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The Influence of Neighborhood Food Stores on Change in Young Girls' Body Mass Index

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Abstract

Background—As the prevalence of childhood obesity has risen in past decades, more attention has been given to how the neighborhood food environment affects children's health outcomes.

Purpose—This exploratory study examined the relationship between the presence of neighborhood food stores within a girl's neighborhood and 3-year risk of overweight/obesity and change in BMI, in girls aged 6 or 7 years at baseline.

Methods—A longitudinal analysis of participants in the Cohort Study of Young Girls' Nutrition, Environment and Transitions (CYGNET) was conducted from 2005–2008. Neighborhood food stores were identified from a commercial database and classified according to industry codes in 2006. Generalized linear and logistic models were used to examine how availability of food stores within 0.25-mile and 1.0-mile network buffers of a girl's residence were associated with BMI z-score change and risk of overweight or obesity, adjusting for baseline BMI/weight and family sociodemographic characteristics. Data were analyzed in 2010.

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Results—Availability of convenience stores within a 0.25-mile network buffer of a girl's residence was associated with greater risk of overweight/obesity (OR 3.38, 95% CI 1.07, 10.68) and an increase in BMI z-score ($\beta=0.13$, 95% CI 0.00, 0.25). Availability of produce vendors/farmer's markets within a 1.0-mile network buffer of a girl's residence was inversely associated with overweight/obesity (OR 0.22, 95% CI 0.05, 1.06). A significant trend was observed between availability of produce vendors/farmer's markets and lower risk of overweight/obesity after 3 years.

Conclusions—Although food store inventories were not assessed and food store indices were not created, the availability of neighborhood food stores may affect a young girl's weight trajectory over time.

Background

As the prevalence of childhood obesity has risen in past decades, studies have examined the influence of the neighborhood food environment on diet and weight gain.¹ The neighborhood food environment includes retail food stores and food service establishments that may influence health through the accessibility, pricing and variety of food items.^{2,3} Previous studies of the neighborhood food environment and adult obesity have reported mixed results. The presence of supermarkets has been associated with higher consumption of fruits and vegetables,⁴ and a lower prevalence of obesity.⁵⁻¹⁰ The presence of fast-food restaurants has been positively linked to obesity in certain studies,^{6,10-15} while other studies observed no association.^{16,17} Other food stores have not been as extensively studied.

Children may interact with the neighborhood food environment differently from adults. Two studies found no association between fast-food restaurants and children's weight gain.^{18,19} Among adolescents, the presence of supermarkets was protective against being overweight, while the presence of convenience stores was positively associated with being overweight.²⁰ Davis and Carpenter also observed that students were more likely to be obese and have poorer diets if their schools were within a half-mile of fast-food restaurants.²¹ These and other studies among children have used cross-sectional data, limiting the ability to determine the effect of food stores on BMI over time.

Household income may act as an effect modifier in the associations between the neighborhood food environment and childhood overweight or obesity. Neighborhoods with low-income households often have fewer supermarkets,²²⁻²⁶ and more small grocery stores,^{22,23,27} convenience stores,^{23,27,28} and fast-food restaurants^{23,27, 29-33} than neighborhoods with higher-income households. Grocery items in low-income areas are usually more costly and of poorer quality, when compared to foods in more-affluent neighborhoods.^{34,35} In some studies, family income predicted children's dietary habits, such that children from lower-income families consumed more meat and full-fat dairy products, and fewer fruits, vegetables, and whole grains than children in higher-income families.^{36,37} Children in lower-income families may be more vulnerable to their neighborhood food environment by consuming more energy-dense, nutrient-poor foods, which can promote weight gain over time.

The objective of this study was to examine how the availability of neighborhood food stores affects 3-year change in BMI and risk of overweight or obesity in young girls, and whether associations were modified by household income. It was hypothesized that food stores carrying nutritious foods (e.g., produce stores/farmer's markets, small grocery stores, specialty stores, supermarkets) would be associated with a lower risk of obesity and a favorable change in BMI, whereas food stores that sell unhealthy food items (e.g., convenience stores, drug stores, fast-food restaurants, full-service restaurants, specific food

service venues, and supercenters) would be associated with a greater risk of obesity and an increase in BMI over time.

