the impact of childhood overweight and obesity on human capital are mixed (ibid.). They do note a couple of tendencies in that the effects are largest when overweight and obesity are measured in adolescence, and that females appear to be more affected than boys. There are a couple of things worth noticing in relation to the studies included in Segal et al. (2021). First, the 22 studies rely on ten different longitudinal surveys, six of which are from the US, where especially studies using the AddHealth data find significant effects (e.g., Sabia & Rees, 2015). None of the studies apply full-population administered registry data. Second, many of the studies finding insignificant results rely on relatively small samples. For example, Afzal & Gortmaker (2015) use changes in obesity to identify effects in a differences-in-differences framework. However, only about 300/350 individuals change status in their two cohorts. Third, most of the studies that find significant effects apply an IV strategy. For example, Shi & Li (2018) find significant negative estimates of BMI on test scores using linear regression. The effects are exacerbated when using the BMI of mothers and fathers to instrument for the child's BMI. The validity of using parental BMI as an instrument can be questioned, and recently there has been a debate about IV estimates in this literature. We will discuss this further in Section 3.2 below.

A systematic review concludes that excess weight in childhood is only weakly associated with educational attainment (Caird et al., 2014). While only four of the studies reviewed in Segal et al. (2021) investigated the consequences of overweight and obesity on enrollment in further education, three of the studies find significant negative effects of excess weight measured between the age of 12 and 17. The one study finding an insignificant effect used BMI measured between the age of 7 and 9, and educational attainment measured at the age of 12.

School absenteeism is often considered a key mechanism through which overweight and obesity affect school performance. In a systematic review and meta-study, An et al. (2017) identify 13 studies investigating the association between overweight and obesity, and school absenteeism. They find that the odds of being absent from school increases by 27% among children being overweight and by 54% among children being obese compared to their normal-weight counterparts. However, 11 of these studies were based on American data, while the remaining two were a Dutch and a German study. Furthermore, most of the studies were cross-sectional.

While a comprehensive number of studies investigate the association between overweight and obesity and education performance and school absence, only few take additional measures to account for observed and unobserved factors, and still the findings remain mixed. The few studies that do find significant effects mostly originate from the US or other Anglo-Saxon countries, and none apply registry data. Furthermore, many of the studies used IV strategies, a method that is now highly debated in the literature (See Section 3.2). Analyses using different datasets from countries outside the US as well as studies presenting different estimation strategies are therefore warranted. Furthermore, none of the studies we reviewed investigated the associations of childhood overweight and obesity by SES, which is likely due to relatively small sample sizes or the absence of SES in the available data.

2.4 Labor market

A relatively large literature exists that estimates the impact of body weight on labor market outcomes. Two systematic reviews include literature on the causal impact of obesity on income (Kim & von dem Knesebeck, 2018) and employment and wages (Kesaite & Greve, Forthcoming). Both studies point to adverse effects on income and employment, and larger effects among women than among men. However, only few of the studies included in the systematic reviews measure body weight in childhood/adulthood, and Kesaite and Greve point to the lack of causal evidence of the effects.

Among the studies that estimate adult body weight on labor market outcomes, almost all studies apply data from the US (Amis et al., 2014; Black et al., 2018; Chen, 2012; French et al., 2018). One study from Sweden uses Swedish enlistment data (i.e., measurements of boys' BMI at age 18) and finds significant earnings penalties of being overweight and obese applying similar estimation methods, as we do in our analyses (Lundborg et al., 2014).

Few studies have investigated the impact of overweight and obesity in childhood and adulthood on social income transfers. This outcome is particularly relevant when studying a group of individuals where many have not yet completed their final education and entered the labor market. One exception is a study from Finland that examines the impact of a higher BMI (in adulthood) on the probability of receiving social income transfers, as well as on the average amount of social income transfers received (Böckerman et al., 2019). However, they find a significant positive (increasing amount of social income transfers) impact only when using an instrumental variable approach, and the significance of the result depends on the instrument chosen. These results highlight the uncertainty and volatility in results, when the cost of overweight and obesity is estimated using an instrumental variable method (see Section 3.2 below).

3 Methodology and data

As mentioned above, the purpose of this project is to identify the effect of childhood and adolescent overweight and obesity on education, health care usage, and labor market outcomes. Identifying this effect is challenged by the fact that it is not random who experiences overweight or obesity. Observed and unobserved factors may be related to both overweight/obesity and the outcomes of interest, and if we fail to account for these factors results will be biased (Angrist & Pischke, 2009).

To isolate the effect of overweight and obesity, we apply two different models. The first model is a linear regression model accounting for a long list of relevant observable confounders (all observed at birth or age five or age seven) while the second is a sibling fixed-effects model that besides adjusting for observable characteristics also accounts for unobservable characteristics that are fixed within the family. Each method has its advantages and disadvantages, which we will discuss further below. However, before discussing the empirical methods used in this report in detail, we will explain how we identify children's weight classification.

3.1 Weight classification

Danish municipalities have to offer children at the age of compulsory education a minimum of two health preventive visits at their general practitioner (GP) or the school nurse (§9, BEK 1344 of 12-03-2010).[2] The first visit has to be offered in either grade 0 or grade 1, while the second has to be offered in either grade 7, 8, or 9. At these visits, children are weighed and measured, among other things.

This project relies on data from The Danish National Child Health Register (børnedatabasen), which holds information on all children's height and weight from the aforementioned mandatory visits, i.e., measured height and weight by the GP or school nurse, which have little measurement error (Burkhauser & Cawley, 2008). In the analyses below, we apply height and weight measures from the school years 2011/12 to 2016/17.[3]

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[2] Decree on preventive health services for children and young people [In Danish: Bekendtgørelse om forebyggende sundhedsydelser for børn og unge]: https://www.retsinformation.dk/eli/lta/2010/1344

[3] The National Children Database was established in 2009 and includes all measurement of Danish school children. In late 2011, it became mandatory for municipalities to report to the database. In 2018, The Danish Health Data Authority switched to a new reporting system and database. At the time of writing this database has not been made available for research. Due to lags in data, deliveries some municipalities have reported data from before 2018 to the new database, and we therefore observe incomplete data from 2017 and onwards.

For each child we calculate their body mass index[4] (BMI) and classify their weight status according to The International Obesity Task Force (IOTF) classification scheme (World Obesity Federation, nd.), which takes into account the child's age at measurement and gender (Cole & Lobstein, 2012). A child is classified as *underweight* if its BMI is less than IOTF-18.5, *overweight* if its BMI is larger than IOTF-25, and *obese* if its BMI is larger than IOTF-30. Table 3.1 provides examples of age-18 (216 months) equivalent IOTF cutoffs for girls at the age of 72 months and 160 months.

Table 3.1 Age-18-equivalent IOTF cutoffs

	IOTF-equivalent cutoffs (girls)		
Age in months (years)	72 (6)	160 (13.3)	216 (18)
Underweight	BMI<13.85	BMI<16.45	BMI<18.5
Normal weight	13.85≤BMI≤17.33	16.45≤BMI≤22.77	18.5≤BMI≤25
Overweight	17.33<BMI≤19.61	22.77<BMI≤27.88	25<BMI≤30
Obese	BMI>19.61	BMI>27.88	BMI>30

Note: The table provides examples of age-18 (216 months) equivalent IOTF cutoffs for girls at the age of 72 months and 160 months. The IOTF classification provides an age-18 equivalent cutoff for each age in months between the age of 2 and 18 for boys and girls.

Source: New_cut_off_points_female_children.pdf

3.2 Empirical method

In this project, we are interested in the consequences of overweight (OW) and obesity (OB) on a range of outcomes. Since the classification also allows us to identify children classified as underweight (UW), we estimate the following equation using ordinary least squares (OLS):

$$\text{OLS:} \quad y_i = \beta_0 + \beta_1 UW_i + \beta_2 OW_i + \beta_3 OB_i + \gamma X_i + \varepsilon_i, \tag{1}$$

where y_i is the outcome of interest for child i, for example, 9th grade GPA, and X_i is the list of conditioning variables related to both the child's weight classification and outcome. We present the conditioning set in Section 3.3.2 below. β_1 is the estimate of the consequence of being underweight vis-á-vis normal weight on y while taking X into account. Similarly, β_2 and β_3 are estimates of

[4] BMI = weight(kg)/height(m)^2.

the consequences of being overweight and obese, respectively, vis-á-vis normal weight. We calculate robust standard errors to take heteroscedasticity in the outcomes into account.

When the outcome is binary, we show the results from a linear probability model (using OLS). All regressions with binary outcomes have also been estimated using a logit model, which provides similar results to those of OLS.[5]

For outcomes consisting of costs, such as health care usage or social income transfers, we use a two-part model. In the first part, we estimate the probability of having any health care usage/social transfers, and in the second part we estimate the cost conditioning on having any health care usage/social income transfers. These two estimates are combined to a per-person estimate of the costs. For details, see Appendix Report.

While Equation (1) takes a rich set of observable confounding variables into account, we cannot rule out that other unobservable variables affect the child's weight classification and/or outcome. For example, parental health literacy and family eating habits may well be related to both weight and, for instance, education. We therefore proceed to estimate a sibling fixed-effects (sibling FE) model:

$$\textit{Sibling FE}: \quad y_{ij} = \beta_0 + \beta_1 UW_{ij} + \beta_2 OW_{ij} + \beta_3 OB_{ij} + \gamma X_{ij} + \mu_j + \varepsilon_{ij} \tag{2}$$

Besides accounting for individual level variables, this model takes into account any observable and unobservable characteristics that are constant within the family (μ_i), such as genetic traits shared by the siblings and family eating habits. Standard errors are clustered at the family level.

In practice the sibling FE model is estimated by differencing the variables between siblings indicating that constant characteristics shared by siblings will be differenced out. This means that the estimates on the weight classifications are identified only for children with siblings, as well as for sibling pairs where siblings do not share the same weight classification. Insofar as both siblings are overweight, meaning they may both experience negative consequences, this will not be captured by the model. The model is therefore estimated on data with much less variation, which will likely result in larger standard errors compared to the linear regression model above (Equation 1). Similarly, the sample may not be representative of the general population as it contains sibling pairs only. Appendix Report Tables 1.5 and 1.38 show the means of the sibling sample and the difference in means relative to the OLS sample. For both the sample on children in lower secondary school and children in elementary school, the samples appear very similar overall. We do,

[5] Results are available from the authors upon request.

however, find some significant differences. For example, the sibling sample has more parents cohabiting and parents with higher income. For all outcomes we have estimated the linear regression according to Equation 1 on the sibling sample and compared the results with the results from the full OLS sample model. If the parameter estimates on overweight and obesity are different in this model based on the two samples, this is noted when we comment on the sibling FE model. Another thing to notice about the sibling FE model, is that when we condition on gender, we are effectively left with the sample of same-sex sibling pairs with differences in weight classification, which further restricts the sample size. We provide the estimates of the sibling FE model for boys and girls separately when presenting the results but will not give them much attention in the discussion due to the relative selected sample.

In recent years, a number of studies have documented negative spillovers between siblings when one sibling is affected by a negative health shock (see, e.g., Eriksen et al. (2023). If overweight or obesity affects a child negatively, this may spillover to the other sibling. In this case, a sibling FE model will underestimate the consequences of overweight and obesity.

While the sibling FE model is able to take unobserved family-fixed characteristics into account, there may still be other unobserved characteristics that could bias the estimates. An alternative approach, which much of the previous literature on causal impacts of obesity has applied, is the instrumental variable (IV) method. The IV method controls for both confounding factors and measurement errors and estimates causal local average treatment effects. However, a reliable implementation of the IV method requires that a number of relatively strong assumptions hold, including that the instrument is highly correlated with the main control variable (e.g., BMI) and unrelated to the error term. The main motivation for using the IV strategy when estimating the cost of overweight and obesity is the finding that observed weight has a very strong genetic component (Maes et al., 1997). The initial literature applying this approach used, for instance, parental weight status as an instrument for the child's weight under the assumption that parental weight affects the child's outcome only through its effect on the child's weight status (the exclusion restriction assumption). More recent literature uses polygenic scores (a measure of genetic endowment that is assumed to capture predisposition for a given trait) for overweight and obesity as instruments. However, recently both instrument variables have been questioned as the exclusion restriction is believed to be violated. There are two main reasons why genetic measures do not satisfy the exclusion restriction. First, genetic variants may be associated with several individual characteristics. This is a problem if, for instance, a genetic variant is associated with both BMI and mental health. Second, 'linkage disequilibrium' is the phenomenon where genetic variants tend to be inherited together. Both of these mechanisms suggest that genetic endowment potentially affects both the risk of being overweight and the outcome measure, resulting in biased estimates. We therefore refrain from using the IV method in this report.

As mentioned earlier, to estimate the consequences of overweight and obesity we use both an OLS and a sibling FE model. Due to the reasons mentioned above, the estimates presented in this report cannot be considered causal. While the OLS model accounts for observed characteristics of the children and their family and can be estimated on the full population of children, this model may overestimate the consequences of overweight and obesity as it does not take unobserved heterogeneity, such as family norm and lifestyle, into account. The Sibling FE model accounts for these unobserved characteristics when they are constant (fixed) within the family, but this estimate can be estimated only on the sample of siblings who differ in their weight classification, and this sample might not estimate the same effects as the full samples. Furthermore, the sibling FE model may underestimate the consequences of overweight and obesity if negative spillovers exist between siblings. Therefore, the OLS estimates and the sibling FE estimates may indicate an upper and a lower bound of the “true” effect. Furthermore, we believe that insofar as the estimates are consistent across models, they do provide us with a good indication of the consequences of overweight and obesity in childhood.

3.2.1 Heterogeneity analyses

Analyses on the full population may mask significant heterogeneity in the consequences of childhood overweight and obesity between different groups of individuals. As our data provide access to (almost) the full population of children over a range of cohorts, we are able to split our sample into subgroups. During childhood and adolescence, boys and girls undergo biological changes at different points in time, and as indicated above previous studies often find that overweight and obesity affect girls and boys differently. We therefore conduct our analyses by gender. In addition, as mentioned in the introduction inequality in health has attracted much attention among policy makers in recent years. Yet, as highlighted in Section 2 very few studies investigate the consequences of overweight and obesity by SES. We therefore also estimate our models by mothers with low/high socio-economic status, separately.

Mother’s socioeconomic status (SES)

We identify a mother as being of low SES if she had not obtained any qualifying education (vocational or higher education) when the child was 5/7 years old. Conversely, she is identified as being of high SES if she has a qualifying education. We also tried classifying a mother as low/high SES based on whether her disposable income was below/above the median income level when the child was 5/7 years old. This had very little impact on the results, and they are therefore not presented here. These results are available from the authors upon request.

Using the mother's educational level as an SES indicator has been customary in many previous research articles (Currie, 2009). Furthermore, the World Bank has promoted maternal education in developing countries for the past decades as they believe this to be one of the main drivers in improving health (World Bank, 1993). We therefore consider the mother's education as a good indicator of the child's socio-economic background.

In addition, we identify very few of the children in our data who do not have a mother in the registries. This further highlights the advantage of using the mother's SES as opposed to the father's or family's SES due to very low levels of attrition.

3.3 Data

In this report, we utilize administrative registry data. These data have all been collected for other purposes, e.g., to give information to the children, their parent, and the school about health status or performance, but are highly valuable for the purpose of this report as these measures exist for all children and are based on measurements or assessments made by GPs, school nurses, or teachers.

As mentioned above, we utilize information on children's weight and height from The National Child Health Register in the school years 2011/12 to 2016/17. Since height and weight data has been available only since the school year 2011/12, we are not able to follow all the children throughout their childhood. Therefore, we construct two separate samples, enabling us to investigate both elements of psychosocial well-being and early test scores, as well as compulsory education performance, educational attainment, and early labor market attachment. This further allows us to provide insights into health care utilization at children's different ages.

The first sample comprises of children in grades 0 or 1 in the school years from 2011/12 through 2015/16[6] (elementary school sample), and the second sample comprises children in grade 7, 8, or 9 (lower secondary school sample) in the school years from 2011/12 through 2016/17. Sample selection, descriptive statistics, and results pertaining to each sample will be presented in Chapter 4 (lower secondary school sample) and Chapter 5 (elementary school

[6] To avoid the impact of Corona, which affected the collection of the national well-being survey, and because we are interested in well-being outcomes in 4th grade, we limited the first sample to the school-year 2015/16.

sample). Table 3.2 provides an overview of the samples and observations used in the models.

Table 3.2 Overview of data

	Lower secondary school	Elementary school
Full sample of school children in the school years from 2011/12 through 2016/17	545,254	405,063
Full sample with BMI measurements	340,425	317,246
Sample and outcome	**Outcomes measured age 18/21**	**Outcomes measured age 10**
Sample with education outcomes (min – max)	322,746 – 340,425	256,596 – 317,246
Sample with mental health outcomes (min – max)	18,062 – 340,425	225,736 – 233,507
Sample with health outcomes (min – max)	73,826 – 340,425	78,849 – 317,246
Sample with social income transfers at age 21 (cohorts 1995-2000) (min – max)	25,921 – 224,235	--

Notes: Number of observations in each analysis and by outcome dimension.

Source: VIVE.

We link this information to a long list of registries containing information on socio-demographics, family relations, and information pertaining to school and education, health, and the labor market measured at age 5 for the sample of elementary school children and at age 7 for children in lower secondary school, using the children's social security number (cpr number).[7] See Section 3.3.2 for details on variables used in the analysis, and Sections 4.1.2 and 5.1.2 for outcomes for children in lower secondary school and elementary school, respectively.

3.3.1 Outcomes

As mentioned above, we have access to valid measures of weight and height for the school years from 2011/12 through 2016/17 only, which places restrictions on which outcomes we can obtain for the different samples. For example, children with weight and height measures in grade 0/1 during this period will not have finished grade 9. Similarly, the National Well-being Survey, from

[7] We draw on data from the Danish Civil Registration System, the Birth Register, the Student Register, the Education Register, the National Health Insurance Service Register, The Danish National Patient Registry, The Register of Pharmaceutical Sales, the Income Statistics Register, and DREAM.

which we extract measures on psychosocial well-being, was initiated in 2015, and therefore these measures are unavailable for all but two cohorts in the lower secondary school sample. Table 3.3 presents an overview of the investigated outcomes for each sample. Chapter 4 and 5 provide detailed information on the outcomes related to the different samples, including their specification.

Table 3.3 Overview of outcomes

Education	Well-being	Health care usage	Labor market
Lower secondary school			
▪ Performance in 9th grade exit exam ▪ Enrollment in upper secondary education ▪ School absence (9th grade)	▪ Diagnosis of mental or behavioral disorder between ages 16 and 18 ▪ Psychotropic medication usage and costs of this	▪ Visits to general practitioner and costs of these ▪ Hospital admittance and costs of this	▪ Social income transfers at the age of 21[a]
Elementary school			
▪ National test performance in Danish (2nd grade ▪ National test performance in math (3rd grade) ▪ School absence (4th grade)	▪ Psycho-social well-being (4th grade)	▪ Visits to general practitioner and costs of these ▪ Hospital admittance and costs of this	

Notes: Overview of outcomes for both analysis samples: children in lower secondary school and children in elementary school. [a]The DREAM database and the Income Register from which we extract information for this analysis are limited to cohorts 1995-2000. Age 21 is selected due to labor market relevance and to include a large enough sample.

Source: VIVE.

