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School and Residential Neighborhood Food Environment and Dietary Intake among California Children and Adolescents

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Abstract

Background—Various hypotheses link neighborhood food environments and diet. Greater exposure to fast food restaurants and convenience stores are thought to encourage overconsumption; supermarkets and large grocery stores are claimed to encourage healthier diets. For youth, empirical evidence for any particular hypothesis remains limited.

Purpose—This study examines the relationship between school and residential neighborhood food environment and diet among youth in California.

Methods—Data from 8226 children (age 5–11) and 5236 adolescents (12–17) from the California Health Interview Survey are analyzed. The dependent variables are daily servings of fruits, vegetables, juice, milk, soda, high sugar foods, and fast food, which are regressed on measures of food environments. Food environments are measured by counts and density of businesses, distinguishing fast-food restaurants, convenience stores, small food stores, grocery stores, and large supermarkets within a specific distance (varying from 0.1 to 1.5 miles) from a respondent's home or school.

Results—No robust relationship between food environment and consumption was found. A few significant results are sensitive to small modeling changes and more likely to reflect chance than true relationships.

Conclusions—This correlational study has measurement and design limitations. Longitudinal studies that can assess links between environmental, dependent and intervening food purchase and consumption variables are needed. Reporting a full range of studies, methods and results is important as a premature focus on significant correlations may lead policy astray.

Introduction

Obesity remains a leading health concern for youth.¹ In sharp contrast to the goal of Healthy People 2010 that aimed to reduce obesity of children and adolescents in the U.S. to 5% by 2010,² the obesity rate among 2–19 years old increased steadily from 14% in 2000 to 17% in 2008.³ This triggered a burst of recent policy activities, including a \$400 million healthy food initiative,¹ the founding of White House Childhood Obesity Task Force,⁴ and an updated strategic plan giving obesity prevention a priority in the Department of Health and Human Services.⁵ Many of those efforts targeted food environment as a central area for interventions. The Centers for Disease Control and Prevention (CDC) recommended counts of supermarkets as a measure⁶ and the White House Childhood Obesity Task Force proposed to increase the number of supermarkets in order to reduce childhood obesity.⁴

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Two commonly proposed hypotheses are that diet quality can be improved, and unhealthy weight gain can be prevented through (1) improved access to supermarkets and large grocery stores, or (2) reduced exposure to fast food restaurants, convenience stores, and small food stores. Evidence for these hypotheses is still developing, and at this point, more tentative than presented in media and policy arguments.^{7–9} The Obesity Task Force's recommendation to promote supermarkets, for example, was based on a single study that associated chain supermarkets in a postal zip code with lower body weight among adolescents.¹⁰ Yet earlier studies using very similar methods that reported null findings were not cited.^{11–12}

This study investigates the relationship between food environments, consumption, and body mass index (BMI) among Californian youth. It makes two contributions: (1) We analyze data from the California Health Interview Survey (CHIS) by linking one of its behavior measures (i.e., dietary intake) to the neighborhood food environment. The data has not been used in this context before. (2) We analyze both home and school neighborhoods. Actual locations of homes and schools are used and neighborhoods measured based on distance for each individual. Studies so far have considered either residential or school neighborhood food environments,^{13–15} but never both.

The primary outcome variables in this study are self-reported consumption of fruits, vegetables, 100% juice, milk, soda, high sugar foods, and fast food, with BMI percentile as a secondary outcome. The primary explanatory variables are the counts of a particular type of food outlet (distinguishing fast-food restaurants, convenience stores, small food stores, grocery stores, and supermarkets) within a specific distance from a respondent's home and school.

Methods

Study Sample

The individual data come from the 2005 and 2007 waves of CHIS. Within each household, separate interviews were conducted with a randomly-selected adult (18 years and older), adolescents (12–17), and parents of children (0–11). In the two waves, a total of 11,851 school-age children (5–11) and 7,574 adolescents (12–17) were interviewed. Among them, 3,625 (30.6%) and 2,338 (30.9%) respectively, do not have valid school and residential latitude/longitude, possibly due to unsuccessful geocoding by CHIS. Our main analysis as reported here uses only cases with complete data. For sensitivity analyses, missing values were imputed using the MI procedures in STATA 12.0 (StataCorp, College Station, TX) and reanalyze the data.

