DO SCHOOL LUNCH SUBSIDIES CHANGE THE DIETARY PATTERNS OF CHILDREN FROM LOW-INCOME HOUSEHOLDS?

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This article examines the effects of school lunch subsidies provided through the means-tested component of the National School Lunch Program on the dietary patterns of children aged 10–13 years in the United States. Analyzing data on 5,140 public school children in fifth grade during spring 2004, we find significant increases in the number of servings of fruit, green salad, carrots, other vegetables, and 100% fruit juice consumed in 1 week for subsidized children relative to unsubsidized children. The effects on fruit and other vegetable consumption are stronger among the children receiving a full subsidy, as opposed to only a partial subsidy, and indicate the size of the subsidy is an important policy lever underlying the program's effectiveness. Overall, the findings provide the strongest empirical evidence to date that the means-tested school lunch subsidies increase children's consumption over a time period longer than one school day. (*JEL* H51, I12, I38)

I. INTRODUCTION

Limited access to nutritious foods threatens the development and growth of children throughout the world. Despite the eradication of widespread hunger and malnutrition in the established market economies of Europe and North America, a healthful diet remains the most expensive alternative for families (Maillot et al. 2007). Imbalances in the nutrient composition of children's diets can have long-run consequences because regularly consuming foods high in essential vitamins and minerals is imperative for avoiding deteriorations in the body's ability to resist infections; and a concurrent combination of infection and undernourishment often results in unfavorable development and growth outcomes for children (Scrimshaw and SanGiovanni 1997). The National School Lunch Program (NSLP) is the widest reaching policy response to this threat in the United States, with more than 30 million students taking advantage of its benefits every school day.[1] A central objective of the program is to relax household resource constraints by providing access to free or low-cost domestic agricultural products for children during school. The means-tested component of the NSLP targets students from households with low income relative to national standards, and it now accounts for over half of the total number of program participants and subsidized school lunches. Eligible students

*The authors would like to thank Chris Barrett, Marianne Bitler, Celeste Carruthers, Barbara Devaney, Andy Gill, Phil Gleason, Joanne Guthrie, Bob Mead, Dave Ribar, participants in the "The Effect of School Meal Programs" session at the APPAM Research Conference in fall 2009, and three anonymous referees for many helpful discussions and comments on an earlier draft entitled "Do Means-Tested School Lunch Subsidies Change Children's Weekly Consumption Patterns?"

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1. See http://www.fns.usda.gov/pd/slsummar.htm for a summary of the program's participants and lunches served since 1969. The initial National School Lunch Act was passed in 1946.

ABBREVIATIONS

BMI: Body Mass Index
CCD: Common Core of Data
CNA: Child Nutrition Act
ECLS-K: Early Childhood Longitudinal Study-Kindergarten
GMM: Generalized Method of Moments
NSLP: National School Lunch Program
OLS: Ordinary Least Squares
USDA: U.S. Department of Agriculture
zip: Zone Improvement Plan

Contemporary Economic Policy (ISSN 1465-7287)
doi:10.1111/j.1465-7287.2011.00264.x
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pay 40 cents or less, or nothing for school lunches if they come from a household with income below 185% or 135% of the Federal poverty guidelines, respectively (U.S. Congress 2004a).[2]

There has been considerable debate over the program's effectiveness in providing balanced nourishment to children in light of the increasing national trend in obesity prevalence.[3] However, little work has been carried out to investigate the intermediary mechanisms through which program participation impacts children's body sizes. In the most recent study, Gordon et al. (2007b) find that program participants have higher average intakes for micronutrients, such as calcium and vitamins A and B, relative to nonparticipants in the previous 24 hours; and differences in average macronutrient intakes were mixed with increases in protein and decreases in carbohydrates. Similarly, Gleason and Suitor (2003) find that program participants have higher average intakes for several vitamins and minerals and dietary fat and lower average intakes for added sugars. An important limitation of earlier studies was the omission of any precise, comprehensive measure of children's body sizes in the empirical models. To the extent that differences in body sizes partly explain individual dietary patterns, conclusions based on earlier findings may be incomplete. Furthermore, no analytical distinction has been made for those participants receiving means-tested subsidies, and this is arguably the most vulnerable population targeted by the program. Given the vast reach of the NSLP and its strong potential to improve individual development and growth outcomes, we examine how the dietary patterns of children from low-income households are impacted by the school lunch subsidies.

A healthful diet according to the most recent U.S. Department of Agriculture (USDA) guidelines comprises five main food groups: grain, vegetable, fruit, milk, and meat and beans.[4] In this study, we investigate how the NSLP means-tested subsidies affect children's consumption of items included in the vegetable, fruit, and milk food groups. Although we are unable to fully explore the effects of the subsidies on items in every recommended food group, the items we do analyze are important dietary sources of calcium, iron, and vitamins A and C that support favorable development and growth outcomes (Scrimshaw 1991; Scrimshaw and SanGiovanni 1997). For instance, not having enough iron in the body, even a moderate deficiency, is linked with decreased cognitive performance among school-age children (Halterman et al. 2001). Consumption of vitamin C helps prevent iron deficiencies by enhancing its absorption from different types of meals (Hallberg, Brune, and Rossander-Hulthen 1987), but it also plays a vital role in the optimal functioning of the body's immune system (Wintergerst, Maggini, and Hornig 2006). From a public policy standpoint, it is imperative to identify whether school lunch subsidies increase children's dietary intake of items known to provide vitamins and minerals that are fundamentally related to development and growth outcomes. Moreover, it is important to understand whether intra-household reallocation occurs in response to the subsidies and, if so, whether the responses offset any increases in children's consumption from subsidized school lunches. Although analyzing 24-hour recall data is informative, our outcomes measure consumption for a period of 1 week and can help provide deeper insights into household responses over a longer time horizon than has previously been studied in this context.

In particular, we analyze data on 5,140 public school children in fifth grade, aged 10–13 years, observed during spring 2004 from the Early Childhood Longitudinal Study-Kindergarten (ECLS-K).[5] The extensive information collected in this study enables us to include several variables in our empirical models that are likely to influence dietary patterns, such as children's body sizes and physical activity patterns, and further include detailed control measures from zone improvement plan (zip) code-level and school-level surveys. To address the nonrandom assignment of NSLP means-tested subsidies, we match information on the schools and school districts in which children are enrolled and formulate an instrumental variables estimation strategy based on variation in the demand

2. Congress established uniform national guidelines and criteria in the determination of eligibility beginning fiscal year 1971.

3. In fact, all food and nutrition programs have come under scrutiny. See Currie (2003) for an overview. For more recent analyses of the effects of NSLP participation on obesity, see Schanzenbach (2009) and Millimet, Tchernis, and Husain (2010).

4. See http://www.mypyramid.gov/index.html

5. The NSLP funds school lunches in every public school that children attend in our sample. The consumption survey module was not introduced until the sixth round of the ECLS-K, which prevents us from taking advantage of any time variation while children are in elementary school.

for school meals. Overall, the results suggest that NSLP means-tested subsidies significantly increase the number of servings of fruit, green salad, carrots, other vegetables, and 100% fruit juice consumed by children and provide the strongest empirical evidence to date that the subsidies increase children's consumption over a time period longer than one school day.

This article proceeds as follows. We discuss a conceptual framework for our analysis based on the extant literature in Section II. Our empirical framework and estimation strategy are described in Section III, and the data sources utilized in the analysis are outlined in Section IV. We present the results in Section V, and conclude with Section VI.

II. CONCEPTUAL FRAMEWORK

Economic theory suggests that in-kind commodity transfers can change dietary patterns depending on individual preferences. In the context of welfare assistance targeted toward children, the model developed by Becker (1974) indicates that transfers may stimulate a reallocation of resources within households; however, the extent of any response is contingent on the preferences of the "head" or decision maker of the family, household-specific resource constraints, and the time horizon. On the one hand, if the means-tested subsidies received through a child's participation in the NSLP result in a reallocation of household food spending away from children by the full cash value of the subsidies then we would expect no change in observed dietary patterns because of the school lunches. For instance, Jacoby (2002) finds no intra-household reallocation of the total calories consumed by children in response to participation in a school feeding program. On the other hand, there is the possibility that previous levels of household food spending are only partially displaced or are not displaced at all in response to the subsidies. For instance, Long (1991) finds households that reduce spending on food by 61 cents for each additional dollar value of NSLP school lunches.