3.3.2 Conditioning set

As noted above, being overweight and obese may be related to many observed and unobserved confounders, which may result in unreliable estimates if we fail to account for them. For example, parental SES may be related both to childhood overweight and obesity as well as educational performance. If we fail to take this relationship into account, we will likely overestimate the negative relationship between overweight and obesity on performance. This is particularly relevant for policy application as preventing overweight will probably not result in the expected outcome (here better school performance) if the low performance was actually due to parental SES and not excess weight. The analyses therefore incorporate information on child demography, information pertaining the birth of the child, such as birthweight, health information, such as diagnosis of a behavioral or mental disorder, parental socio-economic information, such as education and income, and parental health, including diagnosis of a mental or behavioral disorder. For full details on the specific variables and their definitions, see Appendix Report Table 1.2. In order to avoid bias related to bad controls, i.e., conditioning on variables which have been affected by treatment – here overweight and obesity – we measure conditioning variables prior to observing weight and height measures (Rosenbaum, 1984). Still, we want to measure them as close as possible to the weight measurement. This means that the timing of measurement of the conditioning variables depends on the sample being used. For the elementary school sample, we measure the conditioning variables at age 5 or earlier, while for the lower secondary school sample we measure them at age 7 or earlier.

The next two chapters describe the two samples in detail and present the results on the selected outcomes.

4 Consequences of overweight and obesity in lower secondary school

This chapter presents the analyses of the consequences of overweight and obesity among children in lower secondary school. First, we provide descriptive statistics, and subsequently we present the results from the linear regression and sibling FE models. Each outcome group will be presented in a separate section.

4.1 Sample

The sample is based on the full population of Danish school children enrolled in lower secondary school (grades 7, 8, and 9) in the school years 2011/2012-2016/2017. Using the Student Registry (KOTRE), we identify 545,254 children enrolled in lower secondary school. Information on weight and height is available for 63% of these children (Danmarks Statistik, nd.). Missing information on height and weight reflects that many children do not show up at the school nurse or doctor, either because they are absent from school on the day of measurement or because they do not wish to be measured. This clearly shows that although it is mandatory for the municipalities to offer a preventive health visit to children in lower secondary school a substantial share of students do not make use of this option.

We exclude observations with extreme outliers on BMI and restrict the sample to only include children observable in the Danish registries who have mothers with non-missing information.[8] The final sample consists of 340,425 children, corresponding to 62% of the full population of school children in lower secondary school in the respective years.

[8] We remove measures of weight and height, if these are below 0.001 or above 0.999 percentiles of gender-age-specific growth curves (see Sundhed.dk, 2023). Afterwards, we calculate BMI and remove BMI measures below 7 and above 55.

Box 4.1 Sample representativeness – lower secondary school

To infer whether the sample of children with BMI measures are representative of the general population, we conduct an analysis regressing an indicator for whether the child has a BMI measure or not on our conditioning set. A brief description of the representativeness of the sample is provided here, while the full set of estimates can be found in the Appendix (see Appendix Report, Table 1.3).

In general, the sample seems to be positively selected. For example, children with a BMI measure appear to be of better health. They are 5 percentage point less likely to have a diagnosis of a mental or behavioral disorder are less likely and less likely to receive any psychotropic medication before the age of 8. Similarly, they appear to be of better socioeconomic status, i.e., their parents have higher educational levels and they are less likely to be employed. Most coefficients small in size, however. For example, the coefficient on birth weight finds a statistically significant difference of 0.01 grams between children with and without a BMI measure.

As the sample is positively selected and we know that there is a social gradient in overweight and obesity, we likely observe fewer overweight and obese children than there actually are in the population. Insofar as overweight and obesity have a negative effect on outcomes we, if anything, underestimate the consequences of overweight and obesity.

4.1.1 Weight classification

For each child, we keep their first measure of BMI in lower secondary school. Table 4.1 shows the distribution of weight class for the final sample and by gender. Around 18% of children in lower secondary school are overweight or obese. Girls are more likely to be underweight compared to boys, whereas more boys are obese relative to girls. However, girls have a higher BMI on average.

Table 4.1 Weight classification in lower secondary school

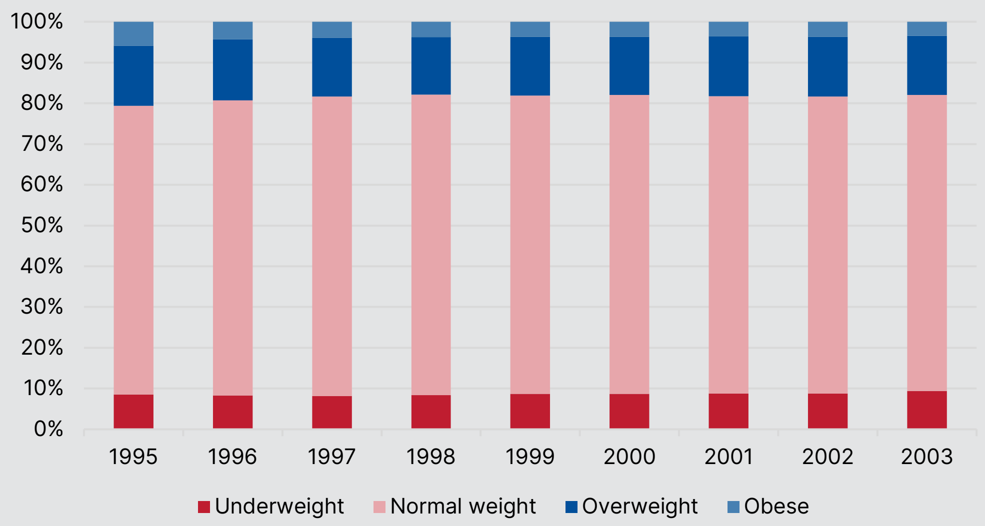
	All	Girls	Boys
Underweight	8.6	9.4	7.9
Normal weight	73.2	72.7	73.7
Overweight	14.5	14.6	14.3
Obese	3.7	3.3	4.1
Total	100	100	100
Average BMI	20.6	20.7	20.4
Observations	340,425	165,891	174,534

Notes: Share in each weight classification for all children and by gender. Underweight = 1(BMI< IOTF 18.5), Normal weight=1(18,5≤BMI≤25), Overweight=1(20<BMI≤30), Obese=1(BMI>30).

Source: VIVE.

Figure 4.1 shows the distribution of weight class of each cohort in the sample. As can be seen in the Figure, the distribution of weight classes appears stable across cohorts.

Figure 4.1 Weight classification by cohort



Notes: Relative shares in each weight classification by birth year (cohort). Comparison of weight classes by cohorts 1995-2003.

Source: VIVE.

4.1.2 Outcomes

The outcomes are divided into the four dimensions: education, mental health treatment, health care usage, and labor market (see Table 3.3).

Education

The education outcomes focus on educational performance in the grade 9 exit exams and enrollment in upper secondary education, i.e., vocational schooling and high school. Below we describe the outcomes in detail.

Attended 9th grade exit exams

We construct an indicator variable equal to 1, if the child attended the grade 9 exit exams and 0 otherwise.

The grade 9 exit exams mark the ending of compulsory schooling in Denmark. It comprises five compulsory examinations and two random examinations that change from year to year. The test is high stake as it can affect the individual's opportunity to continue into upper secondary school.

Sitting the grade 9 exit exams is mandatory. The principal is obliged to adjust the exams if a child has special needs that prevent it from taking the exam under regular conditions, and in extreme cases the child can be exempted from the exam. A recent report from the Ministry of Children and Education (2021) shows that about 90% of children in compulsory education took the exams in 2019. The majority of the 10% who did not take the exams, were children enrolled in a special school (77%).

GPA in grade 9 exit exams

For the children who sat all five compulsory examinations, we calculate their grade-point-average (GPA) and standardize it within year of examination.

School absence in 9th grade

We construct the fraction of days missing school during grade 9 for each child. Schools are obliged by law to provide at least 200 days of schooling, but may provide more.

Enrolled in vocational school by age 18

We construct an indicator variable equal to 1 if the child has been enrolled in vocational school at any point by the age of 18. We choose the age of 18 to allow children to take a gap year or accommodate children who delayed starting school, while at the same time making sure that we observe the children at age 18 in the data.

Enrolled in high school by age 18

Similarly, we also construct an indicator variable equal to 1, if the child is enrolled in high school at any point.

No enrollment in upper secondary education by age 18

This indicator is equal to 1, if the child has not been enrolled in vocational school or high school by age 18, and 0 otherwise.

Mental health and mental health treatment

Diagnosis of a mental or behavioral disorder by age 18

We construct an indicator variable equal to 1, if the child receives a diagnosis of a mental disorder (F-diagnosis according to ICD-10 (World Health Organization, 2019)) between the age of 16 and 18, and 0 otherwise. This includes diagnosis of depression, anxiety, and eating disorders.

Use of psychotropic medication

Following the approach in many studies of health care usage, we analyze the use of psychotropic medication on the extensive margin (probability of usage) and the intensive margin (costs for those with health care costs).

The use of medication is limited to psychotropic medication and is an indicator equal to 1 if a child has had any medication usage at age 18 (extensive margin). Costs are calculated as costs related to psychotropic medication prescriptions for children who have had any prescription of psychotropic medication (intensive margin). Psychotropic medication is defined by the Anatomical Chemical System (ATC) and includes all medication types for the nervous system (ATC=N), which covers antidepressants, antianxiety medication, antipsychotics, and stimulants. The information comes from the Register of Pharmaceutical Sales.

Health care usage

Two dimensions of health care usage are analyzed: usage in the primary sector and usage in the secondary sector. As above, we consider health care usage both on the extensive and the intensive margin.

Use of the primary sector

We construct an indicator equal to 1 if a child has had any health care usage in the primary sector, defined as visits to a general practitioner at age 18 (extensive margin). We calculate health care costs as the total costs from the Danish Health Insurance for children who incur any costs at age 18 (intensive margin). The health care costs cover all health services where the Danish Health Insurance applies, e.g., general practitioner, physio, psychological services, etc. This information comes from the National Health Insurance Service Register.

Use of the secondary sector

We construct an indicator equal to 1 if a child had any interaction with the secondary sector, defined as having any hospital contact at age 18 (extensive margin). We calculate hospital costs incurred by the children who have had any hospital contact at age 18 (intensive margin). The hospital costs consist of costs from the DRG system related to somatic treatments on inpatient, outpatient, and ER patient care. Thus, psychiatric hospital treatment is not included in analysis. The information comes from the National Patient Register.

Labor market outcomes

Social income transfers

We construct an indicator variable that equals 1 if the child is registered to receive social income or unemployment benefits when they are 21 years old. We include a variable measuring the amount of social income transfers and unemployment benefits received. This information comes from the Income Statistics Register at Statistics Denmark.

4.1.3 Descriptive statistics

Table 4.2 shows descriptive statistics by children's weight classification on a selected set of the conditioning variables included in our model specifications.

Table 4.2 Descriptive statistics on children in lower secondary school

	Underweight		Normal weight		Overweight		Obese	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Female (0/1)	0.53***	(0.50)	0.48	(0.50)	0.49***	(0.50)	0.43***	(0.50)
Immigrant (0/1)	0.02***	(0.15)	0.03	(0.17)	0.04***	(0.19)	0.05***	(0.21)
Descendant (0/1)	0.07	(0.26)	0.07	(0.25)	0.12***	(0.32)	0.16***	(0.37)

	Underweight		Normal weight		Overweight		Obese	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Has father (0/1)	0.99**	(0.11)	0.99	(0.12)	0.98***	(0.14)	0.98***	(0.14)
First child (0/1)	0.47***	(0.50)	0.45	(0.50)	0.42***	(0.49)	0.39***	(0.49)
Birth weight in grams	3357***	(600)	3509	(593)	3555***	(610)	3576***	(624)
Birth length in cm	51.57***	(2.90)	51.96	(2.74)	51.98	(2.76)	51.99	(2.71)
Received a psychiatric diagnosis before age 8 (0/1)	0.03***	(0.16)	0.02	(0.14)	0.03***	(0.16)	0.03***	(0.17)
Total number of hospital contacts before age 8	4.56***	(5.18)	4.47	(4.70)	4.82***	(4.94)	5.20***	(5.67)
Age at BMI measurement	14.41***	(1.02)	14.45	(0.98)	14.43***	(1.01)	14.47**	(1.05)
Mother characteristics								
Age at birth	29.82***	(4.73)	29.53	(4.78)	29.03***	(5.03)	28.64***	(5.22)
Psychiatric diagnosis, age 0-7 (0/1)	0.07	(0.26)	0.07	(0.26)	0.08***	(0.28)	0.10***	(0.30)
Cohabiting with partner at age 7 (0/1)	0.79***	(0.41)	0.77	(0.42)	0.73***	(0.44)	0.69***	(0.46)
Education level above high school (0/1)	0.75***	(0.43)	0.74	(0.44)	0.65***	(0.48)	0.54***	(0.50)
Total income in 10,000s (DKK)	23.79***	(15.78)	23.55	(14.25)	21.79***	(9.56)	20.31***	(12.72)
Unemployed at age 7 (0/1)	0.03	(0.18)	0.03	(0.18)	0.04***	(0.20)	0.06***	(0.23)
Not in labor force at age 7 (0/1)	0.15***	(0.36)	0.16	(0.37)	0.22***	(0.41)	0.29***	(0.45)
Total weeks of social assistance per year, age 0-7	3.57	(10.87)	3.64	(10.86)	5.87***	(13.51)	8.89***	(16.10)
N	29,360		249,116		49,242		12,707	

Notes: Table of means and standard deviations on selected characteristics by weight classification on the full sample of children in lower secondary school. Test of differences in means by t-test with reference to normal weight.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: VIVE.

The children are 14.5 years old on average at the time of measurement of weight and height, which means that they are typically measured in grade 8, if they did not enroll early or late for class. Although children with obesity are statistically older at measurement, the size of the difference is negligible. Girls tend to be overrepresented among underweight and overweight children, whereas boys are more likely to experience obesity. Children with overweight and obesity are more likely to come from a non-Danish background. Furthermore, they appear to be of worse health in general, with an increased probability of having a diagnosis of a mental or behavioral disorder and more hospital contacts before the age of 8. They do have a significantly higher birthweight but the differences are less than 75 grams, corresponding to a 2% difference, and must be considered trivial.

Children with overweight or obesity appear to be more likely to come from disadvantaged backgrounds. Their mothers where younger when they gave birth to the child, they are less likely to be cohabiting with a partner, they earn less, and are much more likely to be outside the labor force when the child was 7 years old. Just about half of the mothers of children with obesity had an education above high school when the child was 7 years of age, which is in sharp contrast to the 74% of mothers of children who are normal weight. In the consideration of space, descriptive statistics for the fathers are left out but they follow a similar pattern to that of mothers (see Appendix Report, Table 1.4). To sum up, children with overweight and obesity appear to be of poorer health and poorer social background. As these characteristics are also likely to be related to future health, education, and labor markets prospects, this highlights the importance of taking them into account in model specifications investigating the consequences of excess weight in children.

4.1.4 Sibling sample

As described in Section 3.2, the estimation of the sibling FE model require variation in weight classification within sibling pairs. Table 4.3 therefore shows the observed variation in weight categories within sibling pairs for the children in lower secondary school sample. We identify 12,513 sibling pairs where one sibling is classified as overweight while the other is classified as being of normal weight. An additional 2,220 sibling pairs are identified with one sibling being classified as obese and the other sibling as being of normal weight. While the table indicates sufficient variation in weight classification within sibling pairs, the sample is significantly reduced. In addition, variation in conditioning variables and outcomes is also likely to be much smaller, which likely affects the power of the results from the sibling FE models.

Table 4.3 Weight classifications in lower secondary school within sibling pairs

Sibling 2 \ Sibling 1	Underweight	Normal weight	Overweight	Obese	Total
Underweight	1,677	4,634	302	44	6,657
Normal weight	4,635	42,345	6,250	1,069	54,299
Overweight	305	6,263	2,583	751	9,902
Obese	55	1,151	678	464	2,348
Total	6,672	54,393	9,813	2,328	73,206

Notes: Each cell indicates the number of sibling pairs with that particular weight distribution. For example, column three in row two indicates that 6,250 sibling pairs exist where sibling 1 is overweight while sibling 2 is of normal weight. Thus, we have 12,513 sibling pars where one sibling is overweight and the other is of normal weight.

Source: VIVE.

4.2 Educational consequences

This section presents the results on the educational consequences of overweight and obesity measured in lower secondary school. We first provide a brief summary of the findings and subsequently present the results of the separate analyses in more detail.

4.2.1 Summary

In general, being overweight or obese in lower secondary school has negative associations with educational outcomes, i.e., whether the children sit the exams, their final grades, and whether they are enrolled in upper secondary education at age 18. Furthermore, being overweight or obese has large effects on school absence. Generally, the effect sizes are higher for obese children compared to overweight children.

Children who are overweight or obese are less likely to attend the grade 9 exit exams, and the performance of those who attend is poorer than that of normal-weight children. This particularly applies for children with obesity, who perform about 50% of a standard deviation poorer in their grade 9 exit exams than normal-weight children. In comparison, children with type 1 diabetes perform 5% of a standard deviation poorer in their 9th grade exit exams than children without diabetes (Lindkvist et al., 2022).

An elevated level of school absence can be a reason for lower performance in grade 9. Both overweight and obese children have significantly higher rates of school absence than normal-weight children. While overweight children have

16% more school absence than normal-weight children, the percentage for obese children is 42%.

Performance and, in particular, whether the child attends the grade 9 exit exams has consequences for their further education. There is a clear tendency for children who are overweight and obese in lower secondary schooling to be less likely to be enrolled in high school by the age of 18 (parameter estimates are twice as high for obese compared to overweight children) and more likely to enroll in a vocational education. However, overweight and obese children are also significantly less likely to be enrolled in upper secondary education at age 18. For overweight children, the results from the OLS model show that the probability of not being enrolled in an upper secondary education is 34% higher than for normal-weight children. This percentage is 117% for obese children. The sibling FE estimates are smaller but remain significant.

4.2.2 Results

Table 4.4 provides an overview of the outcome means and standard deviations for each weight classification. Each weight classification is tested vis-à-vis the normal-weight group using a t-test. The table shows that children who are overweight or obese compared to their normal weight counterparts have poorer education outcomes in general. They are significantly less likely to attend the grade 9 exit exams and when their performance is also poorer. Children who are obese have 9% school absence, corresponding to 18 days if we assume that a school year comprises 200 days. This is about 6 days more absence than that of children who are of normal weight. Considering enrollment in upper secondary education, results clearly show that overweight and obese children are much less likely to enter high school. This tendency may have severe consequences as a high school degree is required to attend higher education and thus likely impacts labor market opportunities as well. While the lower enrollment rate of overweight or obese children in high school is to some extent offset by higher rates of enrollment in vocational schooling, a significant number of overweight or obesity children have not entered any upper secondary education when they turn 18. For children with obesity, this number is three times as large as that for children who are of normal weight.

