ECONOMIC, ENVIRONMENTAL, AND ENDOWMENT EFFECTS ON CHILDHOOD OBESITY AND SCHOOL PERFORMANCE

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ABSTRACT

A surge in the prevalence of childhood obesity over the last several decades in the U.S. has raised concerns from not only public health authorities, but also from various fields such as medicine, sociology, psychology, and economics. The present research examines factors associated with childhood obesity in the U.S. The first part of this dissertation identifies economic, environmental, and endowment effects on childhood obesity; the second examines the relationship between childhood malnutrition, both underweight and overweight, on school performance.

A national longitudinal dataset "Early Childhood Longitudinal Study, Kindergarten-Fifth Grade" (ECLS-K), containing data for 12,719 children from fall 1998 (Kindergarten year) through spring 2004 (Fifth grade), with additional information from the U.S. Census and the Bureau of Labor Statistics, is used. A mixed-effect ordered Logit (proportional odds) is used in the first part of this study, and a mixed-effects linear model is used in the second. The first part is estimated in two separate regressions, a reduced-form health demand function, and a health production function.

In the first part of the study, results for the health demand function indicate that the likelihood of childhood obesity increases with the higher number of working hours per week by parent(s), lower level of parents' socioeconomic status (parents' education and household income), fewer number of siblings, higher child birth weight, and minority status.

The results for the health production function, which includes a set of health inputs as explanatory variables, indicate that less-healthy parents, school lunch participation, and fewer physical activities are correlated with the higher likelihood of children being overweight.

The results from the second part show that malnourished children, either underweight or overweight, achieve lower scores on standardized tests, particularly for mathematics. This pattern remains significant, whether contemporaneous weight status or changes in weight status over time are used as explanatory variables.

Additionally, students with higher frequency of reading time, fewer hours spent watching TV, and fewer hours in child care (i.e., non-parental care) achieve higher test

scores. A household's higher socio-economic status (parents' education and income), parents' expectations for their child's schooling, parents' higher level of involvement with school activities, and households that have a computer for their child's use are correlated with higher school achievement. On the other hand, students with more siblings, students whose family move frequently, and households with some level of food insecurity are associated with lower school performance.

Student test scores increase with teacher experience, which is measured by the number of teaching years (for reading scores) and those with a masters or professional degree (for math scores). School institutional characteristics that are important for students' higher achievement are private school (for reading scores), lower teacher turn over rates, higher percentage of students in school testing at or above the national level, and a lower percentage of minority students.

Taken together, the results from both parts of this study emphasize the need to reduce childhood malnutrition, particularly childhood obesity. This task can not be accomplished without a combination of government policies, parents' time commitment, and school's involvement; all are needed to address problems of childhood obesity. Schools can promote good nutrition through healthy school meals and encourage physical activities through physical and health education programs. Given the link between parental working hours and children being overweight, flexibility in working hours and benefits such as health insurance for parents who work part time could promote effective parenting. Most importantly, government programs that affect both school-based and home-based efforts such as school lunch, physical education programs, and parental working conditions play a major role in curbing the childhood obesity problem.

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Chapter 1

Introduction and Problem Statement

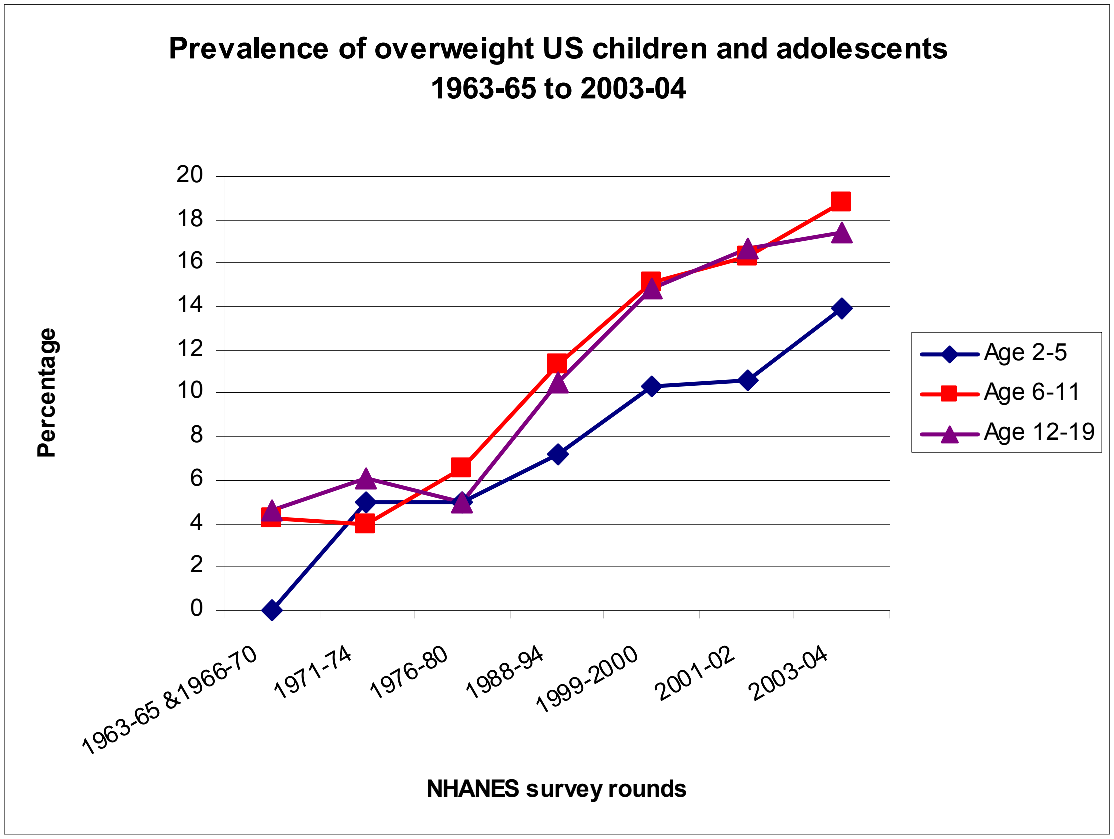
Obesity has become a worldwide epidemic. According to the World Health Organization (WHO), there are over one billion overweight adults worldwide, with more than thirty percent of those being obese (2006). Obesity rates have risen three-fold or more since 1980 in both developed and developing areas of the world. Overweight and obese adults are defined as having a body mass index (BMI) [1] over 25 and 30, respectively. For children and adolescents, these terms are defined as having a BMI above the 85th and 95th percentiles (of growth) for a child's age and sex group.

The United States currently has the highest per capita obesity rate. Nearly two out of three adult Americans are overweight and one out of three is obese (USDHHS 2006). Overweight rates in U.S. children and adolescents 2–19 years of age have more than tripled from 5% in the 1970s to 17.1% in 2003–04 (CDC 2006). This phenomenon disproportionally affects minority groups. According to the National Center for Health Statistics (NCHS), the percentage of overweight African American boys in the 1963–1965 period was 1.7%; this rose to 15.1% in the 1988–1994 period. By 1994, 18.8% of Mexican American boys, 17.4% of African American girls, and 11.7% of white girls were overweight. Moreover, the extent to which children's BMI exceeds the overweight threshold is also increasing at a faster rate during the same time period (Jolliffe 2004). In short, the fraction of children who are overweight is much higher for low-income families

[1] BMI is defined as the weight (in kilograms) divided by height (in meters) squared. Equivalently, the weight (in pounds) divided by height (in inches) squared and multiplied by 703.

and for those with less educated parents (Anderson et al. 2003). Figure 1 below illustrates the prevalence of overweight children and adolescents in the United States from 1963 to 2004.

Figure 1. Prevalence of overweight among children and adolescents ages 2–19 years, NHANES surveys from 1963–65 through 2003–2004.



Data for 1963-65 are for children 6-11 years of age; data for 1966-70 are for adolescents 12-17 years of age, not 12-19 years.
Source: CDC 2006

The true cost of this global epidemic problem is multi-fold. At the public level, there are economic and public health costs. The economic consequences may include reduced disability-adjusted life years (DALYs), decreased worker productivity, and increased healthcare costs. Studies show that the economic costs of obesity account for between 2% and 7% of total health care costs worldwide (WHO 2006).

Overweight and obesity have been shown to be linked with an increased risk of several chronic diseases, including type II diabetes, hypertension, stroke, osteoarthritis, and certain types of cancer. In 1995, the U.S. Department of Health and Human Services estimated costs attributable to obesity in the United States were 300,000 deaths annually, plus about $117 billion, which includes $61 billion of direct and $56 billion of indirect costs. The estimated annual medical spending due to overweight and obesity was $78.5 billion in 1998[2] which was 9.1% of US health expenditures (Finkelstein et al. 2003). In fact, poor diet and physical inactivity were the second leading cause of death in the United States in 2000, and they may soon overtake tobacco as the leading cause of avoidable death (Mokdad et al. 2004, 2005).

At the individual level, there are health consequences, psychosocial effects, and economic costs. The health consequences may reduce overall quality of life or even lead to premature death. Previous research shows that overweight children and adolescents experience strong stigmas, such as isolation (e.g., less likely to be ranked as desirable friends) (Gortmaker et al. 1999a; Strauss and Pollack 2003), depression, low self-esteem, and poor overall mental health (Erickson et al. 2000). These symptoms not only have a direct effect on children's academic outcomes, they may also have lasting consequences that follow children into adulthood.

One of the most important public health concerns created by this dramatic increase in childhood and adolescent obesity is that obese children are at risk of becoming obese adults (USDHHS 2004). A study from the late 1990s shows that 52% of children who are

[2] $92.6 billion in 2002 dollars.

obese between the ages of three and six are obese at age twenty-five, as opposed to only 12% of normal and underweight three- to six-year-old children (Whitaker et al. 1997).

The escalating rate of obesity highlights the importance of understanding household and environmental characterizes that are consistently correlated with excess weight in children. However, while the health, social, and economic costs of obesity are apparent, the mechanisms underlying this problem are less obvious. It is widely believed that parents play a central role in the food choices and activities that impact their children's nutritional and physical health. To achieve healthy outcomes, parents have to devote sufficient time and income to care for their children.

Given the assumption that both nature and nurture factors affect childhood obesity, this dissertation explores aspects of household, lifestyle, and environmental characteristics that explain and are correlated with excess weight in children and the consequences of malnutrition on school performance. First, it seeks to understand the influence of parents' time constraints on childhood obesity, using the economic framework of the household production function developed by Becker (1965). In particular, it examines the relationship between childhood obesity and the quantity and quality of the time that parents devote to at-home activities with their children. In economic terms, this is the effect of the time input that parents use in a household production procedure to produce a healthy output, i.e., a normal-weight child. Next, this paper investigates the link between childhood obesity and educational outcomes, i.e., reading and mathematics scores on national standardized tests.

In particular, there are two key hypotheses:

1. Parents' time constraints (higher number of work-for-pay hours and the lower amount of time that they spend with their children) are associated with higher likelihood of a child being overweight, and are positively correlated with the extent to which a child is overweight.

2. Being overweight or obese is negatively correlated with a child's academic outcomes.

While there are many studies that find socioeconomic (income, lifestyle), environmental (TV viewing, computer use), and endowment (parents' BMI, health conditions, birth weight of a child) factors that influence obesity, less focus has been placed on the economic aspects of this trend. Particularly, only a few studies used parents' time constraints in economic models to explain the increase in childhood obesity. This study seeks to fill a gap in the literature and to extend some recent studies on parents' time constraints in explaining childhood obesity, while controlling for variables that indicate the household lifestyle and a child's endowed environment.

This approach is different from previous studies in two ways. First, it utilizes an economic model of household production to derive a health demand and a health production function for a child in a household. This analysis is different from epidemiology and/or public health studies because it tests whether obesity is a result of not only eating and exercise patterns but is encouraged by parental lifestyle in terms of time-use and household and school environment. That is, it incorporates time-scarcity into an economic framework, by considering parents' time spent on household activities that affect the obesity of their children.

Second, it is different from recent economic studies on this topic because it (1) considers both parents' total work time in the household production framework, not just the mother's work (as compared to Anderson et al. 2003) and (2) controls for other parental variables that potentially affect their children's BMI such as parent's health status, child's birth weight, as well as neighborhood and school environments (compared to You et al. 2005). Furthermore, an attempt was made to address the potential endogeneity issue between a child's BMI and academic achievement. The data used to empirically test the two hypotheses is different from that of Anderson et al. (2003) and You et al. (2005).

This dissertation is organized as follows. Chapter 2 presents two sets of current literature on (1) factors that contribute to childhood obesity, and (2) the link between childhood obesity and educational outcomes. A theoretical model of the household production function is specified in chapter 3, with an application of a Cobb-Douglas health demand function. An achievement production function for educational outcomes is also be presented. Econometric models are detailed in chapter 4. Chapter 5 describes the dataset used for testing the two hypotheses. Chapter 6 lists all variables used for this study. Empirical results for part one are discussed in chapter 7 and part two in chapter 8. Chapter 9 concludes this study with some suggestions for future research.

Chapter 2

Literature Review

Research on childhood obesity spans several academic and professional fields such as medical, public health, psychology, sociology, and economics. This review integrates the health, nutrition, psychology, and economic literatures. The first part reviews recent developments in the economic literature that explains the obesity trend in the United States. The second part discusses factors that contribute to childhood obesity, with a focus on four main components: parental time, socioeconomic, environment, and endowment. The third part assesses consequences of being overweight for children and adolescents, with a focus on educational achievement.

1. Economic Rationalization of Adult and Childhood Obesity

From the economic perspective, several themes have emerged over the last decade to explain general issues of obesity. These include technological changes that affect workers' physical activities, innovations in the food industry that result in lower prices and higher availability of convenience foods, and an increase in the number of women in the work force over the last 30 years.

1.1 Technological Change

Technological change is considered a major contributor to adult obesity[3]. Philipson (2001) argues that advancement in technology facilitates the reduction of energy expenditure in the workplace. Lakdawalla and Philipson (2002) empirically show that the

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[3] Studies on this topic seem to disagree which side is affected more by technological change, food intake or energy output.

decrease in strenuous work has contributed to increasing adult BMI. However, other researchers have pointed out that the use of manual labor had begun to decline well before the rapid rise in obesity rates (Finkelstein et al. 2005). Conversely, an analogy can be drawn between the introduction of video games and computers that led to a shift in time away from physical activities, resulting in a rapid rise of obesity rates among children and adolescents (Wilson 2006).

In addition, technological improvements in the workplace have led to higher productivity, which results in higher wage rates. As wages increase, the shadow price of exercising also increases. Therefore, technological change gives rise to a growth in obesity by stimulating calorie intake while discouraging calorie expenditure (Philipson and Posner 2003).

1.2 Technological Innovations in the Food Industry

Changes in food production policy and technology have led to reduced real food prices. In the 1970s, Secretary of Agriculture Earl Butz artificially lowered prices for grain and basic staples such as palm oil. He also inaugurated a new subsidy system for farmers, which eventually led to an overproduction of grain (Critser 2003; Pollan 2003). Furthermore, technological innovation of cheaper ingredients such as high-fructose corn syrup and improved processing and packaging over the last three decades have made pre-processed and packaged foods cheaper, more available, and more palatable for all consumers (Lakdawalla and Phillipson 2002; Cutler et al. 2003).

Rashad et al. (2006) examines the effects of relative prices on BMI and obesity. The authors conclude that the increase in obesity is due in part to the increase in the per capita number of restaurants and is partly an unintended consequence of the effort to reduce smoking. Another study on relative prices by Gruber and Frakes (2006) is inconclusive regarding a relationship between higher cigarette taxes and obesity rates, but the authors do not rule out a small weight gain from cessation of smoking.

1.3 Increasing Female Workforce

The dramatic increase in the female workforce implies an increase in the shadow price of time. From 1970 to 1990, a typical dual-income family increased market work by 600 hours annually (Burton et al. 1998). This trend leads to the phenomenon of increasing substitution of market production over household production of food. For example, the consumption of food-away-from-home increased from 18% to 32% of total calories between 1977–1978 and 1994–1996. Expenditures for food away from home increased from 32% to 38% of total food expenses between 1980 and 2000 (Guthrie et al. 2002). This phenomenon implies that the shadow price of home-cooked meals is becoming relatively higher than away-from-home meals, particularly for fast food restaurants.

2. Factors Affecting Childhood Obesity

2.1 The Time Factor

According to the Bureau of Labor Statistics' American Time Use Survey (ATUS), which has collected annual data since 2003, adults living in households with children under the age of 18 spend an average of 1.31 hours per day providing primary[4] child care

[4] Primary child care is child care that is done as a main activity, such as physical care of children including reading or talking to them. Data is averaged between 2003 and 2007. See www.bls.gov/tus for more details.

to those children; they spend and average of 5.3 hours per day providing secondary[5] child care to children under the age of 13. In this secondary child care category, 2.1 hours are for leisure and sports, 1.26 hours are for household activities, and .65 hours are for eating and drinking. Naturally, the amount of time spent on these activities is systematically different when broken down by employment status, both for males and females.

In the context of the household production framework used in this study, the time factor affects parents' activities not only directly through the time they spend with their children, but also indirectly through their behaviors such as food choice, food preparation, consumption patterns, and physical activities, all of which ultimately affect children's weight. Previous studies have shown that these behaviors differ according to parents' employment status (Sayer 2005; Mancino and Newman 2007).

Two recent studies focus on the link between parents' time constraints and childhood obesity. Anderson et al. (2003) examine the causal link between children's weight and their mother's labor supply. The authors apply five different econometric techniques[6] to data from the National Longitudinal Survey of Youth (NSLY) for children between the ages of 3 and 11. The results indicate that a child is more likely to be overweight if his or her mother works more hours per week over the child's life[7]. However, higher socioeconomic status mothers who work intensively are particularly detrimental to the overweight problem of their children. In other words, the notion that maternal

[5] Secondary child care is defined as time one has a child under 13 "in his or her care" while doing something else as a main activity. Information on secondary child care is not collected for children over 12.

[6] The five techniques employed by the authors are: standard probit, child fixed effect (long difference between first and last observation of each child), two types of family fixed effect (different point in time and at the same age of siblings characteristics), and instrumental variable for mother's work behavior (state unemployment rate, wages of child care workers, welfare benefits, and status of welfare reform in the state)

[7] Mothers' work is defined by two measures: (1) average hours worked per week by mothers and (2) the number of weeks in which they worked at all, from child's birth to each survey date.

employment affects the overweight status of children is not true in all income groups (Anderson et al. 2003).

Another recent study that focuses on parental time spent with their children and the consequence on children's weight status is by You et al. (2005)[8]. The authors use a primary dataset collected for adolescents of two age groups: 9–11 and 13–15[9] in the Houston Metropolitan Statistical Area. One child and his or her parent(s) were selected from each household. The empirical model was estimated using a partial reduced form. A nonlinear seemingly unrelated regression (NLSUR) method was used with two systems of dependent variables: (1) food intake system with percentage of energy from fat and from saturated fat, and (2) outcome system with BMI and waist circumference. The results can be classified into three main themes. First, each parent has different impacts on their children. That is, the more time mothers spend with their children, the lower the children's BMI, while the father's time has the opposite effect. One possible explanation is that each parent has different work experiences (work spillover effects and work flexibility). Second, the quality—not just quantity—of time and income is important. Third, there are more significant effects of parents' time in the obesity status of the 9–11 age group than in the 13–15 age group.

[8] A revised and extended version of this paper was later published as a Contractor and Cooperator Report No. 19 (ERS) by McIntosh et al. (2006).

[9] None of the children were under 9 years old since they could not provide information themselves; age 12 is excluded because it is the puberty age, which can influence diet intake and outcome measures.

2.2. Socioeconomic Factors and Household Structures

2.2.1. Socioeconomic factors

Economic and social status affects health, nutrition, and weight in many ways. Parents in households of higher economic and social class generally have higher levels of education, better medical and nutritional knowledge, and the ability to sort out often conflicting information in the media on the links between diet and health outcomes. While parents with limited education can provide a good environment for their children, higher education may create better opportunities to promote health outcomes in children (James et al. 1997; Variyam et al. 1999).

Empirical results for specific food items or food groups have been demonstrated by a number of studies. Higher intake of meat products, fats, sugars, preservatives, potatoes, and cereals, coupled with relatively lower intake of fruits, vegetables, and whole wheat breads are found in children of relatively lower socioeconomic groups (James et al. 1997). Exclusive use of whole milk was highest in families where parents had less than a high school degree, and use of low-fat milk was highest among families where parents were college-educated (Dennison et al. 2001). A study of Minnesota adolescents from 7^{th} to 12^{th} grade reveals that as many as 40% of low-income students do not consume the recommended daily amounts of fruits and vegetables (Neumark-Sztainer et al. 1996).

Another explanation for the link between income and obesity relies on the fact that highly processed food is often energy-dense but low in nutrition and cheaper than healthier choices (Drewnowski and Specter 2004). Low-income households often substitute energy-dense food which is palatable (mostly due to added fat and sugar) and cheaper for healthier choices due to tight budget constraints. In fact, this trade-off between cheap, energy-dense foods and more expensive but healthier choices has led to the dual problems of obesity and hunger in many low-income areas in the U.S. (Townsend et al. 2001; Drewnowski and Darmon 2005).

2.2.2 Household Structures

The importance of family structure and children's well-being has been documented extensively across disciplines such as psychology, sociology, education, and health economics. Since the 1960s, changes in marriage, divorce, and fertility in the United States have led to an increase in single parenthood, which increases the likelihood of children living in "nontraditional" families (McLanahan and Casper 1994). Single mothers are more likely to work than married mothers. In 1967, 74% of single mothers worked the previous year; this number jumps to 82% in 1996 (Meyer and Rosenbaum 1999). This phenomenon implies that children are much more likely to have a mother who works outside the home than they were a few decades ago.

Single parenthood imposes additional constraints for the household in terms of role models, financial resources, and stability for children. Existing research suggests that biological parents have a stronger incentive than stepparents to invest time, energy, money, and other resources in their children (Cooksey and Fondell 1996).

2.3. Environmental Factors

2.3.1 Physical Environment

Besides the social environment described above, previous research also shows that children's eating patterns are strongly influenced by their physical environment. That is, they are more likely to eat foods that are available and easily accessible, and they tend to consume more if larger portions are provided. Since parents are responsible for making food available to children and adolescents, at least within the home, they have a profound impact on children's food consumption patterns and preferences.

Empirical studies in public health have shown that children are more likely to consume fruits and vegetables if these items are available at home and school (Hearn et al. 1998; Story et al. 2002). Likewise, the availability of vending machines (stocked mostly with snack foods) in schools also encourages bad eating habits in children (French et al. 2003). Rolls et al. (2000) found a positive linear relationship between larger portion sizes and intake for a group of children aged four to six, regardless of gender, food liking ratings, and BMI percentiles.

In the medical literature, there is evidence that other household environment factors such as the number of persons in the household, lack of social support for the family, child abuse and neglect, drug or alcohol usage, and chronic illness all affect the nutrition status of children in the household (Locard et al. 1992).

2.3.2 Effects of Screen Time

Exposure to Food Advertising on TV

According to the Institute of Medicine Fact Sheet (2004), food and beverage advertisers spend more than $1 billion annually in media advertising—primarily via television—to reach children, and the spend $3 billion on packaging designed for children. Although advertising has not been linked directly to childhood obesity, empirical studies show that exposure to multiple media channels influence children's food preferences and their consumption behavior (Borzekowski and Robinson 2001;

Story and French 2004; Chou et al. 2005). Moreover, young children have been shown to be prone to dietary manipulation from commercials because they are unable to comprehend or evaluate advertising claims (American Academy of Pediatrics 2005).

Time Spent Watching TV

The effects of TV watching time are twofold. First, TV watching reduces energy expenditure by displacing physical activities, and increases energy intake, either during viewing time or as a result of food advertising for children. A survey by the Annenberg Public Policy Center of the University of Pennsylvania shows that American children spend more time watching television and videos and playing video games than doing anything else except sleeping (1997). Likewise, data from the Child Development Supplement to the Panel Study of Income Dynamics in the year 1997 shows the same pattern: children between the ages of 0 and 12 in the sample spent about 74 hours sleeping, 21 hours on their schooling, 15 hours on unstructured play, and 12 hours watching TV per week. For children between the ages of 6 and 12, the time spent watching TV actually exceeded the time spent in unstructured play (Hofferth and Sandberg 2001).

2.3.3 Neighborhood Environment

Built Environment

According to the Institute of Medicine Fact Sheet (2004), in 1969, an average of 48% of all students and 90% of students living no more than a mile away from school walked or bicycled to school. In 1999, only 19% of children walked to or from school and 6% rode bicycles to school. Although there is evidence of a high correlation between the amount of time kids spend outside of the home and a higher level of physical activities (Sallis et al. 2000), the link between neighborhood-built environment and childhood obesity is still inconclusive (Norman et al. 2006; Sallis and Glanz 2006).

Food Outlets Environment

Foods purchased from fast-food outlets, take-out counters in supermarkets, and other deli outlets play an important role in the American diet (Lin et al. 1999; Nielsen et al. 2002). Food-away-from home tends to be more calorie-dense and have a higher level of fat and saturated fat than foods at home (Lin et al. 1999; Prentice and Jebb 2003). Although there are hypotheses about the linkage between the density of food outlets such as supermarkets (which may have a negative correlation) and fast food establishments (which have may a positive correlation) and higher obesity rates, empirical evidence is mixed.

Several studies with national-level data show no link between local food environment and childhood obesity, even after adjusting for individual and household factors (Sturm and Datar 2005; Sallis and Glanz 2006) while others show a positive link either at the local level (Morland et al. 2002) or at the state level (Bettylou et al. 2004; Maddock 2004). Several studies with regional-level data show that there is a negative correlation between the presence of supermarkets—but not fast-food establishments—and obesity rates for eastern Massachusetts (Lopez 2007). One study finds the presence of supermarkets is associated with a lower rate of obesity and overweight while the presence of convenient stores is linked with a higher prevalence of obesity and overweight for some census tracts located in the states of Mississippi, North Carolina, Maryland, and Minnesota (Morland et al 2006).

2.3.4 School Environment

Since school-aged children spend a significant amount of time in school—from 12 hours per week for children 3–5 years old to more than 33 hours per week for 9–12-year-olds (Hofferth and Sandberg 2001)—the school environment plays an essential role in educating them on healthy nutrition and physical activities. Generally, there are two ways that school environments can affect a child's BMI: (1) physical education (PE) programs and (2) the school food environment. The former can affect students' physical activity levels or energy expenditure while the latter can influence their food consumption or energy intake.

Physical Education Programs

While physical activities have been shown to effectively prevent or reduce the weight problem in children in grade 8 or lower (Gortmaker et al. 1999b; Datar and Sturm 2004)[10], many U.S. schools have reduced their commitment to providing students with adequate physical activity and physical education. A 2000 survey by the Institute of Medicine found only 8% of elementary schools, 6.4% of middle schools, and 5.8% of senior high schools provide daily physical education for the entire school year, for all of the students in each grade (Institute of Medicine 2005). These numbers were even lower in 2006. A School Health Policies and Program Study (SHPPS) survey shows that only

[10] A recent study by Cawley et al. (2007) for US high school students shows that a state-level PE requirement does make girls exercise more frequently but it does not find evidence that PE lowers BMI or the probability that a student is overweight.

3.8% of elementary schools, 7.9% of middle schools, and 2.1% of high schools provide enough physical activity and physical education to their students.

School Food Environment

The literature on the effects of school meals and general food intake at school on childhood obesity is substantial. Parallel to the issues of food availability and accessibility at home discussed above, children's food intake is also influenced by what is offered at school settings, particularly from vending machines, *à la carte* menus, and school stores (Zive et al. 2002; Kubik et al. 2003). This is partly because school breakfast and lunch programs are regulated by the U.S. Department of Agriculture nutritional standards (USDA 1995), while *à la carte* foods in snack bars or vending machines are subject to very little regulation. Nevertheless, a report by USDA in the *School Nutrition Dietary Assessment Study* shows that typical school lunches derive 35% of their energy from fat and 12% of their energy from saturated fat, which is higher than the recommended levels of 30% and 10% respectively (USDA 2001).

One survey by the CDC in 2006 showed that 32.7% of elementary schools, 71.3% of middle schools, and 89.4% of high schools had vending machines, school stores, canteens, or snack bars where students could purchase foods or beverages. Moreover, 11.9% of elementary schools, 25.4% of middle schools, and 48% of high schools allowed students to purchase foods and beverages high in fat, sodium, or added sugars from these sources during lunch periods. However, compared to the year 2000, there is a decreasing trend in all categories of not-low-in-fat foods and beverages (CDC 2006).

Given the complexity of environmental effects on childhood and adolescent overweight, it is no surprise that multi-faceted efforts and interdisciplinary approaches are needed in order to curb the obesity problem. There is substantial evidence of school-based intervention programs that are successful in lowering the incidence and prevalence of overweight in adolescents (Gortmaker et al. 1999a; Foster et al. 2008), particularly in girls (Gortmaker et al. 1999b) or in increasing physical activities in boys (Sallis et al. 2003).