The empirical evidence to date suggests there is scope for the means-tested component of the NSLP to change the composition of food and beverages consumed by children from low-income households on a weekly basis or an even longer time horizon. For instance, Hoynes and Schanzenbach (2007) recently find that the marginal propensity to consume food is slightly larger for in-kind transfers as opposed to cash transfers. Although it is difficult to determine whether the response is because of the constraints imposed by the design of in-kind welfare programs or the preferences of the household decision maker, the evidence to date suggests a marginal propensity to spend on food in the range of \$0.17 to \$0.47 and substantially less than 1 (Currie 2003).[6] To gain perspective on the economic impact of the subsidies on household budgets, for the time period of our analysis, the maximum reimbursement rate paid to schools located in the contiguous United States through the NSLP is \$2.36 per meal (U.S. Department of Agriculture 2003) and amounts to an approximate transfer of \$50 per month for each child to a household with income below 135% of the Federal poverty guidelines. If this transfer is viewed by the head of the family as equivalent to a direct cash transfer then total household spending on food would increase by a minimum of about \$9 per month. It remains an empirical question as to whether the households reallocate food resources to other family members in response to the school lunch subsidies or whether the children experience net increases in consumption.

III. EMPIRICAL FRAMEWORK AND ESTIMATION STRATEGY

To examine the relationships between the NSLP means-tested subsidies and the number of servings of food and beverages consumed in a week, we proceed with the following model for the ith child living in a household with zip code j and attending school k in school district l:

$$\begin{aligned}\text{Servings}_{ijkl} &= \beta_0 + \beta_1(\textit{NSLP means-tested subsidy})_{ijkl} \\ &\quad + \beta_2\ln(\text{BMI})_{ijkl} + \boldsymbol{X}_{ijkl}\boldsymbol{\Gamma}_1 \\ &\quad + \boldsymbol{Z}_j\boldsymbol{\Gamma}_2 + \boldsymbol{S}_k\boldsymbol{\Gamma}_3 + u_{ijkl} \qquad (1)\end{aligned}$$

6. The matter is further complicated by the fact that certain households are simultaneously receiving assistance from more than one program. In our full sample, for example, about 11% of households received food stamps in the previous 12 months and 94% of these households had children participating in the NSLP. Similarly, about 4% of households received aid through the Temporary Assistance for Needy Families program in the previous 12 months and 92% of these households had children participating in the NSLP. Simultaneous participation in multiple welfare programs is another reason for why treating children's NSLP program take-up as exogenous can lead to estimation bias. We explicitly account for the endogeneity of children's NSLP beneficiary status in our preferred model.

where NSLP means-tested subsidy is an indicator variable for the child having to pay 40 cents or less for a school lunch; and in an expanded model, we contrast those children receiving a free lunch, *full subsidy*, from those paying a nominal cost for a school lunch, *partial subsidy*[7]:

$$\begin{aligned}\text{Servings}_{ijkl} = {} & \beta_0 + \beta_1(\textit{full subsidy})_{ijkl} \\ & + \beta_2(\textit{partial subsidy})_{ijkl} \\ & + \beta_3 \ \ln(\text{BMI})_{ijkl} + \boldsymbol{X}_{ijkl}\boldsymbol{\Gamma}_1 \\ & + \boldsymbol{Z}_j\boldsymbol{\Gamma}_2 + \boldsymbol{S}_k\boldsymbol{\Gamma}_3 + u_{ijkl}\end{aligned} \quad (2)$$

The control variable ln(BMI) is the natural logarithm of a child's body mass index (BMI) and is constructed as the ratio of weight to squared height. The BMI measure is typically compared against national standards, conditional on age and gender, to gain perspective on the physiological development of children (Cole 1991). We include this measure of body size to control for children's overall nourishment and, more importantly, for the unobserved serving sizes corresponding to children's reported weekly rates of consumption. To a limited extent, BMI also controls for differences in children's appetites and metabolisms that affect dietary patterns.[8]

X is a vector of potentially confounding variables measuring children's ages, gender, and disability status. We further include the natural logarithm of the highest parental years of schooling because of its complex relationship with children's health status and height (Thomas, Strauss, and Henriques 1991) and its potential to affect food choices, serving sizes, and preparation methods of parents. The natural logarithm of annual household income, the number of siblings, and the total household size are included to control for resource constraints affecting children's diets.[9] The number of days per week the child exercises for periods longer than 20 minutes and the average number of minutes per day the child watches television are included to control for behavioral factors affecting children's dietary patterns, appetites, and metabolisms (Dixon et al. 2007; Johnson 2000).

Z is a vector of potentially confounding variables measuring the availability of food sources within the zip code area where children's households are geographically located.[10] There is concern that the dietary patterns of children may depend on the density of food markets and restaurants in the vicinity of their households. For instance, large supermarkets typically charge lower prices and have a wider variety of food items relative to convenience stores and restaurants. Moreover, the evidence suggests that low-income households tend not to concentrate in suburban areas where food costs are generally lower (Kaufman et al. 1997; MacDonald and Nelson 1991). The additional variables we include in our model to control for differences across children in their access to food sources near home are per capita levels of supermarkets, convenience stores, full-service restaurants, and limited-service restaurants within the zip code area of households.[11]

Finally, ***S*** is a vector of potentially confounding school-level characteristics. We include a set of mutually exclusive indicator variables for Title I program eligibility and school-wide Title I program eligibility to control for general differences across schools in the proportion of students from low-income households.[12] To control for the overall quality of each school we include the average student-teacher ratio (Card and Krueger 1992; Rivkin, Hanushek, and Kain 2005) and the total student enrollment (Kuziemko 2006). Furthermore, we include

7. The extent of the household income effect for fully subsidized beneficiaries depends primarily on school attendance and for partially subsidized beneficiaries it depends on attendance, as well as whether their household is able to afford the remaining cost of school lunch. Sample means of the number of days a child were absent during the school year for beneficiaries and non-beneficiaries are close at 6.6 and 5.7, respectively, but statistically different from one another ($p < .001$); data on school absence were only available for approximately 90% of the children in the analytic sample. Differences in absenteeism do not appear to explain our findings.

8. The heights and weights of children's parents were not surveyed in the ECLS-K.

9. Utilizing a more flexible specification of education and/or income, such as a series of dummy variables for different categories, yields very similar results.

10. Zip codes are a classification system developed by the U.S. Postal Service; however, the U.S. Census Bureau reports certain geographical characteristics at the zip code level.

11. Data are unavailable for certain zip codes in the sample. Additional indicator variables are constructed for zip codes with missing values for each of the four control measures. The results we present are generally unaffected by the exclusion of the zip code controls.

12. Title I is a federal aid program that targets public schools serving low-income families. Specific details on the program's purpose are available at http://www2.ed.gov/programs/titleiparta/index.html

indicator variables for the availability of a la carte food and beverage menus, vending machines, and canteen or snack bars, respectively (Anderson and Butcher 2005).

A. Estimation Strategy and Statistical Methods

Ordinary least squares (OLS) estimates of the models in Equations (1) and (2) are likely to be biased if the decision to participate in a public welfare program is related to other unobservable determinants of individual behavior. For instance, variation in appetites among children may result in those with lower energy requirements enrolling into the NSLP with lower frequency even if their households meet the eligibility criteria. Moreover, even if all eligible children enroll in the NSLP, children with lower energy requirements would be less likely to consume school lunches, on average; and this would work to bias the estimated effects of the means-tested subsidies on children's weekly rates of consumption toward zero. In general, energy requirements are highly correlated with an individual's physical activity, body size, and metabolism.[13] To account for omitted and difficult-to-measure factors influencing children's dietary patterns, we include a reliable measure of body size (BMI) in our model to control for general differences in children's appetites and metabolisms. However, the frequency of consumption and the types of foods consumed can affect children's metabolisms which, in turn, can influence their body sizes.[14] Strictly relying on the inclusion of all potential variables affecting children's dietary patterns, body sizes, and NSLP participation decisions is a tenuous solution because appetites and metabolisms are the product of many environmental factors.[15]

To minimize the estimation bias resulting from the nonrandom assignment of NSLP means-tested subsidies and the endogenous relationship between body sizes and dietary patterns, we formulate an instrumental variables estimation strategy based on variation in the demand for school meals across the schools and school districts in which children are enrolled. Conditional on a child's energy requirements, the decision to participate in the NSLP may depend on prevailing social norms within a school or school district. For instance, Moffitt (1983) discusses the general phenomenon of individuals who meet eligibility criteria, but prefer to avoid a benefit entitlement because of a perceived social stigma associated with welfare program participation. In the context of the NSLP, a higher proportion of classmates consuming subsidized school meals on a daily basis would reduce any stigma associated with enrollment in the program and indicate a greater desirability of meals offered within a district. For example, 34% of children in our sample attend schools that report offering a la carte food items, and an increase in the variety of meal options is likely to stimulate overall student demand. In general, districts are granted considerable leeway in designing school meal menus and these menus exhibit wide variation in terms of nutrition and variety (Gordon et al. 2007a; Poppendieck 2010); however, the heterogeneity in menus also implies greater variation in the macro- and micronutrient balance of school meals (Gleason and Suitor 2003; Gordon et al. 2007b). In the United States, prevailing inverse relationships between energy cost and energy density of available foods provide a strong economic incentive for the substitution of low-cost, energy dense meal options for healthier, more expensive alternatives. Moreover, low-income households are more likely to face financial constraints that ultimately exacerbate any imbalances in children's macro- and micronutrient intakes by increasing body sizes and, in turn, minimum daily energy requirements (Darmon, Ferguson, and Briend 2002; Drewnowski and Darmon 2005a, 2005b).

