The Effect of Access to a Supplemental Nutrition Assistance Program Authorized Store Location on Childhood Weight Outcomes*

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Abstract

The Supplemental Nutrition Assistance Program (SNAP) is the largest domestic food assistance program with approximately 1-in-4 children receiving benefits. The relationship between where a child lives and where their guardian's local SNAP benefits can be redeemed has remained largely unexplored. We combine detailed administrative panel data from the United States Department of Agriculture (USDA), the New York State Department of Agriculture and Markets, and New York City's (NYC) Department of Education. Our sample contains information on 530,709 NYC public school students in grades Kindergarten-8. We estimate how the local SNAP food environment affects the likelihood of being overweight or obese, the likelihood of being obese and the body mass index z-score for students from SNAP eligible households. Our identifying variation comes from differences in access to SNAP-authorized store locations within a census tract. To do so we exploit the plausibly exogenous increase in SNAP-authorized store locations due to an increase in SNAP benefits under the 2009 American Recovery and Reinvestment Act. We find that having a SNAP-authorized store location within a block of the student's household increases the likelihood they are overweight or obese by 0.8%, the likelihood they are obese by 0.7% and their BMI z-score by 0.02. We observe heterogeneity across race and geography. Our results are policy relevant because the USDA is currently finalizing new standards for stores to become SNAP-authorized.

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Introduction

Obesity is a major public health issue. As of 2011-2012, approximately 17% of 2 to 19 year olds were obese (Ogden et al. 2014). Being obese as a child increases the likelihood of being obese later in life (Biro and Wien 2010; Freedman et al. 2005; Whitaker et al. 1997). In turn, adult obesity is comorbid with cardiovascular disease, type-2 diabetes, certain cancers, and other diseases (Dixon 2010). The total medical cost of obesity is estimated to be as high as 16.5% of all United States' medical care spending, about $168 billion (Cawley and Meyerhoefer 2012).

Given the demonstrated association between childhood obesity and obesity later in life, many public health advocates have proposed interventions focused on reducing childhood obesity rates (Lobstein et al. 2004; Frieden, Dietz, and Collins 2010). The Supplemental Nutrition Assistance Program (SNAP) is potentially an effective tool to reduce these rates (Farley and Sykes 2015; Leung et al. 2013; Institute of Medicine 2009; Frieden, Dietz, and Collins 2010; Alston et al. 2009; White House Task Force on Childhood Obesity 2010; Schanzenbach 2013). This program is particularly appealing because it is the largest domestic food and nutrition assistance program (Laird and Trippe 2014) and the second largest anti-poverty program for children (Bitler, Hoynes, and Kuka 2014). Public spending on the program peaked at $80 billion in 2013 with the program supporting 23 million low income households (Bonanno and Li 2012). Nationally, half of all children between the ages of one and 20 will live in a household that participates in SNAP (Rank and Hirschl 2009).

SNAP is an effective tool to reduce food insecurity for children, but evidence of the program's effect on childhood obesity is mixed (Executive Office of the United States President

2015). Even less work has examined the relationship between SNAP and the food environment, the availability of both healthy and unhealthy food in a community. Only one study rigorously explores the relationship between the distance to a SNAP-authorized store location and childhood weight outcomes for children from SNAP participating households (Carroll and Andreyeva 2013). Distance is important because it is directly related to access to healthy food items and is included in the total price of all food items. Stores that are closer are more likely to be accessed. Distance is an important factor for where SNAP participants shop (Mabli 2014). Carroll and Andreyeva (2013) uses the distance from a SNAP-authorized store location to the centroid of the zip code for the student's residence. The authors find no effect of access to a SNAP-authorized corner stores on the BMI z-score of a child from a SNAP participating household (Carroll and Andreyeva 2013).

The purpose of this paper is to assess the effect of access to SNAP-authorized store locations on childhood weight outcomes for students from SNAP eligible households. Secondary goals are to determine whether the effect of access to SNAP-authorized store locations varies by student demographic characteristics and the county the student lives in. There is a large literature on disparities in obesity rates by demographic characteristics and the food environment for each county is different before and after the increase in SNAP benefits due to ARRA. Measuring the relationship between the SNAP food environment and childhood weight outcomes is difficult because the threat of selection on unobservables. Families decide where they live based on characteristics of the neighborhood. One such characteristic is available food sources. Similarly, stores locate in neighborhoods where residents will demand their products.

This study improves on Carroll and Andreyeva's work in three important ways. First, we have access to the student's home address and can calculate the number of SNAP-authorized

store locations around the household within a few hundred feet. Second, because of the richness of our data we are able to exploit variation within a census tract, a prime method to address endogeneity. Third, and related, we have access to data on over one million student-year observations making us powered to calculate small effect sizes. Finally, we are the first study to differentiate between stores that are SNAP-authorized and not SNAP-authorized. This is important from a policy standpoint to isolate whether SNAP-authorized locations are a larger contributor to obesity rates than stores that are not SNAP-authorized.

Previous work has established a sharp increase in the number of stores that became SNAP-authorized after the American Recovery and Reinvestment Act (ARRA) increased the size of SNAP benefits (Andrews, Bhatta, and Ploeg 2013). We exploit this plausibly exogenous increase in access to SNAP-authorized stores within small buffers for students who did not move during the sample period as our identification strategy. Focusing on students who did not move in our sample period reduces our identifying variation to two potential sources. The first source of variation is a SNAP-authorized store opening. The second source of variation is a store that was not SNAP-authorized becoming SNAP-authorized.

In our preferred model we find differences in access to SNAP-authorized store locations within a census tract are predictors of an increase in average body mass index (BMI) z-score, the likelihood of being overweight or obese, and the likelihood of being obese for students from SNAP eligible households. Specifically living within a block of a SNAP-authorized store increases the likelihood a student from a SNAP-eligible household is overweight or obese (0.8%), the likelihood of being obese (0.7%) and increases the BMI z-score of the student (0.02). Relative to baseline we find that having a SNAP-authorized store location within a block from the student's house corresponds to a 2.9% increase in the likelihood the student is obese and a

3.4% increase in the BMI z-score. Similar effects are found for whether a new SNAP-authorized store opened within a block from the student's household or a store that was not previously SNAP-authorized becomes SNAP-authorized. The size or significance of the effect differs by the student's race or ethnicity and the county (borough) of the student's household. Statistically significant effects are found for students who are self-described as Hispanic, White or other race. There is no statistically significant impact of access to a SNAP-authorized store locations on African American students. We find no effects for students in Queens County. But we do find the presence of a SNAP-authorized store within a block from the student's household increases the likelihood the student is obese in Bronx, New York and Richmond county.

The next section of the paper summarizes the literature on the relationship between SNAP and obesity. The third section describes the data. The fourth section describes the study's research design. The fifth section reports the results. The sixth section lists limitations with the current study and ends with the policy implications of our results.

Literature Review

SNAP Eligibility Rules

The primary objective of the SNAP program is to reduce food insecurity, the condition where households lack access to adequate food because of limited money or other resources. The program does this by increasing resources allocated to food purchases. There are three eligibility rules: a gross income, a net income and an asset threshold requirement. Households must have net monthly income at or below 100 percent of the federal poverty level. Gross income must be less than 130 percent of the poverty line. The asset test requires income-eligible households to

have less than $2,000. Because it is a federal program, states and local municipalities have little leeway in how they can administer the program.

SNAP benefits can be redeemed at stores that contain at least three of the four staple food categories, or stores that have over 50 percent of its total gross sales come from staple foods (*Training Guide for Retailers* 2014). Due to the 2014 Farm Bill, United States Department of Agriculture (USDA) is finalizing a rule to increase the healthy food stocking requirements for SNAP-authorized stores as a means to reduce diet-related disparities. To become SNAP-authorized a store fills out a detailed questionnaire either online or by mail. The store is then visited by an inspector to verify the information included on the questionnaire. The store is inspected annually to ensure that the store's compliance with SNAP guidelines continues. As of 2011, the Centers for Disease Control and Preventions estimates that approximately 63% of supermarkets, large grocery stores, supercenters and warehouse clubs, and fruit and vegetable specialty stores are SNAP-authorized (Grimm, Moore, and Scanlon 2013). There is no estimate for the percentage of corner stores that are SNAP-authorized.

The existing literature establishes that greater access to corner stores is predicted to lead to lower diet quality and higher BMI in children. This effect is likely due to the items stocked in these types of stores. Less healthy food items are more well stocked at lower prices (He et al. 2012; Larson, Story, and Nelson 2009; Rummo et al. 2015). Corner stores are also important because they are a significant contributor to the entire food environment and the SNAP food environment. According to the authors' calculations, 58% of all food stores in NYC are corner stores. Because corner stores are such an integral part of the SNAP food environment, understanding the effect of an increase in access to them on childhood weight outcomes is important.

In April of 2009 ARRA increased the benefits for SNAP participating households by approximately 17 percent to increase food security during the severe recession of 2008 to 2010. The benefit increase is hypothesized to have led to a disproportionate rise in the number of SNAP-authorized corner stores (Andrews, Bhatta, and Ploeg 2013). Using USDA administrative data Appendix One shows the sharp increase in the total number of SNAP-authorized corner store locations in NYC from 2009 and after. Most existing studies that examine the relationship between access to corner stores and weight outcomes fail to address the endogeneity between choosing where to live and the local food environment. We exploit the plausibly exogenous increase in access to SNAP-authorized store locations due to ARRA within a small buffer to examine the effect of access to SNAP-authorized store locations on student weight outcomes.