2.4. Endowment Factors

The subject of genetic impact on obesity is controversial. In 1997, two massively obese Pakistani children of the same parents were found to have a mutation in the gene encoding *leptin.*[11] Since then, five genetic mutations that cause human obesity have been identified, all presenting in childhood (Farooqi and O'Rahilly 2000). However, while the technology in the medical field is still advancing on this topic, experts seem to agree that gene defects or parental obesity and metabolic variables might account for a small fraction of human obesity; other factors that affect the early stages of childhood obesity play a more important role in determining body weight later in life (Salbe et al. 2002). This is because, as Philipson and Posner (2003) and Philipson (2001) point out, genes do not change as rapidly as the obesity rate, which almost doubled for U.S. children and almost tripled for U.S. adults over the last 30 years.

Empirically, some studies have found strong genetic effects and weak environmental effects (across all types of control groups—twins, parent-offspring, and adoptive relatives) on childhood obesity (Stunkard et al. 1990; Maes et al. 1997; Beunen et al. 1998). Others have found both environmental and genetic influences on BMI to be significant (Price and Gottesman 1991; Segal and Allison 2002; Faith et al. 2004).

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[11] *Leptin* induces satiation while *ghrelin* stimulate appetite

Another group of studies emphasize other conditions such as maternal diabetes, weight gain during pregnancy, and even maternal waist circumference to be important factors in predicting childhood obesity (Whitaker and Dietz 1998, Hirschler et al. 2007). A study by Bouchard and Tremblay (1997) concludes that due to some genetic factors whose exact nature remains to be determined, some people might be more susceptible to weight gain or resistant to weight loss. Anderson and Butcher (2006) explain that parents might influence their children's susceptibility to overweight in the presence of energy imbalance. However, the authors also state that it is difficult to differentiate between genetics and behavior when considering parental influence.

In short, obesity is a complex phenomenon. The literature surveyed in this study indicates that there are a variety of factors contributing to the obesity epidemic: technological change (less strenuous work environment, cheaper food prices, and more screen time for children); time constraints (dual-career families); socioeconomic factors (household structure, income, parent's education and knowledge); environmental factors (physical, built and food environments); and biological and/or endowment factors (genetic susceptibility). While specific results are often debatable, there is a consensus that it is a combination of factors that contributes to this increasing prevalence of both adult and childhood obesity.

3. Childhood Obesity and Academic Outcomes

There is a wealth of literature on the link between children's health, malnutrition, and education, particularly in developing countries. Although the nature of the association is generally the same, the term malnutrition in the developed world often implies a more imminent issue: being overweight or obese as well as being underweight.

While the correlation between childhood obesity and physical health problems is well known, the link between childhood obesity and academic achievement is less obvious due to the complexity of the connection. That is, obesity may also be detrimental to other dimensions of child well-being—such as self-esteem, depression, or feeling isolated—all of which can affect academic outcomes in children and adolescents. Such psychological issues are often not directly observed or measured outside of clinical settings.

This part of the dissertation will review common hypotheses and findings in previous literature which come from different academic fields such as economics, psychology, sociology, epidemiology, and pediatrics. Except for a few studies that examine the direct link between childhood obesity and academic or cognitive growth, the vast majority of the literature covers the mechanism through which childhood obesity could affect educational outcomes.

3.1. BMI, Cognitive Growth, and Academic Achievement

The literature on the direct link between children's BMI and cognitive growth is sparse. The complexity of the association often makes it difficult to tease out an independent relationship between the two (i.e., one that is not confounded with any other factor). While the link seems to be consistently negative for different types of data used in various studies—cross-sectional, longitudinal, or match-case—and across cultures, the association is weakened in some cases once household socioeconomic status (SES) is controlled for.

In the United States, a cross-sectional study with 104 children in 3rd and 4th grades in Philadelphia shows no relationship between obesity and classroom failure (Tershakovec et al. 1994). However, the authors find that obese children are twice as likely to be placed in special education or remedial classes. Another cross-sectional study by Falkner et al. (2001) finds that obese adolescent girls (between 7th and 11th grades) are 1.5 times more likely to be held back a grade, and 2.1 times more likely to consider themselves poor students compared to normal-weight girls. Obese boys of the same age group are 1.5 times more likely to consider themselves poor students, and 2.2 times more likely to expect to quit school. Both studies control for grade level, race, and socioeconomic status. The former also controls for students' birth weight.

Another cross-sectional study by Li et al. (2008) finds that the association between BMI and academic performance is not significant after adjusting for family characteristics, but measures of cognitive functioning remain significantly and negatively associated with higher BMI among children. The authors use NHANES III where participants completed a brief neuropsychological battery.

A longitudinal study with a nationally representative sample of U.S. children between the ages of five and eight by Datar et al. (2004) finds that overweight children have significantly lower mathematics and reading scores compared to normal weight children in kindergarten; this relationship persists through the end of first grade. However, these differences become insignificant after controlling for socioeconomic and behavioral variables such as TV watching and physical activity. This result suggests that overweight might be a marker—but not a causal factor—of lower test scores.

A follow-up study using the same set of data—but updated through third grade—shows a significant association between girls becoming overweight between kindergarten and third grade and lower tests scores. The same effect is not found for boys (Datar and Sturm 2006).

A longitudinal study in Finland that follows a cohort over a course of 31 years finds that obesity at age 14 is associated with low school performance at age 16 and with a low level of education persisting until at least age 31 (Laitinen et al. 2002). A match-case study by Li (1994) using data for 102 obese and 102 normal-weight Chinese students, age 6–13, shows that full-scale IQ and performance IQ of obese children is significantly lower than that of normal-weight students. The study controls for medical problems and parent education.

In short, there seems to be a consistent negative relationship between childhood obesity and academic outcomes or other cognitive measures such as IQ or block design (a measure of visuospatial [12] organization and general mental ability). However, this association is weakened in some cases after controlling for family characteristics.

3.2. BMI and Reflected Self-appraisal

The term "reflected self-appraisal" is a psychosocial concept often used to explain certain behavior. For example, since people are likely to view themselves in others' reactions to them, their functioning is dependent on how their characteristics align with

[12] Visual perception of spatial relationships among objects.

collective norms. In the context of childhood obesity and academic achievement, a study by Crosnoe and Muller (2004) explains the negative link between adolescents' BMI and their academic achievement through the reflected self-appraisal mechanism.

The authors test their general hypothesis of this negative link in three specific scenarios: (1) schools with greater athletic participation, (2) higher rates of romantic activity, and (3) higher mean BMI. Theoretically, the first two scenarios should reinforce the negativity while the last should subdue it somewhat. That is, the authors hypothesize that adolescents at risk of obesity would have lower academic achievement than other students, especially in schools where there is a greater athletic participation and where there are higher rates of romantic activity. This negative link between obesity and academic achievement is expected to be weaker in schools with higher average body size among students.

Their findings are partly in agreement with the general hypothesis (i.e., overweight adolescents have lower achievement than other students, but the change in achievement over time was the same for two groups). For the context-specific scenarios, they find that overweight adolescents do worse in schools where dating is normative, and do better in schools where the average BMI is higher.

Contrary to the authors' expectation, overweight adolescents seem to do better in schools where there is a high rate of athletic participation. Further analysis shows that overweight adolescents become more academically involved, a tangible alternative to athletic activities. That is, overweight children tend to overcome their stigma by focusing on academic achievement compared to their peers, who are more involved in physical activities. A similar explanation of compensatory methods used by obese children and adolescents has been found in other studies (Manus and Killeen 1995; Israel and Ivanova 2002).

3.3. Body Weight and Psychopathology

It has been established in the epidemiology and pediatrics fields that overweight children (particularly female adolescents) are more likely to have lower self-esteem (Stradmeijer et al. 2000; Strauss 2000; Ebbeling et al. 2002; Morgan et al. 2002). They also have higher rates of anxiety disorders and depression (Wallace et al. 1993; Csabi et al. 2000; Vila et al. 2004). However, this view is partially weakened by some other studies that control for other factors (Pesa et al. 2000). That is, once body image is controlled for, there is no significant difference in self-esteem between obese and non-obese children. Furthermore, Mustillo et al. (2003) demonstrate that only chronic obesity is associated with some psychiatric disorders: depression in adolescent boys and oppositional defiance in both genders. This means that the link between childhood/adolescent obesity and psychopathology are different for different obesity classifications, with chronic obesity being the most affected.

An important consideration is the adverse side effect that many psychiatric medications have on body weight, as has been described by several studies (Bryden and Kopala 1999; Malhi et al. 2001; Horrigan et al. 2001). That is, children gain weight when they take certain medications; this effect may be independent from academic achievement. This further complicates the linkage between childhood/adolescent obesity and certain mental disorders such as attention-deficit/hyperactive disorder (ADHD), which in turn affects academic achievement in children.

3.4. Body Weight and Other Stigmas in School Settings

Weight-related stigmatization toward obese children has been documented extensively in the literature. Studies from the early 1960s have shown that overweight children are more likely to be ranked as least likeable by their peers and also by the adults working with them, even more so than for other physical disabilities (Richardson et al. 1961; Maddox et al. 1968). A more recent study duplicates 1961 study done by Richardson et al. and finds the same result (Latner and Stunkard 2003).

Bullying and teasing are commonly found for overweight children in school settings, either with cross-sectional data (Janssen et al. 2004) or with prospective longitudinal data (Griffiths et al. 2006) which implies causality: bullying follows weight change.

In conclusion, the negative association between childhood obesity and academic achievement or cognitive functioning is relatively consistent, despite a small body of literature, concerns about the direction of causality inherent in the data, and/or limitations of estimating methodologies. However, the literature on also indicates that intermediary factors such as health and psychosocial problems often confound analysis of childhood obesity and its affects on academic achievement. That is, being overweight *per se* may not be a strong predicting factor for lower academic outcomes.

Chapter 3

Theoretical Models

1. Household Production Function

The standard economic framework that analyzes the determinants of children's health, nutrition, and educational attainment is the Household Production Model (HPM) (Becker 1965). The HPM incorporates time constraints as one of the constraints households face when they maximize utility. The economic theories of household allocation and children's health outcomes can be categorized into two major strands, unitary and collective/bargaining models.[13] A unitary model assumes all household members have the same set of preferences.

For the purposes of this dissertation, a unitary model is sufficient for modeling the effect of parental work time on childhood obesity for three reasons. First, the traditional separation of roles for each parent in a household has diminished over the last several decades in the United States. Although the gap between the time each working parent spends on household tasks and child care still exists, it has decreased dramatically; experts predict it will converge (Bond et al. 1998). Therefore, a household's decision regarding the time allocation of each parent are not considered to be as important as are the decisions made regarding the total amount of time both parents allocate to child care.

Second, unlike developing countries, where research has shown mothers' education levels and work-for-pay has a substantial impact on children's health, in most U.S. households both parents share a common view of what is a "healthy weight" and what is

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[13] See Schultz (1999) for a more detailed review of the literature on the development of household models.

not. Third, most children studied in this dissertation were between 5 and 12 years old—the age group that is often viewed as "passive children"; they depend on their parents for decisions about food consumption and physical activities, both of which have a direct effect on BMI.[14]

The utility maximization model of a household can be expressed as follows:

$$\text{Max} \quad U = u[H_i, Z, t_l;\ \xi] \qquad (1).$$

where U denotes household utility function, H_i is the measure of the i^{th} child's health, Z is a vector of household-produced goods (viewed as "intermediate goods" used to produce health H_i), and t_l is non-market time. The vector ξ is a set of parameters that represents unobserved household preferences.

When a household maximizes its utility, it faces four constraints. The first one is the monetary budget constraint:

$$pX = wt_w + \upsilon \qquad (2).$$

where p is a vector of prices that corresponds to the vector of market-purchased goods and services X, w is a vector of wages, t_w is the total working hours by household members, and υ is unearned income.

The second constraint is the total time constraint:

$$T = t_l + t_w = t_Z + t_{H_i} + t_w \qquad (3).$$

where T is the total time available, t_Z is the amount of time used to produce household goods, t_{H_i} is the time used to produce health of the i^{th} child in the household, and t_w is the work-for-pay time. The non-market time, t_l, is the sum of t_Z and t_{H_i}.

[14] See Bherman et al. (1995) for a thorough discussion and definition.

The third and fourth constraints are production functions for home-produced goods, Z, and health for the i^{th} child, H_i:

$$Z = z[X, t_Z; \varphi] \quad (4).$$

$$H_i = h_i[Z, t_{H_i}; \kappa_i] \quad (5).$$

where Z, X, t_Z, H_i, t_{H_i} are as defined above, φ is a vector of observed household characteristics, and κ_i is a vector of the i^{th} child's characteristics.

Substituting (3) into (2), we will get a full income equation:

$$wT + \upsilon = pX + w(t_Z + t_{H_i}) \equiv I \quad (6).$$

Substituting (4) and (5) into (1), we will have

$$\text{Max} \quad U = u[z(X, t_Z; \varphi), h_i(Z, t_{H_i}; \kappa_i);\ \xi] \quad (7).$$

Maximizing (7) subject to full income (6) and production functions (4) and (5), using the method of Lagrange, the constrained maximization problem can be expressed as follows:

$$L = u[z(X, t_Z; \varphi), h_i(Z, t_{H_i}; \kappa_i);\ \xi] - \lambda[pX + w(t_Z + t_{H_i}) - wT - \upsilon].$$

Assuming all the conditions hold, that is, the utility function is continuous, strictly increasing, quasi-concave, and twice differentiable, and the constraint set is convex, an interior solution exists for this maximization problem. The necessary conditions for a solution are:

$$\frac{\partial L}{\partial X} : \frac{\partial u(.)}{\partial z(.)} . \frac{\partial z(.)}{\partial X} + \frac{\partial u(.)}{\partial h(.)} . \frac{\partial h(.)}{\partial z(.)} . \frac{\partial z(.)}{\partial X} = p \quad (8),$$

$$\frac{\partial L}{\partial t_{H_i}} : \frac{\partial u(.)}{\partial h(.)} . \frac{\partial h(.)}{\partial t_{H_i}} = w \quad (9),$$

$$\frac{\partial L}{\partial t_Z} : \frac{\partial u(.)}{\partial z(.)} . \frac{\partial z(.)}{\partial t_Z} + \frac{\partial u(.)}{\partial h(.)} . \frac{\partial h(.)}{\partial z(.)} . \frac{\partial z(.)}{\partial t_Z} = w \quad (10),$$

$$\frac{\partial L}{\partial \lambda} : wT + \upsilon - pX + w(t_Z + t_{H_i}) = 0 \quad (11).$$

Dividing (9) by (8) yields the wage rate (w/p).

$$\frac{w}{p} = \frac{\frac{\partial u(.)}{\partial h(.)} . \frac{\partial h(.)}{\partial t_h}}{\frac{\partial u(.)}{\partial z(.)} . \frac{\partial z(.)}{\partial X} + \frac{\partial u(.)}{\partial h(.)} . \frac{\partial h(.)}{\partial z(.)} . \frac{\partial z(.)}{\partial X}} = \frac{\frac{\partial u(.)}{\partial z(.)} . \frac{\partial z(.)}{\partial t_Z} + \frac{\partial u(.)}{\partial h(.)} . \frac{\partial h(.)}{\partial z(.)} . \frac{\partial z(.)}{\partial t_Z}}{\frac{\partial u(.)}{\partial z(.)} . \frac{\partial z(.)}{\partial X} + \frac{\partial u(.)}{\partial h(.)} . \frac{\partial h(.)}{\partial z(.)} . \frac{\partial z(.)}{\partial X}}$$

From here, we can solve for t_Z in terms of X. Substituting this expression of t_Z into (11), we will get the optimal level of market goods demanded:

X*=f[p,I]

and the optimal level of time used to produce household goods:

t_Z^*=f[w,I] .

Since Z is a function of X and t_Z, it follows that the optimal level of household produced goods demanded by the household, Z*, is

$$Z^* = z[w, p, I; \varphi] \quad (12).$$

The same procedure is applied in solving for the optimal time allocated to produce health for the i[th] child:

$$t_{H_i}^* = f[w, I; \kappa_i] \quad (13).$$

Therefore, a reduced-form of the health demand equation can be derived by substituting Z^* and $t_{H_i}^*$ into equation (5)

$$H_i^* = h[Z^*, t_{H_i}^*; \varphi, \kappa_i] = h[f(w, p, I); \varphi, \kappa_i] \quad (14).$$

Equation (14) is the reduced-form of the health demand function, which is the basis of empirical analyses in this study. It is clear from equation (14) that health demand is a function of wages, prices, full income, and time used to produce health for the i^{th} child, given family and the child's characteristics.

Another set of equations that are empirically examined in this study is the health production function. This function comes from equations (4) and (5) above. Specifically, it is used to study how efficient a household is in producing a healthy (i.e., not overweight) child, given parents' time devoted to taking care of a child t_{H_i}, health inputs Z, and household and child characteristics φ and $\kappa_i : H_i = h_i[Z, t_{H_i}; \varphi, \kappa_i]$.

2. An Application of Cobb-Douglas Functional Form for Deriving a Reduced Form Demand Equation.

The utility maximization model of a household with a Cobb-Douglas production function can be expressed as follows:

Max $U = Z^{\alpha} H^{\beta} t_l^{\delta} + \xi$ (15),

where U, Z, H, t_l and ξ are defined after equation 1.

Subject to

Full income: $I \equiv wT + \upsilon = pX + w(t_Z + t_{H_i})$ (16),

Home-goods production function: $Z = X^{\eta} t_l^{1-\eta}$ (17),

Health production function: $H = Z^{\rho} t_l^{1-\rho}$ (18)[15].

[15] For the sake of simplicity, subscript i that denotes the i^{th} child is dropped here,

where the production of home goods and health are expressed as a Cobb-Douglas function.

Substituting (17) into (18), we will have

$$H = X^{\eta\rho} t_1^{(1-\eta)\rho} t_1^{1-\rho} = X^{\eta\rho} t_1^{1-\eta\rho}.$$

Substituting both this expression and equation (17) into (15), we will have

$$\text{Max} \quad U = X^{\eta\alpha+\eta\rho\beta} t_1^{(1-\eta)\alpha+(1-\eta\rho)\beta+\delta} + \xi.$$

Subject to full income $\qquad I = wT + \upsilon = pX + wt_1$

In order to derive the reduced form demand equation for (child's) health, use the method of Lagrange, and obtain the following:

$$L = X^{\eta\alpha+\eta\rho\beta} t_1^{(1-\eta)\alpha+(1-\eta\rho)\beta+\delta} + \xi - \lambda[pX + wt_1 - I].$$

The necessary conditions for a solution are as follows:

$$\frac{\partial L}{\partial X} : (\eta\alpha + \eta\rho\beta) X^{\eta\alpha+\eta\rho\beta-1} t_1^{(1-\eta)\alpha+(1-\eta\rho)\beta+\delta} = \lambda p \qquad (19),$$

$$\frac{\partial L}{\partial t_1} : [(1-\eta)\alpha + (1-\eta\rho)\beta + \delta] X^{\eta\alpha+\eta\rho\beta-1} t_1^{(1-\eta)\alpha+(1-\eta\rho)\beta+\delta-1} = \lambda w \qquad (20),$$

$$\frac{\partial L}{\partial \lambda} : pX + wt_1 = I \qquad (21).$$

Dividing (20) by (19), we have

$$\frac{(1-\eta)\alpha + (1-\eta\rho)\beta + \delta}{\eta\alpha + \eta\rho\beta} . \frac{X}{t_1} = \frac{w}{p} \Rightarrow t_1 = X . \frac{p}{w} . \frac{(1-\eta)\alpha + (1-\eta\rho)\beta + \delta}{\eta\alpha + \eta\rho\beta}$$

Substituting this expression of t_l into equation (21), we will get the optimal level of market goods and services demanded:

$$X^* = \frac{I}{p} . \frac{\eta\alpha + \eta\rho\beta}{\alpha + \beta + \delta}$$

Equivalently, the optimal time demanded for household produced goods/services is

$$t_1^* = \frac{I}{w} . \frac{(1-\eta)\alpha + (1-\eta\rho)\beta + \delta}{\alpha + \beta + \delta}$$

For simplicity, let $A = \eta\alpha + \eta\rho\beta$, $B = (1-\eta)\alpha + (1-\eta\rho)\beta + \delta$, and $C = \alpha + \beta + \delta$.

The reduced-form of the health demand function is derived by first substituting the demand for market goods and services X* and non-market time t_1^* into the home-produced goods Z in (17), then altogether into (18). After these derivations, it is clear that the health demand equation is a function of wages, prices, and full income:

$$Z^* = X^{*\eta} t_1^{*1-\eta} = \left[\frac{I}{p}\frac{A}{C}\right]^{\eta} \left[\frac{I}{w}\frac{B}{C}\right]^{1-\eta}$$

$$H^* = Z^{*\rho} t_1^{*1-\rho} = \left[\left(\frac{I}{p}\frac{A}{C}\right)^{\eta} \left(\frac{I}{w}\frac{B}{C}\right)^{1-\eta}\right]^{\rho} \left[\frac{I}{w}\frac{B}{C}\right]^{1-\rho}$$

Empirically, health demand is estimated as a function of full income, prices, and wage rates, given the characteristics of households and children. Since this example adopts specific functional forms for the home-produced goods vector Z and health H, we do not see explicitly the time that households devoted for each activity because they are implicitly included in the full income equation.

3. Educational Production Function

The concept of educational production function was first introduced in the "Coleman Report" (Coleman et al. 1966), which stemmed from the *Equality of Educational Opportunity* (itself a result of the Civil Rights Act of 1964). This concept has been utilized by a number of studies since then. Hanushek (1986) provided detailed discussion and proposed a more appropriate term, *input-output approach.* This is because the education process does not have universally accepted single output measures and thus the implicit assumption of an optimizing producer allocating inputs may not be justifiable in the case of education (Lamdin 2001).

Generally, an input-output approach models the achievement of the i^{th} student in k^{th} school at time t, Y_{itk}, as a function of student and family characteristics, X_{itk}; a vector of school resources, S_{tk}, which are assumed to be constant across students within a school, and a random error term ε_{itk}:

$$Y_{itk} = \beta' X_{itk} + \gamma' S_{tk} + \varepsilon_{itk} \qquad (22).$$

In other words, this input-output framework is employed to study the impact of the combination of a child's innate ability, motivation, and family background, together with teacher capability and other school resources on educational outcomes for that child. In this study, a particular student variable of interest is the weight status of a child, which is measured in two ways: current weight and changes in weight over time. This variable is used to capture the effect of health and nutrition on cognitive growth.

Specifically, the output Y_{itk} is measured in two ways: reading and mathematics test scores. The input, vector X, includes a child's weight category, TV time, physical activity level, an index of frequency of activities that parents do with the child at home, parents' expectation for the child's schooling, type of discipline, and other child- and household-demographic factors. Vector S includes teacher and school characteristics. Teacher factors include teacher experience, college degree, race, and whether teachers enjoy teaching. School characteristics include school size, teacher turnover rate, the percentage of students in school who test at or above grade level on national standardized tests, percentage of minority students in school, the community where a school is located, and school safety environment.

Chapter 4

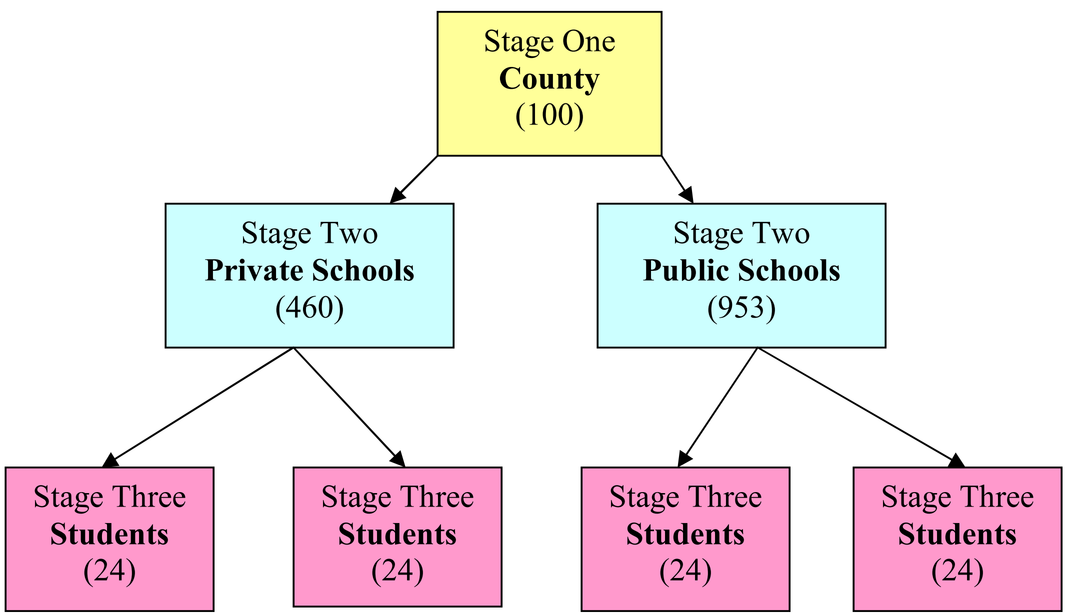
Data

1. Dataset

The data used in this study comes from the U.S. Department of Education's Early Childhood Longitudinal Study, Kindergarten class of 1998–99 (ECLS-K). This is an ongoing study that collects data on the early school experiences of a cohort of children, beginning in kindergarten and following the children through high school. The ECLS-K is the first national survey on public and private kindergarten programs and children who attend them. The newest round of data available at the time of this study (and thus the round of data used herein) includes students through fifth grade in the year 2004. The data set provides a wide range of data on approximately 22,000 children who were enrolled in 1,000 kindergarten programs in 1998–99. The data provides information required to understand children's health, early learning, development, and educational experiences. Data is collected about the child, the child's parents/guardians, teachers, and schools through direct child assessment and also through home and school interviews.

The ECLS-K follows a cohort of children from kindergarten into high school. The survey used a multi-stage probability sampling design to ensure a nationally representative sample of children attending kindergarten in 1998-99. In the base year (1998-99), the primary sampling units (PSUs) were geographic areas consisting of counties or groups of counties selected with probability proportional to size (PPS) where size was the number of five-year-olds. There were 100 PSUs selected. In the second-stage, schools within sampled PSUs were selected to represent both public and private schools. The selection of schools was systematic, with probability proportional to a weighted measure of size based on the number of kindergarteners enrolled. As with the PSU sample, the measure of size was constructed taking into account the desired oversampling of Asian Pacific Islanders (APIs). In the third and final stage, students were randomly selected from within the schools. In the fall of 1998, approximately 24 kindergarteners were selected within each of the sampled schools. In total, 1,280 schools were sampled from the original frame, and 133 additional schools were selected in the subsequent freshened frame.[16] Of these, 953 were public schools and 460 were private schools. Figure 2 depicts the nested structure of the sampling process, with students nested within schools in the three-stage sample.

Figure 2: ECLS-K dataset structure – Sampling Frame.



[16] The sample was freshened in first grade (1999-2000 school year) to include students who were not sampled during kindergarten (1998-1999 school year). Such students include immigrants to the United States who arrived after fall 1998, students living abroad during the 1998-99 school year, students who were in first grade in 1998-99 and repeated it in 1999-2000, and students who did not attend kindergarten.

This data set contains detailed information on children, their parents, teachers, and school characteristics in a longitudinal design. Baseline data were collected in the fall of 1998 with kindergarten children (wave 1) followed by additional rounds of data collection in the spring kindergarten class (wave 2). Subsamples of data were collected in the fall for first grade (wave 3), spring of first grade (wave 4), spring of third grade (wave 5), and spring of fifth grade (wave 6). Since waves 1 and 2 were collected in the same school year, this data was merged. Wave 3 was omitted from the original dataset since it was a subsample of 30% of the baseline students. This is to preserve as much of the data as possible and also to streamline the time gap between waves. From now on, these rearrangements of data will be labeled "rounds" to avoid confusion with the original data. Therefore, there are 4 "rounds" of data in this study: round 1 is for kindergarteners, round 2 corresponds to first graders, round 3 for third graders, and round 4 for fifth graders. While the average time between rounds 1 and 2 is one year, the gaps between subsequent rounds are two years.

Child assessments were done directly and parent interviews were conducted using computer-assisted interview techniques. The teacher and school administrator questionnaires were self-administered.

2. Additional Data: Market Information

In order to estimate a reduced-form demand equation which, by definition, is a function of prices, wage rates, and full income (equation (14) in chapter 3), a measure for the price level is extracted from the U.S. Census Bureau database. The *median monthly owner's costs of owner-occupied housing units with a mortgage* in the county in which the student lives (Table TM-H028, Census 2000 Summary File 3) is used to capture the cost-of-living at the county level[17]. This is a proxy for prices in the counties where the children live.

A second market information variable is extracted from the U.S. Bureau of Labor Statistics database. Data for *county-level median wage rates for all occupations in all industries* (manufacturing and service) are available for over 300 of the largest counties or 100 metropolitan areas (www.bls.gov/schedule/archives/cewqtr_nr.htm). Therefore, state-level or metropolitan-level information is used for counties in the main dataset that do not have these wage data. This serves as a proxy for the income variation of households living in different counties.

Overall, the merging of market data to represent the variation in costs confronting households was done by using the census tracts of the students' households' zip codes that were made available from the ECLS-K restricted dataset. These zip codes were aggregated at the county level and then matched with information available from the U.S. Census Bureau and the U.S. Bureau of Labor Statistics for each round of data, corresponding to market data for the years 1999, 2000, 2002, and 2004.