Table 4.4 Educational outcomes for 9th grade and at age 18

	Underweight		Normal weight		Overweight		Obese	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
9th grade exit exams								
Sat exams (%)	94.54***	(22.72)	95.48	(20.77)	93.46***	(24.72)	89.01***	(31.27)
N	29,360		249,116		49,242		12,707	
GPA (standardized score)	0.15***	(0.98)	0.10	(0.97)	-0.24***	(0.97)	-0.58***	(0.95)
N	27,737		237,727		45,988		11,294	
School absence 9th grade								
Total absence (%)	5.65***	(7.26)	5.83	(7.00)	7.11***	(8.39)	9.09***	(10.25)
Legal absence (%)	1.36***	(2.67)	1.41	(2.64)	1.54***	(2.90)	1.70***	(3.47)
Enrollment into upper secondary education by age 18								
High school (%)	77.58	(41.70)	77.49	(41.77)	64.47***	(47.86)	47.94***	(49.96)
Vocational (%)	18.09***	(38.49)	20.28	(40.21)	30.58***	(46.07)	40.05***	(49.00)
No education (%)	7.71***	(26.67)	6.22	(24.15)	10.16***	(30.21)	17.72***	(38.19)
N	29,360		249,116		49,242		12,707	

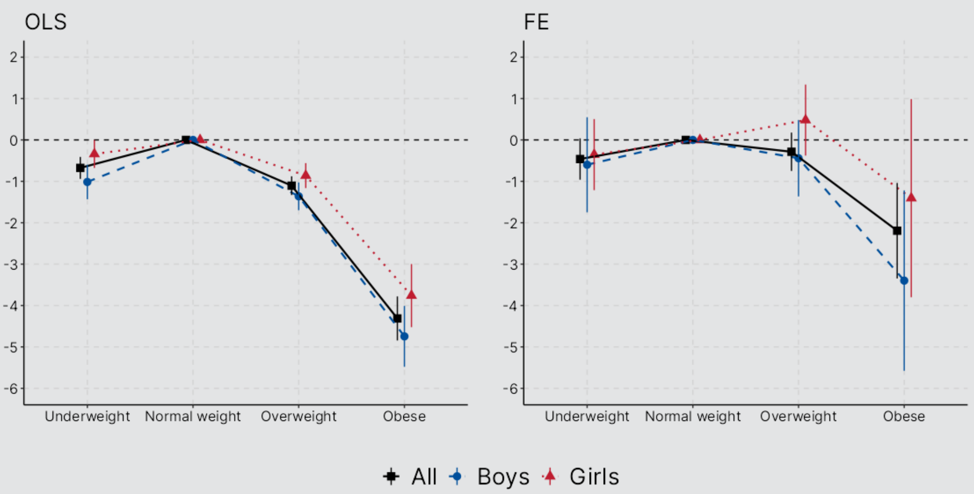
Notes: Summary table of means and standard deviations on education outcomes by weight classification, in percentage and standardized score. Simple t-tests of means by weight class relative to baseline of normal weight. Standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

Source: VIVE.

The estimates above present the raw differences between the children across different weight classifications and may mask systematic underlying differences between children of different weight classifications. As discussed in Chapter 3, we therefore proceed to estimate linear regression models taking both observable (OLS) and unobservable fixed-family characteristics (Sibling FE) into account.

Educational performance

Figure 4.2 Attended 9th grade exit exams



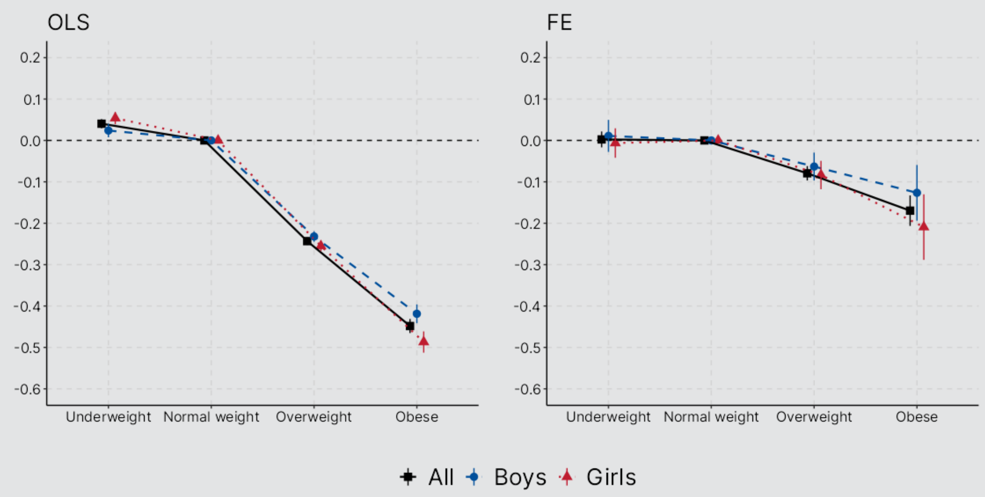
Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has attended the 9th grade exit exams or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 340,425, N(FE) = 140,830, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 95.5. The corresponding regression table is Appendix Report, Table 1.6.

Source: VIVE.

Figure 4.2 shows the results on the likelihood of sitting the grade 9 exit exams from both the OLS regression and the Sibling FE model. The OLS results show that children who are overweight or obese are less likely to attend the grade 9 exit exams, even when demographics, early health, and parental characteristics are taken into account. In particular, the probability of attending the grade 9 exit exams for boys are reduced by 1.4 percentage-points (pp) if they are overweight, and 4.8 pp if they are obese compared to normal-weight boys. The estimates are slightly smaller for girls, where the probability of a girl attending the grade 9 exit exams is reduced by 0.9 pp if a girl is overweight and 3.8 pp if she is obese compared to normal-weight girls. When we account for family fixed effects in the sibling FE model, the size of the estimate on the full sample is halved but remains negative and significant for children with obesity. This suggests that attending the exit exams is to some extent driven by unobserved family characteristics.

If children with overweight or obesity sit the exam, they perform significantly worse than normal-weight children (Figure 4.3). This particularly applies to children with obesity, who perform about half of a standard deviation poorer in their grade 9 exit exams than normal-weight children. As before, the estimates are attenuated when we take unobserved family fixed characteristics into account, but they remain sizeable and significant. We find no gender differences in the consequences of overweight and obesity on exam performance.

Figure 4.3 Standardized 9th grade GPA



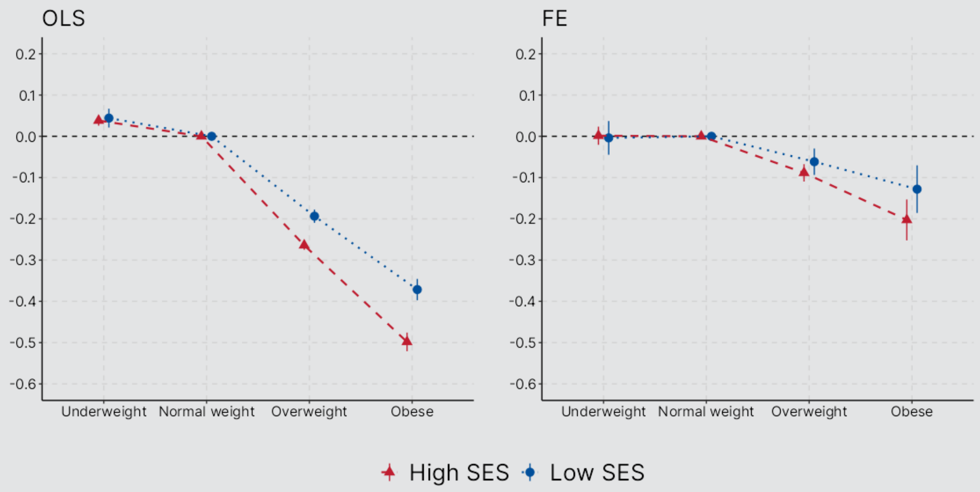
Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of the standardized 9th grade GPA for the child on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 322,746, N(FE) = 130,052, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 0.1. The corresponding regression table is Appendix Report, Table 1.8.

Source: VIVE.

Figure 4.4 examines whether the results on attending the grade 9 exit exams and performance differ by SES. We find that children with obesity are 5.6 pp less likely to sit the grade 9 exit exams when their mothers are of low SES, compared to 3.4 pp when their mothers are of high SES. This suggests that obesity affects educational attainment the most among children of low SES as having taken the grade 9 exit exams is a requirement to enroll in upper secondary education. Once again, the estimates are attenuated when we account for family-fixed effects. They do, however, remain significant for overweight children of high SES mothers as well as children with obesity.

In contrast, overweight and obesity appear to have stronger impacts on educational performance among high SES children compared to low SES children, although the estimates are not statistically different in the sibling FE models.

Figure 4.4 Standardized grade 9 exit exams GPA by SES



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of the standardized 9th grade GPA for the child on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for high SES (red) and low SES (blue). N(OLS) = 89,859 and N(FE) = 31,663 when we apply the Low SES. N(OLS) = 235,887, N(FE) = 95,112 when we apply the High SES. In the Low SES sample, the outcome mean for normal-weight children is -0.27. In the High SES sample, the outcome mean for normal-weight children is 0.2 The corresponding regression table is Appendix Report, Table 1.9.

Source: VIVE.

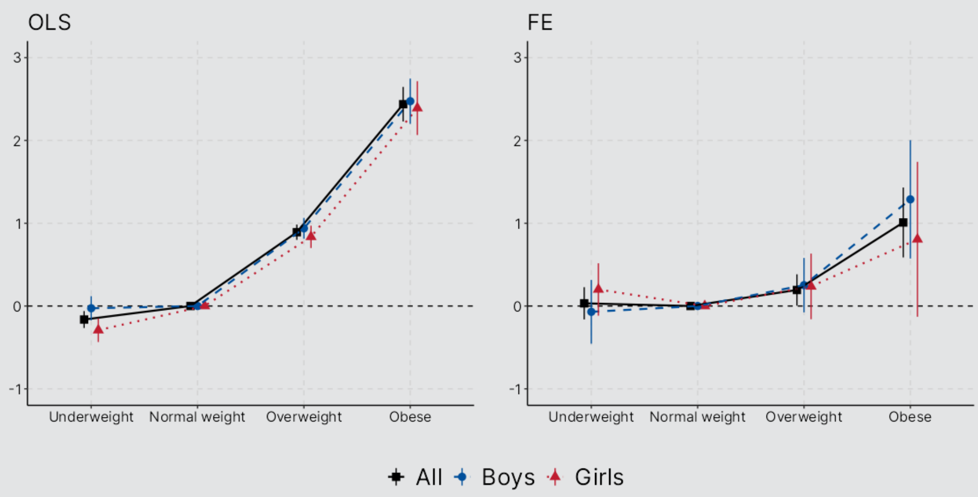
School absence

As mentioned above, school absence is often considered one of the key mechanisms to explain why children of poor health perform poorer in school. We therefore use the Danish School Absence Registry to estimate whether overweight and obesity affect total absence in grade 9. The results are presented in Figure 4.5. According to the OLS estimates, overweight children have 0.9 pp more school absence than normal-weight children, corresponding to 15%.[9] Children with obesity have 2.4 pp more absence than normal-weight children. This means that children with obesity in lower secondary school have 42% more absence than their normal-weight peers. Considering that grade 9 is the final year of compulsory schooling and a year mostly spent on preparing the children for their final examination, this can have a substantial impact on their future prospects in life. The size of the estimates is reduced when we account for family-fixed characteristics, but they remain significant when we consider the full sample. For example, absence among children with obesity is

[9] 15% = 0.89/5.83 (estimate divided by the average level of absence for normal-weight children).

19% higher. When we split the sample by gender, the estimates remain constant but become insignificant for girls due to larger standard errors. We also find no differences in SES (see Appendix Report, Table 1.11).

Figure 4.5 Total share of absence in 9th grade



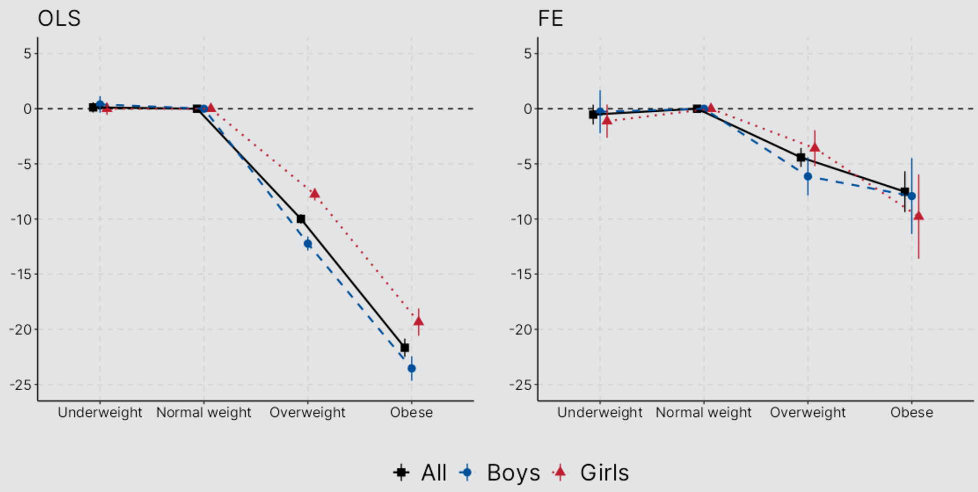
Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of the total share of absence in 9th grade for the child on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 241,657, N(FE) = 87,528, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 5.8. The corresponding regression table is Appendix Report, Table 1.10.

Source: VIVE.

Educational attainment

In order to obtain a qualifying education, following compulsory education children in Denmark either primarily continue into 3 years of high school if they aim for an academic track at a university or university college, or enter vocational education, which typically takes 4 years to complete. Both high school and vocational education can also be a qualification for business academies or similar. The choice of upper secondary education can therefore be crucial for future labor market opportunities. Figure 4.6 shows that children who are overweight are ten percentage points less likely to enroll in high school by the age of 18, while children who are obese are 21.7 pp less likely to enroll in high school by age 18 than normal-weight children. This corresponds to a decrease in high school enrollment of 13% and 28%, respectively.

Figure 4.6 High school enrollment by age 18

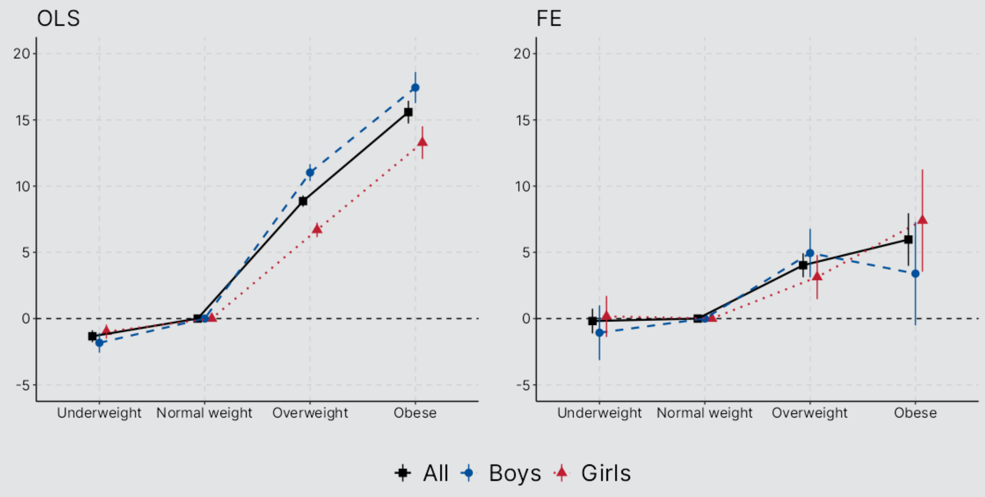


Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has enrolled in high school at age 18 or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 340,425, N(FE) = 140,830, when we apply the full sample. In the full sample the outcome mean for normal weight children is 77.5. The corresponding regression table is Appendix Report, Table 1.12.

Source: VIVE.

The lower level of enrollment in high school is to some extent offset by an increased enrollment in vocational education (see Figure 4.7). However, we also see a significant increase in both overweight and obese children who have not enrolled in either high school or vocational education by age 18. In particular, the OLS estimates in Figure 4.8 show that 2.1 pp of overweight children and 7.3 pp of obese children have not enrolled in any upper secondary education by age 18. This is equivalent to an increase of 34% and 117%, respectively, in the probability of not enrolling in upper secondary education compared to normal-weight children. The sibling FE estimates are again smaller but remain significant when considering the full sample. Once we partition the sample by gender, we see that especially boys appear to be less likely to enroll in high school and more likely not to obtain any education. The confidence bands are too wide, however, to warrant the conclusion that the estimates for boys and girls are statistically significantly different from each other.

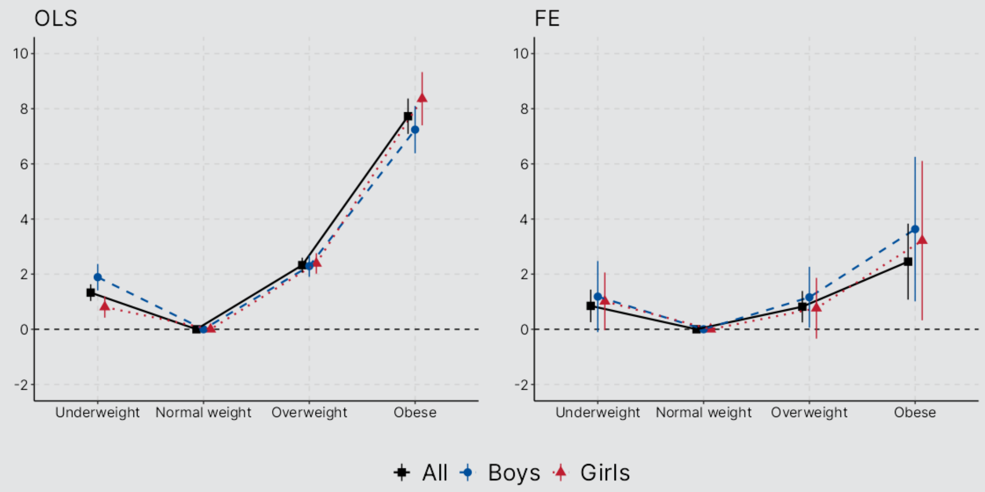
Figure 4.7 Enrollment in vocational education by age 18



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has enrolled in vocational education at age 18 or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 340,425, N(FE) = 140,830, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 20.3. The corresponding regression table is Appendix Report, Table 1.14.

Source: VIVE.

Figure 4.8 Not enrolled in upper secondary education by age 18



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has not enrolled into upper secondary education at age 18 on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue). And girls (red). N(OLS) = 340,425, N(FE) = 140,830, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 6.2. The corresponding regression table is Appendix Report, Table 1.16.

Source: VIVE.

Table 4.5 shows the OLS estimates of the relationship between weight classification and enrollment in upper secondary education by SES. Although we cannot say that the estimates differ statistically from each other, it does appear to be the case that children of high SES mothers are more likely to substitute between educational tracks towards more vocational training, whereas children of low SES mothers are to some extent more likely not to enroll in any education. The sibling FE estimates (not shown here) reveal similar associations though the differences between high SES and low SES are less pronounced.[10]

[10] See Appendix Report, Table 1.13, Table 1.15, and Table 1.17.

Table 4.5 OLS results: Enrollment in upper secondary education by age 18, by SES

	High school		Vocational edu.		No education	
	Low SES	High SES	Low SES	High SES	Low SES	High SES
Underweight	0.21	0.07	-1.72***	-1.20***	1.29***	0.71***
	(0.53)	(0.26)	(0.52)	(0.25)	(0.40)	(0.15)
Overweight	-8.73***	-10.56***	6.64***	9.83***	2.72***	1.87***
	(0.39)	(0.26)	(0.39)	(0.26)	(0.29)	(0.14)
Obese	-19.49***	-23.19***	10.91***	19.01***	8.98***	5.94***
	(0.62)	(0.57)	(0.65)	(0.58)	(0.54)	(0.38)
N	95,106	245,319	95,106	245,319	95,106	245,319
Adjusted R-squared	0.188	0.136	0.071	0.087	0.150	0.093
Mean of normal weight	65.49	81.70	27.29	17.82	12.11	4.15

Notes: The table shows covariate-adjusted estimation coefficients and standard errors (in parentheses) from OLS regressions of three binary outcomes on, respectively, weight classification: 1) attended high school at age 18, 2) attended vocational education at age 18, and 3) no education at age 18. Covariates are measured at age 7 or earlier (see Appendix Report, Table 1.2 for a full description of included variables). We apply robust standard errors in the OLS estimations, and family-clustered standard errors in the sibling FE estimations. * p < 0.1, ** p < 0.05, *** p < 0.01. R-squared adjusted for number of predictors.

Source: VIVE.