The primary dependent variables are a respondent's consumption of fruits, vegetables, juice, milk (only for children), soda, high sugar foods, and fast food on the day before the interview. It is a self-report for adolescents, and a parent-report for children. The adolescent questions are: "Yesterday, how many servings of fruit, such as an apple or banana did you eat? Do not count juices."; "Yesterday, how many servings of vegetables, like corn, green beans, green salad, or other vegetables did you eat?"; "Yesterday, how many glasses of 100% fruit juice such as orange or apple juice did you drink? Include only 100% pure juices. Do not include fruit drinks."; "Yesterday, how many glasses or small cartons of milk did you drink? Include milk on cereal."; "Yesterday, how many glasses or cans of soda, such as Coke, or other sweetened drinks, such as fruit punch or Sunny Delight did you drink? Do not count diet drinks."; "Yesterday, how many servings of high sugar foods, such as cookies, candy, doughnuts, pastries, cake or popsicles did you have? Do not include kinds that are completely sugar-free. Include low-fat kinds."; and "Yesterday, how many times did you eat fast food, such as food you get at McDonald's, Panda Express, or Taco Bell? Include

fast food meals eaten at school, at home or at fast-food restaurants, carryout, or drive thru.” It should be noted that serving of food is self-defined in CHIS; In the child component of the survey, “a serving is the child’s regular portion of this food”, and in the adolescent component, “a serving is whatever it means to you.”

As a secondary outcome measure, parent-reported (for children) and self-reported (for adolescents) height and weight is used to calculate age- and gender-specific BMI percentile based on the 2000 BMI-for-age growth chart issued by CDC. It is considered as secondary because measurement error, at least for parent-reported child height/weight, is believed to be substantial and higher than in the adult self-report.^{16–18}

The analysis uses separate multivariate models for children and for adolescents. The following individual variables are included as control variables in the regression: gender; age (in years and age squared); race/ethnicity (indicator variables for White, African American, Hispanic, Asian or Pacific Islander, Native American, and other race/multi-race); household size; annual household income (in national logarithm); parent’s education (indicator variables for education lower than high school, high school graduate, education higher than high school but lower than college, college graduate, and education higher than college); parent’s BMI; and survey wave. In CHIS, one parent was randomly selected within each surveyed household with children. Some school and home census tract characteristics (using the 2000 Census data) are included as additional control variables - population density, median household income, and proportion of non-Hispanic Whites.

Measurement of the Neighborhood Food Environment

ArcMap version 9.3.1 (ESRI, Redlands, CA) is used to draw circular buffers with 4 different radii (0.1, 0.5, 1.0, and 1.5 miles), centered at students’ schools and residences. A distance of 0.1 to 1.5 miles is approximately a 2- to 30-minute walk¹⁹ and thus captures a wide range of what might be considered a “neighborhood.” Food outlet data is geocoded to latitude/longitude and overlaid over the buffers, and neighborhood food environment is constructed as the counts of a particular type of food outlet located within each buffer.

Food outlet data come from the 2006 release of InfoUSA, which compiles business data including name, type, location, and sale volume for about 14 million businesses in the U.S. Businesses in InfoUSA are classified using the North American Industry Classification System (NAICS). While there is no NAICS code for fast-food restaurants, 63 major fast-food franchises are identified with main menus containing items such as hotdogs, burgers, pizza, fried chicken, subs or tacos under the NAICS codes 72221105-6. Convenience stores are identified as NAICS code 44512001, and small food store (annual sales < \$1m), mid-size grocery store (annual sales \$1–5m), and large supermarket (annual sales > \$5m) are identified as NAICS codes 44511001-3.

Statistical Methods

Our primary dependent variables (i.e., counts of food consumption) are regressed on the explanatory variables using negative binomial regression models, a generalization of Poisson models that avoids the Poisson restriction on the mean-variance equality.²⁰ Separate regressions are conducted for children and adolescents, for school and/or residential neighborhood, and for each of the 4 buffer sizes (0.1-, 0.5-, 1.0-, and 1.5-mile radius). Outlet counts are created for school and home buffers separately, but also for the joint area that corrects for overlap. For instance, if the school and home buffer contain 3 and 5 fast-food outlets, and one of them is located in their overlapping area, the outlet count is 7. If a respondent’s school and home are located in different census tracts, average tract characteristics are used.