3. Data Attrition

In the course of six school years, the number of children who participated in all four rounds of data collection is 10,590 students. This represents 46% of children sampled for the base year. Sample attrition was due mainly to children changing schools and to families moving outside of the PSUs or to areas where they could not be located.

[17] This is the total cost of home owners, including utility and taxes.

Approximately 50% of movers were followed by ECLS. Therefore, most of the children lost for follow up were those randomly selected and would be unlikely to bias the results. In addition, data on the parent questionnaire ranged between 80% and 91% between rounds compared to the original sample. The non-response rates on the parent questionnaire tended to be higher among non-whites due to language barriers. For more details on sample attritions (including non-response and change in eligibility status over time) see Tourangeau et al. (2006).

4. Data Sample Used in this Study

In this study, the sample consists of roughly 14,000 children (the exact number may vary across models) for whom measures of body mass index (BMI) are available for at least two rounds. The BMIs were measured and recorded using the Shorr Board[18] for height (accurate to within a quarter of an inch) and a Seca[19] digital bathroom scale (accurate to within 0.2 pounds) at each of the data collection rounds. All children were measured twice to minimize errors. For the height composite, if the two height values from the instrument were less than 2 inches apart, the average of the two heights was computed. Otherwise, the value that was closest to the median height for children of the same age group would be used. For the weight composite, if the two weight values from the instrument were less than 5 pounds apart, the average of the two was computed for the composite value. Otherwise, the value that was closest to the median weight for that age group would be used. The two measurements were less than 0.25 inches in height apart for 96% of students, and they were less than 0.5 pounds in weight apart for 97% of

[18] More information can be found at http://www.shorrproductions.com/index.html
[19] More information can be found at https://www.seca-online.com

students. The anthropometric measurement protocols were standardized across sites and over time.

Chapter 5

Econometric Models

1. Part One: The Effects of Economic, Environmental, and Endowment Factors on Childhood Obesity

The first part of this dissertation utilizes a mixed-effects ordered Logit (also known as proportional odds) model to examine the association between parent's time constraints and childhood obesity. A mixed-effects ordered Logit model (with three categories: normal weight, overweight, and obese) is chosen over an Ordinary Least Square (OLS) model (with continuous BMI measures as dependent variable) for two reasons. First, although the underlying BMI is continuous, what matters most is whether children are below or above certain levels that have been determined by the medical community and published by the U.S. Department of Health and Human Service's Center for Disease Control to indicate whether or not children are healthy. [20] Second, a mixed-effects model takes into account the nested nature (Pinheiro and Bates 2000) of the dataset used in this study while an OLS model does not.

1.1. General Form

Both of the health demand and production functions can be expressed generally as a latent model with continuous response

[20] That is, student's BMI scores are first converted to percentiles. If their scores are less than or equal to the 85^{th} percentile, they are classified into the normal weight category. Equivalently, students whose score are between the 85^{th} and 95^{th} percentiles are considered overweight, and greater than the 95^{th} percentile is considered obese. This scale of "healthy weights" was first developed by the National Center for Health Statistics in 1977, and subsequently revised by CDC in 2000. As the ethnic and demographic mix of the children change the scale may less accurately represent a healthy weight for height and age. As diets change and the human body evolves the scale may also need to be adjusted in the future. However, it is a widely accepted and used standard to estimate the healthy weight of children in the U.S. The scale and graph of the scale can be found at http://www.cdc.gov/nchs/data/ad/ad314.pdf.

$$Y^*_{itk} = \beta' X_{itk} + \varepsilon_{itk} \tag{23}$$

where Y^*_{itk} is the i^{th} child's actual BMI score measured at t^{th} round in k^{th} school, X_{itk} is a vector of corresponding explanatory variables, β' is the vector of coefficients associated with X, and ε_{itk} is the error term. For the purpose of this dissertation, although actual BMI scores are continuous, categorized student weight status according to the CDC's guidelines is used as the outcome[21]. Specifically, the BMI measurements of each child are converted to three ordered categories, so that

$$\begin{aligned} Y_{itk} &= 0: \text{Normal weight} \quad \text{if } Y^*_{itk} \le \alpha_1 \\ Y_{itk} &= 1: \text{ Overweight} \quad \text{if } \alpha_1 \le Y^*_{itk} \le \alpha_2 \\ Y_{itk} &= 2: \text{Obese} \quad \text{if } Y^*_{itk} \ge \alpha_2, \end{aligned} \tag{24}$$

where Y_{itk} is the observed weight category for the i^{th} child at t^{th} round in k^{th} school and the α_j's (j = 1,2)are the cut-off values for BMI scores that place a child in one weight category or another. For example, j=1 corresponds to the cut-off point between the base of normal weight (NW) and the other two categories, overweight (OW) and obese (OB). When j=2, α_2 is the cut-off point between OB and the other two categories, NW and OW. These cut-off points, α_1 and α_2, are estimated by the model.

1.2. Ordered Logit Model

Assuming that the distribution of the error term ε_{itk} in the latent model (equation (23)) is logistic, one way to specify an ordered Logit model is (Greene, 2003)

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[21] That is, student's BMI scores are first converted to percentiles. If their scores are less than or equal to the 85^{th} percentile, they are classified into the normal weight category. Equivalently, students whose score are between the 85^{th} and 95^{th} percentiles are considered overweight, and greater than the 95^{th} percentile is considered obese.

$$\text{Logit}\left[\text{Prob}(Y_{itk} = j \mid X_{itk}\right] = \alpha_j + \beta' X_{itk}, \; j=1,2 \qquad (25)$$

where Y_{itk} and α_j are defined as above, vector X includes exogenous variables that correspond to full income I, wages w, prices p, the i[th] child characteristics κ_i, and household characteristics φ as specified theoretically by equation (14) for the health demand function in Chapter 3. For the health production function, vector X includes input variables (many of which are the same as in the demand equation) that correspond to home-produced goods and services Z, time used to produce health for the i[th] child t_{H_i}, given a child and household characteristics κ_i and φ, as specified theoretically by equations (4) and (5) in Chapter 3.

The probability that Y_{itk} (weight category) will equal 0, 1, or 2 is given by

$$\begin{aligned}
\left[\text{Prob}(Y_{itk} = 0 \mid X_{itk}\right] &= 1 - \Pr(Y_{itk} > 0 \mid X_{itk}) \\
&= 1 - F(\beta' X_{itk} - \alpha_1 \mid X_{itk}) \\
\left[\text{Prob}(Y_{itk} = 1 \mid X_{itk}\right] &= \Pr(Y_{itk} > 0 \mid X_{itk}) - \Pr(Y_{itk} > 1 \mid X_{itk}) \\
&= F(\beta' X_{itk} - \alpha_1 \mid X_{itk}) - F(\beta' X_{itk} - \alpha_2 \mid X_{itk}) \\
\left[\text{Prob}(Y_{itk} = 2 \mid X_{itk}\right] &= \Pr(Y_{itk} > 2 \mid X_{itk}) \\
&= F(\beta' X_{itk} - \alpha_2 \mid X_{itk})
\end{aligned} \qquad (26)$$

where F(.) is the cumulative logistic distribution.

It follows that the cumulative probabilities become

$$\text{Prob}(Y_{itk} > j \mid X_{itk}) = \frac{e^{\beta' X - \alpha_j}}{1 + e^{\beta' X - \alpha_j}}$$

and the corresponding log-odds are

$$\ln\left\{\frac{\text{Prob}(Y_{itk} > j \mid X_{itk})}{1 - \text{Prob}(Y_{itk} > j \mid X_{itk})}\right\} = \beta' X - \alpha_j$$

The ratios of the odds that the response Y exceed j for two covariates values x_1 and x_2 (for given values of i, t, and k) becomes

$$\frac{\text{Prob}(Y > j \mid x_1)/\{1-\text{Prob}(Y > j \mid x_1)\}}{\text{Prob}(Y > j \mid x_2)/\{1-\text{Prob}(Y > j \mid x_2)\}} = e^{\{\beta(x_1 - x_2)\}}$$

Thus, for a unit increase in the covariate, x_1-x_2=1, the odds ratio is e^{β}.

1.3. Mixed-effects Ordered Logit Model

In order to account for the nesting effects of children within a school and several observations (i.e., rounds of data) within a student, random effects at the school level and at the children level are included. Therefore, the mixed-effects ordered logit model fitted in this study is

$$\text{Logit}\left[P(Y_{itk} = j \mid X_{itk}\right] = \alpha_j + \beta' X_{itk} + \varsigma_{ik}^{(\text{Student})} + \varsigma_{k}^{(\text{School})} \; ; j = 1,2 \quad (27)$$

where $\varsigma_{ik}^{(\text{Student})}$ and $\varsigma_{ik}^{(\text{School})}$ are the intercepts that represents student- and school-level random effects, respectively.

The random intercept $\varsigma_{ik}^{(\text{Student})}$ captures any student-specific but unobserved characteristics of each student in the k[th] school. It is assumed to vary across students in the sample data with variance ψ_{Student}. That is, $\varsigma_{ik}^{(\text{Student})} \mid X \sim N(0, \psi_{\text{Student}})$. The random intercept $\varsigma_{ik}^{(\text{School})}$ captures any school-specific but unobserved characteristics of each school. $\varsigma_{ik}^{(\text{School})}$ is assumed to vary across schools in the sample data with variance ψ_{School}. That is, $\varsigma_{ik}^{(\text{School})} \mid X \sim N(0, \psi_{\text{School}})$.

Following the notations employed in Rabe-Hesketh and Skrondal (section 7.6.1, 2008) for the equivalence of the mixed-effects logit model written in terms of latent-response formulation, the intra-class correlation for the ith student between two time periods is

$$\rho_{Student} = \frac{\psi_{Student} + \psi_{School}}{\psi_{Student} + \psi_{School} + \pi^2/3} \tag{28}$$

and for students within the kth school is

$$\rho_{School} = \frac{\psi_{School}}{\psi_{Student} + \psi_{School} + \pi^2/3} \tag{29}$$

The *gllamm* (generalized linear latent and mixed model) procedure (Rabe-Hesketh and Skrondal 2008) in Stata10 is used to estimate the model.

2. Part Two: Childhood Overweight and Educational Outcomes

In the second part of this dissertation, a multilevel mixed-effects linear model (ME) is used to estimate the Educational Production Function (equation 22) (not to be confused with the household production function). It examines the relationship between childhood obesity and educational outcomes. This ME model addresses the nested structure of the dataset by including two random intercepts, one for schools and the other for students within a school (Pinheiro and Bates, 2000).

In this dissertation, a simple case of random-intercept at two levels, school and students in school, is considered. Following the notation of the theoretical equation (22) in Chapter 3 for the education production function, the fitted model is as follows:

$$\begin{aligned} &Y_{itk} = \beta' X_{itk} + \gamma' S_{ik} + \varsigma_{ik}^{(Student)} + \varsigma_{k}^{(School)} + \varepsilon_{itk} \\ &\varsigma_{ik}^{(Student)} \sim N(0, \psi_{Student}) \\ &\varsigma_{k}^{(School)} \sim N(0, \psi_{School}) \\ &\varepsilon_{itk} \sim N(0, \theta^2 I) \end{aligned} \tag{30}$$

where Y_{itk} is reading or math test scores for the i^{th} student at t^{th} round in k^{th} school, X_{itk} is a vector of student and household characteristics with the corresponding coefficient vector β', S_{ik} is a vector of teacher and school factors with the corresponding coefficient vector γ', $\varsigma_{ik}^{(Student)}$ and $\varsigma_{ik}^{(School)}$ are the intercepts that represents student- and school-level random effects, and ε is the error term.

Analogous to part one in this study, the random intercept $\varsigma_{ik}^{(Student)}$ captures any student-specific but unobserved characteristics of each student in k^{th} school. It is assumed to vary across students in the sample data with variance $\sigma^2_{Student}$. That is, $\varsigma_{ik}^{(Student)} \mid X \sim N(0, \psi_{Student})$. The random intercept $\varsigma_{ik}^{(School)}$ captures any school-specific but unobserved characteristics of each school. $\varsigma_{ik}^{(School)}$ is assumed to vary across schools in the sample data with variance σ^2_{School}. That is, $\varsigma_{ik}^{(School)} \mid X \sim N(0, \psi_{School})$.

The intra-class correlation for the ith student between two time periods is

$$\rho_{Student} = \frac{\psi_{Student} + \psi_{School}}{\psi_{Student} + \psi_{School} + \theta} \qquad (31)$$

The intra-class correlation for the k^{th} school is

$$\rho_{School} = \frac{\psi_{School}}{\psi_{Student} + \psi_{School} + \theta} \qquad (32)$$

The command “xtmixed” in Stata 10 was used to fit this model.

Chapter 6

Variables

1. Dependent Variables

1.1. Part One: Categorical Body Mass Index

Body Mass Index (BMI) is a reliable indicator of body fatness for most children and adolescents (Centers for Disease Control and Prevention (CDC) 2007). BMI is gender- and age-specific and is often plotted on the CDC's BMI-for-age growth chart[22] for each gender separately. These charts are used to obtain percentile rankings, which is the indicator most commonly used to assess the size and growth patterns of children. The percentile rankings show the relative position of a child's BMI among children of the same gender and age.

According to the CDC's weight status categorization, children with a BMI that ranks below the 5^{th} percentile of the growth chart are considered "underweight"; BMI between the 5^{th} and 85^{th} percentiles is considered "healthy weight"; between the 85^{th} and 95^{th} percentiles is "at risk of overweight"; and above the 95^{th} percentile is overweight. These rankings are taken from the CDC's 2000 growth charts, a revised set of growth charts (from the original National Center for Health Statistics (NCHS) 1977 set) reflecting the size and growth of children in the United States. The charts are based primarily on physical measurements taken as part of a series of national health examination surveys conducted by the NCHS from 1963 to 1994. These updated national survey data represent

[22] These growth charts were revised in 2000 from the original set that were developed by the National Center for Health Statistics in1977. More details on the history of these charts and currently used charts are available at http://www.cdc.gov/nchs/data/ad/ad314.pdf.

the combined size and growth patterns of breast- and formula-fed infants in the general U.S. population (the original growth charts were based on Fels data collected in 1929-75 with primarily formula-fed, white, middle-class infants in a limited geographic area of southwestern Ohio (Kuczmarski et al. 2000)).

To avoid confusion, this study uses the terms “underweight”, “normal”, “overweight”, and “obese” to correspond to the four classifications used by the CDC. Therefore, there are four categories of weights used in this study. The thresholds are age- and gender-specific.

Figure 3 illustrates the trends and figure 4 illustrates the relative shares of the four weight categories in the ECLS-K dataset between 1998–99 and 2003. The four weight categories are presented by their initials: e.g., UW corresponds to underweight, NW is normal weight, OW is overweight, and OB is obese. .

Figure 3: Trends in weight categories.

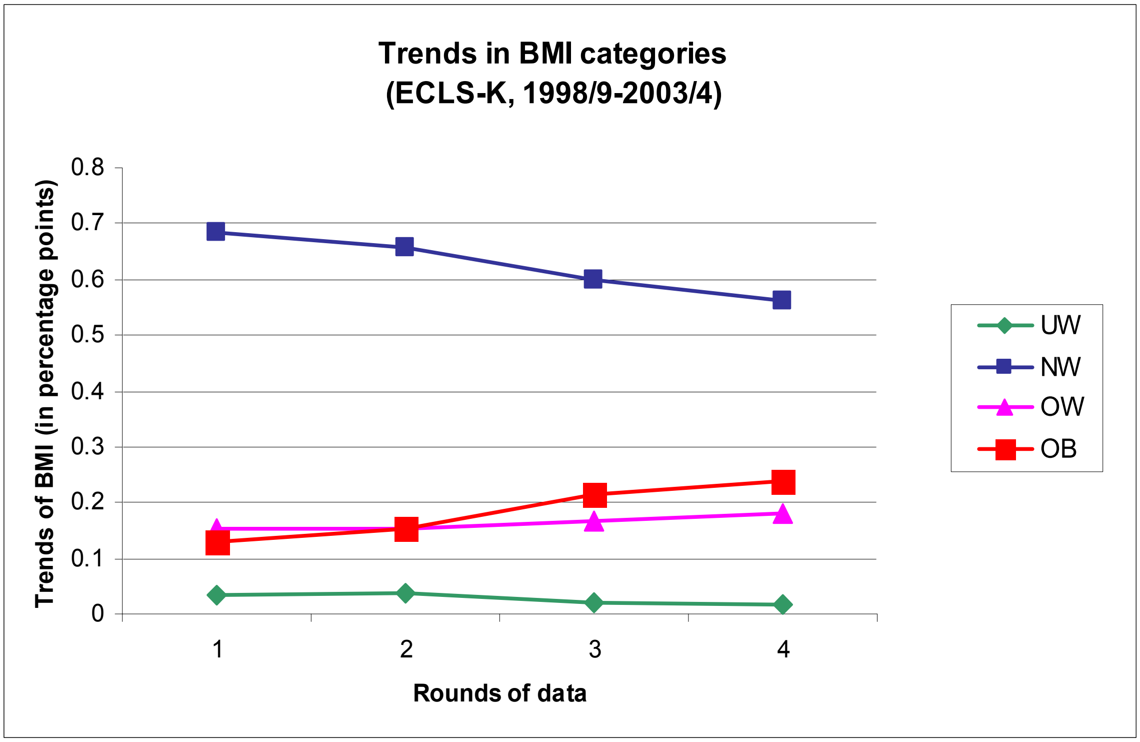
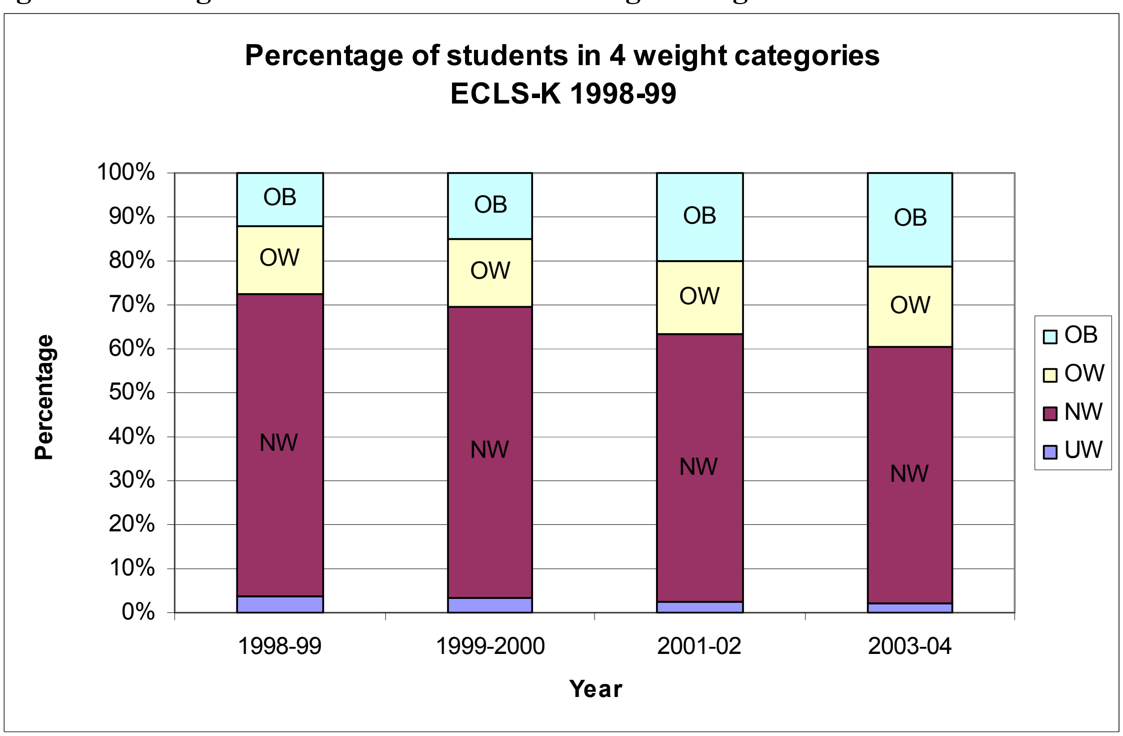


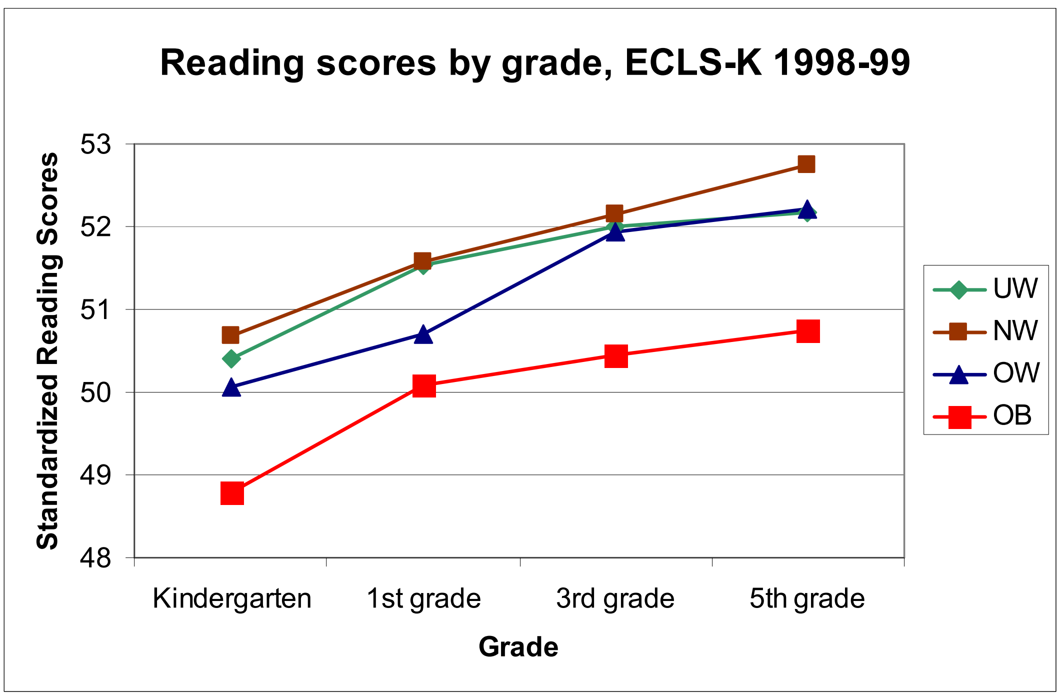
Figure 4: Changes in the shares of the four weight categories over time.



1.2. Part Two: Test Scores

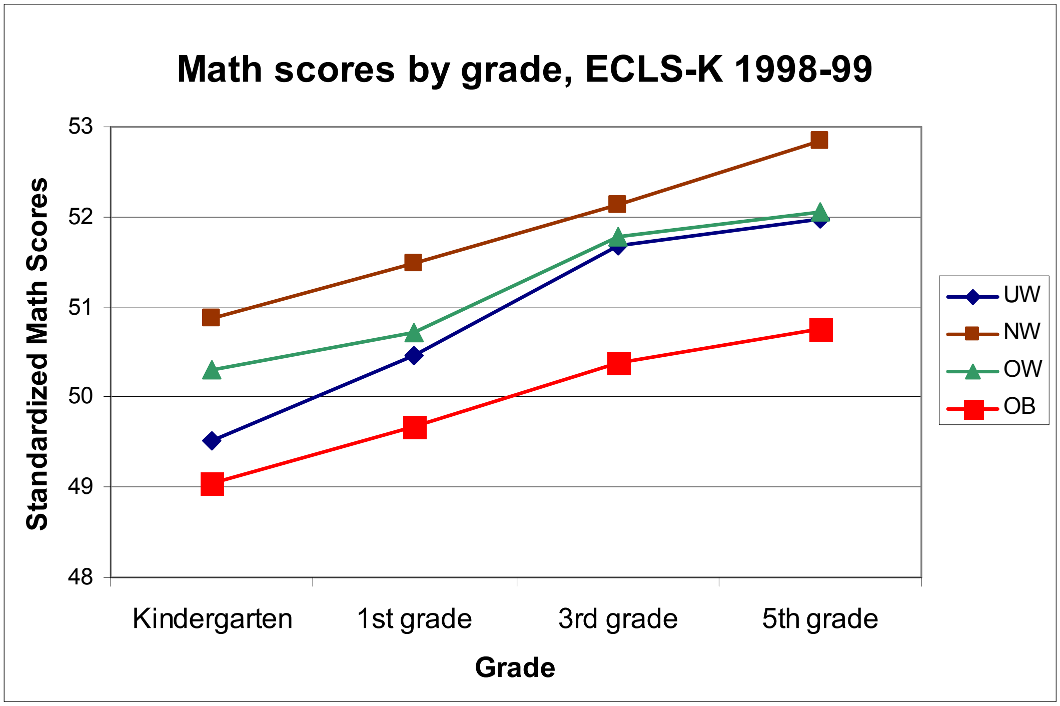
ECLS-K students were tested on reading and mathematics during each data collection round using a two-stage assessment for each subject[23]. In the first stage, students received a 15–20 item routing test. Results from these routing tests led to the selection and administration of one of the alternative second-stage tests, which had items of appropriate difficulty for the ability level indicated by the first-stage (i.e., routing) test. Figures 5 and 6 illustrate the differences in reading and mathematics test scores for students by weight categories, between kindergarten and fifth grade, from the ECLS-K dataset. The four weight categories are presented by their initials as above.

Figure 5: Average reading (IRT) scores.



[23] The assessment instruments and scale scores are designed and implemented from the collaboration of the U.S. Department of Education, National Center for Education Statistics (NCES), and Westat (consulting company). See Pollack et al. (2005) for more details.

Figure 6: Average mathematics (IRT) scores.



Since students do not necessarily take the same tests, item response theory (IRT) scores were computed for all students. IRT scores are the closest measure of the number of items students would have answered correctly if they had attempted all of the 186 reading questions and 153 mathematics questions in both stages in all rounds. In other words, IRT procedures use the pattern of responses to estimate the probability of correct responses for all assessment questions. Therefore, IRT scoring makes possible the longitudinal measure of gain in achievement over time, even with different assessment tests at each point in time. Note that these scores are not integers; they are probabilities of correct answers, summed over all items in the pools that span from kindergarten to fifth grade. The reliability of IRT scores is high: .93 for reading and .92 for mathematics (Tourangeau et al. 2006).

Standardized IRT scale scores for reading and mathematics are used to measure students' direct cognitive skills. These scores are an indicator of students' performance relative to their peers. They have a mean of 50 and standard deviation of 10. That is, a standardized score of 60 on a reading test represents a reading proficiency at one standard deviation higher than the mean for a student in a given grade level, relative to the student population of the same grade represented by the ECLS-K study sample.

2. Independent Variables

2.1. Part One: Factors Associated with Children's BMI

For part one of this dissertation, there are four main groups of independent variables: (1) parental time, (2) environmental factors, (3) endowment factors, and (4) market information. Parental time includes both quantity and quality of time that parents have at home for their children. Environmental variables include factors that contribute to the "nurture" process of raising a child. Endowment variables consist of demographic as well as the "nature" characteristics of the child. Market factors (price and income) are used to estimate the reduced form demand equations. The first three groups of variables are also used in the household production function.

For part two, independent variables can be viewed as belonging to three groups: (1) child and household characteristics, (2) teacher quality, and (3) school attributes. Certain child-specific and household characteristics overlap between the two parts of this study.

2.1.1. Parental Time

Working Time and Child Care Settings

The theoretical model developed in chapter 3 suggests that the parental time constraint may negatively affect home-produced goods -- in this study the health status of children (as measured by the BMI ranking on standardized growth charts). The hypothesis is that children whose parents have less time to spend with them are more likely to be overweight or obese compared to those whose parents spend more time with them. There are two quantitative measures of parental time: (2) parents' working time[24] (for pay), and (2) the total time children spend in non-parental care settings (i.e., child care).

There is a wealth of information that draws a direct link between dual-career families, specifically those with working mothers, and social outcomes for children such as poor health, behavioral problems, and lower school achievement (Golan and Crow 2004). These issues are assumed to arise because working parents have less time to spend with their children. In a report in the Washington Post, "two-thirds of the people surveyed said that although it may be necessary for a mother to work, it would be better for her family if she could stay home and care for the house and children" (Grimsley and Melton 1998). In 1967, about 48% of married mothers worked during the previous year. In 1996, that number had increased to 75% (Meyer and Rosenbaum 2001). By 2002, only 7% of all U.S. households consisted of married couples with children in which only the husband worked (Pop. Ref. Bureau 2007). In terms of actual working-for-pay hours, mothers' paid

[24] Although the dataset does differentiate the working time for each adult member of a household in the survey, we cannot identify whether it is the mother or the father or another person who was interviewed. Therefore, the working time is labeled P1HRS for person 1 and P2HRS for person 2. 85% of respondents (hence person 1) were women, however.

work increased from 9.3 hours per week in 1965 to 22 hours per week in 2003 (Bianchi and Raley 2005).

Moreover, parental time constraints also affect household food preparation and consumption patterns, which in turn affect children's weight outcomes. Single-parent households and those with both parents working full time may not have the time to prepare healthy meals; they may also have a tendency to favor the consumption of prepared foods, which tends to be high in fat and sodium (Crockett and Sims 1995; Mancino and Newman 2007).

