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DISSERTATION

# Evaluating the Impacts of School Nutrition and Physical Activity Policies on Child Health

Meenakshi Maria Fernandes

This document was submitted as a dissertation in December 2009 in partial fulfillment of the requirements of the doctoral degree in public policy analysis at the Pardee RAND Graduate School. The faculty committee that supervised and approved the dissertation consisted of Roland Sturm (Chair), Pierre-Carl Michaud, Chloe Bird, and Don Bundy. This dissertation was supported by the Jim Lovelace Foundation, Active Living Research (a national program of the Robert Wood Johnson Foundation), and RAND Health.

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## Acknowledgements

I would like to acknowledge my committee – Roland Sturm, Chloe Bird, Pierre-Carl Michaud and Don Bundy – for their exceptional mentorship. They are outstanding health policy researchers and I am grateful for the opportunities I have had to learn from their example. I am especially indebted to Roland Sturm for training me and setting me on this path.

My dissertation was supported by Roland Sturm (through Active Living Research and the NICHD) and the Jim Lovelace Foundation Dissertation Scholarship for Child Policy Research. Data assistance provided from Suzy Adler at RAND and Jill Carlavati at the National Center for Education Statistics is much appreciated.

The Pardee RAND Graduate School is a unique and special place and I am proud to serve among its alumni. Several Fellows have been instrumental in the preparation of this work and my development as a researcher. These are Tatiana Andreyeva, Ricardo Basurto, Benjamin Bryant, Seo Yeon Hong, Ying Liu, Yang Lu, Silvia Montoya, Baoping Shang, Victoria Shier and Khoa Truong. Others who have guided me through this process include John Graham, Bonnie Ghosh-Dastidar, Raquel Fonseca Benito, Erik Meijer, Stephanie Taylor, Maggie Weden and Patty Mabry, Senior Advisor to the OBSSR. I hope that this is just the beginning and we will continue to collaborate in the years to come. Last but not least, many thanks are due to my family and Domenec Ruiz Devesa for their patience, love and encouragement.

## Abstract

This dissertation evaluates the impact of elementary school policies on child health behaviors and obesity in the United States. Two chapters address nutrition policies, two chapters address physical activity policies, and a final chapter estimates the health care cost savings associated with a decline in childhood obesity prevalence. The use of large national datasets allows for the investigation of disparities by child, school and regional factors. This is in contrast to other studies which are based on a limited geographic area or small, demographically homogeneous samples.

Policymakers have promoted restrictions on competitive foods, which are subject to minimal federal regulations and typically have low nutrient value. I find that many states implemented a limit or nutrition standard between 2004 and 2007 and that these policies have had the intended effect of limiting sugar-sweetened beverages and increasing the availability of low-fat snacks and sweets in schools. While restrictions on availability are associated with lower school-based consumption, no impact on obesity is found. Plausible explanations include that children respond to restrictions by substituting purchases from outside of school and that children's purchasing power increases as they age.

In regards to physical activity, I find that children from disadvantaged backgrounds are more likely to attend schools with poorer gymnasium and playground provision. Furthermore, having a gymnasium is associated with more time in physical education class. A related analysis finds suggestive evidence that an expansion of

physical education and recess programs to meet national recommendations would mitigate body mass increase.

While school policies are a promising tool for obesity prevention, few interventions have proven effective. However, even a small effect could imply sizeable health benefits over the life-course. Estimates from my simulation model suggest that a 1% decline in childhood obesity would result in lifetime savings of about $1 billion.

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## Background and Motivation

As children spend a large portion of the day at school, the policies and programs they are exposed to have potential to shape their dietary intake, physical activity and ultimately their health. Obesity among children in particular has garnered the attention of policy makers due to its high prevalence and association with worse health outcomes (IOM, 2005). While 5% is considered to be the natural prevalence of obesity in a population, rates among youth were about 10% in the early 1990s and is approach 20% today (Ogden, 2002; Ogden, 2008). Rates have increased across all population subgroups though racial/ethnic minorities may face a higher risk (IOM, 2005). For example, the highest rates of childhood obesity are concentrated among female Blacks and male Mexican-Americans (Ogden et al., 2008).

Given this context, school nutrition policies have received considerable attention and policy intervention due to the fact that a significant fraction of a child's caloric intake occurs at school (IOM, 2005). The National School Lunch Program provided over 28 million children received free or reduced price lunches in 2002 (GAO, 2003). Competitive foods, which include food items sold a la carte, in vending machines or school stores, face minimal federal regulations and are typically high in sugars and fats.

Nutrition-related initiatives that have occurred at the national level include the Child Nutrition and WIC Reauthorization Act of 2004, which mandates changes to the school lunch program and the development of school wellness policies, and the industry agreement negotiated by the Alliance for Healthier Generation with the American Beverage Association, Cadbury Schweppes, Coca-Cola and PepsiCo in May 2006, which restricts the caloric content of drinks sold in schools. Farm to school programs have increased in recent years and the Child Nutrition Promotion and School Lunch Protection Act of 2009, which will amend the Child Nutrition Act this fall, currently contains many provisions to alter the content of school lunches. A variety of policies restricting competitive foods have been adopted at the district- and state-level; however the degree to which school practice is in accordance with policy is unclear (GAO, 2004; Mâsse, Chriqui et al., 2007; Mâsse, Frosh et al., 2007).

There however appears to be little change in physical activity environment since the early 1990s (SHPPS, 1994; 2000; 2006) and it might have even worsened due to concerns that time spent in non-academic activities such as physical education (PE) and recess may result in worse academic performance. Currently less than half of youth meet the recommended level of physical activity per week (Troiano, 2008). School programs may be more important for children who are at risk for not being physically active, such as girls and racial/ethnic minorities, who have fewer opportunities to engage in organized physical activity at home (Sallis, Prochaska et al. 2000; Romero 2005; Ferreira, van der Horst et al. 2007). Schools can counter this effect to some extent by providing at least some structured and unstructured activity for children, which tends to become more important over time as activity levels generally decline with age (Gordon-Larsen, Nelson et al 2004).

Policies regarding sugar-sweetened beverages (SSB) have been a focus of policy efforts at the local and national level as they represent "empty calories" and consumption has increased substantially since the late 1970s (Nielsen & Popkin, 2004). Over 10% of daily energy needs for 6-11 year olds now comes from SSB (Wang et al, 2008). The *Los*

*Angeles Unified School District*, the second largest school district in the country, banned SSB in January 2004 and California followed by passing legislation to limit SSB availability 6 months later. Less is known about the impact of these actions and of restrictions of competitive foods more broadly on consumption behaviors and obesity.

National recommendations for school physical activity environment are provided by Healthy People 2010 and the National Association of Sport and Physical Education (NASPE). Policy development has focused however at the state and district level and has reflected the national recommendations. These policies include mandates on time spent in PE and recess, staffing, curriculum standards and fitness assessments (Masse, 2007). The benefits of increasing time spent in PE and recess is unclear as few studies have documented the effectiveness of existing time spent in PE and recess. Furthermore, while numerous academic studies have highlighted the relevance of facilities and equipment for physical activity, this has not translated to national recommendations.

Evaluations of school policies generally consider two types of outcomes: 1) behavioral measure outcomes such as healthy eating and active living; and 2) health status outcomes such as obesity and cardiovascular disease risk factors. Evaluations of school policy effectiveness mainly take two approaches: descriptive cross-sectional or small randomized controlled trials (Campbell et al, 2001; Foster et al., 2008; Kahn et al, 2004; Peterson & Fox, 2007; Sharma, 2006; Kubik et al 2003). While they may be illustrative, results from descriptive cross-sectional analyses and results should be interpreted with caution. If disadvantaged children are more likely attend disadvantaged schools, a positive correlation between a school characteristic and child behavior may simply be due to the condition of being disadvantaged rather than a causal mechanism.

The other most common approach is randomized intervention trials based on small samples in a limited geographic area. While internal validity may be strong, estimates obtained may not readily apply to children with different characteristics.

Recommendations issued by government agencies and advocacy groups (Bundy, Beegle, Hoffman, Camara, & Takeuchi, 2006; Center for Science in the Public Interest, 2008) are mainly based on studies using these two approaches. Some investigations have applied stronger methods to national-level data (Anderson & Butcher, 2006; Datar & Sturm, 2004; Schanzenbach, 2005). However, environment measures in these studies are less detailed and comprehensive as those from many studies based on a more limited sample. School policy recommendations should be based on studies that encompass different approaches. A weakness of one study may be the strength for another and together they may provide a more well-balanced picture.

Reducing the prevalence of childhood obesity through school-based programs can have substantial benefits particularly if considered over the lifecycle. Furthermore, from a policy perspective, school-based programs are feasible to implement. Obese children may be discriminated by others, are also at greater risk for developing psychosocial conditions (Dietz, 1998). They may also develop conditions that traditionally occur in adults such as type 2 diabetes mellitus and hypertension (Freedman et al, 1999; Goran et al, 2003; Jones, 2008). Obese children are at greater risk for being obese as adults (Serdula, 1993). It is well-established that obese adults face a higher relative risk for diseases including hypertension, type 2 diabetes, stroke, liver abnormalities and osteoarthritis and face difficulty in maintaining weight loss (CDC, 1998; Must et al., 1999; Rocchini, 2002; Skender et al., 1996). Estimates of the lifetime costs associated with childhood obesity would inform the value of reducing prevalence among the youth population today. While the costs of obesity prevention programs are readily available, the potential benefits are less discernable.

This dissertation contributes to this literature and policy discussion described above in several ways. Chapters 1 and 2 are on physical activity policies and Chapters 3 and 4 are on competitive food policies. Chapter 5 develops a model to estimate the lifetime costs associated with childhood obesity. All investigations are conducted at the national level. More specifically, Chapter 1 assesses the effectiveness of existing PE and recess time in obesity development for a cohort of children progressing from $1^{st}$ to $5^{th}$ grades. Chapter 2 describes sociodemographic disparities in school facility provision and the relation between facility provision and program time. Chapter 3 considers the role of SSB availability at schools on overall consumption prior to the implementation of the national agreement between the Alliance for a Healthier Generation and beverage manufacturers. Chapter 4 evaluates the effectiveness of state policies to alter the competitive food landscape and the ensuing impact on consumption and obesity trajectories of children.

## Data: The Early Childhood Longitudinal Survey

The Early Childhood Longitudinal Study - Kindergarten Cohort (ECLS-K) was conducted by the National Center for Educational Statistics to support investigations into how a wide range of family, school, neighborhood and individual factors are associated with child cognitive and social development (http://nces.ed.gov/ecls/). It follows a nationally-representative cohort of kindergarteners (n=17,565) in the 1998-1999 school year through elementary school. The survey was fielded in the fall of kindergarten and 1st grade as well as the spring of kindergarten, 1st grade, 3rd grade, 5th grade and 8th grade. The base year cohort, selected based on a multistage probability design covering the United States including Alaska and Hawaii. The primary sampling units were counties or groups of counties, the second-stage units were schools, and the 3rd-stage units were children within schools. Children from racial/ethnic minority groups or attending private schools were over-sampled. About 50% of children who changed schools were randomly selected for follow-up and the sample was refreshed in spring 1st grade. More details on the survey are available at http://nces.ed.gov/ecls/.

For each child, the ECLS-K conducted a direct assessment, a telephone computer-assisted interview of the child's parent or guardian and self-administered interviews of the child's teacher and school administrator. The ECLS-K followed-up with the children, parents or guardians, teachers and school administrators in each round of data collection. Data collected in the spring of 2000 (1st grade), 2002 (3rd grade) and 2004 (5th grade) were used for the analysis. The rate of attrition between the spring of 1st grade when the sample was freshened and the spring of 5th grade is 28%. Those sampled in 1st grade but not followed-up with in 5th grade are more likely to be male, Black, Hispanic or from a low-income household ($P<0.05$).

The key variables of the analysis and the waves in which they were collected are listed in the table below. Assessors from the ECLS-K measured children's height and weight in the direct child assessment of each wave. These measurements will be used to compute BMI (measured as weight in kilograms divided by squared height in meters) and obtain the corresponding BMI percentile using the Centers for Disease Control (CDC) age- and gender-specific growth charts. A child is defined as being at risk of being overweight if the BMI percentile exceeds the 85th percentile and overweight if the BMI percentile exceeds the 95th percentile (CDC, 1998; Kuczmarski & National Center for Health, 2000).

Key ECLS-K Measures for Dissertation Analyses

| | | Questionnaire | K | 1 | 3 | 5 | 8 |
|---|---|---|---|---|---|---|---|
| Height/Weight | | C | x | x | x | x | x |
| School physical activity | | | | | | | |
| | Gymnasium/playground provision | F | | x | x | x | x |
| | PE/recess time | T | x | x | x | x | x |
| | Activity level | T/P | x | x | | x | x |
| School nutrition | | | | | | | |
| | Availability of competitive foods | A/C | | | | x | x |
| | Venue of availability | C | | | | x | x |
| | Competitive food consumption | C | | | | x | x |

[a] A=administrator, C=child assessment, F=facilities inspector, P=parent, T=teacher.

# Chapter 1: Facility Provision in Elementary Schools: Correlates with Physical Education, Recess and Obesity

## Introduction

Despite growing recognition of the role of physical activity in obesity prevention, recent estimates indicate that less than half of children meet national recommendations (Troiano et al. 2008). Physical education (PE) and recess programs at school could address this concern. As the built environment can shape physical activity patterns, the availability and adequacy of school facilities may be a critical component in obesity prevention (Davison et al. 2006; Sallis, 2006).

National recommendations regarding physical activity focus on the length and content of programs and many states have guidelines regarding physical activity facilities (CDC, 2008; Bogden, 2000; NASBE, 2001). In California, the Department of Education provides guidelines for the number and size of facility types per school depending on the school's enrollment and grade levels (California Department of Education, 2000); in North Carolina guidelines include recommended size, ventilation and temperature (North Carolina Department of Education, 2003). These guidelines are supported by studies suggesting that neighborhood recreational facilities are associated with higher activity levels among youth (Davison et al. 2006; Gordon-Larsen et al. 2006; Ferreira et al. 2007; Powell et al. 2007; Romero, 2005), although few studies have been conducted on the provision of facilities in schools themselves. A recent national assessment highlighted that 22.6% of schools did not have a gymnasium (Lee et al. 2007). While facility types were not specified, facility availability and equipment was associated with more physical activity opportunities in a sample of elementary schools (Barnett et al. 2006). Significant interactions between supervision and facility qualities such as area improvements and area type found in another study suggest that facility provision alone may not be supportive of higher physical activity (Sallis et al. 2001). A parallel and more developed literature in the education field has investigated how the provision of academic facilities contributes to academic achievement (Lemasters, 1996; Picus et al. 2005).

This study documents the state of physical activity facilities in US elementary schools and how it relates to child characteristics, school factors, PE and recess. We hypothesized that child and school disadvantage would be associated with worse facility provision which in turn would be associated with less time scheduled for PE and recess programs. In addition, we investigated if the latter relationship was more pronounced for schools with environmental constraints such as a climate that is not supportive of outdoor activity, or a lack of alternate facilities, such as an auditorium or multi-purpose room, that could support physical activity programs. As poor facilities may result in shorter and lower quality PE and recess, we also considered the relationship between facility provision and obesity trajectory between kindergarten and 5$^{th}$ grade.

## Measures

Key measures from the ECLS-K that were used for this analysis are described below (for more information on the ECLS-K, please refer to page 8).

*School facility measures:* The school administrator (principal or headmaster) assessed the availability and adequacy of the school gymnasium, playground, multi-purpose room, cafeteria, auditorium and classroom. The gymnasium and playground were primary facilities for physical activity programs. The playground was defined as an alternate facility for PE while the gymnasium was an alternate facility for recess. For each facility the administrator was asked: “in general, how adequate is the [facility] for meeting the needs of the children in your school?” Response options included ‘Do not have’, ‘never adequate’, ‘often not adequate’, ‘sometimes not adequate’ and ‘always adequate.’ As “do not have” and “always adequate” were the most common responses, the ‘never adequate’, ‘often not adequate’, and ‘sometimes not adequate’ responses were collapsed into a category referred to as ‘inadequate’ to preserve sample size. Two binary measures were constructed: 1) whether or not the school had the facility; and 2) whether or not the facility was adequate conditional on the school having the facility in question. The term ‘facility provision’ refers to both facility availability and adequacy.

*Physical education (PE) and recess time:* The child’s math and reading teachers reported the number of times PE and recess were held per week and the number of minutes per session. These numbers were multiplied by each other to obtain the minutes of PE and recess time in the past week. The average value was used if both teachers responded. Responses from teachers likely reflected scheduled times for PE and recess as opposed to the actual lengths of these programs.

*Childhood obesity measures:* Body-mass-index (BMI) was calculated from measured height and weight. ECLS-K trained assessors collected two measures each for height and weight using a Shorr Board (Shorr Productions, Olney, MD) and a digital bathroom scale. The age- and sex-specific BMI percentile for each child was calculated using a SAS program (SAS Institute, Inc., Cary, North Carolina) based on the updated 2000 Growth Charts (Kuzmarski, 2002; CDC 2000). Children with a BMI exceeding the 95$^{th}$ percentile were classified as obese and those with a BMI between the 85$^{th}$ and 95$^{th}$ percentiles were classified as overweight. Obesity trajectory was defined as the change in BMI percentile over time.

*School characteristics and other measures*: The percentage of free-or-reduced lunch (FRPL) students at the school and whether or not the school received Title I funds was reported by the school administrator. Schools where 50% or more of the student body was minority were considered to be high minority while schools with at least 500 children enrolled were considered to be high enrollment. The child's parent or guardian reported on how safe it was for the child to play outside the home. Household income and child race/ethnicity, school management type (private or public), Census geographic region (Northeast, Midwest, South and West), and degree of urbanization (regions which were large or mid-size cities were classified as urban, large or mid-sized suburbs and large towns were classified as suburban and small towns and rural areas were classified as rural) were also included in the analysis.

*Climate zone:* Each county in the United States is classified into one of six climate zones (refer to Figure 1.1) as defined by a report commissioned to assist builders in home construction (U.S. Department of Energy Building America Program, 2007). Climate zones are defined by heating degree days (the difference between the average outdoor temperature and the room temperature), average temperatures, and precipitation. The ‘cold’, ‘very cold’ and ‘subarctic’ zones were combined into the category ‘cold’, and the ‘hot-dry’ and ‘mixed dry’ zones were combined into the category ‘dry’.

Climate data were merged with ECLS-K using the school county identifiers. The final analytic sample included 8,392 5$^{th}$ graders in 1,387 schools across the country. 6,777 of these children attended the same school in kindergarten and 5$^{th}$ grade and had recorded weight and height in both years.

*Statistical Analyses*

Descriptive statistics and multivariate regression were used to analyze the correlates of facility provision, PE, recess and obesity trajectory. Analysis of variance (ANOVA) was used to test the statistical significance of differences in facility provision by child and school factors. Logistic models were estimated when facility provision was the dependent variable while linear models were estimated when PE or recess time was the dependent variable. Facility availability and adequacy were investigated separately. If facility provision was not determined to be a significant predictor for the full sample, the analyses were repeated for subgroups of schools with an environmental constraint. These constraints included urban location, having fewer than five alternate facilities and climate zone. Child-level regressions were clustered on schools and employed robust standard errors to adjust for the sampling design of ECLS-K. Sampling weights were applied to approximate the 5th grade population. Regression results were not reported if the sample had fewer than fifty observations.

## Results

### *Facility Provision by Child and School Characteristics*

Table 1.1 indicates that 67.9% of schools in the 5th grade sample had a gymnasium and that the figure was significantly lower for schools that were high enrollment, high minority, located in urban areas or had fewer than five alternate facilities ($P<0.05$). Most schools in cold and mixed-humid zones had a gymnasium as compared with 24.3% in dry climate zones and 11.1% in marine climate zones. Hispanic and Black children were less likely to have a gymnasium at school than White children (49.1% and 76.1% as compared to 82.0%). Children from low-income households and for whom it was unsafe to play outside were also less likely to attend a school with a gymnasium. No significant findings emerged for obesity or overweight status (overweight status not shown).

The gymnasium was reported to be adequate in 77.8% of schools. Differences by child and school characteristics were similar but less stark as compared with our findings regarding gymnasium availability. For example, high enrollment, high minority and urban schools were not more likely to have an inadequate gymnasium.

As only 2.5% of schools do not have a playground, only the correlates of having an adequate as compared to an inadequate playground are displayed in Table 1.1. Schools with a high fraction of minority children were more likely to report an inadequate playground. Children from low-income households or from racial/ethnic minorities were also less likely to have an adequate playground at school.

*Physical Activity Time by Facility Provision*

Schools provided an average of 77 minutes for PE class and 38 minutes for recess during the past week. Table 1.2 shows that schools with a gymnasium provided 8.3 more minutes of PE than schools without a gymnasium after controlling for other covariates ($P<0.01$). The association is stronger for schools in humid climate zones – gymnasium availability in hot-humid regions was associated an additional 17.4 minutes of PE while it was associated with 25.0 additional minutes of PE in mixed-humid regions. Gymnasium adequacy was not associated with significantly more PE time, nor was playground adequacy associated with more recess time.

Schools located in dry or hot-humid zones spent at least 25 more minutes in PE in the past week as compared to schools in cold zones. Schools that were high minority also reported 6.3 fewer minutes of PE class ($P<0.05$). Schools in rural regions reported 11.1 more minutes of recess as compared to urban regions while no differences by urbanization were found for PE ($P<0.001$). Schools that were high enrollment also devoted less time to recess. The number of alternate facilities was not associated with PE or recess time.

As the main effects for gymnasium and playground adequacy were not found to be significant, we investigated the significance of the effect for subgroups of schools with an environmental constraint. Environmental constraints included urban location, less than five alternate facilities and climate zone. Table 1.3 presents these results. Gymnasium adequacy was associated with more PE time in all of the considered subgroups, but none of them were statistically significant except for schools in an urban location. For these schools, gymnasium availability was associated with 10.3 more minutes of PE time ($P<0.05$). Playground adequacy was not associated with more recess time for several subgroups such as schools located in dry or hot-humid climate zones. None of the estimates however reach the statistical significance thresholds.

*Obesity Trajectory by Facility Provision*

The prevalence of obesity in the sample increased from 11.8% to 20.1% between kindergarten and $5^{th}$ grade and the average BMI percentile increase was 5.4 units. Gymnasium and playground provision in $5^{th}$ grade were not predictive of a lower obesity or overweight trajectory both overall and for stratifications separately by gender, obesity or overweight status in kindergarten, household poverty, region and climate zone (results not shown).

## Discussion

We find that 26.1% of children attended a school without a gymnasium which is comparable to figures reported elsewhere (Lee et al. 2007). Overall, 21.7% of children had an inadequate gymnasium at school while 37.3% had an inadequate playground at school. Our descriptive findings complement other studies indicating that neighborhoods with low-income and high-minority residents have less access to recreational facilities (Powell et al, 2006; Gordon-Larsen et al, 2006). While school facilities may represent a safe area to play for children in neighborhoods with safety concerns, we find that these children attend schools with worse facility provision.

Gymnasium availability was associated with 8.3 more minutes of PE time per week which represents 10.8% of the average time spent the sample spends in PE. The sample average of 77 minutes of PE per week falls drastically short of the recommended 150 minutes (CDC, 2008). The stronger association between gymnasium availability and PE time for schools in hot-humid and mixed-humid climate zones may be due to the survey being conducted in April. Although we are unable to test this hypothesis with this data, we would expect that the association would be stronger for schools in cold climates during the winter months. That schools in hot-humid and mixed-humid zones spend more time in PE and less in recess also supports weather being a determining factor in school physical activity programs.

