Competitive Food and Beverage Availability in School: Implications for Adolescent Consumption Patterns

by Tracy C. Vericker

B.A. May 2001, Miami University
M.P.A. May 2003, American University

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Kathryn E. Newcomer
Professor of Public Policy and Public Administration

The Columbian College of Arts and Sciences of The George Washington University certifies that Tracy C. Vericker has passed the Final Examination for the degree of Doctor of Philosophy as of December 10, 2010. This is the final and approved form of the dissertation.

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Tracy C. Vericker

Dissertation Research Committee:

Kathryn E. Newcomer, Professor of Public Policy and Public Administration, Dissertation Director

Dylan Conger, Associate Professor of Public Policy and Public Administration, Committee Member

Philip Gleason, Senior Fellow, Mathematica Policy Research, Inc., Committee Member

Dedication

For Rob and Sophia

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Abstract

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Nationwide, one in five children are obese—over twice the prevalence rate of past decades. Schools have come under fire for their potential role by selling competitive foods (foods not sold as part of the National School Lunch Program) that are low in nutritional quality and high in energy density to students. In this dissertation, I use the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 fifth- and eighth-grade waves of data to estimate the relationship between changes in competitive food and beverage practices and changes in student consumption of fruits and vegetables, milk and juice, and sweetened beverages using first difference models. Results reveal no significant effects of competitive food and beverage practices on children's consumption of these foods and beverages. These findings suggest that policy and future research may need to target more comprehensive strategies to improve dietary behaviors to achieve a reduction in obesity prevalence among children.

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Chapter One: Policy Problem

Introduction

A healthy diet is the cornerstone of overall good health. Poor nutrition is linked to a number of unfavorable outcomes including obesity (DHHS & USDA, 2005). Obesity, a level of body fatness associated with type II diabetes, cancer, and other serious illnesses, has become a serious public health concern in the United States for adults and children. Public policy leaders in the Obama Administration, Congress, state governments, non-profit and philanthropic organizations, among others have begun to take action to diagnose and remediate the problem. In this dissertation, I examine the potential effect of one policy lever—regulating the sale of foods and beverages in schools—policymakers may use to positively influence children's consumption behaviors as one strategy for reducing the prevalence of obesity among children.

This chapter provides context for the purpose of this dissertation research. I have identified improving children's diets as a means of reducing the prevalence of obesity among children as the public policy problem that my research is intended to address. Because obesity reduction is the overarching goal, I devote this chapter to discussing childhood obesity with regard to the following: (1) definition and consequences; (2) measurement; (3) prevalence; (4) etiology; and (5) the role of the school food environment. I will also discuss the current state of knowledge about the effects of school competitive food and beverage policies on dietary behaviors—the policy lever I examine. I will conclude the chapter with a description of the research I conduct and how it

contributes to the existing body of knowledge. I will also provide a brief overview of the organization of this dissertation.

Childhood Obesity

Defining Childhood Obesity and Its Consequences

Obesity is a term used to describe a level of body fatness that has shown to be associated with a variety of health problems and diseases. Reviewing the literature on obesity-related health consequences, the National Institutes for Health (1998) report that adult obesity increases the risk of the onset of hypertension, type 2 diabetes, stroke, gallbladder disease, osteoarthritis, sleep apnea and respiratory problems, and endometrial, breast, prostate, and colon cancers. Some of these conditions contribute to premature death.

Obese children have increased risks of developing the same deleterious health conditions as their adult counterparts. More troubling, obese children are also more likely than non-obese children to become obese adults, increasing the risk of developing these negative health conditions at some point in life. For obese adolescents, the risk of becoming an obese adult is particularly high, as one study estimates that 60 percent of obese adolescents ages 10 and older will become obese adults (Miller, Rosenbloom, & Silverstein, 2004).

The costs—both public and private—associated with obesity are high. A study by Finkelstein et al. (2003) found that obesity-related expenditures for adults amount to anywhere between $51.5 and $78.5 billion annually. Half of these costs are covered with

taxpayer dollars via Medicare and Medicaid. Johnson, McInnes, and Shinogle (2006) estimate that approximately $124 million per year is spent on obesity-related medical expenditures on children. Recent research by McKinnon (2009), suggests that the total lifetime costs of obesity may be as much as $500 billion.

While obesity may lead to health problems and contribute to increased public expenditures, Koplan, Liverman, and Kraak (2005) report that the effects of excess body fat vary considerably across individuals. In some cases obesity may only cause low-self-esteem, while in other cases obesity may lead type II diabetes.

A number of non-health related concerns have been linked with childhood obesity as well. For instance, a recent study in Philadelphia found that obese elementary school students missed 20 percent more days during the school year as a result of health issues, stigma, and bullying associated with being overweight (Geier et al., 2007). Similarly, Schwimmer, Burwinkle, & Varni (2003) found that obese children missed on average three more days per month than healthy weight children. Research has also found associations between obesity and academic performance, with heavier children more likely placed in special education or remedial classes (Tershakovec, Weller, & Gallagher, 1994). While the relationship between obesity and school performance has not been found to be causal, many believe that obesity negatively affects self-esteem, acting as a mediator of school performance (Wang & Veugelers, 2008; Taras & Potts-Datema, 2005).

Measuring Childhood Obesity

Measuring obesity, or body fatness, is difficult and not often done directly. Densitometry is the only direct measure of body fatness, taken by completely submerging the body in water, but the availability of this method is very limited, given its expense (Goran, 1998). Typically, body fat is approximated, given ease and low cost of measurement, by the Body Mass Index (BMI). The National Heart, Lung and Blood Institute, Obesity Education Initiative, Expert Panel on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults, recommend the use of BMI to estimate body fatness (NIH, 1998). BMI is calculated by dividing weight in kilograms by height in squared meters.

Though BMI is not a direct measure of body fatness, it has been shown to correlate highly with body fatness (Hu, 2008). For children ages 2 to 19, BMI values are considered separately by gender and age, given differential growth rates for boys and girls. Children at or above the 95th percentile of BMI for their age and sex are considered to be obese (National Institutes for Health, 1998). For instance, a 12 year old girl, weighing 140 pounds and measuring five feet in height would be considered obese.

There are cases in which BMI does not measure body fatness well. For instance, athletes often have higher BMIs due to higher levels of muscle mass rather than higher levels of body fatness. Additionally, women and older adults tend to have higher levels of body fat at the same BMI level than men and younger adults (CDC, 2009). Asians have been

found to have a higher percentage of body fat than whites at the same BMI level (Hu, 2008).

Obesity Prevalence

The prevalence of obesity among adolescents has increased rapidly over the last 30 years, leading many to consider the phenomenon an epidemic. For children ages 6 to 11, the prevalence of obesity has more than tripled from 6.5 percent in 1976-1980 to 20 percent in 2007-2008 (Ogden et al., 2002; Ogden et al, 2010). Likewise, the prevalence of obesity for youth ages 12 to 19 has increased—from 5.0 percent in 1976-1980 to 18.1 percent in 2007-2008 (Ogden et al., 2002; Ogden et al, 2010).

Examining these trends for the entire population masks some important differences between subgroups. For instance, the prevalence of obesity for boys is higher than that of girls. In 2007-2008, 20.1 percent of boys' ages 6 to 19 were obese compared with 17.3 percent of girls (Ogden et al, 2010). Racial differences are also apparent. For instance, among all children ages 6 to 19 in 2007-2008, 17.0 percent of non-Hispanic white children were obese compared with 22.3 percent of non-Hispanic black children and 23.4 percent of Mexican American children (Ogden et al, 2010).

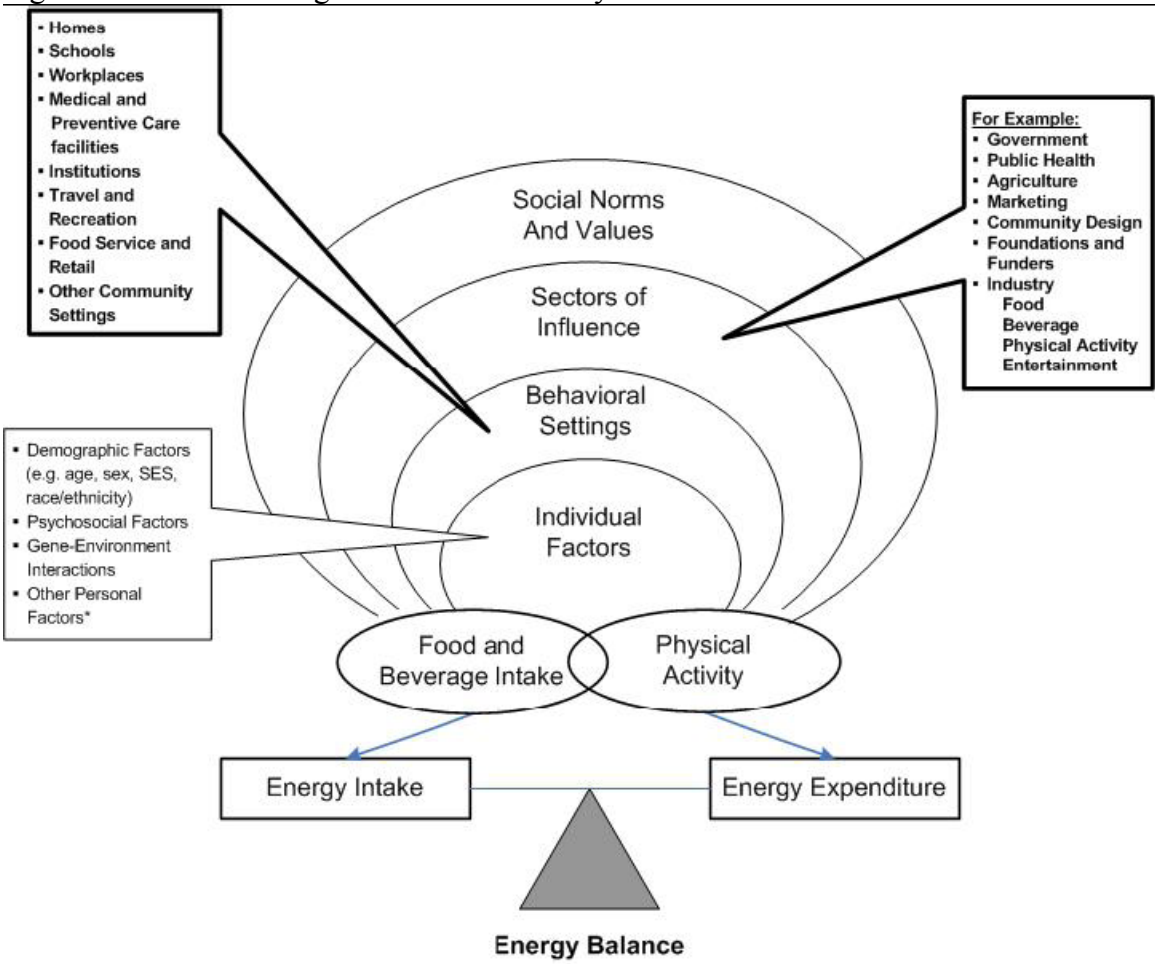
Poverty may also contribute to disparities in obesity prevalence. Miech, Kumanyika, Stettler, Link, Phelan, and Chang (2006) found that older youth, ages 15 to 17, living in poverty had higher rates of obesity than those living in non-poor households (25.2 and 22.4 percent, respectively) in 1999-2004. The authors found no difference in obesity

prevalence between youth ages 12 to 14 living in poverty compared to youth not living in poverty. The authors argued that obesity disparities in later adolescence were likely due to youth from poor families engaging in less physical activity, consuming more calories from sweetened beverages, and skipping breakfast more frequently than youth living in families with incomes above the poverty threshold. The authors found no difference in these activities for adolescents, ages 12 to 14.

Obesity Etiology

A social ecological model is the primary framework used for understanding obesity causation, and is discussed in a variety of settings where obesity reduction is a goal—such as the Obama administration's "Let's Move!" campaign. At a basic level, the social ecological model recognizes that individuals exist in multiple social settings, or environments, and these social environments can interact with an individual's genetic predispositions to alter consumption and physical activity behaviors, which ultimately affect energy balance and weight (see Figure 1.1.). Figure 1.1, featured below, is the model presented by the Centers for Disease Control and Prevention (CDC), showing that individuals are nested within a complex social system of factors that affect weight. Interpersonal relationships (e.g., peers, family), organizations (e.g., schools, churches, work), and communities (e.g., zoning regulations, food availability, transportation systems) all have an effect on weight. In addition, a number sectors influence weight, including, for instance, government, foundations, and the businesses. Finally, overarching social values and norms interact with all of the spheres of influence depicted in Figure 1.1 to affect weight.

Figure 1.1: Social Ecological Model of Obesity Causation



*Note: Other relevant factors that influence obesity prevention interventions are culture and acculturation; biobehavioral interactions; and social, political, and historical contexts.
Sources: Adapted from IOM (2007); CDC (2006)

Source: Center for Disease Control and Prevention (2008), accessible from: http://www.cdc.gov/obesity/downloads/TA_Manual_1_31_08.pdf

The Role of the School Food Environment

With the emphasis on the socio ecological approach to obesity reduction, there is increasing concern as to whether the school food environment is contributing to poor dietary habits, resulting in increased obesity prevalence (Food Research Action Committee, 2009; U.S. House of Representatives, 2000; U.S. Department of Agriculture, 2001). One of the key debates is over the sale of competitive foods and beverages in

schools. The USDA defines competitive foods in regulation as: "…any foods sold in competition with the Program [NSLP] to children in food services areas during the lunch periods" (7CFR 210.11). These foods may be found in such places as vending machines, a la carte lines, and school stores. Currently, only foods of minimal nutritional value, such as hard candy and soda, are restricted from sale in the lunch area during lunchtime by the federal government. Many have argued that the USDA has not gone far enough in regulating the sale of competitive foods and beverages; however, the Department is limited in its regulatory capacity by current statute.

In 2005, Congress directed the CDC to undertake a study with the Institute of Medicine (IOM) of the National Academy of Sciences to review and provide recommendations regarding the sale of food in schools, with emphasis on the sale of competitive foods. In 2007, the Committee on Nutrition Standards for Foods in Schools of the Institute of Medicine (IOM) concluded that "Schools contribute to current and life-long health and dietary patterns and are uniquely positioned to model and reinforce healthful eating behaviors in partnership with parents, teachers, and the broader community." The IOM presented a number of recommendations to Congress. Two key recommendations were made in reference to the sale of competitive foods in school. First, the committee recommended that schools only allow elementary and middle school children access to water, low-fat and nonfat milk, and 100 percent fruit juice at school. If implemented, this recommendation would prevent the sale of sweetened beverages such as soda and sports drinks in school. Second, the committee recommended limiting the sale of foods sold in school to those that are fruits, vegetables, whole grains, related combination products,

and nonfat or low- fat dairy products, among further nutrient restrictions. If implemented, this recommendation would eliminate the sale of such items as candy, baked goods, ice cream, chips, and other sweet and salty snacks.

Regulation of competitive foods is one of the issues under debate in 2010 with the Children Nutrition Act up for reauthorization. Tom Vilsack, Secretary of Agriculture in the current Obama Administration, announced that the administration proposes a $10 billion dollar over 10 years investment beginning in 2011 as part of the reauthorization of the Child Nutrition Act (USDA, 2010). This investment is intended to improve the food environment in schools and would set universal standards for the sale of competitive foods. The key priorities of the Obama Administration for reauthorizing the Child Nutrition Act align closely to the 2007 IOM committee recommendations.

States, school districts and individual schools can also regulate the sale of competitive foods and beverages. The IOM (2007) reported that in 2007 about half of states, 27, had competitive food policies that went beyond what the federal government requires. Of these, only 16 regulated the nutritional quality of the foods. In 2006, Greves and Rivara reported that just over half of the 10 largest school districts had policies that went beyond federal and state policies. They found, however, that none of the largest districts in the United States, representing 11 percent of all students, had implemented regulations that completely followed the Institute of Medicine's recommendations for school nutrition. In 2004, GAO reported that a few individual schools had enacted their own policies.

Current State of Knowledge Regarding the Effect of Competitive Food Policies on Dietary Behavior

Competitive foods are pervasive in the nation's schools, they are often low in nutritional value, and many students are consuming them. GAO (2004) reports that over 80 percent of all schools offer competitive foods and beverages other than milk. Fox et al. (2009a) find that 40 percent of school children consume at least one competitive food per day and those foods were typically low in nutritional value and higher in calories than foods offered as part of the National School Lunch Program (NSLP).

There is a growing body of literature examining the relationship between competitive foods and beverages and children's dietary behaviors. Results are mixed. A number of studies have found *some* relationships between offering competitive foods and beverages in school and children's consumption behaviors. For instance, some studies have found access to unhealthy foods and beverages (e.g., candy, chips, soda) schools decreases children's consumption of healthy foods and beverages (e.g., fruits, vegetables, milk, 100 percent fruit juice) and access to healthy foods and beverages increases consumption of healthy foods and beverages (Briefel, Crepinsek, Cabili, Wilson, and Gleason, 2009; Cullen, Eagen, Baranowski, Ownes, and de Moor, 2000; Kubik, Lytle, Hannan, Perry, and Story, 2003; Cullen and Zakeri, 2004; Datar and Nicosia 2009; Grimm, Harnack, and Story, 2004; Wiecha et al., 2006; Fernandes, 2008; Hartstein, Cullen, Reynolds, Harrell, Resnicow, and Kennel, 2008; Schwartz, Novak, and Fiore, 2009). The evidence that food practices in school effect dietary behaviors, however, is tenuous. Many of these same

studies have found a number of "null" findings, or no evidence of a link between the school food environment and consumption of healthy foods and beverages.

Proposed Research and Intended Contribution

This dissertation seeks to assess the extent to which the food choice architecture in school affects student's consumption patterns. The purpose of this study is to build on the previous literature in this area to understand better the extent to which school policymakers can affect dietary behavior in an effort to curb the current childhood obesity epidemic. Specifically, I address the following research questions:

1. To what extent does the availability competitive foods and beverages sold in school affect children's weekly consumption of fruits and vegetables, milk and juice, and sweetened beverages (e.g., soda)?
2. How do these effects vary by characteristics of the youth? By gender? By race/ethnicity? By family poverty status?
3. To what extent do the characteristics of competitive foods and beverages sold in school (i.e., types of foods and beverages sold and locations of foods and beverages offered) affect children's weekly consumption of fruits and vegetables, milk and juice, and sweetened beverages (e.g., soda)?

To this end, my unique contribution to the previous literature is to provide a stronger identification strategy than previous studies to better assess the causal relationship between access to competitive foods and beverages in school and children's consumption behaviors. While earlier research provides some evidence that limiting access to

competitive foods at school may positively influence dietary patterns among children and adolescents, each suffers from several threats to internal and external validity that limit the ability to draw causal inferences. I will discuss these limitations in chapter two and my identification strategy in chapter 3.

Organization of the Dissertation Proposal

In the chapters that follow, I present a review of the relevant literature (chapter 2), the methods underpinning this study (chapter 3), the results of the analyses I conduct (chapter 4), and implications for policy and future research (chapter 5). Chapter 2 begins with a discussion of the social ecological model for understanding obesity causation and also includes a review of the literatures assessing the relationship between dietary behaviors and obesity and the relationship between the school food environment and dietary behaviors.

Chapter Two: Literature Review

Introduction

The purpose of this dissertation is to assess the extent to which the food choice architecture in school is associated with children's consumption patterns. In chapter 1, I state that the motivation of this research is to help shed light on a potential policy intervention—regulating competitive foods and beverages—that decision-makers can adopt to improve children's eating patterns in an effort to reduce the prevalence of obesity among children. In this chapter, I will examine the theoretical underpinnings of childhood obesity causation, provide an overview of the literature that links dietary behaviors with obesity, examine the literature assessing the link between availability of competitive foods in schools and children's consumption patterns, and discuss my contribution to the literature.

Theoretical Framework for Understanding Obesity Causation

To ameliorate the childhood obesity problem, policymakers must first understand the roots of its causes. Prior to the 1990s, theories of obesity causation were focused primarily on the individual (French 2005). The idea was that individuals control their net caloric intake; therefore, to rectify an energy imbalance, efforts should focus on changing the behavior of the individual (Stokols, 1992). These behavior models called for individualized interventions to promote healthy eating and increasing physical activity. By the early 1990s, however, there was a growing realization in the public health field that individual health behaviors are not developed in a vacuum. Borrowing from systems

theory, Stokols (1992) was among the first in the public health world to advocate for using a social ecological theory of health promotion.

Social ecological theory is grounded in the idea that individuals are inextricably linked to a broader society and are nested in physical environments. The theory asserts that influences of the physical environment (e.g., geography, architecture, and technology) and the social environment (e.g., culture, economics, and politics) influence health outcomes as do individual behaviors (Stokols, 1992). Conversely, the theory assumes that individual behaviors can have an effect on the social and physical environments around them. An example of the effect of the social environment would be if individual A has a predisposition for enjoying unhealthy foods. Individual A lives in a household of family members who eat healthfully and promote healthy eating behaviors. As a result, individual A may be more inclined to choose healthier foods than if he lived with a family who ate unhealthy foods. Alternatively, individual A's desire to eat unhealthy foods may negatively influence his family members' eating behaviors.

An example of the role of the physical environment is the following: suppose the same individual A lives in a neighborhood that has access to farmers' markets that sell low-cost, fresh fruits and vegetables. The physical proximity to healthy foods may influence individual A to make healthy food choices. Alternatively, individual A may choose not to shop at the local farmer's market, given his preference for unhealthy foods. As a result of individual A's choice not to shop at the market, the local farmers may begin to

introduce unhealthy foods (e.g., brownies and cookies) to increase sales by individual A and others who share individual A's tastes and preferences.

Social ecological theory argues that the degree of influence that physical and social environments have on an individual is determined by a number of factors. According to Stokols (1992), the objective or subjective nature of the environment, the proximal or distal relationship of the environment, and the level of aggregation of individual attributes in the environment all affect health behaviors. For instance, neighborhood safety may be a factor for deciding whether or a parent will allow his child to go outside and play. The parent's perception of neighborhood safety, however, may be different from the actual threat of danger in the neighborhood. They key issue is that the parent's perception of the environment can influence his child's health promoting behaviors.

Proximity to the environment can also play a role in influencing an individual's behavior. For instance, the school food environment (e.g., access to a hot school lunch, vending machine snacks, or a la carte food options) could be an important factor in influencing a child's eating behaviors, as many children consume at least one meal at school. For those children who bring lunch to school, however, the school food environment may be distal, and may therefore have less influence on food choices.