Part of this dual-career phenomenon results in more non-parental care for children. According to the American Time Use Survey (ATUS) 2003 data, employed mothers reported engaging in 6 fewer hours of child care per week than non-employed mothers. This is due to a higher workload (both paid work and housework) for employed mothers (on average 66 hours per week) than for non-employed mothers (on average 52 hours per week) (Bianchi and Raley 2005). To capture the effect of non-parental care and source of child care, situations with non-parental care in the child's home, at someone else's home, at a center, or as a combination of the three types of non-parental child care are compared to situations where there is no non-parental child care. Approximately half of the children in this dataset had non-parental child care at kindergarten age; this percentage decreased to 34% by fifth grade.

Mothers Working Early—between Childbirth and Kindergarten

The timing of mothers returning to work after childbirth has been shown to be linked to childhood obesity, perhaps due to infant feeding methods (Hammer et al 1999;

Gillman et al 2001). Although the literature thus far has no definite conclusion on this link, it is less likely that women who work or return to work shortly after childbirth will breast feed, or at least it is less likely that they breast feed as often as those who stay at home with their infants. Approximately three-quarters of mothers in this dataset returned to work early, i.e., between childbirth and kindergarten age of the child.

Quality of Time and Frequency of Evening Meals Together

Besides the actual time that parents work for pay, the quality of time that parents have at home with their children is captured by including an index of the frequency of nine activities that involve parents and children at home. These activities include reading books, telling stories, singing songs, helping a child do art, playing games together, teaching a child about nature, building things, doing sports together, and having a child do chores at home. Another variable that captures the quality of parental time spent with their children is the frequency of times that they share "warm, close feelings" together. These frequencies range from zero for "no time" per week to three for "everyday" of the week.

The number of evening meals per week that parents eat with their children is another factor that might contribute to a child's weight. It is well documented that children who eat meals with other family members consume more healthy foods, fewer soft drinks, and a better variety of the nutrients found in fruits, vegetables, and calcium-rich foods (Neumark-Sztainer et al 2003; Videon and Manning 2003). In addition, by eating together, parents can be role models for their children through their own eating patterns.

This variable has values ranging from zero for “none of the time” to seven for “everyday.”

2.1.2. Environment

Family Structure and Size

The importance of family structure and children’s well-being has been documented extensively across disciplines such as psychology, sociology, education, and health economics. Since the 1960s, changes in marriage, divorce, and fertility in the United States have led to an increase in single parenthood, which increases the likelihood of children living in a “nontraditional” family (McLanahan and Casper 1994). Single mothers are more likely to be employed than married mothers. In 1967, 74% of single mothers worked the previous year and this number jumped to 82% in 1996 (Meyer and Rosenbaun 1999). This phenomenon implies that children are now, at the time of this study, much more likely to have a mother who works outside the home than they were a few decades ago.

Single parenthood imposes additional constraints on the household in terms of role models, financial resources, and stability for children. Existing research suggests that biological parents have a stronger incentive than stepparents to invest time, energy, money, and other resources in their children (Cooksey and Fondell 1996). Therefore, a dummy variable is included in this study to indicate a household with a single mother, single father, or other household structures such as stepparents or adoptive guardians, using households with both biological parents as the base. Approximately 74% of children in the database live with both biological parents; 19% live with a single mother; 2% live with a single father; and 4% with a different type of parental situation.

A variable is also included to indicate the number of siblings. This is to capture household size and to be an indicator of a systematic difference in the motivation to cook meals at home due to the economies of scale of food preparation. It is more economical for large families to cook at home than to eat out. Additionally, the per-unit price is lower for food bought in bulk. The number of siblings a child has in the database ranges from 0 to 14; the average number varies between ethnic groups.

Parental Education

Higher parental education has been associated with health consciousness in nutrition knowledge and food choices (North and Emmett 2000; Xie et al. 2003). Adolescents whose parents were relatively more educated had higher intakes of fiber, folate, vitamin A, and calcium, and were more likely to consume the recommended servings of dairy products. Particularly, exclusive use of whole milk was highest in families in which parents had less than a high school education, and the use of reduced-fat milk was highest among children who had college-educated parents (Dennison et al. 2001). Since the theoretical economic model is based on the unitary assumption (one utility function for the household), the educational levels of parents are pooled, using the highest level of the two. There are four categories for this variable: less than high school, high school graduate, some college, and college graduate or higher.

Household Income

Family financial resources affect household food patterns directly through food prices and indirectly through the opportunity costs of meal preparation. The price factor not only affects food choices at home (e.g., inexpensive, energy-dense foods versus higher priced natural foods) but also influences eating out options (e.g., cheaper fast-foods versus more expensive full-service restaurants). Therefore, this variable might have an opposite effect on childhood obesity, particularly for middle-range incomes. That is, households at the lowest income group may not be able to afford healthy food choices, which often cost more, either at home or away from home. Households with higher income levels may not face the same constraints on their food budgets, thus the effect of income on food choice or food patterns is less clear. Research often utilizes an index that indicates the socioeconomic status (SES) of a family as an explanatory variable. The SES is comprised of each parent's career prestige scores[25], education, and household income. Both methods (SES index and separate components) are used in this study, although the separate components method is preferred. This is because it facilitates a standardized comparison between this study and previous research, the majority of which uses only parents' education and household income.

Parental Health

Genetic factors have been cited as an important indicator of childhood obesity. A number of studies link children's BMI with parental BMI (Agras et al. 2004). However, this hypothesis has been partly refuted by the fact that genetic factors do not change in a short period of time, yet childhood obesity has more than tripled over the last 30 years.

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[25] See Table D in the appendix for more information on the prestige scores for parents' occupations.

Self-reported parental health status is used in this study as a proxy for this factor. This variable is ranked from zero for excellent health to four for poor health. Approximately 50% of parents rank themselves as having excellent health in this dataset.

Food Security Status

Thus far there are only a few studies that focus on the relationship between food insecurity[26] and weight problems (Alaimo et al. 2001; Jyoti et al. 2005; Rose and Bodor 2006). Although there is a compelling argument for this factor to contribute to childhood obesity from a physiological point of view (Drewnowski and Specter 2004; Drewnowski and Darmon 2005), research results are mixed. The main effects are often found to differ between genders and among ethnic groups. The ECLS-K dataset uses 18 questions from the USDA Household Food Security Scale to classify households into three groups: (1) food secure, (2) food insecure without hunger, and (3) food insecure with hunger (USDA 2007). Since only 9% of households are food insecure in this data set, a dichotomous variable is used to indicate whether the household is food secure or not (either with or without hunger).

Frequency of Doctor Visits

It is hypothesized that children who are seen regularly by their doctors maintain a good preventive regimen. Through routine health checkups, doctors might be sharing information and educating parents on health issues, nutritional needs, and physical activities to keep children at a healthy weight. A dichotomous variable with the value of 1

[26] American households are defined as being food secure if, throughout an entire year, they have access at all times to enough food for an active, healthy life for all household members. In 2007, 11.1% of households were food insecure at least part of the year.
Source:http://www.ers.usda.gov/Publications/ERR66/ERR66Appa.pdf

indicates households where parents have had their children visit doctors for routine checkups within a year of the time of the interview.

Bedtime

Lacking sleep has been shown in prospective studies to be linked with obesity in adults and children (Agras et al. 2004; Taheri 2006). Although the precise physiological functions of sleep are unknown, some studies show that short sleep duration is associated with reduced leptin (a hormone that regulates food intake) and elevated ghrelin (a hormone that stimulates food intake and conserves fat) (Spiegel et al. 2005; Taheri et al. 2004). Specifically for children, a later bedtime is associated with shorter sleep duration (Snell et al. 2007; Nixon et al. 2008). A dummy variable is included in this study to indicate if a child often goes to bed after 10 pm.

Physical Activity and Physical Education at School

Physical activity has been shown to effectively prevent or reduce weight problems in children. Concurrent with the increase in childhood obesity, many U.S. schools have reduced their commitment to provide students with adequate physical activity and physical education. A 2000 survey shows that only 8% of elementary schools, 6.4% of middle schools, and 5.8% of senior high schools provide daily physical education for the entire school year for all of the students in each grade (Institute of Medicine, 2005).

Due to the potential endogenous problem, particularly with reverse causality[27] between children's activity levels and childhood overweight, explanatory variables are chosen from the rich set of ECLS data in ways that are least likely to cause concerns. For

[27] See Greene (2003), chapter 15, or Wooldridge (2002), chapter 4 for detailed discussion on the endogeneity issue.

example, four variables are available in this dataset to describe a child's activity level: (1) number of times per week a child exercises for at least 20 minutes (parent recall), (2) the child's physical activity level compared to others (less, same, more; parent evaluation), (3) an index of different physical activities a child is involved in on a regular basis[28], and (4) time (in minutes) that a child spends in physical education (PE) at school.

Theoretically, all four measures are valid in capturing the physical activity levels of a child. Technically, however, the first two measures are prone to two types of errors: (1) measurement error (parent recall of frequency for their child's activity) and (2) a potential endogeneity problem in correlation with overweight status (sedentary children are overweight, or overweight children tend to be inactive). Therefore, the latter two variables are used; an index of the number of physical activities a child is involved in regularly could capture the outside-of-school activity level and PE time could assess the in-school level of physical activity. Also, these two variables are more likely to have other parties (parents or school) involved in the decision making process for a child. For example, parents might jointly decide with their children which activities they will participate in, and the parents might have to drive children to the activities if they occur outside of school. Likewise, PE time often follows the school's curriculum rather than an individual child's own decision to exercise.

Home Computer Using and TV Watching

The literature on childhood obesity shows strong support for a link between childhood obesity and increased time watching TV and playing computer games. One

[28] These activities include group sports, individual sports, dance, recreational sports, martial arts, playground activities, calisthenics/general exercise, or others that are specified by parents.

survey shows that American children spend more time watching TV and videos and playing video games than they spend doing anything else except sleeping (Robinson 1999). The effects of these sedentary activities are multifold. They reduce energy expenditure by displacing time for physical activities, and they increase dietary intake of calories either during viewing time or as a result of food advertising for children (Institute of Medicine 2004).

A randomized controlled study by Robinson (1999) empirically showed that children in an intervention group (which required reduced TV, videotape, and video game use) had statistically significant decreases in BMI, triceps skin fold thickness, waist circumference, and waist-to-hip ratio compared to the control group. This study was done for two socio-demographically and scholastically matched public elementary schools in San Jose, California, between September 1996 and April 1997. The results indicated a strong positive relationship between increased time in viewing TV and increased BMI in children.

There are several measures for these activities available in this dataset. Categorical variables include whether a household has a computer for the child to use at home, and whether parents have TV viewing rules such as what programs, how much time per day, and how late a child can watch TV. Continuous variables include the average amount of time (in minutes) that a child spends on each activity (TV watching and computer using) during weekdays and weekends.

Due to the potential endogeneity problem discussed above, categorical indications for having a computer at home for children's use and an index of parents' three rules on watching TV are preferred to continuous variables which are more prone to a reverse causality problem.

School Lunch Participation

The National School Lunch Program has been administered by the USDA since 1946. Its intention was to reduce undernutrition or malnutrition among low-income children while supporting the demand for U.S. agriculture (Ralston et al. 2008; http://www.ers.usda.gov/Publications/ERR61/). However, with the increasing trends in childhood obesity, there are critics who blame the school lunch system for contributing to obesity, either by encouraging over-consumption of foods that are high in fat and calories or by enabling food consumption beyond what is necessary for growth (Besharov 2003).

While the results on nutrition components (food) consumed by school meal participants and non-participants are clear, the relationship between school meals programs and childhood obesity is mixed. Some studies find no relationship (Hofferth and Curtin 2003, von Hippel et al. 2007)[29] while others find that school meal programs contribute to childhood obesity (Fox et al. 2004b, Schanzenbach 2005). Differences in results might be partly due to methodologies—controlling for unobserved characteristics and/or selection bias—and partly due to the complexity of the relationship among nutrition, energy intake and expenditure, and BMI scores. That is, BMI is a cumulative measure of a dynamic relationship between energy intake and expenditure: it is difficult to tease out a single cause. On the other hand, measures of nutrient components are often

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[29] This study compared students' BMIs between the school year and summer time, which implicates the overall school environment and not necessarily only the school lunch program.

clearer. In this study, a dummy variable is used to identify students who receive a complete lunch from school.[30]

2.1.3. Endowment

Race, gender, age, and birth weight are used to control for the endowment, or the "nature" part of child development, in explaining childhood obesity. Studies have shown that there is virtually no difference in childhood obesity between genders, but the link between race and obesity is strong. High birth weight is also a strong indicator of developing a weight problem during childhood and adolescent years (Rose and Bodor 2006). Dummy variables are used to indicate race and gender, while actual age (in months) and birth weight (in ounces) are used in this study.

2.1.4. Other Demographics

It has been documented that the rates of obesity in children and adults differ among different regions of the U.S. Generally, southern states such as Alabama, Mississippi, Arkansas, and West Virginia have the highest concentration of obese persons (CDC 2007). Dummy variables for the four major regions of the U.S., and dummies for central cities, urban fringes and large towns, and small towns and rural areas are included.

Below are summary tables of variables used to estimate the household's demand for children's health and the household production function, part one of this dissertation. Table 1 reports the mean quantities and qualities of parental time, environmental, and endowment factors for each category of a child's BMI. Columns (1) and (2) list names and descriptions of variables used in this study. Columns (3)–(7) display means and

[30] This variable includes complete lunch meals a child receives at school but it does not differentiate free/reduced from paid ones.

standard deviations of all variables in the sample used in this study overall and by categories of underweight, normal weight, overweight, and obese, respectively. Columns (8)–(10) describe the significance of pair-wise t-tests between normal weight (NW) and each of the other three categories: underweight (UW), overweight (OW), and obese (OB) children, respectively.

There are several variables that differ significantly among the four categories of a child's weight status. The second variable is if person 1's working hours (note that 85 percent of "person 1"s are mothers) are significantly less than person 2's working hours (the other adult living in the same household at the time of the interview). Perhaps this is due to the fact that in a typical two-parent household, fathers tend to work full time while mothers' working status varies. We observe that person 1's working hours are not significantly different between UW and NW, but the hours are significantly different between NW and OW as well as between NW and OB children. Person 2's hours are not different across children's weight categories, except between NW and OB. This might explain why mothers' working hours affect their children's health more significantly than do fathers' working time.

Table 1: Descriptive statistics and pair-wise t-tests for all variables used in part one.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Definition	Overall	Underweight	Normal	Overweight	Obese	Normal vs. UW	Normal vs. OW	Normal vs. OB
		Mean/Standard Deviation							
ConBMI	Continous BMI	17.899 (3.73)	13.137 (0.70)	16.114 (0.010)	19.268 (1.78)	24.108 (3.95)	***	***	***
P1HRS	Person 1 total working hours	35.775 (12.67)	35.459 (12.59)	35.242 (13.01)	36.583 (12.03)	37.049 (11.82)	-	***	***
P2HRS	Person 2 total working hours	46.765 (10.81)	46.772 (10.69)	46.859 (10.79)	46.723 (11.09)	46.411 (10.59)	-	-	*
CCHOME	Childcare at child's home	0.103 (0.31)	0.087 (0.28)	0.099 (0.29)	0.104 (0.31)	0.119 (0.32)	-	-	***
CCOHOME	Childcare at someone else's home	0.144 (0.351)	0.136 (0.34)	0.134 (0.34)	0.165 (0.37)	0.161 (0.37)	-	***	***
CCCENTER	Childcare at centers	0.148 (0.36)	0.166 (0.37)	0.152 (0.36)	0.145 (0.35)	0.133 (0.34)	-	-	***
CCOTHER	Other arrangments of childcare	0.017 (0.13)	0.011 (0.09)	0.015 (0.12)	0.018 (0.13)	0.021 (0.14)	*	-	***
WOKEARLY	Mothers work between childbirth and kindergarten	0.763 (0.76)	0.753 (0.43)	0.729 (0.44)	0.746 (0.42)	0.746 (0.43)	-	***	***
WARMCL	Frequency of warm close time together	2.657 (0.53)	2.655 (0.53)	2.662 (0.53)	2.658 (0.53)	2.636 (0.56)	-	-	***
EVENG	Number of evening meals eaten together	5.632 (1.72)	5.682 (1.74)	5.645 (1.71)	5.637 (1.71)	5.579 (1.78)	-	-	*
PCHINVOL	Index of parent-child involvement	15.001 (4.15)	14.952 (4.27)	15.037 (4.17)	15.042 (4.09)	14.839 (4.11)	-	-	***
BothPA	Child lives with both biological parents	0.815 (0.39)	0.847 (0.36)	0.827 (0.38)	0.809 (0.39)	0.776 (0.42)	-	***	***
SingleM	Child lives with biological mother only	0.161 (0.37)	0.141 (0.35)	0.148 (0.36)	0.141 (0.35)	0.169 (0.37)	-	***	***
SingleD	Child lives with biological father only	0.007 (0.08)	0.006 (0.07)	0.006 (0.07)	0.006 (0.07)	0.007 (0.08)	-	-	-
OtherPA	Child lives with adopted parent(s) or guardian(s)	0.017 (0.13)	0.006 (0.08)	0.018 (0.13)	0.013 (0.11)	0.014 (0.12)	***	-	-
NUMSIB	Number of siblings a child has	1.505 (1.08)	1.386 (1.09)	1.537 (1.09)	1.476 (1.06)	1.409 (1.05)	***	***	***
PARED	Parents' education	2.098 (0.89)	2.195 (0.86)	2.153 (0.88)	2.068 (0.91)	1.914 (0.92)	*	***	***
IN15C	Household income, <$15,000/yr	0.089 (0.28)	0.092 (0.29)	0.082 (0.27)	0.088 (0.28)	0.112 (0.31)	-	*	***
IN30C	Household income, $15,001-$30,000	0.161 (0.37)	0.142 (0.35)	0.144 (0.35)	0.171 (0.37)	0.216 (0.41)	-	***	***
IN50C	Household income, $30,001-$50,000	0.244 (0.43)	0.267 (0.44)	0.239 (0.43)	0.245 (0.43)	0.259 (0.44)	*	-	***
IN75C	Household income, $50,001-$75,000	0.214 (0.41)	0.206 (0.41)	0.218 (0.41)	0.218 (0.41)	0.195 (0.39)	-	-	***
INCHIGH	Household income higher than $75,000	0.262 (0.44)	0.293 (0.46)	0.316 (0.46)	0.277 0.45	0.218 (0.41)	-	***	***

PAHEALTH	Parents' health	1.137 (0.89)	1.096 (0.88)	1.079 (0.88)	1.182 (0.91)	1.323 (0.93)	-	***	***
FSSTAT	Food security status, have food problem sometimes	0.065 (0.23)	0.055 (0.21)	0.059 (0.22)	0.062 (0.23)	0.088 (0.27)	-	-	***
DOC2VIS	Visit doctor for routine care within one year	0.863 (0.34)	0.886 (0.32)	0.861 (0.35)	0.868 (0.34)	0.869 (0.34)	**	*	*
SLUNCH	Child receives complete lunch from school	0.700 (0.46)	0.640 (0.48)	0.669 (0.47)	0.703 (0.45)	0.757 (0.43)	***	***	***
BEDTIME	Child goes to bed after 10pm	0.044 (0.21)	0.050 (0.22)	0.041 (0.19)	0.048 (0.21)	0.055 (0.23)	-	**	***
HOMECM	Has a home computer	0.766 (0.42)	0.754 (0.43)	0.775 (0.42)	0.759 (0.42)	0.736 (0.44)	*	**	***
TV3RULE	Has rule for how many hours a child can watch TV per day	0.433 (0.49)	0.480 (0.50)	0.438 (0.51)	0.428 (0.49)	0.415 (0.49)	***	-	**
PHYED	Physical education at school (minutes/week)	47.063 (31.22)	45.955 (30.13)	46.962 (31.32)	47.513 (31.41)	47.053 30.65	-	-	-
ACTYPE	Child is involved in at least 2 types of physical activities	0.523 (0.49)	0.478 (0.50)	0.529 (0.49)	0.533 (0.49)	0.514 (0.49)	***	-	*
raceA	Child is Asian	0.046 (0.21)	0.106 (0.31)	0.047 (0.22)	0.039 (0.19)	0.042 (0.21)	***	***	*
raceB	African American	0.091 (0.29)	0.102 (0.30)	0.083 (0.28)	0.095 (0.29)	0.112 (0.32)	**	*	***
raceH	Hispanic	0.146 (0.35)	0.127 (0.33)	0.129 (0.34)	0.162 (0.37)	0.195 (0.39)	-	***	***
raceR	Other races	0.027 (0.16)	0.041 (0.20)	0.025 (0.16)	0.027 (0.16)	0.036 (0.18)	***	-	***
raceW	White	0.689 (0.45)	0.624 (0.49)	0.713 (0.45)	0.676 (0.47)	0.615 (0.48)		***	***
AGE	Child's age	8.082 (1.78)	7.649 (1.65)	7.952 (1.76)	8.182 (1.81)	8.505 (1.77)	***	***	***
GEND	Child's gender (female)	0.495 (0.49)	0.513 (0.50)	0.497 (0.50)	0.501 (0.51)	0.456 (0.49)	-	-	***
BWEIGH	Birthweight	119.167 (20.88)	108.157 (22.62)	117.629 (20.64)	121.772 (20.24)	122.841 (21.68)	***	***	***
NE	Region: Northeast	0.184 (0.38)	0.141 (0.35)	0.174 (0.38)	0.198 (0.39)	0.206 (0.41)	***	***	***
MW	Midwest	0.294 (0.45)	0.226 (0.42)	0.299 (0.46)	0.299 (0.46)	0.265 (0.44)	***	-	***
SO	South	0.314 (0.46)	0.378 (0.49)	0.311 (0.46)	0.303 (0.46)	0.334 (0.47)	***	-	***
URBAN	Urban area	0.352 (0.48)	0.368 (0.48)	0.358 (0.48)	0.329 (0.47)	0.349 (0.47)	-	***	-
TOWN	Large town (pop is more than 100,000)	0.405 (0.49)	0.413 (0.49)	0.411 (0.49)	0.406 (0.49)	0.349 (0.47)	-	-	***
HOUSECOST	Monthly cost of housing with mortgage, county-level	1180 (350)	1175 (369)	1178 (345)	1187 (369)	1210 (388)	-	*	**
WAGE	Median weekly wages for all occupations in all industries	729 (152)	721 (138)	723 (148)	731 (158)	746 (169)	-	**	***
PRIVATE	Private school	0.229 (0.42)	0.237 (0.43)	0.238 (0.42)	0.228 (0.42)	0.195 (0.39)	-	*	***
PUBLIC	Public school	0.771	0.763 (0.43)	0.762 (0.42)	0.772 (0.42)	0.805 (0.39)	-	*	***
Number of observations		29454	796	18982	4647	5029			

*Significant at 10%; ** significant at 5%; *** significant at 1%

Standard deviation in parentheses

UW and NW children who receive some type of child care (i.e., non-parental care) tend to be in a center-based service while the other two categories (OW and OB) are more likely to have other arrangements such as child care at child's home (by someone other than the parent(s)), child care at someone else's home, or a combination of methods. Other qualitative measures of parental time with children (i.e., whether mothers work between childbirth and kindergarten age; frequency of warm, close time between parents and children; number of evening meals eaten together; and the level of parental involvement with children in other activities) are not significant between NW and UW or OW children, but these measures are significant between NW and OB children.

Underweight and NW children are more likely to live with both parents or with single mothers than OW and OB children. Single father or other parental types are not significantly different among the four child weight categories, except that UW children are less likely to live with adopted parents or guardians compared to NW children. Finally, NW children are more likely than OW and OB, but less likely than UW, to have siblings.

Consistent with past research, we observe that socioeconomic status (SES) and other environmental factors are significantly different between NW children and both OW and OB categories, but these factors are not significantly different between NW and UW children. A lower percentage of obese children tends to live in (biological) two-parent households than do the other three categories of children, and the parents of obese children have lower SES scores and more health problems. Obese children's parents also face higher risks of food insecurity.

Compared to OW and OB categories, UW and NW children are less likely to receive a complete school lunch, with UW children being least likely of all. UW and NW children tend to go to bed earlier (before 10 pm), are more likely to have a home computer, and have stricter computer rules than OW and OB children. In addition, UW children tend to see a doctor more often than the other three categories. Although there is no difference in the physical education time among the four weight categories, UW children are most likely to be involved in at least two types of physical activities and OB children least likely.

Endowment factors such as race and gender are consistent with the norm observed by the NHANES data (NHANES 2007). There are higher percentages of overweight black or African American and Hispanic children compared to Asian and white children; Asian children are most likely to be UW. Boys tend to be heavier than girls in the age group of 5–12. According to the 2001–2004 NHANES data, 18.7% of boys versus 16.3% of girls (for all races) were obese (at or above the 95^{th} percentile of BMI cutoff points from the CDC growth charts). However, for black or African Americans, 17.2% of boys and 24.8% of girls were obese. Also, overweight and obese children in this study were born significantly heavier than normal ones. This trend matches with several cohort studies (Eriksson et al. 2001).

Geographic factors which are controlled for in this study show a higher percentage of obese children living in the Northeast and Southern areas compared to the Midwest and Western regions. They also show a higher concentration of obese children living in rural areas than in urban areas and large towns.

These descriptive statistics shown are for the sample used for all regressions in this study (which has 29,454 observations of children over the four rounds of studies) and not the entire ECLS-K dataset (which has roughly 47,900 observations). The discrepancy is due to missing data, certain variables not being collected for all rounds, and sample attrition. See Tourangeau et al. (2006) for more details on sample attrition and assumptions.

2.2. Part Two: Factors associated with students' school outcomes

In addition to the variables above, part two of this study includes some other child, household, teacher, and school characteristics needed to examine the relationship between students' weight status and academic outcomes. Since there is considerable overlap of variables used in both parts of this study, only additional variables are described below.

2.2.1. Child Characteristics

In addition to the four weight categories described above, a set of variables that captures changes in weight status between any two rounds of data for each student is included. These variables are in four categories: (1) students who become NW after being OW are coded "BN" (become normal), (2) students who become OW after being NW are coded "BO" (become overweight), (3) students who remain overweight are "AO" (always overweight), and (4) the base category is for students who remain NW between rounds of data. On average, less than 3% of students becomes NW after being OW, 64% remains NW, 13% becomes OW, and 20% remains OW in this dataset.

To preserve data, gaps (i.e., missing BMI data) are replaced by the weight category of the previous time period. Given the facts that the majority (over 83%) of students does not change weight status between rounds of data, and that the percentage of students that becomes OW is about six times higher than the percentage that becomes NW (12.9% versus 2.6%), using the previous round's weight categories should not create major bias. Table 2 facilitates these comparisons for reading scores. An equivalent table for math scores is in the appendix, table A.

Table 2: Summary of reading scores by grade level and weight categories, including missing data for reading scores.

Reading	Kindergarten		1st grade		3rd grade		5th grade	
Weight category	Num. obs	Mean	Num. obs	Mean	Num. obs	Mean	Num. obs	Mean
Underweight (UW)	507	50.41	540	51.53	269	52.00	174	52.17
Normal weight (NW)	10182	50.68	9586	51.57	7473	52.16	5616	52.75
Overweight (OW)	2235	50.07	2221	50.69	2106	51.93	1812	52.22
Obese (OB)	1876	48.78	2185	50.09	2626	50.45	2323	50.74
Missing	96	39.42	1000	51.80	466	50.97	226	51.63
Weight over time								
Become normal (BN)	25	37.49	739	51.43	489	51.52	345	54.11
Always normal (AN)	10689	50.66	9942	51.64	7499	52.16	5494	52.68
Become overweight (BO)	3984	49.96	1070	50.31	1404	51.55	753	51.11
Always overweight (AO)	135	34.65	3553	50.62	3434	50.93	3421	51.44
Missing	53	39.99	216	47.60	126	50.06	110	50.11

In table 2, we observe that the mean reading scores for the missing data are not significantly different from that of the normal weight category, except for kindergarten.[31] For weight status over time, the mean scores in the missing category is lower for first grade. However, the number of missing values in these two cases is small, less than 1% of the total sample. Therefore, it should not cause major concern. In practice, Stata software disregards all observations that have a missing value for the dependent variable or missing values for any of the independent variables.

[31] This result is due to using pairwise t-tests between NW and missing category, and between AN and missing category.

The frequency of reading time that a student engaged in outside of a school setting is used to capture the child's motivation. This subtle variable is often not available from other datasets and has been missed by previous studies that used this ECLS dataset. Children who read by themselves three or more times per week are hypothesized to have a higher level of motivation, and thus might achieve better scores in reading. In addition, students who are diagnosed with some type of learning problem are expected to perform worse than their peers in both reading and math.

Because there can be a high level of student turnover in a given classroom, the number of times a student changed schools since the previous data round was collected and used to capture possible learning disruption. The majority of students (about 90%) did not change schools between two data rounds (which is one year between the 1st and 2nd rounds and two years each thereafter).

Another variable that could capture school disruption is the number of places a child (or a household) lives during the previous year of interviewing time. Although closely related to the measure of school changing, these two variables do not measure the same thing. That is, a household could move to a different residence but not necessarily change their child's school and vice versa. The pairwise correlation between these two variables is .27.