While gymnasium and playground adequacy were not found to be related to PE and recess time for the overall sample, gymnasium adequacy was found to be associated with PE time for schools in urban locations. As space is at a higher premium for urban schools, adequacy may refer to the capacity of the facility in relation to class sizes. Statistically significant findings were not obtained for other environmental constraints as we had hypothesized.

Facility provision is not a significant predictor of obesity trajectory although gymnasium provision is associated with more PE time. As our measure of PE time is more likely to be scheduled as opposed to actual time, one possible explanation is that children do not engage in high levels of physical activity during PE class. While in theory facilities may shape the curriculum and quality of PE class, no information regarding how time is spent is collected in the survey.

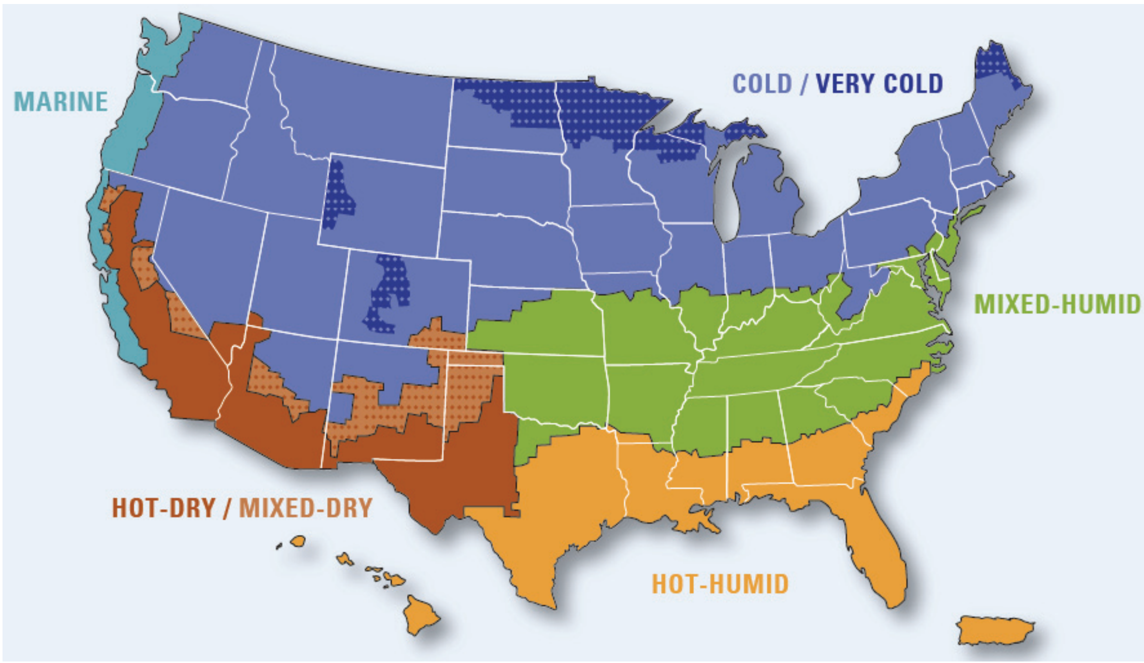
*Important Study Limitations:* School administrators were asked about physical activity programs in the previous week, not over the course of a year, and their responses were collected in the spring. Our measures of facility provision were reported by the school-administrator and not validated by an outside source. School administrators may have demonstrated a reluctance to report that facilities were inadequate or may have exaggerated their inadequacy in order to procure more funds for renovations. The latter bias may explain our findings that lower SES schools have worse facilities. Lastly, we are unable to determine if the schools provided after-school programs or had established community partnerships even though studies suggest that these might be important policies for increasing children's engagement in physical activity (CDC, 2008; Mota et al. 2003; Trost et al. 2008). After-school or weekend access to school gymnasiums and playgrounds may be particularly important for children from neighborhoods that lack green space or recreational facilities.

## Conclusions

We find difference in facility provision by sociodemographic characteristics, but it is unclear if they have a substantial impact on programs and health outcomes. Insights into how school facilities shape physical activity programs and child physical activity levels could support the development of appropriate recommendations and interventions.

Tables and Figure

FIGURE 1.1: Climate Zones Recognized by *Building America* [a]




Reproduced with permission from: *Building America Best Practices: Series for High-Performance Technologies: Determining Climate Regions*, December 200

TABLE 1.1: Gymnasium and Playground Provision by Child and School Characteristics [a]

| | Gymnasium Available | | | Gymnasium Adequate [b] | | | Playground Adequate [c] | | |
|---|---|---|---|---|---|---|---|---|---|
| | n | mean | 95% CI | n | mean | 95% CI | n | mean | 95% CI |
| Child Level | | | | | | | | | |
| Race/ethnicity | | | | | | | | | |
| White | 4,983 | 82.0 | (81.0, 83.1) | 4,056 | 80.2 | (78.9, 81.4) | 4,899 | 66.1 | (64.8, 67.4) |
| Black | 897 | 76.1 | (73.3, 78.9) | 693 | 74.5 | (71.3, 77.8) | 845 | 54.8 | (51.4, 58.2) |
| Hispanic | 1,450 | 49.1 | (46.5, 51.7) | 710 | 80.1 | (77.1, 83.0) | 1,405 | 58.7 | (56.2, 61.3) |
| Other [d] | 1,062 | 69.6 | (66.9, 72.4) | 619 | 67.1 | (63.4, 70.8) | 1,114 | 62.1 | (59.1, 65.1) |
| Household income (456 unknown) [e] | | | | | | | | | |
| $25,000 or less | 1,700 | 70.0 | (67.7, 72.1) | 1,146 | 76.0 | (73.5, 78.4) | 1,633 | 57.7 | (55.3, 60.1) |
| More than $25,000 | 6,236 | 76.0 | (74.9, 77.0) | 4,634 | 79.6 | (78.5, 80.8) | 6,101 | 64.5 | (63.3, 65.7) |
| Obesity status [f] | | | | | | | | | |
| Not obese | 6,679 | 73.8 | (72.8, 74.9) | 4,823 | 78.1 | (77.0, 79.3) | 6,518 | 62.6 | (61.5, 63.8) |
| Obese | 1,713 | 74.1 | (72.0, 76.2) | 1,255 | 79.2 | (76.9, 81.4) | 1,658 | 63.1 | (60.8, 65.4) |
| Safety around home (628 unknown) [g] | | | | | | | | | |
| Not safe or somewhat safe | 1,799 | 67.2 | (65.1, 69.4) | 1,140 | 74.3 | (71.8, 76.8) | 1,720 | 56.0 | (53.6, 58.3) |
| Very safe | 5,965 | 77.2 | (76.2, 78.3) | 4,529 | 80.0 | (78.9, 81.2) | 5,848 | 65.3 | (64.0, 66.5) |
| Overall | 8,392 | 73.9 | (73.0, 74.8) | 6,078 | 78.3 | (77.3, 79.4) | 8,176 | 62.7 | (61.7, 63.8) |
| School Level | | | | | | | | | |
| School enrollment | | | | | | | | | |
| <500 children | 776 | 75.5 | (72.5, 78.5) | 586 | 76.6 | (73.2, 80.1) | 758 | 60.4 | (56.9, 63.9) |
| >500 children | 611 | 58.3 | (54.3, 62.2) | 356 | 79.8 | (75.6, 84.0) | 595 | 61.3 | (57.4, 65.3) |
| Minority | | | | | | | | | |
| <50% | 789 | 78.1 | (75.2, 81.0) | 616 | 79.1 | (75.8, 82.3) | 779 | 65.6 | (62.3, 68.9) |
| >50% | 598 | 54.5 | (50.5, 58.5) | 326 | 75.4 | (70.8, 80.2) | 574 | 54.4 | (50.3, 58.4) |
| Number of Facility Alternates [h] | | | | | | | | | |
| Less than five | 1,161 | 65.9 | (63.2, 68.6) | 765 | 77.6 | (74.7, 80.6) | 1,176 | 59.7 | (56.9, 62.5) |
| Has five | 226 | 78.3 | (72.9, 83.7) | 177 | 78.5 | (72.4, 84.6) | 177 | 68.3 | (61.4, 75.3) |
| Degree of urbanization [i] | | | | | | | | | |
| Urban | 646 | 60.4 | (56.6, 64.2) | 390 | 78.7 | (74.6, 82.8) | 625 | 59.2 | (55.3, 63.1) |
| Suburban | 525 | 70.5 | (66.6, 74.4) | 370 | 78.6 | (74.5, 82.8) | 518 | 62.7 | 58.6, 66.9) |
| Rural | 216 | 84.3 | (79.4, 89.2) | 182 | 74.2 | (67.8, 80.6) | 210 | 61.0 | (54.3, 67.6) |
| Climate zone (29 unknown) [j] | | | | | | | | | |
| Cold | 515 | 88.3 | (85.6, 91.1) | 455 | 77.4 | (73.5, 81.2) | 500 | 61.0 | (56.7, 65.3) |
| Dry | 255 | 24.3 | (19.0, 29.6) | 62 | 66.1 | (54.0, 78.2) | 252 | 54.4 | (48.2, 60.6) |
| Hot-humid | 210 | 45.7 | (38.9, 52.5) | 96 | 84.4 | (77.0, 91.8) | 206 | 66.0 | (59.5, 72.5) |
| Marine | 36 | 11.1 | (0.3, 21.9) | 4 | -- | -- | 36 | -- | -- |
| Mixed-humid | 342 | 90.4 | (87.4, 93.5) | 309 | 79.3 | (74.7, 83.8) | 331 | 61.3 | (56.1, 66.6) |
| Overall | 1,387 | 67.9 | (65.5, 70.4) | 942 | 77.8 | (75.2, 80.5) | 1,353 | 60.8 | (58.2, 63.4) |

[a] All analyses are univariate. Values at the child level are weighted; values at the school level are not weighted.

[b] Conditional on the school having a gymnasium.

[c] Conditional on the school having a playground.

[d] Includes Native Hawaiians, Pacific Islanders, American Indians, Alaskan Natives and multirace non-Hispanics.

[e] Child lives in poverty if household income, based on parent report of household annual pre-tax income, is below 200% of the federal poverty threshold.

[f] A child is obese if the BMI exceeds the 95th age- and sex-specific BMI percentile.

[g] Reported by the child's parent or guardian.

[h] Facilities that could serve as a substitute for a gymnasium or playground. Includes multi-purpose room, cafeteria, classroom and bla. Playground is a substitute for a gymnasium and a gymnasium is a substitute for a playground.

[i] Rural refers to small towns, suburban refers to large and mid-size suburbs and large towns and urban refers to large and mid-size cities.

[j] Refer to Figure 1 for definition.

TABLE 1.2: Association between Facility Provision and Minutes of Physical Education and Recess Time per Week in 5th Grade [a]

| | Physical Education Time (min) | | | | | | Recess Time (min) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coeff | (SE) | | Coeff | (SE) | | Coeff | (SE) | |
| Facility Provision | | | | | | | | | |
| Gymnasium Available | 8.29 | (3.79) | ** | | | | | | |
| Gymnasium Available and Adequate | | | | 3.04 | (3.05) | | | | |
| Playground Available and Adequate | | | | | | | -1.41 | (1.85) | |
| Number of Alternates | -1.00 | (1.41) | | 1.9 | (1.53) | | -1.05 | (1.01) | |
| Climate Zone (Ref = Cold) [b] | | | | | | | | | |
| Dry | 36.50 | (5.95) | *** | 45.32 | (8.59) | *** | -1.46 | (2.92) | |
| Hot-Humid | 27.29 | (5.98) | *** | 44.10 | (5.72) | *** | -21.43 | (2.40) | *** |
| Marine | 9.16 | (7.50) | | 22.65 | (25.53) | | 2.13 | (5.76) | |
| Mixed-Humid | 30.57 | (10.19) | ** | 5.58 | (2.74) | * | -12.45 | (2.20) | *** |
| Interactions Between Facility Provision and Climate Zone [c] | | | | | | | | | |
| Dry*Gym Available | 8.92 | (9.97) | | -- | -- | | -- | -- | |
| Hot-Humid | 17.40 | (8.25) | * | -- | -- | | -- | -- | |
| Marine*Gym Available | 14.22 | (25.55) | | -- | -- | | -- | -- | |
| Mixed-Humid * Gym Available | 24.96 | (10.53) | * | -- | -- | | -- | -- | |
| School Characteristics | | | | | | | | | |
| High Enrollment [d] | 1.22 | (2.81) | | 1.74 | (2.82) | | -4.37 | (1.84) | * |
| Private | -2.24 | (3.19) | | 2.39 | (3.52) | | 0.06 | (3.27) | |
| Title 1 receipt | -0.72 | (2.47) | | -6.10 | (2.67) | | -0.18 | (2.16) | |
| High Minority [e] | -6.28 | (2.80) | ** | -4.35 | (3.02) | | -1.72 | (2.35) | |
| Urbanization (Ref = Urban) [f] | | | | | | | | | |
| Suburban | -2.19 | (2.89) | | -1.92 | (3.36) | | 1.41 | (2.09) | |
| Rural | 2.94 | (3.45) | | 5.39 | (3.49) | | 11.05 | (3.10) | *** |
| Constant | 62.87 | (6.57) | *** | 62.03 | (6.92) | *** | 57.00 | (5.04) | *** |
| Number of Schools, n | 1,358 | | | 926 | | | 1,325 | | |

[a] * p<0.05; ** p<0.01; *** p<0.001
[b] Refer to Figure 1 for definition.
[c] Interactions not included for models with gymnasium adequacy and playground adequacy as dependent variables because the main effects were not statistically significant.
[d] School has 500 or more students.
[e] School has 50% or higher minority students.
[f] Rural refers to small towns, suburban refers to large and mid-size suburbs and large towns and urban refers to large and mid-size cities.

TABLE 1.3: Association of Facility Adequacy with Physical Education and Recess Time for Schools with an Environmental Constraint [a, b, c]

| | PE time (min) Gymnasium Adequacy [c] | | | | Recess Time (min) Playground Adequacy [d] | | |
|---|---|---|---|---|---|---|---|
| | n | Coeff | (SE) | | n | Coeff | (SE) |
| Urban | 382 | 10.32 | (5.15) | * | 611 | 2.81 | (2.58) |
| <5 Alternates | 750 | 4.87 | (3.41) | | 1,149 | -1.97 | (2.01) |
| Climate Zone | | | | | | | |
| Cold | 455 | 2.43 | (3.29) | | 500 | -5.34 | (3.37) |
| Dry | 62 | 2.65 | (20.65) | | 252 | 5.54 | (4.29) |
| Hot-Humid | 96 | 7.84 | (16.90) | | 206 | -2.67 | (3.39) |
| Marine | 4 | -- | -- | | 36 | -- | -- |
| Mixed-Humid | 309 | 1.67 | (4.95) | | 331 | 1.93 | (3.33) |

[a] * p<0.05; ** p<0.01; *** p<0.001

[b] Other controls include enrollment, public, Title 1 funds receipt, % minority, census region, degree of urbanization and number of alternate facilities.
[c] Environmental constraints a school may have include urban location, having fewer than 5 alternate facilities, and climate zone location.
[d] Conditional on the school having a gymnasium.
[e] Conditional on the school having a playground.

# Chapter 2: The Role of School Physical Activity Programs in Childhood Body Mass Trajectory

## Introduction

Lack of physical activity is a risk factor for childhood obesity which affects almost one out of five children ages 6 to 11 (Ogden et al, 2008; IOM, 2005). According to a national-level study using accelerometer data, 42% of children met minimum recommended activity levels (Troiano et al, 2008). Those at greater risk for being inactive include girls, racial/ethnic minorities, and those living in neighborhoods with few public recreational facilities (CDC, 2006; Ferreira et al, 2007; Gordon-Larsen et al, 2006).

National recommendations highlight school physical activity programs as an intervention opportunity to mitigate obesity development among children. The National Association for Sport and Physical Education (NASPE) and the Institute of Medicine recommend 150 minutes of physical education (PE) instruction time per week for elementary schoolchildren (IOM, 2005; NASBE, 2000). One of the Healthy People 2010 objectives is for all schools to require students to attend PE classes everyday. In addition, the NASPE recommends 20 minutes of recess per day and the Centers for Disease Control and Prevention (CDC) supports time reserved for unstructured play during school hours (NASPE, 2006; CDC, 1997). Schools which meet these recommendations can help children achieve the recommended 60 minutes of physical activity daily (CDC, 2008).

This study investigates the role of PE and recess time in body mass development for a national sample of children progressing from 1$^{st}$ to 5$^{th}$ grades between 2000 and

2004 in the Early Childhood Longitudinal Study - Kindergarten Cohort (ECLS-K). We use growth curve models to estimate the likely impact of an additional hour per week of PE and recess as well as an expansion of existing programs to meet national recommendations.

Our study considers the effectiveness of PE programs as they are currently implemented. This is a different approach than most studies that have evaluated interventions to improve the quality of programs, such as Sports, Play and Active Recreation for Kids (SPARK) and Child and Adolescent Trial for Cardiovascular Health (CATCH).

## Measures

Key measures from the ECLS-K that were used for this analysis are described below (for more information on the ECLS-K, please refer to page 8). The main dependent variable for the analysis was body mass index (BMI) percentile. The main explanatory variables for the analysis were the weekly number of hours spent in PE class and recess in the past week and the number of school days for which PE and recess were held. Indicator variables noting if children engaged in the NASPE-recommended levels of PE and recess (150 minutes and 100 minutes per week respectively) as well as daily PE and recess were also tested as explanatory variables. Child demographics and school characteristics were included in regression models to control for confounding effects. These variables are described in more detail below.

*BMI Percentile.* BMI was calculated from measured height and weight from the direct child assessment and the age- and sex-specific height, weight and BMI percentile for each child was calculated using the SAS program (SAS Institute, Inc., Cary, North Carolina) developed by the Centers for Disease Control and Prevention (CDC) based on the updated 2000 Growth Charts (CDC, 2008; Kuczmarski, et al, 2002). Height and weight were measured by ECLS-K trained assessors using a Shorr Board (Shorr Productions, Olney, MD) and a digital bathroom scale (Seca Model 840, Hanover, MD). Two measurements of each were taken and the average was recorded as the composite weight or height. Those with a BMI percentile of 95 or higher were classified as obese (Kuczmarski, et al, 2002).

*Exposure to Physical Education (PE) and Recess.* In each wave of the data, the child's teacher was asked about the frequency of PE class and recess for the relevant child in the past week and the average length for each episode. Response options for PE class frequency include "never", "less than once a week", "1-2 times per week", "3-4 times per week" and "daily". Conditional on PE class being offered, the response options for class length included "1-15 minutes", "16-30 minutes", "31-60 minutes", and "more than 60 minutes". Regarding recess, the child's teacher was asked how many days the child had recess and class length response options included "1-15 minutes", "16-30 minutes", "31-45 minutes", and "more than 45 minutes". We constructed time exposure variables by multiplying the frequency per week (assumed to be the midpoint for each response option and 5 for the "daily" option) by the number of minutes per session (assumed to be the mid-point for each response option).

*Other Explanatory Variables.* Our models controlled for child and family sociodemographics, child risk behaviors and school characteristics. Child and family sociodemographics included age, gender, race/ethnicity, single-parent household, mother's education level (less than high school degree, high school graduate, some college, college degree or more) and household poverty status (below or above the federal poverty threshold). Child health behaviors included parent-reported hours of television watched in the previous week and participation in sports outside of school which include group sports, individual sports, recreational sports, dance, martial arts, playground activities and calisthenics. School characteristics included management type (private or public), total school enrollment (low enrollment is 0-499 students and high enrollment is 500 or more students), degree of urbanization (rural, suburban or urban), Census region and the percentage of minority students enrolled (0-25%, 25-50%, 50-75% or 75% or more) which were reported by the school administrator.

*Construction of the Analytic Sample*

Our analysis is limited to children with measures of BMI percentile in all waves, at least one measure of PE and recess and who did not switch schools during the time period. Those who switched schools were more likely to be male, overweight, Black, Hispanic or from a low-income household ($P<0.05$). Additional data cleaning to remove biologically implausible values resulted in an analytic sample of 8,246 children in 970 schools (see the Appendix for details on the construction of the analytic sample). The average number of children per school was 8 with a maximum of 28. Children from 40 states across the country were represented in the sample.[1]

Analysis

We used growth curve models (a method for longitudinal modeling within the broader class of hierarchical or multi-level models) to identify the effect of PE instruction time and recess time on child BMI trajectory (Snidhers and Bosker, 1999; deLeeuw and Meijer, 2008; Goldstein, 1995). Variation in the dependent variable of our analysis was decomposed into variation at the child-level and the school-level. The serial correlation of measurements within children and the clustering of children in schools were reflected in the intra-class correlation estimates from the empty model. Growth curve models have been applied in several analyses of health trajectories (Kahng et al, 2004; McLeod and Shanahan, 1996; Duncan et al, 2004), but not in this context before.

BMI percentile rather than BMI was chosen as the dependent variable because BMI percentile measures from multiple time points are directly comparable. An increase in the BMI percentile can be interpreted as excess weight while in increase in BMI may only reflect the natural growth curve of the child. The time and frequency of PE class and recess, the explanatory variables of interest, were introduced as fixed effects into the model. PE and recess time was tested in a separate model from the number of days PE and recess were held at school. Interaction terms between PE and recess time with age

[1] States not represented in the sample are Idaho, District of Columbia, Nevada, Arkansas, Montana, Nebraska, New Hampshire, Vermont, South Carolina and West Virginia.

were tested to determine if school programs attenuated the BMI percentile trajectory. Same-level interactions, for example between PE and recess time with school enrollment, and cross-level interactions, such as between PE and recess time with child race/ethnicity, were tested.

Residual unexplained variation was captured in the random intercept term of the models. A random slope on age at the child-level allowed for child-specific patterns in BMI percentile trajectory. We also considered random slopes on PE and recess time and frequency at the school-level that relaxed the assumption that programs were similarly effective across schools. The effect of PE and recess on BMI percentile trajectory may be heterogeneous due to variation in teacher quality, program content or facility provision.

Physical activity can prevent excess BMI gain, but this not a concern for children who are not overweight. For children who are not overweight, we could even expect the opposite to occur if physical activity increases lean body mass. After testing the impact of PE and recess on BMI percentile for the full sample, we also test the impact for sub-groups of children at the upper end of the distribution. More specifically, the groups considered were children whose BMI percentile in 1$^{st}$ grade was 90 or higher, 60 or higher or 30 or higher. If PE and recess were not found to be significant for the full sample, we conducted stratified analyses by gender.

Continuous fixed effect variables were centered separately for boys and girls to ease interpretation of coefficients in all models. This was done by subtracting the grand mean from each of the variables.[16] Hierarchical linear models were conducted in Stata 9.0 (StataCorp. 2005. *Stata Statistical Software: Release 9*. College Station, TX: StataCorp

LP) using the "xtmixed" package. Longitudinal sampling weights were applied for descriptive statistics. Maximization was conducted via the Newton-Raphson method and models were fitted using maximum likelihood. Error terms were assumed to have a Gaussian distribution. Final models were selected based on the deviance test.