Results

Table 1 shows descriptive statistics of the sample population in CHIS 2005 and 2007 waves. Adolescents 12–17 years old consume considerably more soda, high sugar foods, and fast food compared to children 5–11 years old ($P < 0.0001$); while daily consumptions of fruits, vegetables, and juice are similar.

Table 2 shows the percentages of children and adolescents who have 0, 1, 2, and 3 or more food outlets of a specific type within 0.5 mile (about 10-minute walking distance) from home or school. Children and adolescents interviewed in CHIS lived and attended schools in 3,534 and 3,508 census tracts in California, respectively, with considerable variation in population, median household income, and minority composition. Similar variation exists in neighborhood food environment across respondents. For example, 45% of adolescents had no fast-food restaurants in 10-minute walking distance, while 28% had 3 or more in close proximity from school. 70% of families with children had no supermarkets within 0.5 mile from home, but 7% had 2 or more.

Table 3 shows the estimated associations between neighborhood food environment and dietary intake for the 0.5-mile radius buffer. The numbers show estimated incidence rate ratios (IRR) for consumption of different type of food as a function of the food environment measure. Most of the estimated IRRs from negative binomial models are close to unity and statistically insignificant at the 0.05 level. Moreover, the small number of significant findings do not show systematic patterns and some of them are contradictory to the hypotheses. In total, 780 effects are estimated. In the absence of any actual relationship, about 39 significant findings (5%) could well be due to chance. In fact, 38 relationships are found significant at $P < 0.05$. If the Bonferroni's adjustment for multiple comparisons is adopted, none of them turns out to be statistically significant.

Table 4 shows the results from ordinary least squares (OLS) regressions of BMI percentile on neighborhood food measures, controlling for other covariates. Almost none of the coefficients of food outlet types is significant.

Several sensitivity analyses were conducted to assess the robustness of findings across alternative model specifications, population subgroups, and approaches to deal with missing data. While the statistical tool for Table 3 (i.e., negative binomial regression for counts) appears to be the most appropriate for this type of dependent variable, all models were re-estimated using OLS and Poisson regressions. Instead of BMI percentile, we also created indicator variables of overweight and obesity status, analyzed with Logit models. We performed subgroup analyses separately for boys and girls and for urban and rural areas. We also repeated the analyses by omitting parent's BMI and using imputed values (mainly for food environment as the main source of missing data is due to geocoding failure). The qualitative results were not sensitive to those alternative model specifications, population subgroups, and the way missing data are handled and did not indicate any systematic evidence that local food outlets were associated with consumption or BMI.

In contrast to the null findings for the relationship between neighborhood environment on dietary intake and body weight among California children and adolescents, the estimated effect sizes of key individual covariates are significant and stable across models. Male, age, and parents' BMI are consistent predictors for students' BMI percentile. Boys tend to consume significantly less vegetables and fruits but more milk, fast food, and soda than girls.

Discussion

This study found no evidence to support the hypotheses that improved access to supermarkets, or that less exposure to fast-food restaurants or convenience stores within walking distance improve diet quality or reduce BMI among Californian youth. There are isolated significant coefficients, but the number of significant coefficients is about what would be expected due to chance.

No single study resolves a major research question. Establishing reliable empirical relationships (even without establishing causality) requires the accumulation of evidence through many studies. Every study will have its own set of limitations and our analysis certainly has many. The response rate of CHIS (29.5% in 2005 and 21.1% in 2007) remains low, and our study sample has a large proportion of missing values (30.6% for children and 30.9% for adolescents). The data are not complete dietary recalls but single item questions without probing or guidance on serving size. Similarly, self-reported height and weight (and even more so for parent-reported height and weight) is likely to have substantial measurement errors. Relatively small sample sizes and noisy measures of dependent variables lower the statistical power to detect small but true associations.