We utilize the following instrumental variables for children's NSLP participation decisions and body sizes. First, we use the number of students in the school who participated in the means-tested component of NSLP in the previous school year and disaggregate the students into those receiving full and partial subsidies, respectively. Holding school enrollment constant, a higher proportion of students receiving subsidies would work to reduce any stigma

13. Bhargava, Jolliffe, and Howard (2008) find a greater frequency of physical exercise per week is negatively associated with children's body weights and BMIs. See Prentice et al. (1989) for a discussion of the complex interrelationships between energy intake, energy expenditure, and body size.

14. An individual's metabolism, or basal metabolic rate, is the minimum daily amount of energy required to sustain life. See Johnstone et al. (2005) for recent evidence on factors, such as fat-free body mass, which explain variation in these rates across individuals.

15. Escobar (1999) and Birch and Fisher (1998) provide a nice qualitative overview of the developmental and environmental factors affecting food preferences and patterns of consumption from early ages onward.

associated with program participation. However, holding participation stigma constant within a school, the appeal of school meals would also affect the decision to participate. To measure variation in demand for school meals we use total school district revenues from all school meals sales and disaggregate the revenues into the mutually exclusive funding categories of *federal*, *state*, and *local* sources. The revenues from each source are then expressed in per student levels to normalize by school district size.[16] Although the number of children in our analytic sample from each school district is very small relative to a district's total size, we take spending levels from the previous school year before the children are observed to avoid the possibility of simultaneity bias in our estimates.

The variable *federal* measures the revenues allocated by the federal government for Child Nutrition Act (CNA) programs such as the NSLP, School Breakfast Program, Special Milk Program, and A La Carte Program, and the variable *state* measures the revenues allocated by the state government for CNA program matching payments.[17] In contrast, the variable *local* measures the gross school meal sales revenues for each district, minus the revenues from state or federal sources. Holding constant a school district's total school meal sales revenues (*local*), higher federal and state revenues per student imply a higher number of CNA program participants consuming subsidized school meals, as well as lower stigma associated with program participation. Similarly, holding constant all CNA program revenues (*federal* and *state*), higher local revenues per student imply a higher aggregate demand for school meals in a district. The higher aggregate demand is for school meals, the greater the likelihood that children's body sizes will reflect the macro- and micronutrient composition of school meal items available within a district. Because we do not directly observe what the children consume at school during a typical week and the consumption outcomes we analyze are general categories of food and beverages, our estimation strategy controls for any substantive differences in the nutritional composition of school district meal options impacting students' dietary patterns by treating children's body sizes and, hence, minimum daily energy requirements, as endogenously determined.[18]

In the empirical analysis, consistent parameter estimates are obtained in this case using the heteroscedasticity-robust generalized method of moments (GMM) estimator available through Stata (Version 11, StataCorp LP, College Station, TX). The moment conditions implied by our instrumental variables estimation strategy are tested, and the results support our identification strategy (see Table A2). All reported standard errors are adjusted to allow for potential school-level clustering effects throughout the analysis.

IV. DATA

Data from a number of sources are utilized in the empirical model. A description of each source is provided along with an explanation for how certain variables are constructed from the best available data. The descriptive statistics for the analytic sample are reported in Table A1.

A. Data on Children and their Households from the ECLS-K

The ECLS-K is a longitudinal study that began in the fall of 1998 by observing nearly 20,000 children in kindergarten throughout the United States. Attrition as a result of geographical relocation resulted in approximately 11,000 children remaining in this study from kindergarten through fifth grade, and the locatable students were followed for a random 50% of schools (Tourangeau et al. 2006). We focus exclusively on the sixth survey round because this was the first in which children were surveyed on various types of food and beverages consumed in the previous week. As a result of missing observations on individual child and household data and the availability of specific school and school district characteristics discussed below, complete data were analyzed on

16. Data on school-level revenues from meal sales are unavailable.

17. With the passage of the CNA, the minimum state contribution could not be less than 30% of the administrative cost for all programs funded through the act (U.S. Congress 2004b).

18. The estimated reduced-form effects are jointly significant at a 5% level of significance for children's consumption of fruit, green salad, potatoes, 100% fruit juice, and sweetened beverages, are jointly significant at a 10% level of significance for children's consumption of carrots, and are statistically insignificant for children's consumption of other vegetables and cow milk, on average.

5,140 children in the fifth grade who attended over 1,200 schools in nearly 700 different public school districts located across 40 states during the spring of 2004.[19]

The consumption outcomes we analyze are based on children's own response to survey questions regarding the food they consumed during the previous 7-day period. The responses range 1 to 7 corresponding to answers of none, 1–3 times, 4–6 times, 1 time per day, 2 times per day, 3 times per day, or 4 or more times per day, respectively. Using cell midpoints, outcomes are constructed to measure the number of servings consumed in the previous week and range from 0 to 28. There are eight specific categories of consumption: (1) green salad; (2) carrots; (3) potatoes that do not include "French fries," fried potatoes, potato chips, or tater tots; (4) other vegetables not including green salad, potatoes, or carrots; (5) fruit such as apples, bananas, oranges, berries, or other types of fruit, and does not include fruit juice; (6) 100% fruit juice including only non-sweetened, 100% fruit juices such as orange juice, apple juice, or grape juice; (7) sweetened beverages including soda pop, sports drinks, or fruit drinks that are not 100% fruit juice; and (8) milk including all types of milk such as cow's milk, soy milk, or any other kind of milk, and whether it was in a carton, cup, glass, or with cereal.[20]

In addition, information was collected on the attributes of children and their households. Parents were asked directly whether their child was currently receiving a full or partial means-tested NSLP subsidy. Children's heights and body weights were measured using a Shorr Board and digital scale, respectively; duplicate measures were taken and the mean values were used.[21] The highest parental education level achieved was assessed as a categorical variable that ranges from 1 to 9 corresponding to answers of 8th grade or below, 9th to 12th grade, high school diploma/general equivalency diploma, vocational program, some college, bachelor's degree, graduate/professional school with no degree, master's degree, doctorate, or professional degree, respectively. Using cell midpoints, responses are mapped into one variable measuring the years of schooling for a child's parent and ranges from 4 to 20 treating categories 4 and 5 as equivalent to 14 years of schooling. Annual household income was assessed as a categorical variable that ranges from 1 to 13 corresponding to answers of <5, 5–10, 10–15, 15–20, 20–25, 25–30, 30–35, 35–40, 40–50, 50–75, 75–100, 100–200, >200 in US$1,000, respectively.[22] Using cell midpoints, responses are mapped into one variable measuring the annual household income in dollars and ranges from $2,500 to $200,000. Other relevant variables we include in our models are number of siblings, household size, the number of days per week the child exercises for periods longer than 20 minutes, the average number of minutes per day the child watches television, the age in months of the child, and gender. Finally, we construct an indicator variable measuring whether a child had been diagnosed by a professional to have a disability such as difficulty with eyesight or in hearing and understanding speech, or other impairments resulting in developmental disorder or delay.

B. Data on Food Sources Near Children's Households

We utilize the zip code location of children's households to match data from the U.S. Census Bureau 2004 Zip Code Business Patterns Survey. Variables that indicate the availability of sources for food and beverages close to a child's home are used to construct per capita measures for each child who lives in a zip code included in the survey universe. Establishments are classified according to the North American Industry Classification System and we utilize data on the number of supermarkets (#445110), convenience stores (#445120), full-service restaurants (#722110), and limited-service restaurants (#722211). Establishments meet the definition of a full-service restaurant if they provide food services to patrons who order and are served while seated from waiters and then pay after eating.

19. Demographic characteristics of the sample in the analysis were similar to the full sample covering all children from kindergarten through the fifth grade.

20. For our analysis of milk consumption, we restrict the analytic sample to 3,930 children reporting the milk consumed in the previous week was cow's milk because this is the particular type of milk provided by the NSLP.

21. A Shorr Board vertical stadiometer (Shorr Production, Olney, MD) measures standing height to the nearest 0.1 cm.

22. Finer measures of household income were not extensively surveyed after the base round in 1998. For example, only 14% of households in our full sample reported a specific value for their total annual household income; 35% and 2% of NSLP beneficiaries and non-beneficiaries, respectively.

In contrast, limited-service restaurants include establishments that provide food services to patrons who order and pay before eating. Per capita measures are constructed using zip code population data from the Census 2000 Summary File 1.