Results

Table 2.1 provides descriptive statistics of the children and schools represented in the base year of the analysis. The sample included children from low-income households and racial/ethnic minorities as well as schools that were private or in rural locations. Table 2 indicates that the increase in obesity prevalence that occurred during the time period is concentrated between 1st and 3rd grades. The prevalence of obesity grew from 13.3% in 1st grade to 20.2% in 5th grade while average BMI percentile increased from 60.8 in 1st grade to 65.7 in 5th grade.

PE time increased slightly while recess time dropped substantially on average. The average 1st grader received 64.6 minutes of PE and 111.8 minutes of recess in the past week. 71.4% of children met the NASPE recommendation for recess (100 minutes per week) while only 6.6% met the recommendation for PE (150 minutes per week) in 1st grade. This changed to 54.2% and 12.4% respectively by 5th grade. For children who did not meet recommended levels in 1st grade, the average shortfall was 94.1 minutes of PE and 16.0 minutes of recess.

Trends in health behaviors that could potentially be confounding factors in body mass trajectory are also shown in Table 2.2. Parents reported that children watched about two hours of television per day. Participation in sports outside of school increased from 72.0% in 3rd grade to 76.3% in 5th grade.

A random slope on age improved the fit of the growth curve models, but random slopes on PE time, recess time, PE frequency and recess frequency at the school level did not. The intra-class correlation for BMI percentile measurements within children from the empty model for PE and recess time was 0.81, suggesting that measurements in later years were highly correlated with measurements in prior years. The corresponding intra-class correlation for children within schools was smaller but still substantial at 0.04. Similar intra-class correlation estimates were obtained from the model where days of PE and recess per week were the explanatory variables.

Table 2.3 presents the fixed effect estimates for the impact of PE and recess time on BMI percentile trajectory. The impact of an additional hour of PE and recess as well as meeting the NASPE recommended levels of recess and PE are shown. Results are presented for the full sample as well as for the models stratified by gender. Interactions between PE and recess with gender and age were not statistically significant and not included in final models.

Most coefficients presented in Table 2.3 are negative, but few are statistically significant. For children whose BMI percentile was 30 or less in 1st grade, most estimates were also negative (not shown). We find that an additional hour of recess for the full sample is associated with a 0.30 unit decrease in BMI percentile while meeting the NASPE recommended time for recess is associated with a 0.74 unit decrease ($P<0.05$). The magnitude of the recess time coefficient for children whose BMI exceeded the 30th percentile was greater than for children whose BMI exceeded the 90th percentile in 1st grade. An additional hour of recess was not significant in the stratified models although it approached statistical significance for boys (P=0.10). In contrast to recess, an additional hour of PE was not found to be a significant predictor of BMI percentile. Meeting the NASPE recommended level of PE however was associated with a decrease of 1.56 BMI percentile units among boys but not girls ($P<0.05$). The magnitude of the coefficient for PE was higher for children whose BMI exceeded the 30th percentile than for children whose BMI percentile exceeded the 90th percentile in 1st grade. The magnitude of the coefficients for PE were substantially higher for boys than girls overall, but a similar pattern for recess was not evident.

Similar models where the number of days that PE and recess offered at school served as the explanatory variables were tested. No significant findings were obtained for the full sample overall. Among boys, an additional day of PE at school led to a 0.39 unit decrease while daily PE was associated with a 1.63 unit decrease. These findings parallel those found for an additional hour of PE.

Figure 2.1 plots the predicted BMI percentiles based on the NASPE-recommended PE and recess time model which is presented in Table 3. Boys and girls who do not meet NASPE recommended levels have a higher predicted BMI percentile than those who do; however the difference is only statistically significant for boys.

## Discussion

Meeting the recommended levels of PE and recess at school can be effective in obesity prevention for elementary school children. However, only 6.6% of 1st grade children met the NASPE recommended level of PE with an average shortfall of 94.1 minutes in the 2003-2004 school year. 71.4% of 1st graders met the NASPE recommended level for recess with an average shortfall of 16.0 minutes. 10.2% of 1st graders attended PE on all school days as recommended by Healthy People 2010.

Obesity prevalence grew over the time period with the greatest increase occurring between 1st and 3rd grades. Our growth curve modeling analysis found that meeting the NASPE recommendation for recess time was associated with a decrease of 0.74 BMI percentile units while meeting the NASPE recommendation for PE time was associated with a decline of 1.56 BMI percentile units for boys. These decreases are substantial in consideration that the average increase in BMI percentile over the time period is 3.6 units overall and 4.7 for boys alone. That the impact of meeting the recommendations is substantially larger than an additional hour suggests that there may be a threshold effect such that health benefits do not accrue linearly from physical activity.

This analysis builds on an earlier study that found that an increase in PE between kindergarten and 1st grade had a protective effect for girls at risk for overweight but not for other children (Datar and Sturm, 2004). We do not find that this effect continues between 1st and 5th grade. We also explore gender differences in activity levels during school programs (Lopes, et al, 2006; Sarkin, et al, 1997). However, our results are not consistent with a prior study finding that boys and girls were similarly active in PE class (Sarkin, et al, 1997). Our findings contribute to the literature suggesting that opportunities for physical activity at school can be effective in stemming the development of obesity in children (Datar and Sturm, 2004; Luepker, et al, 1996; Sallis et al, 1993; Vandongen et al, 1995). In addition, they provide evidence of the effectiveness of the current national recommendations regarding school physical activity programs.

A main finding of our analysis is that meeting the recommended levels of recess is associated with a lower BMI percentile for children between 1$^{st}$ and 5$^{th}$ grade while PE is effective only for boys. Given the current low rates of meeting national recommendations particularly for PE, it is important to evaluate existing policies and consider how resources should be allocated to achieve better child health outcomes. Schools can counter this effect to some extent by providing PE and recess programs for children, which tends to become more important over time as activity levels generally decline with age (Gordon-Larsen et al, 2004; Kohl III and Hobbs, 1998).

# Tables and Figure

TABLE 2.1: Descriptive Characteristics of Children and Schools in 1st Grade [a]

| Children (n=8,246) | n | % | Schools (n=970) | n | % |
|---|---|---|---|---|---|
| Gender | | | Region[b] | | |
| Girls | 4,106 | 49.6 | Northeast | 170 | 17.5 |
| Boys | 4,131 | 50.4 | Midwest | 251 | 25.9 |
| Race/ethnicity | | | South | 313 | 32.3 |
| White | 5,026 | 61.2 | West | 236 | 24.3 |
| Black | 869 | 13.1 | Urbanization [c] | | |
| Hispanic | 1378 | 18.7 | Urban | 401 | 41.3 |
| Other [d] | 973 | 7.0 | Suburban | 344 | 35.5 |
| Mother's education | | | Rural | 220 | 22.7 |
| < High school | 754 | 10.5 | Unknown | 5 | 0.5 |
| High school diploma | 2,422 | 29.8 | Management type | | |
| Some college | 2,460 | 29.9 | Private | 198 | 20.4 |
| College degree or | 2,400 | 27.4 | Public | 772 | 79.6 |
| Unknown | 210 | 2.4 | Enrollment [f] | | |
| Poverty threshold [e] | | | High | 466 | 48.0 |
| Above | 7,255 | 87.6 | Low | 496 | 51.1 |
| Below | 884 | 11.3 | Unknown | 8 | 0.7 |
| Unknown | 107 | 1.1 | | | |

[a] Percentages are weighted.
[b] Census 2000 designations of geographic regions in the United States.
[c] Rural refers to small towns, suburban refers to large and mid-size suburbs and large towns and
[d] Includes Native Hawaiians, Pacific Islanders, American Indians, Alaskan Natives and multi-
[e] Household poverty status measure constructed by ECLS-K is based on parent report of
[f] High enrollment schools are those with at least 500 students.

TABLE 2.2: Trends for Body Mass, Physical Education, Recess and Health Behaviors between 1st and 5th Grades [a]

| | Grade 1 | | Grade 3 | | Grade 5 | |
|---|---|---|---|---|---|---|
| | % or Mean | (SD) | % or Mean | (SD) | % or Mean | (SD) |
| Body mass | | | | | | |
| BMI percentile [b] | 60.8 | (28.3) | 65.2 | (28.5) | 65.7 | (29.7) |
| Obese [c], % | 13.3 | | 18.2 | | 20.2 | |
| Physical education (PE) time | | | | | | |
| Minutes per week | 64.6 | (43.9) | 68.0 | (46.6) | 78.7 | (50.8) |
| Recommended level [d], % | 6.6 | | 8.4 | | 12.4 | |
| Average shortfall (min) [f] | 94.1 | | 93.4 | | 87.9 | |
| Days per week | 2.2 | (1.3) | 2.1 | (1.3) | 2.2 | (1.3) |
| Provided daily, % | 10.2 | | 9.1 | | 11.1 | |
| Recess time | | | | | | |
| Minutes per week | 112.8 | (61.0) | 106.1 | (60.4) | 88.3 | (55.7) |
| Recommended level [e], % | 71.4 | | 68.3 | | 54.2 | |
| Average shortfall (min) [f] | 16.0 | | 17.4 | | 26.7 | |
| Days per week | 4.6 | (1.2) | 4.5 | (1.4) | 4.3 | (1.5) |
| Provided daily, % | 77.8 | | 69.3 | | 71.8 | |
| Child health behaviors | | | | | | |
| TV hours per week | 13.6 | (8.5) | 13.2 | (8.8) | 14.7 | (8.6) |
| Outside school sports [g], % | -- | -- | 72.0 | | 76.3 | |

[a] All estimates are weighted. Differences across all three waves were significant at p<0.001.

[b] Age- and sex-specific BMI percentiles are obtained from the CDC Growth Charts using measured weight and height.
[c] A child is obese if the BMI exceeds the 95th age- and sex-specific BMI percentile.

[d] The National Association of Sport and Physical Education (NASPE) recommends 150 minutes per week of PE.

[e] The National Association of Sport and Physical Education (NASPE) recommends 100 minutes per week of recess.
[f] Among those who do not meet the recommended level.
[g] Includes group sports, individual sports, recreational sports, dance, martial arts, playground activities and calisthenics.

TABLE 2.3: Growth Curve Model Results for Children between 1st and 5th Grades with BMI Percentile as the Dependent Variable[a]

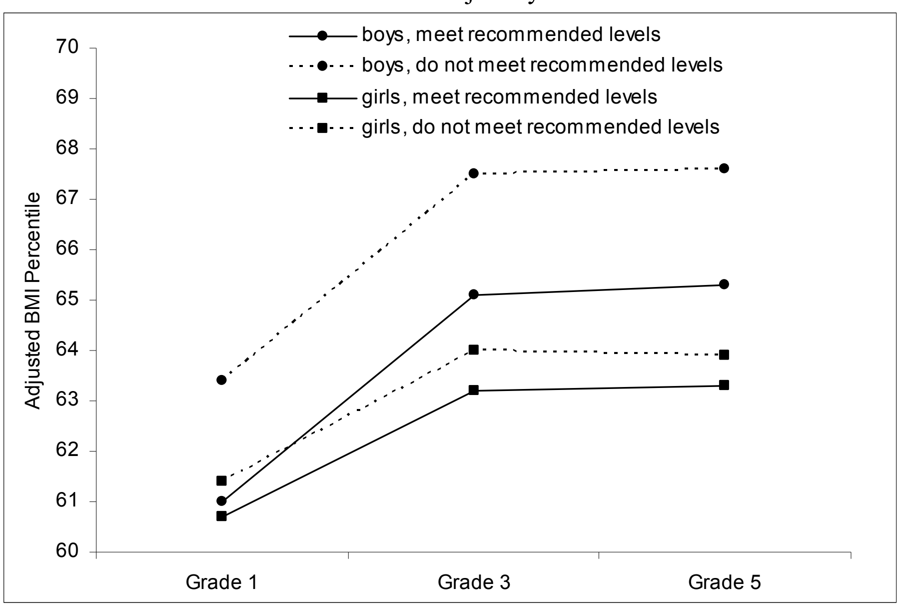
| | Boys | | | Girls | |
|---|---|---|---|---|---|
| | Coeff | (SE) | | Coeff | (SE) |
| Hours per week | | | | | |
| PE | -0.91 | (0.30) | ** | 0.01 | (0.31) |
| Recess | -0.35 | (0.21) | | -0.27 | (0.20) |
| NASBE recommended time [b] | | | | | |
| PE | -2.18 | (0.74) | ** | 0.07 | (0.74) |
| Recess | -0.73 | (0.42) | | -0.63 | (0.40) |
| Days held per week | | | | | |
| PE | -0.50 | (0.19) | ** | -0.04 | (0.83) |
| Recess | -0.21 | (0.17) | | -0.08 | (0.59) |
| Daily provision | | | | | |
| PE | -1.69 | (0.71) | * | 0.06 | (0.67) |
| Recess | -0.40 | (0.48) | | -0.32 | (0.06) |

[a] Model includes random intercepts and the child and school level. Child-level fixed effects include age, mother's education, race, hours of televisions watched and single parent household. School-level fixed effects include urbanization, percent minority, region and management type. Random slope on age.

[b] The National Association of Sports and Physical Education (NASPE) recommends 150 minutes per week of PE and 100 minutes per week of recess.

* p<0.05, ** p<0.001, *** p<0.0001.

FIGURE 2.1: Predicted BMI Percentile Trajectory from Models in Table 2.3



# Chapter 3: The Effect of Sugar-Sweetened Beverage Availability in Elementary Schools on Consumption

## Introduction

Schools play an important role in addressing childhood obesity. Because children spend a substantial amount of time at school, the school food environment occupies a central part in shaping eating behaviors (NAS, 2006; Alliance for a Healthier Generation, 2007). While the National School Breakfast and Lunch Programs are regulated, no similar federal standards exist for competitive foods (e.g. foods and beverages sold through a la carte lines, vending machines, school stores and school fund raisers). Competitive foods, typically high in calories and low in nutritional value, are widely available in schools (O'Toole et al, 2007; French et al, 2003). Revenue that the schools receive from competitive food contracts is used to fund programs such as food service operations and field trips (GAO, 2005).

The availability of competitive foods at schools is not a new issue in the policy debate, and legislation to regulate competitive foods has been proposed for decades. The United States Department of Agriculture (USDA) regulations were quite comprehensive until 1983 when, following a successful lawsuit by the National Soft Drink Association, they became limited to food service areas during meal hours (GAO, 2004). Guidelines and legislation to fill this gap have developed in private schools as well as at the school district- and state-level, though there remains substantial variation in policies and the timing of their institution across states (GAO, 2004; HPTS, 2007). For example, California became the first state to ban soft drinks in public elementary schools in October 2003 (CA SB 677, 2003) and Connecticut followed in 2006 (CT SB 373, 2006). Other states have updated nutrition standards for school food service meals and competitive foods, for example, Indiana (IN SB 111, 2006) which legislated that 50% of food choices in public schools meet certain nutritional guidelines. Finally, there have been recent efforts at the federal level to increase the nutritional value of foods offered in schools. In March 2007, Senator Tom Harkin of Iowa reintroduced the Child Nutrition and School Lunch Protection Act of 2007 (S 771), which would amend the Child Nutrition Act of 1966 by modifying “food of minimal nutritional value” to be in accord with current nutrition science.

Voluntary sales restrictions are another new development, such as the agreement reached between the Alliance for a Healthier Generation and the American Beverage Association; Cadbury Schweppes; Coca-Cola; and PepsiCo in May 2006. Among other prescriptions, the guidelines under the agreement stipulate that by the beginning of the 2009-2010 school year, no soft drinks will be available in public elementary schools during school hours (2). While this agreement removes the “push” from major beverage companies, the impact of the initiative depends on whether and how other parties, including independent distributors, contract operators, vending brokers, vending service companies, schools and school districts, support and adopt the guidelines.

While several local studies have reported associations between the availability of competitive foods and eating behaviors at school (Harnack, et al, 2000; Cullen et al, 2000; Cullen et al, 2004; Kubik et al, 2003), none have conducted a national scale evaluation or investigated the level of consumption of certain food items at school as compared to at home. Research has focused on middle and high schools where competitive foods are more available (Harnack, et al, 2000; Cullen et al, 2000; Cullen et al, 2004; Kubik et al, 2003) although policy changes in elementary schools may be more feasible to implement. The relationship between school availability of soft drinks and overall consumption of soft drinks is particularly important to assess in light of the possible link between soft drink intake and obesity (Ludwig et al, 2001; Vartanian et al, 2007; Malik et al, 2006). Low-income and racial/ethnic minority children are at a higher risk for poor diet and obesity (Miech et al, 2006; Drewnowski and Specter, 2004), but the absence of large representative samples until now has not permitted the study of how exposure to the school food environment and the ensuing effects on diet may vary within the population.

This paper provides nationally-representative data on predictors of soft drink consumption among elementary school children for the 2003-2004 school year. At the time the survey was conducted, no state-level restrictions on soft drink availability in schools had yet been introduced. Specifically this study investigates sociodemographic differences in how availability of soft drinks at elementary schools relates to consumption of soft drinks at school and overall. Findings based on this analysis can serve as a benchmark for future evaluations of the effects of school food environment changes on eating behaviors.

Methods

The sixth wave of the ECLS-K, which corresponds to 5th graders in the spring of the 2003-2004 school year, is used for the analysis (for more information on this survey, please refer to page 8). The 19-item Child Food Consumption Questionnaire was introduced in the sixth wave as part of the direct child assessment which was administered without the supervision of parents, teachers or school administrators. Questionnaire items were based on those from School Health Program and Policies Survey (SHPPS), the Youth Risk Behavior Surveillance Survey (YRBBS) and the California Children's Healthy Eating and Exercise Practices Survey (CalCHEEPS). Administrators are asked about soft drink availability at school, but not the consumption behavior of children. Parents are not asked about food item availability or consumption.

The sixth wave includes data on 11,420 children. Of these children, 526 do not respond to the Child Food Consumption Questionnaire and an additional 44 respond that they do not know, refuse to answer or are not ascertained due to being home-schooled. Non-respondents are slightly more likely to be male and Hispanic (P<0.01).

*Key Measures*

The consumption measures investigated in the analysis include *any* consumption of soft drink *at school* in the past week, *overall* consumption of soft drinks *at school* in the past week, consumption of *any* soft drink in the past week, *overall* consumption of soft drinks in the past week and share of all consumption in the past week which is school-based. Measures of school-based consumption are constructed from the question: "During the last week that you were in school, how many times did you buy soda pop, sports drinks or fruit drinks that are not 100% juice?" Possible responses are: "I did not buy any at school during the last week", "one or two times during the last week in school", "three or four times during the last week in school", "one time per day", two times per day", "three times per day", and "four or more times per day". Measures of overall consumption are based on the question: "During the past seven days, how many times did you drink soda pop, sports drinks or fruit drinks that are not 100% juice?" Possible responses are: "I did not drink any during the past seven days", "one to three times during the past seven days, four to six times during the past seven days", "one time per day", "two times per day", "three times per day", and "four or more times per day". The term "soft drink" in this study refers to "soda pop, sports drinks or fruit drinks that are not 100% juice". No distinction is made between diet and regular soft drinks in the direct child assessment and consumption measures are based on episodes rather than volume consumed.

Beverages purchased at school are assumed to be consumed at school and overall consumption is assumed to include school consumption. Continuous levels of consumption are derived by taking the value or midpoint for each of the response category and multiplying by five for school consumption and seven for overall consumption. The lower threshold of the highest response category is assumed.

The measure of soft drink availability, the independent variable of interest for this analysis, is based on the question in the child assessment: "Can students purchase either from vending machines, school store, canteen, snack bar or a la carte items from the cafeteria during school hours soda pop, sports drinks, or fruit drinks that are not 100% juice?" That child-reported availability is significantly higher than administrator-reported availability (37% versus 28%) may be due to administrators focusing on vending machines as the only source of soft drinks at school. When children report that they can purchase soft drinks at school and their school administrator disagrees, 18% of children respond that their purchases were made somewhere else in school. In contrast, if the child and school administrator agree that soft drinks are available at school, only 11% of children report purchasing soft drinks somewhere else in school. The difference between these percentages are statistically significant (P<0.01).

Children from the same school sometimes give conflicting responses regarding availability. One explanation could be that those who abstain from soft drinks may be less aware of soft drink availability at school. To circumvent this potential bias, an adjusted measure of school-level availability, which is defined as the majority response among children sampled from the school, is constructed. Two sensitivity measures of availability are also tested. The first sensitivity measure uses the school administrator-reported availability response if the share of children giving a positive response is greater than 30% and less than 70%, or in other words, has a 30% margin of error. The second sensitivity measure has a 40% margin of error. These are reasonable margins of error to consider as there are on average four to five children sampled from each school in the sample.

Child (from the parent interview) and school (from the school administrator interview) characteristics are also considered as covariates in the analysis. Child characteristics include race/ethnicity, gender, overweight status and whether or not the child's household lives below the federal poverty threshold as determined from reported pre-tax annual household income. A child is considered to be overweight if the age- and sex-specific body mass index (BMI) percentile exceeds 95% (CDC Clinical Growth Charts, 2000). BMI was constructed from composite measurements collected in the direct child assessment in each wave of data collection. ECLS trained assessors made two measurements each of height using a Shorr Board (Shorr Productions, Olney, MD) and weight using a digital bathroom scale. The average of the two measurements was recorded as the composite weight or height. School characteristics include whether the school is public or private, the percentage of minority children enrolled, the percentage of free or reduced lunch (FRL) eligible children enrolled, urbanicity (urban, suburban or rural) and Census geographic region (Northeast, Midwest, South or West). The final analytic sample includes 10,215 children in 2,303 schools across 40 states.[2]

*Statistical Methods*

Descriptive statistics and multivariate regression are used to assess the association between the availability of soft drinks at school and consumption. Chi-square tests (for categorical variables) and t-tests (for continuous variables) are used to determine if estimates for a certain population are significantly different from the overall population. When any consumption is the dependent variable, a logistic model is estimated. When the level of overall consumption is the dependent variable, a linear model is estimated. Availability at school is the explanatory variable for both models. Interactions between race/ethnicity, household poverty status and Census region are tested. The regressions cluster on schools and apply robust standard errors to account for correlated residuals of children sampled from the same schools. Analyses use sampling weights from the ECLS-K and are repeated using the two sensitivity measures of availability to verify the robustness of the results. All statistical estimations are conducted with Stata software

[2] States not represented in the sample are Idaho, District of Columbia, Nevada, Arkansas, Montana, Nebraska, New Hampshire, Vermont, South Carolina and West Virginia.

(release 9.0, 2005, StataCorp LP, College Station, TX). As the analysis is based on secondary data, this study is exempt by the Institutional Review Board.

## Results

Almost 40% of elementary schools offered soft drinks in spring 2004 (879 out of 2,303 schools), the primary venue being vending machines (771 out of 879 schools). Characteristics of children and the schools they attend can be found in Table 3.1. While the majority in the sample is White non-Hispanic, attends public school and has a household income above the poverty line, the sample does include a significant number of minorities and children who attend schools in rural areas. 20.3% of children in the full sample are overweight which is comparable to a national estimate of 18.8% among 6-11 year olds in 2004 (Ogden et al, 2006).

There is little variation in the characteristics of children and schools attended by whether soft drinks are available at school. Fewer schools located in the West have soft drinks available (16% in the West versus 39% overall) and Hispanics in the sample disproportionately reside in the West (43% of residents in the West are Hispanic as opposed to 19% nationally).

The levels of consumption at school and overall can be compared for children who have soft drinks available at school. Out of 4,015 children reporting the availability of soft drinks at school, Table 3.2 shows that about one out of four children report positive school-based consumption in the past week -- 19% report one to two episodes, and the remainder report higher levels. Black non-Hispanic and low-income children are significantly more likely to consume soft drinks at school conditional on availability (P<0.01). Children attending schools located in the South are more likely to consume soft drinks at school (P<0.001). Overweight children are not more likely to purchase soft drinks.