4.3 Mental health and mental health treatment

This section presents the results analyzing the relationship between weight classification and mental health and mental health treatments, i.e., diagnoses of any mental or behavioral disorder between the age of 16 and 18, and usage of psychotropic medication at age 18 and its related costs.

Studies show that most youths who experience psychological distress do not seek professional help (Biddle et al., 2004; Radez et al., 2021), which indicates that there are more children experience poor mental health than those identified through the psychiatric diagnosis register. We are, however, limited to data obtainable in the Danish registries, which include public paid health care and medical treatment for mental health problems. However, we expect the most severe cases to be represented in the registry. For other aspects of psychosocial well-being, we refer the reader to Section 5.3, which discusses the results on well-being among children in 4th grade.

As most psychiatric medications are known to generate weight gain, and for some patients, obesity, reverse causality is a particular concern when estimating the relationship between overweight and obesity, on the one hand and mental health care treatments on the other. We do control for early diagnoses of a mental or behavioral diagnosis at age 7 as well as usage of psychotropic medication, also at age 7, but this may not be sufficient to account for reverse causality.

4.3.1 Summary

Children who are overweight and obese in lower secondary school are significantly more likely to receive a diagnosis of a mental or behavioral disorder. However, the results become insignificant in the sibling FE models. The insignificant results from the sibling FE model suggest that differences in mental health care use between normal-weight and overweight/obese children is explained by unobserved family characteristics.

4.3.2 Results

Table 4.6 shows that 5.8% of normal weight children receive a diagnosis of a mental or behavioral disorder between the ages 16 and 18. This is significantly lower compared to children who are underweight, overweight, and obese, with prevalences of 6.4%, 6.9%, and 8.1%, respectively. Similarly, underweight, overweight, and obese children all have significantly higher probabilities of receiving psychotropic medication and incur higher expenditures for this.

Table 4.6 Mental health outcomes

	Underweight		Normal weight		Overweight		Obese	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Diagnosis of a mental or behavioral disorder at age 16-18 (%)	6.39***	(24.46)	5.78	(23.34)	6.88***	(25.32)	8.11***	(27.31)
Any psychotropic medication (%)	5.77***	(23.31)	5.00	(21.80)	6.09***	(23.92)	7.09***	(25.67)
N	29,360		249,116		49,242		12,707	
Psychotropic medication costs (DKK), conditional on any costs	3,200	(4,921)	3,181	(4,999)	3,387**	(5,464)	3,655***	(5,655)
N	1,693		12,467		3,001		901	
Average psychotropic costs per person (DKK)	185		159		206		259	
Difference from normal weight (DKK)	26		-		47		100	

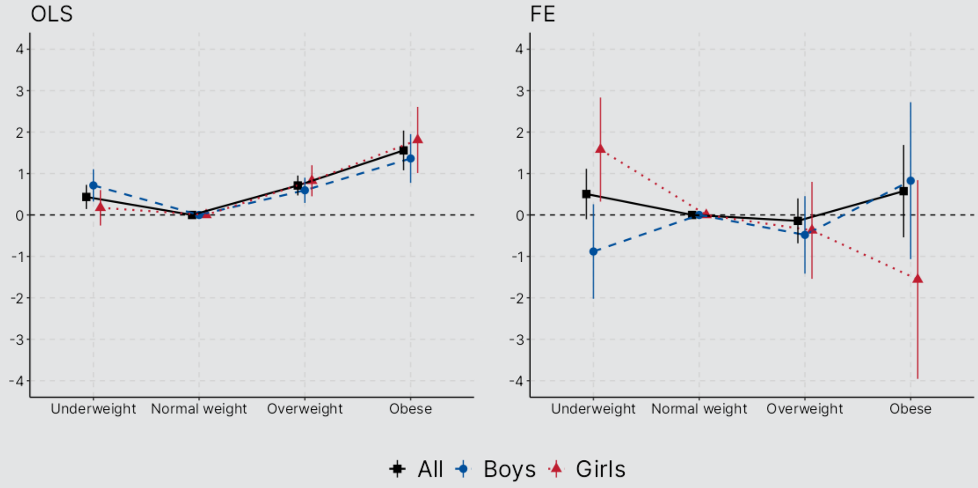
Notes: Summary table of means and standard deviations on mental health outcomes by weight classification, in percentage and DKK. Means in costs only for persons who have any costs. Simple t-tests of means by weight class relative to baseline of normal weight. Standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01

Source: VIVE.

Diagnosis of a mental or behavioral disorder

Taking observable confounders into account, the OLS estimates in Figure 4.9 show that children with overweight are 0.7 pp more likely to be diagnosed with a mental or behavioral diagnosis than normal-weight children. Similarly, children with obesity are 1.6 pp more likely to be diagnosed with a mental or behavioral diagnosis between the ages of 16 and 18. This corresponds to a 27% increase compared to normal-weight children. Girls are slightly more likely to be diagnosed compared to boys, though they the difference is not statistically significant. When accounting for family-fixed effects the results change substantially; apart from underweight girls now being more likely to receive a diagnosis of a mental or behavioral disorder, none of the results are statistically significant. Thus, when controlling for family-fixed effects, there is no longer a significant impact of overweight or obesity on the likelihood of being diagnosed with a mental or behavioral diagnosis. We find no statistical differences between children with low and high SES mothers albeit the coefficients are larger for children of high SES mothers, which could indicate a higher health care utilization (See Appendix Report, Table 1.19).

Figure 4.9 Being diagnosed with a mental or behavioral diagnosis at age 16-18



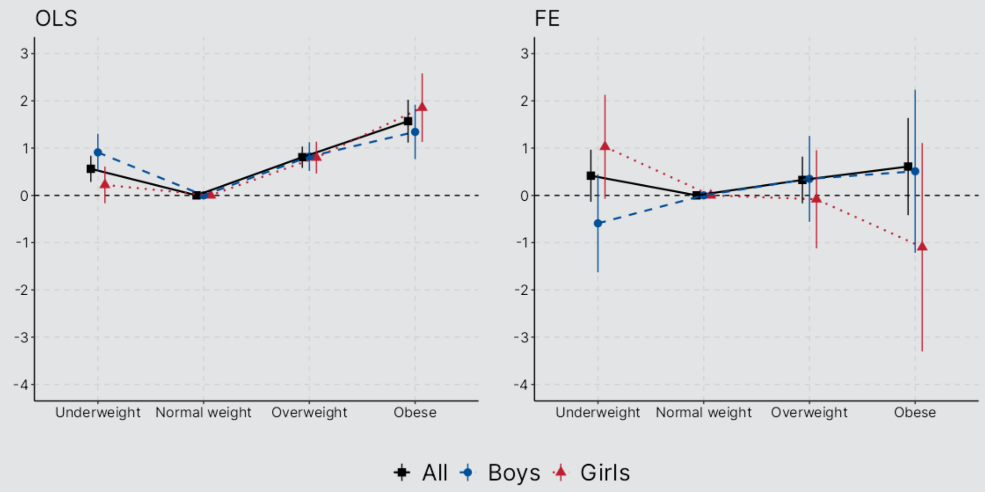
Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has been diagnosed with a mental or behavioral diagnosis at age 16-18 or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 340,425, N(FE) = 140,830, when we apply the full sample. In the full sample, the outcome mean for normal weight children is 5.8. The corresponding regression table is Appendix Report, Table 1.18.

Source: VIVE.

Psychotropic medication usage

The analysis on whether a child receives psychotropic medication at age 18 is shown in Figure 4.10. Based on the OLS specification, overweight (obese) children have 0.8pp (1.6 pp) higher probability of receiving psychotropic medication. This corresponds to very large effect sizes of 16% and 32% relative to normal-weight children and both are statistically significant at a 1% level. The FE specification for the full sample produces positive, but smaller and insignificant estimates.

Figure 4.10 Receiving psychotropic medication at age 18



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has received psychotropic medication at age 18 or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 340,425, N(FE) = 140,830, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 5.0. The corresponding regression table is Appendix Report, Table 1.20.

Source: VIVE.

The results from the analysis on psychotropic medication costs are shown in Table 4.7. These results are based on those who receive a prescription of medication, and it is thus a relatively small sample. The OLS estimates show that compared to normal-weight children overweight children have 6% higher medication costs and obese children have 14% higher costs (statistically significant at a 10% level). This corresponds to DKK 188 per overweight child receiving this medication in the year they turn 18, and DKK 433 per obese child receiving psychotropic medication in the year they turn 18[11]. The FE results are based on an even smaller sample and an OLS regression on this sample does not compare well with the OLS results found in the full sample. The FE estimates on overweight and obesity are smaller than OLS results and insignificant. For overweight children and girls, the sign is reversed (and the results are insignificant). Thus, the results on cost of psychotropic medication are small, and as they become insignificant in the FE model, may also be interpreted as a zero.

[11] See details on calculations in Appendix Report 1.1. Here based on OLS estimate on intensive margin times mean costs in DKK for normal weight children, see Table 4.6. For overweight: 0.059 * DKK 3,181 = DKK 188.

Table 4.7 Psychotropic medication costs at age 18

FE	All		Girls		Boys	
	OLS	FE	OLS	FE	OLS	FE
Underweight	0.01 (0.04)	-0.09 (0.23)	-0.02 (0.06)	0.52 (0.35)	0.04 (0.06)	-0.12 (0.46)
Overweight	0.06* (0.04)	-0.04 (0.17)	0.16*** (0.05)	-0.03 (0.36)	-0.07 (0.05)	0.30 (0.33)
Obese	0.14** (0.06)	0.08 (0.31)	0.13 (0.09)	0.53 (1.11)	0.16* (0.08)	0.07 (0.39)
N	18,062	1,106	9,619	298	8,443	323
Adj. R-squared	0.075	0.383	0.029	0.455	0.069	0.409

Notes: The table shows covariate-adjusted estimation coefficients and standard errors (in parentheses) from OLS and sibling FE regressions of an indicator for costs of psychotropic medication for the child at age 18 on weight classification. In the full sample, the outcome mean for normal-weight children is DKK 3,181. Covariates are measured at age 7 or earlier (see Appendix Report, Table 1.2 for a full description of the included variables). We apply robust standard errors in the OLS estimations and family-clustered standard errors in the sibling FE estimations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. R-squared adjusted for number of predictors.

Source: VIVE.

4.4 Health care usage

This chapter covers the analyses on public paid primary and secondary health care usage for children in lower secondary school. As described in Section 2.1, overweight and obesity is linked to negative health consequences for both adults and children. However, as most health complications show up in adulthood we expect little impact on health care usage among children. In this analysis, we study the short-term health care usage consequences at age 18 and calculate the aggregated cost.

4.4.1 Summary

Being overweight or obese in lower secondary school has an impact on the health care costs related to primary and secondary health care usage at age 18. However, the additional health care costs of being overweight and obese compared to being of normal weight are relatively small and only significant for secondary health care (hospital costs). While overweight and obese children have almost the same probability of being hospitalized (compared to normal-weight children), we find that obese children have higher hospital costs than overweight children when hospitalized. Based on the OLS estimates, the higher hospital cost corresponds to DKK 241 per overweight child and DKK 370 per obese child at age 18. This aggregates to DKK 2.1 million and DKK 0.8

million higher annual hospital costs in an average school cohort[12] for overweight and obese children, respectively, relative to normal-weight children. In the Danish health care setting, these costs are very low. Furthermore, the hospital costs are not significant when we control for family-fixed effects.

4.4.2 Results

Table 4.8 shows the means of the health outcomes at age 18 by weight classes. For children who are of normal weight in lower secondary school, 85% have visited a general practitioner (GP). Overweight children have a similar share of visits to a GP, while both underweight and obese children are significantly less likely to visit a GP, suggesting an inverse u-shape in the utilization of health care in the primary sector. Twenty percent of normal-weight children have any hospital contact. Both overweight and obese children have significantly higher shares of hospital contact (1.6 pp and 2.9 pp higher, respectively). Underweight children are significantly less likely (1.9 pp) to have any hospital contact.

The costs associated with health care usage are presented in the lower part of Table 4.8. While overweight and obese children do have significantly higher costs than normal weight children, they are very small in a larger economic context. Normal-weight children have health care costs in the primary sector of DKK 1,303, on average, at age 18 if they have any contact with the primary sector. Though underweight and overweight children have significantly higher costs compared to normal-weight children, these costs are still low. Normal-weight children have health care costs in the secondary sector DKK 11,708, on average, conditional on having any contact. Overweight children have DKK 850 higher costs on average per child with a hospital contact. Which is statistically significant at a 10% level. Children with obesity do not incur average costs that are statistically significantly different from normal weight children, while underweight children incur significantly higher costs than normal weight children.

Compared to normal-weight children, the average health costs related to primary and secondary sector at age 18 are DKK 403 higher per person for overweight children and DKK 586 higher per person for obese children. These are based on raw correlations without any control for socioeconomic characteristics. The analysis below, where we control for both observable and unobservable factors, will provide more credible estimates of the costs.

[12] An average school cohort is approximately 60,000. See Appendix Report 1.1 for an example of the cost calculation.

Table 4.8 Health care outcomes at the age of 18

	Underweight		Normal weight		Overweight		Obese	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Any GP visit (%)	83.81***	(36.83)	85.21	(35.50)	85.01	(35.70)	83.47***	(37.15)
Any hospital contact (%)	17.99***	(38.41)	19.92	(39.94)	21.49***	(41.07)	22.79***	(41.95)
N	29,360		249,116		49,242		12,707	
Primary sector costs (DKK), conditional on any costs	1,335**	(2,290)	1,303	(2,060)	1,349***	(2,214)	1,312	(2,126)
N	25,402		218,337		42,947		10,869	
Secondary sector costs (DKK), conditional on any costs	13,152**	(62,968)	11,708	(46,823)	12,558*	(51,784)	12,870	(47,798)
N	5,768		53,780		11,253		3,025	
Primary sector cost per person (DKK)[a]	1,119		1,110		1,147		1,095	
Secondary sector cost per person (DKK)[a]	2,366		2,332		2,699		2,933	
Average costs per person in primary and secondary sector (DKK)	3,485		3,443		3,846		4,082	
Difference from normal weight (DKK)	42		-		403		586	

Notes: Summary table of means and standard deviations on health outcomes by weight classification, in percentage and DKK. Means in costs only for persons who have any costs. Simple t-tests of means by weight class relative to baseline of normal weight. Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

[a]Per-person calculation of extensive margin times intensive margin.

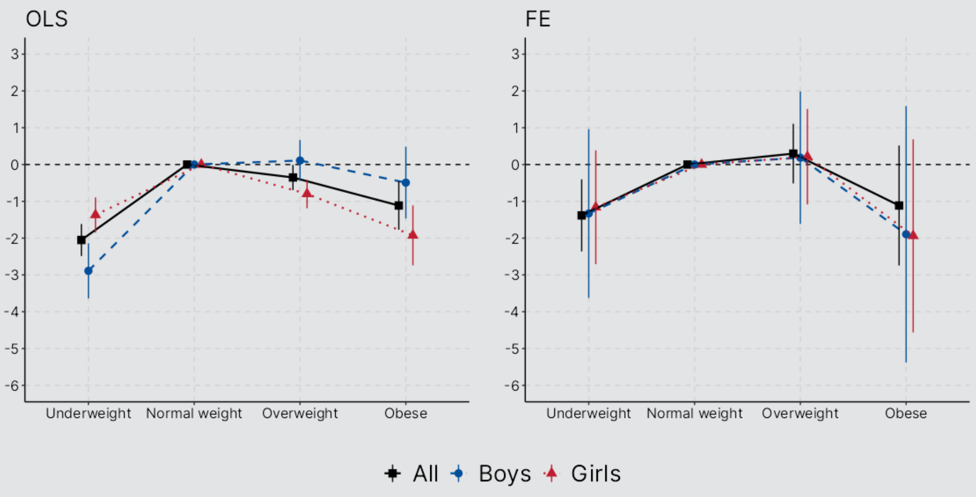
Source: VIVE.

Primary sector

Figure 4.11 shows the probability of visiting a GP at age 18 for the full sample and by gender using a linear probability model. The plot to the left shows the estimates from the OLS model specification and the plot to the right shows the estimates from the sibling FE model specification. The models show similar patterns and estimates, the only difference is the larger standard errors of the FE specification, which provides insignificant results.

According to the OLS estimates, children who are overweight or obese are 0.35 pp and 1.1 pp, respectively, less likely to visit a GP. Both results are statistically significant at a 5% level, which is modest in absolute terms, though, relative to a mean of 85% for the group of normal-weight children. The effect size is larger for underweight children compared to both overweight and obese children (2.1 pp). The results are driven by girls as there are no significant differences between boys being overweight/obese vis-à-vis of normal weight. Accounting for unobserved family-fixed characteristics using the sibling FE model, all estimates become insignificant, although the estimate is of a similar size for the full sample. When we estimate an OLS on the sibling sample, these results differ from the OLS results based on the full sample, suggesting that the sibling sample does not have the same health care utilization as the general population. The results do not differ by socioeconomic status (see Appendix Report, Table 1.25).

Figure 4.11 Visiting a general practitioner at age 18

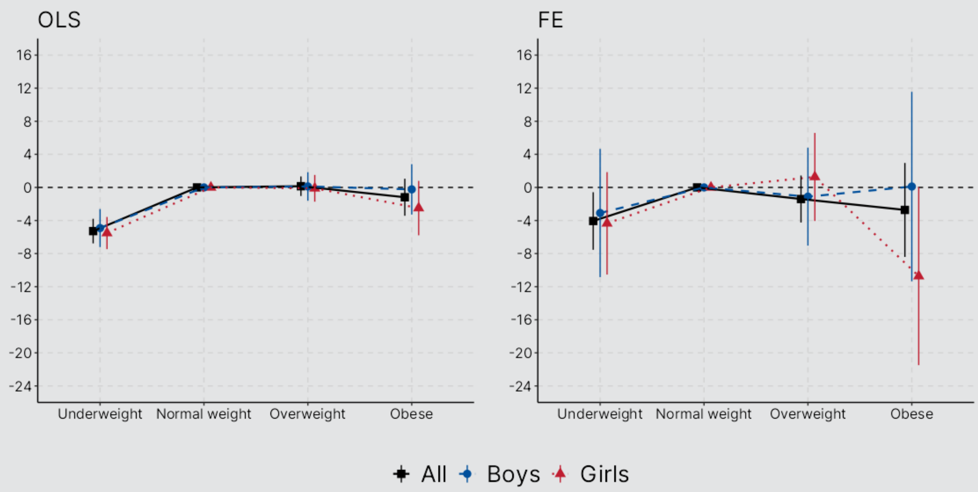


Notes: The figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has visited a general practitioner at age 18 or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 340,425, N(FE) = 140,830, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 85.2. The corresponding regression table is Appendix Report, Table 1.24.

Source: VIVE.

Figure 4.12 shows the analysis on primary sectors costs at age 18 for those with any cost. The results are similar to those in Figure 4.11, and the specifications follow the same pattern. Based on the OLS results, there are no statistically significant differences between normal-weight, overweight and obese children for the full sample or by gender on primary health care costs. Underweight children do generally have 5% lower costs, which is supported by the FE specification, though this corresponds to approximately DKK 84 lower costs per child relative to normal-weight children, which must be considered a minor difference.

Figure 4.12 Primary sector costs at age 18



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of primary sector costs of the child on weight classification. The dependent variable is log-transformed, and coefficients are scaled to 0-100. The graph shows differences in percentage for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 297,555, N(FE) = 108,869, when we apply the full sample. In the full sample, the outcome mean for normal weight children is DKK 1,303. The corresponding regression table is Appendix Report, Table 1.26.