C. Data on Children's Schools and School Districts

We utilize the National Center for Education Statistics school identifiers to match data from the Common Core of Data (CCD), Public Elementary/Secondary School Universe Survey for school year 2003–2004. School-level control measures include a set of mutually exclusive indicator variables for Title I program eligibility and school-wide Title I program eligibility, the student-teacher ratio, and the total school enrollment. Furthermore, we utilize the CCD, Public Elementary/Secondary School Universe Survey for school year 2002–2003 to construct instrumental variables measuring the number of students who are fully and partially subsidized, respectively, through the NSLP. We use the previous fiscal year before the children are observed to avoid the possibility of simultaneity bias in our instrumental variables identification strategy. Similarly, we utilize the CCD, School District Finance Survey for school year 2002–2003 to construct instrumental variables based on school district revenues from federal, state, and local sources allocated for specific expenditures related to meals served in schools within the district. Specifically, we construct three per student revenue measures for each school district in the sample. The federal revenues are those allocated for CNA programs such as the NSLP, School Breakfast Program, Special Milk Program, and A la Carte Program. It does not include the monetary value of commodities that have been donated to the school districts. The state revenues are those allocated by the state government for CNA program matching payments.[23] The local revenues are the reported gross receipts from the sale of school breakfasts, lunches, and milk from students, teachers, and adults, and exclude revenues from state or federal funds (Berry and Cohen 2006).

23. With the passage of the CNA, the minimum state contribution could not be less than 30% of the administrative cost for all programs funded through the act (U.S. Congress 2004b).

V. RESULTS

We present the estimates from our models in Equations (1) and (2) for children's consumption of fruit, green salad, carrots, potatoes, other vegetables, cow milk, 100% fruit juice, and sweetened beverages in Tables 1–8, respectively. Columns (1)–(4) report the OLS estimates, whereas columns (5)–(8) report the GMM estimates under the assumption that children's BMIs and decisions to participate in the means-tested component of the NSLP are endogenous. The main findings are, first, OLS estimates indicate significant positive associations between NSLP means-tested subsidies and children's consumption of fruit, carrots, other vegetables, and 100% fruit juice by a magnitude in the range of 0.5–1.2 servings per week; however, the association is strongest among the population of children receiving full school lunch subsidies. In contrast, neither full nor partial school lunch subsidies are significantly related to children's consumption of green salad, potatoes, cow's milk, and sweetened beverages in models that assume the random assignment of NSLP participation decisions and exogeneity of children's body sizes.

Second, we applied the instrumental variables estimation strategy outlined in Section III(A) to draw stronger conclusions regarding the causal effects of the subsidies on children's dietary patterns. GMM estimates indicate significant increases in the number of servings of fruit, green salad, carrots, other vegetables, and 100% fruit juice consumed in a week for subsidized children relative to unsubsidized children. The local average treatment effect for children receiving full and partial subsidies is an additional 10.8 servings of fruit per week, 3.1 servings of green salad per week, 5.6 servings of carrots per week, 5.2 servings of other vegetables per week, and 10.2 servings of 100% fruit juice per week. Although the cost of school lunches for children receiving partial subsidies is nominal at 40 cents or less, GMM estimates of the model in Equation (2) suggest the cost constraint is binding. For instance, children receiving full school lunch subsidies have significant increases in fruit consumption per week, whereas partial school lunch subsidies are not significantly associated with changes in fruit consumption (Table 1, column 7); and a similar pattern is evident for children's consumption of other vegetables (Table 5, column 7).

TABLE 1
Estimates of the Effect of NSLP Means-Tested Subsidies on Children's Weekly Consumption of Fruit[a,b]

	Servings of Fruit Consumed in Previous Week							
	OLS				GMM			
Explanatory Variable	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
NSLP means-tested subsidy	1.2216**	0.3411	—	—	10.7691**	4.5427	—	—
Full subsidy	—	—	1.4715**	0.3634	—	—	10.5532**	4.4795
Partial subsidy	—	—	0.8633*	0.4488	—	—	7.3259	7.2839
Ln(BMI)	0.5324	0.5414	0.5313	0.5417	−33.7977**	16.7927	−33.7091**	16.5061
Physical exercise	0.1232*	0.0633	0.1255**	0.0633	−0.2155	0.1903	−0.2056	0.1874
Television watching	−0.0062**	0.0016	−0.0062**	0.0016	0.0034	0.0055	0.0036	0.0054
Age	−0.0440*	0.0265	−0.0429	0.0265	0.0271	0.0513	0.0322	0.0514
Male	−0.3716	0.2345	−0.3665	0.2346	0.1849	0.4273	0.2310	0.4297
Disability	−0.1060	0.3415	−0.1172	0.3426	−0.2965	0.4647	−0.3279	0.4659
Number of siblings	0.0218	0.1996	0.0169	0.1999	−1.0271*	0.5564	−0.9938*	0.5496
Household size	0.2143	0.1595	0.2133	0.1598	0.2819	0.2612	0.3235	0.2643
Ln(parent years of schooling)	0.1511	0.5459	0.1840	0.5445	−0.2111	0.9402	−0.2713	0.9288
Ln(annual household income)	0.0388	0.1971	0.0935	0.1967	2.3925**	1.2128	2.2135*	1.2282
Supermarkets per capita	373.4325	726.5483	356.9790	723.7473	323.3424	1,097.3127	444.3521	1,093.1519
Convenience stores per capita	319.1263	224.5403	315.0864	227.6194	13.7820	325.7235	−7.5281	294.5129
Full-service restaurants per capita	−91.9099	247.0015	−76.8117	247.1868	−51.3155	378.3586	−61.1964	368.3130
Limited-service restaurants per capita	−35.1554	126.8007	−41.0388	127.0963	3.0075	189.5711	2.9923	182.7357
Title I program eligibility	−0.0977	0.2868	−0.0967	0.2863	0.8541	0.5987	0.8215	0.5930
School-wide Title I program eligibility	0.4136	0.3019	0.4019	0.3012	0.2997	0.5464	0.4565	0.5947
Student-teacher ratio	0.0716*	0.0382	0.0726*	0.0382	0.0664	0.0521	0.0701	0.0525
Total student enrollment	0.0002	0.0005	0.0001	0.0005	0.0002	0.0007	0.0001	0.0007
School has a la carte food and beverage menu	−0.0962	0.2400	−0.0921	0.2396	0.5517	0.4464	0.5143	0.4446
School has vending machines for students	−0.2552	0.2870	−0.2539	0.2867	0.0529	0.4354	0.0839	0.4342
School has canteen or snack bar for students	−0.7215**	0.2626	−0.7175**	0.2621	−0.1683	0.4596	−0.2044	0.4568

Notes: Coefficients and standard errors reported. Standard errors are adjusted for school-level clustering. Data on 5,140 public school children in fifth grade observed during spring 2004 in the ECLS-K were used in the estimation. All regressions include a constant term and indicator variables for missing zip code data on supermarkets, convenience stores, full-service restaurants, and limited-service restaurants, respectively.

[a]Includes fruit such as apples, bananas, oranges, berries, or other types of fruit, and does not include fruit juice.

[b]GMM models treat children's BMIs and decisions to participate in the means-tested component of the NSLP as endogenous. The instrumental variables strategy is presented in Section III(A) of this article and the results from instrumental variables diagnostic tests are presented in Table A2.

*Significant at 10% level; **significant at 5% level.

TABLE 2

Estimates of the Effect of NSLP Means-Tested Subsidies on Children's Weekly Consumption of Green Salad[a,b]