Lastly, an individual may be influenced by a number of specific attributes of an environment, or alternatively, an individual may be influenced by a set of attributes. For example, a student may be influenced to eat at school based on meal quality, amount of

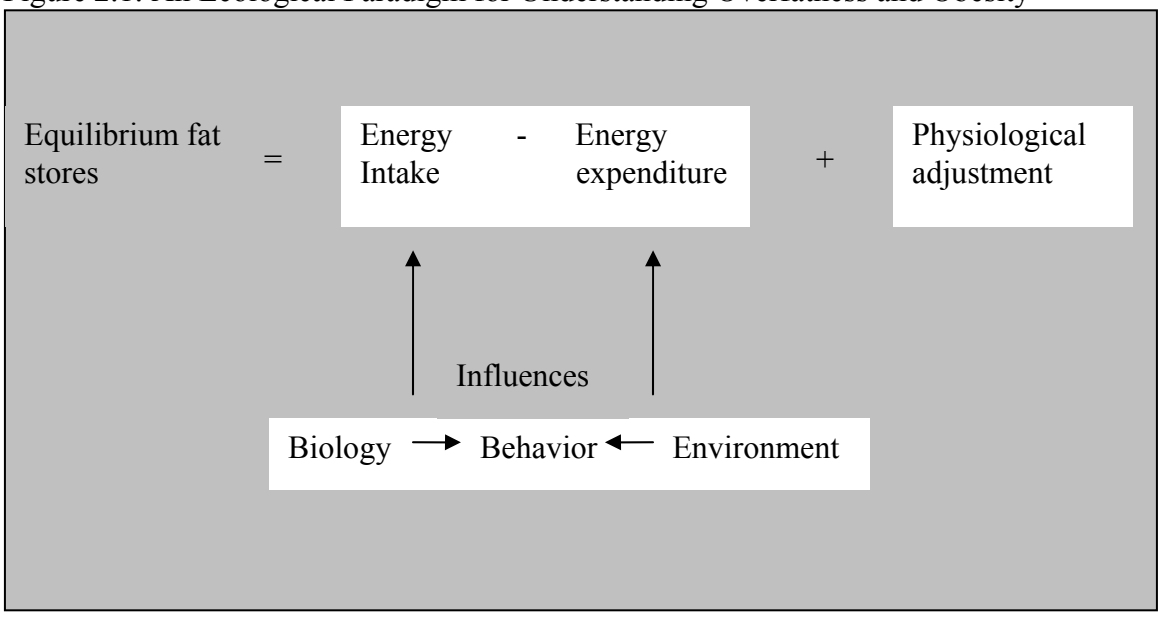
time allotted to eat lunch, and meal cost—all of which are individual characteristics of a school food environment. Or, a child could be influenced by the social climate—composed of a set of environmental attributes—in the school towards eating a school lunch. For instance, if the student attends a school where many peers bring lunches and it is considered the socially-desirable thing to do, the child may choose not to purchase foods at school.

Building on the work of Stokols and others writing about social ecological theory and its application to public health issues, Egger and Swinburn (1997) apply the general ecological theory of health promotion to understand the obesity pandemic. Egger and Swinburn point out two key issues in the obesity debate that require further attention. First, the medical literature indicates that obesity is not as simple an equation of calories in and calories out. Rather, studies show that fat balance is a dynamic process between energy stores, appetite mechanisms, and nutrient partitioning. Second, while these medical breakthroughs increase our knowledge of how obesity develops in individuals, they do not explain why obesity rates have increased rapidly over time. Egger and Swinburn (1997) apply the social ecological framework to the obesity problem to help fill in this knowledge gap.

Egger and Swinburn (1997) argue that equilibrium fat stores are a function of energy intake (food consumption) minus energy expenditure (physical activity) modified by physiological adjustments (e.g., metabolic rate and appetite adjustments due to changes in energy balance) (Figure 2.1). Further, energy balance, energy intake minus energy

expenditure, is influenced by behaviors (e.g., sloth and gluttony), which are jointly determined by biology (e.g., age, sex, hormonal factors, and genetics) and the environment (e.g., fitness and food service industries, access to local gyms and supermarkets). According to Swinburn, Egger, and Raza (1999), much of the earlier research on causes, treatment, and prevention of obesity were focused on the roles of biology and behavior. Drawing a parallel to other public health problems—smoking reduction, injury prevention, and infectious disease prevention—the authors contend that population-based approaches will not work without also focusing on the influences of the environment. The authors also suggest that environmental measures may be more influential on groups that are difficult to reach with health education programs (e.g., low-income and less-educated).

Figure 2.1: An Ecological Paradigm for Understanding Overfatness and Obesity



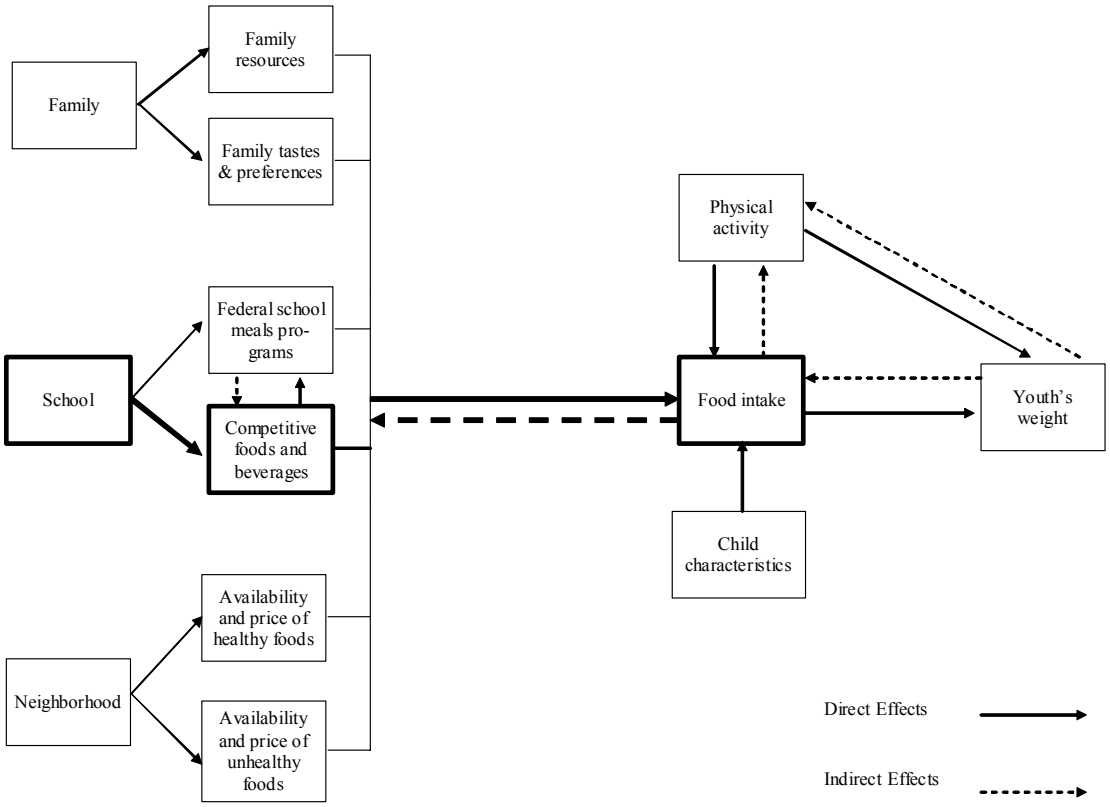
Source: Egger and Swinburn (1997).

Swinburn, Egger and Raza (1999) describe two types of environments, those that are obesogenic and those that are leptogenic. Obesogenic environments are defined as "the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations" (Swinburn, Egger, and Raza, 1999, p. 564). In contrast, leptogenic environments promote leanness. Swinburn, Egger, and Raza (1999) further classify these environments on the basis of their type (i.e., physical, economic, political, and sociocultural) and size (i.e., micro or macro). Physical environments refer to what is available; economic environments refer to the costs; political environments refer to the societal rules; and the sociocultural refer to the cultural norms. Macro environments, as previously articulated by Stokols (1992) are systems such as transportation and regulation that affect people's food and activity choices. Micro environments are more proximal to individuals and their food and activity decisions—families, schools, and neighborhoods.

The theoretical work of Swinburn, Egger and Raza (1999) has been embraced by most in the public health field as a reasonable starting place to understand obesity causation (McLaren and Hawe, 2005; French, 2005). For instance, the Centers for Disease Control and Prevention use the Social-Ecological model as a framework for states funded by the Nutrition and Activity Program to Prevent Obesity and Other Chronic Diseases (CDC, 2009). As a result of its acceptance by the field, I use the social-ecological theoretical framework as the basis for this dissertation.

Figure 2.2 depicts the conceptual framework I use to frame this research. This framework suggests that child weight is directly influenced by food intake and physical activity. The focus of this study is on food intake, which is a function of child characteristics and the family, school, and neighborhood food environments. This model also shows that the school food environment may be a function of food intake (i.e., school food practices may be determined based on characteristics of the students in the school). Characteristics of the child that may affect food intake include such attributes as behavioral factors (e.g., food tastes and preferences) and genetic factors (e.g., metabolic functioning). The school food environment includes availability of the National School Lunch Program (NSLP) and the School Breakfast Program (SBP) and competitive foods and beverages. The family food environment includes both resources such as income and time as well as behavioral factors such as food tastes and preferences. Finally, the neighborhood food environment includes access to and price of healthy and unhealthy foods. The purpose of this study is to reveal the direct effects of the school food environment, and specifically the effects of competitive food availability in school, on adolescents' consumption patterns.

Figure 2.2: Conceptual Framework for Proposed Research



Relationship between Diet and Obesity

Newby (2007) conducted a systematic review of the literature on diet and childhood obesity and found a tenuous linkage. While it is clear that obesity results from a net positive energy balance, it is not clear whether changes in dietary behaviors or changes in physical activity are driving obesity trends. There are a number of reasons that studies have found mixed results. First, Newby (2007) notes that most studies are descriptive and do not control for potential confounders. Those that do control for potential confounders are typically based on cross-sectional data and are therefore open to a number of threats to internal validity, reducing the reliability of findings. Second, Newby asserts a need for

more studies with larger sample sizes to gain the statistical power needed to examine the potential interactive effects of the relationship between diet and obesity with baseline BMI, age, sex, ethnicity, and the presence of an overweight parent. If these interactive effects hold, additional studies would be needed to examine genetic influences on diet and obesity. Currently, most studies do not include genetic variables. Those with any genetic controls only use parent weight as a proxy. Other genetic factors, such as metabolic function are also relevant. Third, studies have found that overweight and obese people tend to under-report total energy and food consumption. It could be that inconsistent results in the link between diet and obesity are due to reporting issues, with many studies relying on self-reported food consumption. Fourth, databases on the nutritional value of food need to be updated. Changes in the food supply are occurring rapidly and the data analysts typically have to assess nutrient quality may not be accurate. Fifth, many studies do not take into account children's growth patterns, which may account for some of the discrepancies in the literature (i.e., some children may appear to be overweight, but are simply in the middle of a growth spurt). Finally, the author notes that many of the studies lack generalizability to other populations, as most studies examine Caucasian children living in North America and Europe.

While we lack evidence to clearly link the childhood obesity epidemic to changes in dietary patterns, it is still true that certain types of foods are lower in caloric content and therefore would have a negative effect on total energy intake if they replaced energy-dense foods. Fruits and vegetables are examples of foods that are typically low in energy and high in nutrient content, while soda and sweetened beverages are typically higher in

energy and lower in nutrient content. Barlow and the Expert Committee (2007), composed of 15 members of national health care organizations, made recommendations to reduce childhood obesity; the first two recommendations they made were (1) to limit consumption of sugar-sweetened beverages and (2) to increase consumption fruits and vegetables.

Relationship between the Snacks Sold in School and Selected Dietary Behaviors

A number of studies have examined the role that competitive foods play in the dietary patterns of children and adolescents, and many have found that access to unhealthy competitive foods in school, via a la carte lines, vending machines, school stores, et cetera, is negatively associated with consumption of healthy foods and beverages and positively associated with the consumption of unhealthy foods and beverages (see Table 2.1). Cullen et al. in 2000 and Cullen and Zakeri in 2004, assessing the effect of access to snack bars on fifth-grade students in five schools in southeast Texas, found that students without access—those in fourth-grade—consumed more fruits, juices and vegetables during lunch compared with fifth-graders who had access to snack bars. Recently, Cullen, Watson and Zakeri (2008) assessed the effect of a change in Texas policy that limited portion sizes of high-fat and sugary snacks and imposed other nutrient standards on middle school students. They found that students consumed more vegetables and milk and key nutrients, such as protein, fiber, vitamins A and C, calcium and sodium, and fewer unhealthy items such as sweetened beverages and low-nutrient dense snacks at lunchtime; however, they also found that more students purchased unhealthy items from the school snack bar and brought unhealthy snacks from home.

Similar findings are noted in other areas of the country. A study of the effect of the access to vending machines and a la carte programs on seventh-grade students in the Minneapolis-St. Paul, Minnesota metropolitan area found that access reduced fruit consumption and increased their consumption of fat and saturated fat during a 24-hour period (Kubik Lytle, Hannan, Perry, and Story, 2003). Harstein et al. (2008) examined the effect of promoting water, fruit, and vegetable consumption in school while simultaneously reducing access to unhealthy foods and vegetables from a la carte lines and snack bars in six schools (two schools in North Carolina, two schools in California, and two schools in Houston). They found that over a two-year period, students purchased more water and fewer sweetened beverages and potato chips. Schwartz, Novak and Fiore (2009) examined the effect of implementing nutrition guidelines and removing sweetened beverages on children's dietary patterns from three middle schools in Connecticut, using three schools that did not face the policy changes as a comparison group. The authors found that removing low nutrition snacks from school resulted in a decrease in the frequency of consumption of salty snacks and sweetened beverages, but no change in consumption patterns of sweet snacks. Also of note, they found no change in snacking behaviors at home between students from intervention schools compared with students from comparison schools. Weicha et al. (2006), conducting a study in 10 Massachusetts schools found that students who reported making purchases from vending machines in schools consumed more sugar-sweetened beverages per day than those who reported not making purchases from vending machines in school.

Grimm, Harnack and Story (2004) collected survey data from 560 youth who subscribed to *Dragonfly* magazine, a children's magazine distributed nationally to elementary and middle schools, to assess the effects of access to soft drinks in school on consumption of those beverages. They found that students with access to soda at school were twice as likely as students with no access to report consuming soft drinks five or more times per week.

Four studies used nationally-representative data to assess the effect of access to competitive foods in school on dietary behaviors. Briefel, Crepinsek, Cabili, Wilson, and Gleason (2009) used data from the School Nutrition Dietary Assessment Study III (SNDA III), which assessed children's dietary intakes and school food environments from grades one through twelve for the 2004-2005 school year. Using multivariate regression models, controlling for a range of other factors that might contribute to dietary patterns, such as school, household, and child characteristics, the authors found some evidence that access to competitive foods affect student's dietary behaviors during the school day. They found that limiting access to unhealthy items from school stores and snack bars reduced energy consumed from sweetened beverages for middle school students; restricting access to unhealthy a la carte foods promotes vegetable consumption for middle school students; and access to competitive foods reduces fruit juice consumption for elementary age students.

Kakarala, Keast, and Hoerr (2010) also used SNDA-III data. They examined differences in nutrient intakes of children who consumed competitive foods and beverages from

vending machines, school stores and other locations in school other than from a la carte lines to children who did not consume competitive foods from these locations, controlling for a range of observable factors. They found higher levels of energy, sugar, and sodium consumption for children who reported consumption of competitive foods and lower levels of dietary fiber, B vitamins, and iron.

Datar and Nicosia (2009), using data from the fifth-grade round of the ECLS-K found less evidence of an effect of access to competitive foods on fifth-graders frequency of eating certain foods over the prior week. Using OLS regression models, controlling for a host of potential confounding factors, the authors found access to junk foods in school reduced the frequency of consumption of some vegetables.

Fernandes (2008), using the same data as Datar and Nicosia (2009), assessed the relationship between access to sweetened beverages in school and frequency of consumption of sweetened beverages using multivariate logistic regression models. Fernandes found that students attending schools without access to sweetened beverages decreased their odds of *any* consumption of sweetened beverages in the past week by 4 percent.

While these studies indicate a possible relationship between competitive food practices and food and beverage intake, many of these studies also found null results. For instance, Briefel et al. (2009) found few associations between competitive food practice and fruit and vegetable consumption and those significant relationships they did find varied by

grade level. They found no effect of competitive food policies on elementary age children's consumption of sweetened beverages. Similarly, Datar and Nicosia (2009) found no associations between junk food availability in school and milk, green salad, carrot, and potato consumption. Kubik et al. (2003) found no association between access to a la carte and vending machines and vegetable consumption. Schwartz et al. (2009) found no evidence that limiting access to unhealthy snacks in school reduces consumption of sweet snacks.

Four studies also examined the relationship between access to snack foods in school and children's weight, with mixed results. Datar and Nicosia (2009) found no link between access to competitive foods and BMI for fifth graders. Fox et al. (2009) found no relationship between access to vending machines and a la carte lines and BMI for elementary or high school students. However, they found that the availability of vending machines in close proximity to the cafeteria was associated with increased BMI among middle school students and the availability of a la carte items in close proximity to the cafeteria was associated with decreased BMI among middle school students. Searcy (2007) found that snacking at school was associated with an increased probability of being obese, but only among females. Sanchez-Vaznaugh, Sanchez, Baek, and Crawford (2010) examined the effect of a new policy in California schools restricting access to competitive foods and beverages in schools and found that after the policy change, the prevalence of overweight among fifth graders in Los Angeles declined. They also found that the prevalence of overweight for boys in the fifth grade in the rest of the state declined and the prevalence of overweight among seventh graders declined. They found

no evidence that the prevalence of overweight declined in Los Angeles among seventh graders or among girls in the fifth grade in the rest of the state.

There are some key limitations of these studies: most have focused on small, localized areas (with small samples), nearly all relied upon cross-sectional data and/or pre-post or post-test only with a comparison group analyses, and many have only looked at the effect of access to snack foods and beverages on lunchtime eating behaviors. As I will discuss below, I attempt to increase the reliability of the results of my study by addressing these key limitations.

In sum, the literature suggests that there may be an association between the school food environment and children's dietary behaviors. The extent to which the environment affects dietary behavior, what types of environments have the greatest influence, and who is most affected is still in question.

Contribution to the Literature

There are a number of ways in which this dissertation builds upon the existing body of knowledge regarding the role of the sale of snacks and beverages in school on children's dietary behavior. First, the socio-ecological framework suggests that obesity is caused by a number of forces acting on an individual. Some of the studies discussed above controlled for some individual-level characteristics and others controlled for some family-level characteristics, but none of the studies were able to capture neighborhood-level characteristics. This is of particular concern for the non-localized studies, where

respondents could be affected by very different environmental conditions. Similar to three of the aforementioned studies, I use the data from the ECLS-K; however, I use the restricted-access geocoded ECLS-K data file to merge in some characteristics of the neighborhood food environment at the zip code level to help fill in this gap in the literature.

Second, a review of the literature reveals a lack of knowledge about the potential interactive effects of individual characteristics with access to snack foods that could lead to differential dietary behaviors. Those studies that attempted to disaggregate findings by gender, race, income and other factors had inconsistent findings. I include gender, race, and poverty interactions with competitive school policy variables to investigate these potential effects, as the literature on obesity has shown that the probability of becoming obese may differ between these subpopulation groups (Ogden et al., 2002; Ogden et al., 2008; Miech et al., 2006).

Third, most of the studies examining the relationship between snacks and beverages sold in school and children's dietary behaviors used cross-sectional data. All of the nationally-representative studies reviewed used cross-sectional data. While cross-sectional data allows for the exploration of associations, it typically does not allow for an exploration of a causal path. I use two panels of data, which moves the literature further along the road towards assessing causality, though my study is not able to completely replicate the conditions of a randomized experiment necessary to infer causal impacts.

Fourth, many of the studies, particularly those examining localized areas, relied upon measures of intake at lunchtime. While looking at the relationship between access to competitive foods and beverages at school and lunchtime dietary behaviors is useful, it is more useful to understand how food consumed in school affect dietary behaviors throughout the day. It may be that students who lack access to junk foods consume fewer of these types of foods at lunchtime, but then go home and make up for the difference. I use data that assesses frequency of consumption of specific foods and beverages throughout a week to help fill this gap in the literature.

Lastly, only one of the studies assessing the relationship between snacks and beverages sold in school and children's dietary behaviors considered that school competitive food policies could be endogenous—that is, school policies may be designed to affect characteristics of children in the school (Briefel et al., 2009). That study only controlled for observable characteristics in an attempt to address the endogenous relationship. I attempt to account for this potential endogenous relationship by using an empirical design that controls for both observable and some unobservable characteristics, which I will discuss further in chapter 3.

Table 2.1: Studies Assessing the Relationship between Access to Competitive Foods and Beverages at School and Children's Dietary Behaviors

Author	Year	Dependent Variable(s)	Key Independent Variables	Key Findings	Design, Analysis Method	Sample Size	Population Studied	Data Source
Briefel, Crepinsek, Cabili, Wilson, and Gleason	2009	Caloric intake, fruit and vegetable consumption	Access to competitive foods in school	(1) No effect of competitive food policies on elementary children's consumption of sweetened beverages. (2) Limiting access to unhealthy items from school stores or snack bars and a la carte lines reduces energy consumed from sweetened beverages for middle students; no effect of access to vending machines on middle school students' consumption of sweetened beverages. (3) Few significant differences in fruit and vegetable consumption by type of competitive food practice. (3) Consumption of vegetables increases when no unhealthy a la carte foods are available for middle school students. (4) Access to competitive foods negatively related to fruit juice consumption for elementary school students.	Cross-sectional, OLS	n = 2,314	Nationally-representative sample of children in grades 1 - 12	Collected own data (School Nutrition Dietary Assessment III)
Cullen, Eagan, Baranowski, Ownes, and de Moor	2000	Fruit, juice, and vegetable intake	Snack bars	(1) No access to snack bars led to higher consumption of fruits, juice and vegetables. (2) Those who ate only snack bar meals consumed fewer fruits, juices, and vegetables	Cross-sectional; analysis of variance	n = 312 students with no access to snack bars and n = 282 students with access to snack bars	Fourth and fifth-graders in a school district in southeast Texas (4 experiment schools; 1 comparison school)	Collected own data

Table 2.1: Studies Assessing the Relationship between Access to Competitive Foods and Beverages at School and Children's Dietary Behaviors (cont.)

Author	Year	Dependent Variable(s)	Key Independent Variables	Key Findings	Design, Analysis Method	Sample Size	Population Studied	Data Source
Cullen, Watson, and Zakeri	2008	Vegetables, fruit, milk, juice, sweetened beverages, snack foods and nutrient consumption	Effect of Texas policy changes and access to snack bars and vending machines	(1) Students consumed fewer high fat vegetables, regular vegetables, and milk from snack bars; students consumed more deserts and sweetened beverages. (2) Consumption of chips, sweetened beverages, and deserts from vending machines reduced. (3) More chips, sweetened beverages, and deserts were brought from home.	Non-parametric descriptive statistics, Mean differences over 3 time periods	About 3,000 students	3 middle schools in southeast Texas	Collected own data
Cullen and Zakeri	2004	Fruit, vegetable, milk and sweetened beverage consumption	Access to snack bars	(1) Fewer fruits, vegetables and milk consumed with access to snack bars. (2) More sweetened beverages and high fat vegetables consumed with access to snack bars. (3) Students with no change in access (had access both years) reported an increase in high fat vegetable and milk consumption and declines in regular vegetable and sweetened beverage consumption (4) Older children with access to snack bars consumed lower amounts of fruit and more sweetened beverages	Cross-sectional, descriptive with comparison group	n = 594	Fourth through sixth-graders in a school district in southeast Texas	Collected own data
Datar and Nicosia	2009	Milk, green salad, carrots, potatoes, other vegetables, and fruit consumption; BMI	Access to competitive foods in school	(1) Limited effects on particular foods (reduces consumption other vegetables); no effect on milk, green salad, potatoes, fruits, or carrot consumption); (2) No effect of access to competitive foods on children's BMI.	Cross-sectional, multivariate	n = 9,378	Nationally-representative sample of children from the 1998-1999 kindergarten class, fifth-grade students	Early Childhood Longitudinal, Kindergarten Class of 1998-1999
Fernandes	2008	Soft drink consumption	Limiting access to soft drinks	(1) Decreases the odds of any consumption by 4 percent.	Cross-sectional, multivariate	n=10,215	Fifth-grade students	ECLS-K, fifth-grade

Table 2.1: Studies Assessing the Relationship between Access to Competitive Foods and Beverages at School and Children's Dietary Behaviors (cont.)