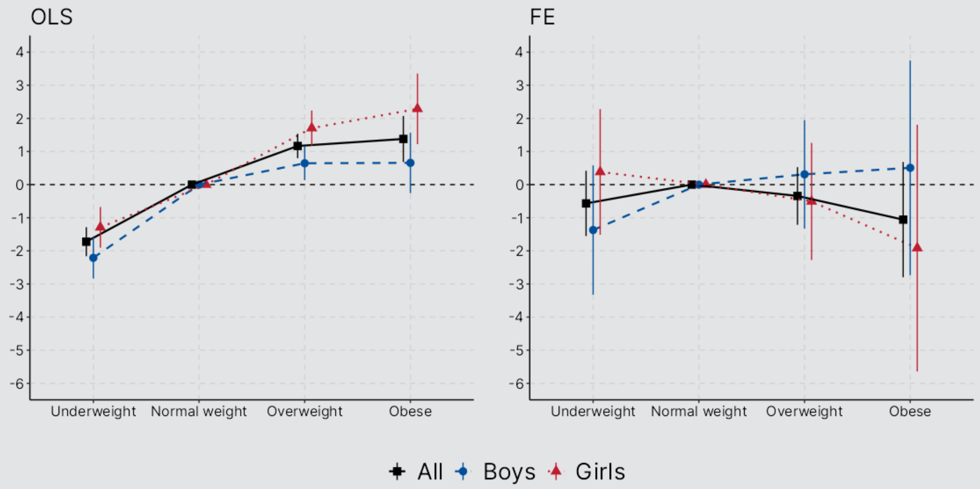
Source: VIVE.

Secondary sector

Figure 4.13 shows the results from the linear probability model of having a hospital contact at age 18. The estimates differ in the OLS and fixed-effects models. Compared to the OLS results, for the full sample and girls alone, the parameter estimates are reversed in the Sibling FE model. Based on the OLS specification, children who are overweight and obese are 1.2 pp and 1.4 pp, respectively, more likely to have a hospital contact – both parameter estimates are statistically significant at a 1% level. These effect sizes correspond to a 6-7% increase relative to normal-weight children and are, thus, similar for overweight and obese children. Again, the results are driven by girls. The estimate for boys does not change when applying the FE model, whereas for girls the sign on the estimate is reversed. However, as before, the FE specification produces large standard errors with no statistically significant results.

Investigating the associations by socioeconomic differences, we find that low SES and high SES follow a similar pattern, see Appendix Report, Table 1.29.

Figure 4.13 Having a hospital contact at age 18



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has had a hospital contact at age 18 or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 340,425, N(FE) = 140,830, when we apply the full sample. In the full sample, the outcome mean for normal weight children is 19.9. The corresponding regression table is Appendix Report, Table 1.28.

Source: VIVE.

Figure 4.14 shows the results from estimating a linear model of hospital costs for those with any hospital cost. The OLS results show that children who are overweight and obese have 4% and 8%, respectively, higher hospital costs than children who are of normal weight. Both estimates are statistically significant at a 1% level. This corresponds to DKK 241 and DKK 370 per overweight and obese child, respectively.[13] For all overweight and obese children in a regular cohort, this aggregates to DKK 2.1 million and DKK 0.8 million, respectively, per year of hospitalization costs.[14] This result highlights that the health care costs of overweight and obesity children are mainly related to hospital costs, which confirms the results previously found in the literature. The FE estimates on the full sample are similar for overweight children, but for underweight and obese children the estimates are tripled in size – and all FE esti-

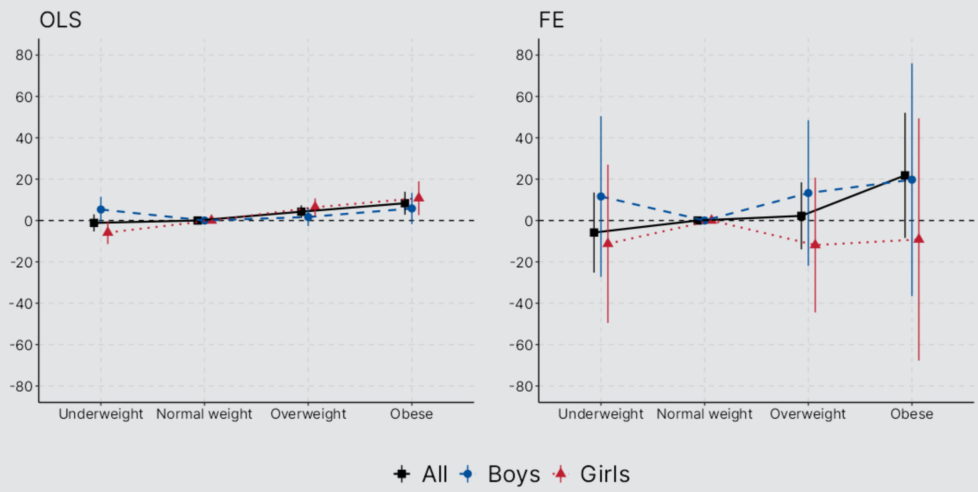
[13] See details in Appendix Report 1.1. Here based on OLS estimates for intensive margin and extensive margin, and means for normal weight in Table 4.8. For overweight children: (0.1992+0.0117)*(DKK 11,708*(1+0.042)) – 0.1992*DKK 11,708 = DKK 241.

[14] Back-of-the-envelope calculation using: cost estimate per child times share of overweight/obesity in cohort. A regular cohort is roughly 60,000. For overweight children, it is DKK 241 * 60,000 * 0.145 = DKK 2.1 million.

mates are insignificant, though the estimate on obesity on the full sample actually increases. When we conduct an OLS regression on the sibling sample, we also find no significant results, suggesting that power is not an issue.

The effects of overweight and obesity on hospital cost, estimated with the OLS model, are significant for girls but not for boys. We further identify a socioeconomic gradient in the results: overweight and obese children of high-SES families have higher costs than those from low SES-families (see Appendix Report, Table 1.31). None of these subgroup results are significant in the fixed-effects model.

Figure 4.14 Secondary sector costs at age 18



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of secondary sector costs of the child at age 18 on weight classification. The dependent variable is log-transformed, and coefficients are scaled to 0-100. The graph shows differences in percentage for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 75,826, N(FE) = 6,910, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is DKK 11,708. The corresponding regression table is Appendix Report, Table 1.30.

Source: VIVE.

4.5 Social income transfers

The cohorts included in our data are still young and may not yet have completed their final education and/or entered the labor market. In this chapter, therefore, we study the consequences of overweight and obesity on receiving social income transfers. The definition of social income transfers includes social assistance and unemployment benefits – for a detailed description, see Section 4.1.2.4. For the individual, it is relevant to study this outcome as it is an indicator of poor labor market success. It also tells us something about the young people's relation to the labor market at age 21 and is thus a predictor of their long-term labor market outcomes. For society, social income transfers are important in countries like Denmark, with a relatively generous welfare system, where the cost of being out of employment is paid by the taxpayers.

4.5.1 Summary

Based on the OLS model, we find that being overweight or obese in lower secondary school increases the probability of being a recipient of social income transfers at age 21, and more so for girls than boys. We find the same tendencies in the models using sibling fixed effects. However, due to large standard errors the results are not statistically significant for boys.

4.5.2 Results

Table 4.9 presents the raw differences in social income transfers between the children with the various weight classifications. On average, about 10% of normal-weight children received some kind of social income transfer when they were 21. Sixteen percent of overweight children received some kind of social income transfers, among obese children this share is 23%, i.e., for the latter more than twice as many as among normal-weight children. Among those who received social income transfers, normal-weight children received DKK 45,813, on average, whereas overweight and obese children received an average of DKK 49,672 and DKK 53,640, respectively.

Table 4.9 Social income transfers at age 21

	Underweight		Normal weight		Overweight		Obese	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Any social income transfers (%)	10.94***	(31.22)	10.19	(30.25)	15.86***	(36.53)	23.12***	(42.16)
N	19,071		164,409		32,207		8,548	
Social income transfers (DKK)	47,312	(40,853)	45,813	(42,441)	49,673***	(43,634)	53,640***	(44,221)
N	2,087		16,749		5,109		1,976	
Social income transfers per person (DKK)	5,176		4,668		7,878		12,402	
Difference from normal weight (DKK)	508		-		3,210		7,733	

Notes: Summary table of means and standard deviations on social income transfers outcomes by weight classification, in percentage and DKK. Means in DKK only for persons who have any transfers. Results for subsample of cohorts 1995-2000 only. Simple t-tests of means by weight class relative to baseline of normal weight. Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

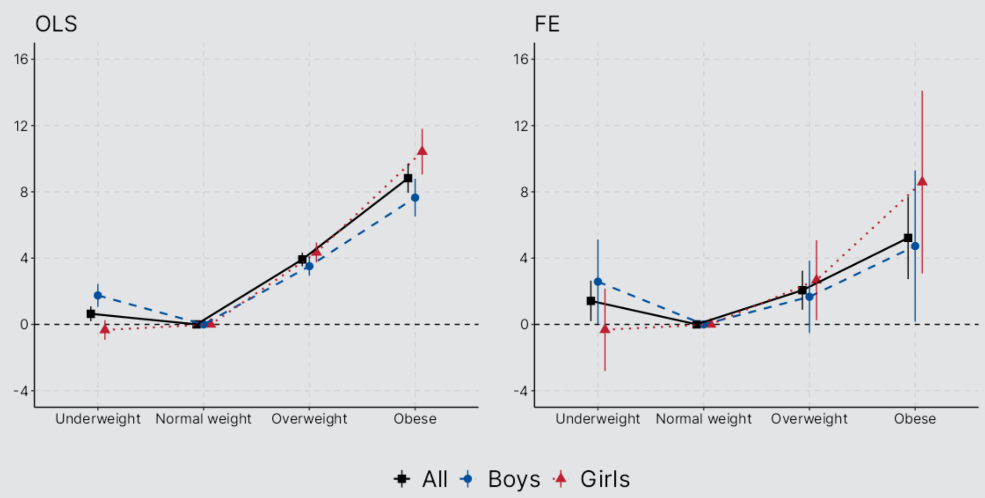
Source: VIVE.

As discussed in Chapter 3, there might be both observed and unobserved factors affecting body weight and outcomes, such as dependency on social income transfers. Therefore, we have estimated linear regression models taking both observable (OLS) and unobservable fixed-family characteristics (sibling FE) into account.

Figure 4.15, Figure to the left, shows the results from a linear probability model (OLS regression) where we include control variable listed in section 3.3.2. For both overweight and obese children, the probability of receiving a social income transfer at age 21 is significantly higher than for normal weight children. For all children, the probability of receiving a social income transfer is 3.9 pp higher when they are overweight compared to normal weight. For girls, this estimate is 4.3 and for boys this estimate is 3.5. These estimates are higher for obese children where the probability of receiving a social income transfer at age 21 is 8.8 pp higher compared to normal weight children. The OLS estimate suggests a 10.4pp higher likelihood for girls and 7.6pp higher likelihood for boys. Consequently, being obese seems to have a higher impact on girls w.r.t receiving social income transfers.

The rightmost figure in Figure 4.15 presents the results from a model using siblings fixed effects. When we account for unobserved fixed-family characteristics, the size of the estimates is attenuated and the standard error increased. Compared to normal-weight children, the fixed-effects model estimates the probability of receiving social income transfers at age 21 to be 2.1 pp (21%) higher for overweight children and 5.3 pp (54%) higher for obese children. Among girls, the estimates on overweight and obese children remains positive (large) and significant. Among boys, the estimates are still positive but become insignificant.

Figure 4.15 Receiving social income transfers at age 21

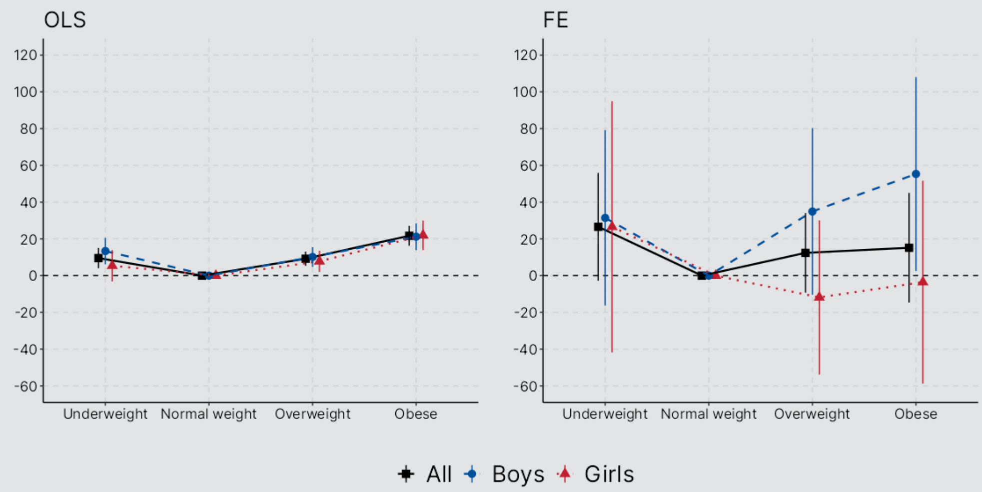


Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of the probability of receiving social income transfers for the child at age 21 on weight classification. The graph shows differences in percentage points for each weight class relative to normal weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 340,425, N(FE) = 140,830, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 6.7. The corresponding regression table is Appendix Report, Table 1.32.

Source: VIVE.

In Figure 4.16, we present the results of a log-linear model of the average annual amount of social income transfers among those who receive these transfers. The figure to the left presents the results from the OLS model. For all children, and for girls and boys separately, being overweight or obese significantly increases the average amount of social income transfers received. Compared to normal-weight children, the estimates are higher for obese children (22%) than for overweight children (9%). With a mean of DKK 45,813, the higher amount of social income transfers among overweight and obese children, when using the OLS model, corresponds to an annual increase of DKK 2,390 and DKK 5,931 for overweight and obese children, respectively. This amounts to DKK 21 million and DKK 14 million in additional costs due to overweight or obesity[15]. These differences are statistically significant at a 1% level[16]. In the sibling FE model (the figure on the right) the effects remain positive but become insignificant for all children and for girls. The FE estimates are high (55%) and significant for obese boys.

Figure 4.16 Social income transfers at age 21



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of log-transformed social income transfers for the child on weight classification. The dependent variable is log-transformed, and coefficients are scaled to 0-100. The graph shows differences in percentage for each weight class relative to normal weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 25,921, N(FE) = 1,912, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is DKK 10.2. The corresponding regression table is Appendix Report, Table 1.34.

Source: VIVE.

The results from the OLS model on the probability of receiving social income transfers suggest that there is little difference in the impact of overweight and obesity on social income transfers by socioeconomic status (See Appendix Report, Table 1.33 and Table 1.35).

[15] See Appendix Report 1.1 for details on calculations of costs.

[16] As a sensitivity check, we also estimate a tobit model, which provides similar results (available from the authors upon request).

5 Consequences of overweight and obesity in elementary school

This chapter presents the analyses of the consequences of overweight and obesity among children in elementary school. The chapter first provides a description of the utilized sample, and then presents the analyses on each of the outcomes. As above, each outcome group will be presented in a separate section.

5.1 Sample

We identify 405,063 children enrolled in grade 0 or 1 in the school years from 2011/12 through 2015/16. Out of these, 80% have valid information on weight and height, and most of the missing data is likely due to the fact that the children were weighed and measured before it became obligatory for the municipality to report it to the Danish Health Data Authorities.[17] When excluding children who were very old or very young for class (i.e., children born in the cohorts 2002, 2003, and 2011) as well as only including children observable in the population registry with non-missing registry information on the mother, the sample is restricted to 392,986 individuals, of whom 81% have a measure of BMI. Box 5.1 gives an overview of the sample representativeness. For a detailed description, see Appendix Report, Table 1.36).

[17] If we restrict the sample to pupils enrolled in grade 0 or 1 from the school year 2012/13 to 2015/16, we have valid BMI measures for 97% of the children.

Box 5.1 Sample representativeness

In the elementary school sample, 20% do not have a measure on BMI. This is primarily due to children enrolled in first grade in our first year of sampling – the school year 2011/12 – who will already have had their weight and height measured in grade 0, the year before the National Child Health Register was initiated by the Danish Health Data Authorities. From the school years 2012/13-2015/16, between 89% and 93% of children in our sample have a BMI measure.

Through the Danish registries, we can follow all children enrolled in elementary schooling in our sampling period, though they might not have a weight and height measurement. We therefore regress our set of conditioning variables on an indicator equal to 1 if the child has a BMI measure. A statistically significant correlation between the indicator and a conditioning variable suggests selectivity with respect to the given trait. The regression estimates are shown in Appendix Report, Table 1.36. Results show that there is a slight positive selection into the sample, where children with BMI measures are less likely to have a diagnosis of a mental or behavioral disorder by age 5. In general, the children with a BMI measure appear to be of better health. Their mothers are more likely to be single, but are also more likely to have a higher education and earn more, though the size of the estimates is small. The same associations hold for fathers. We find no selection on mothers' mental health, but fathers are less likely to have a diagnosis of a mental or behavioral disorder.

As above, we expect that this positive selection, if anything, causes us to underestimate the consequences of overweight and obesity.

5.1.1 Weight classification

As above, we keep the first BMI measure measured in elementary school for each child in our sample. Table 5.1 shows the distribution of weight classification for the elementary school sample. Approximately 12% of the children are overweight in grade 0 and 1. The weight distribution among girls is slightly more dispersed as they are more likely than boys to be underweight, overweight, and obese.

Table 5.1 Weight classification

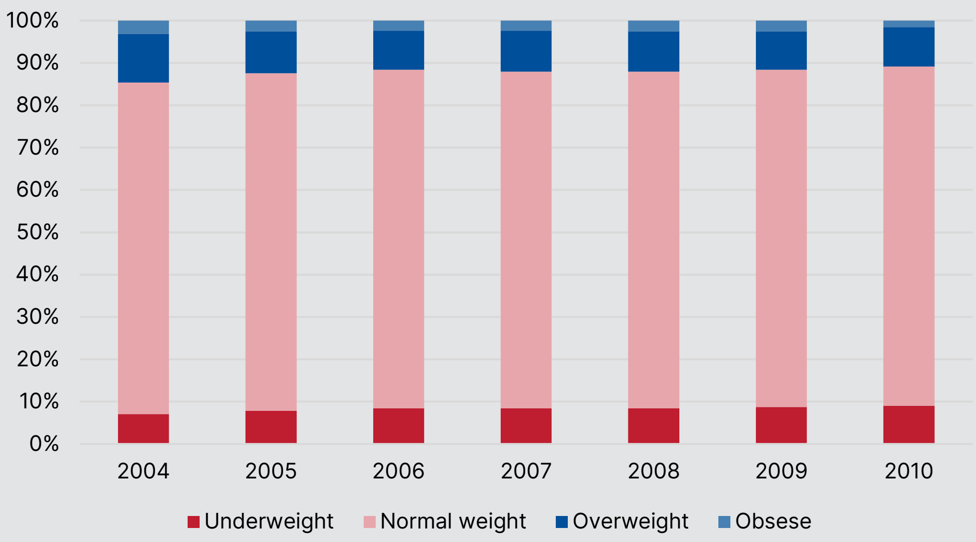
	All	Girls	Boys
Underweight	8.3%	8.7%	7.9%
Normal weight	79.5%	77.3%	81.7%
Overweight	9.7%	11.2%	8.3%
Obese	2.5%	3.0%	2.1%
Total	100%	100%	100%
Average BMI	15.911	15.891	15.930
Observations	317,246	154,913	162,333

Notes: Share in each weight classification for all children and by gender. Underweight = 1(BMI< IOTF 18,5), Normal weight=1(18,5≤BMI≤25), Overweight=1(20<BMI≤30), Obese=1(BMI>30).

Source: VIVE.