Literature on SNAP and Childhood Obesity

The relationship between SNAP participation and obesity is complex. One of the more prominent theories for why SNAP participation is associated with obesity rates is the income effect theory (DeBono, Ross, and Berrang-Ford 2012; Gundersen 2015; Meyerhoefer and Yang 2011). Participation in SNAP expands the consumer's budget constraint, while the prices of food items remain the same. Presumably, because of the income effect, SNAP participants will spend more money on all food items that are normal goods. The increase in spending should coincide with an increase in food consumption and in turn weight.

A largely unexplored factor in the case of SNAP is the distance needed to travel to purchase a food item. According to the authors' calculations the majority of stores that became SNAP-authorized in NYC due to the increase in SNAP benefits under ARRA are corner stores which generally stock fewer fruits and vegetables than traditional grocery stores (Farley et al. 2009).

Most supermarkets were already SNAP-authorized prior to the increase in SNAP benefits under ARRA. Consumers likely consider the total price of a food item to include both the retail price and the time cost to purchase the item. Assuming the price of food remains the same after a store becomes SNAP-authorized, the increase in access to corner stores should reduce the time cost for purchasing food. With the total cost of shopping at a corner store now lower, healthier alternatives at grocery stores are relatively more expensive. We expect the consumer to shop at the closer corner store now and, all else equal, purchase food items that are less healthy. These less healthy food options are likely to contribute to childhood obesity (Gamba et al. 2014). There is evidence to support the assertion that the price of food items in SNAP-authorized store locations remains relatively stable (Bruich 2014) and that corner stores are more well stocked with lower healthy food items at lower prices (He et al. 2012; Larson, Story, and Nelson 2009; Rummo et al. 2015).

Few studies have looked at the relationship between SNAP participation and childhood obesity. Early research finds that SNAP participation does not have an effect on childhood weight outcomes (Bhatacharya and Currie 2001; Boumtje et al. 2005; Jones et al. 2003; Ploeg, Mancino, and Lin 2007). Of those initial studies, only Gibson (2003) finds that for young girls less than 12 years of age, an additional year SNAP participation led to a greater probability of being overweight. The Gibson (2003) study is important because it accounts for selection into the program and uses the National Longitudinal Survey of Youth (NLSY).The study includes individual and family fixed effects (Gibson 2003). Other early studies use cross-sectional data and fail to control for selection bias.

Subsequent work resorts to more advanced statistical and econometric techniques. Schmeiser (2012) also uses the NLSY and the expansion of the Earned Income Tax Credit (EITC) to

instrument for changes in SNAP participation. An increase in the EITC leads to changes in the labor supply, labor earnings and SNAP eligibility for low income families. The author concludes that household SNAP participation reduces the BMI of boys between the ages 5 and 18 and females between the ages of 5 and 11 (Schmeiser 2012). Similarly, Burgstahler et al. (2012) uses county level SNAP participation rates to instrument for individual SNAP participation. The authors using cross sectional data, find that SNAP participation leads to a lower BMI in children from low income counties (Burgstahler, Gundersen, and Garasky 2012). Fan and Jin (2014) use a difference-in-difference design with propensity score matching again with the NLSY. Ultimately they find no relationship between SNAP participation and childhood obesity (Fan and Jin 2014). Clearly, the evidence on the effect of SNAP participation on weight outcomes is currently mixed and is sensitive to the sample, data and methods.

Identifying the effect of SNAP on childhood weight outcomes is difficult because SNAP participation is endogenous. Food insecurity, poor health, financial stability, and other human capital characteristics are all likely to be associated with the decision to participate in the program (Kreider et al. 2012). An additional problem is the frequent misreporting of SNAP participation (Almada and Tchernis 2015). Underreporting is as high as 15 percent in the Current Population Survey's Food Security Supplement and the Survey of Income and Program Participation (Bitler, Currie, and Scholz 2003). Similar to most welfare programs, there is a stigma associated with SNAP enrollment, and redemption of benefits that helps explain the high rate of misreporting (Breunig and Dasgupta 2005; Gundersen 2015).

To our knowledge, there is only one study that examines the link between having access to SNAP-authorized retailers and individual childhood obesity rates. This is surprising since stakeholders in the program care about how the program affects access to healthy foods and

obesity rates (Blumenthal et al. 2014). Carroll and Andreyeva (2013) use The Early Childhood Longitudinal Study and USDA SNAP retailer data from 40 states to evaluate how access to food stores that are SNAP-authorized relates to body weight in children from SNAP participating households. Models are stratified by the type of store that was SNAP-authorized (convenience store, supermarket, specialty stores, and liquor stores), and the type of area that the child resides in (urban, suburban and rural). The authors conclude that there is a weak association between access to SNAP-authorized food stores and childhood BMI. The closer the distance a SNAP-authorized supermarket is to an adolescent in a SNAP participating household, the higher the adolescent's BMI z-score (Carroll and Andreyeva 2013).

We improve on the work by Carroll and Andreyeva (2013) in the following ways. First, we have access to the student's home address. The Carroll and Andreyeva (2013) study uses the centroid of the student's zip-code, a coarse geographic measure, to evaluate the distance to the closest SNAP-authorized retailer and the number of each type of store within a one mile buffer zone. Having the student's address improves our identification strategy by allowing us to calculate the effect of the local SNAP food environment within a few hundred feet from the student's household. Second, this paper has a much larger sample size and is better powered to detect statistically significant effects. Finally we are able to identify which stores are SNAP-authorized or not. Therefore we are the first study to compare the effect of the same type of store location within the same census tract with the only difference being whether or not the store is SNAP-authorized or not.

Data

SNAP Retailer Database

Administrative SNAP retailer data was acquired from USDA. The data are between the years 2006 and 2014. The database includes information on the store's name, ownership, street address, city, and zip-code. The data contain information on the initial date of authorization and verification that the location was SNAP-authorized as of January 1st each following year. We classify a store location as being new if it was authorized at any time in the previous year. USDA classifies each store location into a different store type category. Previous work done by the Centers for Disease Control has established that healthy food locations in these data include supermarkets, supercenters/warehouse clubs, large grocery stores or fruit and vegetable specialty stores (Grimm, Moore, and Scanlon 2013). The USDA does not have an official designation for corner stores.

New York State Department of Agriculture and Markets

We use licensing data from the New York State Department of Agriculture and Markets to identify all non-restaurant food outlets in NYC. These data include inspections of every food store location in New York State between the years 2006 and 2014. The data include the name of the store, the name of the owner, and the address of the store. In addition, the data have the square footage of the store. We use the square footage of the store for classification purposes. We classify store locations that are less than 2,000 square feet as corner stores. Store locations greater than 5,000 square feet are classified as supermarkets. Store locations that are between the sizes of 2,000 and 5,000 are designated as mid-sized grocery stores with one exception. Pharmacies are identified by their name and were made a separate category.

Matching of SNAP Retailer Data and Agriculture and Market Data

This is the first paper to classify each food store in a city by whether it is SNAP-authorized or not. We match the list of all non-restaurant food sources from the New York State Department of Agriculture and Markets, with the list of all SNAP-authorized store locations. A store location that is in both datasets is considered SNAP-authorized. A store location that only appears in the New York State Department of Agriculture and Markets licensing data is assumed to not be SNAP-authorized.

A classification and regression tree model links the two datasets. Matches were done using the following criteria: store name, store address, store zip code, store city, store x and y coordinate. The model is agnostic to the year the individual store location appears in either dataset. We find a match for 89% of the store locations in the SNAP Retailer Database to a store location in the New York State Agriculture and Markets licensing data. Stores in the SNAP Retailer Database without a match are excluded from the analysis. Our estimates indicate that approximately 63% of all food stores in NYC are SNAP-authorized and that 64% of corner stores are SNAP-authorized.

Student Weight Outcome Data

Measured student height and weight data come from the NYC Department of Education (DOE) FITNESSGRAM. The FITNESSGRAM data are collected by DOE starting in 2005 for all NYC public school students. Schools collect data for the FITNESSGRAM reports as part of a compliance checklist for a school's overall report card. Height and weight measurements for students are taken by trained physical education teachers from each school. Students in all grades are assessed for their body composition by a trained school nurse or physical education teacher. There is confidence in these measures with one study determining that they have high reliability

and validity and unrelated to school or student characteristics (Morrow, Martin, and Jackson 2010).

The FITNESSGRAM data are merged to administrative student-level data also from NYC's DOE. The combination of the FITNESSGRAM data and the DOE data is a census of NYC public school students from kindergarten to 12th grade and includes measures of race, gender, age, country of origin, eligibility for reduced or free lunch, recent immigration status and language spoken at home. We restrict our analysis sample to students who are in kindergarten through 8th grade because they contain the most reliable height and weight measurements.

All students from a SNAP participating household are eligible for free school meals based off of their household income. In New York State, households receiving SNAP still need to enroll for free or reduced school lunches. The DOE administrative data does not include information on household SNAP participation. Instead we use a measure for if the student ever participates in the reduced (185% of federal poverty) or free school lunch (130% of federal poverty) program as a proxy for household SNAP eligibility. Because household incomes fluctuate from year to year the existing literature has assumed SNAP eligible households with income as high as 250% of the federal poverty line (Almada, Mccarthy, and Tchernis 2015). Our results should be interpreted as the causal effect of distance to a SNAP-authorized store for students from a SNAP eligible household. Our results can also be interpreted as a lower bound estimate for the effect of access to a SNAP-authorized store location on children from SNAP participating households.