	Servings of Green Salad Consumed in Previous Week							
	OLS				GMM			
Explanatory Variable	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
NSLP means-tested subsidy	0.0939	0.1653	—	—	3.0944*	1.8611	—	—
Full subsidy	—	—	0.1191	0.1804	—	—	3.7934*	2.2104
Partial subsidy	—	—	0.0576	0.2299	—	—	8.6505**	3.7163
Ln(BMI)	0.7781**	0.2837	0.7780**	0.2837	−7.9699	6.5965	−10.3437	7.8489
Physical exercise	0.0454	0.0346	0.0457	0.0345	−0.0399	0.0724	−0.0800	0.0885
Television watching	−0.0011	0.0008	−0.0011	0.0008	0.0013	0.0021	0.0019	0.0025
Age	−0.0011	0.0133	−0.0010	0.0134	0.0185	0.0208	0.0141	0.0243
Male	−0.5355**	0.1163	−0.5350**	0.1166	−0.3957**	0.1689	−0.4251**	0.1945
Disability	−0.0920	0.1547	−0.0931	0.1550	−0.1684	0.1812	−0.0989	0.2042
Number of siblings	0.1102	0.0922	0.1097	0.0921	−0.1501	0.2185	−0.2545	0.2659
Household size	−0.0844	0.0734	−0.0845	0.0735	−0.1068	0.0940	−0.1557	0.1176
Ln(parent years of schooling)	0.2249	0.2604	0.2283	0.2604	0.1266	0.3735	0.1190	0.4323
Ln(annual household income)	−0.0018	0.1004	0.0038	0.1019	0.7807	0.5048	1.1241*	0.6113
Supermarkets per capita	−10.1160	285.6747	−11.7796	286.0285	−99.5277	365.6336	−208.1607	420.0420
Convenience stores per capita	73.0132	77.8298	72.6047	77.7834	16.9876	156.0389	16.6080	247.4972
Full-service restaurants per capita	−69.6185	109.7517	−68.0919	110.5576	−49.6066	136.6833	−47.2050	171.3504
Limited-service restaurants per capita	23.1033	57.9649	22.5084	58.3194	29.4683	74.3532	36.4371	98.5201
Title I program eligibility	−0.1363	0.1448	−0.1362	0.1449	0.1136	0.2439	0.2129	0.2853
School-wide Title I program eligibility	−0.0389	0.1541	−0.0400	0.1541	−0.1436	0.2310	−0.3359	0.2855
Student-teacher ratio	0.0383**	0.0165	0.0384**	0.0165	0.0357*	0.0193	0.0271	0.0225
Total student enrollment	0.0005*	0.0003	0.0005*	0.0003	0.0004	0.0003	0.0006	0.0004
School has a la carte food and beverage menu	−0.0204	0.1239	−0.0200	0.1239	0.1831	0.1700	0.2497	0.1976
School has vending machines for students	0.1505	0.1345	0.1507	0.1346	0.2131	0.1700	0.1946	0.1977
School has canteen or snack bar for students	−0.0733	0.1497	−0.0729	0.1495	0.0726	0.1879	0.1350	0.2168

Notes: Coefficients and standard errors reported. Standard errors are adjusted for school-level clustering. Data on 5,140 public school children in fifth grade observed during spring 2004 in the ECLS-K were used in the estimation. All regressions include a constant term and indicator variables for missing zip code data on supermarkets, convenience stores, full-service restaurants, and limited-service restaurants, respectively.

[a]Includes only green salad.

[b]GMM models treat children's BMIs and decisions to participate in the means-tested component of the NSLP as endogenous. The instrumental variables strategy is presented in Section III(A) of this article and the results from instrumental variables diagnostic tests are presented in Table A2.

*Significant at 10% level; **significant at 5% level.

TABLE 3

Estimates of the Effect of NSLP Means-Tested Subsidies on Children's Weekly Consumption of Carrots[a,b]

	Servings of Carrots Consumed in Previous Week							
	OLS				GMM			
Explanatory Variable	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
NSLP means-tested subsidy	0.6047**	0.2375	—	—	5.5933*	2.9970	—	—
Full subsidy	—	—	0.7984**	0.2721	—	—	5.9095*	3.1304
Partial subsidy	—	—	0.3271	0.2930	—	—	7.5962*	4.6075
Ln(BMI)	−0.0002	0.3381	−0.0011	0.3377	−16.9651*	9.7711	−17.5733*	10.1216
Physical exercise	0.0656	0.0429	0.0674	0.0429	−0.1005	0.1059	−0.1109	0.1109
Television watching	−0.0030**	0.0009	−0.0030**	0.0009	0.0017	0.0031	0.0019	0.0032
Age	−0.0632**	0.0178	−0.0624**	0.0178	−0.0269	0.0302	−0.0288	0.0314
Male	0.0108	0.1540	0.0147	0.1542	0.2709	0.2413	0.2564	0.2490
Disability	0.1863	0.2278	0.1776	0.2274	0.0949	0.2790	0.1031	0.2863
Number of siblings	−0.0155	0.1222	−0.0193	0.1219	−0.5285	0.3272	−0.5697*	0.3449
Household size	0.0542	0.1112	0.0534	0.1114	0.0611	0.1561	0.0480	0.1630
Ln(parent years of schooling)	0.1024	0.3489	0.1279	0.3469	−0.0759	0.5403	−0.0872	0.5568
Ln(annual household income)	0.2012	0.1242	0.2436*	0.1295	1.4676*	0.8079	1.6126*	0.8647
Supermarkets per capita	80.6089	401.8225	67.8602	400.5739	93.8033	498.1221	22.2170	536.8264
Convenience stores per capita	177.8522	380.6809	174.7220	382.7176	55.8265	264.2196	57.2737	246.5341
Full-service restaurants per capita	3.4912	166.9271	15.1899	166.7258	34.3395	240.4235	53.1478	252.7948
Limited-service restaurants per capita	−41.1119	112.1532	−45.6705	112.3750	−35.9894	132.0424	−40.6629	136.2822
Title I program eligibility	−0.0072	0.2146	−0.0064	0.2142	0.4464	0.3846	0.4733	0.3976
School-wide Title I program eligibility	0.1084	0.2018	0.0994	0.2013	−0.0042	0.3715	−0.0947	0.4113
Student-teacher ratio	0.0523**	0.0233	0.0531**	0.0232	0.0476	0.0298	0.0447	0.0310
Total student enrollment	0.0003	0.0004	0.0003	0.0004	0.0002	0.0004	0.0003	0.0005
School has a la carte food and beverage menu	0.0466	0.1636	0.0498	0.1634	0.3381	0.2774	0.3709	0.2909
School has vending machines for students	−0.0390	0.1848	−0.0379	0.1845	0.1387	0.2500	0.1247	0.2595
School has canteen or snack bar for students	−0.2119	0.1842	−0.2088	0.1839	0.0577	0.2654	0.0823	0.2764

Notes: Coefficients and standard errors reported. Standard errors are adjusted for school-level clustering. Data on 5,140 public school children in fifth grade observed during spring 2004 in the ECLS-K were used in the estimation. All regressions include a constant term and indicator variables for missing zip code data on supermarkets, convenience stores, full-service restaurants, and limited-service restaurants, respectively.

[a]Includes only carrots.

[b]GMM models treat children's BMIs and decisions to participate in the means-tested component of the NSLP as endogenous. The instrumental variables strategy is presented in Section III(A) of this article and the results from instrumental variables diagnostic tests are presented in Table A2.

*Significant at 10% level; **significant at 5% level.

TABLE 4
Estimates of the Effect of NSLP Means-Tested Subsidies on Children's Weekly Consumption of Potatoes[a,b]

	Servings of Potatoes Consumed in Previous Week							
	OLS				GMM			
Explanatory Variable	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
NSLP means-tested subsidy	0.1253	0.1587	—	—	−1.3402	1.9095	—	—
Full subsidy	—	—	0.2263	0.1791	—	—	−1.3448	1.9181
Partial subsidy	—	—	−0.0195	0.1900	—	—	−1.4898	3.0344
Ln(BMI)	−0.0898	0.2618	−0.0903	0.2617	12.4715*	6.5853	12.4642*	6.6456
Physical exercise	−0.0107	0.0302	−0.0098	0.0302	0.1130	0.0752	0.1131	0.0761
Television watching	0.0008	0.0007	0.0008	0.0007	−0.0031	0.0021	−0.0031	0.0022
Age	−0.0043	0.0115	−0.0038	0.0115	−0.0291	0.0194	−0.0288	0.0194
Male	0.0677	0.0964	0.0698	0.0965	−0.1693	0.1652	−0.1667	0.1660
Disability	0.1465	0.1427	0.1420	0.1425	0.1670	0.1736	0.1656	0.1777
Number of siblings	−0.1633	0.1024	−0.1652	0.1022	0.1443	0.2384	0.1462	0.2426
Household size	0.1269	0.0864	0.1265	0.0862	0.0458	0.1186	0.0463	0.1189
Ln(parent years of schooling)	−0.3047	0.2480	−0.2914	0.2487	0.1044	0.3914	0.1051	0.3916
Ln(annual household income)	−0.1090	0.0830	−0.0869	0.0833	−0.3542	0.5085	−0.3622	0.5225
Supermarkets per capita	−131.2704	329.2077	−137.9194	328.2122	−296.4010	416.6202	−292.1360	420.2031
Convenience stores per capita	−238.7394**	69.6282	−240.3720**	69.3435	−114.9765	129.4519	−112.3375	130.1841
Full-service restaurants per capita	−41.8430	112.9170	−35.7417	113.8395	37.8108	154.5342	34.7467	155.1617
Limited-service restaurants per capita	75.6045	56.5307	73.2270	56.8762	24.0004	80.0072	24.7790	80.4995
Title I program eligibility	0.1899	0.1157	0.1903	0.1157	−0.1015	0.2299	−0.1060	0.2330
School-wide Title I program eligibility	0.4143**	0.1223	0.4095**	0.1227	0.1474	0.2360	0.1520	0.2497
Student-teacher ratio	0.0090	0.0147	0.0094	0.0148	0.0074	0.0199	0.0075	0.0203
Total student enrollment	−0.0001	0.0002	−0.0001	0.0002	−0.0002	0.0003	−0.0002	0.0003
School has a la carte food and beverage menu	−0.0280	0.1028	−0.0264	0.1026	−0.1867	0.1681	−0.1869	0.1722
School has vending machines for students	0.1099	0.1379	0.1105	0.1377	−0.1071	0.1900	−0.1033	0.1932
School has canteen or snack bar for students	−0.1280	0.1215	−0.1264	0.1214	−0.2358	0.1819	−0.2380	0.1850

Notes: Coefficients and standard errors reported. Standard errors are adjusted for school-level clustering. Data on 5,140 public school children in fifth grade observed during spring 2004 in the ECLS-K were used in the estimation. All regressions include a constant term and indicator variables for missing zip code data on supermarkets, convenience stores, full-service restaurants, and limited-service restaurants, respectively.