2.2.2. Parents and Households Characteristics

An index of parents' involvement with student's school activities is created to capture an aspect of parents' motivation in helping children learn. This index includes five activities: parents attending parent-teacher meetings (including parent-teacher associations and parent-teacher organizations), conferences, school events, open-houses, and parents volunteering at their child's school. On average, parents are engaged in about 3.5 school activities in this dataset.

Parents' expectation for students' schooling is used to capture another aspect of parents' motivation that can affect their children's academic achievement. A dummy variable with a value of 1 indicates that parents expect their child to at least finish college. Seventy-eight percent of parents in this dataset expressed high expectations for their children's schooling. The pair-wise correlation between this variable and parents' education levels is .3.

Parenting styles are widely believed to affect children's school performance (Spera 2005). To capture the disciplinary style of parents, a dummy variable with a value of 1 indicates that a child's parents use physical force more frequently than non-physical methods (e.g., discussions or taking away a privilege) to discipline their child. About 10 percent of parents frequently use these physical discipline methods in this sample.

2.2.3. Teacher Characteristics

One of the most controversial studies on students' academic performance was the Coleman Report (Coleman et al. 1966). This study proposed that family background and peers are more important inputs than teachers and schools when it comes to students' academic performance. However, there are also several studies that indicate that schools and teachers make a difference in student performance (Worthington 2001; Hanushek 1986, 1997a, 2002; Rivkin et al. 2005; Bishop and Wößmann 2004).

Several teacher characteristics are presented in this study: namely whether a teacher enjoys teaching (captures the motivation factor) and a teacher's years of teaching and its square (depicts a non-linear function of teacher experience). On average, teachers have taught about 14 years in this dataset, with a wide range from 0 to 39 years.

Whether a teacher has a masters or professional degree is another indicator of a teacher's experience and knowledge. About 38% of teachers have obtained such a degree in this dataset. The teacher's race is also controlled for. However, since there is a small fraction of non-white teachers (about 8%) a dummy variable with a value of 1 is used to indicate if a teacher is white. These variables are fairly common in the literature on educational production functions.

2.2.4. School Characteristics

In addition to the dummy variable that differentiates private from public schools, there are six other school characteristics. One of the most important factors that needs to be controlled for is the school's "average" performance. This factor is captured by using the percentage of students testing at or above grade level on nationally standardized tests. This variable is important in hierarchical linear modeling since it represents the mean level of achievement of each school.

Other variables that are commonly controlled for are a school's size and the percentage of minority students in a school. School size is categorized into five levels in this dataset. The lowest level is for schools of up to 149 students. The highest level is for schools with 750 or more students. The variable for percentage of minority students has five categories, with one corresponding to less than 10 percent, and 5 corresponding to 75 percent or higher percentages of minority students in a given school.

High turnover rates among teachers have been documented as a negative factor in students' academic achievement (Rivkin et al. 2005). A dichotomous variable is used to indicate this problem in a given school. About 13% of schools in this dataset experience high teacher turnover rates. Another dichotomous variable is used to indicate the size of the community where a school is located, with 1 being a large city and its suburbs with more than 100,000 in population. An index of security problems (e.g., gangs, drugs, and violent crimes) is used to capture another aspect of a school's safety environment.

Table 3 summarizes the three additional sets of variables—child and household, teacher, and school—that correspond to part two of this dissertation.

Table 3: Descriptive statistics for additional variables used in part two.

Variable	Mean	SD	Min	Max
Dependent variables: test scores				
Reading scores, IRT scale	52.59	9.07	6.79	87.73
Reading scores, raw	95.76	46.65	16.15	181.22
Math scores, IRT scale	52.71	9.09	7.43	84.39
Math scores, raw	77.03	37.75	9.36	150.94
Student and household characteristics				
Number of times a student changes schools since last interview	0.09	0.32	0	5
Number of places a student lives during the previous year of interview time	0.41	0.23	0	3
Frequency of times a student read on own outside of school settings	0.75	0.43	0	1
Number of hours a student receives non-parental care per week (for those who do)	14.13	11.99	0	146
A student's grade level	2.28	1.93	0	6
A student has learning problems	0.17	0.38	0	1
Number of hours a student watches TV per day	1.83	1.06	0	7.29
Index of parent's involvement with a student's school activities	3.58	1.19	0	5
Parents' expectation of a student's schooling	0.78	0.42	0	1
Physical discipline	0.1	0.3	0	1
Teacher characteristics				
A teacher enjoys teaching	0.93	0.25	0	1
Teacher's years of teaching	14.61	9.93	0	39
Teacher's college degree	0.38	0.49	0	1
Teacher is white	0.92	0.26	0	1
School characteristics				
School size, 1 is up to 149 students, 5 is 750 or more students	3.18	1.09	1	5
Percentage of minority students in school, 1 is less than 10 percent, 5 is more than 75 percent	2.77	1.57	1	5
Large community where the school is located (at least 100,000 in population)	0.29	0.45	0	1
Percentage of students in a school tested at or above grade level on national standardized reading tests	69.17	20.83	0	100
Percentage of students in a school tested at or above grade level on national standardized math tests	69.06	20.84	0	100
Private school	0.26	0.44	0	1
A school experiences high teacher's turn-over rates	0.13	0.34	0	1
A school experiences security problems	0.63	0.94	0	3

Chapter 7

Empirical Results for Part One: Economic, Environmental, and Endowment Effects on Childhood Obesity

This section discusses the regression results of the reduced-form health demand (equation (14) in chapter 3) and health production equations (equations (4) and (5)). Since the health demand equation is derived by solving the utility maximizing problem subject to full income and technology constraints, health demand is a function of full income, prices, and wage rates, given household and child characteristics.

Specifically in the context of this study, the health demand equation is specified for the i^{th} child at t^{th} time (round of data) and k^{th} school as follows:

$$\text{Logit}\left[P(Y_{itk} \leq j \mid \text{X}\right] = \alpha_j + \beta_1 \text{ (Parents' working time)}_{itk} + \beta_2 \text{ (Family structure)}_{itk} + \beta_3 \text{(Parents' education)}_{itk} + \beta_4 \text{(Household income)}_{itk} + \beta_5 \text{(Price)}_{itk} + \beta_6 \text{ (Wage)}_{itk} + \beta_7 \text{ (Race)}_{ik} + \beta_8 \text{ (Age)}_{itk} + \beta_9 \text{ (Gender)}_{ik} + \beta_{10} \text{(Birth weight)}_{ik} + \beta_{11} \text{(Region)}_{itk} + \beta_{12} \text{ (Locality)}_{itk} + \beta_{13} \text{(Private school)}_{itk} + \beta_{14} \text{(data round)}_t + \varsigma_{ik}^{\text{(Student)}} + \varsigma_k^{\text{(School)}}; \; j=1,2.$$

The health production function is a function of non-health goods and services produced at home, child and household health inputs, time devoted by parents to produce healthy children, and child and household characteristics. In the context of this study, the health production equation is specified for the i^{th} child at t^{th} time (round of data) and k^{th} school as follows:

$$\text{Logit}\left[P(Y_{itk} \leq j \mid \text{X}\right] = \alpha_j + \beta_1 \text{ (Parent working time)}_{itk} + \beta_2 \text{ (Childcare source)}_{itk} + \beta_3 \text{ (Quality of time parent spend with child)} + \beta_4 \text{ (Family structure)}_{itk} + \beta_5 \text{(Parent education)}_{itk} + \beta_6 \text{(Household income)}_{itk} +$$

β_7 (Household health inputs) $_{itk}$ + β_8 (Child health inputs) $_{itk}$ + β_9 (Race)$_{ik}$ + β_{10} (Age)$_{itk}$ + β_{11} (Gender)$_{ik}$ + β_{12} (Birth weight)$_{ik}$ + β_{13} (Region)$_{itk}$ + β_{14} (Locality)$_{itk}$ + β_{15} (Private school)$_{itk}$ + β_{16} (data round)$_t$ + $\varsigma_{ik}^{(Student)}$ + $\varsigma_{k}^{(School)}$; j=1,2.

Table 4 presents the results for the mixed-effects ordered Logit models health demand function with the dependent variable being three categories of weight status: normal, overweight, and obese. The results are reported as odds ratios for ease of interpreting. That is, all coefficients (β's) are reported as e^{β}, which represents the odds ratio of a child being classified as either overweight or obese.

1. Health Demand Functions

The reduced-form health demand equation includes prices, wages, and full income but excludes health input factors in predicting a child's likelihood of being overweight.

1.1. Parent Working Time

Parent's total work-for-pay hours are associated with an increase in the likelihood of a child being overweight. In this health demand model, a 10-hour increase in person 1's work-for-pay hours is associated with a 7% increase in the odds ratio of a child being overweight,[32] while person 2's work-for-pay hours have no effect. Since 85% of the correspondents in this data (hence "person 1") are mothers, this result could be viewed as

[32] Since the unit of working time is hours per week, a 10-hour increase in working time is equivalent to having 1.007^{10} or 1.07, which means the odds ratio is 7% higher for the overweight and obese categories compared to the normal weight category.

mothers' working time having a more significant effect on childhood obesity than fathers' working time does.[33]

These results are in line with several previous studies. A study by Anderson et al. (2003) found that an additional 10-hour increase of maternal employment over the life time of a child is associated with an increase of 1.2 percentage points in the probability of a child being overweight (which is defined at the 95th percentile, i.e., equivalent to the obese status in this dissertation). A study by Phipps et al. (2006) denoted that a 15-hour increased in mother work per week increases the probability of a child being overweight by 3 to 5 percentage points. Phipps et al. used a simulation technique to derive these figures. The authors used a Logit model with overweight status defined at or above the 85th percentile.

1.2. Family Structure

Children who live with both biological parents are not significantly different from other parental types such as single parenthood or adopted/foster parent(s). However, the number of siblings a child has is negatively associated with the likelihood of a child being overweight (i.e., 29% less likely). Likewise, children whose parents have at least a high school degree are associated with 18% lower in odds ratios of being overweight.

[33] A separate regression using the total working hours of both parents in a household also yields a 6% increase in the likelihood of a child being overweight. This pool-hour variable is significant at a 99% confident level. However, for comparison purposes with previous studies, only the case with separate working hours is reported in this study.

Table 4: Results for mixed-effects Ordered Logit, health demand function.

Dependent variable has 3 categories NW, OW, and OB

Variable	Definition	Value	Mixed-effects ordered Logit (Proportional Odds) Health Demand Function			
			Coeficient	SE	95% Confident Interval	
P1HRS	Person 1 working hours	0-80 hours per week	1.007***	0.001	1.004	1.010
P2HRS	Person 2 working hours	0-80 hours per week	1.002	0.001	0.998	1.005
SingleM	Live with biological mother only	0: no, 1: yes	1.119	0.125	0.899	1.392
SingleD	Live with biological father only	0: no, 1: yes	0.913	0.231	0.557	1.498
OtherPA	Live with adopt parent(s) or guardian(s)	0: no, 1: yes	1.019	0.256	0.622	1.668
NUMSIB	Number of siblings child has	0-14	0.711***	0.026	0.661	0.763
PARED	Parents' education	0: less than highschool - 3: BA or higher	0.825***	0.043	0.746	0.912
IN15C	Household income, <$15,000/yr	0: no, 1: yes	1.699***	0.228	1.307	2.211
IN30C	Household income, $15,001-$30,000	0: no, 1: yes	1.908***	0.208	1.541	2.362
IN50C	Household income, $30,001-$50,000	0: no, 1: yes	1.581***	0.141	1.327	1.886
IN75C	Household income, $50,001-$75,000	0: no, 1: yes	1.361***	0.108	1.163	1.589
RaceA	Asian	0: no, 1: yes	2.041***	0.510	1.250	3.332
RaceB	African-American	0: no, 1: yes	3.078***	0.462	2.294	4.131
RaceH	Hispanic	0: no, 1: yes	4.003***	0.535	3.081	5.203
RaceR	Other races	0: no, 1: yes	2.866***	0.796	1.663	4.941
GENDER	Gender of child	0: male, 1: female	0.798***	0.070	0.675	0.948
BWEIGH	Birthweight	16-177 (in ouces)	1.038***	0.002	1.033	1.042
HOUSECOST	Cost of housing with mortgage, average at county level	Monthly mortgage, $688 - $3,755	1.000	0.0002	0.9996	1.0004
WAGE	Wages, average at county-level	Weekly, $390 - $1,608	0.999	0.0004	0.9991	1.0006
NE	Northeast	0: no, 1: yes	2.073***	0.341	1.547	2.860
MW	Midwest	0: no, 1: yes	1.097	0.200	0.767	1.568
SO	South	0: no, 1: yes	1.566***	0.248	1.148	2.137
Urban	Urban	0: no, 1: yes	0.762*	0.117	0.546	1.031
Town	Large town	0: no, 1: yes	0.746*	0.119	0.547	1.019
Private	Private school	0: no, 1: yes	1.063	0.177	0.766	1.475
y2	Round 2		1.504	0.080	1.355	1.671
y3	Round 3		5.001	0.311	4.426	5.649
y4	Round 4		8.202	0.637	7.043	9.552
cut_11	Cutpoint between NW and the other two: OW &OB		7.569	0.407		
cut_12	Cutpoint between OB and the other two NW & OW		10.169	0.414		
ID_cons	Variance at student's level		18.105	0.538		
S2ID_con	Variance at school's level		1.353	0.137		
Number of observation			36397			
Number of student			15956			
Number of school cluster			2532			
Log likelihood			-23721			

*Significant at 10%; ** significant at 5%; *** significant at 1%
Standard deviation in parentheses
Logit coeficients are reported as odds ratios

Besides the impact of parents' education, which has long been recognized as an important factor in determining children's health (Variyam 2001), the number of siblings, which indicates how large a family is, makes intuitive sense in relation to childhood obesity. The economies of scale for food purchasing and cooking behaviors suggests that households with children are more likely to invest time in home-cooking since the cost per person is relatively lower while the benefit of consuming healthful meals is at least as high as consuming foods away from home (Mancino et al. 2004). Moreover, having more than one child would not necessarily command more time from parents since many activities at home can be done in groups such as reading books, telling stories, or playing games together.

1.3. Household Income

Compared to children in households at the highest income level ($75,000 or higher), those in households with lower income levels have a higher risk of being overweight. Particularly, children in households at the $15,000 to $30,000 household income range have the highest risk (1.9 times higher in the odds ratio) and .15 units higher in excess BMI scores. This is consistent with previous research that used various measures of socioeconomic status (James et al. 1997; Dietz 1998; Anderson et al 2003; McIntosh et al 2006).

1.4. Endowment Effects

The endowment effects include several variables: race, gender, and child birth weight. Children from all races have a higher risk of being overweight compared to whites, particularly Hispanic and African American children. Girls in the 5–12-year-old age group face a lower risk of being overweight compared to boys. This might be due to the fact that girls are more likely to be sensitive about their appearance compared to boys of the same age (McCreary and Sasse 2000; O'Dea and Rawstorne 2001; Kater et al. 2002).

Heavier newborns face a higher risk of becoming overweight later in life. A pound heavier at birth translates into an 82% increase in the odds ratios of being overweight.[34] A systematic literature review of 15 studies by Baird et al. (2005) on this particular issue reports the same results across countries.

1.5. Other Effects

The housing cost variable is not significant in predicting children's weight status in this health demand estimation. Housing cost serves as a proxy for the cost of living at the county level. Particularly, it serves as a proxy to denote differences in public services or amenities such as school district quality and resources, crime levels, and public recreational parks, all of which might indirectly correlated with childhood obesity.

Likewise, county-level wage rates are not significant in predicting the likelihood of children being overweight. Perhaps this factor is highly generalized and thus can not capture the individual effect at the household level. Household total working hours and income categories stand for the full income in this health-demand equation. An increase in working hours of parents in households with incomes less than $75,000 is significant in predicting an increase in the odds ratio of children being overweight.

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[34] $1.036^{16} = 1.816$

Control variables such as urbanization and region of household residence as well as a dummy variable for time (for each round of data) are all consistent with previous findings. Two regions—Northeast and South—show a higher likelihood of childhood obesity compared to the Western region. This is consistent with NHANES data that show a lower prevalence of obesity rates in the Western region of the United States (CDC 2007). Children who live in rural areas are more likely to be overweight than children who live in urban areas or large towns. This result is in line with previous studies that use national data either for adolescents (Nelson et al. 2006) or for adults (Lopez 2004).

The time dummy variables serve two functions. First, they represent the increase in children's age since the data is collected for the same cohort of children over time. Second, they also pick up the idiosyncrasies of each round of data collection. These time dummy variables show that the children in this cohort are more likely to be overweight or obese in subsequent rounds of data compared to the beginning of the study when most of these children were in kindergarten.

For this health demand mixed-effects ordered Logit model, the two cut-off points are significant at the 1% level[35]. These are the intercepts used to differentiate normal from overweight and obese (cut-off 11) and normal and overweight from obese (cut-off 22) when values of the independent variables are evaluated at zero.

[35] Stata provides only one set of coefficients for each independent variable in Ordered Logit regression. That is, there is an assumption of parallel regression. The majority of the independent variables pass the Brant test for this assumption, except for the number of siblings, income between $50,000 and $75,000, and gender of a child. See Long and Freese (2001) for more details on this test.

1.6. Random Intercepts

The estimated intra-class correlations from the variances of the random intercepts shows that 86% of the variation in BMI observed is within student level and 6% is at school level (using formulas (28) and (29) presented in chapter 5). At the baseline, different schools differ from each other with a standard deviation of 1.16 in mean BMI scores while differences among students within a school are greater, with a standard deviation of 4.25 in mean BMI scores. Overall, the likelihood ratio test indicates statistical significant at the 1% level or better for this model when compared to the null model with no covariates.

2. Health Production Function

Table 5 presents the results for the mixed-effects ordered Logit models health production function with the dependent variable being three categories of weight status: normal, overweight, and obese. The results are reported as odds ratios for ease of interpreting. Results presented in Table 5 include only variables that are statistically significant at 10% or higher and omit control variables such as race, regions, and residence locality. See the appendix; table B for complete tables of result

Table 5: Results for mixed-effects Ordered Logit, health production function.

Dependent variable has 3 categories NW, OW, and OB

Variable	Definition	Value	Mixed-effects ordered Logit (Proportional Odds) Health Production Function			
			Coeficient	SE	95% Confident Interval	
P1HRS	Person 1 working hours	0-80 hours per week	1.005***	0.002	1.001	1.009
P2HRS	Person 2 working hours	0-80 hours per week	0.999	0.002	0.995	1.003
SingleM	Live with biological mother only	0: no, 1: yes	1.005	0.132	0.777	1.299
SingleD	Live with biological father only	0: no, 1: yes	2.111*	0.919	0.899	4.954
NUMSIB	Number of siblings child has	0-14	0.732***	0.029	0.678	0.790
PARED	Parents' education	0: less than highschool - 3: BA or higher	0.765***	0.043	0.685	0.853
IN15C	Household income, <$15,000/yr	0: no, 1: yes	1.556**	0.247	1.138	2.125
IN30C	Household income, $15,001-$30,000	0: no, 1: yes	1.780***	0.217	1.401	2.261
IN50C	Household income, $30,001-$50,000	0: no, 1: yes	1.373**	0.133	1.136	1.659
IN75C	Household income, $50,001-$75,000	0: no, 1: yes	1.309**	0.113	1.105	1.552
CCHOME	Childcare at child's home	0: no, 1: yes	1.117	0.108	0.924	1.349
CCOHOME	Childcare at someone else's home	0: no, 1: yes	1.247**	0.114	1.043	1.491
CCCENTER	Childcare at centers	0: no, 1: yes	0.989	0.092	0.824	1.186
SLUNCH	Child receive complete lunch from school	0: no, 1: yes	1.233***	0.085	1.078	1.411
ACTYPE	Child involved in at least 2 types of physical activities	0: no, 1: yes	0.862*	0.052	0.766	0.969
PAHEALTH	Parents' health	0: excellent - 4: poor	1.308***	0.052	1.210	1.413
BWEIGH	Birthweight	16-177 (in ouces)	1.030***	0.002	1.026	1.034
raceA	Asian	0: no, 1: yes	1.500*	0.346	0.954	2.358
raceB	African American	0: no, 1: yes	2.255***	0.363	1.645	3.092
raceH	Hispanic	0: no, 1: yes	3.887***	0.507	3.009	5.019
raceR	Other races	0: no, 1: yes	2.136**	0.589	1.244	3.667
GEND	Child's gender	0: male, 1: female	0.757**	0.065	0.641	0.894
NE	Region: Northeast	0: no, 1: yes	2.403***	0.415	1.713	3.369
MW	Midwest	0: no, 1: yes	1.450*	0.230	1.063	1.978
SO	South	0: no, 1: yes	2.210***	0.341	1.634	2.989
URBAN	Urban area	0: no, 1: yes	0.522***	0.075	0.394	0.692
TOWN	Large town	0: no, 1: yes	0.641***	0.088	0.491	0.838
cut_11	Cutpoint between NW and the other two: OW &OB		6.507	0.475	5.576	7.438
cut_12	Cutpoint between OB and the other two NW & OW		9.062	0.481	8.119	10.006
ID_cons	Variance at student's level		14.045	0.463		
S2ID_con	Variance at school's level		1.258	0.121		
Number of observation			25573			
Number of student			13237			
Number of school cluster			1854			
Log likelihood			-17472			

*Significant at 10%; ** significant at 5%; *** significant at 1%
Standard deviation in parentheses
Logit coeficients are reported as odds ratios

1.1. Parent Working Time

In this health production model, a 10-hour increase in person 1's working hours raises the odds ratio of a child being overweight by 5% while person 2's working hours have no effect. This result is comparable to the health demand model above, even after controlling for additional health input variables such as child care sources, participation in school lunch program, and physical activities (but excluding market information such as price and wage rates).

1.2. Household Structure

The number of siblings and parental education are associated with a lower risk of being overweight for children in the age group of 5–12 years old. These results are similar with the health demand function discussed above. Children in single-father households face a higher likelihood of being overweight—the odds ratios is 2.1 times higher—compared to children who live with two biological parents. Children who live with single mothers or other parental arrangements (adoptive parents or foster parents) are not significantly different compared to those with both biological parents.

Previous studies suggest several explanations for the effects of single parenthood on childhood obesity. Two biological parents might provide a more stable environment, with fewer emotional and mental effects. Besides, compared to single-parent households, two parents can switch roles and support each other in supervising children and determining nutrition issues, food intake, and physical activities. Furthermore, they can help each other monitor and reinforce different mechanisms to maintain healthy weight or to control the excess weight for their children (Nord and West 2001; Carlson and Corcoran 2001).

Although this finding is somewhat different from the health demand estimation above, it is in agreement with a study by You et al. (2005). You et al. found that father's time spent with a child was positively correlated with that child's higher BMI scores and waistline while mother's time had the opposite effect. Besides, it is not expected to have similar results between the health demand and health production functions since they have different specifications in their empirical models.

1.3. Household Income

Lower household income is strongly correlated with higher likelihood of childhood overweight. This result is in line with previous studies. Compared to households with income at $75,000 or higher, the odds ratios of being overweight and obese are higher for children from lower income groups, with the income level between $15,000 and $30,000 being the highest, by 78%.

1.4. Health Inputs

1.4.1. Child Care Settings

Compared to children who have no non-parental care (i.e., they are only cared for by their parents), those who are cared for in someone else's home have a 25% increase in the odds ratio of being classified as overweight or obese. This result indicates that non-parental care at private homes is detrimental to children's overweight risk. An interesting pattern of center-based child care emerges, showing no difference in the relationship with children's weight status when compared to those who are cared for by their parent(s).

There are several possible explanations for the higher risks of childhood obesity from non-parental care arrangements. Although there are federal funding programs for meals and snacks served to children in licensed child care entities, only non-profit child care centers or for-profit centers with 25% or more low-income children qualify for subsidies. Family child care homes tend to be small businesses, and their participation is limited (Glanz 2004). One important characteristic of federal funding programs is that they require the subsidized meals to meet the Dietary Guidelines for Americans, including fat and saturated fat content (Story et al. 2006). Moreover, previous studies often find that child care programs vary greatly in their policies and practices influencing children's physical activities (Finn et al. 2002; Pate et al. 2004; Dowda et al. 2004). Particularly, some studies find that children spend more time watching TV in child care homes than in child care centers (Fellmeth 2003).

1.4.2. School Lunch Participation

Students who receive a complete lunch from school have a 23% increase in the odds ratio of being overweight compared to students who do not. This finding is in line with a study by Schanzenbach (2005), however, the author limits the data sample to include only white students who are ineligible for free or reduced-price lunch. The magnitude of the difference (normal and overweight versus obese) was found to be around 2 percentage points. The difference in the magnitude of this school lunch participation between Schanzenbach's paper and this study might be due partly to the higher percentage of non-white students (who are found to be much more likely to be overweight compared to white students in this study) that participate in school lunch program.

On one hand, this school lunch participation result highlights the role of parental time constraints in this framework: packing lunches for children is one example of the time parents devote to home production. On the other hand, there might be other factors that affect these findings: (1) either children do not always choose healthy foods such as fruits and vegetables and prefer calorie-dense foods such as french fries when they are available at school (Becker and Burros 2003), or (2) the food environment at school cafeterias might provide fewer healthy food choices for children (USDA, FNS 2001; Miller et al. 2004). Therefore, care should be taken in interpreting this relationship between school lunch program participation and childhood overweight.

1.4.3. Children's Activity

Children who are engaged in several types of physical activity are associated with a decreased risk (14% lower) of being overweight in the 5–12-year-old age group. Other children activities such as having a computer at home for child use, bedtime, TV watching rules, and physical education at school are not statistically significant in this model.

This result depicts an important policy implication: for younger children, emphasis should be placed on play and activities rather than "exercise" per se. This view is confirmed and reinforced by the public health and medical literature (Epstein and Goldfield 1999; Williams et al. 2002). Particularly, a study by Epstein et al. (1982) shows that there is an equivalent weight reduction in obese children aged 8–12 across all groups (controlled and treatment) during the eight-week intensive treatment, with lifestyle[36] subjects losing more additional weight and maintaining their weight loss better than the

[36] The lifestyle program allowed the child to increase energy expenditure by engaging in a wide variety of daily games and activities.

programmed exercise[37] subjects during maintenance and follow-up. That is, these results suggest that lifestyle exercise as a way to increase energy expenditure and long-term weight maintenance is more effective than traditional exercising program. Note that these results are independent of diet effects (i.e., the study also controlled for different types of diet).

1.4.3. Parent Health

Parents who rate themselves as having less than excellent health are correlated with an increased odds ratio (31% higher) of their children being classified as overweight or obese. Since it is not clear from the dataset that this rating stands for a short-term health condition or a chronic health problem, it is difficult to identify if this variable is a proxy for genetic factors. However, not-so-healthy parents, whether their condition is temporally or chronic, might not be able to care for their children as effective as healthy parents.

1.5. Endowment Effects

The endowment effects include several variables: race, gender, and child birth weight. Overall, the results are similar to the health demand function above. Non-white children face a higher likelihood of being overweight or obese, with the odds ratios ranging from 50% higher (for Asian children) to 3.9 times higher (for Hispanic children) compared to white children. Girls in the age group of 5–12 years old have lower odds ratios of being overweight compared to boys. A pound heavier at birth translates into a

[37] The programmed aerobic alternative required the child to perform an aerobic exercise daily.

62% increase in the odds ratios of becoming overweight when the child is in the elementary school age range.

1.6. Other Effects

Similar to the health demand estimation above, urbanization and region of household residence, and a dummy variable for time (for each round of data) are all consistent with previous findings. However, Midwest area is now significant at the 90% level, with an odds ratio of 1.45. That is, children from Midwest region are about 45% more likely to be overweight compared to children from the Western region.

Children who live in rural areas are more likely to be overweight than those who live in urban areas or large towns. The time dummy variables show that the cohort of children in this sample are more likely to be overweight or obese in subsequent rounds of data compared to the beginning of the study when they were in kindergarten.

For this health production mixed-effects ordered Logit model, the two cut-off points are significant at the 1% level. These are the intercepts used to differentiate normal from overweight and obese (cut-off 11) and normal and overweight from obese (cut-off 22) when independent variables are evaluated at zero.

1.7. Random Intercepts

The estimated intra-class correlations in this health production function show that 82% of the variation in BMI observed is at the student level and 7% is at the school level (using formula (28) and (29) in chapter 5). At the baseline, different schools differ from each other with a standard deviation of 1.12 in mean BMI scores while differences among students within the same school are greater, with a standard deviation of 3.75 in mean BMI scores. Overall, the likelihood ratio test indicates statistical significance at the 1% level or better (99% confidence level) for this model when compared to the null model with no covariates.

In conclusion, analysis of the ECLS-K 1998–99 suggests an important connection between parental working hours and the likelihood of children being overweight. Working hours of person 1 (85 percent of this group are mothers) have a positive effect on the higher likelihood of a child being overweight or obese. Working hours of person 2 (the other adult in a household when applicable) are not statistically significant although this odds ratio is greater than 1 (more likely to be correlated with overweight child).