This data also includes the student's exact location of residence, which is updated each year. From these data we get the student’s Borough-Block-Lot (BBL). The BBL is a unique

identifier for buildings or properties in NYC. Based on the student's BBL we identify whether or not the student resides in public housing or not by merging the student's BBL with a list of public housing locations. Additionally, we can determine whether or not the building the student lives in is used for both residential and commercial purposes by merging the student's BBL with NYC's RPAD data. We restrict our analysis sample to only students who did not move during the sample period. This allows us to draw a clearer causal link between the effect of access to SNAP-authorized stores and childhood weight outcomes. In Appendix Two we show demographic characteristics for students who did not move during our sample period and students who did move. The demographic characteristics for the two samples are qualitatively similar to one another.

From the FITNESSGRAM data we calculate the student's BMI z-score using CDC growth charts. The measure is adjusted for the child's age and gender. Based on the z-score measure we calculate separate dichotomous measures for whether the student is overweight or obese. Students above the 85^{th} percentile we classify as overweight or obese. Students above the 95^{th} percentile we classify as obese. BMI values that were classified as biologically implausible by the CDC were excluded.

Linking of Data Sources

Each of the above datasets is geocoded with NYC Department of City Planning Geosupport Desktop Edition. We exclude students who live in the outer boundaries of NYC because we fail to capture the complete food environment. These are students who live within a half mile from the NYC border. The FITNESSGRAM data, student administrative data are all linked to the above retailer data. For each student year combination we calculate a buffer of a full

city block (264 feet) around the student's household. Within that buffer we calculate the total number of store locations, the total number of SNAP-authorized store locations and the total number of non-SNAP-authorized store locations. We then take each of these count variables and transform them into dichotomous measures. This procedure is also used to calculate the presence and number of SNAP-authorized and non-SNAP-authorized corner stores, supermarkets, pharmacies and other mid-sized retailers within the same network buffer. ArcGIS 10.0 (ESRI, Redland, CA) is used to calculate each of the buffers.

Empirical Strategy

Our preferred regression model will take the below form for student i, in census tract c, and year t:

$$BMI_{ict} = B_0 + B_1\, SNAP_{ict} + B_2 NSNAP_{ict} + B_3 X_i + B_4 Housing_{ic} + B_4 Y_c + B_5 D_t + e_{ict}$$

The outcome measure for these models will either be a linear measure of the student's BMI z-score, a dummy variable for whether the student is overweight or not, or a dummy variable for whether the student is obese or not. SNAP represents a dummy variable for whether or not the student's household has a SNAP-authorized store location within a city block from the student's household. NSNAP represents a dummy variable controlling for the presence of a store location that was not SNAP-authorized within a block from the student's household. X represents controls for student-level characteristics associated with obesity. These include gender, race/ethnicity, grade, whether the student is foreign born or not, whether English is spoken in the student's household and whether or not the student is below proficient on the New York State English as a Second Language Achievement Test (NYSESLAT**)**. Housing includes characteristics of the student's household. Specifically we control for whether or not the student

is in a public housing building and if the building the student lives in is used for both commercial and residential purposes. Students who live in public housing locations are disproportionately more likely to be eligible for SNAP. Likewise students who live in a mixed use building could be in the same building as a SNAP-authorized store. Y is a vector of census tract fixed effects. D is individual year fixed effect. Finally e is the idiosyncratic error term. The above regressions are done with ordinary least squares and represent a linear probability model with robust standard errors clustered at the census tract level. All regressions are done using Stata 13.0.

Identification Strategy

Reviews examining the relationship between food access and childhood weight outcomes stress that researchers who use cross-sectional data are subject to bias (Cobb et al. 2015; Gamba et al. 2014). The endogeneity concern is that both individuals and stores select which neighborhoods they are located in. This study will address possible endogeneity concerns by leveraging the longitudinal nature of both datasets and by restricting our analysis sample to students who did not move in the sample period. The SNAP Retailer Database has the exact date when a store became SNAP-authorized. In addition, the FITNESSGRAM data include both the specific date of measurement, as well as the home address of the student. As such, we will be able to track changes in openings and closings of local SNAP-authorized locations.

By restricting our analysis to students who did not move there are two possible sources for identifying variation. The first is the opening of a new SNAP-authorized store on the student's block. The store's opening can reduce the distance needed to be traveled to reach a SNAP-authorized store location. To observe this variation we run regression models where the main predictor is a dummy variable for the presence of a new store opening that is SNAP-

authorized in the past calendar year within a block from the student's household. The second possible source of identifying variation is a pre-existing store becoming SNAP-authorized on the student's block. The store becoming SNAP-authorized can also reduce the distance needed to travel to reach a SNAP-authorized store location. To observe this variation we run regression models where the main predictor is a dummy variable for a pre-existing store becoming SNAP-authorized within a block from the student's household.

The key identification assumption is that within-census tract variation in SNAP-authorized store proximity is exogenous to the choice of neighborhood. Comparing groups of students with only a slight difference in the distance to a SNAP-authorized store location should reduce the impact of unobservable differences. A similar identification strategy has been applied in the case of access to fast food restaurants (Currie et al. 2010). We believe that our key identifying assumption is valid because the current study focuses on even smaller geographic distances.

Subgroup Analyses

We run the above model for several subgroups. First, we stratify our sample by the gender of the student. Boys tend to have a higher prevalence of obesity than girls (Wang 2011). Second, we stratify our sample by the race and ethnicity of the student. We do this because disparities continue to exist between lower and higher socioeconomic status groups nationally (Frederick, Snellman, and Putnam 2014; Wang 2011). It is possible that SNAP is a contributor to these disparities and that the distance to a corner store is one mechanism for why. Third, we run regressions by the county the student's household is in. The sudden increase in the number of SNAP-authorized corner store locations after the increase in SNAP benefits differed by county.

This can be seen in Appendix Three. Because of the difference in change in access to SNAP-authorized stores within each county, we expect students in each county would be impacted differently.

Robustness Checks

To test the above exogenous assumption we run regression models predicting the presence of a SNAP-authorized store location, and separately a SNAP-authorized corner store location within a block from the student's household based on their demographic characteristics. We focus on the corner store results because of our assumption that there was an increase in the number of SNAP-authorized corner stores due to the increase in SNAP benefits under ARRA. Next we run regressions additionally controlling for the presence of a fast food restaurant or wait service restaurant within a block from the student's household. The fast food restaurant and wait service restaurant controls come from NYC Department of Health and Mental Hygiene restaurant inspection data between the years 2009 and 2013. As a placebo test we run models for the sample of students who are from households that are not SNAP eligible at any point in our sample period. This is a population we expect is unaffected by the presence of a SNAP-authorized store close to the household. Finally we run models removing the census tract fixed effects but include either block fixed effects or student fixed effects. The block fixed effect models use differences in distance to a SNAP-authorized store location within a city block for identification. The student fixed effects models control for within student differences across the sample period and uses differences in access for identification.

Results

In total we have 1,531,989 students who did not move in the sample between the academic years 2008 and 2013. Table One reports the differences in the sample between students we consider ever coming from a SNAP eligible household during the sample period versus students from households that were never SNAP eligible during the sample period. Between 2008 and 2013 86% of the entire sample of NYC public school students came from a SNAP eligible household. Approximately 22% of students are obese with a higher rate in the sample of students from a SNAP eligible household (24%). Similarly, 41% of students are overweight or obese with a higher rate found for students from a SNAP eligible household (42%). The mean BMI z-score of the sample is 0.67. The sample of students is predominately Hispanic (39%) or African American (27%). The percentage of Hispanics (43%) and African Americans (29%) is even higher for the sample of students from SNAP eligible households. In contrast, 57% of students who are not from a SNAP eligible household are white. Similarly 37% of the entire sample did not speak English at home. More students from SNAP eligible households do not speak English at home (40%) compared to students who did not come from households that are not SNAP eligible (17%). A higher percentage of students from a SNAP eligible household (11%) reside in public housing compared to students who do not reside in a SNAP eligible household (1%). The same can be said for mixed housing. Students from a SNAP eligible household (3%) are more likely to live in a building for commercial and residential use. The above demographic differences are statistically significant at the 1% level.

There are also differences in access to SNAP-authorized stores based on the assumed SNAP eligibility of the student's household. Approximately 30% of SNAP eligible households have a SNAP-authorized store location within a block. This number is only 12% for households that are assumed to not be SNAP eligible. Similarly 23% of SNAP eligible households have a

SNAP-authorized corner store within a block from their household. Only 12% of households that are not SNAP eligible have a SNAP-authorized corner store within a block of their household. All differences were statistically significant at the 1% level. Students from SNAP-eligible households with a SNAP-authorized store location within one block from their home had on average 1.8 (±1.2) SNAP-authorized stores within the block buffer. Of students who had a SNAP-authorized corner store within one block from their household there was an average of 1.1 (±0.9) SNAP-authorized corner stores within the block buffer.

Table Two includes the results for students who are ever from a SNAP eligible household during the sample period using census tract fixed effects. The outcome measure is either a dummy variable for the student being overweight or obese, a dummy variable for whether the student is obese, and a continuous measure for the student's BMI z-score. In Panel One we report the results of regressions based on having access to any type of SNAP-authorized store location within a block. We find that having a SNAP-authorized store location within a block of the student's household is indicative of a 0.8% increase in the likelihood of the student being overweight or obese, compared to other students from SNAP-eligible households in that tract. Similarly having a SNAP-authorized store location within a block increases the likelihood the student is obese by 0.7%. The student's BMI z-score increases by 0.02 if there is a SNAP-authorized store within a block. Having a store that is not SNAP-authorized within a block from the student's household is not a statistically significant predictor for any of the weight outcome measures. T-tests done between the coefficients for access to a SNAP-authorized store versus access to a non-SNAP-authorized store were statistically significant at the 5% level.