The weight distribution is quite stable across cohorts (Figure 5.1). It does appear that children born in 2004 are more overweight, but this could simply be due to the fact that there is a slight overrepresentation of children who are late for class in the 2004 cohort – our sampling period starts in the school year 2011/12 and children normally enter school the year they turn 6 according to Danish legislation.

Figure 5.1 Weight classification by birth cohort



Notes: Relative shares in each weight classification by birth year (cohort). Comparison of weight classes by cohorts 2004-2010.

Source: VIVE.

5.1.2 Outcomes

For the sample of elementary school children, we consider outcomes pertaining to their educational performance, well-being, and health care usage.

Educational performance

The outcomes on educational performance rely on information from the national tests in second and 3rd grade. Since 2010, it has been mandatory for children enrolled in public schools to participate in the national tests, with a few exceptions. In second grade, the children take a test in reading, while in 3rd grade they take a math test. The national tests are adaptive and scored on a theta-scale ranging from -7 to 7. Each test comprises three different profile areas that are scored individually (for more information regarding the national tests, see Beuchert and Nandrup (2017)).

Attended the national test in reading in grade 2

We construct an indicator variable equal to 1, if the child took the national test in reading in second grade, and 0 otherwise.

Reading test score in grade 2

We calculate the average theta score of the three profile areas in the reading test in second grade and standardize it within cohort.

Attended the national test in math in grade 3

We construct an indicator variable equal to 1, if the child took the national test in math in 3rd grade and 0 otherwise.

Math test score in grade 3

We calculate the average theta score of the three profile areas in the math test in 3rd grade and standardize it within cohort.

Well-being

Since the school year 2014/15, children enrolled in Danish public school have participated in the national well-being survey (NWS).[18] The NWS was developed by an expert group, who identified six key areas of interest – general wellbeing, competencies, supportive surroundings, psychosocial educational environment, peace and order, and the physical educational environment. Forty questionnaire items were defined for children in 4th to 9th grade. In 2015,

[18] It has been mandatory for students to answer the questionnaire, since the school year 2018/19.

Andersen et al. (2015) conducted an evaluation of the NWS. They found that the items in the questionnaire did not group in their respective key areas. They conducted an additional analysis validating the single items against previously validated scales. To maintain both external and high face validity, we construct four outcomes based on items that are highly correlated with validated scales measuring children's self-efficacy, academic confidence, experience of bullying, and of being lonely in Andersen et al. (2015).

Moderate self-efficacy

Self-efficacy is the child's belief in its ability to set a goal and follow it through (Bandura et al., 1999). We follow Rayce and Andreasen (2023) and construct an indicator variable equal to 1 if a child answers "Very often" or "Often" to either of the items, "How often can you find a solution to problems if only you try hard enough?" and "How often can you achieve your goals?". As shown in Andersen et al. (2015), both questions show high correlations with the International Personality Item Pool's (IPIP) (Goldberg et al., 2006) instrument on self-efficacy, as well as Bandura's Self-efficacy Scale (CSES) (Bandura, 2006).

Academic confidence

Academic confidence refers to a person's belief in their own academic abilities. We define a child as being confident if it responds, "Highly agree" or "Agree" to the item, "I do well in school academically." In Andersen et al. (2015), this item is the item with the highest correlation with the IPIP instrument on "Achievement Striving" as well as reading scores in the Danish National Tests.

Loneliness

We define a child as being lonely if it responds, "Very often" or "Often" to the question, "Do you feel lonely?" This is equivalent to (Rayce & Andreasen, 2023) and it is also the item showing the highest correlations with the validation instrument Middle Years Development Instrument (MDI) (Schonert-Reichl et al., 2013) in (Andersen et al., 2015).

Bullying

We identify a child as being bullied if it answers, "Very often" or "Often" to the item, "Have you been bullied this school year?". According to Andersen et al., (2015) the question has high face validity. Compared to national Danish population surveys, the prevalence rate according to our definition of bullying is of a similar magnitude (e.g. Ottosen et al., 2022).

Health care usage

Use of primary sector health care

We construct an indicator equal to 1 if a child has had any health care usage in the primary sector, defined as visits to a general practitioner at age 10 (extensive margin). We calculate health care costs as the total costs from the Danish Health Insurance for children who incur any costs at age 10 (intensive margin). The health care costs cover all health services to which the Danish Health Insurance applies, e.g., general practitioner, physio, psychological services etc. This information comes from the National Health Insurance Service Register.

Use of secondary sector health care

Here we also construct an indicator equal to 1 if a child had any interaction with the secondary sector, defined as having any hospital contact at age 10 (extensive margin). We calculate hospital costs incurred by the children who have had any hospital contact at age 10 (intensive margin). The hospital costs consist of costs from the DRG system related to somatic treatments on inpatient, outpatient, and ER patient care. Thus, psychiatric hospital treatment is not included in analysis. The information comes from the National Patient Register.

5.1.3 Descriptive statistics

As mentioned above, 317,251 children have a valid BMI measure. Of these we delete five observations with a measurement age above ten as we will not be able to provide descriptive statistics for this group due to data security rules imposed by Statistics Denmark. The final sample consists of 317,246 children in grades 0 or 1 in the school years from 2011/12 through 2015/16.

Table 5.2 shows descriptive statistics for a selected set of conditioning variables. As mentioned above, all conditioning variables are measured the year the child turns 5, or earlier if indicated. In general, we observe a social gradient in children with overweight or obesity. They are more likely to be immigrants, more likely to have a psychiatric diagnosis at the age of 5, and have more contacts with the hospital. Their mothers are more likely to be younger, although the difference is relatively small. The mothers are much more likely to be single, they are more likely to be unemployed, and they earn significantly less when the child is obese compared to of normal weight (16% less when the child is obese). We also see that mothers are 17% (33%) more likely to have a diagnosis of a mental or behavioral disorder, if the child is overweight (obese). While the table presents descriptive statistics for the mothers only, similar estimates can be seen for the fathers in Appendix Report, Table 1.37.

There appears to be no selection between children with overweight or obesity and normal-weight children in the likelihood of attending public school in second grade. This is important as the Danish National tests only compulsory are in Danish public schools and not in private schools.

Table 5.2 Descriptive statistics on children in elementary school

	Underweight		Normal weight		Overweight		Obese	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Female (0/1)	0.51***	(0.50)	0.47	(0.50)	0.56***	(0.50)	0.57***	(0.49)
Immigrant (0/1)	0.03***	(0.16)	0.02	(0.15)	0.03***	(0.17)	0.04***	(0.21)
Descendant (0/1)	0.07***	(0.26)	0.07	(0.25)	0.12***	(0.32)	0.19***	(0.39)
Has father (0/1)	0.99*	(0.12)	0.99	(0.11)	0.98***	(0.13)	0.98***	(0.15)
First child (0/1)	0.47***	(0.50)	0.45	(0.50)	0.43***	(0.50)	0.40***	(0.49)
Birth weight in grams	3,232***	(628)	3,496	(578)	3,617***	(583)	3,629***	(597)
Birth length in cm	51.03***	(3.19)	51.80	(2.69)	52.05***	(2.59)	52.02***	(2.63)
Treated with a psychiatric diagnosis before age 5 (0/1)	0.02***	(0.15)	0.01	(0.12)	0.02***	(0.13)	0.02***	(0.15)
Total number of hospital contacts before age 5	5.35***	(5.52)	4.97	(4.58)	5.18***	(4.99)	5.45***	(4.97)
in public school in 2nd grade (0/1)	0.83***	(0.38)	0.84	(0.37)	0.83	(0.37)	0.83	(0.37)
Age at BMI measurement	6.75***	(0.79)	6.76	(0.79)	6.82***	(0.81)	6.82***	(0.80)
Mother characteristics								
Age at birth	29.82***	(4.80)	29.61	(4.87)	29.32***	(5.22)	29.24***	(5.57)
Treated with a psychiatric diagnosis, age 0-5	0.12*	(0.32)	0.12	(0.33)	0.14***	(0.35)	0.16***	(0.37)

	Underweight		Normal weight		Overweight		Obese	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cohabiting with partner (0/1)	0.80***	(0.40)	0.78	(0.41)	0.73***	(0.44)	0.67***	(0.47)
Education level above high school (0/1)	0.79***	(0.41)	0.78	(0.41)	0.71***	(0.46)	0.59***	(0.49)
Total income in 10,000s (DKK)	25.06	(10.99)	25.14	(22.76)	23.22***	(10.31)	21.21***	(16.60)
Unemployed at age 5 (0/1)	0.04	(0.21)	0.04	(0.20)	0.06***	(0.23)	0.08***	(0.27)
Not in labor force at age 5 (0/1)	0.17	(0.38)	0.17	(0.37)	0.22***	(0.42)	0.31***	(0.46)
Weeks of unemployment benefits per year, age 0-5	2.28***	(8.22)	2.53	(8.66)	3.97***	(10.78)	6.33***	(13.38)
N	26,181		252,335		30,737		7,993	

Notes: Selected relevant characteristics of the sample split by weight classification. Test of differences in means by t-test with reference to normal weight. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: VIVE.

5.1.4 Sibling sample

As described in Section 3.2, we estimate a sibling FE model, which requires variation in weight classification within sibling pairs.

Table 5.3 shows that we have variation in weight categories within sibling pairs with, i.e., 8,074 sibling pairs where one sibling is overweight while the other is of normal weight. Similarly, we have 1,386 sibling pairs where one is obese and the other is of normal weight. This is of course a smaller identifying sample, which will likely affect the power of the results pertaining to obesity in the sibling FE models. Appendix Report, Table 1.38 provides descriptive statistics for the sibling sample and allows for a comparison with the full sample.

Table 5.3 Weight classifications within sibling pairs

Sibling 2 \ Sibling 1	Underweight	Normal weight	Overweight	Obese	Total
Underweight	1,457	3,879	130	23	5,489
Normal weight	3,904	43,371	4,022	679	51,976
Overweight	143	4,052	1,121	356	5,672
Obese	21	707	335	225	1,288
Total	5,525	52,009	5,608	1,283	64,425

Notes: Each cell indicates the number of sibling pairs with that particular weight distribution. For example, column three in row indicates that 4,022 sibling pairs exist where sibling 1 overweight and sibling 2 is normal weight. Thus, we have 8,074 sibling pars where one sibling is overweight and the other is normal weight.

Source: VIVE.

5.2 Educational consequences

This section presents the analyses of the consequences of overweight and obesity in elementary school on early test scores in the Danish National tests in second grade reading and 3rd grade math.

5.2.1 Summary

For the full sample of children, those who are overweight or obese are as likely as normal-weight children to attend the reading test in second grade and the math test in 3rd grade. However, in the analyses by gender we find significant effects only of being obese (not overweight) among boys.

For all children, overweight and obesity reduces performance in reading in 2nd grade and math in 3rd grade. The effect size is much larger for children with obesity than for children who are overweight compared to normal-weight children. Children who are overweight or obese are also more likely to be absent from school, and the estimate is largest for obese children. However, when we account for family-fixed effects in the models on performance and absence the parameter estimates are reduced and become (close to) insignificant, suggesting that unobserved fixed-family characteristics are central in explaining differences in performances and absence in early schooling.

5.2.2 Results

Table 5.4 shows the raw means of the educational outcome measures by weight classification. According to Table 5.4, children with overweight or obesity are significantly less likely to take the Danish National Test in reading in second grade and math in 3rd grade, and they perform significantly worse if they sit the test. In addition, as was also the case in the lower secondary school sample, overweight and obese children have a higher level of absence from school compared to normal-weight children. Here we measure absence in 4th grade.

Table 5.4 Test outcomes in grades 2-4

	Underweight		Normal weight		Overweight		Obese	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Attended National test in reading (grade 2) (%)	81.11***	(39.14)	82.04	(38.38)	81.38***	(38.93)	80.06***	(39.96)
Attended National test in math (grade 3) (%)	80.02***	(39.99)	81.06	(39.18)	80.52**	(39.61)	79.48***	(40.39)
N	26,181		252,335		30,737		7,993	
Test score in reading (grade 2) (standardized score)	0.05**	(0.98)	0.04	(0.98)	-0.11***	(1.01)	-0.32***	(1.05)
N	21,235		207,021		25,013		6,399	
Test score in math (grade 3) (standardized score)	0.04	(0.99)	0.05	(0.99)	-0.13***	(0.98)	-0.33***	(0.99)
N	20,950		204,545		24,748		6,353	
School absence (grade 4) (%)	5.18	(5.64)	5.12	(5.32)	5.73***	(5.84)	7.16***	(7.18)
N	21,119		204,357		25,023		6,574	

Notes: Summary table of means and standard deviations on education outcomes by weight classification, in percentage and standardized score. Simple t-tests of means by weight class relative to baseline of normal weight. Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

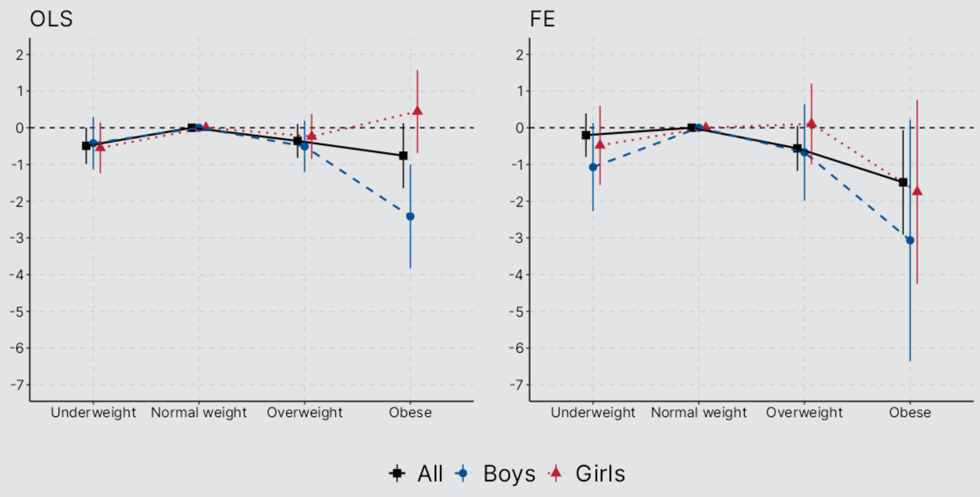
Source: VIVE.

Test performance

In contrast to the observed differences in raw means presented above, the OLS estimates in Figure 5.2 show that children experiencing overweight or obesity are not less likely to attend the reading test in second grade (significant at a 10% level). Hence, once we account for the conditioning variables including background characteristics it is less clear that overweight or obesity impacts the likelihood of attending the 2nd grade reading test. The same appears to be the case for the math test. However, these overall insignificant differences mask the fact that boys are significantly less likely to sit the tests if they are obese.

Accounting for fixed-family characteristics in the sibling FE model, the estimates becomes slightly larger, albeit insignificant due to larger standard errors when considering the reading test in second grade. Only overweight children are significantly less likely to attend the 3rd grade math test when applying the sibling FE model. However, the estimate on obesity is equivalent but with larger standard errors.

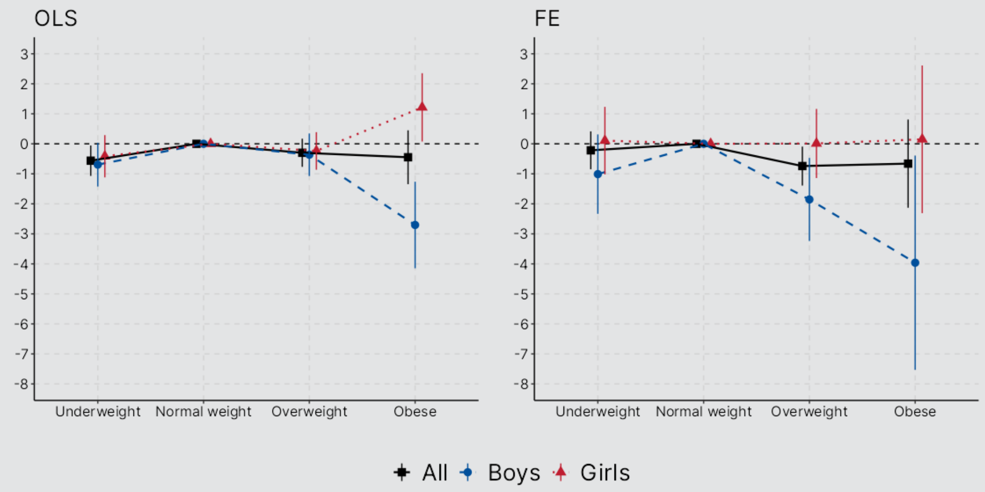
Figure 5.2 Attended National Test in 2nd grade reading



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child attended the National Test of reading in 2nd grade or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal weight-children for the full sample (black), boys (blue), and girls (red). N(OLS) =317,246, N(FE) = 125,240, when we apply the full sample. In the full sample, the outcome mean for normal weight children is 82.0. The corresponding regression table is Appendix Report, Table 1.39.

Source: VIVE.

Figure 5.3 Attended National Test in 3rd grade mathematics



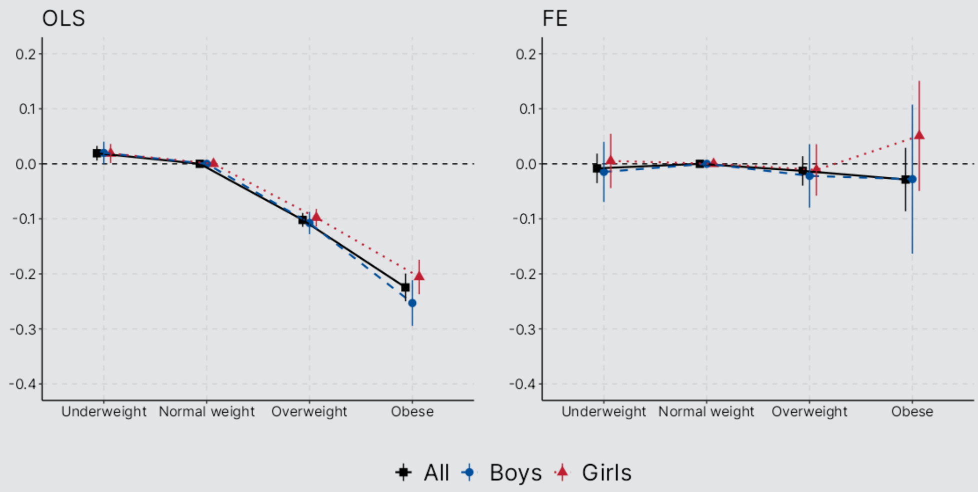
Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child attended the National Test on mathematics in 3rd grade or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 317,246, N(FE) = 125,240, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 81.1. The corresponding regression table is Appendix Report, Table 1.41.

Source: VIVE.

Children with overweight or obesity perform 6% and 20% of a standard deviation (SD), respectively, poorer in the reading test and 11% and 21% of a SD worse in the math test. We find no differences between boys and girls. However, accounting for family-fixed effects the estimated impacts on test scores are reduced and close to 0. This suggests that in the lower grades, family characteristics are much more central in explaining differences in performances. We find no significant differences in the results by SES. This suggests that in relation to early school performance SES background is not important for the consequences of overweight and obesity.

Relating these results to those presented in Chapter 4 for the children in lower secondary school, this suggests that in primary education differences in school performance across weight classifications are mostly driven by family components. As the child grows older, the differences in performance increase, likely because learning is a hierarchical process where future learning builds on knowledge attained earlier (Cunha & Heckman, 2007). This suggests that investment in child learning in middle school is crucial for children with overweight or obesity to mitigate the gap in performance observed in lower secondary school.