Conditional on any school-based consumption, children consume on average 2.4 soft drinks per school week. A consistent pattern between level of school-based consumption and any consumption is not evident. Low-income children are more likely to consume soft drinks at school and consume significantly more soft drinks at school conditional on any consumption. Black non-Hispanic children are also more likely to consume soft drinks at school, however, the amount they consume is not significantly higher.

For the 26% of children who consume soft drinks at school given that soft drinks are available, school-based soft drink consumption amounts to approximately half of overall consumption on average. No significant differences are evident across the sociodemographic characteristics considered except for Asians. Asians consume significantly less at school and overall, but the share of consumption at school is significantly higher at 54% as compared to 48% overall (P<0.05). If school-based consumption is high, overall consumption also tends to be high.

Considering reports of overall consumption among 5$^{th}$ grade children, 15% do not consume any soft drink, 38% consume one to three soft drinks, 17% consume four to six soft drinks and 7% consume 4 drinks per day or more in the past week. Only ten children report the maximum level for both school-based and overall consumption. Table 3.3 compares the likelihood of any consumption by availability at school using the full sample. Those with soft drinks available at school are significantly more likely to report any soft drink consumption. The difference is 5% for children on average. This effect is evident across all sociodemographic groups and is particularly pronounced for children attending private schools (10%, $P<0.01$), who are Black non-Hispanic (11%, $P<0.05$) and who attend a school with a high concentration of minorities (7%, $P<0.01$). Given that soft drinks are available at school, average total consumption for those abstaining from soft drinks at school is 6.0 as compared to 8.5 for those who consume at school. However, no consistent pattern across sociodemographic characteristics is evident for overall consumption.

Multivariate logistic regression is conducted to test the significance of availability and covariates in the consumption of any soft drink in the past week. Interactions between race/ethnicity, household poverty status and Census region, as well as the concentration of minority or eligible FRL children in the school attended, are not statistically significant ($P>0.05$). Results from the final model in Table 3.4 show that school availability remains a significant predictor of soft drink consumption net of child and school characteristics (OR=1.38, $P<0.01$). Males are more likely, while low-income and Asian children are less likely, to consume soft drinks regardless of school availability. No significant relationship between availability and overall consumption is found.

As the logistic model is non-linear, the effect of availability on consumption, or the marginal effect of availability, is specific to each child. By computing the marginal effect for each child in the sample and the average for the sample, the average marginal effect of availability is estimated to be 4%. Thus the availability of soft drinks at school is associated with a 4% increase in the share of all children who consume any soft drink in the past week. The average marginal effect varies by sub-group. For Black non-Hispanics the marginal effect is 6%, while for White non-Hispanics and Hispanics, it is 3%. The average marginal effect for females is 5% as compared to 3% for males.

## Discussion

Policy efforts to limit the availability of soft drinks at school have potential to reduce consumption of soft drinks among elementary school children. This reduction will affect not only consumption of soft drinks in schools, but overall intake as well. When soft drinks are available at school, 26% of children consume at least one soft drink over the course of a week and their level of school-based consumption accounts for about half of total consumption. Black non-Hispanic and low-income children have a greater likelihood of consuming conditional on availability. Furthermore, those consuming a high level of soft drinks at school, such as low-income children and children attending rural schools, are more likely to consume a high level of soft drinks overall. Using the full sample, soft drink availability is associated with a 5% lower rate of any soft drink consumption in the past week. Controlling for child and school characteristics, the pull-out of soft drinks from schools is estimated to decrease the rate of any soft drink consumption by 4% and result in no significant effect for overall soft drink consumption.

It is unclear why the marginal effect of availability varies by child sociodemographics. Possible explanations may be the eating behaviors of parents, residential food environment, friends or exposure to food advertising on television

(Grimm et al, 2004). Several studies indicate that there may exist disparities along sociodemographic lines regarding these contextual factors (Yancey and Kumanyika, 2007; Morrill and Chinn, 2004).

For the 85% of children who report positive soft drink consumption in the past week, average overall soft drink consumption is 7.5 or about one soft drink per day. To put this figure in context, a study found that an additional serving of non-diet soft drink per day increased adolescent BMI by 0.24 $kg/m^2$ over 19 months (Ludwig et al, 2001). As such, even a modest increase in daily soft drink consumption could contribute to the development of obesity over the course of adolescence.

A broader question raised by this investigation is how limiting availability may alter eating behaviors over time. The cross-sectional data can only support descriptive interpretation, but this would be an interesting avenue for further research. If soft drinks are no longer are available at schools, children may instead purchase them from food retail outlets close to school. One study found a high concentration of fast-food restaurants in close proximity to schools in Chicago suggesting that substitution could likely occur if soft drink availability were curtailed in schools (Austin et al, 2005). Another possibility is that children may desire soft drinks less as fewer members of their peers are consuming them due to limited availability (Grimm et al, 2004). The effects on overall beverage intake are also not clear. Several studies have found that children who consumed high levels of soft drinks consumed less milk and fruit juice (Cullen and Zakeri, 2004; Harnack et al, 1999). However the inverse need not be true if healthier beverages are not made available to children and children are not encouraged to consume them.

The study has several limitations. Beverage purchase and consumption data is self-reported by children and is therefore subject to memory recall bias (Domel et al, 1994). However, all children are subject to this possible bias and the survey instrument has been determined to be reliable (Domel et al, 1994; Domel, 1997). In addition, the ECLS-K does not include information on the volume or type of soft drink consumed. The assumption that servings represent a consistent unit of measurement for each child and across children is made for the analysis. While one study found that high schools offering soft drinks were somewhat different from those not offering soft drinks, little difference was found for elementary schools in the ECLS-K (Probart , 2006).

Caution must be taken in extrapolating findings from this analysis, which are based on elementary school students, to middle and high school students. Children in elementary school often have less free time, less pocket money and more teacher oversight regarding when and where they can go during school hours. As such, older children are more likely to be affected by competitive foods at school.

## Conclusions

While competitive food sales restrictions at school are an important step in decreasing the consumption of unhealthy foods, attention should also be granted to other approaches for limiting availability or attenuating the relationship between availability and consumption. Greater reductions in children's consumption of soft drinks will require policy changes that go beyond food availability at school if we aim to significantly reduce children's consumption of soft drinks. Such policies may include zoning regulations on food outlet types in residential or school areas and promotion of healthier substitutes such as milk and fruit juices. Creating an environment that promotes healthy food options can serve to improve diets among American children.

## Tables

TABLE 3.1: Characteristics of Children and Schools Attended in the Sample [a]

| | n | % | | n | % |
|---|---|---|---|---|---|
| Child Characteristics | | | School Characteristics [e] | | |
| Race/Ethnicity | | | Soft drinks | | |
| White non-Hispanic | 5,993 | 59 | Available | 4,015 | 39 |
| Black non-Hispanic | 1,529 | 15 | Not available | 6,200 | 61 |
| Hispanic | 1,937 | 19 | Management type | | |
| Asian | 279 | 3 | Private | 1,148 | 11 |
| Other [b] | 477 | 4 | Public | 9,067 | 89 |
| Household income [c] | | | FRL eligible, % [f] | | |
| Below poverty threshold | 2,193 | 21 | 0-49% | 6,247 | 61 |
| Above poverty threshold | 8,022 | 79 | 50-100% | 3,968 | 39 |
| Body mass index [d] | | | Percentage minority | | |
| Overweight | 2,075 | 20 | 0-49% | 6,633 | 65 |
| Not overweight | 8,140 | 80 | 50-100% | 3,582 | 35 |
| | | | Urbanicity [g] | | |
| | | | Rural | 2,194 | 22 |
| | | | Suburban | 4,167 | 43 |
| | | | Urban | 3,442 | 35 |
| | | | Region [h] | | |
| | | | Northeast | 1,838 | 18 |
| | | | Midwest | 2,410 | 24 |
| | | | South | 3,689 | 36 |
| | | | West | 2,278 | 22 |

[a] Values are weighted.

[b] Includes Native Hawaiians, Pacific Islanders, American Indians, Alaskan Natives and multirace non-Hispanics.

[c] Household poverty status measure constructed by ECLS-K is based on parent report of household annual pre-tax income.

[d] Children whose age- and sex-specific BMI percentile exceeds 95% are classified as overweight.

[e] These estimates do not reflect the characteristics of the schools themselves in the sample as some children attend the same school.

[f] The percentage of children who are eligible for free or reduced lunch (FRL).

[g] Rural refers to small towns, suburban refers to large and mid-size suburbs and large towns and urban refers to large and mid-size cities.

[h] Region refers to the Census 2000 designations of geographic regions in the United States.

TABLE 3.2: Soft Drink Consumption in the Past Week for Children with Soft Drinks Available at School [a]

| | Share that consume at least one soft drink at school, % (n=4,015) [i] | Conditional on any consumption at school (n=963) [j]: Consumption level at school | Overall consumption level | Share of overall consumption which is school-based, % |
|---|---|---|---|---|
| Child Characteristics | | | | |
| Race/Ethnicity | | | | |
| White non-Hispanic | 23*** | 2.4 | 8.5 | 49 |
| Black non-Hispanic | 39*** | 2.5** | 8.8* | 49 |
| Hispanic | 29 | 2.1 | 6.9 | 50 |
| Asian | 18 | 2.3 | 7.6 | 54* |
| Other [b] | 22 | 3.1 | 13.3 | 36 |
| Gender | | | | |
| Female | 28 | 2.2 | 8.4** | 49 |
| Male | 25 | 2.6 | 8.6** | 47 |
| Household income [c] | | | | |
| Below poverty threshold | 31** | 2.7** | 10.5** | 44 |
| Above poverty threshold | 25** | 2.3** | 7.8** | 50 |
| Body mass index [d] | | | | |
| Overweight | 27 | 2.5* | 7.9 | 49 |
| Not overweight | 26 | 2.4* | 8.7 | 48 |
| School Characteristics [e] | | | | |
| Management type | | | | |
| Private | 30* | 2.2 | 6.2* | 54 |
| Public | 26* | 2.5 | 8.9* | 48 |
| Percentage FRL eligible [f] | | | | |
| <50% | 22*** | 2.5 | 9.0 | 48 |
| 51-100% | 33*** | 2.4 | 8.0 | 49 |
| Percentage minority | | | | |
| <50% | 24*** | 2.5* | 8.7 | 49 |
| 51-100% | 30*** | 2.4* | 8.3 | 47 |
| Urbanicity [g] | | | | |
| Rural | 25*** | 2.6** | 10.1** | 44 |
| Suburban | 27 | 2.5 | 8.3 | 49 |
| Urban | 28** | 2.2* | 7.2 | 53 |
| Region [h] | | | | |
| Northeast | 18*** | 2.3 | 8.9 | 45 |
| Midwest | 20*** | 2.3 | 8.5 | 49 |
| South | 33*** | 2.6 | 9.1* | 48 |
| West | 25 | 2.2 | 6.4 | 51 |
| Overall | 26 | 2.4 | 8.5 | 48 |

[a] Values are weighted.

[b] Includes Native Hawaiians, Pacific Islanders, American Indians, Alaskan Natives and multirace non-Hispanics.

[c] Household poverty status measure constructed by ECLS-K is based on parent report of household annual pre-tax income.

[d] Children whose age- and sex-specific BMI percentile exceeds 95% are classified as overweight.

[e] These estimates do not reflect the characteristics of the schools themselves in the sample as some children attend the same school.

[f] The percentage of children who are eligible for free or reduced lunch (FRL).

[g] Rural refers to small towns, suburban refers to large and mid-size suburbs and large towns and urban refers to large and mid-size cities.

[h] Region refers to the Census 2000 designations of geographic regions in the United States.

[i] Chi-square tests are used to determine the statistical significance of estimates. If there are two sub-groups within a category, the test determines if the estimates for the two sub-groups are significantly different from each other. If there are more than two sub-groups within a category, the test compares the estimate for each sub-group with everyone else in the population.

[j] t-tests are used to determine the statistical significance of estimates. If there are two sub-groups within a category, the test determines if the estimates for the two sub-groups are significantly different from each other. If there are more than two sub-groups within a category, the test compares the estimate for each sub-group with everyone else in the population.

* P<0.05, **P<0.01, ***P<0.001.

TABLE 3.3: Percentage who Consume at Least One Soft Drink in the Past Week by Availability at School [a]

| | Not Available, % [A] (n=6,200) | Available, % [B] (n=4,015) | Difference, % [i] |
|---|---|---|---|
| Child Characteristics | | | |
| Race/Ethnicity | | | |
| White non-Hispanic | 85.5 | 88.2 | 3* |
| Black non-Hispanic | 79.5 | 88.6 | 11* |
| Latino | 81.1 | 86.3 | 6 |
| Asian | 72.5 | 82.2 | 13 |
| Other [b] | 83.3 | 82.6 | -1 |
| Gender | | | |
| Female | 81.1 | 85.4 | 5** |
| Male | 85.6 | 89.2 | 4 |
| Household income [c] | | | |
| Below poverty threshold | 78.3 | 87.3 | 11 |
| Above poverty threshold | 84.8 | 87.5 | 3*** |
| Body mass index [d] | | | |
| Overweight | 83.2 | 86.0 | 7 |
| Not overweight | 83.5 | 87.8 | 2** |
| School Characteristics [e] | | | |
| Management type | | | |
| Private | 79.8 | 87.7 | 10** |
| Public | 83.9 | 87.4 | 4** |
| Percentage FRL eligible [f] | | | |
| <50% | 85.8 | 87.4 | 2 |
| 51-100% | 79.5 | 87.5 | 8*** |
| Percentage minority | | | |
| <50% | 85.6 | 88.3 | 3* |
| 51-100% | 79.4 | 85.9 | 7** |
| Urbanicity [g] | | | |
| Rural | 84.9 | 88.4 | 4 |
| Suburban | 85.5 | 86.5 | 1* |
| Urban | 80.1 | 89.1 | 11** |
| Region [h] | | | |
| Northeast | 84.2 | 82.7 | -2 |
| Midwest | 85.4 | 88.5 | 4 |
| South | 84.7 | 88.8 | 5 |
| West | 79.5 | 87.2 | 10** |
| Overall | 83.4 | 87.4 | 5*** |

[a] Values are weighted.

[b] Includes Native Hawaiians, Pacific Islanders, American Indians, Alaskan Natives and multirace non-Hispanics.

[c] Household poverty status measure constructed by ECLS-K is based on parent report of household annual pre-tax income.

[d] Children whose age- and sex-specific BMI percentile exceeds 95% are classified as overweight.

[e] These estimates do not reflect the characteristics of the schools themselves in the sample as some children attend the same school.

[f] The percentage of children who are eligible for free or reduced lunch (FRL).

[g] Rural refers to small towns, suburban refers to large and mid-size suburbs and large towns and urban refers to large and mid-size cities.

[h] Region refers to the Census 2000 designations of geographic regions in the United States.

[i] Values are the mean value of [B] minus the mean value of [A] all divided by the mean value of [A]. T- tests are * P<0.05, **P<0.01, ***P<0.001.

TABLE 3.4: Association between Soft Drink Availability at School and Any Consumption in the Past Week [a]

| | OR [b] | 95% CI [c] |
|---|---|---|
| Soft drinks available at school | 1.38** | 1.11-1.70 |
| <u>Child Characteristics</u>[d] | | |
| Male | 1.36** | 1.10-1.67 |
| Black non-Hispanic | 0.98 | 0.68-1.41 |
| Hispanic | 0.95 | 0.69-1.31 |
| Asian | 0.58 | 0.39-0.87 |
| Other race | 0.81 | 0.50-1.32 |
| Overweight [e] | 0.94 | 0.74-1.19 |
| Below poverty threshold [f] | 0.75* | 0.57-0.99 |
| <u>School Characteristics</u> [g] | | |
| Private | 1.15 | 0.77-1.71 |
| Suburban | 1.04 | 0.79-1.36 |
| Rural | 1.08 | 0.80-1.46 |
| Midwest | 1.21 | 0.86-1.69 |
| South | 1.31 | 0.96-1.78 |
| West | 0.95 | 0.68-1.33 |

[a] Values are weighted.
[b] OR= odds ratio.
[c] CI = confidence interval.
[d] Comparison group is female, white, non-Hispanic, not overweight and above poverty threshold.
[e] Children whose age- and sex-specific BMI percentile exceeds 95% are classified as overweight.
[f] Household poverty status measure constructed by ECLS-K is based on parent report of household annual pre-tax income.
[g] Comparison group attends a public school in the urban Northeast.
* P<0.05. ** P<0.01, *** P<0.001.

# Chapter 4: The Impact of State Policies on the School Competitive Food Environment, Dietary Intake and Obesity

## Introduction

One of the most widely implemented policies targeting childhood obesity has been restrictions on competitive foods in schools. Competitive foods broadly encompass foods and beverages sold through a la carte lines, vending machines, stores, and fundraisers that are typically high in calories, low in nutritional value, and have historically faced minimal regulations (GAO 2004; O'Toole, Anderson et al. 2007). Policies to restrict competitive foods have been considered a promising approach for narrowing the energy gap, an estimated 110 to 165 kcal a day or the equivalent of a regular 12-oz soft drink, which underlies the growth in childhood obesity prevalence (Wang, Gortmaker et al. 2006).

Several landmark changes have occurred at the national level in recent years. First, schools participating in the National School Lunch and Breakfast Program were mandated to develop guidelines regarding competitive foods as part of their Wellness Policies starting in the 2006-2007 school year. Second, the Alliance for a Healthier Generation brokered a voluntary sales agreement with major food and beverage manufacturers in 2006. In regards to beverages, the agreement stipulated that only water, 100% juice and milk would be available for purchase in elementary and middle schools by the beginning of the 2009-2010 school year.

Policies have also been implemented at the state level. By August 2009, 27 states had set nutrient-based standards for competitive foods while 29 states had introduced measures to limit their availability (Trust for America's Health, 2009). These policies typically apply for elementary schools and extend in some cases with oftentimes less stringent provisions to middle and high schools (Simon and Fried 2007; Wootan, Johanson et al. 2007). The adoption of a standard by schools themselves may require additional hurdles such as having the requisite staff for monitoring and enforcement (McGraw, Sellers et al. 2000; Greves and Rivara 2006; IOM 2007). While disadvantaged schools may be less likely to have these resources, schools in California with a higher non-white population and located in an area of higher population density were more likely to adhere to the state's beverage standard (Samuels 2006; Samuels, Bullock et al. 2009). In the same study, school population characteristics were not associated with the adoption of California's nutrient standards (Samuels, Bullock et al. 2009). While two studies did not identify an impact of competitive food policies on obesity or overweight among middle and high school children, another found that the presence of vending machines was associated with a higher body mass for children attending middle schools (Datar and Nicosia 2009; Fox, Dodd et al. 2009; Terry-McElrath, O'Malley et al. 2009).

This study assesses how the competitive food environment has changed for a national cohort of children progressing from 5$^{th}$ grade in 2004 to 8$^{th}$ grade in 2007 and how this relates to competitive food consumption and child body mass over the time period. If state policies altered availability, I estimated the impact of state policies on consumption and body mass. The main factors underlying the change in the competitive food environment were hypothesized to be children switching from elementary to middle schools and the introduction of state policies. In addition, I investigated if children from disadvantaged backgrounds were differentially affected by existing school policies on competitive foods as well as the introduction of state policies. The conceptual framework for the analysis is described below. Descriptions of the data sources (Section 3), the statistical methods (Section 4) and the estimation strategies (Section 5) follow.

Conceptual Framework

The framework considers a sample of children who were assessed at two points in time. Children are indexed by *i*, schools are indexed by *s*, and the time point is indexed by *t*. A child's perception of the availability of a competitive food item type at school ($A_{it}^{f,r}$) is a function of the year of assessment ($T_t$), the state policies in effect ($P_{st}^{n,l}$), whether or not the child switched to a school with a different grade structure ($SW_i$), the child's sociodemographic profile ($X_{it}$), and the characteristics of the school attended by the child ($S_{st}$) according to the relationship below:

$$A_{it}^{f,r} = F(T_t,\ P_{st}^{n,l},\ SW_i,\ X_{it},\ S_{st}) \qquad (1)$$

Food item *f* refers to soft drinks, snacks or sweets while food item type *r* refers to low-fat or regular. While actual, physical availability is constant within a school, child-perceived availability may vary among children within the same school. For example, soft drinks may only be available for purchase after school hours when some children have already left the school property. $S_{st}$ includes variables such as enrollment as schools with higher enrollment may be more likely to offer competitive foods due to greater economies of scale.

State policies ( $P_{st}^{n,l}$ ) affecting a school include limits (*l*) and nutrient-based standards (*n*). A limit refers to time or place restrictions on availability. In elementary schools in Georgia for example, foods of minimal nutritional value (FMNVs)[3] cannot be sold on school premises from the beginning of the school day until the end of lunch period. In contrast, a standard dictates the nutritional content of food items sold in schools irrespective of sales venue. For example, in Alabama a serving must have less than 30 grams of carbohydrates, less than 360 mg of sodium and 10% or less of the recommended daily value of total fat. Bans on soft drinks are considered to be a beverage standard, a type of nutrient-based standard, even though they can be conceived as a limit instead. In general, state policies have sought to restrict the availability of discretionary calories derived from fat or sugar rather than promote nutrients that would support children in meeting the Dietary Guidelines for Americans such as iron and calcium (DHHS and USDA, 2005). The Institute of Medicine, however, has recommended that competitive foods include whole grains, fruits and vegetables (IOM 2007).

Although they take different approaches, both standards and limits can shape the competitive food environment in schools. A state limit would be expected to restrict the availability of all food items, while a state standard would be expected to decrease the availability of soft drinks and regular food items and increase the availability of low-fat

[3] The US Department of Agriculture (USDA) defines these to be foods that provide less than 5% of the dietary reference intake for eight nutrients: protein, vitamin A, vitamin C, niacin, riboflavin, thiamine, calcium and iron per serving. These foods typically include soft drinks, water ices and chewing gum. The National School Lunch and School Breakfast programs prohibit the sale of FMNVs during mealtime.

food items. A limit may in theory be as or more effective than a standard, but in practice standards have tended to be more stringent. Limits, however, may be easier for schools to adopt and enforce (Samuels, Bullock et al. 2009).

The change in a child's consumption of food item *g* between 5th and 8th grade ($\Delta C_i^{g,o}$) was modeled as the change in the availability of a competitive food item at school ($\Delta A_i^{f,r}$), changes in child health behaviors such as hours of television watched per week ($\Delta H_i$), and changes in school characteristics ($\Delta S_s$) over the same time period according to equation (2):

$$\Delta C_i^{g,o} = G(\Delta A_i^{f,r}, \Delta X_i, \Delta H_i, \Delta S_s) \quad (2)$$

The subscript *g* denotes the food item (soft drinks, regular snacks, low-fat snacks, regular sweets, low-fat sweets, milk and juice) while *o* notes if the consumption is school-based or overall. The set of items that can be classified under *f* can also be classified under *g*. As children may substitute soft drinks for milk or juice, I hypothesized that an increase in soft drink availability at school may result in a decrease in milk and juice consumption (Harnack, Stang et al. 1999; Nielson and Popkin 2004).