Possibly even more of a limitation is the quality of the InfoUSA business listings, although this is a criticism that applies to all similar studies, including those reporting significant findings. Powell et al. (2011)²¹ advises caution when using commercial listings, reporting only fair agreement between commercial data and field observations for supermarkets, grocery stores, convenience stores and full-service restaurants, and poor agreement for fast-food restaurants. Field studies by Bader et al. (2010)²² and Liese et al. (2010)²³ find reasonably good predictive values, although there are substantial discrepancies. The precision of coding on a very small scale (i.e., less than 100 meters) is unreliable. That is not surprising, however, as 100 meters is a distance smaller than a shopping center (or even a strip mall), and street-address geocoding will not match to the exact location within a shopping center. More generally, categorizing food outlets by type tends to be insufficient to reflect the heterogeneity of outlets and it is possible that more detailed measures, such as store inventories, ratings of food quality, and measuring shelf space, would be more predictive for health outcomes.²⁴⁻²⁶ Unfortunately, such data are very costly and time consuming to collect and may never exist on a national scale. Simple measures will remain important for surveillance and tracking on a large scale where feasibility is paramount. This is reflected in the recommendations by the CDC to use the number of full-service grocery stores and supermarkets as one community measures in efforts to prevent obesity.⁶ But unless such measures have predictive value for what are the ultimate desired outcomes (e.g., to improve diet or lower obesity rates), they are not useful to inform policy.

Our findings seem to be in conflict with a recent study that reports positive association between proximity of fast-food restaurants surrounding schools, and soda consumption and obesity among adolescents using the California Healthy Kids Survey.²⁷ That study focuses on BMI and the BMI results clearly differ from ours. The inconsistency could result from statistical power as that study has much larger sample size (over half a million survey respondents). Even so, there a few issues remain unexplained. For instance, the regression coefficient for counts of soda consumption in that study is statistically nonsignificant just as in our analysis (in both cases, the point estimate is positive). Nor did that study find a significant effect on fried potato consumption, the diet measure with a direct plausible causal relationship to nearby fast-food outlets. No relationships between other type of food outlets and consumption patterns are reported.. The study by Powell et al. (2007)¹⁰ is cited as support for the hypothesis that supermarkets have a protective effect, but that study reports no results on fast-food outlets, although that variable was analyzed as well.

While our null findings may be due to technical limitations (e.g., data quality, sample size), there are substantive reasons why the association between local food outlets and consumption or BMI may be much weaker than commonly believed. Today's society is very mobile and the role of transportation has altered the definition of the shopping environment - both across areas and individuals.²⁸ Access to transportation could be a more essential determinant of dietary behaviors than immediate availability, an issue highlighted in the USDA report on "food deserts."²⁸ In a Los Angeles study, Inagami et al. (2006) found that less than 20 percent of respondents shop in their census tract.²⁹ Only 3% of households in the 2007 CHIS data report not having access to a car.

Research on how environmental factors affect obesity and related health behaviors is rapidly growing. One particular problem in new fields of investigation is that early results often do not hold up, or require some qualification that is only detectable through replication, a central principle of scientific method. The rate of false-positive results is particularly high for new and competitive research topics, which has led some methodologists to claim that "most published research results are false."³⁰⁻³¹ Research on environmental impacts on obesity is probably not dissimilar to other emerging research areas where there is an initial explosion of findings, but successful replication rates are low.³² Our study can only provide one data point, but reporting a full range of results is important as a selective focus on significant results (and especially those that appear to confirm - rather than contradict - a hypothesis) may lead policy astray. In contrast to basic research, publications on associations between obesity and the environment have an immediate and sizeable impact on policy. Accelerating this "shake down" period through systematic replication is thus potentially beneficial. At least equally important is the research design. Existing studies examining the environmental impact on body weight are mostly correlational. To infer causality from the mechanisms through which community retail food outlets might (or might not) influence youth's diet and obesity, new studies should focus on improvement in research design by examining the critical intervening variables (such as shopping and purchasing practices), through experimentation, or through the rigorously-founded and carefully-implemented quasi-experimental methods.³³