[a]Does not include "French fries," fried potatoes, potato chips, or tater tots.

[b]GMM models treat children's BMIs and decisions to participate in the means-tested component of the NSLP as endogenous. The instrumental variables strategy is presented in Section III(A) of this article and the results from instrumental variables diagnostic tests are presented in Table A2.

*Significant at 10% level; **significant at 5% level.

TABLE 5

Estimates of the Effect of NSLP Means-Tested Subsidies on Children's Weekly Consumption of Other Vegetables[a,b]

	Servings of Other Vegetables Consumed in Previous Week							
	OLS				GMM			
Explanatory Variable	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
NSLP means-tested subsidy	0.4786*	0.2593	—	—	5.2005*	2.7963	—	—
Full subsidy	—	—	0.7989**	0.2927	—	—	4.9641*	2.8179
Partial subsidy	—	—	0.0195	0.3292	—	—	0.8824	4.6466
Ln(BMI)	0.1055	0.4287	0.1041	0.4291	−10.4829	9.7383	−11.5104	9.8066
Physical exercise	0.1044**	0.0501	0.1074**	0.0501	0.0011	0.1099	0.0063	0.1099
Television watching	−0.0015	0.0013	−0.0015	0.0013	0.0010	0.0032	0.0016	0.0033
Age	−0.0437**	0.0200	−0.0424**	0.0200	−0.0194	0.0291	−0.0130	0.0299
Male	−0.3970**	0.1861	−0.3905**	0.1862	−0.2341	0.2590	−0.1667	0.2691
Disability	−0.0421	0.2601	−0.0564	0.2598	−0.0937	0.2816	−0.1608	0.2894
Number of siblings	−0.1371	0.1620	−0.1433	0.1624	−0.4950	0.3192	−0.5028	0.3178
Household size	0.2645**	0.1305	0.2633**	0.1310	0.2106	0.1508	0.2922*	0.1662
Ln(parent years of schooling)	0.6380*	0.3852	0.6802*	0.3827	0.7737	0.5858	0.6694	0.5908
Ln(annual household income)	0.0143	0.1481	0.0845	0.1542	1.2806*	0.7507	1.0472	0.7807
Supermarkets per capita	192.7466	659.9651	171.6579	657.6193	−175.4485	726.7640	60.8407	748.5456
Convenience stores per capita	310.0444	248.3181	304.8664	244.3869	235.8740	387.6787	179.7740	339.1271
Full-service restaurants per capita	−247.3545	204.3621	−228.0029	205.2986	−125.9124	239.8157	−139.2130	235.7857
Limited-service restaurants per capita	56.3848	111.9131	48.8440	112.1112	34.1082	135.6137	33.7019	129.0545
Title I program eligibility	−0.0674	0.2384	−0.0661	0.2383	0.2913	0.3561	0.2535	0.3630
School-wide Title I program eligibility	−0.1011	0.2508	−0.1161	0.2507	−0.4130	0.3630	−0.1743	0.4264
Student-teacher ratio	0.0081	0.0336	0.0094	0.0336	0.0154	0.0364	0.0161	0.0369
Total student enrollment	−0.0003	0.0004	−0.0003	0.0004	−0.0004	0.0005	−0.0004	0.0005
School has a la carte food and beverage menu	−0.1096	0.1950	−0.1043	0.1950	0.1908	0.2592	0.1311	0.2670
School has vending machines for students	−0.1898	0.2505	−0.1881	0.2501	−0.2048	0.2803	−0.1097	0.2922
School has canteen or snack bar for students	−0.1369	0.2390	−0.1318	0.2391	0.1000	0.2884	0.0778	0.2920

Notes: Coefficients and standard errors reported. Standard errors are adjusted for school-level clustering. Data on 5,140 public school children in fifth grade observed during spring 2004 in the ECLS-K were used in the estimation. All regressions include a constant term and indicator variables for missing zip code data on supermarkets, convenience stores, full-service restaurants, and limited-service restaurants, respectively.

[a]Does not include green salad, potatoes, or carrots.

[b]GMM models treat children's BMIs and decisions to participate in the means-tested component of the NSLP as endogenous. The instrumental variables strategy is presented in Section III(A) of this article and the results from instrumental variables diagnostic tests are presented in Table A2.

*Significant at 10% level; **significant at 5% level.

TABLE 6

Estimates of the Effect of NSLP Means-Tested Subsidies on Children's Weekly Consumption of Cow's Milk[a,b]

	Servings of Cow's Milk Consumed in Previous Week							
	OLS				GMM			
Explanatory Variable	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
NSLP means-tested subsidy	−0.0252	0.3983	—	—	−2.2304	3.9375	—	—
Full subsidy	—	—	0.3839	0.4600	—	—	−2.2055	3.9526
Partial subsidy	—	—	−0.5661	0.4944	—	—	−0.7048	6.3099
Ln(BMI)	−1.4818**	0.6714	−1.4721**	0.6704	4.4204	10.7753	5.4379	11.0471
Physical exercise	0.0771	0.0759	0.0789	0.0758	0.1502	0.1460	0.1593	0.1470
Television watching	−0.0046**	0.0020	−0.0046**	0.0020	−0.0062*	0.0037	−0.0067*	0.0038
Age	0.0121	0.0340	0.0143	0.0340	−0.0039	0.0443	−0.0090	0.0465
Male	0.8110**	0.2910	0.8167**	0.2908	0.7136**	0.3397	0.6919**	0.3457
Disability	0.8605**	0.4263	0.8420**	0.4256	0.8749**	0.4318	0.8798**	0.4360
Number of siblings	0.2563	0.2499	0.2519	0.2495	0.5169	0.4945	0.5420	0.4936
Household size	−0.2851	0.2055	−0.2917	0.2053	−0.3112	0.2296	−0.3505	0.2539
Ln(parent years of schooling)	1.0578*	0.6260	1.0974*	0.6291	1.1289	0.7090	1.2159	0.7616
Ln(annual household income)	0.3387	0.2302	0.4324*	0.2363	−0.2385	1.0881	−0.1632	1.1257
Supermarkets per capita	−180.4125	960.1655	−210.5492	961.9663	−37.3005	1,006.7750	−105.1410	1,027.4783
Convenience stores per capita	914.6457**	361.7405	910.3067**	352.7020	1,017.3955**	330.6079	1,025.9992**	342.1047
Full-service restaurants per capita	−98.9784	377.6306	−84.4935	381.0396	−189.3517	393.6548	−167.8134	397.8197
Limited-service restaurants per capita	328.8047	479.5595	347.6822	483.4716	307.3726	495.2149	281.4955	498.7161
Title I program eligibility	0.1258	0.4546	0.1343	0.4559	0.1114	0.4981	0.0927	0.5034
School-wide Title I program eligibility	−1.4421**	0.4403	−1.4544**	0.4414	−1.2636**	0.5765	−1.3685**	0.6827
Student-teacher ratio	−0.0222	0.0507	−0.0211	0.0509	−0.0109	0.0503	−0.0120	0.0509
Total student enrollment	−0.0005	0.0006	−0.0005	0.0006	−0.0004	0.0006	−0.0004	0.0006
School has a la carte food and beverage menu	0.0024	0.3542	0.0055	0.3545	−0.1968	0.3822	−0.1885	0.3828
School has vending machines for students	0.6823	0.4241	0.6737	0.4256	0.5098	0.4383	0.5089	0.4401
School has canteen or snack bar for students	−0.6816*	0.3701	−0.6664*	0.3708	−0.7463*	0.4324	−0.7701*	0.4364

Notes: Coefficients and standard errors reported. Standard errors are adjusted for school-level clustering. Data on 3,930 public school children in fifth grade observed during spring 2004 in the ECLS-K were used in the estimation. All regressions include a constant term and indicator variables for missing zip code data on supermarkets, convenience stores, full-service restaurants, and limited-service restaurants, respectively.

[a]For our analysis of milk consumption, we restrict the analytic sample to 3,930 children reporting the milk consumed in the previous week was cow's milk because this is the particular type of milk provided by the NSLP.