The regression results in Panel Two include the controls for the presence of each type of SNAP-authorized and non-SNAP-authorized store location in the same model. These models

isolate the effect of having a specific type of SNAP-authorized corner store controlling for all other types of store locations. Having a SNAP-authorized corner store within a block from the student's household increases the likelihood the student is overweight or obese by 0.7%. While having a SNAP-authorized corner store within a block from the student's household increases the likelihood of the student being obese by 0.6%. The presence of a SNAP-authorized corner store within a block from the student's household increases the BMI z-score of the student by 0.02. The coefficients for corner stores that are not SNAP-authorized are not statistically significant. T-tests done between the coefficients for access to a SNAP-authorized corner store versus access to a non-SNAP-authorized corner store were only statistically significant at the 5% level for the BMI z-score outcome.

In Table Three we try to unpack whether the mechanism is from a new store that opens in the neighborhood and is SNAP-authorized within the first year of opening or an existing store that becomes SNAP-authorized. In Panel One we report regression results from any store within the buffer becoming SNAP-authorized in the past calendar year. We find that the opening of a new SNAP-authorized store within a block from the student's household leads to 0.6% increase in the likelihood the student is overweight or obese, a 0.7% increase in the likelihood the student is obese and a 0.02 increase in the student's BMI z-score. Panel Two is a similar model broken down by the different store types all in the same model while still controlling for the presence of stores that are not SNAP-authorized. The opening of a new SNAP-authorized corner store within a block from a student's household increases the likelihood the student is overweight or obese (1.0%), the likelihood the student is obese (1.0%) and the student's BMI z-score (0.03).

Panel Three in Table Three reports the results for a store that was not SNAP-authorized previously becoming SNAP-authorized. Having a pre-existing store become SNAP-authorized

within a block from the student's household corresponds to a 1.7% increase in the likelihood of being overweight or obese, a 2.1% increase in the likelihood of being obese and an increase in the student's BMI z-score by 0.05. Panel Four examines the effect of a pre-existing corner store becoming SNAP-authorized. A corner store that becomes SNAP-authorized within a block from the student's household increases the likelihood the student is overweight or obese (2.0%), the likelihood the student is obese (2.2%) and the student's BMI z-score (0.06). Both forms of entry into the SNAP food environment for corner stores seem to have a significant effect on the weight outcomes of students from SNAP eligible households.

Subgroup Analyses

Table Four contains subgroup analyses for access to any SNAP-authorized store location for students from a SNAP eligible household. Specifically we examine the regression results broken down by the gender, and race of the student. We find similar effects for both males and females. For males, having access to a SNAP-authorized store within a block led to a 0.8% increase in the likelihood of being overweight or obese, a 0.8% increase in the likelihood of being obese and a 0.03 increase in the student's BMI z-score. Female students have comparable results predicting increases in the likelihood of being overweight or obese (0.7%), likelihood of being obese (0.6%) and BMI z-score (0.02).

Table Four also contains the results by the race of the student. African American students are no more likely to have been overweight or obese if a SNAP-authorized store is located within a block from their household. In contrast, Hispanic students have a 0.6% increase in the likelihood of being overweight or obese and a 0.7% increase in the likelihood of being obese if they have a SNAP-authorized store within a block of their household. Similarly, having a SNAP-

authorized store within a block leads to a 0.02 increase in the BMI z-score for Hispanic students. The effect of having access to a SNAP-authorized store location within a block from a student's household was higher for both white and other race students. White students who have a SNAP-authorized store location within a block from their household are 1.5% more likely to be overweight or obese, 1.3% more likely to be obese and have a 0.04 increase in the student's BMI z-score. Students who are of a different race are 1.5% more likely to be overweight or obese, 0.8% more likely to be obese and have a BMI z-score that is 0.03 higher. Appendix Four, reports the results for models where the main predictor is access to a SNAP-authorized corner store. We find similar results except for Hispanic students. The presence of a SNAP-authorized corner store within a block from the student's household does not increase the likelihood the student is overweight or obese or the likelihood the student is obese.

Table Five presents the results by the county the student's household is in. We find that a SNAP-authorized store within a block from a student's household when the student resides in Queens County does not have any effect on childhood weight outcomes. Having a SNAP-authorized store location within a block from the student's household in New York County increases the likelihood they are overweight or obese (1.4%), the likelihood they are obese (1.3%) and their BMI z-score (0.04). Students who reside in Bronx County and Richmond County are also affected. Living a block from a SNAP-authorized store in Bronx County increases the likelihood the student is overweight or obese (0.7%) and their BMI z-score (0.03). Similarly a student living in Richmond County who has a SNAP-authorized store within a block from the household is 3.3% more likely to be overweight or obese and has a 0.08 increase in their BMI z-score. A student in Kings County that lives within a block from a SNAP-authorized store location has a 0.02 increase in their BMI z-score. Appendix Five reports the results where

the main predictor is the presence of a SNAP-authorized corner store within a block from the student's household. We find similar results in magnitude and significance with one exception. A SNAP-authorized corner store within a block from the student's household in Bronx County is not a statistically significant predictor of the student being overweight or obese.

Robustness checks

Even within a census tract the placement of a SNAP-authorized store location can be seen as endogenous. In Table Six we predict the presence of having a SNAP-authorized corner store, the opening of a new SNAP-authorized corner store and a pre-existing corner store becoming SNAP-authorized within a block from the student's household for students who live in the same census tract. We find that student demographic characteristics predict the likelihood of having a SNAP-authorized corner store within a block from the student's household. Students who we define as being from a SNAP-eligible household have a 1.7% increase in the likelihood of living within a block from a SNAP-authorized corner store. Hispanic students are 2.1% more likely to live within a block of a SNAP-authorized corner store. Similarly, whether or not a student lives in a residential and commercial building greatly increases the likelihood of living within a block from a SNAP-authorized corner store. We find similar results with smaller point estimates for the likelihood of having a SNAP-authorized corner store opening within a block from the student's household. Finally, only whether or not a student speaks English at home or lives in a residential and commercial building are related to the likelihood of living within a block from a pre-existing store that becomes SNAP-authorized. As a result of these models we conclude there are some concerns that the presence of a SNAP-authorized corner store or the opening of a SNAP-authorized corner store within a block is endogenous. But a pre-existing corner store becoming SNAP-authorized does not at least appear to be endogenous. Appendix Six predicts

the presence of any SNAP-authorized store location within a block from the student's household. The results for these models are similar to those for SNAP-authorized corner stores. We also run the corner store and any store models removing the census tract fixed effects and replacing them with block fixed effects. These models use differences in distance within a block to predict the presence of a SNAP-authorized corner store. We find similar results to the census tract models.

In Table Seven we run regression models with additional controls for the local food environment. Specifically we include controls for the presence of fast food and wait service restaurants within network buffers a full city block. The results are similar in magnitude and significance to those found in Table Two making our core results robust to additionally controlling for the presence of fast food and wait service restaurants.

Results reported in Table Eight are restricted to the sample of students who are from households that are not SNAP eligible household in our sample period. We find that the presence of a SNAP-authorized store location within a block from the student's household does not predict the likelihood of being overweight or obese and the BMI z-score of the student. That said the presence of a SNAP-authorized store or corner store within a block from a student's household increases the likelihood of the student being obese by 0.9% and 1.0% respectively. This result could indicate that the presence of a corner store independent of SNAP-authorization status has an impact on student weight outcomes. We find the introduction of a new SNAP-authorized store location within a block from the student's household increases the likelihood that the student is obese by 2%. In contrast, a pre-existing store becoming SNAP-authorized had no statistically significant effect on any student weight outcomes.

Finally in Table Nine, we report results for regression models that remove census tract fixed effects and instead include either block fixed effects or student fixed effects. The block fixed effects uses within block variation in the distance to a SNAP-authorized store for identification. Our results for the presence of a SNAP-authorized store within a block are robust to these specifications. In such models we find that having a SNAP-authorized store location increases the likelihood of a student being overweight or obese (0.4%), the likelihood of being obese (0.4%) and the BMI z-score of the student (0.01). The presence of a SNAP-authorized corner store did not cause a rise in the likelihood of being overweight or obese and the likelihood of being obese. Instead the presence of a SNAP-authorized corner store within a block from the household increased the student's BMI z-score by 0.03. It is also possible that our regression models fail to capture changes in either census tracts or blocks that vary over time. As a result we run additional models with either census tract time trends or block time trends. These results are reported in Appendix Seven. Our results appear to be robust to these specifications as well.

The individual fixed effect models are the models with the strongest identification assumptions. The variation comes from differences in access to SNAP-authorized store locations while controlling for time invariant characteristics of the student. In general the individual fixed effect models generate insignificant coefficients. The effect sizes were smaller and less significant than those found in either the census tract or block models. It is possible that while our sample size is large we are not powered to detect statistically significant effects for this particular sample when using individual student fixed effects.

Discussion

SNAP is the largest domestic food and nutrition program. The relationship between the program, the local food environment and childhood obesity has been mostly unexplored. This study finds that variation in access to a SNAP-authorized store locations within a census tract corresponds to an increase in the likelihood of a student from a SNAP eligible household being overweight or obese (1.9% increase from baseline), the likelihood of being obese (2.9% increase from baseline) and an increase in their BMI z-score (3.4% increase from baseline). We fail to find statistically significant effects for living near a store that is not SNAP-authorized. Statistical testing indicates that the size of the effect of access to a SNAP-authorized store location is larger than the size of the effect of access to a store that is not SNAP-authorized. Corner stores appear to be the most consistently influential types of stores on weight outcomes for students from SNAP eligible households. Our results are robust to models that use variations in distance to a SNAP-authorized store location for students who live on the same block.