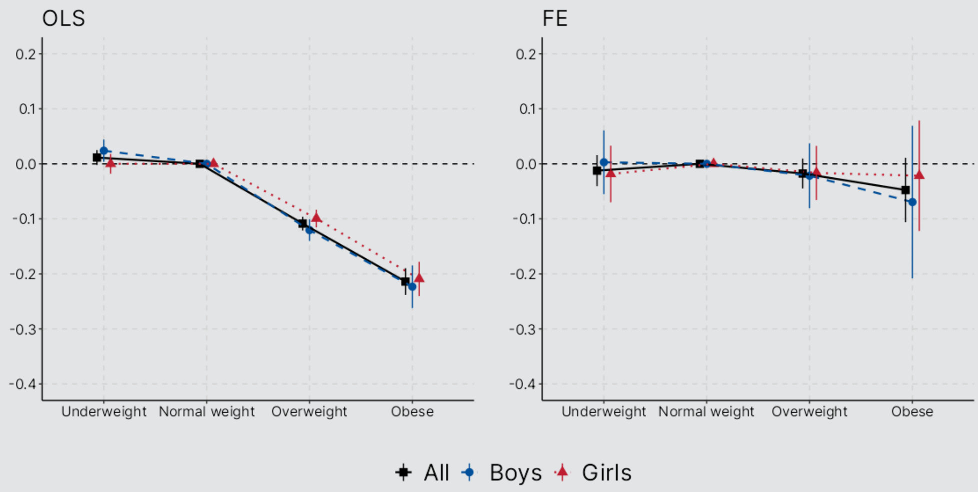
Figure 5.4 Standardized test score in 2nd grade reading



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of the standardized 2nd grade test scores in reading for the child on weight classification. The graph shows differences in percentage points for each weight class relative to normal weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 259,668, N(FE) = 99,608, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 0.04. The corresponding regression table is Appendix Report, Table 1.43.

Source: VIVE.

Figure 5.5 Standardized test score in 3rd grade math



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of the standardized 3rd grade test scores in mathematics for the child on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 256,596, N(FE) = 97,978, when we apply the full sample. In the full sample the outcome mean for normal weight children is 0.05. The corresponding regression table is Appendix Report, Table 1.45.

Source: VIVE.

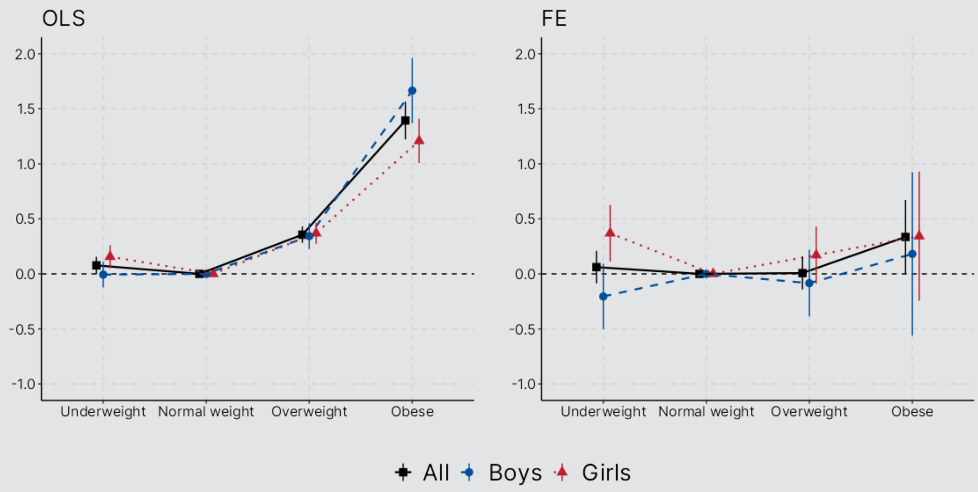
School absence

The OLS estimates in Figure 5.6 show that, on average, overweight children have 0.4 pp more school absence in 4th grade than normal-weight children. This is equivalent to about 1 day's more absence per year compared to an average of 10 absence days per year for normal-weight children. According to our estimates, children with obesity have 1.4 pp more absence in 4th grade than normal-weight children, which is equivalent to an average of 13 days of absence per year. According to the Figure, obese boys have significantly more absence than girls.

The estimates are attenuated once we condition on family-fixed characteristics. This suggests that absence behavior is highly related to family characteristics and not necessarily due to impacts from being overweight or obese. However, further investigating the type of absence we find that children with obesity are significantly more likely to have almost a day more of legal absence (4 days in total) compared to normal-weight children, and this estimate is consistent across specification.[19]

[19] This could be due to children with obesity being more likely to go to "julemærkehjem", which is considered legal absence. The estimates are not presented here but are available from the authors upon request.

Figure 5.6 4th grade school absence



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of total 4th grade school absence for the child on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 257,073, N(FE) = 97,957, when we apply the full sample. In the full sample, the outcome mean for normal weight children is 5.1. The corresponding regression table is Appendix Report, Table 1.47.

Source: VIVE.

Considering differences by SES, we do see a tendency of children from low SES families having more school absence in 4th grade. However, as before the differences are not statistically significantly different (see Appendix Report, Table 1.48).

5.3 Well-being

This section presents the results investigating the relationship between overweight and obesity on psychosocial well-being measures obtained from the National Well-being Survey in 4th grade. As mentioned above, we consider four outcome measures pertaining to social exclusion, academic self-confidence, and self-efficacy.

5.3.1 Summary

Children who are overweight or obese in grade 1 or grade 1 experience significantly more bullying in 4th grade. The likelihood of being bullied is 28% and

55% higher for overweight and obese children, respectively, compared to normal-weight children. The estimates are reduced when we account for family-fixed effects but remain significant.

Children who are overweight and obese also experience more loneliness compared to normal-weight children. When we account for family-fixed effects, the effect of overweight on loneliness disappears, while the effect of obesity remains the same and significant.

For both academic confidence and self-efficacy, the results from the OLS model suggest a negative association with overweight and obesity. However, when we apply family-fixed effects the signs of the estimates of being overweight or obese become positive (and the same size), and, for self-efficacy, statistically significant. The positive effect of overweight and obesity on self-efficacy in the fixed-effects model is mainly driven by children from high-SES families.

5.3.2 Results

Table 5.5 shows raw means and standard deviations for the selected well-being outcomes. Children with overweight and obesity generally report lower well-being. Children with obesity are almost twice as likely to report that they are being bullied. Similarly, children with overweight are significantly more likely to report that they are lonely. They also report lower academic confidence and a lower level of self-efficacy.

Table 5.5 Well-being outcomes

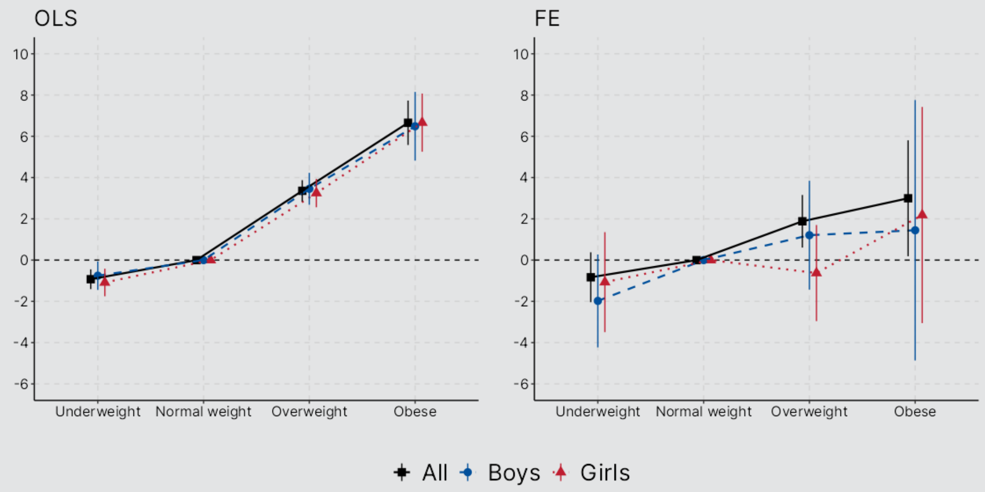
	Underweight		Normal weight		Overweight		Obese	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Bullying (%)	11.34***	(31.71)	12.20	(32.73)	16.53***	(37.14)	21.11***	(40.82)
N	18,794		182,406		22,003		5,669	
Loneliness (%)	5.82	(23.41)	5.94	(23.63)	8.04***	(27.19)	9.83***	(29.78)
N	19,158		186,023		22,530		5,796	
Academic confidence (%)	73.88***	(43.93)	72.91	(44.44)	70.31***	(45.69)	68.07***	(46.62)
N	18,647		181,579		21,946		5,644	
Self-efficacy (%)	79.48	(40.38)	79.94	(40.04)	76.99***	(42.09)	74.80***	(43.42)
N	18,430		180,063		21,692		5,551	

Notes: Summary table of means and standard deviations on well-being outcomes by weight classification, in percentages. Simple t-tests of means by weight class relative to baseline of normal-weight children. Standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

Source: VIVE.

Figure 5.7 shows that children who are overweight or obese in grade 0 or grade 1 experience significantly more bullying in 4th grade. Children with overweight are 3.4 pp more likely to be exposed to bullying than normal-weight children, while children with obesity are 6.7 pp more likely to experience bullying. As stated above, according to our definition of bullying, about 12% of normal-weight children experience bullying, meaning that the increase in prevalence corresponds to a 28% and 55% increase in the likelihood of being bullied. Interestingly, underweight children are significantly less likely to experience bullying, suggesting that body ideals are important determinants of bullying. However, the low adjusted R-squared also indicates that weight classifications generally explain very little of the individuals' probability of being bullied. The results do not vary by gender. The estimates are reduced, once we account for family-fixed effects in the analysis on the full population, but remain significant. The sibling FE for boys and girls become more imprecise as standard errors increase, but apart from the estimate on overweight girls they give rise to the same conclusion.

Figure 5.7 Bullying



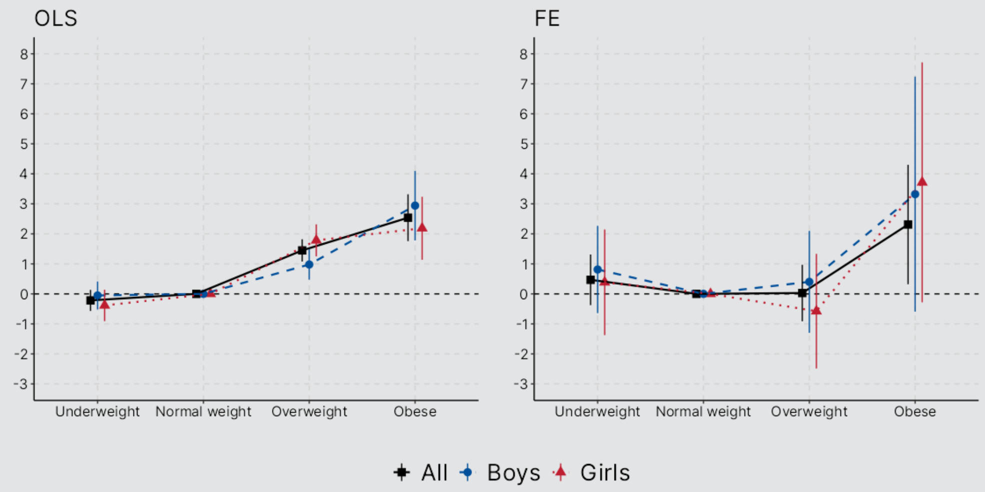
Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has experienced bullying or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 228,872, N(FE) = 79,551, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 12.2. The corresponding regression table is Appendix Report, Table 1.49.

Source: VIVE.

Children with overweight or obesity in elementary school are also more likely to report being lonely in 4th grade (Figure 5.8). The higher their weight category, the larger the association. The size of the estimates resembles those presented above for the outcome on bullying. The probability of experiencing loneliness increases by 24% for overweight children and 43% for children with obesity vis-à-vis normal-weight children.[20] The associations are largest for overweight girls compared to overweight boys, but are slightly larger for boys with obesity than for girls with obesity.

[20] A 1.45 pp (2.54 pp) increase in loneliness for overweight (obese) children relative to a mean of 5.95 percent of normal-weight children who feel lonely.

Figure 5.8 Loneliness

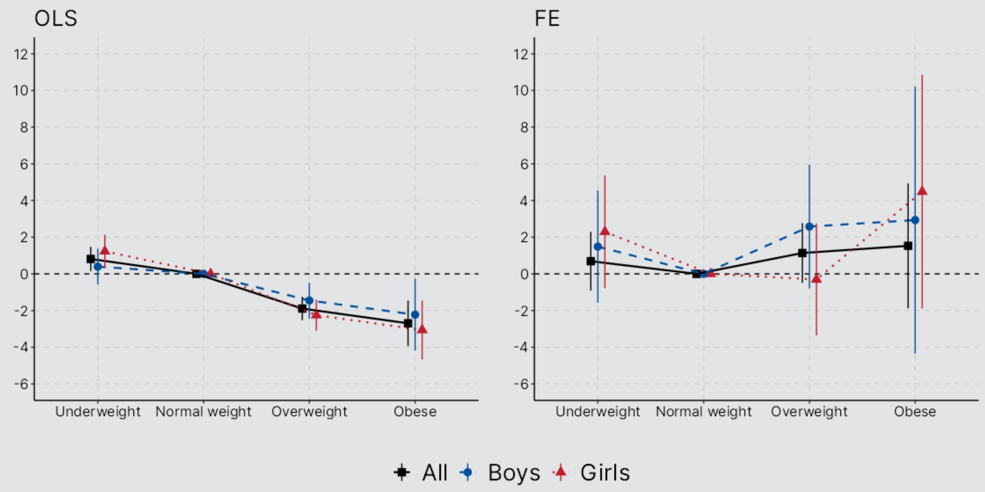


Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has experience loneliness or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) =233,507, N(FE) = 82,437, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 5.9. The corresponding regression table is Appendix Report, Table 1.51.

Source: VIVE.

Once we account for family-fixed characteristics, the association between overweight and loneliness disappears. However, it remains stable and significant for children experiencing obesity. Investigating the associations by gender, we finder no difference between boys and girls.

Figure 5.9 Academic confidence



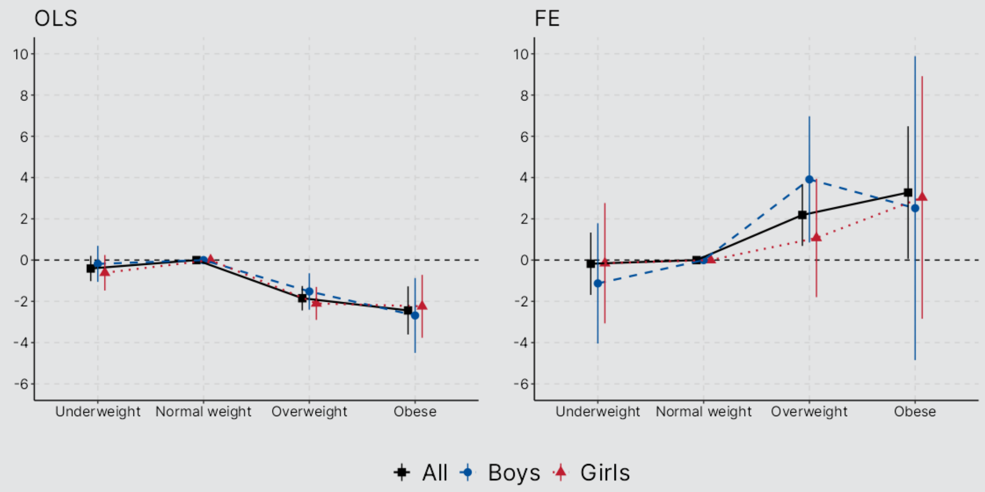
Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child is academically confident or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 227,816, N(FE) = 78,830, when we apply the full sample. In the full sample, the outcome mean for normal weight children is 72.9. The corresponding regression table is Appendix Report, Table 1.53.

Source: VIVE.

When we consider the OLS results on academic confidence (Figure 5.9) and self-efficacy (Figure 5.10), we also find negative associations with being overweight or obesity for both boys and girls. However, once we take family-fixed characteristics into account in the sibling FE models the signs of the estimates are reversed and become significantly positive. When we estimate an OLS regression on the sibling sample, the parameter estimate on obesity becomes small and insignificant. This suggests either that the consequences of overweight and obesity in terms of academic confidence and self-efficacy differ a lot between children with and with-out siblings, or that other things happens within the family, i.e., an increased focus on increasing academic well-being likely through increased adult support among these children (Herzer et al., 2011), or, that the sibling sample is a selected sample, which makes it difficult to compare the results to the OLS results. Results not shown here indicate that children with overweight and obesity experience more teacher support, which could suggest that they rely more on adult interaction, which may spill over into their academic well-being.[21]

[21] Results available from the authors upon request.

Figure 5.10 Self-efficacy



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has self-efficacy or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) =225,736, N(FE) = 77,780, when we apply the full sample. In the full sample, the outcome mean for normal weight children is 79.9. The corresponding regression table is Appendix Report, Table 1.55.

Source: VIVE.

Table 5.6 gives an overview of the OLS estimates on the different well-being outcomes by SES. The table does not provide an indication of a negative social gradient. If anything, the results on academic confidence appear to be driven by high SES children. This could be attributable to high-SES children being more likely to interact more with other high-SES children, making them perceive their performance as being poorer. Turning to the sibling FE by SES, the coefficients on bullying and loneliness are stable, though mostly insignificant (see Appendix Report, Table 1.50 and Table 1.52). With respect to the results on academic confidence and self-efficacy, the positive associations mentioned above appear to be largely driven by high-SES children. For example, the coefficients on overweight and obesity are negative and sizeable (albeit insignificant) among low-SES children, and positive and sizeable among high-SES children (see Appendix Report, Table 1.54 and Table 1.56).

Table 5.6 OLS Results: Weight classification and well-being by SES

	Bullied		Lonely		Academic confidence		Self-efficacy	
	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES
Under-weight	-1.83*** (0.60)	-0.68** (0.26)	-0.92** (0.44)	-0.02 (0.19)	0.86 (0.79)	0.78** (0.37)	0.18 (0.82)	-0.39 (0.43)
Overweight	2.17*** (0.53)	3.80*** (0.30)	1.42*** (0.39)	1.44*** (0.21)	-0.98 (0.64)	-2.17*** (0.38)	-1.59** (0.65)	-2.41*** (0.42)
Obese	5.24*** (0.90)	7.55*** (0.69)	2.15*** (0.66)	2.83*** (0.50)	-0.25 (1.02)	-4.25*** (0.81)	-2.60** (1.04)	-2.81*** (0.87)
N	52,030	176,842	53,259	180,248	51,377	176,439	50,756	174,980
Adj. r-squared	0.014	0.011	0.010	0.006	0.014	0.014	0.014	0.012
Mean of normal weight	16.82	10.93	8.15	5.33	66.80	74.58	36.89	45.85

Notes: The table shows covariate-adjusted estimation coefficients and standard errors (in parentheses) from OLS regressions of four binary outcomes, respectively, on weight classification: 1) being bullied, 2) being lonely, 3) having academic confidence, and 4) having moderate or higher self-efficacy. Covariates are measured at age 5 or earlier (see Appendix Report, Table 1.2 for a full description of included variables). We apply robust standard errors in the OLS estimations, and family-clustered standard errors in the sibling FE estimations. * p < 0.1, ** p < 0.05, *** p < 0.01. R-squared adjusted for number of predictors.

Source: VIVE.

5.4 Health care usage

This chapter covers the analyses on publicly paid health care usage in the primary and secondary sector for children at age 10. Thus, in the analyses we study the short-term health consequences on aggregate outcomes of children in elementary school.

5.4.1 Summary

Overall, being overweight or obese as a child in elementary school has consequences for the health care usage measured at age 10. These effects are mainly driven by girls. All of the short-term consequences for overweight and obese children have small effect sizes.