Moreover, after controlling for household socioeconomic status, a set of environmental and endowment factors are found to be significantly correlated with childhood obesity. Home environment[38] factors include child care settings and single-parent households (both are positive), number of siblings a child has, whether a child is involved in a variety of physical activities, and parental health (all are negative). Only one significant factor from the set of school environment[39] variables is school lunch participation (positive). Endowment factors include a child's birth weight (positive), race (positive for non-white children), being female, and living in large urban area (both are negative).

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[38] & [39] Environmental factors are labeled "health inputs" and are only used in the health production estimation.

Chapter 8

Empirical Results for Part Two: Childhood Weight and Educational Outcomes

This section discusses the regression results of the mixed-effects model used to analyze the relationship between a child's weight status and educational outcomes. In this study, the educational production equation is specified for the ith child at tth time (round of data) and kth school as follows:

$$(\text{Test scores})_{itk} = \beta_0 + \beta_1(\text{Child weight status})_{itk} + \beta_2(\text{Child and household characteristics})_{itk} + \beta_3(\text{Teacher qualification})_{itk} + \beta_4(\text{School factors})_{itk} + \varsigma_{ik}^{(\text{Student})} + \varsigma_{k}^{(\text{School})} + \varepsilon_{itk}$$

Results presented in Table 4 include only variables that are significant at 10% or higher and omit control variables such as race, regions, and residence locality. See the appendix; table C for complete tables of result.

1. Students' Weight Status

In this model, the dependent variables are standardized reading and math scores. Independent variables include four main groups: (1) students' weight status, (2) other students and households' characteristics, (3) teachers' characteristics, and (4) schools' factors.

Student's weight status is considered in two ways: *current weight status* and *weight status over time*. In the *current weight status* approach, normal weight (NW) is used as base, to compare with underweight (UW), overweight (OW), and obese (OB). In the *weight status over time* approach (i.e., change in weight status between two rounds of data), students who have been normal weight (AN) are used as base, to compare with students who become normal weight (BN), become overweight (BO), or always overweight (AO) between given two rounds of data.

When *current weight status* of students is used as an explanatory variable, OB children have lower reading scores compared to NW students, by 0.3 units of standardized score. UW, OW, and OB students also achieve lower math scores compared to NW students. UW students have .73 units, OW students have .42 units, and OB students have .54 units lower in standardized math scores compared to NW students.

When *weight status over time* of students is used, there is no significant difference among BN, BO, AO, and normal students in reading scores. However, BO students achieve .46 units lower and AO students achieve .37 units lower in math test scores compared to normal weight students.

These results reinforce and are somewhat stronger than previous studies on several aspects. First, all the results interpreted here are from full models that control for an extensive set of explanatory variables including child and household characteristics as well as teacher and school factors. Second, they show a consistent pattern through different weight status classifications. To illustrate, a comparison of the results here with three other studies which use longitudinal data and various econometric methods to study the link between childhood overweight statuses and academic outcomes follows.

Table 6: Multilevel mixed-effects results.

Variables	Variables description	Values	Current overweight status		Overweight status over time	
READ/MATH	Dependent variables	IRT scale scores	Reading	Math	Reading	Math
Student's characteristics						
BN	Student becomes normal weight	0: no, 1: yes			-0.003	0.156
					(0.278)	(0.267)
BO	Student becomes overweight	0: no, 1: yes			-0.233	-0.455***
					(0.155)	(0.151)
AO	Student has been overweight	0: no, 1: yes			-0.089	-0.367**
					(0.157)	(0.158)
BMI_0	Student is underweight	0: no, 1: yes	-0.177	-0.726**		
			(0.327)	(0.315)		
BMI_2	Student is overweight	0: no, 1: yes	-0.134	-0.422***		
			(0.149)	(0.145)		
BMI_3	Student is obese	0: no, 1: yes	-0.304*	-0.541***		
			(0.169)	(0.169)		
BWEIGH	Birthweight	In ounces	0.012***	0.024***	0.012***	0.025***
			(0.003)	(0.004)	(0.003)	(0.004)
CHREAD	Frequency of time a student reads by him/herself per week outside of school	0: less than 2 times - 1: 3 or more	1.792***		1.803***	
			(0.120)		(0.119)	
BEDTIME	Bedtime	0: before 10pm, 1: after 10pm	0.786**	0.669***	0.796***	0.675***
			(0.249)	(0.240)	(0.247)	(0.238)
NUMTV	Number of hours a student watches TV per day	0-8	-0.107**	-0.103*	-0.121**	-0.102**
			(0.053)	(0.052)	(0.053)	(0.051)
HRSNOW	Number of hours a student receives non-parental care per week	0-146	-0.020***	-0.005	-0.019***	-0.005
			(0.006)	(0.006)	(0.006)	(0.006)
GEND	Gender	0: male, 1: female	0.722***	-1.361***	0.727***	-1.372***
			(0.140)	(0.147)	(0.140)	(0.146)
Parents' and household's characteristics						
PSINVOL	Index of parent's involvement with student's school activities	Index of 5 activities	0.182***	0.308***	0.193***	0.299***
			(0.051)	(0.049)	(0.050)	(0.049)
NUMPLA	Number of places a student lives during the last year of interview time	0-5	-0.276	-0.977***	-0.247	-0.944***
			(0.298)	(0.285)	(0.295)	(0.283)
EXPECT	Parents' expectation for student's schooling	0: at least up to college, 1: at least finish college	1.759***	1.545***	1.758***	1.558***
			(0.140)	(0.134)	(0.138)	(0.133)
DISCIP	Type of discipline	0: non-physical, 1: physical	0.334*	0.199	0.382**	0.224
			(0.178)	(0.172)	(0.176)	(0.170)
NUMSIB	Number of sibblings a student has	0-14	-0.553***	-0.249***	-0.562***	-0.260***
			(0.063)	(0.064)	(0.063)	(0.064)
PARED	Parents' highest level of education	0: less than highschool - 3: BA or higher	1.491***	1.508***	1.478***	1.496***
			(0.094)	(0.095)	(0.093)	(0.094)
IN15C	Household income, <$15,000/yr	0: no, 1: yes	-2.349***	-2.301***	-2.316***	-2.263***
			(0.296)	(0.290)	(0.293)	(0.287)
IN30C	Household income, $15,001-$30,000	0: no, 1: yes	-1.631***	-1.649***	-1.620***	-1.659***
			(0.222)	(0.217)	(0.219)	(0.215)
IN50C	Household income, $30,001-$50,000	0: no, 1: yes	-1.091***	-1.262***	-1.090***	-1.278***
			(0.175)	(0.172)	(0.174)	(0.171)
IN75C	Household income, $50,001-$75,000	0: no, 1: yes	-0.404***	-0.485**	-0.441**	-0.480***
			(0.155)	(0.150)	(0.153)	(0.149)
FSSTAT	Food security status, household has food problem sometimes	0: no, 1: yes	-0.098	-0.417*	-0.197	-0.564**
			(0.268)	(0.263)	(0.265)	(0.260)
HOMECM	Household has computer for student's use	0: no, 1: yes	0.868***	0.943***	0.880***	0.889***
			(0.144)	(0.138)	(0.142)	(0.137)

Teacher's characteristics						
YRSTC	Teacher's years of teaching	0-39	0.051**	0.009	0.053***	0.009
			(0.019)	(0.018)	(0.019)	(0.018)
TDEGREE	Teacher's degree	0: less than master/ professional degree, 1: otherwise	-0.092	0.225*	-0.104	0.220**
			(0.114)	(0.107)	(0.112)	(0.106)
School characteristics						
PRIVATE	Private school	0: no, 1: yes	0.940***	-0.089	0.924***	-0.116
			(0.258)	(0.260)	(0.256)	(0.260)
PERREAD/MATH	Percentage of student in school tested at or above grade level on national	0-100	0.012***	0.017***	0.013***	0.018***
			(0.003)	(0.003)	(0.003)	(0.003)
TRNOVR	A school experiences problems of teacher's turn over rates	0: no, 1: yes	-0.354**	0.038	-0.363*	0.029
			(0.162)	(0.154)	(0.161)	(0.153)
SCHMINOR	Percentage of minority students in school	0: up to 10 - 4: 75 or more	-0.293***	-0.152**	-0.275***	-0.154**
			(0.072)	(0.070)	(0.071)	(0.070)
S1COMM	Community where the school is located	0: up to 100,000 in population, 1: otherwise	0.732***	0.702***	0.757***	0.745***
			(0.215)	(0.219)	(0.213)	(0.218)
Random-effects parameters						
S2ID_cons	Standard deviation of school-level constant		1.945	1.895	1.936	1.910
			(0.109)	(0.115)	(0.109)	(0.115)
ID_cons	Standard deviation of student-level constant		5.607	6.302	5.617	6.303
			(0.069)	(0.065)	(0.066)	(0.065)
Resid.	Standard deviation of the model's residual		4.829	4.368	4.816	4.347
			(0.041)	(0.037)	(0.040)	(0.037)
Rho (school)	The intraclass correlation for different students within a school		0.065	0.058	0.064	0.059
Rho (student,school)	The intraclass correlation for same student over time		0.537	0.597	0.539	0.638
N	Number of observations		17,780	17,727	18,072	18,016

Standard errors in parentheses
*p<0.10 **p<0.05 *** p<0.01

A study by Datar and Sturm (2006) investigated the same issue as this study, using the same dataset, ECLS-K, The authors found that becoming OW between kindergarten entry and the end of third grade is associated with reductions in test scores in girls but not in boys. However, the Datar and Sturm (2006) study is different from this research in three important ways. First, the dataset they used was available up to third grade only. Second, the authors employed school-level random effects (school cluster) modeling while a multilevel cluster structure, both at the school- and student-level, is used in this dissertation. Third, the set of control variables is more extensive in this research. Important variables such as parents' expectation for student's schooling, student's learning problems, teacher's characteristics, and certain school characteristics (e.g., percentage of students in a school testing at or above grade level on national tests, teacher turnover rates) are not controlled for in the Datar and Sturm paper. In other words, since these variables could potentially capture the motivation factor that is confounding both the explanatory and dependent variables, not controlling for them could lead to omitted variables bias (see Greene 2003, section 8.2 or Wooldridge 2002, section 4.1 for a thorough discussion).

Using data from the National Longitudinal Survey of Youth 1979 cohort, a study by Averett and Stifel (2007) reports a significant correlation between standardized BMI scores and math scores. This relationship is positive for UW children and negative for OW children. Specifically, a 1.0 standard deviation (SD) increase in BMI for age at the UW threshold leads to a .03 SD increase (for fixed-effects model) or a 1.37 SD increase (for hetero-instrument variable model) in math scores. On the other hand, a 1.0 SD increase in standardized BMI leads to between a .25 and .88 SD decline in math scores for overweight children. Although the results are consistent through five different estimating techniques (to control for unobserved characteristics and reverse causality), their magnitude vary greatly among models used. The authors note that this might due to weak instruments.

In contrast to the findings of this research, a study by Kaestner and Grossman (2008) shows that a significant difference in math test scores between UW and OB (with a base of NW) diminishes as maternal characteristics are added into the cross-sectional regression results. With a first-difference method (in longitudinal settings), the results show no consistent evidence that being either UW or OB is associated with lower test scores. This pattern holds for both male and female students, and for all three age-groups: 7–8 year olds, 9–10 year olds, and 11–12 year olds. The results are unchanged with an instrumental variable technique. The authors conclude that OW or OB children have test scores that are about the same as children with average weight. Note that the authors use the same dataset as in Averett and Stifel (2007).

Unlike this dissertation, neither Averett and Stifel (2007) nor Keaestner and Grossman (2008) controls for teacher or school inputs, which theoretically have a strong impact on student achievement. Both of these papers are listed as working papers in the National Bureau of Economic Research (NBER) Working Paper Series.

2. Student Characteristics

Except for the differences in the results between the two ways of classifying student weight status discussed above, the rest of the explanatory variables yield similar results between these two sets of regression. Therefore, the results from the set of regression with *current weight status* will be discussed from this point on.

Besides the effects of weight status on academic outcomes, a set of other student characteristics is also controlled for in this research. Higher birth weight is positively correlated with higher test scores[40]. A pound heavier at birth corresponds to a .2 (0.012*16oz) higher score in reading and a .4 higher math score. Frequency of reading by students outside of school settings is correlated with 1.8 unit increase in reading scores. This reading frequency variable is important since it captures a student's motivation in

[40] Although birth weight has been shown to be a strong predictor of weight categories, using both of them as explanatory variables do not create a multicollinearity problem in the reported models. This is based on pairwise correlation scores in a multiple variables correlation table.

learning and enjoying reading. Previous studies (e.g., Datar and Sturm 2004 and 2006) that use the same dataset have often skipped this subtle variable.

Controlling for other activities that might compete for studying time, the results show that the more hours students spend watching TV, the lower their reading and math scores. This observation is in line with previous studies that used the displacement theory to explain this association (Hancox et al. 2005; Zimmerman and Christakis 2005). However, several studies that control for the content of TV programs show that there might be a positive correlation between children's educational TV viewing and subsequent academic achievement (Anderson et al. 2001; Wright et al. 2001). The content of TV programs is not controlled for in this research.

The number of hours that students spend in child care settings is negatively correlated with their reading scored but not with their math scores. Since this variable represents only those students who receive child care, caution should be taken in interpreting its meaning. First, we cannot say much about the difference, if there is any, between the students who are cared for by parents and those who receive child care from others. Second, the sources of child care are not controlled for, and there is no indication of the quality of child care programs. Therefore, we merely observe the negative effect of long hours spent in child care on lower reading skills. It is worthwhile to note that the literature studying the effects of child care quality is much larger and more conclusive than the literature concerned with child care quantity, but the effects tend to diminish after kindergarten age, and vary across different socioeconomic groups (Downer and Pianta 2006; Magnuson et al. 2006; Belsky et al. 2006).

Girls score higher than boys in reading but boys have higher math scores than girls. This pattern emerges clearly from the descriptive statistics of this dataset (Tourangeau et al. 2006). The large body of literature on this topic seems to be controversial. A meta-analysis of 100 studies published between 1963 and 1988 (Hyde et al. 1990) reveals that there is no gender difference in mathematics—particularly in problem solving—between boys and girls at the elementary school level. In fact, girls show a slight superiority in computation skill. However, differences favoring men and math scores emerge in high school and in college. This is in contrast to many other studies (Benbow and Stanley 1983; Leahey and Guo 2001). The literature on reading skills is less controversial: girls tend to have higher levels of reading motivation than boys (Wigfield and Guthrie 1997; Wigfield et al. 1997).

3. Household Characteristics

There are a number of household characteristics that affect students' academic outcomes. Students whose parents have at least finished high school, have high expectation for their children's schooling (i.e., that their children at least finish college), and are more involved in their children's school activities outperform their peers. Similar to previous literature, household income level shows a strong correlation with a academic outcomes of students. Compared to households with annual income of at least $75,000, students in households in any other income groups score lower, with students at the lowest income level scoring the lowest on both math and reading tests.

Students in households that have a computer also score higher in both tests compared to those who do not have a computer at home. The pair-wise correlations between parental education and these household characteristics range from .31 to .39, which do not seem to cause multi-collinearity problems in all regressions. Students from households with some level of food insecurity achieve lower math scores, by about 0.42 units. This negative relationship has been shown by previous studies (Center on Hunger, Poverty and Nutrition Policy 1999; Alaimo et al. 2001; Winicki and Jemison 2003).

Students whose parents tend to use physical discipline more frequently than non-physical methods have significantly higher scores in reading but not in math. This result seems to be counterintuitive. First, children whose parents use harsh methods tend to suffer from some type of behavior problem (Vitaro et al. 2006). Second, there is a consensus that children with some type of behavioral problem (e.g., oppositional defiant disorder) tend to achieve lower scores than their peers (Kellam et al 1998; Snyder 2001). The literature on this particular topic (physical vs. non-physical discipline) is thin, although there is a large body of studies on parenting styles and students' academic achievement.

Brown and Iyengar (2008) conducted a comprehensive review of the literature on parenting styles and student achievement. Their result shows that authoritarian parents (parents who give firm direction, but also provide warmth and reasons for their children with verbal give-and-take) have the most positive influence on student academic achievement. However, the complexity between definitions of parenting styles (i.e., authoritarian versus authoritative versus permissive) and actual behavior still needs clarification. Moreover, the overlapping effects linking parenting styles and children's behavior problems, as well as the connections between children's behavior problems and their academic performance further complicate this association.

The higher the number of siblings a student has, the lower his or her reading and math scores. This result is in line with perhaps one of the most robust effects in human capital studies across academic disciplines over the last few decades (Powell and Steelman 1990; Conley and Glauber 2005). The two most accepted explanations for this phenomenon are the confluence model (Zajonc and Markus 1975) and the resource dilution hypothesis (Anastasi 1956; Blake 1981). See Powell and Steelman (1990) for detailed discussion on these two explanations.

Frequently moved households seem to be deleterious to students' performance in math but not in reading skills. Although there is no clear reason for the difference between reading and math results, perhaps reading skills are less curriculum-dependent compared to math skills. Although this observation may be purely speculation, available information at the national level shows some support; mathematical understanding among U.S. elementary students is often shown to lag behind that of their peers in other countries (National Commission on Excellence in Education 1983; Putnam et al. 1990).

4. Teacher Characteristics

Teacher experience, measured by a teacher's years of teaching, is positively correlated with students' reading, but not math, scores. On the other hand, teachers with at least a masters or professional degree are associated with their students' higher math scores but not reading scores. Comprehensive literature reviews by Darling-Hammond

(1999) and Whitebook (2003) confirm the general consensus of teacher quality on student's achievement.

5. School characteristics

There is a broader range of school characteristics that are controlled for in this research compared to previous studies. Five variables emerge as important: (1) whether or not the school is a private school, (2) the percentage of students in school testing at or above grade level in standardized tests, (3) the size of community where the school is located, (4) teacher turnover rates, and (5) the percentage of minority students in a school. The first three factors are positively and the last two are negatively associated with reading and math scores.

Private school students achieve higher reading scores than public school students. The difference in math scores is minimal. These patterns are consistently observed from longitudinal descriptive statistics of this dataset which has the latest round for eighth graders (Walston et al. 2008). The variable that indicates the percentage of students in school testing at or above grade level in standardized tests is an important factor because it represents the school-specific performance level. In other words, the higher the scores across a school, the higher the scores for individual students. This variable captures the often unobserved characteristics of schools. Teacher turn-over rates are another important indicator of school atmosphere, be it stability or adequate support for teachers and staff.

Overall, the significant relationships between teacher and school characteristics and student academic achievement are sustained by numerous studies. The results in this dissertation support previous studies, such as findings from a meta-analysis by

Greenwald et al. (1996) and more recent studies by Rowan et al. (2002) and Rivkin et al. (2005).

6. Model Goodness of Fit

The random-effect parameters are statistically significant in the multilevel mixed-effects model. In the reading equation, the standard deviation is 1.95 at the school level and 5.61 at the student level. That is, on average, schools vary from the population mean with a standard deviation of 1.95 points and students within a school vary from the school mean with a standard deviation of 5.61 points on standardized reading tests.

The correlation among students within a school is 0.07 and within a student is 0.54 (See formulas (31) and (32) in chapter 5). That is, the variation of reading scores over four rounds of data is due mostly to student characteristics (54%); only 7% is due to school factors. The rest is due to error terms (unobserved).

In the math equation, the standard deviation is 1.89 at the school level and 6.30 at the student level. The correlation among students within a school is 0.06 and within a student is 0.60. The likelihood ratio tests that measure the goodness of fit are significant in all models. Separate likelihood ratio tests are used to test the (joint) significance of the weight status, either *current* or *over time*. The results prove that these weight variables play a significant role in explaining the variations among test scores.

Chapter 9

Conclusion and Future Research

1. Conclusion

Effective policies and programs to alleviate childhood obesity require an understanding of underlying determinants as well as consequences. This study adds to the rapidly expanding literature that has greatly increased our knowledge on this topic over the last several years. There are two parts of this study: part one estimates factors associated with childhood obesity, with a focus on parental time constraints; part two analyzes the impact of childhood obesity on school performance.

1.1. Part One: Economic, Environmental, and Endowment Effects on Childhood Obesity

Utilizing the theoretical economic models of household production, the first part of this study focuses on the influence of parents' time constraints on producing healthy children, particularly children of normal weight. Given the assumption that both nature and nurture factors affect childhood obesity, the analysis includes a set of environmental and endowment variables while controlling for a set of socio-economic factors.

Due to the hierarchical and longitudinal structure of the data, (there are several measures for individual students, and students are nested within schools), a mixed-effects ordered Logit model (proportional odds) is used. Particularly, this model is fitted under the framework of Generalized Linear Latent and Mixed Models (GLLAMM) which incorporates structural information into the data. Two economic functional forms—health demand and health production—are estimated.

The results of part one reinforce and extend the findings of previous research in this area. The number of hours parents, particularly mothers[41], work (for pay), positively affects the likelihood of children being overweight. This result makes intuitive sense on two counts. First, in two-adult households, fathers often work full time while mothers' work hours vary. Therefore, it is more likely to be the mother who has more time to spend with children, supervising them on nutritional intake and energy expenditure. Second, parents working fewer hours per week (regardless of which parent) have more time for family activities such as shopping, cooking, and organizing children's physical activities, all of which have direct effects on children's health and BMI scores. This variable is significant in both the health demand and health production functions.

Specifically, the health demand regression is a function of prices, wage rates, and full income, given family and child characteristics. In this study, a greater number of siblings, a high school degree for parents, and higher household annual income ($75,000 or higher) are found to be negatively correlated with the likelihood of a child being overweight or obese. Non-white boys with higher birth weights are found to be positively correlated with the likelihood of being overweight or obese.

Market information that includes a measure of price level (median monthly owner's costs of owner-occupied housing units with a mortgage) and wage rates (county-level median wage rates for all occupations in all industries) are not statistically significant in this estimation of the health demand function. Other control factors such as urbanization

[41] Recall that 85 percent of respondents (hence "person 1" as opposed to "person 2," the other adult in a household) are mothers in this dataset.

and region are in line with previous studies and similar to the trends depicted from the NHANES data (CDC 2005).

In the health production regression, an additional set of variables that stands for health inputs is considered. Children who receive child care (i.e., those that are *not* cared for by their parents) in private homes are more likely to be overweight than children who are cared for by parents or by center-based child care services. Children who receive complete lunch from school and those whose parents are not in excellent health are more likely to be overweight or obese. On the other hand, children who are involved in a variety of physical activities such as recreational sports are less likely to be overweight compared to those who do not.

Overall, these results are in agreement with previous findings across disciplines such as economics, sociology, and epidemiology.

1.2. Part Two: Childhood Overweight and Academic Outcomes

Using the theory from the educational production framework, the second part of this study analyzes the impact of being overweight and becoming overweight on children's reading and math test scores. This analysis also includes a comprehensive set of household, teacher, and school characteristics.

Due to the hierarchical structure of the dataset, a mixed-effects linear model is used. Particularly, this model examines factors that affect a student's achievement at the student and school (students nested within schools) levels[42].

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[42] With the potential endogeneity problem that often plagues economic studies, two other econometric models were also employed. First, a Hausman-Taylor (HT 1981) method was used to control for individual heterogeneity. This is a good alternative to traditional fixed-effects models which suffer from dropping all time-invariant explanatory factors. Second, a dynamic model that utilizes a set of methods by Arellano-

The results show that overweight students achieve lower scores on standardized tests, particularly for mathematics. This pattern remains significant whether current weight status or changes in weight status over time are used as explanatory variables. Frequency of reading time outside of school settings is positively correlated with a student's reading score. On the other hand, the higher the number of hours a student is in child care (i.e., non-parental care), the lower the reading scores. Also, the more hours a student spends watching TV, the lower the student's scores in both reading and math.

Besides a student's weight status and activities, a set of household characteristics emerges as important variables in explaining the student's academic achievement. Parents with at least a high school degree, parents with high expectation for their child's schooling, and parents with a high level of involvement in their child's school activities are positively correlated with higher scores in students' tests. Households that move frequently, households that experience some type of food insecurity, and households with more siblings are all negatively correlated with students' test scores.

Teachers' characteristics do not show a strong correlation with students' achievement with the exception of the teacher's experience (measured by the number of years teaching) and their educational degree (Masters or professional degree or higher). Experienced teachers are correlated with higher reading scores and teachers with higher degrees are correlated with higher math scores.

Bond (1991) and Arellano-Bover (1995)/Blundell-Bond (1998) called generalized method of moments (GMM) estimation is used. This model utilizes available instruments within a longitudinal dataset (i.e., lags of the instrumented variables) to eliminate the problem of continuing endogeneity, or dynamic panel bias. However, since neither one of these models pass model-specific tests (the overidentifying tests for qualifying instruments in both models, and the Difference-in-Hansen tests for exogeneity of instrument variables for the GMM model), the results are not reported in this dissertation.

Several school characteristics are significantly correlated with student achievement. Schools with a higher percentage of students who tested at or above grade level in standardized tests are positively related to individual students' scores. Higher teacher turnover rates and a larger percentage of minority students in schools are negatively correlated with students' test scores. Private school students achieve higher reading scores but do not receive not higher math scores.

While the second part of this dissertation focuses on the link between overweight students and their academic performance, all regressions that use current weight status include the underweight category as well. Results show that underweight children achieve lower math—but not reading—scores compared to normal-weight children. In other words, malnutrition appears to be a significant factor associated with test scores at the elementary school level.

In short, these results imply that academic achievement (reading and math scores) are importantly linked to childhood malnutrition, particularly for obese children. If malnourished children perform poorly on cognitive tests, and if this trend persists into adulthood, it is likely that they will be less productive adults. Clearly, the economic consequences of these problems, malnourishment and low productivity, are incurred at both individual and societal levels.

Taken together, these results emphasize the need for reducing childhood malnutrition, particularly childhood obesity. This task cannot be accomplished without a collaboration of efforts dealing with government policies, parents' time commitments, and schools' involvement in addressing the childhood obesity problem. Schools can promote good nutrition through healthy school meals and physical activities through physical and health education programs. Given a strong link between parental working hours and child overweight status, flexibility in working hours and good benefits such as health insurance for parents who choose to work would promote the effectiveness of parents in caring for their children. Most importantly, government programs that affect both school-based and home-based efforts such as school lunch, physical education programs, and working conditions could play a major role in curbing the childhood obesity problem.

2. Future Research

This study raises several important issues which can be explored in future research. First, with the available information on household and school locations, better market information could be used to strengthen the price-level measures in the first part of this dissertation. Furthermore, external data that could serve as instrumental variables should be exploited to address the potential problem of endogeneity between children's activity levels and obesity. In addition, subsequent data rounds with more detailed information on food intake could also be incorporated into the model. Likewise, good instruments from external data could complement the models used in the second part of this study.

Besides the methodology matter, there are several other issues that could be pursued further from the results of part one in this dissertation. The relationship between school lunch programs and childhood obesity deserves further study. The literature on this topic is currently thin and controversial. One possible way to further this understanding is to compare nutrition components among school lunches, lunches brought from home, and lunches bought from *à la carte* menus available in the school cafeteria. In addition, food intake patterns over time should also be considered to complement the nutrition components.

Another interesting issue is the consistent trend of childhood obesity that is linked with non-parental child care in the home. For example, controlling for the selection bias of choices of child care service may reveal new insights.

There are several issues from the results of part two of this study that warrant further study. The mechanism mediating the effect that being overweight has on a child's educational outcomes could be explored. One possible method is to construct latent factors and utilize GLLAMM to model the effects of a child being overweight together with other exogenous variables. Specifically, a model could be constructed to allow a child's overweight status to affect a set of mediating mechanisms (e.g., psychological, medical, and certain behavioral problems) which in turn influence academic scores. In other words, a constructed latent variables method might help us better understand the mechanisms through which childhood obesity affects educational outcomes in children and adolescents.

Given the result that TV hours are negatively correlated with test scores, more details of specific programs or other parental rules regarding TV watching may yield better understandings of this effect. Likewise, total screen time (e.g., computer, video games, and TV) might be a better choice if the hypothesis of time-displacement holds.

REFERENCE

Agras, W.S., L.D. Hammer, F. McNicholas, and H.C. Kraemer, "Risk factors for childhood overweight: a prospective study from birth to 9.5 years." *The Journal of pediatrics* 145 (2004):20-5.

Alaimo, K., C.M. Olson, and E.A. Frongillo Jr., "Low family income and food insufficiency in relation to overweight in US children: is there a paradox?" *Archives of Pediatrics & Adolescent Medicine* 155 (2001):1161-7.

American Academy of Pediatrics, online resource at http://www.aap.org

Anastasi, A. "Intelligence and Family Size," *Pschychological Buletin* 53 (1956): 187-209.

Anderson, D.R., A.C. Huston, K.L. Linebarger, and J.C. Wright, "Early Childhood Television Viewing and Adolescent Behavior: Monographs of the Society for Research in Child Development" *Blackwell Publishing*, 2001.

Anderson, P.M., and K.F. Butcher, "Childhood Obesity" *The Future of Children* 16 (2006):19-45.

Anderson, P.M., K.F. Butcher, and P.B. Levine, "Economic Perspectives on Childhood Obesity." *Economic Perspectives* 27 (2003): 30-49.

Arellano, M., and S. Bond, "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations." *Review of Economic Studies* 58 (1991): 277–97.