Methods

Study population

The Cohort Study of Young Girls' Nutrition, Environment and Transitions (CYGNET) is a prospective cohort study of young girls, aged 6 or 7 years at baseline, investigating environmental precursors to breast cancer, with a focus on identifying dietary, environmental and other exposures associated with differences in age-at-onset of pubertal development.³⁸ In 2005, 444 girls were recruited from the Kaiser Permanente Northern California (KPNC) health plan membership through the KPNC Infant Cohort File, a database containing information on all live births at KPNC facilities. Children were eligible for recruitment if they were female, aged 6 or 7 years at baseline, current members of KPNC, and residents of the surrounding communities currently and at time of birth. Children were excluded if they had a preexisting condition known to influence the onset of puberty, or a psychiatric condition that could limit study participation. Parental consent and child assent were obtained from all study participants.

Baseline clinical visits were conducted between June 2005 and August 2006. Children continue to complete annual clinic visits where anthropometric measurements, samples of blood and urine, and Tanner stage evaluations are conducted by clinic staff.³⁹ Interviews with the primary parent/caregiver are administered to assess environmental exposures and changes in residential history. Follow-up exams for the study period were completed by November 2008. All CYGNET Study procedures were approved by the Kaiser Permanente Northern California IRB.

Four counties in the San Francisco Bay Area (Alameda, Contra Costa, Marin, and San Francisco) were included in the study area. Census data demonstrate that these counties are ethnically and socioeconomically diverse, with non-Hispanic white ranging from 36% in Alameda County⁴⁰ to 81% in Marin County,⁴¹ and 9%–11% of individuals living in poverty across all counties⁴². In order to assess weight change over the 3-year study period, the study population was restricted to girls who provided anthropometric measurements in the first and third year of follow-up. Girls who changed residences after the baseline year were also excluded in order to avoid exposure misclassification. Girls excluded from analysis did not differ from the study population in terms of age, parent's/caregiver's highest education level or weight status. However, there were small differences by race/ethnicity, household income, and county of residence. The analytic sample consisted of 353 girls.

Measuring the neighborhood food environment

Information about neighborhood food stores came from 2006 InfoUSA data, a comprehensive database that provides information on business locations, openings and closings based on yellow page listings, and utility companies.²² Standard Industrial Classification and revised North American Industry Classification System (NAICS) codes were used to identify types of establishments. Food service (NAICS 722) and food store (NAICS 445) establishments were identified and coded as convenience stores, drug stores, fast-food restaurants, full-service restaurants, specific food store venues, specialty stores, small grocery stores, supermarkets, supercenters, and produce vendors/farmer's markets. Definitions and descriptive statistics of food store types are presented in Table 1. Establishments outside of the pre-defined NAICS criteria were excluded from analysis. Additional information was obtained from the California Federation of Certified Farmers'

Markets. Study procedures were approved by the University of California, San Francisco IRB.

Count variables were created to describe the number of individual food stores within a particular neighborhood. Neighborhoods were defined as 0.25-mile and 1.0-mile network buffers around each girl's residence, where 0.25 mile represents a typical walking distance for young girls⁴³ and 1.0 mile represents a typical walking distance for adults.^{44,45} Network buffers, measured along roads and streets used by pedestrians, were used to characterize neighborhoods as they are a better measure of neighborhood accessibility than Euclidean buffers.^{46,47} Network buffers will vary in shape and size if an area is suburban, urban with dense road networks, or it has hilly terrain with limited road networks.

Count variables were combined with population measures to create variables representing neighborhood food stores available per 1,000 people. These variables were standardized in order to account for population density that may be associated with food store density, and allows for a better comparison of food stores across multiple counties. Due to skewed distributions and a large number of zero food stores within buffers, neighborhood food store counts within 0.25-mile and 1.0-mile buffer zones were collapsed into two-, three-, four- or five-category ordinal variables. For interpretability, the number of stores within the buffer per every 1,000 people will henceforth be referred to as "neighborhood food store availability."