Child body mass and obesity ($BMI_i$) was similarly modeled to (2) with the key predictors being the changes in consumption for all competitive food item types at school or overall ($\Delta C_i^{g,o}$) instead of the change in availability:

$$\Delta BMI_i = H(\Delta C_i^{g,o}, \Delta X_i, \Delta H_i, \Delta S_s) \quad (3)$$

The framework delineated in equations (1), (2) and (3) relies on the assumption that policies mitigate child body mass growth through altering the availability of competitive foods which in turn alters their consumption. Health behaviors were assumed to affect body mass independently of policies. Other possible mechanisms through which policies may improve diet quality and reduce body mass were beyond the scope of this analysis. For example, children may alter their food purchase decisions in response to informational campaigns that accompany the introduction of a policy. If these campaigns also targeted parents and teachers, these individuals may also influence children's intake of competitive foods.

A concern with this framework is that availability may be endogenous in equation (2) and that consumption may be endogenous in equation (3). Children who have a greater propensity to consume competitive foods may be more perceptive of their availability at schools and schools located in areas where the consumption level is high may also be more likely to offer competitive foods. For example, soft drinks are more likely to be offered at schools located in the South where consumption levels are also above average (Fernandes 2008). In both of these cases, the impact of availability (and of state policies indirectly) on consumption would be overstated. Regarding equation (3), children with higher body mass may be of lower socioeconomic status, a recognized risk factor for having a poor diet (Darmon and Drewnowski 2008). The potential endogeneities of availability and consumption were addressed in the estimation using an instrumental variables approach. This is described in Section 4.

## Data

The analysis is based on the Early Childhood Longitudinal Survey (ECLS-K), which follows a nationally representative sample of students from kindergarten (1998-

1999 school year) through 8th grade (2006-2007 school year). The two time points considered were 5th grade and 8th grade. Key variables include the availability and consumption of competitive foods at school, and child body mass. Measures indicating if a state introduced a limit or a nutrient-based standard on competitive foods were constructed based on reports from several organizations. The data sources and the construction of the variables for the analysis are described below.

*The Early Childhood Longitudinal Survey*

The ECLS-K was administered in the spring of each wave and included a direct-assessment of the student, a telephone computer-assisted interview of the student's parent or guardian, and self-administered mail interviews of the student's teacher and school administrator. A multistage probability design was used to select the sample of students within schools for the base year of the sample.

The Child Food Questionnaire (CFQ), which includes questions regarding the availability and consumption of sweets, salty snacks, and soft drinks, was administered in the waves that corresponded to 5th and 8th grades. These food items broadly reflect the range in competitive foods available in schools. The CFQ is based on survey instruments from the School Health Program and Policies Survey, the Youth Risk Behavior Surveillance Survey, and the California Children's Healthy Eating and Exercise Practices Survey and was administered without the supervision of parents, teachers or school administrators. A parallel set of questions about the availability of soft drinks, sweets and snacks at school were included in the school administrator survey in the same waves that the CFQ was administered. Survey items for both the CFQ and the administrator survey were identical in both waves of data collection. All measures of the food environment are self-reported and subject to memory recall bias (Domel 1997).

*Food Availability, Consumption and Obesity Measures:* The survey items regarding food item availability in the FCQ are: "In your school, can kids buy soda pop, sports drinks, or fruit drinks that are not 100% fruit juice?", "In your school, can kids buy candy, ice cream, cookies, cakes, brownies or other sweets in the school?" and "In your school, can kids buy potato chips, corn chips (Fritos, Doritos), Cheetos, pretzels, popcorn, crackers or other salty snack foods at school?" The term "soft drink" refers to "soda pop, sports drinks or fruit drinks that are not 100% juice".

For children who report that an item is available, the following question was posed: "During the last week that you were in school, how many times did you buy [food item]?" Response options include: "I did not buy any at school during the last week", "one or two times during the last week in school", "three or four times during the last week", "one time per day", two times per day", "three times or four times per day", and "four or more times per day". While the FCQ does not distinguish between regular and low-fat snacks and sweets, the survey items in the school administrator questionnaire do. No distinction is made between diet and regular soft drinks in either the FCQ or administrator survey. An imputed measure of child-reported availability of snacks and sweets was constructed to incorporate the information provided by the administrators. This imputed measure uses the administrator's response regarding the type of snacks and sweets when the child provides a response. These measures were used for the availability of low-fat and regular snacks and sweets.

Continuous consumption levels were derived by taking the value or midpoint for each of the response categories and multiplying by five, the number of days in a typical school week. The overall consumption (both home and school) of soft drinks, juice and milk, which were also collected in the FCQ, were also assessed. Consumption was reported in servings and no information about serving size was provided. This is of concern as what could be considered a serving size by a child may have changed during the time period. For example, 20 ounce bottles have become more common relative to 12 ounce cans of soft drinks.

*Body mass measures:* Body mass index (BMI) was constructed from composite measurements collected in the direct child assessment in each wave of data collection. ECLS trained assessors made two measurements each of height using a Shorr Board (Shorr Productions, Olney, MD) and weight using a digital bathroom scale (Seca 840 model, Hanover, MD). The average of the two measurements was recorded as the composite weight or height. Age- and sex-specific BMI percentile was obtained using the CDC growth charts (CDC, 2000). A child was considered to be obese if the age- and sex-specific body mass index (BMI) percentile was 95 or higher and overweight/obese if it was 85 or higher.

*Switching Schools and School Structure:* The school identification codes provided by ECLS-K in every wave were used to determine if children switched schools between 5$^{th}$ and 8$^{th}$ grade. The structure of a school was determined by the lowest and highest grades in the school as reported by the school administrator. Schools in the sample were classified in one of five categories: elementary schools (e.g. kindergarten to 5th or 6th grade), middle schools (e.g. 5th to 8th grade), elementary-middle schools (e.g. kindergarten to 8th grade), middle-high schools (e.g. 5th to 12th grade) and elementary-middle-high schools (kindergarten to 12th grade). Children who switched to a school with the same structure as the origin school were not considered as having switched schools.

*Child and School Covariates:* Child covariates included in the analysis were race/ethnicity, household income, hours of television watched in the previous week and the number of days in the past week that the child spent at least 20 minutes in vigorous activity. The physical activity variable was reported by the parent in 5th grade and by the child in 8th grade. School characteristics included enrollment (0-299, 300-499, 500 or more), percent minority (less than 25%, 25-75%, 75% or more), Census geographic region, degree of urbanization (urban, suburban and rural), and management type (private or public). High enrollment schools were those with 500 or more enrollees and high minority schools were those where the percent minority was 75 or higher. Measures of health behaviors, which included hours of television watched per week and parent-reported activity level, were included in regression models where the dependent variable was consumption or body mass.

*State Policies regarding Competitive Foods*: Indicator variables that noted if a state had a limit or nutrient-based standard in place at the time the child was interviewed were constructed from several sources. The “F as in Fat” report published annually by the

Trust for America's Health, provided the basis for the measures. As these reports are published in August/September and children in the ECLS-K were assessed in the spring, a state could appear to have implemented a policy in the year in which the child was assessed, but after the interview took place. In cases for which more information was needed to identify the date of a policy's implementation and whether the policy applied to elementary schools, I referred to reports from the Institutes of Medicine, the School Nutrition Association and the Center for Science in the Public Interest.

While the Trust for America's Health annual assessments allow for comparability across states, they are an approximation. Most state nutrient-based standards addressed drinks, snacks and sweets separately rather than on competitive foods overall as the Trust for America's Health assessments may suggest. Earlier standards tended to focus on soft drinks while later standards were more likely to address all competitive foods.

Appendix 4.1 presents the assignments given to each state for April 2004 and April 2007, which correspond to the dates that the ECLS-K children were surveyed. The policy variables were merged with the ECLS-K using the state identification codes of the schools attended by the children.

*Construction of the Analytic Sample*

The 5$^{th}$ grade sample includes 11,820 children of which 9,609 who were followed up with in 8$^{th}$ grade. Children who dropped from the sample were more likely to be from racial/ethnic minorities ($p<0.01$). There were 489 children who lacked a school identification code in 5$^{th}$ or 8$^{th}$ grade, 1,570 children who were missing values for key covariates in the analysis, 1,265 children who were missing a report of soft drinks, low-fat snacks, regular snacks, low-fat sweets or regular sweets availability at school, and 412 children who were missing a BMI percentile measurement. The final analytic sample was comprised of 6,003 children from 47 states across the country.[4] These children attended 1,305 schools in 5$^{th}$ grade and 1,563 schools in 8$^{th}$ grade.

## Statistical Methods

The main analysis estimated equations (1), (2) and (3) separately. To investigate the potential endogeneity in equations (2) and (3), I considered an instrumental variables (IV) approach where state policies served as instruments. State policies were chosen as they represent a potential source of variation in availability that is exogenous to choices made or perceptions by the child or school. In order for this approach to provide consistent estimates, policies should be a significant predictor of availability in equation (1), which would be the first-stage equation. After controlling for child and school characteristics, the introduction of policies should also be uncorrelated with predictors of competitive food consumption and child body mass change between 2004 and 2007. If this condition known as the exclusion stage and the first-stage condition held, the IV approach would produce attenuated estimates. The estimations are described in more detail below. The implementation of the analysis is described in Section 6.

### *OLS Estimation*

[4] States not represented in the sample were Idaho, North Dakota, Montana and Arkansas.

As the availability measures were binary, a logistic model was used to estimate the contributions of child, school and state policy factors according to equation (1a) which is the empirical counterpart of equation (1):

$$\ln\left(\frac{A_{it}^{f}}{1-A_{it}^{f}}\right) = \beta_0 + \beta_1 T + \beta_2 P_{st}^{l} + \beta_3 P_{st}^{n} + \beta_4 SW_i + \beta_5 SW_i T_i + \beta_6 X_{it} + \beta_7 S_{st} + u_{ist} \qquad (1a)$$

Reports from the same child would be expected to be correlated across time as would reports from children within the same school. Changes in reported availability over time were assumed to stem from three factors: state and local policies, children switching schools and children aging into adolescents. Empirically this was captured by including indicator variables noting a state limit or standard, the year of assessment, and interactions between year of assessment with child switch status. The year of assessment variable captured the residual time trend, which would reflect competitive food policies implemented at the school or district level. These policies may be due to the industry agreement brokered by the Alliance for a Healthier Generation.

I hypothesized that $\beta_1$ would be negative for regular food items and positive for low-fat food items. The statistical significance and magnitude of $\beta_3$ were expected to exceed that of $\beta_2$ for all food items. $\beta_4$ would reflect systematic differences between children who switch and those who do not switch to a school with a different structure. In addition, $\beta_5$ was expected to be positive for all food types if most children switched from elementary to middle schools.

Interaction terms between the policy variables with race/ethnicity, household income and private school attendance were included to explore the hypothesis that implemented policies may not be evenly enforced across the population. While older children may have a greater awareness of competitive food availability at school, age cannot be included as a control as the ECLS-K is a longitudinal cohort study. Decreases in reported availability over time would be expected to understate actual availability while increases in reported availability over time would be expected to overstate actual availability.

A differences-in-differences approach that assumed a linear functional form was used to assess the relative contributions of availability to consumption and of consumption to child body mass between 5th and 8th grades. The empirical equation counterpart for equations (2) was:

$$\Delta C_i^{g,o} = \beta_0 + \sum_{r=1}^{2} \beta_r \Delta A_i^{f,r} + \beta_3 \Delta X_i + \beta_4 \Delta H_i + \beta_5 \Delta S_s + v_{is} \qquad (2a)$$

where $C_i^{g,1}$ referred to the school-based consumption of soft drinks, snacks and sweets in the past week and $C_i^{g,2}$ referred to the overall consumption of soft drinks, milk or juice in the past week. $\beta_1$ and $\beta_2$ in equation (2a) were estimated for regular and low-fat snacks and sweets. Only $\beta_1$ was estimated when the availability of soft drinks was the dependent variable as the type of soft drinks was not assessed in the ECLS-K. The reference case for $\beta_1$ and $\beta_2$ in equation (2a) were children for whom availability does not change between 5th and 8th grade. The differences-in-differences approach thus controls for the secular increase in consumption over the time period. In addition to levels of consumption, any school-based or overall consumption (the intensive margin), and the level of consumption given any consumption (the extensive margin) were also considered.

The empirical counterpart for equation 3 was:

$$\Delta \mathrm{BMI}_i = \beta_0 + \sum_{f=1}^{3} \beta_f \Delta C_i^{g,o} + \beta_4 \Delta \mathrm{X}_i + \beta_5 \Delta \mathrm{H}_i + \beta_6 \Delta \mathrm{S}_s + \mathrm{w}_{is} \qquad (3a)$$

where BMI was BMI percentile, obesity status or obesity/overweight status. Equation (3a) indicates that school-based consumption of all competitive food items were regressors in the prediction of child body mass rather than tested separately. As the overall consumption of snacks and sweets was not collected in the survey, a separate specification tested the relationship between overall soft drink consumption alone in body mass increase. The reference case for $\beta_1$ and $\beta_2$ in equation (3a) were children for whom consumption does not change between 5$^{th}$ and 8$^{th}$ grade. The estimation of $\beta_1$ and $\beta_2$ accounts for the increase in body mass over the time period that was independent of competitive food consumption.

As the identification in equations (2a) and (3a) was obtained from changes in predictors and outcomes, variables that did not vary over time such as child race/ethnicity dropped out from the estimation. School characteristics remained if children switched to a school by 8$^{th}$ grade which had different characteristics than the school attended in 5$^{th}$ grade. Interaction terms between the main predictor variable (availability or consumption) with gender, race/ethnicity and household income were also included to investigate differential effects. Consumption behaviors at school may mirror gender and racial/ethnic disparities evident in overall dietary intake (Munoz, Krebs-Smith et al. 1997; Harnack, Stang et al. 1999).

The OLS policy impact was obtained from the estimates for the impact of policies and the time trend on availability from equation (1), the impact of availability on consumption from equation (2) and the impact consumption on body mass from equation

(3). These would be $\frac{\partial A_{it}^{f,r}}{\partial P_{st}^{n,l}}$, $\frac{\partial \Delta C_{i}^{g,o}}{\partial \Delta A_{it}^{f,r}}$ and $\frac{\partial \Delta BMI_{i}}{\partial \Delta C_{i}^{g,o}}$ respectively. Policy impacts were only calculated if the underlying estimates were statistically significant. If both standards and limits were significant predictors of availability, they were assumed to have an additive impact. The estimated policy impacts on school-based consumption and body mass where policies could be standards ($P_{st}^{n}$) or limits ($P_{st}^{l}$) were estimated as follows:

OLS policy impact on the consumption of food item *f* =

$$\sum_{r=1}^{2}\sum_{n,l}\left(\frac{\partial \Delta C_{i}^{g,o}}{\partial \Delta A_{i}^{f,r}}\right)\left(\frac{\partial A_{it}^{f,r}}{\partial P_{st}^{n}}\right) \tag{4}$$

OLS policy impact on body mass =

$$\sum_{f=1}^{3}\sum_{r=1}^{2}\sum_{n,l}\left(\frac{\partial \Delta BMI_{i}}{\partial \Delta C_{i}^{g,o}}\right)\left(\frac{\partial \Delta C_{i}^{g,o}}{\partial \Delta A_{i}^{f,r}}\right)\left(\frac{\partial A_{it}^{f,r}}{\partial P_{st}^{n}}\right) \tag{5}$$

Policy impacts were negative if they resulted in a decrease in consumption and positive if they resulted in an increase in consumption. The estimated policy impact for population sub-groups was calculated using the main effect if the relevant interaction term for the sub-group was not statistically significant.

*Instrumental Variables (IV) Approach*

The instrumental variables approach used predicted availability and consumption instead of reported availability and consumption in estimating equations (2a) and (3a). Predicted availability A* was obtained from estimating equation (1a) and used instead of reported availability in equation (2a). Similarly, predicted consumption C* was obtained from estimating equation (2a) and was used instead of reported consumption in equation (3a).

While the exclusion condition cannot be explicitly confirmed, I tested the likelihood that it holds by estimating the association of state policy implementation between 2004 and 2007 with baseline consumption or body mass. As a previous study hypothesized that state factors such as socioeconomic status and resources devoted to education may be related to policy implementation, I also tested the inclusion of a set of state-level controls (Cawley, Meyerhoefer et al. 2007). These controls included adult obesity prevalence, per-capita income, percent of the population with at least a college degree, average pupil to teacher ratio and average teacher salary.

The IV policy impacts were estimated according to the following equations and compared with the OLS policy impacts:

IV policy impact on the consumption of food item *g* =

$$\sum_{r=1}^{2}\sum_{n,l}\left(\frac{\partial \Delta C*_{i}^{g,o}}{\partial \Delta A*_{i}^{f,r}}\right)\left(\frac{\partial A*_{i}^{f,r}}{\partial P_{st}^{n}}\right) \qquad (4a)$$

IV policy impact on body mass =

$$\sum_{f=1}^{3}\sum_{r=1}^{2}\sum_{n,l}\left(\frac{\partial \Delta BMI_{i}}{\partial \Delta C*_{i}^{g,o}}\right)\left(\frac{\partial \Delta C*_{i}^{g,o}}{\partial \Delta A*_{i}^{f,r}}\right)\left(\frac{\partial A_{it}^{f,r}}{\partial P_{st}^{n}}\right) \qquad (5a)$$

For soft drinks, there could be a maximum of two instruments while for sweets and snacks there could be a maximum of four each (two types of policies and two types of food items).

<u>Estimation Strategies</u>

All analyses were conducted using Stata software (release 9.0, 2005, StataCorp LP, College Station, TX). Equation (1a) was estimated using a multi-level logistic model where availability, a binary measure, was a function of both child and school level factors. The GLLAMM add-in program was used to implement a three-level model with random intercepts at the child and school level, which was specified with a log-link and binomial distribution of residuals. Child characteristics, school factors and state policies were introduced as fixed effects. Residual unexplained variation was captured in the random intercept terms. Maximization was conducted via the Newton-Raphson method and models were fitted using maximum likelihood. Error terms were assumed to have a Gaussian distribution.

To assess the nesting of observations within children and for children within schools, I estimated two types of intra-class correlations. First, the intra-class correlation of reports regarding competitive food availability from children within the school was estimated for each wave of the survey. Second, the intra-class correlations of availability reported by the same child over time and of availability reported by children within the same school were estimated simultaneously for children who did not switch schools between 5$^{th}$ and 8$^{th}$ grades.

Predicted availability, based on both the fixed and random effects, was obtained from the multi-level models using the "glappred linpred" command. These values were used for the IV analysis. The predicted availability for each level of an explanatory variable while holding all other explanatory variables at their mean value was estimated using "gllapred mu". A marginal effect could be calculated as the difference in predicted availability between two levels of an explanatory variable. For example, the marginal effect of a state nutrient-based standard would be the difference between predicted availability when the standard variable was 0 and predicted availability when the standard variable was 1. The coefficients obtained through this simulation were compared to the marginal effects estimated with a multi-level linear estimation using “xtmixed”. Results from the linear and logistic modeling approaches were expected to be comparable. A uni-level logistic model for equation (1a) was also estimated to compare with the multi-level findings.

Linear differences-in-differences models for the estimation of equations (2a) and (3a) were implemented using child fixed effects. The “xtreg” package was used for the estimation of all differences-in-differences models as the changes in consumption and body mass were approximately normal. In the case of binary measures such as obesity status that served as a dependent variable for equation (3a), the change in obesity status could be -1, 0 or 1 with the majority of observations being 0. An ordered logit model was used to test the robustness of all findings from the OLS estimation of equation (2a) and when obesity and obesity/overweight status were dependent variables for equation (3a). The use of the categorical response categories for consumption instead of the continuous constructed measure was also tested in the estimation of equation (3a).

Longitudinal sampling weights were applied for descriptive statistics and different model specifications were compared with the log-likelihood, AIC criterion and BIC criterion. The IV results served to test the robustness of the OLS estimation results.

## Results

### *Descriptive Findings*

Table 4.1 presents descriptive characteristics of the sample in $5^{th}$ and $8^{th}$ grades. About 30% of the sample was Black or Hispanic, and about one out of every four or five children came from a low-income household. Hours of television watched increase substantially between the two time points – children watched an average of 15.5 hours of television per week in 5th grade as compared with 23.6 hours per week in 8th grade. Over the same time period, the average number of days per week that children engaged in at least 20 minutes of mid-vigorous physical activity increased by about a day.

About 80% of the sample switched to a school with a different structure between 5th and 8th grades. The majority of these children attended elementary schools in 5th grade and middle schools in 8th grade. Almost all of the children who did not switch schools attended elementary-middle schools in both years and almost all of elementary-middle-high schools were private schools. Average school enrollment increased over time as did the fraction of children attending high-minority schools. About a third of the sample resided in the South, which is where the introduction of state policies was concentrated (see Appendix A). Children attending rural or private schools were also represented in the sample.

Table 4.2 presents trends for the key measures of the analysis. Limits were the most common state policy in 2004 while standards became as common by 2007. The fraction of children who resided in a state where a nutrient-based standard was introduced increased from 15.3% in 2004 to 46.1% in 2007. Overall, 40.9% of the sample resided in a state with a standard or a limit in 2004 as compared with 61.6% in 2007.

The availability of all food items increased substantially between 5th and 8th grade. For example, 40.1% of the sample reported soft drinks at school in 5th grade as compared with 63.3% in 8th grade. The availability of low-fat snacks and sweets increased more relative to regular snacks and sweets. In addition, the likelihood of food item consumption conditional on availability grew over time. For example, the chances that a child consumed a soft drink at school more than doubled from 12.2% to 24.6% while a similar magnitude of increase occurred for snacks (from 16.5% to 29.4%). No significant changes in the level of school-based soft drink consumption over time conditional on availability were detected, while overall soft drink consumption decreased from 6.3 to 5.7 servings ($P<0.05$). Irrespective of availability, the average number of servings a child had at school increased from 1.5 to 2.5 per week ($P<0.05$). In addition, no significant changes in BMI percentile or high body mass detected. While the distribution of BMI percentile was skewed left in both of the surveys, the change in BMI percentile was approximately normal in distribution.

The implementation of standards but not limits was associated with higher soft drink consumption and BMI percentile in 5$^{th}$ grade. After taking child and school factors into account, standards were associated with 0.82 more servings of soft drinks and BMI percentile that was on average 2.6 units higher ($P<0.01$). The inclusion of the state-level controls reduced the magnitude of these associations, but they remained statistically significant (results not shown).

*Predictors of Competitive Food Availability*

Table 4.3 presents child- and school-level predictors of competitive food availability. The introduction of a state standard was associated with lower availability of soft drinks (0.54 versus 0.41, $p<0.001$), regular snacks (0.35 versus 0.15, $P<0.001$) and regular sweets (0.43 versus 0.29, $P<0.001$). State standards had the greatest impact on the availability of regular snacks. State limits appear to complement the effect of standards for regular snacks (0.30 versus 0.27, P<0.05), but the magnitude of the impact was weaker. Limits were also associated with a small increase in the availability of low-fat snacks (0.42 to 0.47, P<0.001) and low-fat sweets (0.38 to 0.42, P<0.05). A substantial level of variation over time cannot be explained by state policies. This is especially true in regards to low-fat snacks (0.38 versus 0.48, P<0.001) and sweets (0.31 versus 0.46, P<0.001).

Relative to children who attended the same school over the time period, children who switched schools reported lower availability of all food items in 5$^{th}$ grade and higher availability of all food items in 8$^{th}$ grade. For example, the reported availability of soft drinks was 0.67 for children who attended the same school in both years. For children who switched schools, reported availability increased from 0.44 to 0.75 (P<0.001).