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Table 1

Descriptive statistics of sample population

Variable	Attribute	Child Mean (SD)	Adolescent Mean (SD)
<i>Daily food consumption</i>			
Servings of fruit	count	1.79 (1.22)	1.68 (1.41)
Servings of vegetables	count	1.30 (1.01)	1.37 (1.30)
Servings of 100% juice	count	1.06 (1.24)	1.01 (1.14)
Servings of milk	count	1.79 (1.21)	/
Servings of soda	count	0.61 (0.91)	1.09 (1.39)
Servings of high sugar food	count	1.07 (1.02)	1.31 (1.60)
Times of having fast food	count	0.34 (0.45)	0.49 (0.59)
<i>Body weight</i>			
BMI percentile	continuous	0.69 (0.34)	0.68 (0.27)
<i>Gender</i>			
Male	dichotomous	0.51 (0.50)	0.51 (0.50)
<i>Age</i>			
Age in years	continuous	8.28 (1.98)	14.52 (1.67)
Age in years squared	continuous	72.49 (32.47)	213.50 (48.59)
<i>Race/ethnicity</i>			
White (non-Hispanic)	dichotomous	0.46 (0.50)	0.39 (0.49)
African American (non-Hispanic)	dichotomous	0.08 (0.28)	0.08 (0.27)
Asian or Pacific Islander (non-Hispanic)	dichotomous	0.11 (0.31)	0.11 (0.31)
Native American (non-Hispanic)	dichotomous	0.01 (0.10)	0.01 (0.10)
Other race or multi-race (non-Hispanic)	dichotomous	0.06 (0.23)	0.10 (0.30)
Hispanic	dichotomous	0.27 (0.45)	0.31 (0.46)
<i>Household size</i>			
Number of adults, children, and adolescents in household	count	4.54 (1.28)	4.49 (1.32)
<i>Income</i>			
Natural logarithm of annual household income in US\$	continuous	10.85 (1.26)	10.74 (1.45)
<i>Parent's education</i>			
Education lower than high school	dichotomous	0.12 (0.33)	0.21 (0.41)
High school graduate	dichotomous	0.23 (0.42)	0.21 (0.41)
Education higher than high school but lower than college	dichotomous	0.19 (0.39)	0.18 (0.39)
College graduate	dichotomous	0.32 (0.46)	0.28 (0.45)
Education higher than college	dichotomous	0.14 (0.35)	0.12 (0.32)
<i>Parent's body weight</i>			
Parent's BMI	continuous	27.13 (6.03)	27.52 (6.14)
<i>Survey wave</i>			
Proportion of sample in 2005 wave	dichotomous	0.48 (0.50)	0.51 (0.50)

Note: Sample size is 8,827 for children 5–11 years old and 5,236 for adolescents 12–17 years old. Statistics are adjusted using CHIS sampling weights.

Table 2

Food Outlet Type	Food Outlet Count	Child		Adolescent			
		School	Home	School & Home	School	Home	School & Home
Fast-food restaurant	0	50.94%	53.89%	35.19%	45.03%	56.11%	30.12%
	1	14.48%	13.46%	13.24%	14.44%	11.96%	13.08%
	2	10.04%	9.80%	11.10%	12.22%	9.49%	11.54%
	≥ 3	24.54%	22.85%	40.47%	28.30%	22.44%	45.26%
Convenience store	0	68.32%	70.11%	53.72%	64.17%	69.44%	49.10%
	1	22.68%	21.04%	27.45%	25.02%	21.08%	28.04%
	2	6.87%	6.64%	12.00%	8.38%	7.10%	14.34%
	≥ 3	2.13%	2.21%	6.83%	2.43%	2.37%	8.52%
Small food store	0	58.87%	61.72%	44.58%	55.92%	62.15%	40.51%
	1	21.16%	18.62%	22.78%	21.70%	17.84%	23.13%
	2	8.39%	7.20%	11.44%	9.00%	6.99%	11.65%
	≥ 3	11.57%	12.46%	21.20%	13.39%	13.03%	24.71%
Grocery store	0	81.64%	83.86%	72.74%	82.28%	83.37%	71.49%
	1	13.86%	11.97%	18.44%	12.95%	12.41%	19.08%
	2	2.83%	2.81%	5.39%	3.38%	2.54%	5.56%
	≥ 3	1.67%	1.36%	3.43%	1.39%	1.68%	3.88%
Large supermarket	0	66.51%	69.62%	51.28%	63.67%	70.68%	47.59%
	1	24.82%	23.00%	30.12%	26.05%	21.58%	31.88%
	2	6.88%	5.85%	13.07%	8.44%	5.92%	13.62%
	≥ 3	1.79%	1.53%	5.53%	1.83%	1.81%	6.91%
Census tract	Population per square mile	5271 (5466)	5565 (6259)	4863 (5208)	5367 (5634)	5661 (6842)	4746 (5084)
	Median household income US\$	73293 (36063)	72513 (35166)	72860 (33025)	68662 (33306)	71031 (35872)	70114 (31307)
	Proportion of non-Hispanic White	0.640 (0.194)	0.627 (0.200)	0.631 (0.187)	0.626 (0.195)	0.620 (0.203)	0.621 (0.184)