The effect of access to a SNAP-authorized store location differs by student demographics for different groups of students. The effect varied by the student's race and the county of the student's household. Hispanic, white and other race students are more likely to be overweight or obese, more likely to be obese and have an increase in their BMI z-score if they live within a block from a SNAP-authorized store location. This was not the case for African American students. These results correspond with the existing literature which shows Hispanic students in NYC are more likely to be overweight or obese compared to their counterparts (Thorpe et al. 2004). Differential access in SNAP-authorized store locations could be a contributor to these disparities. We also find that students who reside in New York County saw substantial increases in each of their weight outcomes if they reside within a block from a SNAP-authorized store location. Students who reside in Queens County are unaffected by the presence of a SNAP-

authorized location within a block from the household. Finally, our results suggest that having a pre-existing store location become SNAP-authorized has a larger impact on student weight outcomes than the introduction of a new SNAP-authorized store into the community.

Limitations

This study has several limitations. First, the results from this study are limited to NYC public school students. Therefore they may not extend to NYC private school students, or students who live elsewhere. USDA estimates report that New York State SNAP participating households behave differently compared to SNAP participating households from other states (Castner and Henke 2011). In addition, according to Kimbro and Rigby (2010), the effect size of SNAP participation on childhood weight outcomes differs in the literature due to differences in contextual factors (i.e. food prices) in different cities and states (Kimbro and Rigby 2010).

Second, the USDA SNAP retailer data does not include information on the exact date that the location closes or is no longer SNAP-authorized. Instead, the measure includes information on the date they are authorized to accept benefits and whether the location is authorized as of the following January 1st. But it is possible that stores that are SNAP-authorized close before they are reauthorized.

Third, we do not know whether or not the student belongs to a SNAP participating household. Instead, we proxy for participation (the student receives reduced or free lunch in our sample period). Although all students who are on SNAP are required to be enrolled in free lunch, students who are not on SNAP are potentially able to enroll into the program. Almost all non-experimental studies on SNAP are susceptible to self-selection bias. As described above, not all eligible individuals enroll into the program. The reasons an individual chooses to enroll in the

program are likely correlated with body weight. One possibility is that families with higher needs for food participation are more likely to enroll in the program. That said our results can be interpreted as the equivalent of intent to treat analysis or a lower bound for the effect of access to a SNAP-authorized store location on SNAP participating households.

Fourth, as our robustness checks indicate students from SNAP-eligible households tend to live closer to SNAP-authorized locations or SNAP-authorized corner stores. This is a threat to our identifying assumption that SNAP eligible individuals do not decide where they live based on the presence of SNAP-authorized store locations. However, our results also indicate that the decision for a store that was previously not SNAP-authorized becoming SNAP-authorized does not appear to be endogenous or associated to any other factors. This gives us more confidence in the results for already open stores becoming SNAP-authorized. Fifth, this study uses a machine learning algorithm to identify SNAP-authorized store locations. That said not all of our SNAP-authorized store locations were able to be matched to a store in the food source inspection data. Instead 11% of the stores in our sample had to be excluded.

Policy Implications

SNAP is a federal program that focuses on the consumer. Very little work has been done to examine how store owners respond to administrative changes in the program. The increase in SNAP benefits due to ARRA coincided with an increase in the number of SNAP-authorized stores. Nationally, the number of SNAP-authorized convenience stores and SNAP-authorized grocery stores rose after the benefit increase (Andrews, Bhatta, and Ploeg 2013). The increase in the number of SNAP-authorized stores, presumably led to changes in the local food environment for SNAP participating households. Our results would suggest that the rapid increase in the

number of SNAP-authorized corner stores could be associated with elevated childhood obesity rates. A recent study done by the USDA suggests increasing the benefit size for SNAP participants could increase food access (Andrews, Bhatta, and Ploeg 2013). Given our results we think policymakers should carefully consider the effect of future SNAP benefit increases on both the local SNAP food environment and childhood obesity for SNAP eligible households.

Nearly all of our results indicate that an increase in access to SNAP-authorized store locations corresponds to an increase in student weight outcomes. Our findings suggest the USDA should consider changes to the stocking requirements for stores to be SNAP-authorized. Such changes are being discussed due to the 2014 Farm Bill. The current agreement requires SNAP-authorized stores to offer at least seven items in each of four basic categories (fruits and vegetables, grains, dairy, and meat) and to offer perishable items in at least three of these categories (up from the current requirement of two). These changes could help reverse the recent increase in the number of SNAP-authorized corner stores and in turn have an effect on childhood obesity rates.

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Table One: Demographic characteristics of study sample (Academic years 2008-2013)

	Total		SNAP-eligible sample (Household Income 185% of Poverty Level or Less)		Not SNAP-eligible sample (Household Income Over 185% of the Poverty Level)		p-value
	n	%	n	%	n	%	
Dummy obese or not							
Obese	341,732	22.31%	311,660	23.68%	30,072	13.94%	0.000
Not	1,190,257	77.69%	1,004,623	76.32%	185,634	86.06%	
Dummy overweight/obese or not							
Overweight	622,815	40.65%	559,097	42.48%	63,718	29.54%	0.000
Not	909,174	59.35%	757,186	57.52%	151,988	70.46%	
Gender							
Male	766,649	50.04%	656,184	49.85%	110,465	51.21%	0.000
Female	765,340	49.96%	660,099	50.15%	105,241	48.79%	
Race variable							
Other	235,413	15.37%	199,475	15.15%	35,938	16.66%	0.000
Hispanic	594,534	38.81%	563,781	42.83%	30,753	14.26%	
Black	411,439	26.86%	385,611	29.30%	25,828	11.97%	
White	290,603	18.97%	167,416	12.72%	123,187	57.11%	
Below proficient score on NYSESLAT							
Below proficient score on NYSESLAT	151,137	9.87%	145,503	11.05%	5,634	2.61%	0.000
Not	1,380,852	90.13%	1,170,780	88.95%	210,072	97.39%	
English at home							
English at home	965,230	63.01%	786,885	59.78%	178,345	82.68%	0.000
Not	566,759	36.99%	529,398	40.22%	37,361	17.32%	
Student lives in public housing							
Student lives in public housing	151,075	9.86%	148,626	11.29%	2,449	1.14%	0.000
Student does not live in public housing	1,380,914	90.14%	1,167,657	88.71%	213,257	98.86%	
Student lives in a mixed use building							
Student lives in a mixed use building	44,969	2.94%	42,281	3.21%	2,688	1.25%	0.000
Student does not live in a mixed use building	1,487,020	97.06%	1,274,002	96.79%	213,018	98.75%	
Any SNAP-authorized store within a block							
Yes	418,233	27.30%	391,388	29.73%	26,845	12.45%	
No	1,113,756	72.70%	924,895	70.27%	188,861	87.55%	0.000
SNAP-authorized corner store within a block							
Yes	319,867	20.88%	306,267	23.27%	13,600	6.30%	
No	1,212,122	79.12%	1,010,016	76.73%	202,106	93.70%	0.000
N	1,531,989		1,316,283		215,706		

Note: p-value reflects differences between the SNAP-Eligible sample the sample that is not SNAP-Eligible using a chi-square tests.

Table Two: Effect of SNAP food environment on weight outcomes for SNAP eligible households (Academic years 2008-2013)

	(1) Overweight	(2) Obese	(3) BMI z-score
Outcome measure mean or proportion	0.42	0.24	0.67
Panel One			
Any type of SNAP-authorized store			
Within full city block	0.008***	0.007***	0.023***
	(0.002)	(0.002)	(0.005)
Not SNAP-authorized store			
Within full city block	0.002	0.002	0.005
	(0.002)	(0.002)	(0.005)
Panel Two			
SNAP-authorized corner store			
Within full city block	0.007***	0.006***	0.023***
	(0.002)	(0.002)	(0.005)
Not SNAP-authorized corner store			
Within full city block	0.003	0.003	0.005
	(0.002)	(0.002)	(0.005)
N	1,316,283	1,316,283	1,316,283

Note: Panel One and Panel Two represent two separate regressions. Ordinary least squares is used. All models control for English proficiency, whether the student speaks English at home or not, gender, grade, ethnicity, whether the student lives in public housing, if the building the student lives in is used for both residential and commercial purposes, tract and year fixed effects. Panel Two additionally controls for the presence of either SNAP-authorized or not SNAP-authorized supermarkets, pharmacies and other midsized grocers. Sample is restricted to students who qualified for free or reduced lunch during any year in the sample period and who did not move at any point during the sample period. In parentheses are robust standard errors clustered at the census tract level. A corner store is classified as a store location that is less than 2,000 square feet. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

Table Three: Effect of SNAP food environment on weight outcomes for SNAP eligible households (Academic years 2008-2013) different sources of variation

	(1) Overweight	(2) Obese	(3) BMI z-score
Outcome measure mean or proportion	0.42	0.24	0.67
Panel One: Introduction of a SNAP-authorized store			
Any SNAP-authorized store			
Within full city block	0.006*	0.007*	0.020*
	(0.003)	(0.003)	(0.008)
Panel Two: Introduction of a SNAP-authorized corner store			
SNAP-authorized corner store			
Within full city block	0.010**	0.010**	0.031**
	(0.004)	(0.004)	(0.010)
Panel Three: Pre-existing store becomes SNAP-authorized			
Any SNAP-authorized store			
Within full city block	0.017*	0.021**	0.046*
	(0.008)	(0.007)	(0.021)
Panel Four: Pre-existing corner store becomes SNAP-authorized			
SNAP-authorized corner store			
Within full city block	0.020*	0.022*	0.063*
	(0.009)	(0.009)	(0.026)
N	1,316,283	1,316,283	1,316,283