Author	Year	Dependent Variable(s)	Key Independent Variables	Key Findings	Design, Analysis Method	Sample Size	Population Studied	Data Source
Fox, Hedley Dodd, Wilson, and Gleason	2009	BMI; obesity	Access to low-nutrient, energy-dense foods in school	(1) Offering french fries and similar potato products as well as desert in elementary school increases the probability of obesity among children; no effects for middle or high school students (2) Availability of vending machines near the cafeteria was associated with a higher BMI among middle school students; no effects for elementary or high school students (3) Availability of a la carte food items near a cafeteria was associated with a lower BMI for middle school students; no effects for elementary or high school students	Cross-sectional, multivariate	n = 2,228	Nationally-representative sample of children in grades 1 - 12	Collected own data (School Nutrition Dietary Assessment III)
Grimm, Harnack, and Story	2004	Soft drink consumption five or more times per week	Availability at school	(1) Students with access to soda at school twice as likely as students without access to consume five or more soft drinks per week.	Cross-sectional; multivariate	n = 560	8 to 13 year old children who received Dragonfly magazine	Survey conducted by Dragonfly magazine
Hartstein, Cullen, Reynolds, Harrell, Resnicow, and Kennel	2008	Water, fruit, vegetable, sweetened beverages, and dietary fat from sales of competitive foods	Promoting water, fruit, and vegetable consumption; reducing access to unhealthy foods and beverages in a la carte and snack bars	(1) More water and less sweetened beverages and regular chips sold. (2) Total energy reduced.	2 periods of data, linear regression, controlled for clustering in schools	n = 6248 students	6 middle schools: 2 in the Chapel Hill, NC area; 2 in the Irvine, CA area; and 2 in the Houston, TX area	Collected own data

Table 2.1: Studies Assessing the Relationship between Access to Competitive Foods and Beverages at School and Children's Dietary Behaviors (cont.)

Author	Year	Dependent Variable(s)	Key Independent Variables	Key Findings	Design, Analysis Method	Sample Size	Population Studied	Data Source
Kakarala, Keast, and Hoerr	2010	Nutrient intakes	Consumption of competitive foods in school from sources other than a la carte	(1) For those who consumed competitive foods from places in school other than a la carte compared with those who did not consume competitive foods, mean energy, sugar, and sodium intake was higher; dietary fiber, B vitamins, and iron intake was lower.	Cross-sectional, multivariate	n = 2,309	Nationally-representative sample of children in grades 1 - 12	School Nutrition Dietary Assessment III
Kubik, Lytle, Hannan, Perry, and Story	2003	Fruit and vegetable servings per day; percent total energy from fat and saturated fat	Availability of vending machines and a la carte programs	(1) A la carte availability negatively associated with fruit consumption and positively related to total and saturated fat intake. (2) Snack and vending machines negatively related to fruit consumption. (3) No effect of access on vegetable consumption found.	Cross-sectional, multivariate, allowed school to vary randomly	n = 598	Seventh-grade students in school districts within a 30-mile radius of St. Paul/Minneapolis (16 schools participated)	Collected own data
Sanchez-Vasnaugh, Sanchez, Baek, & Crawford	2010	Overweight	Change in competitive food policies in California	(1) After new policies took effect, prevalence of overweight in fifth graders was reduced in Los Angeles. (2) After new policies took effect, prevalence of overweight was reduced in the rest of California for boys in the fifth grade and all seventh graders	Population-level longitudinal analysis, pre and post reform, with controls	N = 5,389,819	Fifth and seventh grade students in California	Administrative data

Table 2.1: Studies Assessing the Relationship between Access to Competitive Foods and Beverages at School and Children's Dietary Behaviors (cont.)

Author	Year	Dependent Variable(s)	Key Independent Variables	Key Findings	Design, Analysis Method	Sample Size	Population Studied	Data Source
Schwartz, Novak, and Fiore	2009	Low nutrition snacks	Access to competitive foods in school	(1) Removing low nutrition snacks from school resulted in a decrease in consumption of salty snacks and sweetened beverages, but not sweet snacks; students increased consumption of water and fruit juice. (2) No substitution effect from home was found.	Two periods of data (not same students in each period); 6 intervention schools and 6 comparison schools (no random assignment); used multilevel model to control for clustering of students in school; controlled for gender and school	n = 495	Middle school students from 12 schools in Connecticut	Collected own data
Searcy	2007	BMI and obesity	Access to competitive foods in school	(1) Purchasing snacks at school is only associated with an increased BMI or probability of being obese among females.	Cross-sectional, OLS, two-stage least squares	n = 748	Youth ages 10 - 18 in five distressed urban areas	Urban Health Initiative Survey of Adults and Youth (2004-2005) and supplementary survey data
Wiecha, Finkelstein, Troped, Fragala, and Peterson	2006	Intake of sugar-sweetened beverages	Vending machine purchases	(1) Students who made purchases from vending machines in schools consume more sugar-sweetened beverages than those who make no purchases. (2) Students who eat at fast food restaurants consume more sweetened beverages than those who do not eat at fast food restaurants.	Randomized experiment comparing schools with vending machines to those without, multivariate regressions .	n = 1,474	Students in 10 middle schools in Massachusetts	Collected own data

Conclusion

This chapter provides an overview of the literature related to the socio-ecological model of obesity causation—the theoretical model upon which this dissertation relies, an overview of the literature examining at the association between dietary behaviors and obesity, and an extensive review of the literature examining the association between snacks and beverages sold in school and children's dietary behaviors. It is clear from the literature review that the attention of those concerned with obesity prevention is on a theoretical paradigm that focuses on the context in which an individual is situated and not just *individual* physical activity and dietary behaviors—family, peers, schools, neighborhoods, and society influence dietary behaviors as well. This review also identified a limited knowledge about the role of diet in obesity prevention, as studies have shown conflicting evidence of the effect of diet on obesity. Finally, this review has shown that there is some evidence that foods and beverages sold in school may affect children's dietary behavior, but the evidence is not overwhelming.

In the next chapter, chapter three, I describe the methods I employ in this dissertation. I describe the research questions I address, the methods I use to answer these questions, how I construct variables, the data I use, and the limitations of my approach.

Chapter Three: Methods

Introduction

The purpose of this dissertation is to assess the extent to which the food choice architecture in school is associated with children's consumption of healthy foods and healthy and unhealthy beverages. In chapter 1, I note that the motivation of the proposed study is to help shed light on a potential policy intervention—limiting access to unhealthy foods and beverages at school—that decision-makers can adopt to reduce the childhood obesity epidemic. In chapter 2, I review the relevant theoretical underpinnings of the childhood obesity problem and highlight the role that schools may play in encouraging or discouraging healthy eating behaviors by changing the food environment. This review reveals limitations of prior work that this study can begin to address. For instance, most studies were limited in geographic scope, and no study attempted to control for the potential endogenous relationship between access to unhealthy foods in school and children's dietary behaviors other than by controlling for observable characteristics. In this chapter, I discuss the research questions I address, the methods I use to answer these questions, variable construction, data, and the limitations of the approach.

Research Questions

The primary research question this dissertation addresses is the following: To what extent does the food choice architecture in school affect students' eating behaviors? To answer this question, I examine the following three sub-questions:

1. To what extent does the availability competitive foods and beverages sold in school affect children's weekly consumption of fruits and vegetables, milk and juice, and sweetened beverages (e.g., soda)?
2. How do these effects vary by characteristics of the youth? By gender? By race/ethnicity? By family poverty status?
3. To what extent do the characteristics of competitive foods and beverages sold in school (i.e., types of foods and beverages sold and locations of foods and beverages offered) affect children's weekly consumption of fruits and vegetables, milk and juice, and sweetened beverages (e.g., soda)?

Of note, data do not support looking at the effect of competitive food practices on consumption of unhealthy foods.

Methods Strategy

The analysis is conducted in four phases ranging from least rigorous to most rigorous, with the goal of assessing the effect of school competitive food and beverage policy on child consumption behaviors. First, I conduct a descriptive analysis, examining the competitive food and beverage practices offered to students when they were in the fifth and the eighth grades. Second, I conduct a simple bivariate analysis, assessing the potential relationship between policy and behavior by examining food and beverage consumption behaviors of children in the fifth and eighth grades by the type of competitive food and beverage practice that they experienced at school. Third, I control for potential confounders that are observable by estimating the relationship between food

and beverage consumption behaviors and school competitive food and beverages practices using OLS models with controls for individual, family, school and neighborhood characteristics. I estimate these models for fifth and eighth grade separately. Lastly, I attempt to control for both observable and some unobservable confounders by using first difference models. This last strategy is my best attempt at assessing impacts of policy on behavior. I discuss each of these analyses in detail below.

Descriptive and Multivariate Analysis Strategy

To begin assessing the competitive food and beverage environments experienced by youth, I examine the percent of the population in fifth and eighth grade that experience a set of mutually-exclusive school food and beverage practices. I look at school competitive food and beverage practices from both a broad and a more narrow view. First, I assess the percent of students who attend schools that have any competitive foods or any competitive beverages offered. Second, I examine where in the school competitive foods and beverages (if offered) are located and the types of foods and beverages available. Detail on variable creation is discussed later in this chapter.

After assessing the competitive food and beverage practice experiences of children in the sample, I conduct a bivariate comparison of food and beverage consumption behaviors (i.e., the outcome variables) by types of school competitive food and beverages practices (i.e., the key independent variables) for fifth- and eighth-graders. I examine whether there are statistically significant differences in mean dietary behaviors between children without access to competitive foods and beverages to those with access to competitive

foods and beverages using t-tests. I use children with no access to competitive foods or beverages as the reference group.

While bivariate differences can reveal some interesting associations between the dependent and independent variables, they are by no means definitive in establishing a causal relationship. There are a number of potential confounding factors that may affect the relationship between school competitive food and beverages practices and mean consumption of foods and beverages, that when unaccounted for, may produce biased coefficient estimates.

In the ideal scenario, I would choose to run a randomized control trial to establish whether a causal link exists between school competitive food and beverage practices and student's eating behaviors. For instance, random assignment of some schools to a treatment group offering competitive foods and beverages and other schools to a control group offering no competitive foods and beverages would reasonably control for differences in characteristics of the schools that may affect the outcome of interest—children's food and beverage consumption behaviors.

A randomized experiment is not an option for my dissertation, so I use a non-experimental approach and attempt to replicate the conditions of a randomized experiment as closely as possible. The challenge with any non-experimental approach is that the goal to artificially create the counterfactual—what would have happened if school X implemented policy A instead of policy B—can be daunting.

I begin the multivariate estimation strategy using cross-sectional ordinary least squares (OLS) regression models to control for observable differences in eating patterns across children when they are in the fifth and the eighth grades. The notation for the OLS model(s) I estimate is as follows: there are a set of individuals (i=1,…,I) who attend a set of schools (j=1,…J). The three dependent variables, frequency of eating healthy foods and drinking healthy and unhealthy beverages, in fifth (eighth) grade are *y*. The independent variables in the models include a set of competitive school food (x1) and beverage practices (x2), and a set of factors related to children, their families, schools, and neighborhoods (x3). B1, B2, and B3 are vectors of the coefficients on x1, x2, and x3, B0 is an intercept term, and ε represents error that is assumed to be zero. I estimate models separately for when children are in the fifth grade and when they are in the eighth grade. Model 1 depicts these relationships.

(1) $y_{ij} = \beta 0 + \beta 1 x1_{ij} + \beta 2\, x2_{ij} + \beta 3 x3_{ijt} + \varepsilon_{ij}$

Even if I control for all relevant *observable* characteristics that might affect mean differences in weekly food and beverage consumption, there may be a number of *unobservable* characteristics for which I have no measures. These "unobservables" would fall into the error term in the model and if they were correlated with the outcome, *y*, and with the competitive food and beverage practices, x1 and x2, the OLS model would produce biased estimates of B1 and B2, the coefficients on competitive food and beverage practices.

To address potential unobservable confounders, my primary identification strategy relies on a first difference model. When there are at least two periods that the dependent variable is measured for individuals, a first difference model can be used to control for some unobserved characteristics; that is, those that are time invariant (Wooldridge, 2002). The notation is as follows: there are a set of individuals (i=1,…, I) who attend a set of schools (j=1,…,J). There are two time periods considered, eighth-grade (time period = *t*) and fifth-grade (time period = *t-1*). The three dependent variables, frequency of eating healthy foods and drinking healthy and unhealthy beverages, are *y*. The independent variables in the models include school competitive food practices that vary over time, x1, school competitive beverages practices that vary over time, x2, a set of factors related to children, their families, schools, and neighborhoods that vary over time, x3. β1, β2, and β3 are vectors of coefficients and β0 is an intercept term that varies over time. There are two error terms included in the model, α and ε. ε represents error that varies by individual and over time, while α represents error that varies only by individual and does not vary over time. Model 1 depicts these relationships during time *t-1* (fifth grade) and model 2 depicts these relationships at time *t* (eighth grade).

(1) $y_{ijt-1} = \beta 0_{t-1} + \beta 1_{t-1} x1_{ijt-1} + \beta 2_{t-1} x2_{ijt-1} + \beta 3 x3_{ijt-1} + \alpha_{ij} + \varepsilon_{ijt-1}$

(2) $y_{ijt} = \beta 0_{t} + \beta 1_{t} x1_{ijt} + \beta 2_{t} x2_{ijt} + \beta 3 x3_{ijt} + \alpha_{ij} + \varepsilon_{ijt}$

To estimate the first difference, model 1 is subtracted from model 2, deriving the following equation:

(3) $(y_{ijt} - y_{ijt-1}) = (\beta 0_{t} - \beta 0_{t-1}) + (\beta 1_{t} x1_{ijt} + -\beta 1_{t-1} x1_{ijt-1}) + (\beta 2_{t} x2_{ijt} + -\beta 2_{t-1} x2_{ijt-1}) + \beta 3\ (x3_{ijt} - x3_{ijt-1}) + (\varepsilon_{ijt} - \varepsilon_{ijt-1})$

In equation 3, I have allowed the effects of competitive food practices (x1) and beverage practices (x2) to vary over time. This relationship is noted by allowing B1 and B2 to vary by *t*. I have allowed this flexibility in functional form because I want to be sure I capture effects of competitive food and beverage practices, which may not be constant over time. Of note, I have not allowed the effects of the control variables to vary over time.

The differencing strategy removes all time invariant factors common to individual i in school j, α_{ij}, from the model. Alpha does not capture time invariant factors where their effects on *y* vary over time. These effects are included in ε. This model can be simplified by replacing the difference scores with asterisks (Allison, 2005).

(4) $y_{ij}^* = \beta 0^* + (\beta 1_t x1_{ijt} + -\beta 1_{t-1} x1_{ijt-1}) + (\beta 2_t x2_{ijt} + -\beta 2_{t-1} x2_{ij\,t-1}) + \beta 3 x3_{ij}^* + \varepsilon^*$

The coefficients on x1 and x2 represent the effects of changes in competitive school food and beverage practices on changes in food and beverage consumption behaviors during a given week for children who experienced such conditions compared with children who did not have access to competitive foods and beverages in school in either year. In essence, these are my best estimates of effects of competitive food and beverage policies on consumption patterns. These effects are derived by using each student as his own control. For each individual student, frequency of consumption patterns in fifth- and eighth-grade are subtracted (a difference score). The resulting difference scores for each individual will allow me to estimate the average relationship between a difference in consumption patterns over time and a difference in competitive food and beverage practice conditions for the entire sample (Allison, 2005).

To investigate time-invariant factors that may differentially affect food and beverage consumption behaviors for different sets of students, I estimate separate models that include interactions between school competitive food and beverage practices and gender, race, and fifth grade poverty status. Of note, I found no interactive relationships between these variables and the policy variables of interest, so those regression results are not shown in chapter 4, only discussed.

The benefit of using first difference models over a basic OLS regression is that unobserved time-invariant factors that could bias estimates (α_{ij}) are subtracted out; that is, those "unobserved factors" from the OLS model that fell into the error term. This approach may at least in part resolve a key issue that is often cited in the literature that there is a potentially endogenous relationship between school food practices and child dietary behaviors. For instance, some schools may enact healthy competitive food practices because children are overweight or obese and school officials are trying to combat the problem. Simply estimating a model without considering this relationship could produce biased estimates by confusing the initial condition of children being overweight and having poor eating habits with the effect of the school policy (Fox et al., 2009). Without controlling for the endogenous relationship, the model could, over- or understate the relationship between healthy competitive food and beverage practices and students' consumption of healthy foods and beverages.

The primary limitation using first difference models to identify effects is the threat of omitted variable bias. Omitted variable bias could take three forms. First, there may be

unobserved characteristics that are fixed over time, but their effects on *y* vary between fifth and eighth grade. Second, there may be unobserved characteristics that vary between fifth and eighth grade and there effects on *y* do not vary over time. And third, there may be unobserved characteristics that vary over time and their effects on *y* vary over time. These three types of error are represented by ε* in the model. Only those unobserved characteristics that are correlated with both competitive food and beverage practices and consumption behaviors could bias the estimates of the effects of competitive food and beverage practice. Otherwise, omitted variables could reduce the efficiency of the estimates by exaggerating the standard errors I estimate, making it more difficult to reject the null hypothesis. There is no way to assess the extent to which unobserved characteristics could be affecting the results.

Statistical Significance

I use two-tailed t-tests to assess the statistical significance of the independent variables in all analyses. Because I make many comparisons, it is likely that some results will appear significant, even if they are not real. To try and curtail the extent to which I could incorrectly conclude that significant results exist, I use a 95 percent confidence level to indicate statistically significant results and I also run a number of sensitivity analyses to test the robustness of my findings, thereby reducing the likelihood of incorrectly rejecting the null hypothesis.

Weighting

The data supporting this analysis are based on a sample drawn from a complex survey design. Individual students are nested within schools which are nested within larger geographic units (often counties). To account for the complex survey design, I estimate all models using survey weights and a statistical software package that adjusts the standard errors to account for clustering. I provide a description of the complex survey design later in this chapter in the section about data sources. I also include a sensitivity analysis to assess the effect of using survey weights by excluding the survey weights on a subset of the models. These results are presented in chapter 4.

Missing Data

For all analyses I use imputed data to fill in missing values on all variables. Missing data can be a concern in any analysis because simply dropping observations with missing data can lead to a loss of statistical power and potentially bias parameter estimates. For most variables in the analyses I conduct, few cases have missing observations. There are two exceptions. First, up to 10 percent of school administrators did not respond to some questions leading to a 10 percent missing rate on some school-level variables, including the competitive food and beverage practice variables. Second, 20 percent of cases have missing food price data.

To impute missing values, I use an analysis technique called multiple imputation and implement it using a statistical software package, SAS 9.1. Multiple imputation is an increasingly popular analysis method used to impute missing values on observations and

has shown to be a reasonably reliable method of producing unbiased and statistically valid parameter estimates (Puma, Olsen, Bell, and Price, 2009).

Multiple imputation creates multiple analysis datasets with randomly generated values on the missing observations (Allison, 2002). Models are estimated on each of the newly-created datasets with imputed data and the parameter estimates and variance estimates associated with the models are combined to create statistically valid inferences that include uncertainty about the missing values (SAS, 2010). Like other imputation methods such as listwise deletion, multiple imputation assumes that the data missing are missing at random (MAR), which means that the probability of missing data on the dependent variable is unrelated to the value of the dependent variable after controlling for observable factors. There is no way to check whether this assumption is tenable. To assess the effects of using multiple imputation, I include a sensitivity analysis whereby I estimate a set of models using non-imputed data. I present these results in chapter 4.

Statistical Software

I use SAS 9.1, a statistical analysis software program, to create the analysis dataset and conduct all analyses. I used Proc MI to impute data, the Survey procedures to estimate regression models accounting for clustering using survey weighting, and MI Analyze procedure to obtain coefficient estimates that account for the imputation process.

Variable Creation

For each of the variables I outline below, I subtract the value from the fifth-grade round of data from the eighth-grade round of data to get a difference score to use in the first difference models. The difference scores represent change over time. In the variable descriptions below, I will not discuss the actual creation of the difference scores.

Dependent Variables

To assess the role of school competitive food and beverage practices on a student's consumption behaviors, I examine three outcomes, or dependent variables: 1) weekly frequency of healthy food consumption; 2) weekly frequency of healthy beverage consumption; and 3) weekly frequency of unhealthy beverage consumption. Data supporting each of these variables comes from the Child Food Consumption Questionnaire administered in the fifth-grade round of the Early Childhood Longitudinal Survey, Kindergarten Class of 1998-1999 (ECLS-K) and the Spring Student Questionnaire administered in the eighth-grade round of the ECLS-K (National Center for Education Statistics, 2004; National Center for Education Statistics, 2007). The questions and response categories are the same in each wave.

Weekly Frequency of Healthy Food Consumption

As a proxy measure for healthy food consumption, I use students' responses to four questions about the number of times they consume fruits and vegetables over the course of the week (see Table 3.1).

Table 3.1: Survey Questions Used to Create Weekly Frequency of Healthy Food Consumption

Survey Question	Response Categories
During the past 7 days, how many times did you eat green salad?	a. I did not eat green salad during the past 7 days b. 1 to 3 times during the past 7 days c. 4 to 6 times during the past 7 days d. 1 time per day e. 2 times per day f. 3 times per day g. 4 or more times per day
During the past 7 days, how many times did you eat carrots?	a. I did not eat carrots during the past 7 days b. 1 to 3 times during the past 7 days c. 4 to 6 times during the past 7 days d. 1 time per day e. 2 times per day f. 3 times per day g. 4 or more times per day
During the past 7 days, how many times did you eat other vegetables? (Do not count green salad, potatoes, or carrots.)	a. I did not eat other vegetables during the past 7 days b. 1 to 3 times during the past 7 days c. 4 to 6 times during the past 7 days d. 1 time per day e. 2 times per day f. 3 times per day g. 4 or more times per day
During the past 7 days, how many times did you eat fruit, such as apples, bananas, oranges, berries or other fruit? (Do not count fruit juice.)	a. I did not eat fruit during the past 7 days b. 1 to 3 times during the past 7 days c. 4 to 6 times during the past 7 days d. 1 time per day e. 2 times per day f. 3 times per day g. 4 or more times per day

Sources: National Center for Education Statistics, 2004 and National Center for Education Statistics, 2007.

To estimate the number of times per week a student eats fruits and vegetables, I multiply response categories *d* – *g* by seven (I top-code response category *g* at four); take the midpoint of response categories *b* and *c*; and assume response category *a* is equal to zero.

I create a summed weekly consumption measure for each type of fruit and vegetable, and then I combine them into a single summed score. Thus, the minimum number of times per week a student could consume fruits and vegetables is 0 (i.e., students who reported consuming no fruits and vegetables during the week) and the maximum is 112 (i.e., students who report each fruit and vegetable four or more times each day during the last seven days).

Weekly Frequency of Healthy Beverage Consumption

As a proxy measure for healthy beverage consumption, I use students' reported consumption of times drank milk and 100 percent fruit juices during the week. Similar to the questions about fruit and vegetable consumption, two questions were posed to students as shown in table 3.2.

Table 3.2: Survey Questions Used to Create Weekly Frequency of Healthy Beverage Consumption

Survey Question	Response Categories
During the past 7 days, how many glasses of milk did you drink? (Include all types of milk, including cow's milk, soy milk or any other kind of milk; include the milk you drank in a glass or cup, from a carton, or with cereal. Count the half pint of milk served at school as equal to one glass.)	a. I did not drink milk during the past 7 days b. 1 to 3 glasses during the past 7 days c. 4 to 6 glasses during the past 7 days d. 1 glass per day e. 2 glasses per day f. 3 glasses per day g. 4 or more glasses per day
During the past 7 days, how many times did you drink 100% fruit juices such as orange juice, apple juice, or grape juice? (Do not count punch, Kool-Aid, sports drinks, or other fruit-flavored drinks.)	a. I did not drink 100% fruit juice during the past 7 days b. 1 to 3 times during the past 7 days c. 4 to 6 times during the past 7 days d. 1 time per day e. 2 times per day f. 3 times per day g. 4 or more times per day

Sources: National Center for Education Statistics, 2004 and National Center for Education Statistics, 2007.