Note: Sample size is 8,226 for children 5–11 years old and 5,236 for adolescents 12–17 years old. Mean and standard deviation (in parenthesis) are reported. Statistics are adjusted using CHHS sampling weights. Reported percentages in “Home” and “School” columns denote the proportions of children and adolescents that have less than 1, 1–2, 2–3, or more than 3 food outlets of a specific type within 0.5

mile from their home and school, respectively. Reported percentages in “School & Home” columns denote the proportions of children and adolescents that have 0, 1, 2, and 3 or more food outlets of a specific type within 0.5 mile either from their home or from school.

Table 3

Estimated associations (incidence rate ratios) between neighborhood food environment and dietary intake

Food Outlet Type	Daily Food Consumption			Child		Adolescent			
	School	Home	School & Home	School	Home	School & Home	School	Home	School & Home
Fast-food restaurant	Fruits	1.003 (0.005)	0.999 (0.006)	1.002 (0.004)	1.007 (0.006)	0.991 (0.007)	1.000 (0.005)		
	Vegetables	0.997 (0.006)	0.992 (0.007)	0.994 (0.005)	*1.017 (0.008)	1.004 (0.008)	*1.012 (0.006)		
	100% juice	0.986 (0.009)	0.995 (0.009)	0.990 (0.007)	0.994 (0.010)	1.000 (0.009)	0.997 (0.007)		
	Milk	0.992 (0.004)	1.001 (0.005)	0.996 (0.003)	/	/	/		
	Soda	1.006 (0.011)	1.021 (0.016)	1.010 (0.010)	0.989 (0.011)	1.005 (0.009)	0.997 (0.008)		
	High sugar food	0.998 (0.008)	1.005 (0.009)	0.999 (0.006)	1.029 (0.016)	0.983 (0.011)	1.007 (0.010)		
	Fast food	0.991 (0.010)	1.000 (0.012)	0.998 (0.008)	0.993 (0.012)	1.006 (0.012)	0.995 (0.008)		
Convenience store	Fruits	0.986 (0.015)	1.003 (0.015)	0.997 (0.011)	1.000 (0.021)	1.016 (0.020)	1.008 (0.015)		
	Vegetables	1.003 (0.019)	0.994 (0.019)	1.002 (0.014)	0.987 (0.026)	0.988 (0.022)	0.986 (0.017)		
	100% juice	0.989 (0.027)	0.984 (0.026)	0.984 (0.021)	*0.930 (0.032)	0.979 (0.027)	0.961 (0.021)		
	Milk	0.993 (0.015)	1.016 (0.012)	1.008 (0.010)	/	/	/		
	Soda	0.984 (0.036)	1.051 (0.030)	1.018 (0.024)	0.984 (0.039)	*0.936 (0.031)	*0.952 (0.024)		
	High sugar food	0.986 (0.027)	1.015 (0.024)	0.995 (0.018)	1.051 (0.055)	0.986 (0.043)	1.025 (0.041)		
	Fast food	0.987 (0.033)	0.984 (0.031)	0.987 (0.023)	1.005 (0.032)	*0.935 (0.031)	0.965 (0.023)		
Small food store	Fruits	1.002 (0.005)	1.003 (0.004)	1.002 (0.003)	0.996 (0.007)	0.992 (0.006)	0.995 (0.004)		
	Vegetables	1.004 (0.005)	1.004 (0.005)	1.003 (0.003)	1.002 (0.010)	0.998 (0.005)	1.001 (0.004)		
	100% juice	1.007 (0.007)	1.006 (0.008)	1.005 (0.006)	0.988 (0.010)	1.004 (0.006)	0.999 (0.005)		
	Milk	0.998 (0.004)	0.996 (0.004)	0.998 (0.002)	/	/	/		
	Soda	1.002 (0.011)	1.001 (0.008)	1.003 (0.006)	1.002 (0.009)	1.009 (0.006)	1.004 (0.005)		
	High sugar food	0.999 (0.007)	1.010 (0.005)	1.003 (0.004)	1.013 (0.015)	1.008 (0.008)	1.008 (0.007)		
	Fast food	1.006 (0.009)	0.996 (0.009)	1.003 (0.007)	1.010 (0.009)	**1.017 (0.005)	1.009 (0.005)		
Grocery store	Fruits	1.015 (0.015)	1.002 (0.017)	1.004 (0.012)	0.962 (0.028)	0.982 (0.028)	0.980 (0.019)		
	Vegetables	1.015 (0.018)	0.980 (0.022)	0.998 (0.015)	0.995 (0.029)	0.971 (0.028)	0.988 (0.020)		
	100% juice	1.030 (0.030)	1.035 (0.028)	1.038 (0.021)	0.947 (0.036)	0.966 (0.038)	0.968 (0.028)		
	Milk	1.001 (0.015)	1.001 (0.015)	1.000 (0.011)	/	/	/		