[b]GMM models treat children's BMIs and decisions to participate in the means-tested component of the NSLP as endogenous. The instrumental variables strategy is presented in Section III(A) of this article and the results from instrumental variables diagnostic tests are presented in Table A2.

*Significant at 10% level; **significant at 5% level.

TABLE 7

Estimates of the Effect of NSLP Means-Tested Subsidies on Children's Weekly Consumption of 100% Fruit Juice[a,b]

	Servings of 100% Fruit Juice Consumed in Previous Week							
	OLS				GMM			
Explanatory Variable	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
NSLP means-tested subsidy	0.4510	0.2896	—	—	10.1982**	3.8483	—	—
Full subsidy	—	—	0.6753**	0.3339	—	—	10.4552**	3.9984
Partial subsidy	—	—	0.1294	0.3653	—	—	12.9000*	6.6280
Ln(BMI)	−0.4260	0.4943	−0.4270	0.4943	−21.3123	13.5269	−22.2807	14.1284
Physical exercise	−0.0030	0.0528	−0.0009	0.0527	−0.2116	0.1495	−0.2259	0.1582
Television watching	−0.0022	0.0014	−0.0022	0.0014	0.0031	0.0045	0.0033	0.0047
Age	−0.0196	0.0245	−0.0186	0.0245	0.0263	0.0403	0.0230	0.0421
Male	0.1732	0.2090	0.1778	0.2083	0.4761	0.3509	0.4738	0.3623
Disability	−0.1267	0.2831	−0.1367	0.2829	−0.2786	0.3577	−0.2622	0.3686
Number of siblings	0.1487	0.1833	0.1443	0.1836	−0.6013	0.4487	−0.6461	0.4709
Household size	0.0205	0.1485	0.0196	0.1492	−0.0803	0.2074	−0.1022	0.2176
Ln(parent years of schooling)	−0.0218	0.5198	0.0077	0.5190	0.1605	0.7013	0.1628	0.7236
Ln(annual household income)	−0.2387	0.1750	−0.1896	0.1786	2.4024**	1.0387	2.5507**	1.1074
Supermarkets per capita	277.0410	615.4949	262.2739	613.5582	−107.9848	855.1996	−156.3141	886.4490
Convenience stores per capita	−1.1903	308.5956	−4.8161	306.9604	−171.4489	605.0063	−160.1114	647.7299
Full-service restaurants per capita	−88.3912	213.1923	−74.8405	212.3773	88.2928	329.6231	76.8823	345.1065
Limited-service restaurants per capita	24.9664	119.4127	19.6861	119.0473	−7.2454	194.2391	0.2124	205.6787
Title I program eligibility	0.1764	0.2569	0.1773	0.2568	0.7992	0.4964	0.8431	0.5198
School-wide Title I program eligibility	0.6687**	0.2811	0.6582**	0.2813	0.0429	0.4830	−0.0431	0.5248
Student-teacher ratio	0.0465	0.0331	0.0474	0.0331	0.0360	0.0412	0.0334	0.0426
Total student enrollment	0.0009**	0.0004	0.0009**	0.0004	0.0009	0.0006	0.0009	0.0006
School has a la carte food and beverage menu	0.0683	0.2211	0.0720	0.2208	0.5708	0.3581	0.6120	0.3795
School has vending machines for students	−0.3355	0.2545	−0.3343	0.2541	−0.2158	0.3613	−0.2330	0.3750
School has canteen or snack bar for students	−0.0868	0.2557	−0.0832	0.2558	0.3382	0.3605	0.3730	0.3767

Notes: Coefficients and standard errors reported. Standard errors are adjusted for school-level clustering. Data on 5,140 public school children in fifth grade observed during spring 2004 in the ECLS-K were used in the estimation. All regressions include a constant term and indicator variables for missing zip code data on supermarkets, convenience stores, full-service restaurants, and limited-service restaurants, respectively.

[a]Includes only non-sweetened, 100% fruit juices such as orange juice, apple juice, or grape juice.

[b]GMM models treat children's BMIs and decisions to participate in the means-tested component of the NSLP as endogenous. The instrumental variables strategy is presented in Section III(A) of this article and the results from instrumental variables diagnostic tests are presented in Table A2.

*Significant at 10% level; **significant at 5% level.

TABLE 8

Estimates of the Effect of NSLP Means-Tested Subsidies on Children's Weekly Consumption of Sweetened Beverages[a,b]

	Servings of Sweetened Beverages Consumed in Previous Week							
	OLS				GMM			
Explanatory Variable	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
NSLP means-tested subsidy	0.0699	0.3384	—	—	−2.6681	5.6324	—	—
Full subsidy	—	—	−0.0107	0.3821	—	—	−2.3121	5.6760
Partial subsidy	—	—	0.1855	0.4162	—	—	1.2535	7.8787
Ln(BMI)	−0.6105	0.5176	−0.6101	0.5175	40.9576**	18.4128	41.3205**	18.5379
Physical exercise	0.1990**	0.0568	0.1982**	0.0569	0.6156**	0.2067	0.6069**	0.2075
Television watching	0.0063**	0.0016	0.0063**	0.0016	−0.0065	0.0059	−0.0070	0.0059
Age	0.0689**	0.0247	0.0686**	0.0246	−0.0101	0.0532	−0.0184	0.0547
Male	0.6402**	0.2150	0.6386**	0.2149	−0.1347	0.4175	−0.1749	0.4251
Disability	0.8383**	0.3451	0.8419**	0.3449	0.9372*	0.4898	0.9711**	0.4951
Number of siblings	−0.0428	0.1712	−0.0413	0.1712	0.9210	0.6227	0.8884	0.6237
Household size	−0.1657	0.1479	−0.1654	0.1478	−0.5297**	0.2479	−0.5796**	0.2516
Ln(parent years of schooling)	−1.4812**	0.5034	−1.4918**	0.5014	0.2060	0.8635	0.2398	0.8705
Ln(annual household income)	0.1049	0.1775	0.0872	0.1834	−0.0757	1.4710	0.1594	1.5167
Supermarkets per capita	922.2113	668.6098	927.5184	668.0184	−10.7560	1,003.7235	−186.7933	1,022.0327
Convenience stores per capita	−162.7403	424.5569	−161.4373	423.3610	194.4801	735.4147	242.9041	682.3058
Full-service restaurants per capita	−131.3218	320.4914	−136.1917	321.2065	239.0226	406.1425	227.1405	405.1212
Limited-service restaurants per capita	29.8703	188.2484	31.7679	188.3231	−157.9408	251.5944	−147.5651	245.5647
Title I program eligibility	0.1163	0.3065	0.1160	0.3065	−0.8719	0.6809	−0.8498	0.6865
School-wide Title I program eligibility	0.9295**	0.3131	0.9332**	0.3129	−0.1552	0.6501	−0.3863	0.7216
Student-teacher ratio	−0.0491	0.0396	−0.0495	0.0396	−0.0445	0.0582	−0.0516	0.0593
Total student enrollment	0.0007	0.0005	0.0007	0.0005	0.0005	0.0007	0.0005	0.0007
School has a la carte food and beverage menu	0.0665	0.2620	0.0652	0.2619	−0.4611	0.5370	−0.3986	0.5443
School has vending machines for students	−0.2691	0.3031	−0.2695	0.3030	−0.8099*	0.4876	−0.8501*	0.4937
School has canteen or snack bar for students	0.3876	0.3241	0.3863	0.3242	−0.0632	0.4925	−0.0122	0.4992

Notes: Coefficients and standard errors reported. Standard errors are adjusted for school-level clustering. Data on 5,140 public school children in fifth grade observed during spring 2004 in the ECLS-K were used in the estimation. All regressions include a constant term and indicator variables for missing zip code data on supermarkets, convenience stores, full-service restaurants, and limited-service restaurants, respectively.

[a]Includes soda pop, sports drinks, or fruit drinks that are not 100% fruit juice.

[b]GMM models treat children's BMIs and decisions to participate in the means-tested component of the NSLP as endogenous. The instrumental variables strategy is presented in Section III(A) of this article and the results from instrumental variables diagnostic tests are presented in Table A2.

*Significant at 10% level; **significant at 5% level.

Third, the GMM estimates of the model in Equation (2) also indicate children's body sizes predict dietary patterns over the course a week. In particular, children with higher BMIs consume fewer servings of fruit and carrots per week and more servings of potatoes and sweetened beverages per week. This finding is consistent with larger body sizes having higher energy requirements and, hence, requiring greater macronutrient intakes, on average. Fourth, higher annual household incomes are positively associated with children's consumption of fruit, green salad, carrots, and 100% fruit juice. Although carrots are generally an inexpensive source of nourishment, the other items are more expensive sources of the micronutrients that form the basis of a healthful, nutrient-dense diet.[24] Moreover, the associations we find between household incomes and children's dietary patterns are conditional on several detailed controls for variation in the availability of food sources close to a child's home, and underscore the importance of accounting for the effects of budgetary constraints in the context of household dietary choices.