Racial/ethnic differences were found in regards to the availability of snacks and sweets at school, but not soft drinks. Hispanics were 6-10% less likely to have any type of snacks or sweets at school relative to Whites, while Blacks were 5-8% more likely to have sweets of any type (P<0.05). Children in rural and high minority schools reported lower availability of sweets and snacks (P<0.001). Greater availability of all food items except soft drinks was reported in high enrollment schools (750 enrollees or more). Private schools were less likely to offer competitive foods, though the magnitude of the difference varied by food item type.

Table 4.4 presents the estimates for the interaction terms for state policies with race/ethnicity, household income and private school attendance. Children who attended private schools in states where standards and limits were in place were more likely to report that soft drinks were available (P<0.001). This differential impact for private schools was also found in regards to limits for low-fat snacks and standards for regular snacks and both types of sweets. Hispanic children who attended schools in states with a standard or a limit were more likely to have regular snacks at school (P<0.01). Black children who attended schools in states with a policy tended to have greater availability of low-fat snacks and lower availability of sweets at school (P<0.05). Low-income children attending schools in states affected by a limit were also more likely to report low-fat sweets being available (P<0.05).

A substantial level of clustering at the school and child levels was found in these models. Within the $5^{th}$ grade sample, the intra-class correlation of reports from children within the same school ranged from 0.48 to 0.87. This suggests that more than half of the total variation in availability reported by children can be explained by school-level factors. The correlations decreased slightly when school characteristics were added to the model. Estimates of the intra-class correlations for children who did not switch schools suggest that child-level factors accounted for a much smaller fraction of the variation in availability reports. Child-level factors accounted for 8% of total variation for soft drinks and 2-4% of total variation for sweets and snacks (results not shown).

*Impact of Soft Drink Availability on Consumption and Body Mass Increase*

Table 4.5 presents differences-in-differences estimates for the relationships between soft drink availability, soft drink consumption and body mass between $5^{th}$ and $8^{th}$ grades. Soft drink availability was reported to be the same in both years for 48% of the sample, to have increased for 38% of the sample, and to have decreased for the remainder. I found that soft drink availability at school was associated with an increase of 0.52 soft drinks consumed per week, or about one soft drink every two weeks (P<0.001). A standard reduced availability by 0.13 (equals 0.41-0.54, see Table 2a) and was estimated to reduce the increase of 0.52 units by 0.04 units. In contrast, the corresponding IV estimate of 0.19 servings, was about half of the OLS estimate (P<0.001).

Black children consumed almost four times as many soft drinks when they were available (2.03 = 0.52+1.51) versus 0.52, P<0.001). Children who were Hispanic, male or from a low-income household also consumed more soft drinks at school conditional on availability, but to a lesser degree than was exhibited by Black children (P<0.01). As a consequence, the policy impact of a nutrition standard was greater for these sub-groups. The IV estimates were significant for all of these sub-groups except for children from low-income households. In addition to soft drink availability, an increase in the hours of television watched between 5$^{th}$ and 8$^{th}$ grade was also associated with higher school-based soft drink consumption. The statistical significance of all findings were confirmed with the ordered logit model except for the interaction with gender.

Soft drink availability was not found to be predictive of higher overall consumption for the full sample. Moreover, it was not predictive of the intensive or extensive margin of overall soft drink consumption (results not shown). The main effect for both the OLS and IV approaches were negative, while only the main effect for the IV approach was statistically significant (P<0.001). When the model was stratified by degree of urbanization, the coefficient for availability was positive and statistically insignificant for urban and suburban children, but negative and statistically insignificant for rural children (results not shown).

Several interactions were significant in the OLS analysis, but were attenuated and statistically insignificant in the IV analysis. For example, soft drink availability at school led to a 1.01 increase in servings for low-income children and a 0.45 serving decrease for Hispanics (P<0.05). Thus, state policies were estimated to increase overall consumption of soft drinks by 0.17 servings for low-income children while increasing overall consumption for Hispanics by 0.07 units, but these results were not confirmed in the IV analysis. Other covariates of an increase in overall soft drink consumption include hours of television watched and the number of days the child engaged in mid-vigorous physical activity (P<0.05).

Table 4.5 also shows that the change in overall soft drink consumption between 5$^{th}$ and 8$^{th}$ grade was not associated with a change in BMI percentile. No significant findings were obtained when change in obesity status or obesity/overweight status was the dependent variable. The lack of statistical significance was also confirmed with the ordered logit estimation and the categorical consumption of soft drink consumption. One statistically significant result was obtained for boys, for whom an additional soft drink per week was associated with an increase of 0.14 BMI percentile units (P<0.05). A substantially larger impact was found with the IV approach (coeff = 3.07, P<0.001). Using this result, state standards were estimated to have increased BMI percentile by 0.20 units for boys. The analysis using the categorical measure of consumption suggested that the relationship between consumption and BMI percentile was concentrated for boys who consumed soft drinks “2 times a day” relative to those who consumed “none”. More hours of television watched was associated with a 0.93 BMI percentile unit increase between 5$^{th}$ and 8$^{th}$ grades (P<0.01).

*Impact of Snack and Sweets Availability on Consumption*

Table 4.6 presents the estimates for the impacts of snacks availability on school-based consumption. The availability of regular snacks was the same in both waves for 65% of the sample while 19% reported them in 8th grade but not in 5th grade. Similarly, the availability of low-fat snacks was reported to be the same in both waves of the survey for 52% of the sample while an increase was reported for 42% of the sample. The differences-in-differences estimation found that the availability of low-fat and regular snacks was associated with 0.37 and 0.18 servings respectively per week ($P<0.001$). As both standards and limits affected the availability of regular snacks (Table 2a), both estimates were used to estimate the policy impact. In contrast, only the estimate for limits was used to estimate the policy impact on low-fat snack consumption. The main effect for low-fat snacks availability corresponded to a policy impact of a 0.02 serving increase while the main effect for regular snacks availability corresponded to a policy impact of a 0.04 serving decrease. Similar to the findings for soft drinks, the IV main estimates were statistically significant but attenuated.

Differences by child race/ethnicity, gender and household income were not found with the IV approach. However, some differential effects emerged with the OLS approach. The statistical significance of these findings was for the most part confirmed with the ordered logit analysis. Boys consumed more low-fat snacks when they were available, while low-income children consumed more regular snacks, but not low-fat snacks, when they were available ($P<0.05$). Based on these figures, we estimated that the introduction of state policies decreased regular snack consumption by 0.13 servings while maintaining low-fat snack consumption at the same level among low-income children.

About 60% of children did not report a change in the availability of regular sweets while 27% reported them to be available in 8th grade but not in 5th grade. In regards to low-fat sweets, 57% of children reported them to have the same availability in both years while 36% reported an increase. Table 4.7 shows that the availability of low-fat sweets at school was not associated with consumption, although the ordered logit analysis found a positive association ($P<0.001$). The availability of regular sweets was associated with 0.59 servings per week on average and was confirmed with the ordered logit estimation ($P<0.001$). The impact of a standard was estimated to reduce regular sweets consumption by 0.08 servings. The corresponding policy impact for regular sweets using the IV approach was a reduction of 0.04 servings per week ($P<0.001$).

Blacks and males did consume low-fat sweets when available, although the effect for boys was not significant with the IV approach. Limits increased the availability of low-fat sweets for all children, but especially so for Black children (Tables 4.3 and 4.4). As such, the policy impact on Blacks was estimated to be 0.02 servings while it was only 0.01 servings for boys. Television and physical activity were not found to be predictive of school-based snacks or sweets consumption.

*Substitution Effects between Soft Drinks, Juice and Milk*

Table 4.8 shows the estimated impact of soft drink availability at school on the overall consumption of juice and milk. The main effects for the OLS estimation were not significant, nor were the coefficients from the ordered logit analysis. However, a negative impact on overall milk consumption was found using the IV approach. Soft drink availability at school was associated with a decrease of 0.67 servings of milk per week and the effect was mitigated among boys. More hours of television watched and physical activity per week were predictive of juice consumption, but not milk consumption ($P<0.01$).

*Impact of School-Based Consumption on BMI Percentile Increase*

School-based consumption of soft drinks, sweets and snacks was not predictive of BMI percentile increase for the full sample (Table 4.9). This was confirmed with a repeat of the analysis using the categorical construction of the consumption variables. While none of the interactions were significant with the OLS approach, an additional serving of snacks per week was associated with a decrease of 5.9 BMI percentile units between 5$^{th}$ and 8$^{th}$ grade among boys ($P<0.001$). In the ordered logit analysis, an additional serving of snacks was not found to be associated with obesity status, but it was predictive of obesity/overweight status (result not shown). The analysis suggests that state policies affecting the availability of snacks can account for an increase of 0.14 BMI percentile units for boys (result not shown).[5]

Discussion

The impact of state policies on the availability of competitive foods in schools generally supports the intention of the policies although standards, not limits, would have

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[5] This figure is calculated from estimates in Tables 2a and 4. Referring to equation (7), the portion due to low-fat snacks is 5.89*[(0.37)(0.471-0.42)] and the portion due to regular snacks is 5.89*[(0.18)(0.151-0.35+0.27-0.30)].

been expected to result in the increased availability of low-fat food items. The magnitude of the effects may increase over time as enforcement mechanisms develop and existing contracts expire (Trust for America's Health; IOM, 2007). Private schools were less likely to adhere to state standards and differential enforcement of policies by child race/ethnicity may be due to district policies that diverge from state policies (Samuels, Bullock et al. 2009). The increase in competitive food availability between 5$^{th}$ and 8$^{th}$ grade was largely due to children switching from elementary to middle schools. This is consistent with studies which have found that competitive foods are more widespread in middle schools relative to elementary schools (Everett Jones, Brener et al. 2003; Masse, Frosh et al. 2007; O'Toole, Anderson et al. 2007; Finkelstein 2008).

State policies decrease availability while switching schools results in an increase in availability. That the body mass distribution for the sample does not change significantly between 2004 and 2007 may be due to these factors canceling each other out. My differences-in-differences analysis, which finds that soft drink availability at school is not predictive of overall soft drink consumption, supports a different story of substitution that is consistent with a prior study (Fernandes 2008). Children may purchase soft drinks, snacks or sweets on the way to and from schools from venues such as corner stores (Borradaile, Sherman et al. 2009). Despite policy endogeneity being a concern, the IV analysis attenuated the estimates in most cases.

The relationship between school availability and overall consumption may differ for snacks, where the probability of consumption at school, given that the item is available for purchase, is much higher. Policies that restrict availability may also be ineffective in reducing overall consumption for older children who consume more competitive foods, but who also have a greater ability to substitute purchases outside of school. The null findings for body mass gain are also consistent with prior studies (Datar and Nicosia 2009; Fox, Dodd et al. 2009; Terry-McElrath, O'Malley et al. 2009).

State policies as currently implemented may have had the unintended consequence of increasing choice of competitive foods rather than limiting options. Furthermore, while low-fat snacks and sweets may have fewer discretionary calories than regular snacks and sweets, they may not necessarily be nutritious. Policies mandating that competitive food items contribute to the recommended daily allowance for specific nutrients (rather than limiting sugar, fat or sodium content), or school programs that teach children about how to make informed decisions about food purchases, may prove to be more effective in altering children's diet and body mass trajectory.

## Appendix

APPENDIX 4.1: State Competitive Food Limits and Standards in Place in April of 2004 and 2007 [a, b]

| State | Limit | | Standard | | State | Limit | | Standard | |
|---|---|---|---|---|---|---|---|---|---|
| | 2004 | 2007 | 2004 | 2007 | | 2004 | 2007 | 2004 | 2007 |
| Alabama [c] | | | | x | Montana* | | | | |
| Alaska | | | | | Nebraska | x | x | | |
| Arizona | | x | | x | Nevada | | | | x |
| Arkansas* | x | x | | x | New Hampshire | | | | |
| California | x | x | x | x | New Jersey | | | | |
| Colorado | x | x | | | New Mexico | | x | | x |
| Connecticut [d] | x | x | | x | New York [g] | x | x | | |
| Delaware | | | | | North Carolina [h] | | x | | |
| District of Columbia | | | | | North Dakota* | | | | |
| Florida | x | x | | | Ohio | | | | |
| Georgia | x | x | | | Oklahoma | | x | | x |
| Hawaii | x | x | x | x | Oregon | | | | |
| Idaho* | | | | | Pennsylvania | | | | |
| Illinois | x | x | | x | Rhode Island | | | | x |
| Indiana [e] | | x | | x | South Carolina | | | | x |
| Iowa | | | | | South Dakota | | | | |
| Kansas | | | | | Tennessee | | | | x |
| Kentucky | x | x | | x | Texas [i] | | x | x | x |
| Louisiana | x | x | | x | Utah | | | | |
| Maine | | x | | x | Vermont | | | | |
| Maryland | | x | | x | Virginia | | | | |
| Massachusetts | | | | | Washington | | | | |
| Michigan | | | | | West Virginia | | x | | x |
| Minnesota | | | | | Wisconsin | | | | |
| Mississippi | x | x | | | Wyoming | | | | |
| Missouri | | | | | | | | | |

[a] Information collected from Trust for America's Health. Additional information collected from the National Academy of Sciences, the School Nutrition Association and the Center for Science in the Public Interest was used to determine the date when a limit or standard was introduced for states that did not have a limit or standard in August 2006 but did in August 2007.

[b] A change from 0 in 2004 to 1 in 2007 indicates the implementation of a standard. A change from 0 to 0.5 indicates the introduction of a limit, and a change from 0.5 to 1 indicates the addition of a standard to existing limits.

[c] Restrictions on vending machines and snack food items went into effect for the 2006-2007 school year. Restrictions for school stores were introduced later on.

[d] Restrictions were introduced in the summer of 2006 and a standard was implemented in the following year

[e] 35% and 50% of food items must meet the standard by July 2006 and September 2007 respectively.

[g] Limits were introduced for sweets but not snacks

[h] Limits on snacks were introduced in the 2006-2007 school year and a broader standard was implemented in the 2007-2008 school year

[i] Texas introduced a nutrition standard in August 2004. The beverage portion was revised in the 2006-2007 school year to allow only water, milk and 100% juice

* Not represented in the analytic sample from the ECLS-K.

# Tables

TABLE 4.1: Availability, Consumption and Body Mass in 5th and 8th Grades [a]

| | 5th Grade | | 8th Grade | | |
|---|---|---|---|---|---|
| | n | % or mean | n | % or mean | |
| Availability | | | | | |
| Soft drinks | 6,924 | 40.0% | 6,924 | 62.9% | *** |
| Snacks [b] | | | | | |
| Low-Fat | 6,360 | 26.7% | 6,360 | 64.0% | *** |
| Regular | 6,360 | 29.3% | 6,360 | 32.5% | *** |
| Sweets [b] | | | | | |
| Low-Fat | 6,669 | 24.6% | 6,669 | 55.4% | *** |
| Regular | 6,669 | 33.8% | 6,669 | 49.1% | *** |
| Any Consumption [c] | | | | | |
| Soft drinks | 2,758 | 30.6% | 4,262 | 39.5% | *** |
| Snacks | 3,341 | 32.0% | 4,978 | 39.3% | *** |
| Sweets | 3,613 | 46.0% | 4,670 | 49.4% | *** |
| Consumption [d] | | | | | |
| Soft drinks | 6,924 | 0.4 | 6,887 | 0.8 | *** |
| Snacks | 6,924 | 0.5 | 6,893 | 0.8 | *** |
| Sweets | 6,924 | 0.7 | 6,888 | 0.9 | *** |
| Obesity [e] | | | | | |
| BMI Percentile | 6,449 | 66.4 | 6,449 | 67.4 | |
| Obese | 6,449 | 20.7% | 6,449 | 19.5% | *** |
| Overweight/Obese | 6,449 | 38.6% | 6,449 | 36.8% | *** |

[a] Percentages are weighted. The statistical significance of differences across waves
[b] The type of snack or sweet (low-fat or regular) is imputed from the school
[c] Probability of any consumption given that the item is available at school.
[d] School-based consumption conditional on availability at school.
[e] BMI percentile is age- and sex-specific. Obesity defined as BMI percentile greater
* p<0.05, ** p<0.01, *** p<0.001.

TABLE 4.2: Characteristics of Children by Whether or Not They Switched Schools between 5th and 8th Grades [a]

| | Attended the Same School in 5th and 8th Grades [b] | | Switched Schools Between 5th and 8th Grades: Origin School [f] | | | Destination School [g] | | |
|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | | n | % | |
| Child Characteristics | | | | | | | | |
| Race/ethnicity | | | | | | | | |
| White | 1,416 | 71.3 | 3,171 | 62.5 | *** | | | |
| Black | 158 | 11.6 | 438 | 12.8 | | | | |
| Hispanic | 232 | 10.7 | 829 | 18.4 | *** | | | |
| Other [c] | 181 | 6.4 | 499 | 6.3 | | | | |
| Household income | | | | | | | | |
| >=$25,000 | 1,743 | 86.0 | 3,887 | 74.0 | *** | 4,039 | 76.4 | ** |
| <$25,000 | 244 | 14.1 | 1,050 | 26.0 | *** | 898 | 23.7 | ** |
| School Characteristics | | | | | | | | |
| Structure [e] | | | | | | | | |
| E | -- | -- | 4,197 | 84.0 | | -- | -- | |
| EM | 1,380 | 60.3 | 327 | 4.4 | *** | 66 | 1.6 | *** |
| EMH | 113 | 7.2 | 113 | 2.0 | *** | -- | -- | |
| M | 464 | 30.4 | 34 | 0.6 | *** | 4,170 | 87.1 | *** |
| MH | 4 | 0.5 | -- | -- | | -- | -- | |
| Unknown | 26 | 1.7 | 266 | 9.0 | | 701 | 11.3 | |
| Management | | | | | | | | |
| Public | 965 | 61.4 | 4,503 | 95.3 | *** | 4,647 | 95.9 | |
| Private | 1,022 | 38.6 | 434 | 4.7 | *** | 290 | 4.1 | |
| Overall | 1,987 | | 4,937 | | | 4,937 | | |

[a] Percentages are weighted.
[b] Includes children who switch to schools which have the same structure as the origin school.
[c] Includes Native Hawaiians, Pacific Islanders, American Indians, Alaskan Natives and multi-race non-Hispanics.
[e] E=elementary school, EM= elementary-middle school, EMH= elementary-middle-high school, M=middle school and MH=middle-
[f] Statistical significance between children who switch schools and those who do not switch was tested using ANOVA for the 5th
[g] Statistical significance of origin school and destination school characteristics was tested using ANOVA.
* p<0.05, ** p<0.01, *** p<0.001.

TABLE 4.3: Marginal Effects of Child- and School-Level Predictors of Child-Reported Competitive Foods Availability in Schools a

| | Soft Drinks | | | Snacks [e] | | | | | | Sweets [e] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Low-Fat | | | Regular | | | Low-Fat | | | Regular | | |
| | Coeff | (SE) | | Coeff | (SE) | | Coeff | (SE) | | Coeff | (SE) | | Coeff | (SE) | |
| State standard [b] | -0.09 | (0.02) | *** | 0.00 | (0.02) | | -0.14 | (0.01) | *** | 0.00 | (0.02) | | -0.08 | (0.02) | *** |
| Standard*Black | 0.08 | (0.04) | | -0.03 | (0.04) | | -0.04 | (0.03) | | -0.06 | (0.04) | | -0.09 | (0.04) | * |
| Standard*Hispanic | 0.01 | (0.03) | | 0.05 | (0.03) | | 0.15 | (0.04) | *** | -0.04 | (0.03) | | 0.04 | (0.03) | |
| Standard*Other [c] | 0.03 | (0.03) | | -0.01 | (0.04) | | 0.07 | (0.04) | | 0.00 | (0.03) | | -0.01 | (0.04) | |
| Standard*Low income | -0.04 | (0.03) | | -0.16 | (0.15) | | -0.08 | (0.02) | | -0.03 | (0.03) | | -0.08 | (0.03) | |
| State limit [b] | 0.01 | (0.01) | | 0.05 | (0.01) | *** | 0.01 | (0.01) | *** | 0.05 | (0.01) | *** | 0.02 | (0.01) | |
| Limit*Black | -0.11 | (0.04) | * | 0.12 | (0.05) | | -0.01 | (0.03) | | 0.01 | (0.04) | | -0.01 | (0.05) | |
| Limit*Hispanic | -0.09 | (0.05) | | 0.03 | (0.05) | | 0.05 | (0.05) | | 0.00 | (0.04) | | 0.01 | (0.05) | |
| Limit*Other [c] | -0.05 | (0.06) | | -0.02 | (0.06) | | 0.02 | (0.06) | | 0.07 | (0.06) | | -0.08 | (0.06) | |
| Limit*Low income | -0.06 | (0.04) | | -0.02 | (0.04) | | -0.10 | (0.03) | * | 0.02 | (0.04) | | 0.00 | (0.04) | |

[a] GLLAMM model fitted with logit link and binomial distribution of residuals. Random intercepts at school and child levels.
[b] State policy (limit or standard) implemented at the time children were surveyed.
[c] Includes Native Hawaiians, Pacific Islanders, American Indians, Alaskan Natives and multi-race non-Hispanics.
[d] Child switches schools between 5th and 8th grades. Includes children who switch to schools which have the same structure as the origin school.
[e] The type of snack or sweet (low-fat or regular) is imputed from the school administrator responses
* p<0.05, ** p<0.01, *** p<0.001.

TABLE 4.4: Estimates for the Impact of Changes in Soft Drink Availability on Changes in Consumption and BMI Percentile [a]

| | School-Based Consumption | | | Estimated Policy Impact [b] |
|---|---|---|---|---|
| | Coeff | (SE) | | |
| Availability | 0.62 | (0.07) | *** | -0.06 |
| Interactions with Availability | | | | |
| Race (ref=White) | | | | |
| Black | 1.43 | (0.21) | *** | -0.13 |
| Hispanic | 0.37 | (0.16) | ** | -0.03 |
| Other [c] | 0.05 | (0.19) | | -- |
| Male (ref=Female) | 0.33 | (0.10) | *** | -0.03 |
| Low income (Ref=high | 0.26 | (0.15) | | -- |
| | **Overall Consumption** | | | **Estimated Policy Impact [c]** |
| | Coeff | (SE) | | |
| Availability | -0.50 | (0.27) | | -- |
| Interactions with Availability | | | | |
| Race (ref=White) | | | | |
| Black | 0.84 | (0.83) | | -- |
| Hispanic | -0.53 | (0.50) | * | 0.05 |
| Other [c] | -0.55 | (0.46) | * | 0.05 |
| Male (ref=Female) | 0.16 | (0.33) | | -- |
| Low income (Ref=high | 0.75 | (0.55) | * | -0.07 |
| | **BMI Percentile** | | | **Estimated Policy Impact [c]** |
| | Coeff | (SE) | | |
| Overall Consumption | -0.09 | (0.05) | | -- |
| Interactions with Overall | | | | |
| Race (ref=White) | | | | |
| Black | 0.05 | (0.08) | | -- |
| Hispanic | -0.03 | (0.07) | | -- |
| Other [c] | -0.12 | (0.10) | | -- |
| Male (ref=Female) | 0.13 | (0.05) | * | -- |
| Low income (Ref=high | 0.08 | (0.06) | | -- |

[a] Results from differences-in-differences model.
[b] Estimates obtained by multiplying corresponding estimate for school-based
[c] Estimates obtained by multiplying corresponding estimate for overall consumption
[d] Estimates obtained by multiplying corresponding estimates for BMI percentile and
[e] Includes Native Hawaiians, Pacific Islanders, American Indians, Alaskan Natives
* p<0.05, ** p<0.01, *** p<0.001.