Note: Panel One, Panel Two, Panel Three and Panel Four represent separate regressions. Ordinary least squares is used. All models control for English proficiency, whether the student speaks English at home or not, gender, grade, ethnicity, whether the student lives in public housing, if the building the student lives in is used for both residential and commercial purposes, tract and year fixed effects. Panels Two and Four additionally controls for the presence of either SNAP-authorized or not SNAP-authorized supermarkets, pharmacies and other midsized grocers. Sample is restricted to students who qualified for free or reduced lunch during any year in the sample period and who did not move at any point during the sample period. In parentheses are robust standard errors clustered at the census tract level. A corner store is classified as a store location that is less than 2,000 square feet. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

Table Four: Demographic subgroup analyses for students from SNAP eligible households during the sample period (Academic years 2008-2013)

	(1) Overweight	(2) Obese	(3) BMI z-score
Male students			
Outcome measure mean or proportion	0.45	0.26	0.73
SNAP-authorized store within full city block	0.008**	0.008***	0.025***
	(0.003)	(0.002)	(0.007)
N	656,184	656,184	656,184
Female students			
Outcome measure mean or proportion	0.40	0.21	0.61
SNAP-authorized store within full city block	0.007**	0.006**	0.020**
	(0.002)	(0.002)	(0.006)
N	660,099	660,099	660,099
African American students			
Outcome measure mean or proportion	0.42	0.23	0.68
SNAP-authorized store within full city block	0.002	0.004	0.014
	(0.003)	(0.003)	(0.008)
N	385,611	385,611	385,611
Hispanic students			
Outcome measure mean or proportion	0.48	0.28	0.82
SNAP-authorized store within full city block	0.006*	0.007**	0.017**
	(0.003)	(0.002)	(0.007)
N	563,781	563,781	563,781
White students			
Outcome measure mean or proportion	0.37	0.20	0.54
SNAP-authorized store within full city block	0.015*	0.013*	0.039*
	(0.007)	(0.006)	(0.017)
N	167,416	167,416	167,416
Other race students			
Outcome measure mean or proportion	0.33	0.15	0.32
SNAP-authorized store within full city block	0.015**	0.008*	0.034*
	(0.006)	(0.004)	(0.017)
N	199,475	199,475	199,475

Note: Ordinary least squares is used. All models control for English proficiency, whether the student speaks English at home or not, gender, grade, ethnicity, whether the student lives in public housing, if the building the student lives in is used for both residential and commercial purposes, tract and year fixed effects. Sample is restricted to students who qualified for free or reduced lunch during any year in the sample period and who did not move at any point during the sample period. In parentheses are robust standard errors clustered at the census tract level. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

Table Five: County subgroup analyses for students from SNAP eligible households during the sample period (Academic years 2008-2013)

	(1) Overweight	(2) Obese	(3) BMI z-score
New York County students			
Outcome measure mean or proportion	0.43	0.24	0.69
SNAP-authorized store within full city block	0.014**	0.013**	0.041**
	(0.005)	(0.005)	(0.014)
N	144,680	144,680	144,680
Bronx County students			
Outcome measure mean or proportion	0.44	0.25	0.73
SNAP-authorized store within full city block	0.007*	0.005	0.026**
	(0.004)	(0.003)	(0.009)
N	293,366	293,366	293,366
Kings (Brooklyn) County students			
Outcome measure mean or proportion	0.42	0.24	0.67
SNAP-authorized store within full city block	0.006	0.003	0.020**
	(0.003)	(0.003)	(0.008)
N	431,938	431,938	431,938
Queens County students			
Outcome measure mean or proportion	0.41	0.22	061
SNAP-authorized store within full city block	0.004	0.005	0.005
	(0.004)	(0.004)	(0.012)
N	374,499	374,499	374,499
Richmond County students			
Outcome measure mean or proportion	0.41	0.23	0.66
SNAP-authorized store within full city block	0.033*	0.013	0.077*
	(0.016)	(0.013)	(0.037)
N	71,800	71,800	71,800

Note: Ordinary least squares is used. All models control for English proficiency, whether the student speaks English at home or not, gender, grade, ethnicity, whether the student lives in public housing, if the building the student lives in is used for both residential and commercial purposes, tract and year fixed effects. Sample is restricted to students who qualified for free or reduced lunch during any year in the sample period and who did not move at any point during the sample period. In parentheses are robust standard errors clustered at the census tract level. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

Table Six: Prediction of presence of a SNAP-authorized corner store a block from student's household (Academic years 2008-2013)

	(1) Any SNAP-authorized corner store	(2) Brand new SNAP-authorized corner store	(3) Pre-existing SNAP-authorized corner store
Proportion of outcome measure	0.233	0.016	0.002
SNAP eligibility? (versus never)			
From a SNAP eligible household	0.017***	0.001***	0.000
	(0.002)	(0.000)	(0.000)
Student Demographic Characteristics			
Gender (versus male)			
Female	-0.000	0.000	0.000
	(0.001)	(0.000)	(0.000)
Race or ethnicity (versus other)			
Hispanic	0.021***	0.002**	0.001
	(0.005)	(0.001)	(0.000)
Black	0.007	0.001	0.001
	(0.005)	(0.001)	(0.000)
White	-0.004	-0.000	-0.000
	(0.003)	(0.001)	(0.000)
English proficiency (versus proficient)			
Below proficient score on NYSESLAT	0.012***	0.001*	0.000
	(0.003)	(0.001)	(0.000)
English at home (versus not)			
English at home	-0.018***	-0.002***	-0.000**
	(0.002)	(0.000)	(0.000)
Housing Characteristics			
Student lives in public housing building (versus not)	-0.035	0.002	-0.000
	(0.023)	(0.004)	(0.001)
Student lives in a mixed use building (versus not)	0.341***	0.032***	0.005***
	(0.010)	(0.003)	(0.001)
N	1,531,989	1,531,989	1,531,989

Note: Ordinary least squares is used. Models additionally include student grade fixed effects, year fixed effects and census tract fixed effects. SNAP eligible is that the student qualified for free or reduced lunch during the sample period. Corner store is defined as a store location that is less than 2,000 square feet. In parentheses are robust standard errors clustered at the census tract level. p<0.05=*, p<0.01=**, p<0.001=***

Table Seven: Effect of SNAP food environment on weight outcomes for SNAP eligible households with additional food environment controls (Academic years 2009-2013)

	(1) Overweight	(2) Obese	(3) BMI z-score
Outcome measure mean or proportion	0.41	0.23	0.61
Panel One			
Any SNAP-authorized Store			
Within full city block	0.007***	0.008***	0.023***
	(0.002)	(0.002)	(0.006)
Not SNAP-authorized store			
Within full city block	0.001	0.002	0.005
	(0.002)	(0.002)	(0.005)
Panel Two			
SNAP-authorized corner store			
Within full city block	0.007**	0.006***	0.024***
	(0.002)	(0.002)	(0.005)
Not SNAP-authorized corner store			
Within full city block	0.003	0.003	0.005
	(0.002)	(0.002)	(0.006)
N	1,128,484	1,128,484	1,128,484

Note: Panel One and Panel Two represent two separate regressions. Ordinary least squares is used. All models control for English proficiency, whether the student speaks English at home or not, gender, grade, ethnicity, whether the student lives in a public housing building or not, whether the building the student lives in is both a residential and store or not, tract and year fixed effects. Panel two additionally controls for the presence of SNAP-authorized and not SNAP-authorized supermarkets, pharmacies and other mid-sized grocery stores within a block from the household. Sample is restricted to students who qualified for free or reduced lunch during any year in the sample period. Sample is also restricted to students who did not move during the sample period. In parentheses are robust standard errors clustered at the census tract level. A corner store is classified as a store location that is less than 2,000 square feet. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

Table Eight: Effect of SNAP food environment on weight outcomes for students who were NOT SNAP-eligible during the sample period. (Academic years 2008-2013)

	(1) Overweight	(2) Obese	(3) BMI z-score
Outcome measure mean or proportion	0.41	0.23	0.61
Panel One: Any SNAP-authorized store			
Any SNAP-authorized stores			
Within full city block	0.008	0.009*	0.021
	(0.005)	(0.004)	(0.015)
Panel Two: Type of SNAP-authorized store			
SNAP-authorized corner store			
Within full city block	0.002	0.010*	0.016
	(0.007)	(0.005)	(0.019)
Panel Three: Introduction of a SNAP-authorized store			
Any SNAP-authorized store			
Within full city block	0.011	0.020*	0.028
	(0.012)	(0.010)	(0.034)
Panel Four: Preexisting store becomes SNAP-authorized			
Any SNAP-authorized store	-0.011	-0.011	-0.072
Within full city block	(0.026)	(0.017)	(0.070)
N	215,706	215,706	215,706