I use the same method of variable construction for healthy beverage consumption as I do for fruits and vegetables. First, I create a separate summed healthy beverage consumption frequency score for milk and juice, and then I sum them. The measure I create has a minimum of zero (i.e., students who reported no consumption of milk or juice during the last seven days) and a maximum of 56 (i.e., students who reported drinking juice and milk four or more times each day during the last seven days.).

Weekly Frequency of Unhealthy Beverage Consumption

I measure unhealthy beverage consumption using students' responses to one question about sweetened beverage consumption. Students were asked the question and shown in table 3.3.

Table 3.3: Survey Questions Used to Create Weekly Frequency of Unhealthy Beverage Consumption

Survey Question	Response Categories
During the past 7 days, how many times did you drink Soda pop? (EXAMPLES Coke, Pepsi, Mountain Dew), sports drinks (EXAMPLE Gatorade), or fruit drinks that are not 100% fruit juice (EXAMPLES Kool-Aid, Hi-C, Fruitopia, Fruitworks)?	a. I did not drink any during the past 7 days b. 1 to 3 times during the past 7 days c. 4 to 6 times during the past 7 days d. 1 time per day e. 2 times per day f. 3 times per day g. 4 or more times per day

Sources: National Center for Education Statistics, 2004 and National Center for Education Statistics, 2007.

I create the variable representing unhealthy beverage consumption in the same manner as the aforementioned dependent variables. Because there was only one question asked, the minimum frequency of unhealthy beverage consumption per week is zero and the maximum is 28 (students who report drinking sweetened beverages 4 or more times a day during the last 7 days).

Key Independent Variables

The key independent variables in this analysis are a set of competitive school food and beverage practice variables. The technical definition of a competitive food by the U.S. Department of Agriculture is "…any foods sold in competition with the Program [NSLP] to children in food services areas during the lunch periods" (7CFR 210.11). I broaden the definition to include any food or beverages sold in school during school hours that are a

not part of the school lunch program. Even if competitive foods and beverages are not available during the lunch period, they could still have an effect on the overall food consumption patterns of a child over the course of a day.

I examine both a broad and a narrow view of food and beverage practices. In one set of models, I examine the effect of offering any competitive foods or any competitive beverages to children in the fifth and eighth grades. In a second set of models, I examine the role of places competitive foods are offered (e.g., vending machines, a la carte lines, school stores, etc.) and types of competitive foods offered (e.g., fruits and vegetables, sugary and salty snacks, milk and juice, and sweetened beverages).

School Competitive Food and Beverage Practices

In both the fifth- and eighth-grade rounds of the ECLS-K, school administrators were asked two questions about food and beverages: (1) whether students could purchase foods or beverages from vending machines, school stores, canteens, or snack bars, and (2) whether students could purchase a la carte items during the school day. School administrators were also asked a question about what types of foods and beverages were available for purchase. School administrators could choose from the following response categories:

a. Chocolate candy?
b. Other kinds of candy?
c. Cookies, crackers, cakes, pastries, or other baked goods that are not low in fat?
d. Salty snacks that are not low in fat, such as regular potato chips?
e. Ice cream or frozen yogurt that is not low in fat?
f. 2% or whole milk?
g. Fruits or vegetables, not juice?
h. Low-fat cookies, crackers, cakes, pastries, or other low-fat baked goods?

i. Salty snacks that are low in fat, such as pretzels, baked chips, or other low-fat chips?
j. Bread sticks, rolls, bagels, pita bread, or other bread products?
k. Low-fat or fat-free ice cream, frozen yogurt, or sherbet?
l. Low-fat or non-fat yogurt?
m. 1% or skim milk?
n. Bottled water?
o. 100% fruit juice?
p. 100% vegetable juice?
q. Soda pop, sports drinks, or fruit drinks that are not 100% juice?

I use the school administrators' responses to these three questions about competitive foods and beverages offered in school to create three sets of categorical variables.

Any Competitive Foods or Beverages Sold

No competitive foods sold. I code this dichotomous variable as a one when the following requirements are met: (1) the school administer responded that the school does not sell food or beverages in vending machines, school stores, canteens, snack bars, or the a la carte line during the school day; or (2) the school administer responded that the school does sell food or beverages in vending machines, school stores, canteens, snack bars, or the a la carte line during the school day, but does not indicate that any foods are available for sale, only beverages.

No competitive beverages sold. I code this dichotomous variable as a one when the following requirements are met: (1) the school administer responded that the school does not sell food or beverages in vending machines, school stores, canteens, snack bars, or the a la carte line during the school day; or (2) the school administer responded that the

school does sell food or beverages in vending machines, school stores, canteens, snack bars, or the a la carte line during the school day, but does not indicate that any beverages are available for sale, only food items.

Location of Competitive Foods and Beverages Sold

A la carte lines only. This dichotomous variable takes the value of a 1 if the school administrator responded that competitive foods or beverages were sold from a la carte lines, but not from any other type of location. This variable takes the value of a zero for all other possible responses.

Vending machines, snack bars, or other locations only. This dichotomous variable takes the value of a 1 if the school administrator responded that competitive foods or beverages were sold from vending machines, school stores, canteens, snack bars or any other location in the school except from a la carte lines. This variable takes the value of a zero for all other possible responses.

A la carte lines and other locations. This dichotomous variable takes the value of a 1 if the school administrator responded that competitive foods or beverages were sold from both a la carte lines and from other locations in the school, such as vending machines, school stores, canteens, and snack bars. This variable takes the value of a zero for all other possible responses.

Types of Competitive Foods Sold

Only healthy competitive foods sold. I code this dichotomous variable as a one when the following requirements are met: (1) foods and beverages are sold from vending machines, school stores, canteens, and snack bars, or from la carte items during the school day; and (2) types of foods sold only include fruits and vegetables.

Only unhealthy competitive foods sold. I code this dichotomous variable as a one when the following requirements are met: (1) foods and beverages are sold from vending machines, school stores, canteens, and snack bars, or from la carte items during the school day; and (2) types of foods sold only include anything other than fruits or vegetables (i.e., all foods listed above other than fruits and vegetables).

Mixture of healthy and unhealthy competitive foods sold. I code this dichotomous variable as a one when the following requirements are met: (1) foods and beverages are sold from vending machines, school stores, canteens, and snack bars, or from la carte items during the school day; and (2) types of foods sold include fruits and vegetables as well as any other food listed above (e.g., candy, chips, crackers, cookies, et cetera).

Types of Competitive Beverages Sold

Only healthy competitive beverages sold. I code this dichotomous variable as a one when the following requirements are met: (1) foods and beverages are sold from vending machines, school stores, canteens, and snack bars, or from la carte items during the school day; and (2) types of beverages sold only include 2 percent or whole milk; 1 percent or skim milk; 100 percent fruit juice; and 100 percent vegetable juice.

Only unhealthy competitive beverages sold. I code this dichotomous variable as a one when the following requirements are met: (1) foods and beverages are sold from vending machines, school stores, canteens, and snack bars, or from la carte items during the school day; and (2) types of beverages sold only include soda pop, sports drinks, or fruit drinks that are not 100 percent juice.

Healthy and unhealthy competitive beverages sold. I code this dichotomous variable as a one when the following requirements are met: (1) foods and beverages are sold from vending machines, school stores, canteens, and snack bars, or from la carte items during the school day; and (2) types of beverages sold include milk and juice as well as sweetened beverages such as soda, sports drinks, and other fruit drinks that are not 100 percent fruit juice.

Other Control Variables

As I outline in the literature review, there are a number of possible factors that influence a child's consumption behaviors besides a school's competitive food and beverage practices. The theoretical framework guiding this analysis, a socio-ecological theory of obesity causation, suggests four areas to explore: the individual, the family, the school, and the community. Table 3.4 outlines the variables I use in the analyses.

Table 3.4: Control Variables Included in the Models

Control Variable	Description
Individual characteristics	
Gender	Controls for potential differences related to gender
Race/Ethnicity	Controls for potential differences related to race/ethnicity
Height	Controls for nutritional need
Family characteristics	
Number of dinners eaten at a regular time	Controls for parental control of and influence on consumption patterns
Television-watching rules	Controls for parental monitoring of children's behavior
School choice	Controls for parental influence and control over type of school child attends
Maternal employment	Controls for parental supervision over children's consumption behaviors
Family structure	Controls for parental control over children's consumption behaviors
Poverty	Controls for resources available to purchase foods and beverages
School characteristics	
School type (i.e., public or private)	Controls for student characteristics
School change	Controls for potential differential school effects of children who changes schools from those who do not change schools.
Cafeteria overcrowding	Controls for time available to consume foods and beverages during the lunch period
Community characteristics	
Access to fast food restaurants	Controls for access to unhealthy foods before and after school
Access to convenience stores	Controls for access to unhealthy foods before and after school
Price of fast food items	Controls for cost of unhealthy foods
Price of fruits and vegetables	Controls for cost of healthy foods
State obesity trends	Controls for societal unhealthy consumption trends
State fruit and vegetable consumption patterns	Controls for societal healthy consumption trends

Individual Characteristics

Gender and Race. The ECLS study collected information on the gender and race of children sampled. For the analysis, I code four race categories: white, black, Hispanic, and other race. Sample sizes do not permit examination of smaller racial groups, such as Asians.

Height. Height is a proxy for a child's basic nutritional needs; taller children are assumed to have higher nutritional needs. The ECLS study team measured height twice using the Shorr Board (Shorr Productions, Olney, Md). I use the variable for height provided in the ECLS-K dataset that combines the findings of these two measurements.

Family Characteristics

Number of dinners eaten at a regular time. Eating regular family dinners has been associated with healthier eating patterns for children (Videon and Manning, 2003). It may be that parents who take the time eat dinner at a regular time with their children are more likely to be involved with helping to establish healthy eating patterns, as they are aware of what their children are and are not eating on a daily basis. These same characteristics may be associated with involvement in school food policy decision-making. The ECLS study asked parents how many dinners they ate with their children at a regular time every night. Parents could choose between zero and seven nights. I include this continuous variable in the models.

Television-watching rules. Parents' regulation of their children's behaviors may have an effect on consumption of foods and beverages. For instance, parents who more closely

regulate their children may have more influence on their children's consumption patterns. Further, parents may more closely regulate their children's behaviors when their children are younger rather than when they are older. To capture these potential effects on consumption behaviors, I use family rules for watching television as a proxy for parental regulation. The ECLS-K asks parents if there are rules about television-watching. I create a dichotomous variable equal to one for households with rules about watching television.

School choice. One could argue that parents who are actively involved in the choice of the school their child attends may also be more concerned with the diet and activity patterns of their children. The ECLS-K asked parents whether the school their child attends is one that they chose, or if it was assigned to them. I include a dummy variable equal to one if a parent reported choosing their child's school. For those parents who reported that the school was assigned to them, but it was their school of choice, I code them as also choosing their child's school. These parents may have moved to the particular school district specifically so their children could attend the parents' school of choice.

Maternal employment. The increase in the number of obese children coincides with women's entry into the labor market and some have argued that this relationship is causal. Recently, Anderson, Butcher, and Levine (2003) found that after controlling for both observable and unobservable differences across children and families, children whose mothers had more hours of employment were more likely to be overweight. The

authors argue that this relationship may be due to a number of factors that influence diet and exercise. For instance, more hours of maternal employment may lead to increased time in child care where children may have access to less nutritious foods. More hours of maternal employment may also result in children consuming more energy-dense meals outside of the home at limited and full-service restaurants. The ECLS-K includes a question about mother's employment. I use this question to create a dummy variable equal to one if the mother was employed 35 hours or more per week as a proxy for full-time work status. For households without a mother figure, I use the response of the head of household.

Family structure. Some literature suggests that family structure affects the probability of obesity, with children from single-parent families more likely to be obese than children from two-parent families (Gibson et al., 2007; Crossman, unpublished). It could be that single parents are less able to monitor their children's eating behaviors than two-parent households given other demands on their time. To account for this possible relationship, I include a categorical variable to capture children who live with two parents, children who live in single parent households, and children who live in other types of households.

Poverty. Family financial resources could affect a parent's ability to purchase healthy foods such as fruits and vegetables, particularly because some studies have found that these foods are more expensive than unhealthy snacks (Jetter & Cassady, 2006). To assess household resources, I include a dummy variable provided by the ECLS-K that indicates whether the family was living below the federal poverty level at the time of the

survey. The federal poverty level takes into account household income, adjusted for family size.

School Characteristics

Cafeteria overcrowding. Students' decisions about whether to bring a lunch to school or to purchase the school lunch and/or competitive foods may be due in part to time available to eat lunch. Students with more time to eat lunch may be more likely to take the time to purchase a meal, while those with less time may choose to bring a meal from home. Recent research has not found a link between overcrowding in cafeterias and school lunch participation (Gorden et al., 2007), but older studies have (Marples & Spillman 1995; Maurer, 1984). As a proxy for time to eat lunch, I included a variable that measures the capacity of the lunchroom, with the assumption that overcrowding in lunchrooms leads to less time to purchase foods at school. This variable is equal to one if the school administrator reported that the cafeteria was over-capacity.

School change. Some children attend different schools in the eighth-grade than they did in the fifth-grade. The change in the school environment may be related to a change in food and beverage consumption outcomes. To control for this potential confounder, I include a dichotomous variable equal to one if the child attended a different school in eighth-grade than in fifth-grade.

Community Characteristics

Access to fast food restaurants. With the growing rates of obesity, many have pointed to the food offerings of fast food restaurants as a potential cause. A recent study by Currie, DellaVigna, Moretti, and Pathania (2009) found that ninth-graders going to school within 0.1 miles of a fast food restaurant were more likely to be obese than students attending schools that did not have fast food restaurants within 0.1 miles, controlling for other factors. The authors did not find evidence, however, that fast food restaurants within 0.25 or 0.50 miles of a school affected the probability of obesity. To control for this aspect of the build environment, I control for the number of restaurants within a child's zip code.

Access to convenience stores. Along with fast food restaurants, many have cited convenience stores as a potential contributor to the obesity epidemic, given that they often sell fewer healthy foods than full grocery stores. A recent study by Morland, Diez Roux, and Wing (2006) found that access to convenience stores was associated with a higher probability of obesity. The argument is that children may be within walking distance to convenience stores from their school, which could potentially affect consumption patterns. To control for this aspect of the built environment, I include a control variable for the number of convenience stores within the child's school's zip code.

Price of fruits and vegetables. There is evidence that healthy foods such as fruits and vegetables are often more expensive than energy-dense food options such as foods consumed at fast food restaurants (Monsivais & Drewnowski, 2009). Particularly for

families with limited income, low-cost, energy-dense foods are often a staple (Drewnowski and Specter, 2004). To account for the cost of fruits and vegetables and the cost of fast foods, I create weighted average price indices of fruits and vegetables and of fast food meals. This requires creating a market basket of fruits and vegetables and a market basket of fast food items. I calculate the fruit and vegetable market basket using 2004 and 2006 American Chambers of Commerce Researchers Association (ACCRA) average prices and weights provided by the ACCRA Cost of Living Index Manual for the following items: potatoes, bananas, lettuce, sweet peas, peaches and frozen corn (Council for Community and Economic Research, 2006). To calculate the fast food market basket, I use ACCRA average price data and use their assumption of equal weighting for the following items: a hamburger, fried chicken and pizza.

ACCRA data is at the Core Based Statistical Area (CBSA) level, which is an urban level of geography. Since not all children reside in urban areas, not all children had a corresponding CBSA code. I use averages of the fruit and vegetable and fast food price indices in each of the CBSAs in the state as a proxy for children living in non-urban areas.

Social Eating Patterns. Societal trends in fruit and vegetable consumption and obesity rates may reflect overall eating patterns and therefore children's eating patterns. To account for societal eating patterns, I include two Major Metropolitan Statistical Area (MMSA) level variables that indicate the percent of the population that consumed fewer than 5 fruits and vegetables each day and the percent of the population who are obese

using Behavioral Risk Factor Surveillance System data (BRFSS). I use state-level averages for children who did not reside in MMSAs.

Data Sources

I use four sources of data to conduct the analyses. The Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 is the primary source of data with information at the child-level. I also merge in food price data from the American Chambers of Commerce Researchers Association (ACCRA); number of convenience stores and fast food restaurants from the U.S. Census Bureau's Zip Business Patterns; and state fruit and vegetable consumption patterns and obesity population estimates from the Behavioral Risk Factor Surveillance System (BRFSS).

Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 (ECLS-K)

The ECLS-K is a study conducted by the U.S. Department of Education with funding from a variety of other government agencies with the purpose of understanding children's development and educational attainment during childhood and early adolescence. The ECLS-K is a nationally-representative sample of 22,666 kindergarteners from the 1998-1999 school year (National Center for Educational Statistics, 2009). The sample was freshened in the spring of first-grade to include first-graders who had never attended kindergarten and therefore were ineligible for sampling in the base year.

It is important to note that the ECLS-K is a nationally-representative sample of children who were in kindergarten in the 1998-1999 school year. The sample is not representative

of fifth or eighth-graders, nor is it representative of schools offering fifth or eighth grade education. According to NCES (2009), the sample of children in the eighth grade represented approximately 80 percent of children who were actually in the eighth grade in 2007. Groups excluded include children who attended kindergarten before age 5, children who immigrated to the country after the first grade, and children who were homeschooled through the first grade. The analyses conducted for this dissertation will therefore be representative of children who were in kindergarten in the 1998-1999 school year and will not be a perfect representation of children in middle school in 2007. It is therefore possible that if this analysis were conducted on a representative sample of eighth graders in 2007, I would find different results.

The study surveys children as well as their parents, teachers, and school administrators when children were in kindergarten, first-, third-, fifth-, and eighth-grades. Of relevance to this study, the fifth- and eighth-grade rounds of data collection (interviews were conducted in the spring) include children's responses to questions about their food consumption over the prior week as well as questions asked of school administrators regarding competitive foods offered during the school day.

There are a number of complexities of the ECLS-K sample, from the actual design to how children are followed over time. The ECLS-K is a multistage probability sample. The primary sampling unit is a geographic unit including either a county or a group of counties. The secondary sampling unit is schools within the primary unit, and the third sampling unit is children within those schools. The ECLS-K oversampled one group of

children—Asian and Pacific Islanders. In the first grade data collection year, the ECLS increased the sample of children to include those who did not attend kindergarten in the base year. In the spring first grade, third grade, and fifth grade rounds of data, only a subsample of children who changed schools were followed. Language minority children were followed at higher rates. All children who changed schools between fifth and eighth grade were followed, given many children attend separate elementary and middle schools. The students sampled in the eighth grade round of data collection represent 41 percent of base year respondents. The ECLS-K includes weights to account for the complex survey design, differential subsampling in each wave, oversampling of Asian/Pacific Islanders, and survey nonresponse. I use these weights in all analyses.

In order to merge in other data sources by geographic identifier, I use a restricted-use variable, child's zip code, located in the restricted-use versions of the fifth- and eighth-grade rounds of data. I merge in child zip code to the public-use data using a unique child identifier. Where the child's zip code was missing, I use the child's school's zip code as a proxy. I use geographic crosswalk files to merge MMSA and CBSA codes to children's zip codes.

The analysis file I construct is limited to only include schools that report offering the school lunch program. By definition, a competitive food is a food that competes with the school lunch program. Few children, approximately 500, were dropped from the analysis file, as most children attend schools that offer the National School Lunch Program (FRAC, 2009).

The analysis file is also limited to children who respond in both the fifth- and eighth-grade rounds of data. As with any longitudinal data set, there has been attrition in the ECLS-K sample. In the first round of data collection, 22,666 children were surveyed; by eighth-grade, only 12,129 respondents remained. The ECLS-K study team only followed a subsample of children who moved schools each year of data collection. I used survey weights to account for loss of sample to maintain representativeness. The total sample for the analyses I conduct is 7,280 children. Per U.S. Department of Education disclosure rules, unweighted sample sizes are rounded to the nearest 10.

Census Zip Business Patterns

I use the U.S. Census Bureaus' Zip Business Patterns data to measure number of fast food restaurants and convenience stores within the child's school's zip code. These data are collected annually by the Census Bureau. Information is available from: http://www.census.gov/epcd/www/zbp_base.html. All businesses operating with an Employer Identification Number (EIN) and employees are counted. Businesses are classified by the 2002 North American Industry Classification System (NAICS), which includes approximately 1,200 industries. I use NAICS code 445120 (convenience food stores) as my measure for convenience stores and code 722211 (limited-service restaurants) as my measure for fast food restaurants.

American Chambers of Commerce Researchers Association (ACCRA)

To capture the effect of a change in fruit and vegetable and fast food prices, I use ACCRA average price data from 2004 and 2006 to calculate a fruit and vegetable as well as a fast food price index. The Council for Community and Economic Research collects quarterly data on prices of items representing six categories, grocery items, housing, utilities, transportation, health care, and miscellaneous goods and services. These data are intended to be representative of average prices in more than 300 urban areas. Data are available at the Core Based Statistical Area (CBSA) level. ACCRA also provides weights for each category to create an expenditure index. These weights are derived from the percent of consumer spending in each food category from the Bureau of Labor Statistics' 2004 Consumer Expenditure Survey.

Behavioral Risk Factor Surveillance System (BRFSS)

The Behavioral Risk Factor Surveillance System is administered by the Centers for Disease Control and Prevention. It is a monthly telephone survey that is conducted in all the states, the District of Columbia, Puerto Rico, Guam and the Virgin Islands. The purpose of the survey is to gather information about risk behaviors, preventive health practices, and health care access primarily related to chronic disease and injury. Every year, the survey is administered to more than 350,000 respondents. Annual data are available to researchers at the Major Metropolitan Statistical Area (MMSA) and state-levels on a number of health outcomes. I use the BRFSS data from 2004 and 2007 on percent of the MMSA and state populations who are obese and the percent of the MMSA and state populations who consume fewer than 5 fruits and vegetables per day.

Potential Limitations

As with any study, the non-experimental approach I conduct is open to a number of threats to validity that may have deleterious effects on the integrity of the results. I will discuss the limitations of my proposed research in terms of construct validity, internal validity, external validity, statistical conclusion validity, and data reliability (Shadish, Cook, & Campbell, 2002). I will also discuss a key limitation of the applicability of my proposed approach to the theoretical model upon which it is grounded. While the limitations I discuss below could all theoretically be problematic for the reliability of my results, some are more serious than others. The most serious threat to this study is omitted variable bias, which I discuss at length below.

The goal of construct validity is to create a construct—a variable or set of variables—that represents the reality that it is intended to measure. For instance, if I were interested in measuring usual intake of fruits and vegetables and I was relying on a food frequency questionnaire to collect this information, one question would be how well the food frequency questionnaire captured usual intake of fruits and vegetables for respondents. Internal validity refers to how well-founded any causal inferences drawn from the data are. External validity asks whether the study results are generalizable. Statistical conclusion validity is the degree to which the statistical methods used are able to correctly measure the covariation between two variables. Finally, data reliability is the extent to which the data used in the analyses reliably measure the variables across jurisdictions and across respondents.

Construct Validity

Inadequate Explication of the Constructs

This threat signifies a mistake in the explication of a construct used in the study. There are two key constructs in the proposed analysis: children's consumption patterns and school competitive food policy, both of which may have weaknesses. I will provide examples of the important ways in which the constructs I have proposed may not be properly explicated. I will also briefly discuss the ways in which some of the controls may be inadequately explicated.