VI. CONCLUSIONS

In this study, we evaluate the effect of the NSLP means-tested subsidies on the number of servings of fruit, green salad, carrots, potatoes, other vegetables, cow's milk, 100% fruit juice, and sweetened beverages consumed by fifth grade public school children aged 10–13 years over the course of 1 week. The empirical methodology we develop here produces results that suggest treating the assignment of the school lunch subsidies as random or ignoring the endogenous relationship between children's body sizes and dietary patterns leads to incorrect conclusions regarding the effectiveness of this large-scale program, or understated conclusions at best. Overall, the findings indicate this policy component of the NSLP has a significant impact on children's dietary patterns and contributes toward meeting USDA recommendations of consumption of items in the vegetable and fruit food groups of a healthful diet.

24. See Andrieu, Darmon, and Drewnowski (2006) for evidence on the relationship between diet cost and macro- and micronutrient density.

This article provides the first empirical analysis of the changes in children's dietary patterns that result from the subsidies over a period longer than one school day. Understanding the extent to which increases in children's consumption persist at a weekly interval of time is an important step in evaluating the effectiveness of the NSLP in meeting its policy objective of preventing the undernourishment of children from low-income households. We find that children receiving full and partial subsidies consume an additional 10.8 servings of fruit per week, 3.1 servings of green salad per week, 5.6 servings of carrots per week, 5.2 servings of other vegetables per week, and 10.2 servings of 100% fruit juice per week. Regularly consuming foods high in essential vitamins and minerals is an important ingredient in the prevention of unfavorable development and growth outcomes for children. In this regard, the NSLP means-tested subsidies are positively affecting children's diets. However, we caution against drawing stronger conclusions on the overall effect of the program on children's nourishment because the dietary survey data analyzed here are somewhat limited in scope. The outcomes do not cover items included in the grain or meat and beans category of a healthful diet, and we are unable to map the reported number of servings of food and beverages into more precise macro- and micronutrient intake levels. More extensive data on the dietary patterns of children and their household members would afford deeper insight into the extent to which low-income households reallocate food resources to other members in response to the benefits of food and nutrition programs.

In conclusion, the estimated effects of the program on fruit and other vegetable consumption are stronger among children receiving full school lunch subsidies, as opposed to partial school lunch subsidies. Although the cost of school lunches for children receiving partial subsidies is nominal at 40 cents or less, the evidence is consistent with the hypothesis that the cost is a binding constraint for certain children on the margin of eligibility. Additional research into the extent to which the nominal cost of school meals is a barrier to access for children from low-income households would likely prove informative for policy makers considering the future direction and overall effectiveness of the NSLP and other entitlement programs concerned with preventing undernourishment among children.

APPENDIX

TABLE A1

Selected Variables for Public School Children in Fifth Grade Observed During Spring 2004 in the ECLS-K

	Subsidized		Unsubsidized	
	Mean	**SD**	**Mean**	**SD**
Servings per week				
Fruit (*n*)	8.6745	9.0238	7.2425	7.6382
Green salad (*n*)	2.3067	4.4494	2.1959	3.7609
Carrots (*n*)	3.0632	5.8533	2.7343	4.9897
Potatoes (*n*)	2.1223	4.0337	1.6818	2.9249
Other vegetables (*n*)	5.4009	6.9677	5.0371	6.0712
Cow's milk[a] (*n*)	10.9950	8.9473	12.5257	9.0712
100% fruit juice (*n*)	5.9088	7.7898	4.9060	6.6553
Sweetened beverages (*n*)	6.5756	7.9931	5.9409	7.2330
Explanatory variables				
NSLP means-tested subsidy (%)	1.000	—	0.000	—
Full subsidy (%)	0.7275	—	0.000	—
Partial subsidy (%)	0.2725	—	0.000	—
BMI (kg/m^2)	21.5114	5.3211	20.1636	4.5792
Physical exercise >20 min (day/week)	3.6872	1.9946	3.8167	1.8093
Television watching (min/day)	160.8185	82.8204	140.3162	66.9441
Age (months)	134.7616	4.5921	134.9365	4.3149
Male (%)	0.4840	—	0.4953	—
Disability (%)	0.1640	—	0.1447	—
Number of siblings (*n*)	1.8416	1.2545	1.3381	0.9384
Household size (*n*)	4.8650	1.5786	4.3575	1.1368
Parent schooling (years)	12.5866	2.8885	15.1448	2.3811
Annual household income ($)	26,516.8110	17,912.3894	80,044.0252	46,706.6327
Supermarkets per capita (*n*)	0.0004	0.0075	0.0002	0.0002
Convenience stores per capita (*n*)	0.0005	0.0188	0.0001	0.0002
Full-service restaurants per capita (*n*)	0.0018	0.0527	0.0007	0.0006
Limited-service restaurants per capita (*n*)	0.0029	0.1016	0.0006	0.0004
Missing supermarkets per capita (%)	0.0998	—	0.1019	—
Missing convenience stores per capita (%)	0.2506	—	0.3475	—
Missing full-service restaurants per capita (%)	0.0948	—	0.0591	—
Missing limited-service restaurants per capita (%)	0.1177	—	0.0950	—
Title I program eligibility (%)	0.2206	—	0.3711	—
School-wide Title I program eligibility (%)	0.6256	—	0.2324	—
Student-teacher ratio (*n*)	16.4395	4.0330	16.6969	3.3572
Total student enrollment (*n*)	568.9078	313.7873	543.4792	250.9324
School has a la carte food and beverage menu (%)	0.2853	—	0.3730	—
School has vending machines for students (%)	0.2506	—	0.2126	—
School has canteen or snack bar for students (%)	0.2109	—	0.2368	—
Instrumental variables				
Students in school receiving full NSLP subsidy in previous school year (*n*)	334.9883	279.2811	135.4296	153.7423
Students in school receiving partial NSLP subsidy in previous school year (*n*)	61.8589	46.7252	42.1387	37.6074
Federal revenue to school district for CNA programs in previous school year ($/student)	221.7160	100.4431	132.6401	81.7323

TABLE A1

Continued

	Subsidized		Unsubsidized	
	Mean	**SD**	**Mean**	**SD**
State revenue to school district for CNA programs in previous school year ($/student)	11.8744	24.0148	9.0231	19.0346
Local revenue to school district from school meal sales in previous school year ($/student)	100.8235	60.7932	145.2961	65.0281
Observations	1,960	—	3,180	—

Notes: Sample means and standard deviations reported. Fruit does not include fruit juice. Potatoes do not include "French fries," fried potatoes, potato chips, or tater tots. Other vegetables do not include green salad, potatoes, or carrots. Fruit juice includes only non-sweetened, 100% fruit juices. Sweetened beverages include soda pop, sports drinks, or fruit drinks that are not 100% fruit juice.

[a]For our analysis of milk consumption, we restrict the analytic sample to 3,930 children reporting the milk consumed in the previous week was cow's milk because this is the particular type of milk provided by the NSLP.

Sources: ECLS-K. National Center for Education Statistics CCD, Public Elementary/Secondary School Universe Survey for school year 2003–2004, Public Elementary/Secondary School Universe Survey for school year 2002–2003, and School District Finance Survey for school year 2002–2003. U.S. Census Bureau Zip Code Business Patterns Survey 2004 and Census 2000 Summary File 1.

TABLE A2

Instrumental Variables Diagnostic Tests

	Model 1	**Model 2**
F-Statistics		
NSLP means-tested subsidy	19.6020 (<.0001)**	—
Full subsidy	—	18.4535 (<.0001)**
Partial subsidy	—	10.6871 (<.0001)**
Ln(BMI)	5.3227 (.0001)**	5.3227 (.0001)**
Chi-square statistics		
Fruit	0.5430 (.9094)	0.2166 (.8974)
Green salad	6.9325 (.0741)*	2.1062 (.3488)
Carrots	2.2475 (.5227)	1.7931 (.4080)
Potatoes	2.6698 (.4454)	2.6211 (.2697)
Other vegetables	1.9941 (.5736)	0.7416 (.6902)
Cow's milk	3.8985 (.2726)	3.7905 (.1503)
100% fruit juice	0.8453 (.8386)	0.5077 (.7758)
Sweetened beverages	0.8263 (.8432)	0.3896 (.8230)

Notes: p-Values are reported in brackets and are adjusted for school-level clustering. F-statistics test the null hypothesis that the instrumental variables are jointly insignificant in each first-stage regression. Chi-square statistics are Hansen J tests of overidentifying restrictions for each weekly consumption outcome; and the tests have 3 df and 2 df for Models 1 and 2, respectively.

*Significant at 10% level; **significant at 5% level.

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