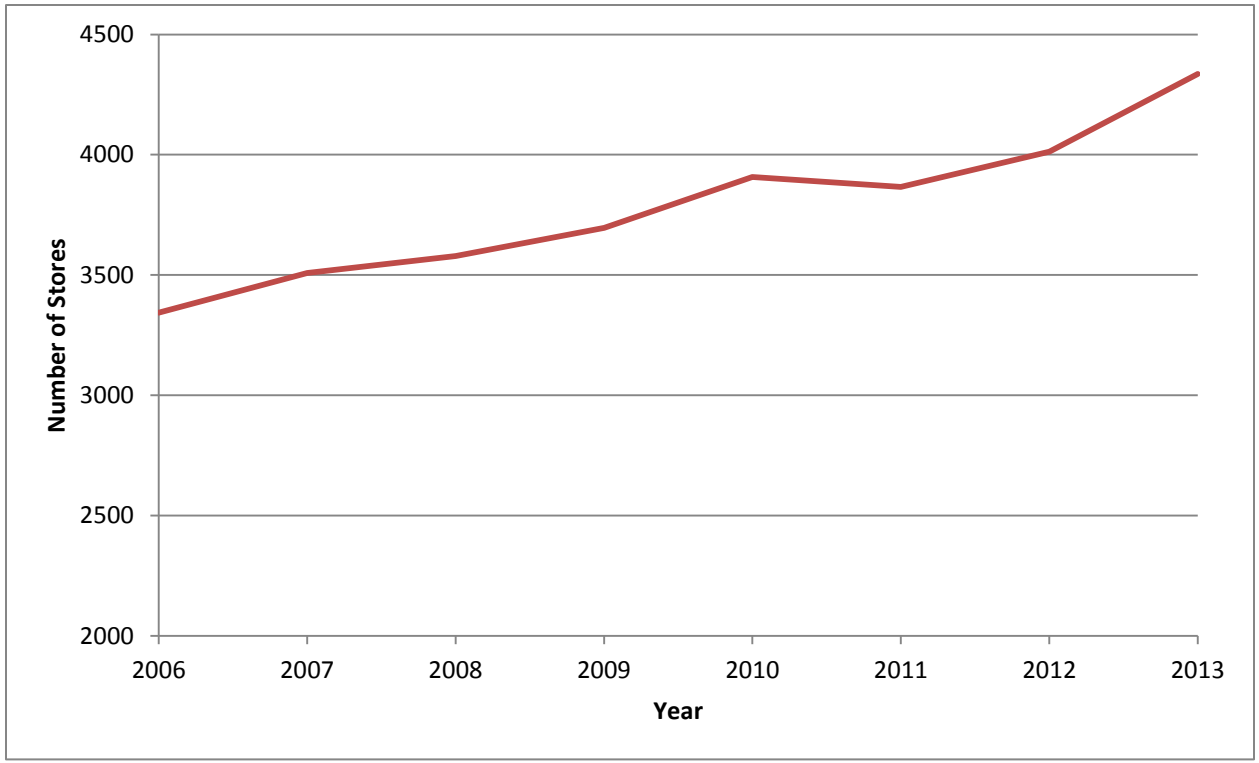
Note: Each panel represents a separate regression. Ordinary least squares is used. All models control for English proficiency, whether the student speaks English at home or not, gender, grade, ethnicity, whether the student lives in public housing, if the building the student lives in is used for both residential and commercial purposes, tract and year fixed effects. Panel, Two additionally controls for the presence of either SNAP-authorized or not SNAP-authorized supermarkets, pharmacies and other midsized grocers. Sample is restricted to students who did not qualify for free or reduced during any year in the sample period, and who did not move during any year in the sample period. In parentheses are robust standard errors clustered at the census tract level. A corner store is classified as a store location that is less than 2,000 square feet. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

Table Nine: Alternative model specifications (Academic years 2008-2013)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Overweight			Obese			BMI z-score	
Outcome measure mean or proportion	0.41	0.41	0.41	0.23	0.23	0.23	0.60	0.60	0.60
Census tract fixed effects	Y	N	N	Y	N	N	Y	N	N
Block fixed effects	N	Y	N	N	Y	N	N	Y	N
Individual student fixed effects	N	N	Y	N	N	Y	N	N	Y
Panel One									
Any SNAP-authorized store									
Within full city block	0.008***	0.004*	-0.002	0.007***	0.004*	0.000	0.023***	0.011*	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.005)
Not SNAP-authorized store									
Within full city block	0.002	-0.001	-0.001	0.002	0.001	0.000	0.005	0.001	-0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.004)
Panel Two									
SNAP-authorized corner store									
Within full city block	0.007***	0.003	-0.001	0.006***	0.003	0.000	0.023***	0.025***	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.005)
Not SNAP-authorized corner store									
Within full city block	0.003	0.002	0.000	0.003	0.002	-0.001	0.005	0.004	-0.005
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.006)	(0.004)
N	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283

Note: Panel One and Panel Two represent two separate regressions. Ordinary least squares is used. All models control for English proficiency, whether the student speaks English at home or not, gender, grade, ethnicity, whether the student lives in public housing, if the building the student lives in is used for both residential and commercial purposes, tract and year fixed effects. Panel Two additionally controls for the presence of either SNAP-authorized or not SNAP-authorized supermarkets, pharmacies and other midsized grocers. Sample is restricted to students who qualified for free or reduced lunch during any year in the sample period and who did not move during any year in the sample period. In parentheses are robust standard errors clustered at the census tract level. A corner store is classified as a store location that is less than 2,000 square feet. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

Appendix One: Number of SNAP-authorized corner store locations in New York City (2006-2013)



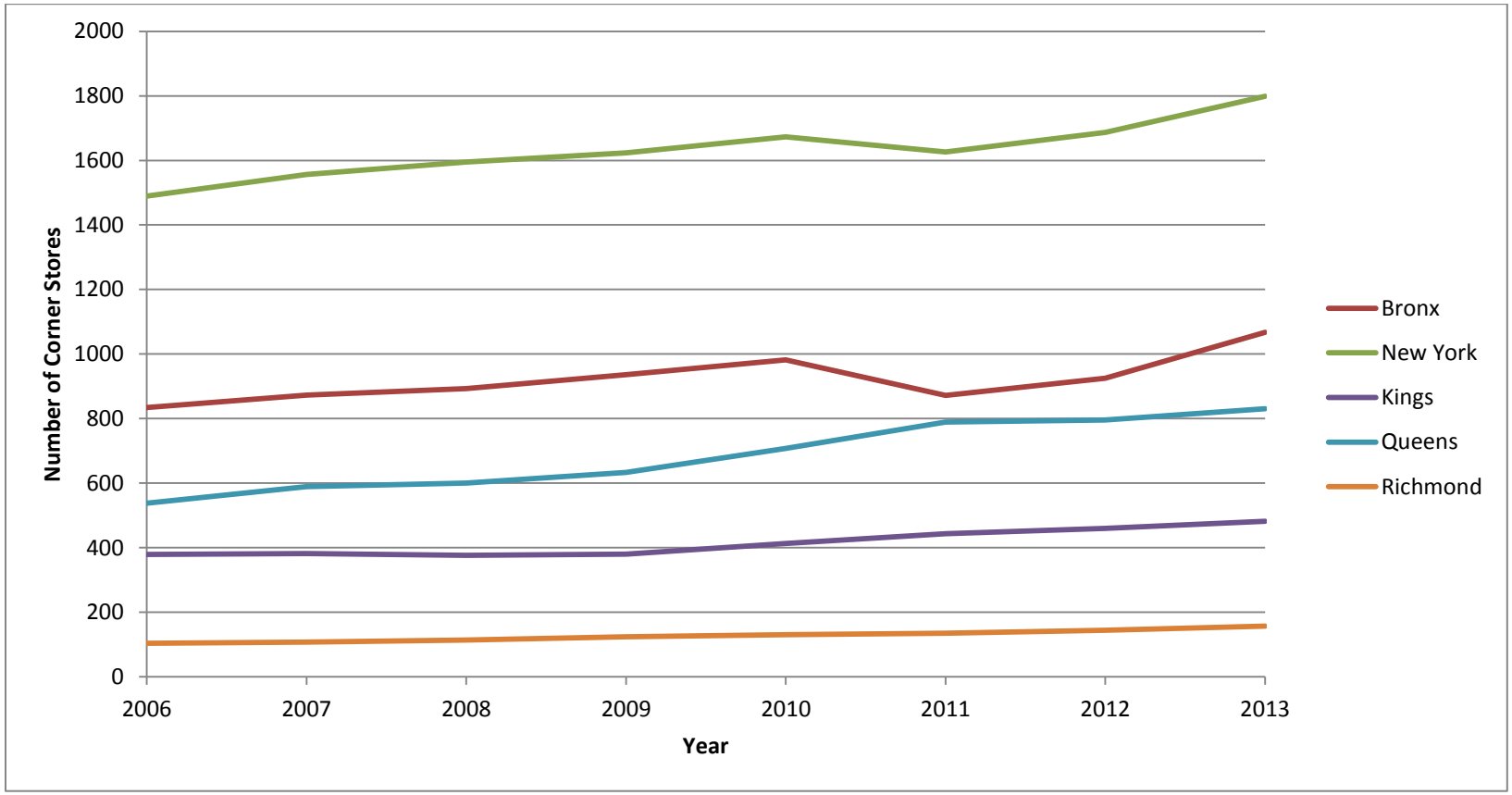
Note: Corner stores are defined as store locations that are below 2,000 square feet.