TABLE 4.5: Estimates for the Impact of Changes in Snacks and Sweets Availability on Consumption [a]

| | School-Based Snack Consumption | | | | School-Based Sweets Consumption | | | |
|---|---|---|---|---|---|---|---|---|
| | Coeff | (SE) | | Estimated Policy Impact [b] | Coeff | (SE) | | Estimated Policy Impact [b] |
| Low-Fat:[b] | | | | | | | | |
| Availability | 0.34 | (0.09) | *** | 0.02 | 0.14 | (0.11) | | |
| Interactions with Availability | | | | | | | | |
| Race (ref=White) | | | | | | | | |
| Black | 0.39 | (0.17) | * | 0.02 | 0.75 | (0.22) | *** | 0.04 |
| Hispanic | 0.15 | (0.14) | | -- | 0.1 | (0.19) | | |
| Other | -0.08 | (0.18) | | -- | -0.12 | (0.24) | | |
| Availability*Male | 0.26 | (0.10) | ** | 0.01 | 0.32 | (0.13) | * | 0.02 |
| Low income household | -0.40 | (0.13) | ** | -0.02 | 0.19 | (0.17) | | |
| Regular:[b] | | | | | | | | |
| Availability | 0.19 | (0.09) | * | -0.03 | 0.49 | (0.11) | *** | -0.04 |
| Interactions with Availability | | | | | | | | |
| Race (ref=White) | | | | | | | | |
| Black | 0.23 | (0.19) | | -- | 0.14 | (0.23) | | |
| Hispanic | -0.01 | (0.17) | | -- | -0.25 | (0.20) | | |
| Other | -0.26 | (0.22) | | -- | -0.21 | (0.26) | | |
| Availability*Male | -0.13 | (0.11) | | -- | -0.05 | (0.14) | | |
| Low income household | 0.42 | (0.15) | ** | -0.06 | 0.18 | (0.18) | | |

[a] Results from differences-in-differences model.
[b] Estimates obtained by multiplying corresponding estimate for school-based consumption with estimate of standard in Table 3
[c] Estimates obtained by multiplying corresponding estimate for overall consumption with estimate of availability in Table 3
[d] Estimates obtained by multiplying corresponding estimates for BMI percentile and overall consumption and estimate of availability in Table 3
[e] Includes Native Hawaiians, Pacific Islanders, American Indians, Alaskan Natives and multi-race non-Hispanics.
* p<0.05, ** p<0.01, *** p<0.001.

# Chapter 5: Estimating the Lifecycle Costs Associated with Childhood Obesity

## Introduction

Obesity is one of the leading threats to health that children face today. Recent estimates indicate that almost one out of five children is obese (Ogden et al., 2008). This is concerning given that obesity in childhood is associated with significant costs in terms of child social development and health. Obese children may endure higher psychosocial stress and have impaired cognitive and non-cognitive skill development (Dietz, 1998; Datar and Sturm, 2006). If these relationships are causal rather than a reflection of the fact that children of lower socioeconomic status exhibit higher rates of obesity, then this may have important implications for labor market outcomes.

Obese children may also suffer worse health than non-obese children. High cholesterol, type 2 diabetes high blood pressure, lower performance on mental health scales and a greater likelihood to engage in substance abuse have also been documented among obese children (Freedman, 2008). These health problems may underlie the increased hospital visits and health care spending that have been found for the obese youth population in several studies (Dietz, 1998).

In addition to current costs, obese children face a higher trajectory of future health care costs. Childhood obesity even as early as at age 6 increases the likelihood of adult obesity (Serdula et al., 1993) and numerous studies indicate that obese adults face a higher relative risk for diseases including hypertension, type 2 diabetes, stroke, liver abnormalities and osteoarthritis that are associated with higher health care costs and lower quality of life. Once obese, adults are unlikely to achieve weight loss through behavioral changes (Skender et al., 1996; Wadden, 2009). Several studies also indicate that childhood obesity influences the development of adult disease-specific morbidity and mortality independently of adult obesity status.

Schools, foundations and government have responded to the childhood obesity epidemic by supporting numerous studies and interventions. As obesity develops from a sustained caloric imbalance, the focus of this work has been on diet and physical activity. Also as children spend substantial portion of the day at school, attention has also focused on school policies (IOM, 2005; Wechsler, 2001). The Robert Wood Johnson Foundation has notably made a commitment to reverse the epidemic by 2015 and schools are required to develop school wellness policies as mandated by the Child Nutrition and WIC Reauthorization Act of 2004.

Most evaluations to date have used changes in health behaviors or outcomes (eg consumption units or obesity) to assess effectiveness. While important insights can be gained from such studies, they do not convey the magnitude of the desired effect particularly in comparison with the costs of implementing the program. The translation of health benefits to monetary units supports cost-effectiveness analyses which allow for such comparisons. Quantifying the health benefits due to a program intervention allows for the comparison of different obesity prevention interventions as well as with other health promotion interventions. Assessing the benefits has been difficult for child health interventions as benefits accrue over the lifespan (Cawley, 2008).

This paper develops a Monte Carlo model that estimates the lifetime health care costs associated with the prevalence of obesity among the US elementary school population. Estimates for key parameters in the model are obtained from the literature. These parameters include obesity tracking from childhood to adulthood and the health care costs associated with adult obesity. Estimates are broken down by gender and race/ethnicity to the degree possible. Findings from the investigation illustrate the lifetime costs associated with childhood obesity and support the use of cost-effectiveness for school-based programs.

## Model Construction

A conceptual model relating childhood obesity to lifetime health care costs is depicted in Figure 5.1. The red arrows indicate the key relationships in the model – obese children are at greater risk for being obese in adulthood which leads to greater obesity-related morbidity and health care costs. The black lines indicate other relationships that may also play a role, but for which there is weaker evidence. The impact of including these additional relationships considered in sensitivity analysis. The increase in lifetime costs due to being obese may be offset to some degree by the decrease in expected life expectancy. The dotted black line indicates that the literature is mixed regarding childhood obesity being an independent risk factor for adult morbidity associated with obesity.

The simulation model we develop consists of three components. The first estimates obesity among the elementary school-aged population in the United States and projects the population until death. The second component estimates the tracking of obesity in the population from childhood to adulthood. The third component estimates the age-specific costs due to obesity. Each component is described in more detail below. The components are pulled together into a Monte Carlo simulation model. Each estimate in the results section is based on 10,000 simulated individuals.

Analyses are stratified by gender and race to investigate disparities. Disparities in obesity by gender, race/ethnicity and income are apparent in children as young as 2 years old and may persist into adulthood. The racial categories considered are White, Black and Other. As there Census does not currently provide a life table for Hispanics (although it is expected to become available this fall), Hispanics and Mexican-Americans were classified as White.

*Component 1: Population*

The population of school-aged children was estimated from Census projections for children ages 6-11. As the average age of the sample was 9, the age-specific life table for 9 year olds in 2004 was applied. Prevalence rates of obesity were estimates from the National Health and Examination Survey (NHANES) 2001-2006. The CDC defines a child to be obese if the age- and gender-specific body mass index (BMI) percentile exceeds the 95$^{th}$ percentile. An adult is defined to be obese if BMI exceeds 30. The International Obesity Task Force (IOTF) adjusts the CDC cut-offs such that the definition of childhood obesity converges with adulthood obesity at age 20. While the CDC definition is predominant in the literature, the IOTF definition is more appropriate for longitudinal investigations. The CDC figures are used for the base analysis while the IOTF figures are explored in the sensitivity analysis. Table 5.1 below shows the results by gender and race.

*Component 2: Tracking of Obesity from Childhood to Adulthood*

A comprehensive review of the literature regarding obesity tracking was conducted. Estimates of tracking were obtained from studies based on a longitudinal cohort and which provided two measurements of obesity for each child. The first measurement needed to be between the ages of 6 and 11 and the second needed to be in adulthood (between ages 20 and 35). The CDC definition of obesity was used in our model as it was the most common among the tracking studies. In addition, none of the tracking studies differentiate between underweight and normal weight. Surveys from which estimates were obtained include the Bogalusa Heart Survey, the Adelaide Nutrition Survey, ADD Health, the National Longitudinal Survey on Youth, the Oslo Youth Study and the Amsterdam Growth and Health Longitudinal Survey.

Several different measures of tracking were reported by these studies. These included correlation coefficients, stability coefficients, risk ratios and probabilities. In order to obtain information from the most number of studies, we collected estimates for two parameters from each study. The first was the positive predictive value or the probability of being obese as an adult given that the individual was obese as a child. The second was the sensitivity or the probability of being obese as an adult given that the individual was normal weight as a child. For almost all studies, we estimated these probabilities based on the distribution of the sample as opposed to the numbers reported by the authors. For studies which reported correlation coefficients, we obtained estimates of tracking based on simulation.

We collected estimates from a total of 13 studies (see Appendix A). Given the distribution in the age at which obesity was assessed in adulthood, we used age 30 as the definition of adulthood for the simulation model. As several studies estimated tracking separately for boys and girls, we included separate parameters into our model based on gender but not by race/ethnicity. A "low", "high" and "best value" was obtained to fit triangular distributions for the positive predictive value and sensitivity parameters in the model. The "low" and "high" estimates were the lowest and highest estimates respectively obtained from the studies. The "best guess" was the simple average from all the studies. These estimates are presented in Table 5.2.

An estimate of positive predictive value and sensitivity were obtained from the triangular distributions for each simulation using a random number generator. Obesity status between the childhood and adulthood time-points was linearly extrapolated.

*Component 3: Costs of Obesity*

A comprehensive literature review was conducted on the health care costs associated with being obese relative to normal weight. 12 studies in total with per-capita annual costs were collected (see Appendix B). While most were nationally representative, some were based on specific populations. As the methodology was not comparable to others, studies that used attributable risk to obtain cost estimates were not included. Major differences across studies were whether or not prescription drugs were included and the study design. Most studies were cross-sectional although several were prospective. All costs were adjusted to 2008 dollars using the medical CPI and lifetime costs were discounted at a rate of 3%.

Estimates were collected by gender and race. The average across studies was used for ages 9-14 and ages 70 onwards as there were only two studies in each of the age groups. Both studies for ages 70 onwards were prospective. Triangular distributions for each age between ages 14 and 70 were constructed. Similar to the construction for obesity tracking, a "low", "high" and "best-guess" estimate was specified for each age. The "best guess" estimates for costs however were from cross-sectional estimates of the Medical Expenditures Panel Survey (MEPS) conducted by Eric Finkelstein and colleagues. The correlation between costs in consecutive years was assumed to be zero conditional on obesity status. Lifetime costs were the sum of costs incurred over the lifespan. Figure 5.2 below presents the simulated distribution of health care costs from simulations of two boys and two girls.

Results

Estimates of obesity tracking and the costs associated with adult obesity were applied to the base sample. The main results from the simulation are presented in Table 5.3. Separate estimates by the age at which it is assumed a cost differential emerges for obese relative to normal weight are presented because of conflicting studies in the literature and because it has a substantial impact on the results. Assuming that an obese individual does not incur higher health care costs until age 30, the additional health care costs an obese child can expect to face over his or her lifetime is $8,399. The higher cost estimate for girls is partly due to the higher average health care costs incurred by women relative to men as well as the longer expected life expectancy among girls. Assuming that obesity is associated with higher health care costs from childhood, the additional costs are estimated to be $12,047. The difference between these two estimates is largely due to the discounting of future costs.

Table 5.4 presents results for the population of elementary school-aged children presented in Table 5.1. If obese children were lean, a savings of about $115 billion in health care costs could be expected. While a higher fraction of boys are obese, the expected overall cost burden is lower than for girls.

## Sensitivity Analyses

We tested the sensitivity of our findings by conducting several sensitivity analyses that test key assumptions. Four sensitivity analyses are described below.

### *Assumption #1: Life Table*

As obese individuals experience a higher disease burden than normal weight individuals, they may also experience higher mortality risk. The model we develop is specific to gender and race/ethnicity, but not to obesity status. To investigate the sensitivity of results to this assumption, we tested a 2% and 5% increased risk for obese individuals between the ages of 30 and 65. The choice of age 65 was made to account for selection. Table 5.5 presents our findings.

An increase in mortality risk among obese individuals results in lower lifetime health care costs, but not to a substantial degree. The decrease among girls is higher. The decrease in costs due to a 5% increased risk in mortality translates to about a 1% decline in overall lifetime costs.

*Assumption #2: Discount Rate*

Our model assumes a discount rate of 3% as a prior study on childhood obesity assumed this rate (Finkelstein, 2008). As Figure 5.2 indicates that higher costs are incurred for older ages, a lower discount rate would be expected to increase our estimates of lifetime costs substantially. Figure 5.3 presents alternative estimates of lifetime costs for different discount rate choices. Lifetime costs are sensitive to the choice of discount rate and the sensitivity declines as the discount rate increases. 5% is another commonly used discount rate. If this is used instead of 3%, an obese girl or boy incurs about $10,000 in additional health care costs over the lifecycle.

*Assumption #3: CDC versus IOTF Definition*

A study which compared obesity tracking using the CDC and IOTF definitions found that tracking was stronger with the IOTF definition (Gordon-Larsen, 2004). Positive predictive value using the IOTF definitions was 82.4% as compared with 76.3% using the CDC definition. Sensitivity was found to be 12.5% using the IOTF definition as compared with 11.1% with the CDC definition. Estimates of lifetime costs using the IOTF definition were 6.2% higher on average. As Table 1 indicates, the IOTF definition results in a lower estimate of childhood obesity prevalence (12.5% versus 13.7%). Employing the IOTF definition of childhood obesity instead of the CDC definition leads to a 4% decline in lifetime health care costs.

*Assumption #4: Obesity as an Absorbing Condition*

The model assumes that obesity status in adulthood is determined by obesity status at age 30. It may however be the case that obese adults become normal weight. In this sensitivity analysis, we test the impact of a declining probability of obesity on lifetime costs according to the function: $P(O_t+1)=(100-x\%)*P(O_t)$. When we assume x=1.0 for girls and 0.25 for boys, we find that obesity declines about 5-10% for obese children and 1-3% for lean children (see Figure 5.4 and 5.5). Lifetime costs are found to be 2-3% lower for boys and 6-7% lower for girls.

## Conclusions

The main finding from this analysis is that an obese child incurs about $10,000 in health care costs relative to a normal weight child over the lifecycle. This estimate is substantial given that average health care spending in the US population was roughly $8,000 in 2008. The specific estimate varies by gender and for key assumptions such as the age at which being obese results in higher health care costs and the discount rate.

Our population-level estimates suggest that reducing obesity prevalence among the elementary school-aged population by 1% would result in a lifetime savings of about $1 billion. Environmental interventions that are successful in lowering obesity prevalence by even a small percentage may thus be worthwhile.

Our sensitivity analyses indicate that our results are sensitive to the discount rate. While the bulk of costs are occurred later in life, discounting places more weight on costs incurred early in life. Using a discount rate of 5% instead of 3% results in lifetime estimates that are about $5,000 lower for boys and about $2,000 lower for girls. Our results however appear to be quite robust to the assumption that obese and normal weight adults have the same life table.

Our model assumes that the CDC and IOTF definitions of obesity are valid. Costs which are unaccounted for in our model include quality of life, education, and labor market outcomes. The relationship between health care costs and obesity status is assumed to remain constant over the lifespan. Future studies should address these limitations as well as others highlighted in this manuscript.

## Tables and Figures

TABLE 5.1: Obesity Prevalence using CDC and IOTF Definitions in the Base Sample

| | | | Obese, % ** | |
|---|---|---|---|---|
| | | Population (mil)* | CDC | IOTF |
| Boys: | White | 19.2 | 18.5 | 12.1 |
| | Black | 3.9 | 18.6 | 14.3 |
| | Other | 1.9 | 15.5 | 12.7 |
| | Total | 25 | 18.3 | 12.5 |
| Girls: | White | 18.2 | 15.4 | 13.4 |
| | Black | 3.8 | 23.7 | 20.8 |
| | Other | 1.9 | 6 | 3.1 |
| | Total | 23.9 | 16 | 13.7 |

* Census 2008 projections. White includes Hispanics.

** Estimated from NHANES 2001-2006; height and weight are measured.

TABLE 5.2: Estimates of Obesity Tracking Between Childhood and Adulthood

| | | Low | High | "Best Guess" |
|---|---|---|---|---|
| $P(O_A \mid O_C)$*: | | | | |
| | Boys | 34% | 76% | 56% |
| | Girls | 34% | 78% | 57% |
| $P(O_A \mid \text{not } O_C)$**: | | | | |
| | Boys | 4% | 22% | 13% |
| | Girls | 2% | 40% | 15% |

* The probability of being obese as an adult given obese as a child (positive predictive value).

** The probability of being obese as an adult given normal weight as a child (sensitivity).

TABLE 5.3: Lifetime Costs Faced by an Obese Child

| | | Lifetime Costs ($) | St Dev |
|---|---|---|---|
| Ages 30+ | | | |
| | Boys | $8,399 | $1,017 |
| | Girls | $9,812 | $433 |
| Ages 9+ | | | |
| | Boys | $12,047 | $1,178 |
| | Girls | $15,639 | $596 |

TABLE 5.4: Cost Burden of Obesity in Elementary School-Aged Population

| | Cost | Population (mil) | |
|---|---|---|---|
| | Burden ($ | Obese | Lean |
| Boys | 55,156 | 4.6 | 20.5 |
| Girls | 59,562 | 3.8 | 20.1 |

TABLE 5.5: Change in Estimates due to Change in Mortality Rate

| | | Decline in Costs ($): | |
|---|---|---|---|
| | Avg Mortality Risk | 2% higher | 5% higher |
| Boys | 0.006 | 569 | 568 |
| Girls | 0.004 | 771 | 769 |

FIGURE 5.1: Conceptual Model Relating Childhood Obesity to Lifetime Healthcare Costs

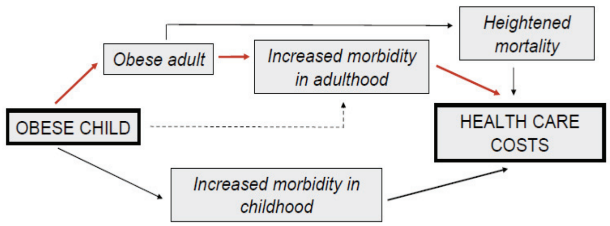



FIGURE 5.2: Health Care Cost Trajectories for Four Children

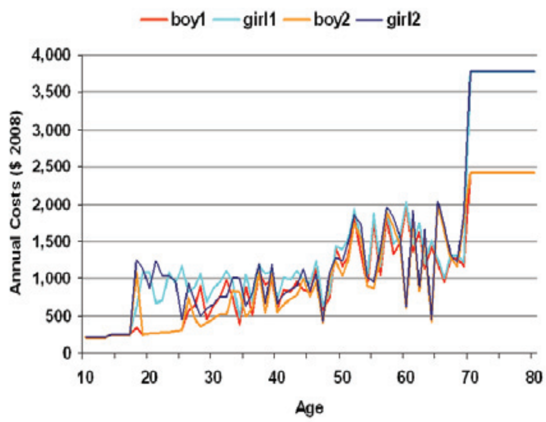



FIGURE 5.3: Lifetime Costs by Choice of Discount Rate

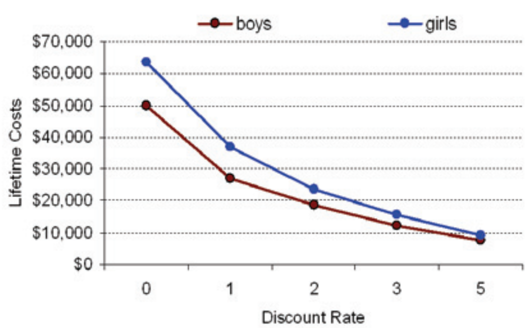


FIGURE 5.4: Decline in Obesity Risk in Adulthood for Normal Weight Children

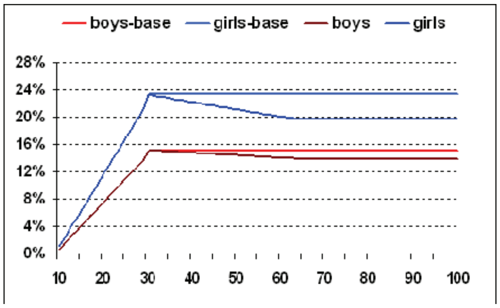
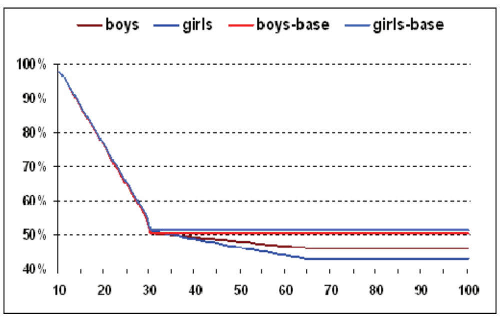



FIGURE 5.5: Decline in Obesity Risk in Adulthood for Obese Children



## Bibliography

Alliance for a Healthier Generation. Available at: http://www.healthiergeneration.org/. Accessed December 30, 2007.

Anderson, P. & Butcher, K. Reading, Writing, and Refreshments: Are School Finances Contributing to Children's Obesity? *Journal of Human Resources* 2006: 41(3): 467-94.

Austin, S.B., Melly, S.J., Sanchez, B.N., Patel, A., Buka, S. & Gortmaker, S.L. Clustering of fast-food restaurants around schools: A novel application of spatial statistics to the study of food environments. *American Journal of Public Health*, 2005; 9:1575-1581.

Barnett, T.A., O'Loughlin, J., Gauvin, L., Paradis, G. & Hanley J. Opportunities for student physical activity in elementary schools: a cross-sectional survey of frequency and correlates*.* *Health Education Behavior* 2006; 33(2): 215-32.

Bogden, J. Fit, Healthy, and Ready to Learn: A School Health Policy Guide. Part I: Physical Activity, Healthy Eating, and Tobacco-Use Prevention. National Association of State Boards of Education (NASBE), Alexandria, VA, 2000.

Borradaile, K., S. Sherman, et al. Snacking in children: The role of urban corner stores. *Pediatrics* 2009; 124(5): 1293-1298.

Bundy, D.A.P., Shaeffer, S., Jukes, M., Beegle, K., Gillespie, A., Drake, L., Lee, S-H.F., Hoffman, A-M., Jones, J., Mitchell, A., Barcelona, D., Camara, B., Golmar, C., Savioli, L., Sembene, M., Takeuchi, T., & Wright, C. School–Based Health and Nutrition Programs. *Disease Control Priorities in Developing Countries (2nd Edition),* New York: Oxford University Press, 2006.

Campbell, K., Waters, E., O'Meara, S. & Summerbell, C. Interventions for preventing obesity in childhood. A systematic review. *Obesity Reviews* 2001; 2(3), 149-157.

Cawley, J., C. Meyerhoefer, et al. The impact of state physical education requirements on youth physical activity and overweight. *Health Economics* 2007; 16: 1287-1301.

Centers for Disease Control and Prevention. *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*. National Institutes of Health, 1998.

Cawley, J., Meyerhoefer, C. & Newhouse, D. The impact of state physical education requirements on youth physical activity and overweight*.* *Health Economics*, 2007; 16: 1287-1307.

Centers for Disease Control and Prevention (CDC). Guidelines for school and community programs to promote lifelong physical activity among young people. *MMWR Recomm Rep* 1997; 46 (RR-6):1–36.