Arellano, M., and O. Bover, "Another look at the instrumental variables estimation of error components models." *Journal of Econometrics* 68 (1995): 29–51.

Averett, S.L., and D.C. Stifel, "Food for Thought: The Cognitive Effects of Childhood Malnutrition in the United States." (2007) Working paper. Dept. of Economics and Business, Lafayette College, Easton, PA.

Baird, J., D. Fisher, P. Lucas, J. Kleijnen, H. Roberts, and C. Law, "Being big or growing fast: systematic review of size and growth in infancy and later obesity." *British Medical Journal* 331 (2005):929-34.

Becker, G.S., "A Theory of the Allocation of Time." *Economic Journal* 75 (1965):493-517.

Becker, E. and M. Burros., "Eat Your Vegetables? Only at a Few Schools." *The New York Times,* January 13, 2003, pp. A1 & A12.

Belsky, J., "Early child care and early child development: Major findings of the NICHD study of early child care." *European Journal of Developmental Psychology* 3 (2006): 95-110.

Benbow, C., and J. Stanley, "Sex differences in mathematical reasoning ability: more facts." *Science* 222 (1983):1029-31.

Besharov, D., “Growing Overweight and Obesity in America: The Potential Role of Federal Nutrition Programs,” testimony before the Committee on Agriculture, Nutrition, and Forestry, April 3, 2003. http://agriculture.senate.gov/Hearings/03ap3besh.pdf. Accessed online on February 10, 2008.

Bettylou, S, Zuguo, M., Scanlon, S. Mokdad, A., Grummer-Strawn, L., "Trends in State-Specific Prevalence of Overweight and Underweight in 2- through 4-Year-Old Children from Low-Income Families from 1989 through 2000." *Archives of Pediatric and Adolescent Medicine* 158 (2004): 1116–24.

Beunen, G., H.H. Maes, R. Vlietinck, R.M. Malina, M. Thomis, E. Feys, R. Loos, and C. Derom, "Univariate and Multivariate Genetic Analysis of Subcutaneous Fatness and Fat Distribution in Early Adolescence." *Behavior genetics* 28 (1998): 279-288.

Behrman, J.R., R.A. Pollak, and P. Taubman, *From Parent to Child: Intrahousehold Allocations and Intergenerational Relations in the United States,* University Of Chicago Press, 1995.

Bianchi, S.M., and S.B. Raley, "Time allocation in families." *Work, Family, Health, and Well-Being* (2005):21-42.

Bishop, J. and Wößmann, L. Institutional Effects in a Simple Model of Education Production. *Education Economic* 12 (2004): 17-38.

Blake, J., “Family Size and the Quality of Children.” *Demography* 18 (1981): 421-42.

Blundell, R., and S. Bond., “Initial conditions and moment restrictions in dynamic panel data models.” *Journal of Econometrics* 87 (1998): 11–143.

Bond, J.T., E. Galinsky, and J.E. Swanberg “The 1997 National Study of the Changing Workforce.” *Families and Work Institute*, New York, 1998.

Borzekowski D.L and T.N. Robinson, “The 30-second effect: an experiment revealing the impact of television commercials on food preferences of preschoolers.” *J Am Diet Assoc* 101 (2001):42-46.

Bouchard, C., and A. Tremblay, "Genetic Influences on the Response of Body Fat and Fat Distribution to Positive and Negative Energy Balances in Human Identical Twins." *Journal of Nutrition* 127 (1997):943-7.

Brown, L., and S. Iyengar, "Parenting Styles: The Impact on Student Achievement." *Marriage and Family Review* 43 (2008):14-38.

Bryden KE, L.C. Kopala., “Body mass index increase of 58% associated with olanzapine.” *Am J Psychiatry* 156 (1999):1835-1836.

Burton, W.N., C.Y. Chen, A.B. Schultz, and D.W. Edington, "The economic costs associated with body mass index in a workplace." *Journal of occupational and environmental medicine / American College of Occupational and Environmental Medicine;* 40 (1998):786-92.

Carlson, M.J., and M.E. Corcoran, "Family Structure and Children's Behavioral and Cognitive Outcomes." *Journal of Marriage and Family* 63 (2001):779-92.

Cawley, J. Meyerhoefer, C., and Newhouse, D., “The Impact of State Physical Education Requirements on Youth Physical Activity and Overweight.” *Health Economics* 16(2007): 1287-1301.

Center on Hunger, Poverty and Nutrition Policy, “Statement on the Link between Nutrition and Cognitive Development in Children.” Center on Hunger, Poverty and Nutrition Policy, Tufts University, Medford, MA, 1999.

Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS). Health, United States, online resource http://cdc.gov/

Chou, S.Y.I., I. Rashad, and M. Grossman "Fast-Food Restaurant Advertising on Television and its Influence on Childhood Obesity." *NBER Working Paper No. W11584* (2005). Available at SSRN: http://ssrn.com/abstract=795268.

Coleman, J.S., Campbell, E.Q., Hobson, C.J, McPartland, J., Mood, A.M., Weinfeld, F.D., and York, R.L. “Equality of educational opportunity.” Washington, D.C.: U.S. Government Printing Office, 1966.

Conley, D., and R. Glauber, "Parental Educational Investment and Children's Academic Risk: Estimates of the Impact of Sibship Size and Birth Order from Exogenous Variation in Fertility." *NBER Working Paper* (2005)

Cooksey, E. C., and M. M. Fondell, “Spending time with his kids: Effects of family structure on fathers' and children's lives.” *Journal of Marriage and the Family*, 58 (1996): 693–707.

Critser G. *Fat Land: How Americans Became the Fattest People in the World*. Boston: Houghton Mifflin 2003.

Crockett, S.J. and Sims, L.S., “Environmental influences on children's eating,” *J Nutr Educ* 27 (1995): 235–249.

Crosnoe, R., and C. Muller, "Body Mass Index, Academic Achievement, and School Context: Examining the Educational Experiences of Adolescents at Risk of Obesity." *Journal of health and social behavior* 45 (2004): 393-407.

Csabi, G., T. Tenyi, and D. Molnar, "Depressive symptoms among obese children." *Eating and weight disorders* 5 (2000):43-5.

Cutler, D., E. Glaeser, J. Shapiro., "Why Have Americans Become More Obese?" *J. Econ. Perspect*. 17 (2003): 93–119.

Darling-Hammond, L., *Teacher Quality and Student Achievement: A Review of State Policy Evidence* Center for the Study of Teaching and Policy, University of Washington, 1999.

Datar, A., and R. Sturm., "Physical Education in Elementary School and Body Mass Index: Evidence from the Early Childhood Longitudinal Study." *American Journal of Public Health* 94 (2004):1501-6.

——— "Childhood overweight and elementary school outcomes." *International journal of obesity* 30 (2006): 1437-49.

Datar, A., R. Sturm, and J.L. Magnabosco, "Childhood Overweight and Academic Performance: National Study of Kindergartners and First-Graders." *Obesity research* 12 (2004): 58-68.

Dennison, B.A., T.A. Erb, and P.L. Jenkins, "Television Viewing and Television in Bedroom Associated with Overweight Risk Among Low-Income Preschool Children." *Preventive medicine* 33 (2001): 536-42.

Dietz, W.H., "Health consequences of obesity in youth: childhood predictors of adult disease." *Pediatrics* 101 (1998): 518-25.

Dowda, M., R.R. Pate, S.G. Trost, M.J. Almeida, and J.R. Sirard, "Influences of preschool policies and practices on children's physical activity." *Journal of community health* 29 (2004):183-96.

Downer, J.T., and R.C. Pianta, "Academic and Cognitive Functioning in First Grade: Associations with Earlier Home and Child Care Predictors and with Concurrent Home and Classroom Experiences." *School Psychology Review* 35 (2006):11-21.

Drewnowski, A., and S. Specter, "Poverty and obesity: the role of energy density and energy costs." *American Journal of Clinical Nutrition* 79 (2004):6-16.

Drewnowski, A., and N. Darmon, "The economics of obesity: dietary energy density and energy cost." *The American Journal of Clinical Nutrition* 82 (2005):265S-73S.

Ebbeling, C.B., D.B. Pawlak, and D.S. Ludwig, "Childhood obesity: public-health crisis, common sense cure." *The Lancet* 360 (2002):473-82.

Epstein, L. H., Wing, R. R., Koeske, R., and Valoski, A. " A comparison of lifestyle exercise, aerobic exercise and calisthenics on weight loss in obese children." *Behavior Therapy*, 16 (1985): 345–356.

Epstein, L.H. and Goldfield, G.S., "Physical Activity in the Treatment of Childhood Overweight and Obesity: Current Evidence and Research Issues." *Medicine and Science in Sports and Exercise* 31 (1999): S553-59.

Erickson, S.J., T.N. Robinson, K.F. Haydel, and J.D. Killen, "Are Overweight Children Unhappy? Body Mass Index, Depressive Symptoms, and Overweight Concerns in Elementary School Children." *Archives of Pediatrics and Adolescent Medicine* 154 (2000):931-5.

Eriksson, J., T. Forsén, J. Tuomilehto, C. Osmond, and D. Barker, "Size at birth, childhood growth and obesity in adult life." *International journal of obesity* 25 (2001):735-40.

Faith, M.S., K.L. Keller, S.L. Johnson, A. Pietrobelli, P.E. Matz, S. Must, M.A. Jorge, J. Cooperberg, S.B. Heymsfield, and D.B. Allison, "Familial aggregation of energy intake in children 1 2 3." *American Journal of Clinical Nutrition* 79 (2004):844-50.

Falkner, N.H., D. Neumark-Sztainer, M. Story, R.W. Jeffery, T. Beuhring, and M.D. Resnick, "Social, Educational, and Psychological Correlates of Weight Status in Adolescents." *Obesity* 9 (2001): 32-42.

Farooqi, I.S., and S. O'Rahilly, "Recent advances in the genetics of severe childhood obesity." *Archives of Disease in Childhood* 83 (2000):31-4.

Fellmeth, R.C., "The child care system in the United States." In: Wallace HM, Green G, Jaros KJ, eds. Health and Welfare for Families in the 21st Century. 2nd ed. Sudbury, MA: Jones & Bartlett Publishers; 2003.

Finkelstein, E.A., I.C. Fiebelkorn, and G. Wang, "National medical spending attributable to overweight and obesity: how much, and who's paying." *Health Affairs* 3 (2003):219-26.

Finkelstein, E.A., C.J. Ruhm, and K.M. Kosa, "Economic Causes and Consequences of Obesity." *Annual Review of Public Health* 26 (2005):239-57.

Finn, K., N. Johannsen, and B. Specker "Factors associated with physical activity in preschool children." *The Journal of pediatrics* 140 (2002):81-5.

Foster, G.D., S. Sherman, K.E. Borradaile, K.M. Grundy, S.S. Vander Veur, J. Nachmani, A. Karpyn, S. Kumanyika, and J. Shults, "A Policy-Based School Intervention to Prevent Overweight and Obesity." *Pediatrics* 121 (2008): e794-e802.

Fox, M.K., Hamilton, W., and Lin, B.H, " Effects of Food Assistance and Nutrition Programs on Nutrition and Health, Volume 3, Literature Review" Food Assistance and Nutrition Research Report No. 19-3, U.S. Department of Agriculture, Economic Research Service, October 2004.

French, S.A., M. Story, J.A. Fulkerson, and A.F. Gerlach, "Food Environment in Secondary Schools: A La Carte, Vending Machines, and Food Policies and Practices." *American Journal of Public Health* 93 (2003):1161-8.

Gillman, M.W., S.L. Rifas-Shiman, J. Camargo C.A., C.S. Berkey, A.L. Frazier, H.R.H. Rockett, A.E. Field, and G.A. Colditz, "Risk of Overweight Among Adolescents Who Were Breastfed as Infants." *JAMA* 285 (2001):2461-7.

Glanz F.,"Child and adult care food program." In: Fox MK, Hamilton W, Lin BH, eds. Effects of Food Assistance and Nutrition Programs on Health and Nutrition. Vol. 3. Literature Review. Food Assistance and Nutrition Research Report No. 19-3. Washington, DC: U.S. Department of Agriculture, Economic Research Service, Oct 2004.

Goland, M. and S. Crow, "Parents Are Key Players in the Prevention and Treatment of Weight-related Problems." *Nutrition Reviews* 62 (2004): 39-50.

Gortmaker, S.L., K. Peterson, J. Wiecha, A.M. Sobol, S. Dixit, M.K. Fox, and N. Laird, "Reducing Obesity via a School-Based Interdisciplinary Intervention Among Youth Planet Health." *Archives of Pediatrics and Adolescent Medicine* 153 (1999a): 409-18.

Gortmaker, S.L., L.W.Y. Cheung, K.E. Peterson, G. Chomitz, J.H. Cradle, H. Dart, M.K. Fox, R.B. Bullock, A.M. Sobol, and G. Colditz, "Impact of a School-Based Interdisciplinary Intervention on Diet and Physical Activity Among Urban Primary School Children Eat Well and Keep Moving." *Archives of Pediatrics and Adolescent Medicine* 153 (1999b): 975-83.

Greene, W. "Econometric Analysis. 5th edition." *New Jersey: Prentice-Hall*, 2003.

Greenwald, R., L.V. Hedges, and R.D. Laine, "The Effect of School Resources on Student Achievement." *Review of Educational Research* 66 (1996): 361-396.

Griffiths, L., D. Wolke, A. Page, and J. Horwood, "Obesity and bullying: different effects for boys and girls." *Archives of Disease in Childhood* 91 (2006): 121-5.

Grimsley, K.D. and R.H. Melton, "Homemakers Get Plenty of Support." The Washington Post, 22 March, 1998, p. A16.

Gruber, J., and M. Frakes, "Does falling smoking lead to rising obesity?" *Journal of health economics* 25 (2006): 183-97.

Guthrie, J.F., B.-H. Lin, and E. Frazao, "Role of Food Prepared Away from Home in the American Diet, 1977-78 versus 1994-96: Changes and Consequences." *Journal of Nutrition Education and Behavior.* 34(2002): 140-150.

Hammer, L.D., S. Bryson, and W.S. Agras. "Development of feeding practices during the first 5 years of life." *Archives of Pediatrics & Adolescent Medicine* 153 (1999):189-94.

Hancox, R.J., B.J. Milne, and R. Poulton, "Association of Television Viewing During Childhood With Poor Educational Achievement." *Archives of Pediatrics and Adolescent Medicine* 159 (2005):614-8.

Hanushek, E. The Economics of Schooling: Production and Efficiency in Public Schools. *Journal of Economic Literature,* 24 (1986): 1141-77.

________. Conclusions and Controversies about the Effectiveness of School Resources. *Educational Evaluation and Policy Analysis* 19(1997a): 141-164.

________. Assessing the effects of School Resources on Student Performance: An update. *FRBNY Economic Policy Review* 1998.

________. Publicly Provided Education. *NBER Working Paper No.8799*, 2002.

Hanushek, E.A., J.F. Kain, and S.G. Rivkin "New Evidence about Brown v. Board of Education: The Complex Effects of School Racial Composition on Achievement." *NBER Working Paper*, 2002.

Hausman, J.A. and Taylor, W.E. "Panel data and unobservable individual effects." *Econometrica* 49 (1981): 1377-1398.

Hearn, M.D., T. Baranowski, J. Baranowski, C. Doyle, M. Smith, L.S. Lin, and K. Resnicow "Environmental Influences on Dietary Behavior Among Children: Availability and Accessibility of Fruits and Vegetables Enable Consumption." *Journal of Health Education* 29 (1998):26-32.

Hirschler, V., M.I. Roque, M.L. Calcagno, C. Gonzalez, and C. Aranda "Maternal Waist Circumference and the Prediction of Children's Metabolic Syndrome." *Archives of Pediatrics & Adolescent Medicine* 161 (2007):1205-1210.

Hofferth, S.L. and Curtin, S. "Food programs and obesity among US children" Paper presented at the Association for Public Policy Analysis and Management, Washington, DC, November 6-8, 2003 http://www.gwu.edu/~labor/papers/hofferth.pdf

Hofferth, S.L., and J.F. Sandberg "How American Children Spend Their Time." *Journal of Marriage and Family* 63 (2001):295-308.

Horrigan, J.P., L.J. Barnhill, and R.R. Kohli "Adderall, the Atypicals, and Weight Gain." *Journal of the American Academy of Child & Adolescent Psychiatry* 40 (2001): 620.

Hyde, J.S., E. Fennema, M. Ryan, L.A. Frost, and C. Hopp "A Meta-Analysis." *Psychology of Women Quarterly* 14 (1990):299-324.

Institute of Medicine, U.S. National Academies, Child Health, 2004, online resource http://www.iom.edu/Object.File/Master/22/615/Fact%20Sheet%20-%20Schools%20FINALBitticks.pdf

Israel, A.C., and M.Y. Ivanova "Global and dimensional self-esteem in preadolescent and early adolescent children who are overweight: Age and gender differences." *International Journal of Eating Disorders* 31 (2002):424-9.

James, W.P.T., M. Nelson, A. Ralph, and S. Leather "Socioeconomic determinants of health: The contribution of nutrition to inequalities in health." *British medical journal* 314 (1997):1545.

Janssen, I., W.M. Craig, W.F. Boyce, and W. Pickett "Associations Between Overweight and Obesity With Bullying Behaviors in School-Aged Children." *Pediatrics* 113 (2004):1187-94.

Jolliffe, D. "Extent of overweight among US children and adolescents from 1971 to 2000." *Journal of the International Association for the Study of Obesity* 28 (2004):4-9.

Jyoti, D.F., E.A. Frongillo, and S.J. Jones "Food Insecurity Affects School Children's Academic Performance, Weight Gain, and Social Skills 1 2 3." *Journal of Nutrition* 135 (2005):2831-9.

Kaestner, R. and M. Grossman "Effects of Weight on Children's Educational Achievement." *NBER* Working Paper No.13764, 2008 Cambridge, MA: National Bureau of Economic Research.

Kater, K.J., J. Rohwer, and K. Londre "Evaluation of an upper elementary school program to prevent body image, eating, and weight concerns." *The Journal of school health* 72 (2002):199-204.

Kellam, S.G., X. Ling, R. Merisca, C.H. Brown, and N. Ialongo "The effect of the level of aggression in the first grade classroom on the course and malleability of aggressive behavior into middle school." *Development and psychopathology* 10 (1998):165-85.

Kubik, M.Y., L.A. Lytle, P.J. Hannan, C.L. Perry, and M. Story "The Association of the School Food Environment With Dietary Behaviors of Young Adolescents." *American Journal of Public Health* 93 (2003):1168-73.

Kuczmarski R.J., Ogden, C., Grummer-Strawn, L., et al. CDC Growth Charts: United States. Advance Data Report No. 314. Vital and Health Statistics of the Centers for Disease Control and Prevention, National Center for Health Statistics, 2000.

Laitinen, J., C. Power, E. Ek, U. Sovio, and M. Järvelin "Unemployment and obesity among young adults in a northern Finland 1966 birth cohort." International journal of obesity 26 (2002):1329-38.

Lakdawalla, D., and T. Philipson. 2002. The growth of obesity and technological change: A theoretical and empirical examination. NBER Working Paper no. 8946. Cambridge, MA: National Bureau of Economic Research.

Lamdin, D.J. "Can PS 27 Turn a Profit? Provision of Public Education by For-Profit Suppliers." *Contemporary Economic Policy* 19 (2001):280-90.

Latner, J.D., and A.J. Stunkard "Getting Worse: The Stigmatization of Obese Children." *Obesity research* 11 (2003):452-6.

Leahy, E., and G. Guo "Gender Differences in Mathematical Trajectories." *Social Forces* 80 (2001):713-32.

Li, X. "A study of intelligence and personality in children with simple obesity." 19 (1994):355-7.

Li, Y., Dai, Q., Jackson, J.C., and Zhang, J. "Overweight is associated with decreased cognitive functioning among school-age children and adolescents." Obesity (Silver Spring) 16(2008):1809-15.

Lin, B.H., Guthrie, J. and Frazão, E. " Nutrient contribution of food away from home. In: America's Eating Habits: Changes and Consequences" (Frazao, E., ed.), (1999) pp. 213–242. AIB No. 750, U.S. Department of Agriculture, Economic Research Service, Washington, D.C.

Locard E, Mamelle N, Billette A, Miginiac M, Munoz F, Rey S. "Risk factors of obesity in a five year old population. Parental versus environmental factors." *Int J Obes.* 16 (1992): 721–729.

Long, J. S. and Freese, J. *Regression Models for Ordered Categorical Variables Using Stata*. College Station, Texas: Stata Corporation, 2001.

Lopez, R. "Urban Sprawl and Risk for Being Overweight or Obese." *American Journal of Public Health* 94 (2004):1574-9.

Lopez, R. "Neighborhood risk factors for obesity." *Obesity* 15 (2007): 2111-9.

Magnuson, K. A., Ruhm, C. J., & Waldfogel, J. 2004 "Does prekindergarten improve school preparation and performance?" NBER Working paper 10452. Cambridge, MA: National Bureau of Economic Research.

Maddock, J. The relationship between obesity and the prevalence of fast food restaurants: State-level analysis, *American Journal of Health Promotion* 19 (2004): 137–143.

Maddox, G.L., K.W. Back, and W.R. Liederman "Overweight as social deviance and disability." *Journal of health and social behavior* 9 (1968):287-98.

Maes, H.H.M., M.C. Neale, and L.J. Eaves, "Genetic and Environmental Factors in Relative Body Weight and Human Adiposity." *Behavior genetics* 27 (1997):325-51.

Malhi, G.S., P.B. Mitchell, and I. Caterson, "Why getting fat, Doc? Weight gain and psychotropic medications." *Australian and New Zealand Journal of Psychiatry* 35 (2001):315-21.

Mancino, L. and C. Newman, "Who Has Time To Cook? How Family Resources Influence Food Preparation?" ERS Report 40. Department of Agriculture, Economic Research Service, Washington, D.C. May 2007.

Mancino, L., B. Lin, and N. Ballenger, "The Role of Economics in Eating Choices and Weight Outcomes" ERS, Agriculture Information Bulletin 791, Department of Agriculture, Economic Research Service, Washington, D.C., 2004.

Manus, H.E., and M.R. Killeen "Maintenance of Self-Esteem by Obese Children." *Journal of Child and Adolescent Psychiatric Nursing* 8 (1995):17-27.

McCreary, D.R., and D.K. Sasse "An exploration of the drive for muscularity in adolescent boys and girls." *Journal of American college health : J of ACH* 48 (2000):297-304.

McIntosh, A., G. Davis, R. Nayga, J. Anding, C. Torres, K. Kubena, E. Perusquia, G. Yeley, and W.You "Parental Time, Role Strain, and Children's Fat Intake and Obesity-Related Outcomes." ERS Contractor and Cooperator Report Number 19. Department of Agriculture, Economic Research Service, Washington, D.C., 2006.

McLanahan, S., and L.M. Casper *The American Family in 1990: Growing Diversity and Inequality* CEPS/INSTEAD, 1994.

Meyer, B.D., and D.T. Rosenbaum, "Welfare, the Earned Income Tax Credit, and the Employment of Single Mothers." *NBER Working Paper* 7363 (1999): 1-70.

Miller, J., A. Rosenbloom, and J. Silverstein, "Childhood Obesity." *Journal of Clinical Endocrinology & Metabolism* 89 (2004):4211-8.

Mokdad, A.H., J.S. Marks, D.F. Stroup, and J.L. Gerberding, "Actual Causes of Death in the United States, 2000." *JAMA* 291 (2004):1238-45.

Mokdad, A.H, Marks, J.S., Stroup, D.F., and Gerberding, J.L. "Correction: Actual Causes of Death in the United States, 2000" *JAMA.* 293 (2005): 293-294.

Morgan, C.M., S.Z. Yanovski, T.T. Nguyen, J. McDuffie, N.G. Sebring, M.R. Jorge, M. Keil, and J.A. Yanovski "Loss of control over eating, adiposity, and psychopathology in overweight children." *International Journal of Eating Disorders* 31 (2002):430-41.

Morland, K., A.V. Diez Roux, and S. Wing, "Supermarkets, Other Food Stores, and Obesity The Atherosclerosis Risk in Communities Study." *American Journal of Preventive Medicine* 30 (2006):333-9.

Morland, K., S. Wing, and A.D. Roux "The Contextual Effect of the Local Food Environment on Residents' Diets: The Atherosclerosis Risk in Communities Study." *American Journal of Public Health* 92 (2002):1761-8.

Mustillo, S., C. Worthman, A. Erkanli, G. Keeler, A. Angold, and E.J. Costello "Obesity and Psychiatric Disorder: Developmental Trajectories." *Pediatrics* 111 (2003):851-9.

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform*. Washington, DC: U. S. Government Printing Office.

Nielsen, S.J., A.M. Siega-Riz, and B.M. Popkin "Trends in Food Locations and Sources among Adolescents and Young Adults." *Preventive medicine* 35 (2002):107-13.

Nelson, M.C., P. Gordon-Larsen, Y. Song, and B.M. Popkin "Built and social environments associations with adolescent overweight and activity." *American Journal of Preventive Medicine* 31 (2006):109-17.

Neumark-Sztainer, D., P.J. Hannan, M. Story, J. Croll, and C. Perry "Family meal patterns: Associations with sociodemographic characteristics and improved dietary intake among adolescents." *Journal of the American Dietetic Association* 103 (2003):317-22.

Neumark-Sztainer, D., M. Story, M.D. Resnick, and R.W. Blum "Correlates of Inadequate Fruit and Vegetable Consumption among Adolescents." *Preventive medicine* 25 (1996):497-505.

Nielsen, S.J., A.M. Siega-Riz, and B.M. Popkin "Trends in Food Locations and Sources among Adolescents and Young Adults." *Preventive medicine* 35 (2002):107-13.

Nixon, G.M., Thompson, J., Han, D.Y, Becroft, D.M., Clark, P.M. Robinson, E., Waldie, K.E., Wild, C., Black, P., and Mitchell, E. “Short sleep duration in middle childhood: Risk factors and consequences”, *Sleep* 31 (2008): 71–78.

Nord, C. and West, J. *Fathers' and Mothers' Involvement in Their Children's Schools by Family Type and Resident Status*National Center for Education Statistics, 2001.

Norman, G.J., S.K. Nutter, S. Ryan, J.F. Sallis, K.J. Calfas, and K. Patrick "Community Design and Access to Recreational Facilities as Correlates of Adolescent Physical Activity and Body-Mass Index." *J. of Physical Activity and Health* 3 (2006):118.

North, K., and P. Emmett "Multivariate analysis of diet among three-year-old children and associations with socio-demographic characteristics. The Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) Study Team." *European journal of clinical nutrition* 54 (2000):73-80.

O'Dea, J.A., and P.R. Rawstorne "Male adolescents identify their weight gain practices, reasons for desired weight gain, and sources of weight gain information." *Journal of the American Dietetic Association* 101 (2001):105-7.

Pate, R.R., K.A. Pfeiffer, S.G. Trost, P. Ziegler, and M. Dowda "Physical activity among children attending preschools." *Pediatrics* 114 (2004):1258-63.

Pesa, J., T. Syre, and E. Jones "Psychosocial differences associated with body weight among female adolescents: The importance of body image." *Journal of adolescent health* 26 (2000):330-7.

Philipson, T. "The world-wide growth in obesity: an economic research agenda." *Health economics* 10 (2001):1-7.

Philipson, T.J., and R.A. Posner "The Long-Run Growth in Obesity as a Function of Technological Change." *Perspectives in biology and medicine* 46 (2003):87-107.

Phipps, S.A., L. Lethbridge, and P. Burton "Long-run consequences of parental paid work hours for child overweight status in Canada." *Social science & medicine* 62 (2006): 977-86.

Pinheiro, J.C. and Bates, D. M. *Mixed Effects Models in S and S-Plus* Springer, New York, 2000.

Pollack, J.M., Atkins-Burnett, S., Najarian, M., and Rock, D.A. (2005). *Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS–K), Psychometric Report for the Fifth Grade* (NCES 2006–036). U.S. Department of Education. Washington, DC: National Center for Education Statistics.

Pollan, M. “The way we live now: the (agri)cultural contradictions of obesity.” The New York Times Magazine. October 12, 2003. Accessed online on September 15, 2006. http://query.nytimes.com/gst/fullpage.html?sec=health&res=9A0DE2D61E3CF931A25753C1A9659C8B63

Population Reference Bureau. “Traditional Families Account for Only 7%.” Access online on February 25, 2008. http://www.prb.org/

Powell, B., and L.C. Steelman "Beyond Sibship Size: Sibling Density, Sex Composition, and Educational Outcomes." *Social Forces* 69 (1990):181-189.

Prentice, A.M. and Jebb, S.A. "Fast foods, energy density and obesity: a possible mechanistic link." *Obesity Reviews* 4 (2003):187-94.

Price, R.A., and I.I. Gottesman "Body fat in identical twins reared apart: Roles for genes and environment." *Behavior genetics* 21 (1991):1-7.

Putnam, R.T., M. Lampert, and P.L. Peterson "Alternative perspectives on knowing mathematics in elementary schools." *Review of Research in Education* 16 (1990):57-150.

Rabe-Hesketh, S. and Skrondal, A. *Generalized Latent Variable Modeling: Multilevel, Longitudinal, and Structural Equation Models*, 2nd ed. College Station, TX: Stata Press, 2008.