Children' Consumption Patterns. I use children's responses to a food frequency questionnaire to construct the measure of their consumption patterns. The constructs I create are healthy eating and drinking behaviors. I use children's responses to questions about fruit and vegetable consumption as a proxy for healthy eating behaviors, responses to questions about fruit juice and milk consumption to proxy for healthy drinking behaviors, and responses to questions about soda and other sweetened beverage consumption to proxy for unhealthy beverage consumption.

There are a number of ways in which I may not accurately measure what I intend to measure. First, my measures for eating and drinking behaviors are not complete. For instance, my measure of healthy eating behaviors neglects all healthy foods that are not fruits and vegetables. Similarly, the measure for healthy drinking behaviors excludes water. Further, recommendations are given to children to drink milk each day; however, they could also get the recommended levels of calcium and vitamins A and D from other

food sources. While these are significant omissions, the Dietary Guidelines for Americans (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2005) recommends that children consume a specific number of servings of fruits, vegetables and dairy, so while the construct does not include all recommended foods, it does measure the extent to which children are consuming a critical set of important food and beverage items.

Second, the food and beverage constructs I include in the analyses are also incomplete in that they do not provide number of servings of healthy foods and beverages consumed during the week. The Dietary Guidelines for Americans recommends a certain number of servings of fruits and vegetables and other foods that different groups should consume to maintain a healthy diet (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2005). The food frequency questionnaire simply asks children how often in the last week they ate particular foods; it does not ask how large the portion consumed was.

Third, the proposed food and beverage constructs may exclude some of the food items I think they are actually measuring. For instance, the questionnaire provides examples of types of fruits and vegetables and beverages to illicit correct responses; however, children may not think to include some fruits and vegetables that they ate in the last week, particularly if they were not included in the list of examples or were served to children as a part of a dish instead of an individual item. In general, a contractor's report to USDA found that children were able to understand the questions asked in the ECLS-K food

frequency questionnaire and their reported consumption were comparable to responses of ninth-graders in the Youth Behavioral Risk Factor Surveillance System questionnaire (Macro, 2002).

A common theme in these potential limitations to construct validity is that food frequency questionnaires are intended to proxy usual intake, but they may not accurately capture usual intake. Some studies have shown that asking respondents to record what they ate results in significant underreporting of total energy (Martin et al., 1996). Studies have concluded that the most accurate assessment of usual intake outside of the costly doubly labeled water (DLW) is the 24-hour multiple pass recall conducted over at least a 3-day period that includes weekdays and weekend days and uses parents as proxy reporters for children ages 4 through 11 (Burrows, Martin, and Collins, 2010). Thus, for the purposes of this study, children may underreport fruits and vegetables, milk and juice, and sweetened beverages, leading to spurious associations with the key independent variables.

School Competitive Food Policy

School competitive food practices are classified by administrator's responses to questions about the availability of snacks in schools. There are two primary sources of potential error in the school competitive food policy construct. First, the survey may have missed potential places in the school where snacks were sold. Second, I classify the school policy based primarily on the types of foods offered. If there are food items missing from the list, I may misclassify the school food policy.

C*ontrol Variables.* There are a number of ways in which the constructs I include in the analyses may not be properly explicated. I will provide some of the most important issues. First, with regard to family characteristics, these measures are intended to capture a change in parental control over their children's time and choices between fifth- and eighth-grade. Further, each of these individual variables could have problems. For instance, I am assuming that parents who enforce television-watching rules are more likely to have control over their children's time and choices; however, it could be that the degree of the rules are more important—parents who are more restricting of time and program choice are more likely to monitor food consumption than parents who have more lenient rules.

Other control variables could have similar limitations. For instance, the poverty indicator variable is intended to measure a change in household resources. This measure, however, only captures income. There may be other sources of financial support such as TANF, food stamps, SSI, or other government benefits that contribute to a household's resources to purchase food.

The variable cafeteria overcrowding is assumed to capture the effect of limited time to purchase and consume meals during lunch, which may cause children to choose higher calorie, less nutrient-dense snacks that are quick to consume. It may be more important, however, to know the amount of time children are provided to eat lunch and how much time they have to spend in line if they choose to purchase food at school.

Finally, the community characteristics variables may not actually pick up characteristics of the child's food environment that matter most. It is possible that the measures I incorporate to capture access to fast food restaurants and convenience stores are not good enough proxies for access to unhealthy foods (e.g., distance to a fast food restaurant may be more important).

Construct Confounding

Construct confounding occurs when the construct developed contains unintended characteristics. This is a potential limitation of the dependent and key independent variables I include in the analyses. For example, I classify milk as a "healthy beverage"; however, there are instances where milk is not necessarily "healthy" (e.g., whole milk, flavored milks).

Mono-method Bias

Mono-method bias may be problematic if all outcome measures are derived from the same source. This is a limitation in the proposed study. The school competitive food policy variable is derived from a school administrator's self-report. Likewise, the dependent variables are constructed from students' self-reports of food consumption behaviors.

Confounding Constructs within Levels of Constructs

Confounding constructs within levels of constructs may be a study limitation if different levels of treatment produce different results. This may apply to my proposed study. For instance, it may be that other treatment factors such as cost of healthy versus unhealthy competitive foods may be important factors affecting children's food choices in school. In my study, I use prices of fast food items and fruits and vegetables in a child's neighborhood as proxies for competitive food prices in school.

Internal Validity

Rival Explanations of Observed Outcomes

Internal validity may be threatened if there are unobserved differences in respondents that could also have caused the observed effect (Shadish, Cook, & Campbell, 2002). As previously discussed, this could be a limitation of my proposed study. For instance, it may be that there are other changes in characteristics, such as other school wellness practices (e.g., nutrition education, increased physical education time) occurring simultaneously with a change in competitive food practice. It may be that these other policies or practices explain a change in dietary behavior, or at least explain a portion of a change in dietary behavior. If this is the case, I may under- or overstate the effect of competitive food practices on students' dietary intakes.

Two other important omitted variables could be school lunch and school breakfast participation. For instance, some research indicates that participation in the School Breakfast Program improves the overall diet of participants by lowering total calories from fat and increasing consumption of key nutrients (Bhattacharya, Currie, & Haider,

2006). With regard to school lunch participation, Gorden et al (2007) found that participants consumed more milk than non-participants over 24-hours. They also found that school lunch participants consumed fewer sweetened beverages such as soda during lunch, but these differences did not persist over a 24-hour period. The authors also found that school lunch participants were more likely than non-participants to consume at least one vegetable in a 24-hour period.

I do not include school meal participation in the main models because they are likely mediating variables, that is, a school's competitive food policy affects a child's decision to participate in the school lunch and breakfast programs. To get a sense of the extent to which school lunch and breakfast participation have an indirect effect on children's consumption patterns, I estimate models with these variables included in the model in a set of sensitivity analyses. The coefficient on school competitive food practices in these models only includes the direct effect and not the indirect effect through school lunch and breakfast participation. I include these sensitivity model results in chapter 4.

There are a number of other variables that could be important, but I do not have in my model. For instance, price of competitive foods and beverages in schools likely influences a child's purchase decision. Peer effects are also likely important, particularly for older children who may make food choices based on what their friends purchase and consume.

Finally, as previously discussed, some have argued that there may be an endogenous relationship between children's consumption patterns and competitive food and beverage practices. To investigate this possibility, I examined the covariates from my models by whether or not schools offered competitive foods and beverages in the fifth grade (see Table 3.5). Results suggest that there may be a selection mechanism at play. Compared with students attending schools that do not offer competitive foods and beverages, children who attend schools that do offer competitive foods and beverages tend to be white and fewer are Hispanic, a smaller share come from families that live below the poverty line, a smaller share have parents who report that they chose their child's school, and students have less access to fast food restaurants in their neighborhoods. It may be that there are unobserved omitted variables that further explain this potential indirect relationship and that ignoring these potential relationships could lead to biased impact estimates.

Table 3.5: Characteristics of Children, Their Families, Schools and Communities in the Fifth Grade by Competitive Food and Beverage Practices, Weighted

	Competitive Food and Beverage Practices			
	Competitive Foods		Competitive Beverages	
	Offered	Not Offered	Offered	Not Offered
Female (%)	47.9	47.8	47.4	48.4
Race (%)				
White	61.3	53.6	61.2	52.3
Black	17.6	16.8	16.8	17.8
Hispanic	15.4	21.5	15.8	22.0
Other race	5.7	8.2	6.2	7.9
Average height (inches)	57.9	57.6	57.9	57.5
Average number of dinners eaten at a regular time each week (days)	4.9	4.9	4.9	4.9
Family has television-watching rules (%)	91.1	87.9	90.7	87.8
Parent chose child's school (or school assigned was parent's choice) (%)	23.4	29.3	24.1	29.5
Mother works full-time (%)	52.2	50.9	52.1	50.9
Family structure (%)				
Two biological parents in household	72.7	73.2	73.1	72.8
Single-parent family	24.6	24.4	24.1	25.0
Other family type	2.7	2.4	2.8	2.2
Below 100% of the Federal Poverty Line (FPL) (%)	18.7	23.9	19.5	23.6
Public School (%)	93.0	89.1	91.9	90.0
Cafeteria is overcrowded at lunchtime (%)	2.5	3.3	2.6	3.4
Average number of convenience stores in the child's zip code	2.3	2.7	2.3	2.8
Average number of limited-service restaurants in the child's zip code	17.2	19.2	16.7	20.4
Average obesity prevalence in state of residence (%)	24.1	23.4	24.0	23.3
Average percent of state population that consumes fewer than 5 fruits and vegetables each day	77.0	76.9	77.1	76.7
Average fast food price index (1999 = base)	107.8	107.9	108.1	107.4
Average fruit and vegetable price index (1999 = base)	117.9	119.4	118.4	119.1
Number of Observations	3,770	3,510	4,330	2,950

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

I attempt to control for these potential factors by using a first difference approach to factor out all time-invariant unobserved individual characteristics and control for time-varying individual characteristics that may pick up the potential selection effect. If I do not include an important time-varying variable, however, the estimates from my models

could be biased. In addition, if effects of time invariant variables vary over time, results may also be biased. For instance, it may be that a child's peers who have influence over him do not change over time, but it may be that the extent to which his peers have an effect does change over time. Of note, the only time-varying characteristics that could produce biased coefficient estimates if left out of the models are those that would be correlated with both the outcome variables and the school competitive food policy variables.

To further investigate the possibility that coefficient estimates could be biased due to omitted time-varying variables, I also examine a set of models on a subset of the population of those children who did not change schools between fifth and eighth grade. These models may minimize the number of characteristics influencing children's consumption patterns that vary over time. I include the results of this sensitivity analysis in chapter 4.

External Validity

Interaction of the Causal Relationship with Units

This limitation suggests that external validity may be threatened if the effect found would not be found if other units were examined. In this study, one could imagine that the effect of competitive food policy on eating patterns may vary by the age of those studied. For instance, in the early elementary years, parents likely exert more control over their children's consumption patterns than children in high school. The effects I find may only be generalizable to students in the fifth and eighth grades.

Interaction of the Causal Relationship with Outcomes

This limitation occurs when the results of the study are valid only for the version of the outcome variable used in the analysis. This could be a limitation of my study. For instance, of notable concern is whether children are getting sufficient vitamins and minerals in the foods they eat and do not exceed recommendations for energy, fat, saturated fat, and sodium. It may be that if I were able to measure actual nutrient intake, I would find different results than by only using reported frequency of certain types of food and beverage consumption. While this may be a limitation, the foods and beverages I am using as proxies for healthy foods and beverages are generally lower in calories and higher in nutrients than other foods and beverages.

Limitations of the Sample

The ECLS-K is representative of children who attended (or who would have attended kindergarten) in the 1998-1999 school year. As noted earlier, NCES estimates that the eighth graders in the sample only represent 80 percent of eighth graders in 2007. Therefore, the results of this study may not be generalizable to all children in eighth grade in the U.S. in 2007.

Statistical Conclusion Validity

Violated Assumptions of Statistical Tests

When violations of the assumptions underlying the tests statistics occur, regression slopes may be biased or conclusions about statistical significance may be incorrect. There is one key limitation of the estimation approach I use. The estimation strategy I use

assumes that there is no correlation between school practices across schools. This may be problematic, as some school districts develop school food practices that dictate food policy for all schools within a district. To my knowledge, there are no data that show the extent to which this may be a problem. In 2004, GAO reported that school districts and individual schools vary in the extent to which they restrict access to competitive foods and beverages (GAO, 2004). Because I have accounted for clustering of students within schools, it is unlikely that higher level clustering that I have not accounted for will affect my results.

Unreliability of Measures

Measurement error can weaken the relationship between the independent and dependent variables. As discussed previously under construct validity, there may be measurement errors in the construction of the dependent and independent variables. If there is measurement error in the key variables of interest, and this error changes over time, the models I estimate exaggerate the measurement error because estimates are based on changes in the variables over time. Generally, an unreliable independent variable will lead to the estimated relationships being biased towards zero; thus, I may minimize the effects of policy on behavior. It is not clear the extent to which school administrators may misrepresent their school's competitive food policies and how this misrepresentation may change from fifth to eighth grade.

Data Reliability

The key potential data reliability issue is with school administrator and child recall. The proposed analyses completely rely on school administrators' ability to recall the types of foods offered in their school and how those foods are offered (e.g., vending machine, school store, a la carte line, etc.) and children's ability to recall the frequency with which they ate specific food items. Error in recall will not affect the estimates unless the error changes substantially between fifth and eighth grade.

Application of Estimation Strategy to the Guiding Theoretical Framework

Another limitation of this study is the applicability the estimation strategy to the guiding theoretical framework. The social-ecological theory of obesity causation, the theory upon which this work is grounded, suggests that multiple contextual factors influence diet and exercise, which ultimately affect weight. And further, that these relationships may be dynamic. The estimation strategy I employ only considers the role of changes in food practices in schools on children's dietary behaviors while holding constant these other contextual factors. The strength of this approach is that I am able to examine the direct effect of competitive food practices on eating behaviors. The limitation of this approach is that I may find no impact of food practices because I am assuming that no other contextual factors are changing in dynamic ways. Given that policymakers are often not satisfied with a design strategy that does not unpack the "black box", and typically have limited resources to direct toward policy interventions, the study I conduct is an important step to take to see if effects of competitive food practices can be found.

Conclusion

This chapter provides the research questions this dissertation seeks to answer, the estimation strategy, a description of the variables included in the analyses, a description of the data sources used, and the potential limitations affecting my findings. The key research question is: To what extent does the food choice architecture in school affect students' eating behaviors? I use first-difference models to estimate this relationship, relying primarily upon the ECLS-K fifth- and eighth-grade waves of data, supplemented with three other data sources. The key dependent variables are: weekly frequency of healthy food consumption; weekly frequency of healthy beverage consumption; and weekly frequency of unhealthy beverage consumption. The key independent variables are schools' competitive food and beverage practices. While the estimation strategy I employ has a number of strengths (e.g., data is nationally-representative and there is a large sample; observations are measured over time; food intake is measured over the course of a week instead of just at lunchtime), there are a number of limitations that could bias the result. The greatest limitation of my approach is that if I have not measured all important time-varying variables that are correlated with school competitive food and beverage practices and children's consumption behaviors, the regression slopes on the school competitive food and beverage policy variables may be biased and I could draw incorrect conclusions. In chapter four, I present the results of these analyses.

Chapter Four: Results

Introduction

As described in chapter one, the prevalence of obesity among children has increased rapidly over the last few decades and policymakers are increasingly trying to find public policy solutions. One policy lever could be changing the availability of competitive foods and beverages in schools to affect children's consumption patterns. In chapter two, I discuss the current state of knowledge in this area and discuss ways in which I can build on that body of knowledge. Two important ways this dissertation raises the level of knowledge are by providing national level estimates on the effects of competitive food and beverage practices on children's consumption patterns and attempting to control for more potential confounders than had been controlled for in previous studies. In chapter three I provide a description of the data I use to conduct the analyses, which primarily come from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999, fifth and eighth grade waves of data, and the strategy I use to identify the relationship between competitive food and beverage practices and children's consumption behaviors—first difference models.

In this chapter I present the results of my estimation strategy. The organization of this chapter is as follows: first, I describe the characteristics of the sample; second, I examine bivariate relationships between competitive food and beverage practices and children's consumption patterns; third, I estimate the relationship between competitive food and

beverage practices and children's consumption behaviors, controlling for a host of observable characteristics; fourth, I estimate the relationship between school competitive food and beverage practices and children's consumption behaviors, controlling for observable and some unobservable characteristics; finally, I examine the robustness of my findings in four sets of sensitivity analyses. I find that while most children have access to competitive foods and beverages in school, and on average, children likely do not consume recommended levels of fruits and vegetables, milk and juice, or sweetened beverages, I find no evidence of a relationship between school competitive food and beverage practices and positive or negative consumption patterns among early adolescent children. I discuss the implications of these findings and considerations for future research in chapter five.

Sample Description

Characteristics of Children, Their Families, Schools and Communities

Among the sample of 7,280 children I examine in this study, which excludes children who did not attend schools offering the National School Lunch Program, 48 percent are female (see Table 4.1). Most children (58 percent) are white, followed by nearly a fifth (18 percent) who are Hispanic, and just under a fifth (17 percent) who are black. A small share of children (7 percent) are a different race (e.g., Asian, Pacific Islander, et cetera). On average, children in the fifth grade are 58 inches tall and grow to 64 inches by the eighth grade.

Family characteristics remain relatively stable between the fifth and eighth grades. On average, children eat dinner at a regular time with their families 5 days a week, suggesting that the children in this sample have a substantial amount of exposure to parents' eating preferences. Results also suggest that parents regulate their children's inactive time. Nearly 90 percent of parents report that they have television-watch rules for their children. Fewer parents report having control over the school their child attends. About a quarter (26 percent) of parents report that their child is in the school of their choice in the fifth grade, falling to under a quarter (22 percent) in the eighth grade.

With regard to more general characteristics of households, more than half of children live in households where their mother works full-time—the share of children living with full-time working mothers rose slightly from fifth to eighth grade (52 and 56 percent, respectively). Over 70 percent of children live with two biological parents, about a quarter live in single-parent households, and less than 5 percent live a different arrangement. About a fifth of children live below the federal poverty line.

There is little fluctuation between fifth and eighth grade in the school characteristics of the children sampled. Most children, over 90 percent, attend public schools in the fifth and eighth grades. Few children face facility constraints that could affect their time to eat lunch. Three percent of students attend schools with overcrowding in the cafeteria.

In the fifth and eighth grades, community characteristics vary somewhat, with some characteristics suggesting that the food environment got worse between fifth and eighth

grades. Access to fast food restaurants and convenience stores remains relatively steady, with children exposed to two convenience stores in their zip code in both years; however, access to fast food restaurants increases with18 fast food restaurants available in a child's zip code in the fifth grade and 20 in the eighth grade. On average, obesity prevalence increases from 24 percent of the state population in the fifth grade to 27 percent of the state population in the eighth grade. In contrast, there was a slight decrease in the proportion of the state population who report eating fewer than 5 or more fruits and vegetables each day from 77 percent in 2004 to 76 percent in 2007. Fast food and fruit and vegetable prices increase between 2004 and 2007, though fruit and vegetable prices rose more steeply.

Table 4.1: Characteristics of Children, Their Families, Schools and Communities in the Fifth and Eighth Grades, Weighted

	Fifth Grade	Eighth Grade
Female (%)	47.8	
Race (%)		
White	57.6	
Black	17.2	
Hispanic	18.3	
Other race	6.9	
Average height (inches)	57.7	64.3
Average number of dinners eaten at a regular time each week (days)	4.9	4.8
Family has television-watching rules (%)	89.5	88.1
Parent chose child's school (or school assigned was parent's choice) (%)	26.2	21.9
Mother works full-time (%)	51.6	55.8
Family structure (%)		
Two biological parents in household	73.0	71.3
Single-parent family	24.5	25.8
Other family type	2.6	2.9
Below 100% of the Federal Poverty Line (FPL) (%)	21.2	20.8
Public School (%)	91.1	91.9
Cafeteria is overcrowded at lunchtime (%)	2.9	3.0
Average number of convenience stores in the child's zip code	2.5	2.3
Average number of limited-service restaurants in the child's zip code	18.2	19.5
Average obesity prevalence in state of residence (%)	23.7	26.6
Average percent of state population that consumes fewer than 5 fruits and vegetables each day	77.0	75.8
Average fast food price index (1999 = base)	107.8	115.0
Average fruit and vegetable price index (1999 = base)	118.6	132.0
Number of Observations	7,280	

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

Food and Beverage Consumption Patterns of Children

Consumption patterns of children in fifth and eighth grade vary little over time may not meet dietary recommendations (see Table 4.2). In the fifth and eighth grades, students report consuming fruits and vegetables on average 13 times per week. The 2005 Dietary Guidelines for Americans recommends that everyone should consume at least 2 servings of fruit per day and 2.5 servings of vegetables per day. It may be that eating fruits and vegetables roughly twice per day does not equate to 4.5 servings. In order to meet

recommendations, children would have to consume just below 2 servings per eating occasion, on average.

Similar low frequencies of milk and fruit juice consumption are found. In the fifth grade, students report consuming milk or 100 percent fruit juice 11.5 times per week, and 11 times per week in the eighth grade. This amounts to about 1.5 times per day a child drinks milk or juice. For milk alone, the 2005 Dietary Guidelines recommend consuming three servings per day; thus, students may be falling well short of recommendations.

The 2005 Dietary Guidelines recommend that children over age eight keep discretionary calories to approximately 13 percent of their total caloric intake per day. Within these discretionary calories, sugars should be kept to a minimum. The Dietary Guidelines recommend consuming no more than 8 teaspoons of sugar each day (based on a 2,000 calorie diet). One can of non-diet soda contains about 12 teaspoons of sugar (Vasanti, Shulze, & Hu, 2006). Hence, consumption of soda and similarly sweetened beverages should be kept to an absolute minimum. In fifth and eighth grades, students report consuming soda and other sweetened beverages on average 4 days per week.

Table 4.2: Food and Beverage Consumption Patterns of Children in the Fifth and Eighth Grades, Weighted

	Fifth Grade	Eighth Grade
Average frequency of fruit and vegetable consumption over 7 days	12.8	13.0
Average frequency of milk and juice consumption over 7 days	11.5	11.0
Average frequency of sweetened beverage consumption over 7 days	4.5	4.3
Number of Observations	7,280	

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

Types of Competitive Food and Beverage Practices Experienced by Children

Over half of students in the fifth and eighth grades are exposed to competitive foods and beverages in schools (see Table 4.3). More students are exposed to competitive foods and beverages in the eighth grade (80 and 86 percent, respectively) compared to the fifth grade (52 and 60 percent, respectively).

The location of competitive foods and beverages offered in school differs over time. In fifth grade, one-fifth of students have access to competitive foods and beverages from a la carte lines only. One-quarter of students have access to competitive foods in beverages from vending machines, school stores and other locations in the school other than a la carte lines. Less than 15 percent (14 percent) of students have access to competitive foods and beverages from a la carte lines as well as other locations in the school. In contrast, in the eighth grade, far more students have access to competitive foods and beverages from multiple locations (52 percent) instead of single sources such as a la carte lines (11 percent) or vending machines or school stores (24 percent).

As students become exposed to competitive foods and beverages in the eighth grade, they are mostly being offered a mixture of healthy and unhealthy foods. In the fifth grade, 33 percent of students have access to fruits and vegetables as well as other snacks (e.g., candy, chips, and crackers); in the eighth grade, this share rises to 59 percent. Similar shares of students have access to *only* fruits and vegetables or *only* snacks that exclude fruits and vegetables in both grades (roughly 1 percent).