Food Outlet Type	Daily Food Consumption	Child		Adolescent	
		School	Home	School & Home	School
Soda	High sugar food	1.013 (0.039)	0.960 (0.042)	0.987 (0.033)	1.023 (0.036)
		1.022 (0.025)	1.041 (0.025)	1.019 (0.018)	0.960 (0.047)
		1.029 (0.035)	1.010 (0.032)	1.028 (0.025)	1.042 (0.043)
Fruits	Vegetables	1.009 (0.016)	1.022 (0.016)	1.018 (0.012)	1.020 (0.021)
		0.996 (0.019)	0.988 (0.020)	0.986 (0.015)	1.001 (0.026)
		0.965 (0.030)	1.009 (0.028)	0.991 (0.022)	1.006 (0.029)
Milk	Soda	0.993 (0.021)	1.010 (0.021)	1.007 (0.017)	/
		0.995 (0.035)	*1.078 (0.035)	1.036 (0.026)	1.038 (0.039)
		0.955 (0.024)	1.043 (0.029)	0.996 (0.019)	1.033 (0.040)
Fast food	High sugar food	1.008 (0.031)	1.045 (0.031)	1.022 (0.025)	1.060 (0.036)

Note: Sample size is 8,226 for children 5–11 years old and 5,236 for adolescents 12–17 years old. Incidence rate ratio and its standard error (in parenthesis) using negative binomial models are reported. Responses are daily servings of fruit, vegetable, 100% juice, milk, soda, high sugar food, and fast food. Individual covariates in Table 1 and census tract characteristics in Table 2 are controlled. Neighborhood food environment is measured as the counts of a particular type of food outlet (e.g., supermarket) within circular buffer with 0.5-mile radius centering at a student's school or home. "School & Home" denotes school AND residential food environment measured by the food outlet counts within the total area identified by the school and the home buffer. Statistics are adjusted using CHIS sampling weights. Eicker-White sandwich estimator is used to calculate standard errors.

* P < 0.05;
 ** P < 0.01.

Table 4
Estimated associations between neighborhood food environment and BMI percentile of children and adolescents