Ralston K., Newman, C., Clauson, JG., and Buzby, J. "The National School Lunch Program Background, Trends, and Issues." ERS Report 61. Department of Agriculture, Economic Research Service, Washington, D.C. July, 2008. Access online on September 28, 2008. http://www.ers.usda.gov/Publications/ERR61/

Rashad, I., M. Grossman, and S.Y.I. Chou "The Super Size of America: An Economic Estimation of Body Mass Index and Obesity in Adults." *Eastern Economic Journal* 32 (2006): 133-148

Richardson, S.A., N. Goodman, A.H. Hastorf, and S.M. Dornbusch "Cultural uniformity in reaction to physical disabilities." *American Sociological Review* 26 (1961):241-7.

Rivkin, S.G., E.A. Hanushek, and J.F. Kain "Teachers, Schools, and Academic Achievement." *Econometrica* 73 (2005): 417-58.

Robinson, T.N. "Reducing Children's Television Viewing to Prevent Obesity A Randomized Controlled Trial." *JAMA* 282 (1999):1561-7.

Rolls, B.J., D. Engell, and L.L. Birch "Serving Portion Size Influences 5-Year-Old but Not 3-Year-Old Children's Food Intakes." *Journal of the American Dietetic Association* 100 (2000):232-4.

Rose, D., and J.N. Bodor "Household food insecurity and overweight status in young school children: results from the Early Childhood Longitudinal Study." *Pediatrics* 117 (2006):464-73.

Rowan, B., R. Correnti, and R.J. Miller "What Large Scale, Survey Research Tells Us About Teacher Effects on Student Achievement: Insights From the Prospects Study of Elementary Schools." *The Teachers College Record* 104 (2002):1525-67.

Salbe, A.D., C. Weyer, R.S. Lindsay, E. Ravussin, and P.A. Tataranni "Assessing Risk Factors for Obesity Between Childhood and Adolescence: I. Birth Weight, Childhood Adiposity, Parental Obesity, Insulin, and Leptin." *Pediatrics* 110 (2002):299-306.

Sallis, J.F., and K. Glanz "The Role of Built Environments in Physical Activity, Eating, and Obesity in Childhood." *Future of Children* 16 (2006):89.

Sallis, J.F., T.L. McKenzie, T.L. Conway, J.P. Elder, J.J. Prochaska, M. Brown, M.M. Zive, S.J. Marshall, and J.E. Alcaraz "Environmental interventions for eating and physical activity A randomized controlled trial in middle schools." *American Journal of Preventive Medicine* 24 (2003): 209-17.

Sallis, J.F., J.J. Prochaska, and W.C. Taylor "A Review of Correlates of Physical Activity of Children and Adolescents" *Medicine and Science in Sports and Exercise* 32 (2000): 963–75.

Sayer, L.C. "Gender, Time and Inequality: Trends in Women's and Men's Paid Work, Unpaid Work and Free Time." *Social Forces* 84 (2005): 285-93.

Schanzenbach, D.W. "Do School Lunches Contribute to Childhood Obesity?" *University of Chicago, mimeo* (2005).

Schultz, T.P. "Women's Role in the Agricultural Household: Bargaining and Human Capital." *Handbook of Agricultural Economics*, in B.L. Gardner and G.C. Rausser (eds), Handbook of Agricultural Economics, Chapter 8, 1(2001): 383-456.

Segal, N.L. and Allison, D.B. "Twins and virtual twins: bases of relative body weight revisited." *International journal of obesity* 26 (2002):437-41.

Snell, E.K., E.K. Adam, and G.J. Duncan "Sleep and the Body Mass Index and Overweight Status of Children and Adolescents." *Child development* 78 (2007):309-23.

Snyder, H. "Epidemiology of official offending." in "Child delinquents: Development, intervention, and service needs" by R. Loeber and D. Farrington (eds). Sage, Thousand Oaks, CA (2001): 25–46.

Spera, C. "A Review of the Relationship Among Parenting Practices, Parenting Styles, and Adolescent School Achievement." *Educational Psychology Review* 17 (2005):125-46.

Spiegel, K., K. Knutson, R. Leproult, E. Tasali, and E.V. Cauter "Sleep loss: a novel risk factor for insulin resistance and Type 2 diabetes." *Journal of applied physiology* 99 (2005):2008-19.

Story, M., French S. "Food advertising and marketing directed at children and adolescents in the US." *Int J Behav Nutr Phys Act* 1 (2004): 1-17.

Story, M., D. Neumark-Sztainer, and S. French "Individual and Environmental Influences on Adolescent Eating Behaviors." *Journal of the American Dietetic Association* 102 (2002):40-51.

Story, M., K.M. Kaphingst, and S. French "The role of child care settings in obesity prevention." *The Future of children / Center for the Future of Children, the David and Lucile Packard Foundation* 16 (2006):143-68.

Stradmeijer, M., J. Bosch, W. Koops, and J. Seidell "Family functioning and psychosocial adjustment in overweight youngsters." *International Journal of Eating Disorders* 27 (2000):110-4.

Strauss, R.S. "Childhood Obesity and Self-Esteem." *Pediatrics* 105 (2000): e15.

Strauss, R.S., and H.A. Pollack "Social Marginalization of Overweight Children." *Archives of Pediatrics and Adolescent Medicine* 157 (2003):746-52.

Stunkard, A.J., J.R. Harris, N.L. Pedersen, and G.E. McClearn "The Body-Mass Index of Twins Who Have Been Reared Apart." *New England Journal of Medicine* 322 (1990):1483-1487.

Sturm, R., and A. Datar "Body mass index in elementary school children, metropolitan area food prices and food outlet density." *Public health* 119 (2005):1059-68.

Taheri, S. "The link between short sleep duration and obesity: we should recommend more sleep to prevent obesity." *Archives of Disease in Childhood* 91 (2006):881.

Taheri, S., L. Lin, D. Austin, T. Young, and E. Mignot "Short Sleep Duration is Associated with Reduced Leptin, Elevated Ghrelin, and Increased Body Mass Index." *PLOS Medicine* 1 (2004):210.

Tershakovec, A., S. Weller, and P. Gallagher "Obesity, School Performance, and Behaviour of Black, Urban Elementary School Children" *International journal of obesity* 18 (1994):323-7.

The Annenberg Public Policy Center of the University of Pennsylvania. "Television in the Home: The 1997 Survey of Parents and Children." Philadelphia: University of Pennsylvania, 1997.

Tourangeau, K, Nord, C., Le, T., Wan, S., and West, J. 'Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 : User's Guide to the Longitudinal Kindergarten-Fifth Grade Public-Use Data File' *National Center for Education Statistics*, 2006.

Townsend, M.S., J. Peerson, B. Love, C. Achterberg, and S.P. Murphy "Food insecurity is positively related to overweight in women." *The Journal of nutrition* 131 (2001):1738-45.

U.S. Census Bureau, U.S. Census 2000 http://www.census.gov/Press-Release/www/2002/sumfile3.html

U.S. Department of Agriculture (USDA), Food and Nutrition Service (FNS). *School Nutrition Dietary Assessment Study II,* Report No. CN-01SNDAII, Washington DC, April 2001.

U.S. Department of Agriculture (USDA), *7 Code of Federal Register Parts 210 and 220—Child Nutrition Programs; School Meal Initiative for Healthy Children*; Final Regulation, Policy and Program Development Branch, Child Nutrition Division, Food and Consumer Service, Alexandria, 1995.

U.S. Department of Labor, Bureau of Labor Statistics, Economic Releases Archives. Accessed July 2nd, 2008. http://www.bls.gov/schedule/archives/cewqtr_nr.htm

U.S. Department of Health and Human Services (USDHHS). *Healthy People 2010*, Washington DC.

Variyam, J.N. "Overweight Children: Is Parental Nutrition Knowledge a Factor?" *FoodReview*, 24, May-August 2001, 18-22.

Variyam, J.N., J. Blaylock, B.H. Lin, K. Ralston, and D. Smallwood "Mother's nutrition knowledge and children's dietary intakes." *American Journal of Agricultural Economics* 81 (1999):373-85.

Videon, T.M., and C.K. Manning "Influences on adolescent eating patterns: the importance of family meals." *Journal of Adolescent Health* 32 (2003):365-73.

Vila, G., E. Zipper, M. Dabbas, C. Bertrand, J.J. Robert, C. Ricour, and M.C. Mouren-Simeoni "Mental Disorders in Obese Children and Adolescents." *Psychosomatic medicine* 66 (2004):387-94.

Vitaro, F., M. Brendgen, and E.D. Barker "Subtypes of aggressive behaviors: A developmental perspective." *International Journal of Behavioral Development* 30 (2006):12.

von Hipple, P.T., B. Powell, D.B. Downey, and N.J, Rowland, "The Effect of School on Overweight in Childhood: Gain in Body Mass Index During the School Year and During Summer Vacation." *American Journal of Public Health*, 97 (2007): 696-702.

Wallace, W.J., D. Sheslow, and S. Hassink "Obesity in Children: A Risk for Depression." *Annals of the New York Academy of Sciences* 699 (1993):301-3.

Walston, J., Rathbun, A., and Germino-Hausken, E. "Eighth Grade: First Findings From the Final Round of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99." (NCES 2008-088). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC., 2008.

Whitaker, R.C. and Dietz W.H. "Role of the prenatal environment in the development of obesity." *Pediatrics* 132 (1998): 768–76.

Whitaker, R.C., J.A. Wright, M.S. Pepe, K.D. Seidel, and W.H. Dietz "Predicting Obesity in Young Adulthood from Childhood and Parental Obesity." *New England Journal of Medicine* 337 (1997):869-73.

Whitebook, M. "Early Education Quality: Higher Teacher Qualifications for Better Living Environments. A Review of the Literature." (2003): 389-402.

Wigfield, A., J.S. Eccles, R. Harold, A. Arbreton, C. Freedman-Doan, and P. Blumenfeld "Change in Children's Competence Beliefs and Subjective Task Values Across the Elementary School Years: A 3-Year Study." *Journal of educational psychology* 89 (1997):451-69.

Wigfield, A., and J.T. Guthrie "Relations of Children's Motivation for Reading to the Amount and Breadth of Their Reading." *Journal of educational psychology* 89 (1997):420-32.

Williams, C.L, L.L Hayman, T.N. Robinson, and S. Paridon, "Cardiovascular Health in Childhood." *Circulation* 106 (2002): 143-60.

Wilson, F. "Explaining the Growth of Child Obesity in the U.S." The University of Chicago (2006). Accessed online on Sept 12, 2007. http://chess.uchicago.edu/ccehpe/hew_papers/winter_2006/Wilson%202006.pdf.

Winicki, J., and K. Jemison "Food Insecurity and Hunger in the Kindergarten Classroom: Its Effect on Learning and Growth." *Contemporary Economic Policy* 21 (2003):145-57.

Wooldridge, J.M. *Econometric Analysis of Cross Section and Panel Data* MIT Press, 2002.

World Health Organization (WHO), 2006. *Obesity and Overweight*, Geneva. Available online at http://www.who.int/mediacentre/factsheets/fs311/en/. Accessed on June 10, 2007.

Worthington, A. "An Empirical Survey of Frontier Efficiency Measurement Techniques Education." *Education Economics* 9(2001): 245-268.

Wright, J.C., A.C. Huston, K.C. Murphy, M. St. Peters, M. Piñon, R. Scantlin, and J. Kotler "The Relations of Early Television Viewing to School Readiness and Vocabulary of Children from Low-Income Families: The Early Window Project." *Child development* 72 (2001):1347-66.

Xie, B., F.D. Gilliland, Y.F. Li, and H.R. Rockett "Effects of ethnicity, family income, and education on dietary intake among adolescents." *Preventive medicine* 36 (2003):30-40.

You. W., Davis, G., Nayga, R., and McIntosh, A. "Parental Time and Children's Obesity Measures" Selected Paper 134418 presented at the annual American Agricultural Economics Association, RI, 2005.

Zajonc, R.B, and Markus, G.B. "Birth Order and Intellectual Development." Psychological Review 82 (1975): 74-88

Zimmerman, F.J., and D.A. Christakis "Children's Television Viewing and Cognitive Outcomes A Longitudinal Analysis of National Data." *Archives of Pediatrics and Adolescent Medicine* 159 (2005):619-25.

Zive, M.M., J.P. Elder, J.J. Prochaska, T.L. Conway, R.L. Pelletier, S. Marshall, and J.F. Sallis "Sources of Dietary Fat in Middle Schools." *Preventive medicine* 35 (2002):376-82.

APPENDIX

Table A. Summary of mathematics scores by grade level and weight category

Math	Kindergarten		1st grade		3rd grade		5th grade	
Weight category	Num. obs	Mean	Num. obs	Mean	Num. obs	Mean	Num. obs	Mean
Underweight (UW)	516	49.5152	549	50.4698	269	51.6781	174	51.9829
Normal weight (NW)	10508	50.8836	9732	51.4858	7498	52.1429	5618	52.8443
Overweight (OW)	2341	50.2949	2260	50.7166	2117	51.7763	1815	52.0459
Obese (OB)	1969	49.0439	2244	49.6706	2671	50.377	2327	50.7509
Missing	95	41.0324	1038	51.0211	463	51.0559	223	51.4385
Weight over time								
Become normal (BN)	26	36.936	751	51.492	490	51.351	345	54.255
Always normal (AN)	11032	50.824	10096	51.454	7522	52.162	5494	52.751
Become overweight (BO)	4179	50.152	1094	50.154	1411	51.71	754	51.451
Always overweight (AO)	139	36.461	3633	50.3542	3447	50.744	3426	51.259
Missing	52	40.135	236	47.688	127	48.861	110	50.672

Table B: Full results for part one, health production function Economic, Environmental, and Endowment Effects on Childhood Obesity

Dependent variable has 3 categories NW, OW, and OB

Variable	Definition	Value	Mixed-effects ordered Logit (Proportional Odds) Health Production Function			
			Coeficient	SE	95% Confident Interval	
P1HRS	Person 1 working hours	0-80 hours per week	1.005***	0.002	1.001	1.009
P2HRS	Person 2 working hours	0-80 hours per week	0.999	0.002	0.995	1.003
SingleM	Live with biological mother only	0: no, 1: yes	1.005	0.132	0.777	1.299
SingleD	Live with biological father only	0: no, 1: yes	2.111*	0.919	0.899	4.954
OtherPA	Live with adopt parent(s) or guardian(s)	0: no, 1: yes	1.031	0.278	0.607	1.751
NUMSIB	Number of siblings child has	0-14	0.732***	0.029	0.678	0.790
PARED	Parents' education	0: less than highschool - 3: BA or higher	0.765***	0.043	0.685	0.853
IN15C	Household income, <$15,000/yr	0: no, 1: yes	1.556**	0.247	1.138	2.125
IN30C	Household income, $15,001-$30,000	0: no, 1: yes	1.780***	0.217	1.401	2.261
IN50C	Household income, $30,001-$50,000	0: no, 1: yes	1.373**	0.133	1.136	1.659
IN75C	Household income, $50,001-$75,000	0: no, 1: yes	1.309**	0.113	1.105	1.552
BWEIGH	Birthweight	16-177 (in ouces)	1.030***	0.002	1.026	1.034
raceA	Asian	0: no, 1: yes	1.500*	0.346	0.954	2.358
raceB	African American	0: no, 1: yes	2.255***	0.363	1.645	3.092
raceH	Hispanic	0: no, 1: yes	3.887***	0.507	3.009	5.019
raceR	Other races	0: no, 1: yes	2.136**	0.589	1.244	3.667
GEND	Child's gender	0: male, 1: female	0.757**	0.065	0.641	0.894
CCHOME	Childcare at child's home	0: no, 1: yes	1.117	0.108	0.924	1.349
CCOHOME	Childcare at someone else's home	0: no, 1: yes	1.247**	0.114	1.043	1.491
CCCENTER	Childcare at centers	0: no, 1: yes	0.989	0.092	0.824	1.186
CCOTHER	Other arrangments of childcare	0: no, 1: yes	1.291	0.271	0.855	1.946
PAHEALTH	Parents' health	0: excellent - 4: poor	1.308***	0.052	1.21	1.413
FSSTAT	Food security status, have food problem sometimes	0: no, 1: yes	1.038	0.145	0.789	1.365
DOC2VIS	Visit doctor for routine care within one year	0: no, 1: yes	1.049	0.084	0.897	1.227
SLUNCH	Child receive complete lunch from school	0: no, 1: yes	1.233***	0.085	1.078	1.411
BEDTIME	Child goes to bed after 10pm	0: no, 1: yes	1.004	0.141	0.763	1.322
HOMECM	Has a home computer	0: no, 1: yes	0.955	0.077	0.815	1.118
TV3RULE	Has TV rule for how many hours child can watch TV per day	0: no, 1: yes	1.017	0.059	0.908	1.141

PHYED	Physical education at school (minutes/week)	0 - 214	0.998	0.001	0.996	1.001
ACTYPE	Child involved in at least 2 types of physical activities	0: no, 1: yes	0.862*	0.052	0.766	0.969
WORKEARLY	Mother work between childbirth and kindergarten	0: no, 1: yes	1.089	0.112	0.891	1.332
WARMCL	Frequency of warm, close time between parent and child	0: rarely - 3: very often	0.982	0.066	0.862	1.121
EVENG	Number of evening meals together	0: none - 7: every day	1.016	0.018	0.981	1.052
PCHINVOL	Index of parent-child involvement	0: none - 27: all 9 activities everyday	1.003	0.008	0.987	1.019
NE	Region: Northeast	0: no, 1: yes	2.403***	0.415	1.713	3.369
MW	Midwest	0: no, 1: yes	1.450*	0.230	1.063	1.978
SO	South	0: no, 1: yes	2.210***	0.341	1.634	2.989
URBAN	Urban area	0: no, 1: yes	0.522***	0.075	0.394	0.692
TOWN	Large town	0: no, 1: yes	0.641***	0.088	0.491	0.838
PRIVATE	Private school	0: no, 1: yes	1.171	0.159	0.896	1.526
y2	Round 2 dummy		1.370***	0.094	1.197	1.569
y3	Round 3		4.182***	0.341	3.565	4.906
y4	Round 4		6.423***	0.549	5.432	7.595
cut_11	Cutpoint between NW and the other two: OW &OB		6.507	0.475	5.576	7.44
cut_12	Cutpoint between OB and the other two NW & OW		9.062	0.481	8.119	10.01
ID_cons	Variance at student's level		14.045	0.463		
S2ID_con	Variance at school's level		1.258	0.121		
Number of observation			25573			
Number of student			13237			
Number of school cluster			1854			
Log likelihood			-17472			

*Significant at 10%; ** significant at 5%; *** significant at 1%
Standard deviation in parentheses
Logit coeficients are reported as odds ratios

Table C: Full results for part two, Childhood Overweight and Educational Outcomes

Variables	Variables description	Values	Current overweight status		Overweight status over time	
READ/MATH	Dependent variables	IRT scale scores, maximum 92 for Reading and 64 for Math	Reading	Math	Reading	Math
Student's characteristics						
ObNo	Student becomes normal weight	0: no, 1: yes			-0.003	0.156
					(0.278)	(0.267)
NoOb	Student becomes overweight	0: no, 1: yes			-0.233	-0.458***
					(0.155)	(0.151)
ObOb	Student has been overweight	0: no, 1: yes			-0.089	-0.367**
					(0.157)	(0.158)
BMI_0	Student is underweight	0: no, 1: yes	-0.177	-0.726**		
			(0.327)	(0.315)		
BMI_2	Student is overweight	0: no, 1: yes	-0.134	-0.422**		
			(0.149)	(0.145)		
BMI_3	Student is obese	0: no, 1: yes	-0.304*	-0.541***		
			(0.169)	(0.169)		
BWEIGH	Birthweight	In ounces	0.012***	0.024***	0.012***	0.025***
			(0.003)	(0.004)	(0.003)	(0.004)
CHGSCH	Number of times a student changed schools since last data round	0-5	0.059	-0.082	0.068	-0.042
			(0.169)	(0.166)	(0.166)	(0.163)
CHREAD	Frequency of time a student reads by him/herself per week outside of school setting	0: less than 2 times - 1: 3 or more	1.792***		1.803***	
			(0.120)		(0.119)	
LRN2PRB	Student has learning problems	0: no, 1: yes	-2.781***	-1.120***	-2.730***	-1.101***
			(0.144)	(0.119)	(0.143)	(0.118)
BEDTIME	Bedtime	0: before 10pm, 1: after 10pm	0.786***	0.669**	0.796**	0.675***
			(0.249)	(0.240)	(0.247)	(0.238)
NUMTV	Number of hours a student watches TV per day	0-8	-0.107**	-0.103**	-0.121**	-0.102**
			(0.053)	(0.052)	(0.053)	(0.051)
HRSNOW	Number of hours a student receives non-parental care per week	0-146	-0.020***	-0.005	-0.019***	-0.005
			(0.006)	(0.006)	(0.006)	(0.006)
raceA	Asian	0: no, 1: yes	0.328	0.793**	0.368	0.751**
			(0.353)	(0.370)	(0.350)	(0.368)
raceB	African American/Black	0: no, 1: yes	-2.530***	-4.331***	-2.606***	-4.392***
			(0.298)	(0.310)	(0.296)	(0.308)
raceH	Hispanic	0: no, 1: yes	-2.024***	-2.708***	-2.051***	-2.685***
			(0.250)	(0.260)	(0.248)	(0.259)
raceR	Others	0: no, 1: yes	-1.394***	-2.415***	-1.404**	-2.335***
			(0.513)	(0.531)	(0.512)	(0.531)
GEND	Gender	0: male, 1: female	0.722***	-1.361***	0.727***	-1.372***
			(0.140)	(0.147)	(0.140)	(0.146)
GRALEV	Student's grade level	Kindergarten-6th grade during 4 rounds of data	7.132***	6.060***	7.068***	5.976***
			(0.278)	(0.273)	(0.274)	(0.269)
Parents' and household's characteristics						
PSINVOL	Index of parent's involvement with student's school activities	Index of 5 activities	0.182***	0.308***	0.193***	0.299***
			(0.051)	(0.049)	(0.050)	(0.049)
BothPA	Student lives with both biological parents	0: no, 1: yes	-0.278	-0.189	-0.294	-0.199
			(0.173)	(0.172)	(0.172)	(0.171)
NUMPLA	Number of places a student lives during the last year of interview time	0-5	-0.276	-0.977***	-0.247	-0.944***
			(0.298)	(0.285)	(0.295)	(0.283)
EXPECT	Parents' expectation for student's schooling	0: at least up to college, 1: at least finish college	1.759***	1.545***	1.758***	1.558***
			(0.140)	(0.134)	(0.138)	(0.133)
DISCIP	Type of discipline	0: non-physical, 1: physical	0.334*	0.199	0.382**	0.224
			(0.178)	(0.172)	(0.176)	(0.170)
NUMSIB	Number of sibblings a student has	0-14	-0.553***	-0.249***	-0.562***	-0.260***
			(0.063)	(0.064)	(0.063)	(0.064)
PARED	Parents' highest level of education	0: less than highschool - 3: BA or higher	1.491***	1.508***	1.478***	1.496***
			(0.094)	(0.095)	(0.093)	(0.094)
IN15C	Household income, <$15,000/yr	0: no, 1: yes	-2.349***	-2.301***	-2.316***	-2.263***
			(0.296)	(0.290)	(0.293)	(0.287)
IN30C	Household income, $15,001-$30,000	0: no, 1: yes	-1.631***	-1.649***	-1.620***	-1.659***
			(0.222)	(0.217)	(0.219)	(0.215)
IN50C	Household income, $30,001-$50,000	0: no, 1: yes	-1.091***	-1.262***	-1.090***	-1.278***
			(0.175)	(0.172)	(0.174)	(0.171)
IN75C	Household income, $50,001-$75,000	0: no, 1: yes	-0.404***	-0.485**	-0.441**	-0.480***
			(0.155)	(0.150)	(0.153)	(0.149)
FSSTAT	Food security status, household has food problem sometimes	0: no, 1: yes	-0.098	-0.430*	-0.197	-0.564*
			(0.268)	(0.263)	(0.265)	(0.260)
HOMECM	Household has computer for student's use	0: no, 1: yes	0.868***	0.943***	0.880***	0.889***
			(0.144)	(0.138)	(0.142)	(0.137)

Teacher's characteristics						
ENJOY	Teacher enjoys teaching	0: no, 1: yes	0.220 (0.194)	0.129 (0.186)	0.195 (0.190)	0.102 (0.183)
YRSTC	Teacher's years of teaching	0-39	0.051*** (0.019)	0.009 (0.018)	0.053** (0.019)	0.009 (0.018)
2YRSTC	Teacher's years of teaching - squared	0-1521	-0.001** (0.001)	-0.000 (0.001)	-0.001* (0.001)	-0.000 (0.001)
TDEGREE	Teacher's degree	0: less than master/ professional degree, 1: otherwise	-0.092 (0.114)	0.225** (0.107)	-0.104 (0.112)	0.220** (0.106)
TWHITE	Teacher is White	0: no, 1: yes	0.340 (0.212)	0.208 (0.202)	0.357* (0.210)	0.195 (0.200)
School characteristics						
PRIVATE	Private school	0: no, 1: yes	0.940*** (0.258)	-0.089 (0.260)	0.924*** (0.256)	-0.116 (0.260)
PERREAD/MATH	Percentage of student in school tested at or above grade level on national standardized	0-100	0.012*** (0.003)	0.017*** (0.003)	0.013*** (0.003)	0.018*** (0.003)
TRNOVR	A school experiences problems of teacher's turn over rates	0: no, 1: yes	-0.354** (0.162)	0.038 (0.154)	-0.363** (0.161)	0.029 (0.153)
SCHSIZE	School's size	0: up to 149 - 4: 750 or more	0.018 (0.079)	0.036 (0.077)	0.013 (0.078)	-0.005 (0.077)
SCHMINOR	Percentage of minority students in school	0: up to 10 - 4: 75 or more	-0.293*** (0.072)	-0.152** (0.070)	-0.275*** (0.071)	-0.154** (0.070)
S1COMM	Community where the school is located	0: up to 100,000 in population, 1: otherwise	0.732*** (0.215)	0.702*** (0.219)	0.757*** (0.213)	0.745*** (0.218)
SCHSECPRB	A school experiences security problems	Index of 3: gang, drug, violent crimes	0.006 (0.068)	0.116 (0.065)	0.010 (0.067)	0.119 (0.064)
y1	Round 1 dummy variable		35.089*** (1.379)	30.398*** (1.355)	34.864*** (1.361)	30.015*** (1.339)
y2	Round 2 dummy variable		27.592*** (1.111)	23.554*** (1.091)	27.423*** (1.097)	23.245*** (1.078)
y3	Round 3 dummy variable		13.988*** (0.565)	11.907*** (0.555)	13.887*** (0.558)	11.754*** (0.548)
_cons	Constant		9.944*** (1.556)	15.481*** (1.528)	10.079*** (1.534)	16.052*** (1.508)
Random-effects parameters						
S2ID_cons	Standard deviation of school-level constant		1.945 (0.109)	1.895 (0.115)	1.936 (0.109)	1.910 (0.115)
ID_cons	Standard deviation of student-level constant		5.607 (0.069)	6.302 (0.065)	5.617 (0.066)	6.303 (0.065)
Resid.	Standard deviation of the model's residual		4.829 (0.041)	4.368 (0.037)	4.816 (0.040)	4.347 (0.037)
Rho (school)	The intraclass correlation for different students within a school		0.065	0.058	0.064	0.059
Rho (student)	The intraclass correlation for same student over time		0.537	0.637	0.539	0.638
S2ID	Number of school-clusters		1440	1435	1471	1466
ID	Number of student (per school-cluster)	1-94	10434	10410	10530	10511
N	Number of observations (per student-cluster)	1-4	17780	17727	18072	18016
AIC	Akaike information criteria		95658	94993	120856	120103
BIC	Bayesian information criteria		96021	95348	121246	120486
Wald Chi-square			4304.697	3358.874	4364.891	3382.337
Log likelihood			-59444	-59056	-60377	-60002

Standard errors in parentheses
*p<0.10 **p<0.05 *** p<0.01

Table D: General Social Survey (GSS) prestige score for parents' occupation

29.60	Handler, Equipment, Cleaner, Helpers, Labor
33.42	Production Working Occupation
34.95	Service Occupation
35.63	Agriculture, Forestry, Fishing Occupation
35.78	Marketing & Sales Occupation
35.92	Transportation, Material Moving
37.67	Precision Production Occupation
38.18	Administrative Support, including Clerk
39.18	Mechanics & Repairs
39.20	Construction & Extractive Occupation
48.69	Technologist, Except Health
52.54	Writers, Artists, Entertainers, Athletes
53.50	Executive, Admin, Managerial Occupation
57.83	Health Technologists & Technicians
59.00	Social Scientist/ Workers, Lawyers
61.56	Registered Nurses, Pharmacists
62.87	Natural Scientists & Mathematicians
63.43	Teacher, except Postsecondary
64.89	Engineers, Surveyors, & Architects
72.10	Teachers, College, Postsecondary Counselors, Librarians
77.5	Physicians, Dentists, Veterinarians
0	Unemployed, Retired.