Access to healthy beverages (i.e. milk and 100 percent fruit juice) and unhealthy beverages (sugar sweetened beverages) from competitive sources increases between fifth and eighth grades. In the fifth grade about one-third of students have access to milk and juice only, rising to 43 percent in the eighth grade. Likewise, less than 30 percent (27 percent) of students have access to both healthy and unhealthy beverages in the fifth grade compared with 41 percent in the eighth grade. In both fifth and eighth grade, few (2 percent or fewer) students have access to only unhealthy competitive beverages.

Table 4.3: Types of Competitive Food and Beverage Practices Experienced by Children in the Fifth and Eighth Grades (%), Weighted

	Fifth Grade	Eighth Grade
Any competitive foods and beverages offered		
Any competitive foods offered	51.8	79.5
Any competitive beverages offered	59.5	85.9
Location of competitive foods and beverages offered		
No competitive food or beverages offered	41.2	13.0
A la carte lines only	19.0	11.0
Vending machines, school stores and other locations only	25.4	23.9
A la carte lines, vending machines, school stores, and other locations	14.4	52.1
Types of competitive foods offered		
No competitive foods offered	45.9	20.1
Fruits and vegetables only offered	0.8	1.1
Fruits, vegetables and other snacks offered	33.1	58.7
Only other snacks offered	20.2	20.1
Types of competitive beverages offered		
No competitive beverages offered	38.7	13.9
Milk and juices only offered	32.5	43.2
Milk, juice, and sweetened beverages offered	27.1	40.9
Only sweetened beverages offered	1.7	2.0
Number of Observations	7,280	

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

Changes in Types of Competitive Food and Beverage Practices Experienced by Children

The primary identification strategy employed in this dissertation is a first difference model. Because first difference models operate off of changes in conditions, it is important to examine how often children experience changes in competitive food and beverage practices. Many children, about 40 percent, experienced a change in competitive food and beverages policies, suggesting there is enough variation for the models to estimate effects of policies on outcomes (see Table 4.4). There is also substantial variation in types of competitive food and beverage policies children experience. For instance, among those children who had access to competitive foods and beverages from a la carte lines only, one in five children experienced a change into or out of that condition between the fifth and eighth grades. There are two categories of types of food and beverage practices where little change occurred and therefore the estimation strategy may have trouble detecting effects. First, among children who experienced a fruit and vegetable only competitive food practice in their school, only 2.1 percent experienced a change into or out of that condition from fifth to eighth grade. Similarly few children experienced a change into our out of a school beverage practice where only sweetened beverages were offered (4.1 percent).

Table 4.4: Change in Types of Competitive Food and Beverage Practices Experienced by Children between the Fifth and Eighth Grades (%), Weighted

	Children Experiencing a Change
Any competitive foods and beverages offered	
Any competitive foods offered	40.6
Any competitive beverages offered	40.1
Location of competitive foods and beverages offered	
No competitive food or beverages offered	
A la carte lines only	20.5
Vending machines, school stores and other locations only	23.9
A la carte lines, vending machines, school stores, and other locations	47.3
Types of competitive foods offered	
No competitive foods offered	34.8
Fruits and vegetables only offered	2.1
Fruits, vegetables and other snacks offered	42.3
Only other snacks offered	27.8
Types of competitive beverages offered	
No competitive beverages offered	32.8
Milk and juices only offered	43.0
Milk, juice, and sweetened beverages offered	42.6
Only sweetened beverages offered	4.1
Number of observations	7,280

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

Bivariate Analyses: Examining Associations between School Competitive Food and Beverage Practices and Children's Consumption Patterns

Next, I examine differences in food and beverage consumption patterns by the types of competitive food and beverage practices that students are exposed to in the fifth and eighth grades. In fifth grade, I find little evidence that mean food and beverage consumption behaviors significantly differ by competitive food and beverage policy (see Table 4.5). The only statistically significant difference I find is between students who attend schools that *only* offer sweetened beverages as competitive beverages and those at schools that offer no competitive beverages. These students consume sweetened

beverages on average 6 times per week, significantly more than students who have no access to competitive beverages in their school, who report consuming sweetened beverages on average 1 time less per week. I find no evidence of a relationship between competitive food and beverages practices, or types of competitive practices, and children's consumption of fruits and vegetables or milk and juice.

Table 4.6 depicts the same relationships between food and beverage consumption patterns and school competitive food and beverage practices for children when they are in the eighth grade. Similar to the findings for when children are in the fifth grade, simple bivariate analyses reveal no association between consumption patterns and competitive food and beverage practices.

Table 4.5: Mean Food and Beverage Consumption Behaviors by Competitive Food and Beverage Practices in the Fifth Grade (%), Weighted

	Mean number of Times Ate Fruits and Vegetables in Last 7 Days		Mean Number of Times Drank Milk and Juice in Last 7 Days		Mean Number of Times Drank Sweetened Beverages in Last 7 Days	
Competitive foods offered						
No competitive foods offered, reference	12.9		11.6		4.5	
Any competitive foods offered	12.6		11.5		4.6	
Competitive beverages offered						
No competitive beverages offered, reference	13.3		11.6		4.7	
Any competitive beverages offered	12.4		11.4		4.5	
Location of competitive foods and beverages offered						
No competitive food or beverages offered, reference	13.4		11.6		4.6	
A la carte lines only	13.0		11.3		4.5	
Vending machines, school stores and other locations only	11.8		11.6		4.4	
A la carte lines, vending machines, school stores, and other locations	12.8		11.4		4.6	
Types of competitive foods offered						
No competitive foods offered, reference	12.9		11.7		4.5	
Fruits and vegetables only offered	13.9		12.6		4.5	
Fruits, vegetables and other snacks offered	12.8		11.4		4.4	
Only other snacks offered	12.0		11.0		4.9	
Types of competitive beverages offered						
No competitive beverages offered, reference	13.3		11.7		4.7	
Milk and juices only offered	12.2		11.6		4.5	
Milk, juice, and sweetened beverages offered	12.3		10.9		4.3	
Only sweetened beverages offered	14.5		12.1		5.8	**
Number of observations	7,280					

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.

Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

**Significantly different from zero at the .05 level, two-tailed test.

***Significantly different from zero at the .01 level, two-tailed test.

Table 4.6: Mean Food and Beverage Consumption Behaviors by Competitive Food and Beverage Practices in the Eighth Grade, Weighted

	Mean number of Times Ate Fruits and Vegetables in Last 7 Days		Mean Number of Times Drank Milk and Juice in Last 7 Days		Mean Number of Times Drank Sweetened Beverages in Last 7 Days	
Competitive foods offered						
No competitive foods offered, reference	12.8		11.0		4.4	
Any competitive foods offered	13.1		11.0		4.2	
Competitive beverages offered						
No competitive beverages offered, reference	12.2		10.5		4.3	
Any competitive beverages offered	13.2		11.1		4.3	
Location of competitive foods and beverages offered						
No competitive food or beverages offered, reference	12.0		10.8		4.0	
A la carte lines only	12.7		11.2		4.8	
Vending machines, school stores and other locations only	13.1		11.0		4.6	
A la carte lines, vending machines, school stores, and other locations	13.3		11.1		4.0	
Types of competitive foods offered						
No competitive foods offered, reference	13.0		11.2		4.4	
Fruits and vegetables only offered	13.6		12.8		4.2	
Fruits, vegetables and other snacks offered	13.1		11.2		4.1	
Only other snacks offered	12.7		10.4		4.7	
Types of competitive beverages offered						
No competitive beverages offered, reference	12.3		10.7		4.3	
Milk and juices only offered	13.2		11.1		4.2	
Milk, juice, and sweetened beverages offered	13.0		11.1		4.3	
Only sweetened beverages offered	14.7		11.5		4.7	
Number of observations	7,280					

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Examining Bivariate Differences in Consumption Patterns among Subpopulations

One of the research questions I pose in this study is whether the effects of competitive food and beverage practices vary by key attributes of children (gender, race, and fifth grade poverty status). In tables 4.7 through 4.12, I examine the following characteristics of these subgroups: children's average weekly consumption of fruits and vegetables, milk

and juice, and sweetened beverages in the fifth and eighth grades (separately) by their access to competitive foods and beverages. Overall, I find no statistically significant differences in consumption patterns among these subgroups. Generally, consumption patterns are very similar across groups. For instance, I find that females with access to competitive foods in the eighth grade report consuming fruits and vegetables 13.1 times per week while females who lack access to competitive foods report consuming fruits and vegetables 12.6 times per week. These means are not statistically different. Some of the differences in means are counterintuitive. For example, white children with access to competitive beverages report consuming sweetened beverages on average 4.6 times per week, while those who lack access report consuming sweetened beverages on average 4.8 times per week. It may be that there are mediating or moderating variables that are driving these unexpected results. Regardless, these bivariate results suggest I may find few differences in the effects of access to competitive foods and beverages in school on children's consumption patterns in the multivariate models I estimate.

Table 4.7: Mean Food and Beverage Consumption Behaviors by Competitive Food and Beverage Practices in the Fifth Grade by Gender (%), Weighted

	Girls			Boys		
	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days
Competitive foods offered						
No competitive foods offered, reference	13.8	10.8	4.3	12.1	12.4	4.7
Any competitive foods offered	13.5	11.7	4.4	11.8	11.3	4.7
Competitive beverages offered						
No competitive beverages offered, reference	14.1	10.8	4.4	12.6	12.5	4.9
Any competitive beverages offered	13.4	11.6	4.3	11.6	11.3	4.6
Number of Observations	3,480			3,800		

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.

Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

**Significantly different from zero at the .05 level, two-tailed test.

***Significantly different from zero at the .01 level, two-tailed test.

Table 4.8: Mean Food and Beverage Consumption Behaviors by Competitive Food and Beverage Practices in the Fifth Grade by Race (%), Weighted

	White			Non-White		
	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days
Competitive foods offered						
No competitive foods offered, reference	12.3	12.6	4.7	13.7	10.5	4.4
Any competitive foods offered	11.9	12.1	4.7	13.9	10.6	4.4
Competitive beverages offered						
No competitive beverages offered, reference	12.5	12.6	4.8	14.2	10.6	4.6
Any competitive beverages offered	11.8	12.1	4.6	13.5	10.5	4.3
Number of Observations	4,190			3,090		

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.

Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

**Significantly different from zero at the .05 level, two-tailed test.

***Significantly different from zero at the .01 level, two-tailed test.

Table 4.9: Mean Food and Beverage Consumption Behaviors by Competitive Food and Beverage Practices in the Fifth Grade by Fifth Grade Poverty Status (%), Weighted

	Poverty			Not Poverty		
	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days
Competitive foods offered						
No competitive foods offered, reference	13.8	10.3	4.7	12.7	12.0	4.5
Any competitive foods offered	12.8	10.2	4.7	12.6	11.8	4.6
Competitive beverages offered						
No competitive beverages offered, reference	14.4	10.3	4.8	13.0	12.1	4.6
Any competitive beverages offered	12.5	10.2	4.6	12.4	11.8	4.5
Number of Observations	1,540			5,740		

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.

Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

**Significantly different from zero at the .05 level, two-tailed test.

***Significantly different from zero at the .01 level, two-tailed test.

Table 4.10: Mean Food and Beverage Consumption Behaviors by Competitive Food and Beverage Practices in the Eighth Grade by Gender (%), Weighted

	Girls			Boys		
	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days
Competitive foods offered						
No competitive foods offered, reference	12.6	9.4	4.4	13.0	13.0	4.4
Any competitive foods offered	13.1	9.9	4.0	13.0	12.0	4.4
Competitive beverages offered						
No competitive beverages offered, reference	11.9	9.2	4.6	12.4	12.1	4.0
Any competitive beverages offered	13.2	9.9	4.0	13.1	12.2	4.5
Number of Observations	3,480			3,800		

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.

Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

**Significantly different from zero at the .05 level, two-tailed test.

***Significantly different from zero at the .01 level, two-tailed test.

Table 4.11: Mean Food and Beverage Consumption Behaviors by Competitive Food and Beverage Practices in the Eighth Grade by Race (%), Weighted

	White			Non-White		
	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days
Competitive foods offered						
No competitive foods offered, reference	13.3	11.5	4.4	12.2	10.5	4.4
Any competitive foods offered	13.3	11.3	4.2	12.8	10.5	4.3
Competitive beverages offered						
No competitive beverages offered, reference	12.7	10.8	4.4	11.7	10.2	4.2
Any competitive beverages offered	13.4	11.4	4.2	12.9	10.6	4.3
Number of Observations	4,190			3,090		

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Table 4.12: Mean Food and Beverage Consumption Behaviors by Competitive Food and Beverage Practices in the Eighth Grade by Fifth Grade Poverty Status (%), Weighted

	Poverty			Not Poverty		
	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days	Mean number of Times Ate Fruits and Vegetables in Last 7 Days	Mean Number of Times Drank Milk and Juice in Last 7 Days	Mean Number of Times Drank Sweetened Beverages in Last 7 Days
Competitive foods offered						
No competitive foods offered, reference	11.6	10.2	4.6	13.3	11.4	4.3
Any competitive foods offered	12.5	9.8	4.5	13.2	11.3	4.2
Competitive beverages offered						
No competitive beverages offered, reference	11.2	9.6	4.5	12.6	11.0	4.2
Any competitive beverages offered	12.5	10.0	4.6	13.3	11.3	4.2
Number of Observations	1,540			5,740		

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.

Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

**Significantly different from zero at the .05 level, two-tailed test.

***Significantly different from zero at the .01 level, two-tailed test.

While these bivariate relationships are interesting, they do not suggest causal attribution. There could be a number of other factors associated with competitive food and beverage policies and children's consumption patterns that are not accounted for in these simple models. In the next section, I examine these same models, but control for a number of potential confounders that are observable in the data.

Multivariate Analyses: Examining Relationships between Competitive Food and Beverage Policies and Children's Consumption Behaviors

Results from OLS Regression Models with Controls

After controlling for observable characteristics of children, their families, schools and communities, I still find no evidence of a relationship between competitive food and beverage practices and children's consumption patterns (see Tables 4.13 – 4.16). Specifically, I compare mean differences in times children reported consuming fruits and vegetables, milk and juice, and sweetened beverages over the course of the week between children who attend schools that offer competitive foods and those that do not and between children who attend schools that offer competitive beverages and those that do not. I find no statistically significant differences in means between these groups of children. Further, I examine mean consumption patterns by the location and types of competitive food and beverage practices available and find no differences in mean consumption behaviors between those with access to competitive foods and beverages in school and those lacking access.

The results from the OLS regression models suggest there is little to no association between competitive food and beverage practices and children's consumption patterns. These models, however, only control for observable characteristics. It may be that there are unobserved characteristics that are driving these results. For instance, it may be that children who attend schools that offer only sweetened beverages in the fifth grade have parents who are actively engaged in decisions about school policies and use the sales from sweetened beverages to raise revenue, but are also very aware and involved in making decisions about what types of beverages their children consume.

Table 4.13: Estimating Associations between Food and Beverage Consumption Behaviors and Offering Competitive Foods and Beverage in the Fifth Grade, Weighted

	Number of Times Ate Fruits and Vegetables in Last 7 Days (logged)		Number of Times Drank Milk and Juice in Last 7 Days (logged)		Number of Times Drank Sweetened Beverages in Last 7 Days (logged)	
Intercept	2.49	***	2.15	***	-0.04	
Any competitive foods offered	0.07		0.01			
Any competitive beverages offered	-0.09		-0.03		0.08	
Female	0.12	**	-0.05		-0.12	**
Race (white, reference)					-0.08	
Black	0.06		-0.25	***		
Hispanic	0.16	***	-0.01		-0.08	
Other race	0.17	**	-0.11		-0.01	
Height (inches)	0.01		0.01		-0.16	**
Number of dinners eaten at a regular time each week	0.01		0.01		0.01	
Family has television-watching rules	0.02		0.01		-0.01	
Parent chose child's school (or school assigned was parent's choice)	0.14	**	-0.03		-0.09	
Mother Works Full-Time	-0.02		-0.03		-0.07	
Family structure (two biological parents in household, reference)					0.07	
Single-parent family	-0.01		0.10	**		
Other family type	0.05		-0.16		0.06	
Below 100% of the Federal Poverty Line (FPL)	0.04		-0.12	**	0.07	
Public School	0.05		0.01		0.02	
Cafeteria is overcrowded at lunchtime	-0.08		-0.06		-0.05	
Number of convenience stores in the child's zip code	-0.02		-0.01		0.01	
Number of limited-service restaurants in the child's zip code imputed	0.00		0.00		-0.01	
Obesity prevalence in state of residence (%)	-0.02		-0.02		0.00	
Percent of state population that consumes fewer than 5 fruits and vegetables each day	-0.01		0.00		0.02	
Fast food price index (1999 = base) imputed with state average CBSA prices	0.00		0.00		0.01	
Fruit and vegetable price index (1999 = base) imputed with state average CBSA prices	0.00		0.00		0.00	
Number of observations	7,280					

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Table 4.14: Estimating Associations between Food and Beverage Consumption Behaviors and Competitive Food and Beverage Practices in the Fifth Grade, Weighted

	Number of Times Ate Fruits and Vegetables in Last 7 Days (logged)		Number of Times Drank Milk and Juice in Last 7 Days (logged)		Number of Times Drank Sweetened Beverages in Last 7 Days (logged)	
Intercept	2.70	***	2.70	***	-0.51	
Location of competitive foods and beverages offered (no competitive foods or beverages offered, reference)						
A la carte lines only	0.04		0.04		-0.02	
Vending machines, school stores and other locations only	-0.05		0.09		-0.07	
A la carte lines, vending machines, school stores, and other locations	0.03		0.06		0.04	
Types of competitive foods offered (no competitive foods offered, reference)						
Fruits and vegetables only offered	0.12		0.07		0.04	
Fruits, vegetables and other snacks offered	0.06		-0.01		0.04	
Only other snacks offered	0.01		-0.08		0.12	
Types of competitive beverages offered (no competitive beverages offered, reference)						
Milk and juices only offered	-0.09		-0.04		-0.08	
Milk, juice, and sweetened beverages offered	-0.08		-0.11		-0.15	
Only sweetened beverages offered	0.13		0.00		0.12	
Female	0.12	***	-0.04		-0.08	**
Race (white, reference)						
Black	0.07		-0.22	***	-0.09	
Hispanic	0.14	**	0.01		-0.01	
Other race	0.20	**	-0.11		-0.16	
Height (inches)	0.01		0.01		0.01	
Number of dinners eaten at a regular time each week	0.01		0.02		0.00	
Family has television-watching rules	0.02		0.02		-0.07	
Parent chose child's school (or school assigned was parent's choice)	0.13	**	-0.03		-0.05	
Mother Works Full-Time	-0.02		-0.04		0.08	
Family structure (two biological parents in household, reference)						

Table 4.14: Estimating Associations between Food and Beverage Consumption Behaviors and Competitive Food and Beverage Practices in the Fifth Grade, Weighted (cont.)

	Number of Times Ate Fruits and Vegetables in Last 7 Days (logged)		Number of Times Drank Milk and Juice in Last 7 Days (logged)		Number of Times Drank Sweetened Beverages in Last 7 Days (logged)	
Single-parent family	0.00		0.11	**	0.06	
Other family type	0.08		-0.16		0.14	
Below 100% of the Federal Poverty Line (FPL)	0.05		-0.13	***	0.02	
Public School	0.04		0.03		0.01	
Cafeteria is overcrowded at lunchtime	-0.06		-0.11		0.01	
Number of convenience stores in the child's zip code	-0.02		-0.01		0.00	
Number of limited-service restaurants in the child's zip code	0.00		0.00		0.00	
Obesity prevalence in state of residence (%)	-0.01		-0.01		0.02	
Percent of state population that consumes fewer than 5 fruits and vegetables each day	-0.01		0.00		0.02	
Fast food price index (1999 = base)	0.00		0.00		0.00	
Fruit and vegetable price index (1999 = base)	0.00		0.00		0.00	
Number of observations	7,280					

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Table 4.15: Estimating Associations between Food and Beverage Consumption Behaviors and Offering Competitive Foods and Beverage in the Eighth Grade, Weighted

	Number of Times Ate Fruits and Vegetables in Last 7 Days (logged)		Number of Times Drank Milk and Juice in Last 7 Days (logged)		Number of Times Drank Sweetened Beverages in Last 7 Days (logged)	
Intercept	3.44	***	2.12	***	0.51	
Any competitive foods offered	-0.03		-0.04		-0.07	
Any competitive beverages offered	0.08		0.05		0.06	
Female	0.01		-0.18		-0.10	**
Race (white, reference)						
Black	-0.01		-0.05		0.04	
Hispanic	-0.07		0.02		0.07	
Other race	0.07		0.03		-0.20	***
Height (inches)	0.01		0.02	***	-0.01	
Number of dinners eaten at a regular time each week	0.01		0.00		-0.01	
Family has television-watching rules	0.11	**	0.15	***	-0.24	***
Parent chose child's school (or school assigned was parent's choice)	0.11	**	0.04		0.02	
Mother Works Full-Time	-0.07	**	-0.07		0.06	
Family structure (two biological parents in household, reference)						
Single-parent family	-0.06		-0.05		0.05	
Other family type	-0.13		-0.04		0.18	
Below 100% of the Federal Poverty Line (FPL)	-0.01		-0.05		-0.03	
Public School	-0.01		-0.05		0.07	
Cafeteria is overcrowded at lunchtime	0.09		0.08		-0.06	
Number of convenience stores in the child's zip code	-0.02	**	-0.01		0.00	
Number of limited-service restaurants in the child's zip code	0.00		0.00		0.00	
Obesity prevalence in state of residence (%)	-0.01		-0.03	***	0.02	***
Percent of state population that consumes fewer than 5 fruits and vegetables each day	-0.02	***	0.00		0.01	
Fast food price index (1999 = base)	0.00		0.00		0.00	
Fruit and vegetable price index (1999 = base)	0.00		0.00		0.00	
Number of observations	7,280					

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Table 4.16: Estimating Associations between Food and Beverage Consumption Behaviors and Competitive Food and Beverage Practices in the Eighth Grade, Weighted

	Number of Times Ate Fruits and Vegetables in Last 7 Days (logged)		Number of Times Drank Milk and Juice in Last 7 Days (logged)		Number of Times Drank Sweetened Beverages in Last 7 Days (logged)	
Intercept	3.18	***	1.94	***	0.43	
Location of competitive foods and beverages offered (no competitive foods or beverages offered, reference)						
A la carte lines only	0.06		0.00		0.08	
Vending machines, school stores and other locations only	0.07		-0.02		0.00	
A la carte lines, vending machines, school stores, and other locations	0.08		-0.03		-0.08	
Types of competitive foods offered (no competitive foods offered, reference)						
Fruits and vegetables only offered	0.02		0.11		-0.14	
Fruits, vegetables and other snacks offered	-0.05		-0.01		-0.11	
Only other snacks offered	-0.07		-0.08		0.02	
Types of competitive beverages offered (no competitive beverages offered, reference)						
Milk and juices only offered	0.05		0.04		0.08	
Milk, juice, and sweetened beverages offered	0.03		0.04		0.14	
Only sweetened beverages offered	0.14		0.08		0.09	
Female	0.03		-0.17		-0.10	***
Race (white, reference)						
Black	-0.01		-0.03		0.03	
Hispanic	-0.07		0.03		0.07	
Other race	0.08		0.03		-0.21	***
Height (inches)	0.01		0.02	***	-0.01	
Number of dinners eaten at a regular time each week	0.01		0.00		-0.01	
Family has television-watching rules	0.11		0.14	**	-0.24	***
Parent chose child's school (or school assigned was parent's choice)	0.10	**	0.01		0.03	
Mother Works Full-Time	-0.07	**	-0.08	**	0.06	
Family structure (two biological parents in household, reference)						
Single-parent family	-0.05		-0.04		0.03	

Table 4.16: Estimating Associations between Food and Beverage Consumption Behaviors and Competitive Food and Beverage Practices in the Eighth Grade, Weighted (cont.)