Outcomes

Height and weight were measured at clinic visits using a fixed stadiometer and a digital Tanita® scale TBF 300A. To account for expected changes in height and weight associated with childhood development, BMI z-scores were calculated based on age- and gender-specific criteria from the CDC.⁴⁸ Overweight or obese was defined as having a BMI-for-age $\geq 85^{\text{th}}$ percentile. Outcomes for analysis were a binary variable corresponding to whether the participant was overweight or obese in the third year of follow-up and a continuous variable representing 3-year change in BMI z-score.

Statistical analysis

The exposures of interest were availability of neighborhood food stores within 0.25-mile and 1.0-mile buffer zones. Because most food stores were not correlated with one another, individual food store types were introduced separately in the models. Effect estimates comparing each category to the reference (lowest) category of neighborhood food store availability were computed; however, only effect estimates comparing the highest category to the reference category were reported.

Logistic regression models were fit for the outcome of overweight or obesity in Year 3. Model 1 included a covariate for baseline weight status (1: BMI-for-age $\geq 85^{\text{th}}$ percentile, 0: BMI-for-age $< 85^{\text{th}}$ percentile) in order to assess change in weight status over time. Model 2 added covariates for race/ethnicity (non-Hispanic white, African-American, Hispanic/Latina, Asian/Mixed/Other), parent's/caregiver's highest education level ($\leq$ high school diploma, any college or associate's degree, bachelor's degree, any graduate school), household income ($< \$100,000$, $\geq \$100,000$), and county of residence. Household income was dichotomized at \$100,000 due to a large proportion (46.2%) of girls with household incomes $\geq \$100,000$, and relatively few girls (18.1%) with household incomes $< \$50,000$. Household income was also correlated with parent's/caregiver's education and dichotomizing household income allowed for an appropriately stratified model that gave stable coefficient estimates. Girls were excluded from models if they were missing

neighborhood food store data ($n=2$), parent's/caregiver's education ($n=4$), or household income ($n=4$).

Generalized linear models using an identity link function and normal distribution were fit for the outcome of 3-year change in BMI z-score. Model 1 did not include covariates since baseline BMI z-score was accounted for in the outcome. Model 2 added the same covariates as the logistic regression models. In adjusted logistic and linear models where neighborhood food stores within a 1.0-mile network buffer were the primary predictors, trend tests were conducted by introducing each food store type as an ordinal variable instead of a categorical variable. In addition, interaction terms corresponding to the product between neighborhood food store availability and household income were introduced into adjusted models to examine potential effect modification by household income on the outcomes of weight status.

Statistical tests were two-sided and significance was determined at $P<0.05$. Statistical analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC). Data were analyzed in 2010.

Results

At baseline, the mean age of the study population was 7.4 ± 0.4 years (Table 2). Forty-eight percent of girls were non-Hispanic white; 54% of girls had a parent/caregiver with at least a bachelor's degree; and 46% of girls had a household income $\geq \$100,000$. At baseline, 28% of participants were classified as overweight, and another 14% were obese. After 3 years of follow-up, the average weight gain was 7.9 kg.

Neighborhood food stores were significantly related to county. In San Francisco, girls had greater access to fast-food restaurants, produce vendors/farmer's markets, and small grocery stores, whereas girls in Marin county had easier access to supermarkets ($P=0.0007$), and girls in Contra Costa county had easier access to convenience stores ($P<0.0001$). Non-Hispanic white girls also had marginally less access to convenience stores, compared to girls of African-American, Latino, or Asian/Mixed/Other race/ethnicity ($P=0.06$). Table 3 describes the associations between neighborhood food store availability within a 0.25-mile network buffer and 3-year weight change. In Model 1, availability of convenience stores, small grocery stores, and supermarkets were positively associated with overweight or obesity. After adjustment for sociodemographic characteristics, availability of convenience stores remained positively associated with girl's risk of overweight or obesity over time (OR 3.38, 95% CI 1.07, 10.68); other associations were attenuated.