Appendix Two: Demographic characteristics of sample of students who did not move during the sample period and the sample of students who did move during the sample period (Academic years 2008-2013)

	Total		Non-movers		Movers		p-value
	n	%	n	%	n	%	
Dummy obese or not							
Obese	501,713	23.63%	311,660	23.68%	190,053	23.55%	0.028
Not	1,621,747	76.37%	1,004,623	76.32%	617,124	76.45%	
Dummy overweight/obese or not							
Overweight	902,160	42.49%	559,097	42.48%	343,063	42.50%	0.708
Not	1,221,300	57.51%	757,186	57.52%	464,114	57.50%	
Gender							
Male	1,051,592	49.52%	656,184	49.85%	395,408	48.99%	0.000
Female	1,071,868	50.48%	660,099	50.15%	411,769	51.01%	
Race variable							
Asian or other	300,536	14.15%	199,475	15.15%	101,061	12.52%	0.000
Hispanic	927,280	43.67%	563,781	42.83%	363,499	45.03%	
Black	653,550	30.78%	385,611	29.30%	267,939	33.19%	
White							
Below Proficient Score on NYSESLAT							
Below proficient score on NYSESLAT	236,192	11.12%	145,503	11.05%	90,689	11.24%	0.000
Not	1,887,268	88.88%	1,170,780	88.95%	716,488	88.76%	
English at home							
English at home	1,285,760	60.55%	786,885	59.78%	498,875	61.80%	0.000
Not	837,700	39.45%	529,398	40.22%	308,302	38.20%	
N	2,123,460		1,316,283		807,177		

Note: Students who are classified as non-movers not reside in the same borough, block and lot during the entire sample period. Students who are classified as movers do not reside in the same borough, block and lot during the entire sample period.

Appendix Three: Number of SNAP-authorized corner store locations in New York City by county (2006-2013)



Note: Corner stores are defined as store locations that are below 2,000 square feet.

Appendix Four: Demographic subgroup analyses for students from SNAP eligible households with access to SNAP-authorized corner stores (Academic years 2008-2013)

	(1) Overweight	(2) Obese	(3) BMI z-score
Male students			
Outcome measure mean or proportion	0.44	0.26	0.73
SNAP-authorized corner store within full city block	0.007*	0.006*	0.022***
	(0.003)	(0.002)	(0.007)
N	656,184	656,184	656,184
Female students			
Outcome measure mean or proportion	0.40	0.21	0.61
SNAP-authorized corner store within full city block	0.007**	0.006**	0.023***
	(0.003)	(0.002)	(0.007)
N	660,099	660,099	660,099
African American students			
Outcome measure mean or proportion	0.42	0.23	0.68
SNAP-authorized corner store within full city block	0.003	0.005	0.016
	(0.004)	(0.003)	(0.009)
N	385,611	385,611	385,611
Hispanic students			
Outcome measure mean or proportion	0.48	0.28	0.82
SNAP-authorized corner store within full city block	0.004	0.003	0.015*
	(0.003)	(0.002)	(0.007)
N	563,781	563,781	563,781
White students			
Outcome measure mean or proportion	0.37	0.20	0.54
SNAP-authorized corner store within full city block	0.019*	0.017*	0.062**
	(0.008)	(0.007)	(0.020)
N	167,416	167,416	167,416
Other race students			
Outcome measure mean or proportion	0.33	0.15	0.32
SNAP-authorized corner store within full city block	0.019***	0.012**	0.039*
	(0.006)	(0.004)	(0.016)
N	199,475	199,475	199,475

Note: Ordinary least squares is used. All models control for English proficiency, whether the student speaks English at home or not, gender, grade, ethnicity, whether the student lives in public housing, if the building the student lives in is used for both residential and commercial purposes, the presence of either SNAP-authorized or not SNAP-authorized supermarkets, pharmacies and other midsized grocers, tract fixed effects and year fixed effects. Corner store defined as a store less than 2,000 square feet. Sample is restricted to students who qualified for free or reduced lunch during any year in the sample period and who did not move during the sample period. In parentheses are robust standard errors clustered at the census tract level. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

Appendix Five: County subgroup analyses for students from SNAP eligible households during the sample period (Academic years 2008-2013)

	(1) Overweight	(2) Obese	(3) BMI z-score
New York County students			
Outcome measure mean or proportion	0.43	0.24	0.69
SNAP-Authorized corner store within full city block	0.011*	0.009*	0.036**
	(0.005)	(0.004)	(0.013)
N	144,680	144,680	144,680
Bronx County students			
Outcome measure mean or proportion	0.44	0.25	0.73
SNAP-Authorized corner store within full city block	0.006	0.005	0.026**
	(0.004)	(0.003)	(0.010)
N	293,366	293,366	293,366
Kings (Brooklyn) County students			
Outcome measure mean or proportion	0.42	0.24	0.67
SNAP-Authorized corner store within full city block	0.006	0.006*	0.021*
	(0.003)	(0.003)	(0.008)
N	431,938	431,938	431,938
Queens County students			
Outcome measure mean or proportion	0.41	0.22	0.61
SNAP-Authorized corner store within full city block	0.003	0.004	0.007
	(0.004)	(0.004)	(0.011)
N	374,499	374,499	374,499
Richmond County students			
Outcome measure mean or proportion	0.41	0.23	0.66
SNAP-Authorized corner store within full city block	0.044*	0.019	0.096*
	(0.019)	(0.016)	(0.043)
N	71,800	71,800	71,800

Note: Ordinary least squares is used. All models control for English proficiency, whether the student speaks English at home or not, gender, grade, ethnicity, whether the student lives in public housing, if the building the student lives in is used for both residential and commercial purposes, the presence of either SNAP-authorized or not SNAP-authorized supermarkets, pharmacies and other midsized grocers, tract fixed effects and year fixed effects. Corner store defined as a store less than 2,000 square feet. Sample is restricted to students who qualified for free or reduced lunch during any year in the sample period and who did not move during the sample period. In parentheses are robust standard errors clustered at the census tract level. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

Appendix Six: Prediction of presence of a SNAP-authorized store a block from student's household (Academic years 2008-2013)

	(1) Any SNAP-authorized store	(2) Brand new SNAP-authorized store	(3) Pre-existing SNAP-authorized store
Mean proportion for outcome measure	0.297	0.022	0.003
SNAP eligibility? (versus never)			
From a SNAP eligible household	0.019***	0.002***	0.000
	(0.002)	(0.000)	(0.000)
Student Demographic Characteristics			
Gender (versus male)			
Female	0.000	-0.000	0.000
	(0.001)	(0.000)	(0.000)
Race or ethnicity (versus other)			
Hispanic	0.023***	0.002**	0.000
	(0.005)	(0.001)	(0.000)
Black	0.009	0.001	0.000
	(0.005)	(0.001)	(0.000)
White	-0.009*	-0.000	-0.000
	(0.004)	(0.001)	(0.000)
English proficiency (versus proficient)			
Below proficient score on NYSESLAT	0.012***	0.001	0.001*
	(0.003)	(0.001)	(0.000)
English at home (versus not)			
English at home	-0.020***	-0.003***	-0.000**
	(0.002)	(0.000)	(0.000)
Housing Characteristics			
Student lives in public housing building (versus not)	-0.047	0.005	0.004*
	(0.025)	(0.004)	(0.002)
Student lives in a mixed use building (versus not)	0.408***	0.048***	0.006***
	(0.009)	(0.003)	(0.001)
N	1,531,989	1,531,989	1,531,989

Ordinary least squares is used. Models additionally include student grade fixed effects, year fixed effects and census tract fixed effects. SNAP eligible is that the student qualified for free or reduced lunch during the sample period. In parentheses are robust standard errors clustered at the census tract level. p<0.05=*, p<0.01=**, p<0.001=***

Appendix Seven: Additional model specifications (Academic years 2008-2013)

	Overweight				Obese				BMI z-score			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome measure mean or proportion	0.41	0.41	0.41	0.41	0.23	0.23	0.23	0.23	0.60	0.60	0.60	0.60
Census tract fixed effects	Y	N	N	N	Y	N	N	N	Y	N	N	N
Census time trends	N	Y	N	N	N	Y	N	N	N	Y	N	N
Block fixed effects	N	N	Y	N	N	N	Y	N	N	N	Y	N
Block time trends	N	N	N	Y	N	N	N	Y	N	N	N	Y
Panel 1												
Any SNAP-authorized stores												
Within full city block	0.008***	0.008***	0.004*	0.006**	0.007***	0.008***	0.004*	0.005*	0.023***	0.024***	0.011*	0.014*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.005)	(0.006)
Not SNAP-authorized store												
Within full city block	0.002	0.002	-0.001	-0.002	0.002	0.002	0.001	-0.000	0.005	0.005	0.001	0.000
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.005)	(0.007)
Panel 2												
SNAP-authorized corner store												
Within full city block	0.007***	0.008***	0.003	0.005	0.006***	0.006***	0.003	0.003	0.023***	0.025***	0.025***	0.014*
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.005)	(0.007)
Not SNAP-authorized corner store												
Within full city block	0.003	0.003	0.002	0.000	0.003	0.003	0.002	0.001	0.005	0.004	0.004	0.000
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.005)	(0.006)	(0.006)	(0.008)
N	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283	1,316,283

Note: Panel One and Panel Two represent two separate regressions. Ordinary least squares is used. All models control for English proficiency, whether the student speaks English at home or not, gender, grade, ethnicity, whether the student lives in public housing, if the building the student lives in is used for both residential and commercial purposes, tract and year fixed effects. Panel Two additionally controls for the presence of either SNAP-authorized or not SNAP-authorized supermarkets, pharmacies and other midsized grocers. Sample is restricted to students who qualified for free or reduced lunch during any year in the sample period and who did not move during the sample period. In parentheses are robust standard errors clustered at the census tract level. A corner store is classified as a store location that is less than 2,000 square feet. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***