	Number of Times Ate Fruits and Vegetables in Last 7 Days (logged)		Number of Times Drank Milk and Juice in Last 7 Days (logged)		Number of Times Drank Sweetened Beverages in Last 7 Days (logged)	
Other family type	-0.12		-0.06		0.23	
Below 100% of the Federal Poverty Line (FPL)	-0.02		-0.05		-0.05	
Public School	-0.01		-0.07		0.11	
Cafeteria is overcrowded at lunchtime	0.10		0.07		-0.06	
Number of convenience stores in the child's zip code	-0.02	**	-0.01		0.00	
Number of limited-service restaurants in the child's zip code	0.00		0.00		0.00	
Obesity prevalence in state of residence (%)	-0.01		-0.02	***	0.02	**
Percent of state population that consumes fewer than 5 fruits and vegetables each day	-0.02	***	0.00		0.01	
Fast food price index (1999 = base)	0.00		0.00		0.00	
Fruit and vegetable price index (1999 = base)	0.00		0.00		0.00	
Number of observations	7,280					

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Results from First Difference Regression Models

Fruit and vegetable consumption. I find no evidence of an effect of competitive food or beverage practices on children's consumption of fruits and vegetables after controlling for time-varying observable characteristics and time-invariant unobserved characteristics using first difference models (see Tables 4.17 and 4.18). In table 4.17, I examine the effect of access to competitive foods in the fifth and eighth grades on changes in times fruit and vegetable are consumed over the course of 7 days between fifth and eighth grades relative to children who have no access to competitive foods in the fifth and eighth grades. I find no statistically significant effects of availability of competitive foods on changes in times fruit and vegetable are consumed over the course of a week.

Coefficients are small—generally less than 1.0—suggesting even if the results were significant, they are not substantively meaningful. Similar results are found for availability of competitive beverages in the fifth and eighth grades. There are no clear patterns that indicate whether food and beverage practices have a positive or negative effect on fruit and vegetable consumption. Most of the coefficients on food practices are positive for fruit and vegetable consumption; however, having access to competitive beverages in the fifth grade may have a negative effect on fruit and vegetable consumption.

In table 4.18, I examine the extent to which location of competitive foods and beverages in school and types of competitive foods and beverages in school may affect changes in fruit and vegetable consumption patterns over the course of 7 days. I find no effects of

location or types of competitive foods and beverages available in school on changes in times children report eating fruits and vegetables over seven days relative to children who have no access to competitive foods and beverages in the fifth and eighth grades. Of note, however, in some cases, few observations experienced a particular policy change (e.g., schools offering competitive fruits and vegetables only), which has the effect of increasing standard errors and therefore making it even more difficult to achieve statistical significance. Regardless, the coefficients are small on all of the policy variables, suggesting again that even if significant effects were found, they would not be particularly meaningful. Further, there are few discernable patterns in the findings. In most cases, it appears that after holding types of competitive foods offered constant, offering competitive foods to children increases the number of times they consume fruits and vegetables over the course of the week.

I also examine whether the effects of food and beverage practices may vary by characteristics of the child. Specifically, I examined whether policies have differential effects based on gender, race, and fifth grade poverty status. I found no interactive effects of competitive food and beverage practices (see Appendix Table 1).

Milk and juice consumption. I find no evidence that competitive food or beverage practices affect changes in times milk and juice are consumed between fifth and eighth grades using first difference models (see Tables 4.17 and 4.18). Coefficients are small—generally less than 1.0 and often negative, suggesting there may be a small negative

effect of offering competitive foods and beverages in school on milk and juice consumption; however, these differences are not statistically significant.

As with changes in times children report consuming fruit and vegetables over 7 days, I examine whether there are differences in milk and juice consumption patterns by any exposure to any type of competitive food or beverage practice and I also examine whether differences in consumption exist by specific attributes of practices (i.e., location and types of competitive foods and beverages offered). Again, I find no significant effects of food and beverage practices on changes in times students report drinking milk and juice. Coefficients are small, and in most cases, it appears that once types of beverages offered are controlled for, offering competitive beverages may have a small, positive effect on milk and juice consumption. I also estimate models that include interactions between the competitive food and beverage practice variables with gender, race and poverty and find no significant differences (see Appendix Table 1).

Sweetened beverage consumption. I also examine the relationship between competitive food and beverage practices and sweetened beverage consumption. Using first difference models, I find no statistically significant effects of competitive food and beverage practices on sweetened beverage consumption (see Tables 4.17 and 4.18). Coefficients are small and the directions of the effects are mixed. However, in table 4.18, I show the results after controlling for location of competitive foods and beverages and types of competitive foods and beverages, and patterns in the data suggest there may be a slight negative relationship between offering competitive beverages and changes in times

children consume sweetened beverages, after accounting for types of beverages sold in school. I also examine whether gender, race, and poverty could differentially affect the relationship between competitive food and beverage practices and sweetened beverage consumption, and I find no interactive effects (see Appendix Table 1).

Table 4.17: Estimating Associations between Changes in Consumption Behaviors and Changes in Offering Competitive Foods and Beverage between the Fifth and Eighth Grades, Weighted

	Change in Number of Times Ate Fruits and Vegetables in Last 7 Days			Change in Number of Times Drank Milk and Juice in Last 7 Days			Change in Number of Times Drank Sweetened Beverages in Last 7 Days		
	Estimate		S.E.	Estimate		S.E.	Estimate		S.E.
Intercept	-2.41		2.55	-0.79		1.88	-0.69		1.34
Competitive foods offered in 5th grade (no access in 5th and 8th grade, reference)	-0.82		1.49	-0.69		1.28	-0.82		0.77
Competitive foods offered in 8th grade (no access in 5th and 8th grade, reference)	0.02		1.17	-0.65		0.90	-0.08		0.60
Competitive beverages offered in 5th grade (no access in 5th and 8th grade, reference)	1.28		1.65	0.71		1.29	0.76		1.00
Competitive beverages offered in 8th grade (no access in 5th and 8th grade, reference)	0.75		1.36	-0.55		1.07	0.41		0.62
Change in height (inches)	0.00		0.21	0.17		0.13	-0.04		0.07
Change in number of dinners eaten at a regular time each week	-0.11		0.20	0.06		0.15	-0.11		0.08
Change in family television-watching rules	-0.26		0.98	0.36		0.92	-0.56		0.50
Change in parents' choice of child's school	0.98		1.17	0.09		0.73	0.32		0.51
Change in mother working full-time	0.79		0.82	0.75		0.70	0.46		0.38
Change in whether two biological parents are in the household	-0.47		1.55	-0.24		0.90	-0.45		0.79
Change in living below 100% of the Federal Poverty Line (FPL)	1.33		1.41	0.64		0.83	0.21		0.68
Change in type of school attended	2.02		1.78	0.59		1.34	-0.17		0.84
Change in cafeteria crowding at lunchtime	0.37		1.36	-1.21		1.33	0.77		0.91
Change in number of convenience stores in the child's zip code	-0.04		0.30	-0.08		0.20	-0.18		0.12
Change in number of limited-service restaurants in the child's zip code	-0.01		0.05	-0.03		0.03	0.02		0.03
Change in fast food price index (1999 = base)	-0.02		0.09	0.02		0.08	0.00		0.04
Change in fruit and vegetable price index (1999 = base)	0.03		0.04	-0.04		0.03	-0.03		0.02
Change in obesity prevalence in state of residence (%)	-0.12		0.45	0.09		0.40	-0.17		0.19
Change in percent of state population that consumes fewer than 5 fruits and vegetables each day	-0.03		0.31	0.27		0.17	0.10		0.10
Changed schools from 5th to 8th grade	0.47		1.05	-0.33		0.76	1.03		0.55
Number of Observations	7,280								

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Table 4.18: Estimating Associations between Consumption Behaviors and Changes in Competitive Food and Beverage Practices between the Fifth and Eighth Grades, Weighted

	Change in Number of Times Ate Fruits and Vegetables in Last 7 Days			Change in Number of Times Drank Milk and Juice in Last 7 Days			Change in Number of Times Drank Sweetened Beverages in Last 7 Days		
	Estimate		S.E.	Estimate		S.E.	Estimate		S.E.
Intercept	-4.88		2.65	-0.46		1.92	-1.47		1.31
Competitive foods and beverages offered from vending machines, school stores and other locations only, 5th grade	-1.36		2.33	-1.63		1.42	0.43		0.82
Competitive foods and beverages offered from a la carte lines only, 5th grade	0.81		2.61	-0.46		1.57	1.18		0.73
Competitive foods and beverages offered from A la carte lines, vending machines, school stores, and other locations, 5th grade	-0.93		2.44	-1.64		1.51	0.17		0.96
Competitive foods and beverages offered from vending machines, school stores and other locations only, 8th grade	0.24		3.77	-0.10		1.70	0.37		1.10
Competitive foods and beverages offered from a la carte lines only, 8th grade	0.37		3.21	0.97		1.31	-0.20		1.04
Competitive foods and beverages offered from A la carte lines, vending machines, school stores, and other locations, 8th grade	0.89		3.80	0.46		1.29	-0.32		1.16
Types of competitive foods offered: fruits and vegetables only, 5th grade	-1.19		5.74	0.77		2.94	-2.37		1.31
Types of competitive foods offered: fruits and vegetables, and other snacks, 5th grade	0.31		1.53	0.20		1.28	-0.40		0.72
Types of competitive foods offered: other snacks only, 5th grade	-0.95		1.43	-0.29		1.56	-0.74		0.67
Types of competitive foods offered: fruits and vegetables only, 8th grade	-0.42		4.47	-2.44		2.69	0.75		1.62
Types of competitive foods offered: fruits and vegetables, and other snacks, 8th grade	0.29		2.37	-0.28		1.04	-0.41		0.63
Types of competitive foods offered: other snacks only, 8th grade	0.26		1.94	-1.37		1.06	0.21		0.63
Types of competitive beverages offered: milk and juice only, 5th grade	1.35		1.76	1.19		1.50	0.15		0.68
Types of competitive beverages offered: milk and juice, and other sweetened beverages, 5th grade	0.89		2.15	1.01		1.63	0.56		0.74
Types of competitive beverages offered: sweetened beverages only, 5th grade	1.42		3.38	3.07		2.50	-1.86		1.11
Types of competitive beverages offered: milk and juice only, 8th grade	0.15		2.79	-0.73		1.10	0.48		1.04
Types of competitive beverages offered: milk and juice, and other sweetened beverages, 8th grade	-0.49		2.93	-1.05		1.13	0.79		1.02
Types of competitive beverages offered: sweetened beverages only, 8th grade	-0.26		3.47	-0.46		2.89	2.94		2.11
Change in height (inches)	0.04		0.16	0.11		0.14	-0.04		0.07
Change in number of dinners eaten at a regular time each week	-0.01		0.23	0.10		0.14	-0.06		0.09
Change in family television-watching rules	-0.65		1.30	0.29		0.72	-0.47		0.49
Change in parents' choice of child's school	0.92		1.12	0.40		0.69	0.09		0.46
Change in mother working full-time	0.57		0.96	0.87		0.63	0.50		0.36

Table 4.18: Estimating Associations between Consumption Behaviors and Changes in Competitive Food and Beverage Practices between the Fifth and Eighth Grades, Weighted (cont.)

	Change in Number of Times Ate Fruits and Vegetables in Last 7 Days			Change in Number of Times Drank Milk and Juice in Last 7 Days			Change in Number of Times Drank Sweetened Beverages in Last 7 Days		
	Estimate		S.E.	Estimate		S.E.	Estimate		S.E.
Change in whether two biological parents are in the household	-0.56		1.39	-0.22		0.99	-0.64		0.81
Change in living below 100% of the Federal Poverty Line (FPL)	1.24		1.40	0.19		0.77	0.29		0.71
Change in type of school attended	2.14		1.96	0.53		1.32	-0.08		0.78
Change in cafeteria crowding at lunchtime	0.07		1.42	-0.84		1.34	0.60		0.93
Change in number of convenience stores in the child's zip code	-0.24		0.44	-0.03		0.21	-0.19		0.15
Change in number of limited-service restaurants in the child's zip code	0.02		0.05	-0.02		0.03	0.02		0.02
Change in fast food price index (1999 = base)	0.04		0.10	0.02		0.07	0.01		0.04
Change in fruit and vegetable price index (1999 = base)	0.03		0.04	-0.03		0.03	-0.01		0.02
Change in obesity prevalence in state of residence (%)	0.37		0.47	0.05		0.38	-0.10		0.16
Change in percent of state population that consumes fewer than 5 fruits and vegetables each day	0.00		0.24	0.25		0.18	0.05		0.12
Changed schools from 5th to 8th grade	0.46		0.99	-0.38		0.85	1.03		0.60
Number of Observations	7,280								

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Sensitivity Analyses

To assess the effects of some of the model specifications on the relationship between the dependent and independent variables, I ran a set of sensitivity analyses. I examined the effects of using imputed data, the effects of using survey weights, the potential effects of omitted school-level attributes in the models, and the effects of omitting school lunch and breakfast program participation from the models. The results of these analyses are shown in Tables 4.19 through 4.22. In each of these models, I still found little to no evidence that competitive food and beverage practices are associated with consumption behaviors.

There are three significant findings. First, in the model using non-imputed data, I find that students with access to competitive foods in the fifth grade consume milk and juice more times per week than children with no access to competitive foods in the fifth or eighth grades (see Table 4.19). In contrast, I also find that students with access to competitive beverages in the fifth grade consume milk and juice fewer times than children with no access to competitive beverages in the fifth and eighth grades. Using unweighted data, I find that children with access to competitive beverages in the fifth grade report drinking sweetened beverages fewer times per week than children who lack access in the fifth and eighth grades (see Table 4.20).

The findings from the models using non-imputed data and unweighted data are likely due to the sample no longer being nationally representative. The models using non-imputed data are run on a subset of cases with complete records. A large group of children are dropped from these models—largely, those who do not live in metropolitan areas. The

variables capturing food prices are derived by using data that is at the Core Based Statistical Area (CBSA) level. Any children who do not live within a CBSA are thus dropped from the analysis file. I reran the models on the non-imputed data and deleted the food price variables. The results of these models were consistent with the models using imputed data—I find no statistically significant effects of food and beverage practices on children's consumption patterns. Similarly, using unweighted data will produce a non-representative sample, as sample weights account for oversampling of Asians and Pacific islanders, attrition, and subsampling of movers.

The findings from the sensitivity analyses are further evidence that the results of my models are robust. I still find no evidence of effects of food and beverage policies even after attempting to account for potentially important omitted variables (i.e., school meal participation and unobserved school-level attributes). The results also suggest that using listwise deletion over multiple imputation as a strategy for dealing with missing observations could lead to biased estimates of effects of food and beverage practices on children's consumption patterns.

Table 4.19: Sensitivity Analysis: Data Not Imputed: Estimating Associations between Changes in Consumption Behaviors and Changes in Offering Competitive Foods and Beverage between the Fifth and Eighth Grades, Weighted

	Change in Number of Times Ate Fruits and Vegetables in Last 7 Days			Change in Number of Times Drank Milk and Juice in Last 7 Days			Change in Number of Times Drank Sweetened Beverages in Last 7 Days		
	Estimate		S.E.	Estimate		S.E.	Estimate		S.E.
Intercept	-4.70		-4.70	0.04		1.68	-0.50		1.25
Competitive foods offered in 5th grade (no access in 5th and 8th grade, reference)	-2.24		-2.24	-2.71	**	1.06	-0.68		0.63
Competitive foods offered in 8th grade (no access in 5th and 8th grade, reference)	-1.23		-1.23	-0.15		1.30	-0.32		0.82
Competitive beverages offered in 5th grade (no access in 5th and 8th grade, reference)	1.51		1.51	2.29	**	1.11	0.62		0.66
Competitive beverages offered in 8th grade (no access in 5th and 8th grade, reference)	2.52		2.52	-1.35		1.31	0.22		1.11
Change in height (inches)	-0.06		-0.06	0.16		0.13	-0.02		0.07
Change in number of dinners eaten at a regular time each week	-0.17		-0.17	-0.02		0.20	-0.06		0.09
Change in family television-watching rules	0.22		0.22	0.71		0.79	-0.65		0.63
Change in parents' choice of child's school	0.66		0.66	0.33		0.87	-0.19		0.75
Change in mother working full-time	-0.14		-0.14	-0.11		0.77	0.51		0.50
Change in whether two biological parents are in the household	0.22		0.22	-0.17		1.25	-0.25		0.81
Change in living below 100% of the Federal Poverty Line (FPL)	1.12		1.12	0.77		0.89	-0.14		0.83
Change in type of school attended	3.43		3.43	1.49		1.61	-1.15		1.19
Change in cafeteria crowding at lunchtime	0.16		0.16	-1.82		1.67	0.38		0.74
Change in number of convenience stores in the child's zip code	-0.19		-0.19	-0.16		0.17	-0.27		0.17
Change in number of limited-service restaurants in the child's zip code	-0.02		-0.02	-0.02		0.04	0.00		0.03
Change in fast food price index (1999 = base)	0.08		0.08	0.00		0.06	0.00		0.04
Change in fruit and vegetable price index (1999 = base)	0.07		0.07	-0.02		0.03	-0.04	**	0.02
Change in obesity prevalence in state of residence (%)	0.51		0.51	0.03		0.50	-0.18		0.21
Change in percent of state population that consumes fewer than 5 fruits and vegetables each day	0.01		0.01	0.17		0.18	0.19		0.11
Changed schools from 5th to 8th grade	-0.12		-0.12	-0.99		0.88	1.36	**	0.68
Number of Observations	3,640			3,700			3,700		

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.

Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Table 4.20: Sensitivity Analysis: Data Unweighted: Estimating Associations between Changes in Consumption Behaviors and Changes in Offering Competitive Foods and Beverage between the Fifth and Eighth Grades

	Change in Number of Times Ate Fruits and Vegetables in Last 7 Days			Change in Number of Times Drank Milk and Juice in Last 7 Days			Change in Number of Times Drank Sweetened Beverages in Last 7 Days		
	Estimate		S.E.	Estimate		S.E.	Estimate		S.E.
Intercept	-1.97		1.60	-1.67		0.94	-1.41	**	0.63
Competitive foods offered in 5th grade (no access in 5th and 8th grade, reference)	-0.67		0.78	-0.63		0.60	-0.61		0.35
Competitive foods offered in 8th grade (no access in 5th and 8th grade, reference)	0.40		0.80	-0.45		0.53	-0.30		0.32
Competitive beverages offered in 5th grade (no access in 5th and 8th grade, reference)	1.19		0.83	0.73		0.64	0.75	**	0.30
Competitive beverages offered in 8th grade (no access in 5th and 8th grade, reference)	-0.76		0.87	-0.62		0.65	0.32		0.41
Change in height (inches)	0.04		0.10	0.20	***	0.07	0.00		0.05
Change in number of dinners eaten at a regular time each week	-0.08		0.10	0.13		0.08	-0.08		0.05
Change in family television-watching rules	-0.61		0.65	-0.13		0.48	-0.52		0.31
Change in parents' choice of child's school	0.47		0.65	0.07		0.49	0.04		0.26
Change in mother working full-time	0.55		0.53	0.32		0.40	0.17		0.26
Change in whether two biological parents are in the household	0.11		0.92	-1.02		0.67	-0.43		0.38
Change in living below 100% of the Federal Poverty Line (FPL)	1.23		0.90	-0.55		0.62	-0.38		0.43
Change in type of school attended	1.29		1.19	-0.38		0.86	0.04		0.47
Change in cafeteria crowding at lunchtime	0.07		1.08	-0.73		0.81	-0.04		0.47
Change in number of convenience stores in the child's zip code	0.03		0.18	0.04		0.11	-0.12		0.07
Change in number of limited-service restaurants in the child's zip code	-0.01		0.03	-0.02		0.03	0.02		0.01
Change in fast food price index (1999 = base)	0.03		0.05	0.03		0.03	0.00		0.03
Change in fruit and vegetable price index (1999 = base)	0.04		0.02	-0.02		0.02	0.00		0.01
Change in obesity prevalence in state of residence (%)	0.08		0.27	0.02		0.15	0.06		0.11
Change in percent of state population that consumes fewer than 5 fruits and vegetables each day	-0.01		0.15	0.05		0.10	0.09		0.06
Changed schools from 5th to 8th grade	-0.82		0.59	-0.55		0.47	0.37		0.27
Number of Observations	7,280								

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.

**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Table 4.21: Sensitivity Analysis: Children Who Did Not Change Schools between Fifth and Eighth Grade: Estimating Associations between Changes in Consumption Behaviors and Changes in Offering Competitive Foods and Beverage between the Fifth and Eighth Grades, Weighted

	Change in Number of Times Ate Fruits and Vegetables in Last 7 Days			Change in Number of Times Drank Milk and Juice in Last 7 Days			Change in Number of Times Drank Sweetened Beverages in Last 7 Days		
	Estimate		S.E.	Estimate		S.E.	Estimate		S.E.
Intercept	-5.99		5.64	0.38		2.56	-2.55		2.13
Competitive foods offered in 5th grade (no access in 5th and 8th grade, reference)	-2.08		2.95	-1.76		1.98	-0.21		1.38
Competitive foods offered in 8th grade (no access in 5th and 8th grade, reference)	2.43		2.66	-1.04		1.95	0.15		1.31
Competitive beverages offered in 5th grade (no access in 5th and 8th grade, reference)	2.41		3.21	1.29		2.26	1.14		1.47
Competitive beverages offered in 8th grade (no access in 5th and 8th grade, reference)	-0.68		3.03	-0.70		2.18	-0.03		1.40
Change in height (inches)	0.44		0.44	0.07		0.31	-0.13		0.15
Change in number of dinners eaten at a regular time each week	-0.31		0.30	-0.06		0.32	-0.28		0.20
Change in family television-watching rules	3.07		1.99	1.95		1.59	1.49		1.11
Change in parents' choice of child's school	4.67		2.62	-1.27		2.19	1.34		1.28
Change in mother working full-time	2.41		1.81	3.41	**	1.58	-0.07		0.98
Change in whether two biological parents are in the household	-2.71		2.40	-4.37	**	1.81	-2.24		1.64
Change in living below 100% of the Federal Poverty Line (FPL)	-3.62		4.77	-0.60		3.02	-0.15		1.92
Change in cafeteria crowding at lunchtime	5.28		3.90	-0.02		3.80	1.94		1.35
Change in number of convenience stores in the child's zip code	-0.47		0.81	0.15		0.35	-0.84	***	0.22
Change in number of limited-service restaurants in the child's zip code	0.28	***	0.07	-0.03		0.08	0.05		0.05
Change in fast food price index (1999 = base)	-0.08		0.12	-0.11		0.12	0.08		0.09
Change in fruit and vegetable price index (1999 = base)	0.06		0.10	-0.02		0.05	0.05		0.04
Change in obesity prevalence in state of residence (%)	-0.19		0.84	0.27		0.69	-0.03		0.42
Change in percent of state population that consumes fewer than 5 fruits and vegetables each day	-0.12		0.39	0.14		0.34	0.28		0.27
Number of Observations	7,280								

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.