Buffer	Food Outlet Type	Child			Adolescent		
		School	Home	School & Home	School	Home	School & Home
0.1-mile radius	Fast-food restaurant	-0.0397 (0.0274)	-0.0075 (0.0210)	-0.0235 (0.0308)	-0.0018 (0.0129)	0.0196 (0.0192)	0.0057 (0.0107)
	Convenience store	-0.0094 (0.0334)	0.0255 (0.0442)	-0.0112 (0.0382)	0.0344 (0.0356)	0.0213 (0.0369)	0.0273 (0.0252)
	Small food store	0.0103 (0.0177)	0.0027 (0.0197)	0.0033 (0.0158)	-0.0048 (0.0225)	-0.0459 (0.0251)	-0.0286 (0.0189)
	Mid-size grocery store	-0.0228 (0.0389)	0.0605 (0.0327)	0.0260 (0.0314)	0.0259 (0.0374)	-0.0452 (0.0429)	-0.0158 (0.0306)
	Large supermarket	-0.0367 (0.0373)	-0.0236 (0.0471)	-0.0631 (0.0396)	0.0418 (0.0409)	0.0134 (0.0358)	0.0323 (0.0285)
0.5-mile radius	Fast-food restaurant	-0.0009 (0.0019)	0.0017 (0.0031)	-0.0005 (0.0023)	-0.0025 (0.0022)	-0.0000 (0.0024)	-0.0010 (0.0016)
	Convenience store	-0.0006 (0.0058)	0.0039 (0.0092)	0.0023 (0.0064)	-0.0060 (0.0073)	0.0041 (0.0072)	-0.0024 (0.0050)
	Small food store	-0.0024 (0.0017)	0.0028 (0.0035)	0.0013 (0.0019)	0.0020 (0.0025)	-0.0003 (0.0019)	0.0004 (0.0013)
	Mid-size grocery store	-0.0040 (0.0058)	0.0097 (0.0111)	0.0055 (0.0073)	-0.0068 (0.0076)	-0.0164* (0.0070)	-0.0082 (0.0048)
	Large supermarket	0.0037 (0.0062)	0.0090 (0.0091)	0.0047 (0.0072)	0.0079 (0.0074)	0.0051 (0.0077)	0.0067 (0.0054)
1.0-mile radius	Fast-food restaurant	-0.0003 (0.0009)	0.0011 (0.0014)	0.0008 (0.0009)	-0.0005 (0.0010)	0.0012 (0.0011)	-0.0004 (0.0007)
	Convenience store	-0.0045 (0.0028)	0.0031 (0.0042)	-0.0008 (0.0032)	-0.0032 (0.0034)	-0.0026 (0.0035)	-0.0033 (0.0023)
	Small food store	-0.0008 (0.0006)	0.0011 (0.0010)	0.0004 (0.0005)	-0.0003 (0.0008)	-0.0002 (0.0007)	-0.0001 (0.0004)
	Mid-size grocery store	-0.0027 (0.0032)	0.0030 (0.0051)	0.0022 (0.0037)	-0.0062 (0.0042)	-0.0038 (0.0039)	-0.0028 (0.0026)
	Large supermarket	0.0014 (0.0032)	0.0015 (0.0049)	0.0016 (0.0034)	0.0021 (0.0038)	0.0094* (0.0040)	-0.0002 (0.0027)
1.5-mile radius	Fast-food restaurant	-0.0003 (0.0005)	0.0005 (0.0008)	0.0003 (0.0005)	-0.0005 (0.0006)	-0.0001 (0.0006)	-0.0004 (0.0004)
	Convenience store	-0.0022 (0.0017)	0.0049 (0.0025)	0.0013 (0.0019)	-0.0016 (0.0020)	-0.0024 (0.0023)	-0.0008 (0.0014)
	Small food store	-0.0003 (0.0003)	0.0007 (0.0005)	0.0002 (0.0003)	-0.0001 (0.0004)	-0.0001 (0.0004)	-0.0000 (0.0002)
	Mid-size grocery store	-0.0006 (0.0022)	0.0034 (0.0032)	0.0024 (0.0023)	-0.0012 (0.0026)	0.0008 (0.0024)	0.0001 (0.0016)
	Large supermarket	-0.0005 (0.0021)	0.0010 (0.0031)	0.0003 (0.0021)	0.0003 (0.0027)	-0.0012 (0.0029)	-0.0015 (0.0018)

Note: Sample size is 8,226 for children 5–11 years old and 5,236 for adolescents 12–17. OLS coefficient and its standard error (in parenthesis) are reported. Response is BMI percentile based on the CDC 2000 BMI-for-age growth chart. Individual covariates in Table 1 and census tract characteristics in Table 2 are controlled. Neighborhood food environment is measured as the counts of a particular type of food outlet (e.g., supermarket) within buffer with certain radius (e.g., 0.1-mile) centering at a student's school or home. "School & Home" denotes school AND residential food environment measured by the food outlet counts within the total area identified by the school and the home buffer. Statistics are adjusted using CHHS sampling weights. Eicker-White sandwich estimator is used to calculate standard errors.

* $P < 0.05$;

*
P < 0.001.

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