Both overweight and obese children are more likely to visit a general practitioner at the age of 10 relative to a normal-weight child. In terms of health care costs in the primary sector overweight (obese) children have 9% (18%) higher costs, which corresponds to DKK 91 (DKK 170) per child. Aggregated to a societal level, this corresponds to increases of DKK 0.8 million in primary health costs in a cohort for both overweight and obesity.

Though still small, the costs in the secondary sector are higher than those found in the primary sector. The hospital costs at age 10 are 7% (25%) higher for overweight (obese) children than for normal-weight children. This corresponds to on average of DKK 430 (DKK 1,350) per child. The increased societal hospital costs associated with overweight and obesity combined are DKK 4.5 million in a cohort. These costs are mainly driven by girls and by children from high socioeconomic backgrounds.

5.4.2 Results

Table 5.7 shows the raw means of the health outcomes at age 10 by weight classes. For children who are normal weight in elementary school, 72% have visited a general practitioner (GP) at age 10. Overweight and obese children are significantly more likely to visit a GP, while underweight children are significantly less likely to visit a GP. Among normal-weight children, 24% have any hospital contact at age 10. Both overweight and obese children have significantly higher shares of hospital contacts (3.8 pp and 8.6 pp higher, respectively). These differences are large in magnitude. Underweight children have a similar rate of hospital contact to normal-weight children.

The average health care costs for children with any costs are presented in the lower part of the table. On average, normal-weight children incur DKK 926 in health care costs in the primary sector. All other weight classes have significantly higher costs. Obese children incur increased costs of DKK 268, which corresponds to 29% higher costs in the primary sector than those for normal-weight children. In the secondary sector, normal-weight children have DKK 8,713 in health care costs, on average, while overweight and obese children do not incur statistically different costs from normal-weight children.

The average total health care costs at age 10 for children with overweight (obesity) in elementary school accumulates to DKK 444 (DKK 1,174) higher than normal-weight children. This corresponds to 16% and 42%, respectively, higher costs relative to normal-weight children.

Table 5.7 Health care outcomes at age 10

	Underweight		Normal weight		Overweight		Obese	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Any GP visit	70.27***	(45.71)	71.77	(45.01)	75.34***	(43.11)	77.67***	(41.65)
Any hospital contact	24.02	(42.72)	24.30	(42.89)	28.07***	(44.93)	32.87***	(46.98)
N	26,181		252,335		30,737		7,993	
Primary sector costs (DKK), conditional on any costs	979***	(2,083)	926	(1,801)	1,023***	(1,876)	1,194***	(2,546)
N	20,149		196,744		24,960		6,722	
Secondary-sector costs (DKK), conditional on any costs	9,141	(48,810)	8,713	(48,478)	8,746	(33,387)	9,214	(26,932)
N	6,288		61,307		8,627		2,627	
Primary-sector cost per person (DKK)[a]	688		665		771		928	
Secondary-sector cost per person (DKK)[a]	2,196		2,117		2,455		3,029	
Total average costs per person (DKK)	2,883		2,782		3,226		3,956	
Difference from normal weight	101		-		444		1,174	

Notes: Summary table of means and standard deviations on health outcomes by weight classification, in percentage and DKK. Means in costs only for persons who have any costs. Simple t-tests of means by weight class relative to baseline of normal-weight children. Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

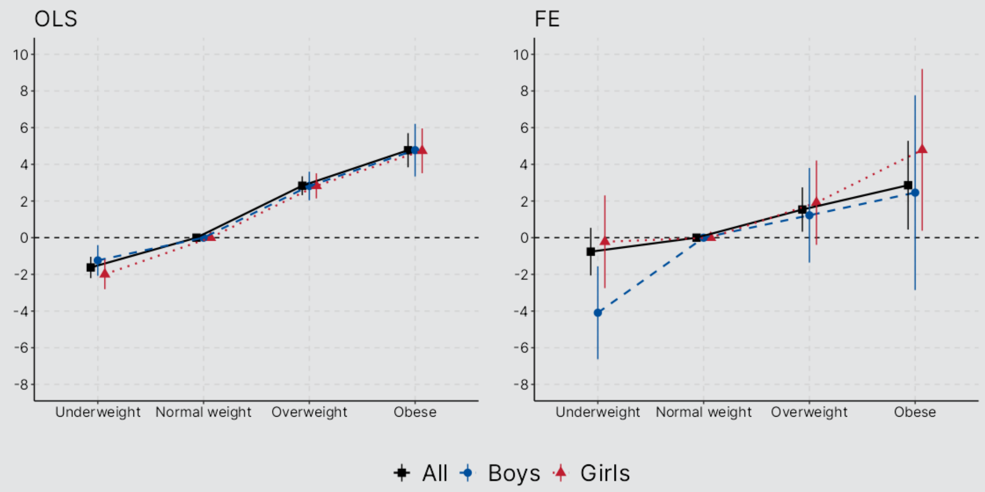
[a]Per-person calculation of extensive margin times intensive margin.

Source: VIVE.

Primary sector

Figure 5.11 shows the analysis on visiting a GP at age 10. OLS estimates show that underweight children are 1.6 pp less likely to visit a GP compared normal-weight children, and that overweight (obese) children are 2.8 pp (4.8 pp) more likely to visit a GP. This corresponds to effects sizes of -2.2%, 3.9%, and 6.7%, respectively. The results are similar for boys and girls across weight classes. The results of the sibling FE specification support the OLS results. The FE specification produces similar results on the full sample with estimates of 1.5 pp and 2.9 pp for overweight and obese children, respectively. Both are statistically significant. These results suggest a higher primary health care usage at age 10 of overweight and obese children.

Figure 5.11 Visiting a general practitioner at age 10



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has visited a general practitioner at age 10 or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 317,246, N(FE) = 125,240, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 71.8. The corresponding regression table is Appendix Report, Table 1.57.

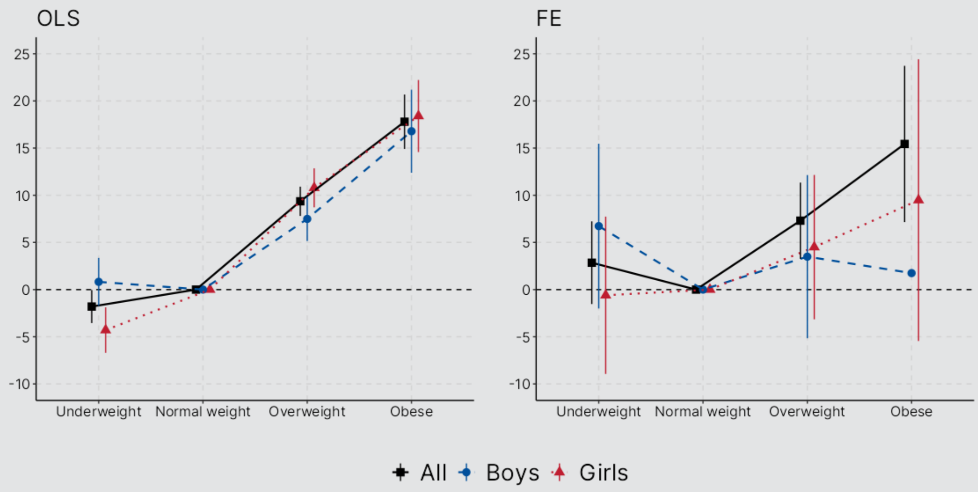
Source: VIVE.

The results of the analysis on primary health care costs are shown in Figure 5.12. The results follow a similar pattern those shown in Figure 5.11. OLS estimates show that overweight (obese) children incur 9% (18%) higher health care costs in the primary sector than normal-weight children. Both estimates are statistically significant at a 1% level. This corresponds to DKK 91 and DKK 170 per child, respectively[22]. Aggregated to the societal cost for a regular cohort, this is DKK 0.5 million for overweight and DKK 0.3 million for obesity[23]. This evidence is supported by the FE specification, which produces estimates of 7% and 15%, respectively. The OLS results show minor differences between boys and girls. Investigating socioeconomic differences in the consequences, we find no evidence of differences, see Appendix Report, Table 1.58).

[22] See details in Appendix 1 in the Appendix Report. Here based on OLS estimates for intensive margin and extensive margin, and means for normal weight in Table 5.7. For overweight: (0.7177+0.0283)*(DKK926*(1+0.094)) – 0.7177*DKK926 = DKK91.

[23] Calculation using cost estimate per child times share of overweight/obesity in cohort. A regular cohort is roughly 60,000. For overweight: DKK 91 * 60,000 * 0.097 = DKK 528,458.

Figure 5.12 Primary sector costs at age 10



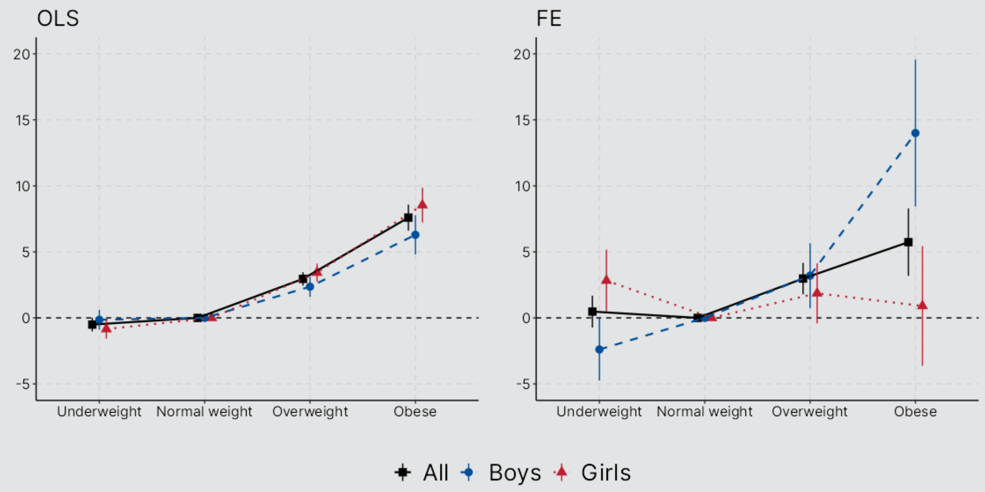
Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of primary sector costs of the child on weight classification. The dependent variable is log-transformed, and coefficients are scaled to 0-100. The graph shows differences in percentage for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 240,635, N(FE) = 75,258, when we apply the full sample. In the full sample, the outcome mean for normal weight children is DKK 926. The corresponding regression table is Appendix Report, Table 1.59.

Source: VIVE.

Secondary sector

Figure 5.13 shows the analysis on hospital contact at age 10. The OLS results show that overweight (obese) children are 3.0 pp (7.6 pp) more likely to have a hospital contact. These are large effect sizes of 12% and 31%, respectively. The OLS estimates show that girls, to some extent, drive the results. Sibling FE estimation on the full sample remains significant and produces estimates of 3.0 pp (5.7 pp) for overweight (obese) children.

Figure 5.13 Hospital contact at age 10



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of an indicator for whether the child has had a hospital contact at age 10 or not on weight classification. The graph shows differences in percentage points for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 317,246, N(FE) = 125,240, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is 24.3. The corresponding regression table is Appendix Report, Table 1.61.

Source: VIVE.

The results on differences in socioeconomic status are also mixed, see Table 5.8. The OLS results show that overweight and obese children from both low-SES and high-SES families experiences significant consequences. The FE results indicate that children of high-SES families to a certain extent drive the total effect.

Table 5.8 Hospital contact by SES.

	Low SES – education		High SES – education	
	OLS	FE	OLS	FE
Underweight	0.74 (0.59)	0.42 (1.46)	-0.84*** (0.30)	0.53 (0.69)
Overweight	2.97*** (0.49)	2.87** (1.23)	2.94*** (0.30)	2.97*** (0.72)
Obese	7.65*** (0.80)	4.08* (2.19)	7.52*** (0.65)	6.75*** (1.68)
N	72,899	24,719	244,347	97,343
Adjusted R-squared	0.094	0.154	0.098	0.146
Mean of normal weight	24.75	24.37	24.17	23.48

Notes: The table shows covariate-adjusted estimation coefficients and standard errors (in parentheses) from OLS and sibling FE regressions of an indicator for whether the child has had a hospital contact at age 10 or not on weight classification. Covariates are measured at age 5 or earlier (see Appendix Report, Table 1.2 for a full description of included variables). We apply robust standard errors in the OLS estimations, and family-clustered standard errors in the sibling FE estimations. * p < 0.1, ** p < 0.05, *** p < 0.01. R-squared adjusted for number of predictors in model.

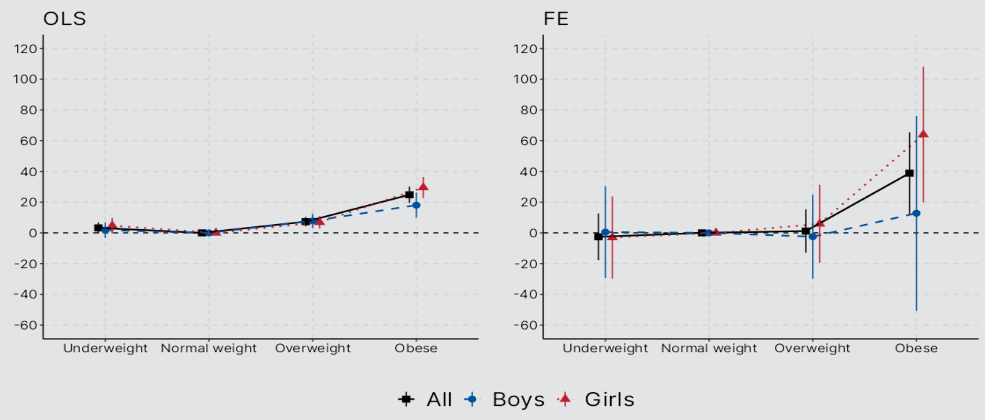
Source: VIVE.

Figure 5.14 shows the analysis on hospital costs at age 10 for those with hospital contact. The OLS results show that overweight (obese) children have 7% (25%) higher costs than normal-weight children, which corresponds to DKK 430 (DKK 1,350) per child[24]. Aggregating this to a regular cohort, the societal hospital costs amount to DKK 2.5 million (DKK 2.0 million) for overweight (obesity)[25]. The sibling FE specification uses a much smaller sample and thus shows larger uncertainty. Most estimates are insignificant, but the result on obesity is statistically significant with 39 percent higher costs. Both the results of OLS and FE show that the effect on girls drives the total effect.

[24] See details in Appendix Report 1.1. Here based on OLS estimates for intensive margin and extensive margin, and means for normal weight in Table 5.7. For overweight: (0.243+0.0296)*(DKK 8,713*(1+0.073)) – 0.243*DKK 8,713 = DKK 430.

[25] Calculation using cost estimate per child times share of overweight/obesity in cohort. A regular cohort is roughly 60,000.
For overweight: DKK 430 * 60,000 * 0.097 = DKK 2,502,504.

Figure 5.14 Hospital costs at age 10



Notes: The Figure presents estimation results with corresponding 95% confidence intervals from OLS and sibling FE regressions of total hospital costs of the child at age 10 on weight classification. The dependent variable is log-transformed, and coefficients are scaled to 0-100. The graph shows differences in percentage for each weight class relative to normal-weight children for the full sample (black), boys (blue), and girls (red). N(OLS) = 78,849, N(FE) = 9,085, when we apply the full sample. In the full sample, the outcome mean for normal-weight children is DKK 8,713. The corresponding regression table is Appendix Report, Table 1.63.

Source: VIVE.

The heterogeneity analysis on socioeconomic background shows mixed results, see Table 5.9. The OLS results show no differences in health costs between low-SES and high-SES families except a minor difference for overweight children between low income and high income.

Table 5.9 Hospital costs at age 10 by SES

	Low SES – education		High SES – education	
	OLS	FE	OLS	FE
Underweight	0.04 (0.04)	-0.21 (0.16)	0.03 (0.02)	-0.00 (0.09)
Overweight	0.08*** (0.03)	0.10 (0.15)	0.07*** (0.02)	-0.02 (0.08)
Obese	0.22*** (0.04)	0.30 (0.23)	0.27*** (0.03)	0.48*** (0.17)
N	18,701	2,033	60,148	6,842
Adjusted R-squared	0.036	0.093	0.032	0.106

Notes: The table shows covariate-adjusted estimation coefficients and standard errors (in parentheses) from OLS and sibling FE regressions of hospital costs of the child at age 10 on weight classification. In the full sample, the outcome mean for normal-weight children is DKK 8,713. Covariates are measured at age 5 or earlier (see Appendix Report Table 1.2 for a full description of included variables). We apply robust standard errors in the OLS estimations, and family-clustered standard errors in the sibling FE estimations. * p < 0.1, ** p < 0.05, *** p < 0.01. R-squared adjusted for number of predictors.

Source: VIVE.

6 Limitations

The results in this report are based on registry data. While these data suffer from much lower levels of attrition compared to population surveys and provide access to height and weight measured by school nurses, the data also has some limitations. First, although all children are offered one preventive visit in elementary and lower secondary school, it is not mandatory to attend the visit, which means that not all children are measured. While this attrition is low among children in elementary school (between 7% and 11%), it is much higher in lower secondary school (about 40%). However, we have exploited access to full population data and investigated the attrition in the sample. The implications of the attrition analysis are included in the interpretation of the main results. Second, our measure of overweight and obesity is based on body weight measure (BMI). BMI is defined as weight in kilograms divided by height in meters squared. As BMI does not differentiate between fat and muscle mass, the measure is considered a crude measure of body weight status. Also, it fails to take account of differences in growth spurts and body composition by ethnicity. However, at the population level the influence of these errors might be small and insignificant. Furthermore, BMI is easy to measure. Thus, BMI is still the preferred form of measurement for many researchers and policymakers (Bell et al., 2018).

Third, the data on measurements of children exist only for a limited period. For the full population of school-aged children, measurements of height and weight exist only from school years 2011 through 2017 (measurements in elementary school and lower secondary school). Fourth, the available height and weight measurements for school children limit the outcomes to study. At the time of publication, most registry data are available up until 2022. Therefore, the analysis has been limited to investigating outcomes at age 18 for children in lower secondary school and at age 10 for children in elementary school. To investigate labor market outcome, we limit the sample to cohorts 1995-2000 and thus study a subgroup of lower secondary school children at age 21.

Fifth, while the data is longitudinal, the high correlation in body weight over time and selected sample of repeated measures of height and weight limits the relevant empirical methods. However, we exploit longitudinal data in identifying a long list of relevant conditioning variables and include measures of BMI and outcomes at different points in time. Furthermore, we exploit the population data and estimate sibling fixed effects, which takes unobserved characteristics related to the family into account.

Overweight and obesity might also have consequences on outcomes that we do not measure in this report, e.g., health complication (not treated and registered), costs for informal care, and parents' well-being or labor market attachment.

In the report, we investigate the consequences of being overweight and obese during childhood. As for overweight and obesity, underweight can also have significant consequences for both the individual, the family, and society. In our analysis, we have included a dummy for being underweight. We do this to construct a reference to overweight and obesity, which includes normal weight only. While the consequences of being underweight constitutes a subject in its own right, the focus of this report is overweight and obesity. A further investigation of the consequences of underweight would require including a broader and different literature, which unfortunately is beyond the scope of this report.

The current results provide a snapshot of the consequences of being overweight and obese. A broader view of the consequences of being overweight and obese, e.g., for health care costs and labor market outcomes, would require that we followed the same individuals over time. Thus, our analysis should be updated over time, when more data become available.

7 Ethical considerations

All data used in this project are registry data and have been available only to the authors in pseudonymized form, and no ethical violations have taken place in the preparation or conduction of this work. Use of data has been granted to us by the relevant authorities.

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