***Significantly different from zero at the .01 level, two-tailed test.

Table 4.22: Sensitivity Analysis: NSLP and SBP Program Participation Included in Model: Estimating Associations between Changes in Consumption Behaviors and Changes in Offering Competitive Foods and Beverage between the Fifth and Eighth Grades, Weighted

	Change in Number of Times Ate Fruits and Vegetables in Last 7 Days			Change in Number of Times Drank Milk and Juice in Last 7 Days			Change in Number of Times Drank Sweetened Beverages in Last 7 Days		
	Estimate		S.E.	Estimate		S.E.	Estimate		S.E.
Intercept	-5.23	**	2.19	-0.70		1.84	-0.72		1.22
Competitive foods offered in 5th grade (no access in 5th and 8th grade, reference)	-1.11		1.51	-0.71		0.82	-0.78		0.73
Competitive foods offered in 8th grade (no access in 5th and 8th grade, reference)	0.49		1.44	-0.91		1.00	-0.21		0.61
Competitive beverages offered in 5th grade (no access in 5th and 8th grade, reference)	1.49		1.24	0.63		0.88	0.72		0.56
Competitive beverages offered in 8th grade (no access in 5th and 8th grade, reference)	0.74		1.74	-0.24		1.32	0.37		0.81
Change in height (inches)	0.02		0.15	0.17		0.12	-0.05		0.08
Change in number of dinners eaten at a regular time each week	-0.02		0.25	0.16		0.16	-0.12		0.08
Change in family television-watching rules	-0.14		1.05	0.63		0.96	-0.48		0.51
Change in parents' choice of child's school	1.16		1.06	0.02		0.69	0.12		0.45
Change in mother working full-time	0.95		1.28	0.88		0.63	0.28		0.45
Change in whether two biological parents are in the household	-0.73		1.60	-0.08		1.04	-0.40		0.75
Change in living below 100% of the Federal Poverty Line (FPL)	1.49		1.30	0.20		1.07	0.42		0.70
Change in type of school attended	1.87		1.76	0.36		1.34	-0.38		0.79
Change in cafeteria crowding at lunchtime	-0.24		1.60	-1.10		1.34	0.77		0.93
Change in number of convenience stores in the child's zip code	-0.20		0.32	0.01		0.17	-0.21		0.12
Change in number of limited-service restaurants in the child's zip code	0.01		0.05	-0.01		0.04	0.01		0.03
Change in fast food price index (1999 = base)	0.08		0.08	0.04		0.06	0.00		0.05
Change in fruit and vegetable price index (1999 = base)	0.05		0.04	-0.03		0.04	-0.01		0.02
Change in obesity prevalence in state of residence (%)	0.32		0.49	0.07		0.39	-0.15		0.18
Change in percent of state population that consumes fewer than 5 fruits and vegetables each day	0.00		0.26	0.24		0.14	0.07		0.13
Changed schools from 5th to 8th grade	0.54		1.06	-0.66		0.81	0.94		0.61
Change in NSLP participation	-1.58		0.96	-0.34		0.68	0.58		0.37
Change in SBP participation	0.96		1.15	0.03		0.63	0.51		0.53
Number of Observations	7,280								

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.

Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.

Conclusion

In this chapter I examine the relationship between school competitive food and beverage practices and consumption patterns of early adolescent children. I find that most children are exposed to competitive food and beverages in the fifth and eighth grades, with more children exposed in the eighth grade. I also find that children likely do not consume recommended levels of fruits and vegetables, milk and juice, and sweetened beverages in fifth or eighth grade, as they report consuming these foods and beverages few times per week. I do not, however, find a relationship between school competitive food and beverage practices and children's consumption behaviors during early adolescence. These results appear to be robust after testing a variety of model specifications. Implications for policy and future research are discussed in chapter five.

Chapter Five: Implications for Policy and Future Research

Introduction

In this chapter, I summarize this dissertation, including a discussion of the policy problem (i.e., childhood obesity), the potential policy lever I examine (i.e., regulation of competitive foods and beverages in school), the relevant literature, the research questions and methods used to answer them, and finally a review of the key findings. I also discuss how the findings from this dissertation fit with prior research. I conclude the chapter with a discussion of the implications of my findings for policy and future research.

Summary of Dissertation

In chapter one of this dissertation, I identify childhood obesity as the policy problem that this research is intended to address. Obesity is a level of body fatness associated with a number of health problems such as type II diabetes and certain forms of cancer. The literature argues that the costs associated with obesity are non-trivial and are shouldered heavily by taxpayers through public health insurance programs such as Medicare and Medicaid. The literature also reveals that the prevalence of obesity among children is high and has increased dramatically over the last three decades, with about one-fifth of all children obese in 2007-2008, suggesting that if policymakers do not act, costs could continue to rise.

In chapter two, I discuss the socio-ecological model—the primary framework for understanding obesity causation—which highlights the role environmental factors have in affecting diet and physical activity, which ultimately affect weight. With this framework in mind, the school food environment is an obvious intervention point for policymakers to affect diet in an effort to curb childhood obesity, as children spend about one-third of the day in school and consume at least one meal there.

Competitive foods, or those foods sold in schools that are not a part of the federal school meal programs, are a target for intervention, given that they are ubiquitous in U.S. schools and are often low in nutritional value. Federal law does not currently allow for comprehensive regulation of competitive foods at the federal level; however, states and school districts do have authority to regulate where foods are offered and what types of foods sold. Research has shown that a number of states and school districts have competitive food policies that go beyond federal policy, but that they still fall short of recommended dietary standards. Additional regulation at the federal level would be possible with modification to the Child Nutrition Act, which is up for reauthorization in 2010. The Obama Administration has requested further restrictions on the types of foods available in school as a part of the reauthorization of the Child Nutrition Act.

A key question is: to what extent can policymakers expect that regulating competitive foods can positively influence children's dietary patterns? In chapter two, I review the literature examining this question and find some support for the idea that regulating competitive foods could positively influence children's consumption patterns. The

research, however, is tenuous with a number of studies finding a mix of significant and non-significant effects of competitive food policy on children's dietary patterns. These studies were open to a number of threats to either internal or external validity, however, that limited their ability to draw causal inferences. In particular, many of these studies may lack generalizability, as they were based on small, localized samples, and those with larger, nationally representative samples may have suffered from omitted variable bias as they were based on cross-sectional data.

In chapter 2, I argue that my contribution to the literature is that my study improves upon the strategy to detect the effects of competitive food and beverage policies on children's dietary patterns. I use nationally-representative data, allowing for generalizations about the population of children in the fifth and eighth grades in the United States, whereas much of the earlier research focused on small, localized populations. Second, I use panel data, allowing me to control for a number of potential threats to internal validity that cross-sectional data does not easily allow for, in contrast to previous work which relied mostly on cross-sectional or pre-post data. In addition, the methods strategy I use allows me to control for a potential endogenous relationship between school food and beverage practices and children's dietary patterns. Only one of the studies I reviewed attempted to account for this selection mechanism and could only use observable controls, given the data was cross-sectional. Finally, a number of the studies I reviewed used dietary recall at lunchtime to detect effects of competitive food and beverage practices. This method does not account for the possibility that changes in competitive food policy may not

change overall dietary patterns. The data I use has dietary information over the course of a week, which allows me to examine effects of policy on overall dietary behaviors.

In chapter 3, I present my research questions and identification strategy. Specifically, I examine the relationship between competitive food and beverage practices at school and children's fruit, vegetable, milk, juice and sweetened beverage consumption patterns. Primarily, I rely on data from the ECLS-K, a nationally-representative survey of children who were in kindergarten in the 1998-1999 school year. I use first difference models to estimate the effect of changes in school competitive food and beverage practices on changes in dietary patterns between the fifth and eighth grades. The key limitation of my research is omitted variable bias. For example, I do not have information on the extent to which schools have multiple wellness policies in place in addition to regulating competitive foods and beverages (e.g., nutrition education, physical activity requirements, et cetera). It could be that changes in these other wellness policies over time masks the relationship between competitive food policies and children's dietary behaviors. Of note, because I use first difference models, only those variables that are unobserved and time-varying that are correlated with competitive food and beverage practices and children's consumption patterns would produce biased results. My identification strategy reduces the margin of error as compared with the prior literature.

In chapter 4, I present the findings of my research. I examine the relationships between competitive food and beverage practices and times per week children consume fruits and vegetables, milk and juice, and sweetened beverages. I examine bivariate relationships,

multivariate relationships, controlling for observable characteristics, and multivariate relationships controlling for observable and some unobservable characteristics. Regardless of the specification, I find no evidence that competitive food and beverage practices have any effect on changes in children's consumption of fruits and vegetables, milk and juice, or sweetened beverages such as soda between the fifth and eighth grades. I also find no interactive relationships between competitive food and beverage practices and gender, race or poverty.

Comparing and Contrasting Findings to Previous Literature

The results of my study align most closely with findings from other studies using nationally-representative data. As previously noted, Briefel et al. (2009) found few associations between competitive food practices and fruit and vegetable consumption and those significant relationships they did find varied by grade level. They found no effect of competitive food policies on elementary age children's consumption of sweetened beverages. Similarly, Datar and Nicosia (2009) found no associations between junk food availability in school and milk, green salad, carrot, and potato consumption.

I have three interrelated hypotheses for why other studies found relationships between competitive food and beverage practices and consumption patterns that I did not. First, there may be important differences in measurement. For instance, Fernandes (2008) examined the effect of access to competitive beverages on *any* sweetened beverage consumption over the past week and found a positive and significant relationship. Similarly, Grimm, Harnack and Story (2004) looked at the relationship between access to

competitive beverages and consumption of sweetened beverages *5 or more days* per week and found a significant, positive relationship. Alternatively, I examine the relationship between access and *average weekly consumption*. I would argue that conceptually, we should be more concerned about average weekly consumption than the alternative specifications used in prior research. However, it could be that if all three studies used the same measures, we would find similar results.

Similarly, a number of studies looked at the effects of policy on lunchtime eating behaviors and found differences. I look at effects of policies on behaviors over the course of a week. It may be that if these other studies were able to observe dietary patterns over a longer period, they would not find that changes and behavior last long past the lunch hour. And conversely, it may be that if I were able to observe lunchtime meal patterns, I may find significant effects of competitive food and beverage practices on children's lunchtime eating patterns.

Further, a number of studies used recall data to examine dietary patterns. These recall data were much more precise than the food frequency questionnaire that was available to me in the ECLS-K. It may be that the precision of the recall data allowed researchers to find differences in eating patterns that a blunt instrument such as a food frequency questionnaire could not.

A second hypothesis for why my findings differed from other studies, particularly the localized studies, is that it may be that a more comprehensive approach to nutrition policy

in school is more likely to change dietary patterns that a less ambitious strategy. For instance, the studies I reviewed that examine changes in Texas school nutrition policies note that there were major changes to the school food environment as a result. These changes went beyond merely offering an apple in the lunch line. Alternatively, in my study, I look at students in schools across the country. I examine if any competitive foods and beverages are offered, and if they are offered, where they are offered (i.e., a la carte versus somewhere else in the school) and what types are offered (i.e., fruits and vegetables, all other food snacks, milk and juice, and sweetened beverages). It may be that, on average, competitive food and beverage practices in schools in the United States do not have an effect on fifth and eighth graders eating patterns. As previously noted, studies have shown that most school competitive food policies in the United States do not align with dietary standards. If I had more nuanced measures of policy, however, I may have found that schools that have more aggressive policies are more likely to affect children's dietary patterns than those with less aggressive policies. For instance, with the data I have, I would consider a school that sells apples as the only fruit or vegetable offered the same as a school that offers a range of fruit and vegetable options. This warrants future investigation.

Third, the theoretical model upon which I base this research asserts a dynamic set of relationships between the individual and his or her environment. The modeling strategy I use assumes a static relationship between the individual, competitive food and beverage practices, other environmental factors, and dietary behaviors. While the model I build has a number of controls for different environmental characteristics, it may be that

competitive food and beverage practices work in concert with the other factors, in which case, I may not pick up significant relationships between competitive food and beverage practices and children's consumption patterns. It could also be that, on average in the United States, competitive food and beverage practices have no effect on dietary behaviors, but in some jurisdictions, schools and communities have more targeted and comprehensive approaches to obesity reduction, of which, competitive food and beverage policies are only a part. In these cases, it may be that competitive food and beverage practices are important, but they are only part of the solution.

Implications for Policy and Future Research

As with any study that has "null" results, I cannot be sure that competitive foods and beverages policies in schools are not associated with children's consumption patterns, that is, I cannot prove the null hypothesis. I can only be sure that I do not find significant effects of policy on behavior. Because of this, my study leaves more questions open for future research.

What I *would not* conclude from my research is that it is not possible that competitive food and beverage practices could matter. Instead, I think my research should lead policymakers and other researchers to try and implement and evaluate more comprehensive approaches to change both dietary and physical activity behaviors, holding truer to the theory articulated by the socio-ecological theory of obesity causation. Some research indicates, for example, that when competitive food options improve with regard to nutrition content, students bring unhealthy options from home (Cullen et al.,

2008). Thus, it may be that targeting the school food environment alone will not alter dietary behavior in any real way for most students.

The Institute of Medicine (2009) identified promising strategies for local governments to take to help fight obesity. These measures include such ideas to improve diet quality as incentivizing super market chains to locate in food deserts, requiring menu labeling in restaurants, and taxing unhealthy foods and beverages to discourage consumption. The report also suggested ways to improve physical activity, such as improving the walkability of neighborhoods by increasing the number of sidewalks that connect to parks, schools, and other neighborhood destinations, mandating minimal amounts of play space in communities that would include equipment for children to play, and maintaining playgrounds and parks. This report built on the earlier work of the IOM (2007) that suggested ways to improve the school food environment such as taking sweetened beverages out of elementary and middle schools and putting more fruits and vegetables in. In general, the approach by the IOM committees has been to encourage the public sector to help foster environments conducive to changing unhealthy eating and activity patterns among children.

One recent study in Philadelphia elementary schools took a comprehensive strategy within the school and had impressive success (Foster et al., 2008). Using an experimental design, schools were randomized into treatment and control schools. Treatment schools implemented a targeted strategy to curb the obesity problem, which included a school self-assessment, nutrition education, nutrition policy, social marketing

and parent outreach. The nutrition policy included substantial changes in the foods offered at schools, including eliminating sugar sweetened beverages from schools and requiring all foods offered to adhere to the recommendations of the Dietary Guidelines. After two years of following students, there was a 50 percent reduction in the incidence of overweight among students in the treatment schools compared with those in the control schools.

One critical factor in determining children's dietary behaviors is likely the family. Schools can only offer or restrict access to foods and beverages; they cannot require students to make healthy decisions. Parents can exert much more control over their children's eating behaviors. Some literature highlights this relationship. For instance, Cullen et al. (2008) found that when restrictions were put in place on access to competitive foods and beverages in school, students brought more unhealthy foods from home to school to consume at lunch. Further, a successful obesity intervention conducted by Foster et al (2008) included parental involvement as well as changes to the school food environment. It is possible that including the family in the intervention may have been important. Additional research attention is needed to understand the extent to which the family food environment affects dietary patterns into adolescence and adulthood.

The desirability of developing a comprehensive framework for fighting obesity is evident at the federal level as well. The Food and Nutrition Service of the U. S. Department of Agriculture has a number of research and evaluation plans for 2010 related to this topic (Food and Nutrition Service, 2009). For instance, the Healthy Incentives Pilot Program,

a $20 million initiative, will test the effects of monetary incentives on Supplemental Nutrition Assistance Program Participants (formerly the Food Stamp Program) to purchase fruits and vegetables and other healthy foods. The Food and Nutrition Service also plans to pilot test community-wide obesity reduction efforts based on the socio-ecological theory of obesity causation to improve eating behaviors of SNAP participants (FNS, 2010). The details of this plan are not yet clear, as Congress has yet to appropriate funds to conduct the study. I think it will be helpful, however, to have federal policymakers strategically test comprehensive obesity reduction initiatives. It would help to move the discussion forward considerably if there were standards set across different demonstration programs so that results could be compared. Results from evaluations of these types of initiatives will help the field to better understand how the causal mechanisms work and how best to positively alter behavior to improve outcomes.

While I think comprehensive strategies are worthwhile to try, there will be obstacles to experimentation. With regard to competitive food policy in particular, there will be barriers that result from practical considerations as well as philosophical considerations. For instance, from a practical perspective, many schools have argued that they rely on the revenue from unhealthy competitive foods and beverages to operate (Story, Nanney, and Schwarz, 2009). Thus, to reduce access to these foods could mean a substantial reduction to food service authority operations, which are already under very tight fiscal constraints. Some studies have found, however, that schools have been able to improve the food environment without sacrificing revenue (Larson & Story, 2010).

The philosophical debate often comes when snack or soda taxes are suggested. There are some who argue that government should not be involved in choosing what foods people eat and that taxing such behavior is imposing on individual autonomy (Basham and Luik, 2010). This line of reasoning would hold for competitive food and beverage regulation as well. Others would argue that like smoking, poor dietary behaviors create a negative externality (Engelhard, Garson, & Dorn, 2009). The costs associated with obesity are not paid for exclusively by obese individuals; rather, the costs are shared by everyone through higher insurance premiums and taxpayers dollars in the form of subsidized government insurance (e.g., Medicare and Medicaid). Thus, others argue that taxation would make those who create the externalities bear fiscal responsibility for them.

Perhaps policymakers could consider interventions that are more 'middle-of-the-road' strategies than strict regulation or taxation. For instance, there is early evidence that there are ways to "nudge" people to make better eating decisions (Mancino & Guthrie, 2009). For instance, Rust et al. (2008) found that forms of payment among college students influenced the types of foods they chose to purchase and consume, with certain forms of payment associated with better nutritional outcomes. Additional behavioral economic theory could be tested to assess the extent to which subtle changes to the food environment could influence people to make healthier decisions rather than trying to change behavior via regulation.

Conclusion

One out of every five children in the United States was obese in 2007-2008. With the costs, both in monetary and quality of life terms, so high, it is clear policymakers need to act. One potential policy lever is to regulate the types of snacks sold in schools in an effort to improve the school food environment. In this dissertation, I use nationally-representative survey data to assess the extent to which competitive food and beverage practices in schools affect children's consumption of fruits and vegetables, milk and juice, and sweetened beverages. On average in the United States, I find no statistically significant relationships between availability of competitive foods and beverages in school and children's consumption patterns. These findings do not mean is that competitive food and beverage policies do not matter. What they do mean is that there is still a lot of work to be done to understand how dietary behaviors are developed and how they can be changed. It may be that a more comprehensive strategy, as articulated in the socio-ecological theory of obesity causation, could result in a decline in the prevalence of obesity in children. This strategy cannot come from one level of government alone. It is likely that this strategy will involve all layers of government, working closely with both the private and non-profit sectors.

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Appendix A. First Difference Models with Interactions

Table A.1: Estimating Associations between Changes in Consumption Behaviors and Changes in Offering Competitive Foods and Beverage between the Fifth and Eighth Grades with Interactions between Gender, Race and Poverty, Weighted

	Change in Number of Times Ate Fruits and Vegetables in Last 7 Days			Change in Number of Times Drank Milk and Juice in Last 7 Days			Change in Number of Times Drank Sweetened Beverages in Last 7 Days		
	Estimate		S.E.	Estimate		S.E.	Estimate		S.E.
Intercept	-1.46		2.75	-0.30		2.03	-0.66		1.35
Competitive foods offered in 5th grade (no access in 5th and 8th grade, reference)	-0.65		2.63	-1.20		1.55	-0.13		1.46
Competitive foods offered in 8th grade (no access in 5th and 8th grade, reference)	-0.02		2.34	0.29		1.18	-0.42		0.94
Competitive beverages offered in 5th grade (no access in 5th and 8th grade, reference)	1.29		2.49	2.10		1.95	0.31		1.59
Competitive beverages offered in 8th grade (no access in 5th and 8th grade, reference)	2.07		2.00	-1.64		1.57	0.50		0.86
Change in height (inches)	-0.12		0.25	0.10		0.16	-0.05		0.08
Change in number of dinners eaten at a regular time each week	-0.10		0.20	0.06		0.15	-0.11		0.08
Change in family television-watching rules	-0.16		0.98	0.34		0.95	-0.59		0.50
Change in parents' choice of child's school	1.07		1.16	0.07		0.73	0.27		0.50
Change in mother working full-time	0.79		0.83	0.70		0.68	0.45		0.38
Change in whether two biological parents are in the household	-0.42		1.54	-0.26		0.88	-0.45		0.78
Change in living below 100% of the Federal Poverty Line (FPL)	1.66		1.64	1.08		1.17	0.32		0.95
Change in type of school attended	2.02		1.76	0.57		1.33	-0.16		0.82
Change in cafeteria crowding at lunchtime	0.20		1.38	-1.16		1.29	0.79		0.90
Change in number of convenience stores in the child's zip code	-0.06		0.30	-0.09		0.20	-0.17		0.12
Change in number of limited-service restaurants in the child's zip code	0.00		0.05	-0.03		0.03	0.02		0.03
Change in fast food price index (1999 = base)	-0.03		0.09	0.03		0.08	0.00		0.04
Change in fruit and vegetable price index (1999 = base)	0.03		0.03	-0.04		0.03	-0.03		0.02
Change in obesity prevalence in state of residence (%)	-0.17		0.46	0.10		0.40	-0.16		0.19
Change in percent of state population that consumes fewer than 5 fruits and vegetables each day	-0.07		0.31	0.28		0.17	0.11		0.10

Table A.1. Estimating Associations between Changes in Consumption Behaviors and Changes in Offering Competitive Foods and Beverage between the Fifth and Eighth Grades with Interactions between Gender, Race and Poverty, Weighted (cont.)

	Change in Number of Times Ate Fruits and Vegetables in Last 7 Days			Change in Number of Times Drank Milk and Juice in Last 7 Days			Change in Number of Times Drank Sweetened Beverages in Last 7 Days		
	Estimate		S.E.	Estimate		S.E.	Estimate		S.E.
Changed schools from 5th to 8th grade	0.60		1.03	-0.43		0.79	0.95		0.55
Competitive foods offered in 5th grade * female	1.53		3.15	1.61		2.15	-0.63		1.78
Competitive foods offered in 5th grade * non-white	-2.38		2.54	-1.01		1.70	0.35		1.41
Competitive foods offered in 5th grade * poverty	0.28		3.34	0.58		2.10	-2.42		1.75
Competitive beverages offered in 5th grade * female	-0.32		2.68	-3.53		2.31	0.48		1.69
Competitive beverages offered in 5th grade * non-white	0.37		2.68	0.79		1.91	-0.58		1.29
Competitive beverages offered in 5th grade * poverty	-0.03		3.49	-0.03		2.09	2.28		1.89
Competitive foods offered in 8th grade * female	-2.21		3.03	-2.19		1.54	1.04		1.20
Competitive foods offered in 8th grade * non-white	1.02		2.13	0.95		1.65	-0.48		1.38
Competitive foods offered in 8th grade * poverty	2.83		2.85	-1.62		2.00	0.46		1.50
Competitive beverages offered in 8th grade * female	0.23		2.21	2.33		1.71	-1.14		1.10
Competitive beverages offered in 8th grade * non-white	-1.81		2.11	-0.21		1.93	1.28		1.28
Competitive beverages offered in 8th grade * poverty	-3.19		2.77	0.69		1.97	-0.59		1.47
Number of Observations	7,280								

Source: Author's tabulations of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 K-8 public-use file, the 5th and 8th grade restricted-use files, Census Zip Business Patterns data, ACCRA Food Price data, and Behavioral Risk Factor Surveillance System data.
Note: Per U.S. Department of Education disclosure rules, unweighted sample sizes have been rounded to the nearest 10. Estimates are based on imputed data using multiple imputation.
**Significantly different from zero at the .05 level, two-tailed test.
***Significantly different from zero at the .01 level, two-tailed test.