Centers for Disease Control and Prevention. Guidelines for Physically Active Americans, (2008). Available at http://www.health.gov/paguidelines/guidelines/. Last accessed 1/15/09.

Centers for Disease Control and Prevention Growth Chart SAS program downloaded May 21, 2008 from URL:http://www.cdc.gov/nccdphp/dnpa/growthcharts/resources/sas.htm.

Centers for Disease Control and Prevention (CDC). Healthy People 2010: Physical Activity and Fitness. Available at: http://www.healthypeople.gov/Document/HTML/Volume2/22Physical.htm

Centers for Disease Control and Prevention (CDC) Clinical Growth Charts, 2000. Available at: http://www.cdc.gov/nchs/about/major/nhanes/growthcharts/clinical_charts.htm. Accessed December 30, 2007.

Center for Science in the Public Interest (2009). Raw Deal: School Beverage Contracts Less Lucrative Than They Seem.

Center for Science in the Public Interest (2006). School Foods Report Card. Available at: http://www.cspinet.org/schoolreportcard.pdf.

Cherlin, A.J., Chase-Lansdale, P.L. & McRae, C. Effects of parental divorce on mental health throughout the life course. *American Sociological Review.* 1998; 63(2): 239-249.

Coe, D.P., Pivarnik, J.M., Womack, C.J., Reeves, M.J. & Malina R.M. Effect of physical education and activity levels on academic achievement in children. *Medicine and Science in Sports and Exercise* 2006; 38: 1515-19.

Committee on Food Marketing and the Diets of Children and Youth. (2006) *Food Marketing to Children and Youth: Threat or Opportunity?* Washington, DC: National Academies Press.

Committee on Nutrition Standards for Foods in Schools, *Nutrition Standards for Foods in Schools: Leading the Way Toward Healthier Youth, Appendix C: Nutrition Standards for Competitive Foods Sold in Elementary, Middle or High School Set by States*, V.A. Stallings and A.L. Yaktine, Editors. 2007, Institute of Medicine of the National Academies: Washington, D.C.

Cullen, K.W., Eagan, J., Baranowski, T., Owens, E. & De Moor, C. Effect of a la carte and snack bar foods at school on children's lunchtime intake of fruits and vegetables. *Journal of the American Dietetic Association* 2000; 12: 1482-86.

Cullen, K.W. & Thompson, D.I. (2005) Texas school food policy changes related to middle school a la carte/snack bar foods: Potential savings in kilocalories. *Journal of the American Dietetic Association* 2005; 12: 1952-54.

Cullen, K.W. & Zakeri, I. Fruits, vegetables, milk, and sweetened beverages consumption and access to a la carte/snack bar meals at school. *American Journal of Public Health* 2004; 94: 463-467.

Darmon, N. and A. Drewnowski. Does social class predict diet quality? *American Journal of Clinical Nutrition* 2008; 87(5): 1107-1117.

Datar, A. and N. Nicosia (2009). Junk food in schools and childhood obesity: Much ado about nothing? RAND Health and Labor & Population, Working Paper W-672.

Datar, A. & Sturm, R. Physical education in elementary school and body mass index: evidence from the early childhood longitudinal study. *American Journal of Public Health*, 2004; 94: 1501-1506.

Davison, K.K. & Lawson, C.T. Do attributes in the physical environment influence children's physical activity? A review of the literature. *International Journal of Behavioral Nutrition and Physical Activity* 2006, 3**:**19

de Leeuw, J. & Meijer, E. *Introduction to Multilevel Analysis*: New York, NY: Springer Science + Business Media, LLA, 2008.

Dietz, W. (1998). Health Consequences of Obesity in Youth: Childhood Predictors of Adult Disease. *Pediatrics*1998; 101*:* 518-25

Donnelly, J.E., Jacobsen, D.J., Whatley, J.E., Hill, J.O., Swift, L.L., Cherington, A., Polk, B., Tran, Z.V. and Reed, G. Nutrition and physical activity programs to attenuate obesity and promote physical and metabolic fitness in elementary school children. *Obesity Research* 1996; 4: 229-43.

Domel, S.B., Thompson, W.O., Baranowski, T. & Smith, A.F. How children remember what they have eaten. *Journal of the American Dietetic Association.* 1994; 11:1267-1272.

Domel, S.B. Self-reports of diet: how children remember what they have eaten. *American Journal of Clinical Nutrition* 1997; 4:1148-52.

Drewnowski, A., & Specter, S.E. Poverty and obesity: the role of energy density and energy costs. *American Journal of Clinical Nutrition* 2004; 1: 6-16.

Duncan, S.C., Duncan, T.E., Strycker L.A. & Chaumeton, N.R. (2004) A multilevel approach to youth physical activity research. *Exercise and Sport Sciences Reviews.* 2004; 32: 95-99.

Everett Jones, S., N. D. Brener, et al. Prevalence of school policies, programs, and facilities that promote a healthy physical school environment. Am J Public Health 2003; 93(9): 1570-1575.

Farley, T., Meriwether, R., Baker, E., Rice, J., Erin, T. & Webber, L. Where do the children play? The influence of playground equipment on physical activity of children in free play. *Journal of Physical Activity and Health* 2008; 5: 319-31.

Fernandes, M. (2008). The effect of soft drink availability in elementary schools on consumption. *Journal of the American Dietetic Association* 108: 1445-1452.

Ferreira, I., Van der Horst, K., Wendel-Vos, W., Kremers, S., van Lenthe, F.J. & Brug, J. Environmental correlates of physical activity in youth – a review and update. *Obesity Reviews* 2007; 8: 129-54.

Finkelstein, D. School food environments and policies in US public schools. *Pediatrics* 2008; 122(1): e251-e259.

Foster, G.D., Sherman, S., Borradaile, K.E., Grundy, K.M., Vander Veur, S.S., Nachmani, J., Karpyn, A., Kumanyika, S. & Shults, J. A policy-based school intervention to prevent overweight and obesity. *Pediatrics,* 2008; 121 (4): e794 – e802.

Fox, M., A. Dodd, et al.Association between school food environment and practices and body mass index of US public school children. *Journal of the American Dietetic Association* 2009;109(2): S108-S117.

Freedman, D., Khan, L., Dietz, W., Srinivasan, S. & Berenson, G. Relationship of childhood obesity to coronary heart disease risk factors in adulthood: The Bogalusa Heart Study. *Pediatrics,* 2001; 108: 712-18.

French, S.A., Story, M., Fulkerson, J.A. & Gerlach, A.F. Food environments in secondary schools: A la carte, vending machines, and food policies and practices. *American Journal of Public Health* 2003; 7: 1161-1168.

Goran, M., Ball, G. & Cruz, M. Obesity and risk of type 2 diabetes and cardiovascular disease in children and adolescents. *Journal of Clinical Endocrinology and Metabolism.* 2003; 88: 1417-27.

Goldstein, H. (1995) *Multilevel Statistical Models* (2nd ed.). London: Edward Arnold.

Gordon-Larsen, P., C Nelson, M.C., Page, P., Popkin, B.M. Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics* 2001; 117: 417-24.

Gordon-Larsen, P., Nelson, M.C. & Popkin, B.M. Longitudinal physical activity and sedentary behavior trends: Adolescence to adulthood. *American Journal of Preventive Medicine.* 2004; 27: 277-83.

Government Accountability Office. (2005) School meal programs: Competitive foods are widely available and generate substantial revenues for schools. Report # GAO-05-563.

Government Accountability Office (2004). Competitive Foods Are Available in Many Schools; Actions Taken to Restrict Them Differ by State and Locality, Report # GAO-04-673.

Government Accountability Office (2003). Efforts Needed to Improve Nutrition and Encourage Healthy Eating. Report # GAO-03-506.

Government Accountability Office. (2004) School meal programs: Competitive foods are available in many schools: Actions taken to restrict them differ by state and locality. Report # GAO-04-673.

Greves, H. M. and F. P. Rivara (2006). Report card on school snack food policies among the United States' largest school districts in 2004-2005: Room for improvement. *Int J Behav Nutr Phys Act* 3: 1.

Grimm, G.C., Harnack, L., & Story, M. Factors associated with soft drink consumption in school-aged children. Journal of the American Dietetic Association 2004; 8: 1244-49.

Harnack, L., Snyder, P., Story, M., Holliday, R., Lytle, L. & Nemark-Sztainer, D. Availability of a la carte food items in junior and senior high schools: A needs assessment. *Journal of the American Dietetic Association* 2000; 6: 701-3.

Harnack, L., Stang, J., Story, M. Soft drink consumption among US children and adolescents nutritional consequences. *Journal of the American Dietetic Association* 1999; 4: 436-41.

U.S. Department of Health and Human Services and U.S. Department of Agriculture. *Dietary Guidelines for Americans*, 2005. 6th Edition, Washington, DC: U.S. Government Printing Office, January 2005.

Healthy People 2010 – Chapter 22: Physical Activity and Fitness*.* Washington, DC: US Department of Health and Human Services; 2001. Available at: http://www.healthypeople.gov/document/html/uih/uih_bw/uih_1.htm. Accessed April 16, 2009.

Health Policy Tracking Service. (2007) Balance: A report on state action to promote nutrition, increase physical activity and prevent obesity, end of year 2006. *Robert Wood Johnson Foundation*.

Humpel, N., Owen, N. & Leslie, E. Environmental factors associated with adults' participation in physical activity: a review. *American Journal of Preventive Medicine* 2002; 22: 188-99

Institute of Medicine, Committee on Prevention of Obesity in Children and Youth. (2005). *Preventing Childhood Obesity: Health in the Balance*. National Academies Press, Washington, DC.

Institute of Medicine (2007). V.A. Stallings and A.L. Yaktine, Editors. *Nutrition Standards for Foods in Schools: Leading the Way Toward Healthier Youth. Appendix C: Nutrition Standards for Competitive Foods Sold in Elementary, Middle or High School Set by States*. Washington, D.C., Institute of Medicine of the National Academies.

Jones, K. Role of obesity in complicating and confusing the diagnosis and treatment of diabetes in children. *Pediatrics* 2008; 121: 361-68

Kahn, E.B., Ramsey, L.T., Brownson, R.C., Heath, G.W., Howze, E.H., Powell, K.E., Stone, E.J., Rajab, M.W. & Corso, P. The effectiveness of interventions to increase physical activity. A systematic review. *American Journal of Preventive Medicine,* 2002; 22 (4 Supplement): 73-107.

Kahng, S.K., Dunkle, R.E., & Jackson, J.S. The relationship between the trajectory of body mass index and health trajectory among older adults: Multilevel modeling analyses. *Research on Aging* 2004; 26: 31-61.

Kohl III, H.W. & Hobbs, K.E. Development of physical activity behaviors among children and adolescents. *Pediatrics* 1998; 101(3 Supplement): 549-54.

Kreft, I.G.G., de Leeuw, J. & Aiken, L.S. (1995) The effect of different forms of centering in hierarchical linear models. *Multivariate Behavioral Research* 1995; 30: 1-21.

Kubik, M., Lytle, L., Hannan, P., Perry, C. & Story, M. The association of the school food environment with dietary behaviors of young adolescents. 2003; 93: 1168-73

Kuczmarski, R.J., Ogden, C.L., Guo, S.S., et al. CDC Growth Charts for the United States: Methods and Development. *National Center for Health Statistics. Vital Health Statistics* 2002; 11(246): 1-190.

Lee, S., Burgeson, C., Fulton, J. & Spain, C. Physical education and physical activity: Results from the School Health Policies and Programs Study. *Journal of School Health.* 2007; 77: 435-63.

Lemasters, E. Review of research on the relationship between buildings, student achievement and student behavior. Council of Educational Facility Planners International. New York, NY, 1996

Lopes, V., Vasques, C., Pereira, B.O., Maia, J. & Malina, R.M. Physical activity patterns during school recess: a study in children 6 to 10 years old. *International Electronic Journal of Health Education* 2006; 9: 192-201.

Ludwig, D.S., Peerson, K.E. & Gortmaker, S.L. Relation between consumption of sugar sweetened drinks and childhood obesity: A prospective, observational analysis. *The Lancet*, 2001; 357: 505-8.

Luepker, R.V., Perry C.L., McKinlay, S.M. et al. Outcomes of a field trial to improve children's dietary patterns and physical activity. The Child and Adolescent Trial for Cardiovascular Health. CATCH collaborative group. *Journal of the American Medical Association.* 1996; 275:768-76

Malik, V.S., Schulze, M.B. & Hu, F.B. Intake of sugar-sweetened beverages and weight gain: a systematic review. *American Journal of Clinical Nutrition*, 2006; 2: 274-88.

Mâsse, L., Chriqui, J. F., Igoe, J. F., Atienza, A. A., Kruger, J., Kohl, H. W., Frosh, M.M. & Yaroch A.L. Development of a physical education–related state policy classification system (PERSPCS). *American Journal of Preventive Medicine* 2007*;* 33 (4S): S264-S276.

Mâsse, L., Frosh, M., Chriqui, J., Yaroch, A., Agurs-Collins, T., Blanck, H., Atienza, A.A, McKenna, M.L. & Igoe, JF. Development of a school nutrition–environment state policy classification system (SNESPCS). *American Journal of Preventive Medicine,* 2007*;* 33(4S): 277-91.

McGraw, S., D. Sellers, et al. (2000). Measuring implementation of school programs and policie to promote healthy eating and physical activiy among youth. *Preventive Medicine* 31(2): S86-S97.

McLeod, J.D., & Shanahan, M.J. Trajectories of poverty and children's mental health. *Journal of Health and Social Behavior.* 1996; 37: 207-20.

Miech, R.A., Kumanyika, S.K., Stettler, N., Link, B.G., Phelan, J.C. &Chang, V.W. Trends in the association of poverty with overweight among US adolescents, 1971-2004 *Journal of the American Medical Association*. 2006; 295: 2385-93.

Morrill. A. & Chinn, C. The Obesity Epidemic in the United States. *Journal of Public Health Policy*. 2004; 3/4: 353-66.

Mota, J.P., Santos, S. Guerra, J.C. & Ribeiro, J.D. Patterns of daily physical activity during school days in children and adolescents. *American Journal of Human Biology* 2003; 15: 547-53.

Munoz, K., S. Krebs-Smith, et al. (1997). "Food intakes of US children and adolescents compared with recommendations." Pediatrics 100: 323-329.

Must, A., Spadano, J., Coakley, E., Field, A., Colditz, G., & Dietz, W. The disease burden associated with overweight and obesity. *Journal of the American Medical Association* 1999; 282: 1523-29.

National Association for Sport and Physical Education (NASBE). Recess for elementary school students, Reston, VA 2006. Available online at: http://www.aahperd.org/naspe/pdf_files/pos_papers/RecessforElementarySchoolStudents.pdf

National Association for Sport and Physical Education (NASBE). Guideline for facilities, equipment and instructional materials for elementary education. Council of Physical Education for Children - A Position Paper from the National Association for Sport and Physical Education. July 2001. Available at http://www.aahperd.org/NASPE/pdf_files/pos_papers/instructional_mat.pdf. Accessed on 1/8/07.

Nielsen, S.J. & Popkin, B.M. Changes in beverage intake between 1977 and 2001. *Am J Prev Med* 2004; 27: 205-10.

Ogden, C. L., Carroll, M. D., & Flegal, K. M. High body mass index for age among US children and adolescents, 2003-2006. *Journal of the American Medical Association* 2008; 299: 2401-5.

Ogden, C., Kuczmarski, R., Flegal, K., Mei, Z., Guo, S., Wei, R., Grummer-Strawn, L., Roche, A., Johnson, C. Centers for Disease Control and Prevention 2000 Growth Charts for the United States: Improvements to the 1977 *National Center for Health Statistics* version. *Pediatrics*, 2002; 109(1): 45-60.

Ogden, C.L., Carroll, M.D. & Flegal, K.M. High body mass index for age among US children and adolescents, 2003-2006. *Journal of the American Medical Association* 2008; 299: 2401-5.

Ogden, C.L., Curtin, L.R., McDowell, M.A., Tabak, C.J. & Flegal, K.M. Prevalence of overweight and obesity in the United States, 1999-2004. *Journal of the American Medical Association* 2006; 295: 1549-55.

O'Toole, T.P., Anderson, S., Miller, C., & Guthrie, J. Nutrition services and foods and beverages available at school: results from the School Health Policies and Programs Study 2006. *Journal of School Health* 2007; 8:500-22.

Peterson, K.E. & Fox, M.K. Addressing the epidemic of childhood obesity through school-based interventions: What has been done and where do we go from here? *The Journal of Law, Medicine & Ethics* 2007; 35: 113-30.

Powell, L.M., Chaloupka, F.J., Slater, S.J., Johnston, L.D. & O'Malley, P.M. The availability of local-area commercial physical activity-related facilities and physical activity among adolescents*. American Journal of Preventive Medicine* 2007; 33(4 S): S292-300.

Powell, L.M., Slater, S., Chaloupka, F.J. & Harper D. Availability of physical activity related facilities and neighborhood demographic and socioeconomic characteristics: a national study. *American Journal of Public Health* 2006; 96:1676-1680.

Probart, C., McDonnell, E., Hartman, T., Weirich, J.E. & Bailey-Davis, L. Factors associated with the offering and sale of competitive foods and school lunch participation. *Journal of the American Dietetic Association* 2006; 2: 242-7

Rocchini, A. Childhood Obesity and a Diabetes Epidemic. *New England Journal of Medicine* 2002; 346, 854-855.

Romero, A.J. Low-income neighborhood barriers and resources for adolescents' physical activity. *Journal of Adolescent Health* 2005; 36: 253-9.

Sallis, J.F. & Glanz, K. *The Role of Built Environments in Physical Activity, Eating, and Obesity in Childhood.* The Future of Children. Spring 2006; 16: 89-108.

Sallis, J.F., Conway, T.L., Prochaska, J.J., McKenzie, T.L., Marshall, S.J, & Brown M. The association of school environments with youth physical activity. *American Journal of Public Health* 2001; 91: 618-20.

Sallis, J.F., McKenzie, T.L., Alcaraz, J.E., Kolody, B., Hovell, M.F. & Nader, P.R. Project SPARK. Effects of physical education on adiposity in children. *Annals of the New York Academy of Sciences* 1993; 699: 127-36.

Sallis, J.F., Prochaska, J.J. & Taylor, W.C. A review of correlates of physical activity of children and adolescents. *Medicine and Science in Sports and Exercise* 2000; 32: 963-75.

Samuels, S., S. Bullock, et al. (2009). To what extent have high schools in California been able to implement state-mandated nutrition standards? *Journal of Adolescent Health* 45: S38-S44.

Samuels, S. (2006). Improving school food environments through district level policies: Findings from six California schools. Oakland, CA, The California Endowment and Robert Wood Johnson Foundation.

Sarkin, J.A., McKenzie, T.L. & Sallis, J.F. Gender differences in physical activity during fifth-grade physical education and recess periods. *Journal of Teaching in Physical Education.* 1997; 17: 99-106.

Schanzenbach, D. (2005). Does the federal school lunch program contribute to childhood obesity? Forthcoming, *Journal of Human Resources*.

School Health Policies and Programs Study: Changes between 2000 and 2006 Factsheet. Downloaded June 12, 2008. http://www.cdc.gov/HealthyYouth/shpps/2006/factsheets/pdf/FS_Trends_SHPPS2006.pdf. Accessed 1/15/09.

School Nutrition Association, Summary of State School Nutrition Standards (list in progress). Updated May 2009. http://www.schoolnutrition.org. Accessed August 18, 2009.

Serdula, M., Ivery, D., Coates, R., Freedman, D., Williamson, D. & Byers, T. Do obese children become obese adults? A review of the literature. *Preventive Medicine,* 1993*; 22*: 167-77.

Sharma, M. School-based interventions for childhood and adolescent obesity. *Obesity Reviews* 2006; 7: 261-9.

Simon, M. and E. Fried (2007). State laws on school vending: the need for a public health approach. *Food and Drug Law Journal* 62: 139-151.

Skender, M., Goodrick, G., Del Junco, D., Reeves, R., Darnell, L., Gotto, A. & Foreyt, J. Comparison of 2-year weight loss trends in behavioral treatments of obesity: diet, exercise, and combination interventions. *Journal of the American Dietetic Association,* 1996; 96: 342-46.

Snidjers, T.A.B. & Bosker, R.J. *Multilevel Modeling: An Introduction to Basic and Advanced Multilevel Modeling*. London, UK: Sage Publications Ltd, 1999.

Terry-McElrath, Y., P. O'Malley, et al. (2009). The school food environment and student body mass index and food consumption: 2004 to 2007 data. *Journal of Adolescent Health* 45: S45-S56.

Tomporowski, P.D. Cognitive and behavioral responses to acute exercise in youths: a review. *Pediatric Exercise Science* 2003; 15: 348–59.

Troiano, R.P.D. Berrigan, D., Dodd, K.W., Mâsse, L.C., Tilert, T. & McDowell, M. Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise* 2008; 40: 181-8.

Trost, S.G., Rosenkranz, R.R. & Dzewaltowski, D.A. Physical activity levels among children attending after-school programs. *Medicine and Science in Sports and Exercise* 2008; 40: 622-9.

U.S. Department of Health and Human Services. Chapter 22. Physical Activity and Fitness. In: Healthy People 2010. Washington DC: U.S. Government Printing Office; 2000. 22.5–22.39.

U.S. Department of Energy Building America Program, Building America Best Practices: Series for High-Performance Technologies: Determining Climate Regions – December 2008. Prepared by Pacific Northwest National Laboratory & Oak Ridge National Laboratory.URL: http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/climate_region_guide.pdf. Last downloaded 2/10/09.

Vandongen, R., Jenner, D.A., Thompson, C., Taggart, A.C., Spickett, E.E., Burke, V., Beilin, L.J., Milligan, R.A., & Dunbar, D.L. A controlled evaluation of a fitness and nutrition intervention program on cardiovascular health in 10- to 12-year-old children. *Preventive Medicine,* 1995; 24: 9-22.

Verstraete, S.J., Cardon, G.M., De Clercq, D.L. & De Bourdeaudhuij, I.M. Increasing children's physical activity levels during recess periods in elementary schools: the effects of providing game equipment. *European Journal of Public Health* 2006; 16: 415–9.

Vartanian, L.R., Schwartz, M.B. & Brownell, K.D. Effects of soft drink consumption on nutrition and health: A systematic review and meta-analysis. *American Journal of Public Health* 2007; 4: 667-75.

Wardle, J., Brodersen, N.H. & Boniface, D. School-based physical activity and changes in adiposity. *International Journal of Obesity* 2007; 31: 1464-8.

Wang, Y. C., S. L. Gortmaker, et al. (2006). "Estimating the energy gap among US children: A counterfactual approach." Pediatrics 118(6): e1721-1733.

Wang, Y.C., Bleich, S.N. & Gortmaker. S.L. Increasing caloric contribution from sugar-sweetened beverages and 100% fruit juices among US children and adolescents, 1988-2004. *Pediatrics* 2008; 121: e1604-e1614.

Wechsler, H., Devereaux, R.S., Davis, M. & Collins, J. Using the school environment to promote physical activity and healthy eating. *Preventive Medicine* 2000; 31: 121-37.

Wootan, M., J. Johanson, et al. (2007). State School Foods Report Card. Washington DC, Center for Science in the Public Interest.

Yancey, A. & Kumanyika, S. Bridging the Gap: Understanding the structure of social inequities in child obesity. *American Journal of Preventive Medicine* 2007; 4: S172 S174.