Analysis of BMI z-score yielded similar results. After adjustment for sociodemographic characteristics, the availability of convenience stores was associated with a 0.13-unit increase in BMI z-score over 3 years (95% CI 0.00, 0.25, $P=0.05$). Additionally, the availability of drug stores was marginally associated with increasing BMI z-score over time ($\beta=0.21$, 95% CI 0.00, 0.43, $P=0.06$). Availability of other types of neighborhood food stores was not significantly associated with girl's risk of overweight or obesity, or BMI z-score. There was no effect modification by household income on neighborhood food store availability within a 0.25-mile buffer and 3-year weight change.

Associations between neighborhood food store availability within a 1.0-mile network buffer and 3-year weight change are shown in Table 4. After adjustment for sociodemographic characteristics, the availability of produce vendors/farmer's markets was marginally associated with a lower risk of overweight or obesity (OR 0.22, 95% CI 0.05, 1.06). Furthermore, there was a significant trend with increasing category of produce vendor's/farmer's markets and a lower risk of overweight or obesity over time (P -for-trend=0.045).

Availability of other neighborhood food stores within a 1.0-mile network buffer was not significantly associated with 3-year weight change, nor were there any other significant trends in the direction of association (results not shown). There was no effect modification by household income on these associations.

Discussion

In a study of young girls residing in California, living in close proximity to convenience stores, and to a lesser extent, drug stores, was positively related to overweight or obesity and BMI z-score after 3 years of follow-up. The availability of produce vendors/farmer's markets was associated with a lower risk of overweight or obesity over time. These associations are consistent with previous studies conducted among adolescents and adults residing in Midwestern and southern states^{6,9,20}, and suggest that relationships may apply to girls before adolescence.

The observed associations with BMI z-score may be mediated by unhealthy dietary behaviors. Past studies among young children have found that living within close proximity to convenience stores was associated with higher consumption of potato chips, chocolate and white bread⁴⁹, and lower consumption of fruits⁵⁰. Conversely, there were no significant associations between the availability of fast-food restaurants, supermarkets, or other food stores within a 0.25-mile network buffer and girls' overweight or BMI z-scores.

A comparison of neighborhood food store availability within two neighborhood boundaries demonstrates the importance of walkability. When the boundary was expanded to a 1.0-mile network buffer, previous associations were attenuated; however, a protective association was observed between the availability of produce vendors/farmer's markets and risk of overweight or obesity. Given that a 1.0-mile network buffer may be too large for children to navigate, it is likely the parents/caregivers who are purchasing fresh produce for their households. The dose-response relationship between produce vendors/farmer's markets and the reduced risk of overweight or obesity also bears important implications. Increasing the accessibility of fruits and vegetables to parents/caregivers may improve the diets of young children, and help to protect against the development of overweight or obesity over time.

A key strength of the study is the longitudinal nature of the data. Because repeated measurements of height and weight were collected from the study participants, it was possible to examine how neighborhood food stores affect weight change over time. Modeling both outcomes of overweight status and BMI z-score allows for the estimation of the relative risk of overweight or obesity as well as the magnitude of change in BMI z-score over 3 years.

This study is limited by a relatively small sample size. For example, "Asian/Mixed/Other" was combined into one race/ethnicity category because only 7.7% of girls identified as Asian and 9.9% of girls identified as mixed or other race/ethnicity. This may have resulted in residual confounding by race/ethnicity. Excluding girls who changed residences after the first year of follow-up may have further limited the ability to determine how changes in the neighborhood food environment affect changes in girls' weights over time. Previous research has suggested that the effects of the neighborhood environment on children's health outcomes are small. However, the literature describing the neighborhood food environment in relation to children's weight is still growing, and these findings corroborate previous studies that have also observed similar associations with neighborhood food stores and BMI.^{51,52}

Second, there is potential for misclassification of the neighborhood food environment. Because neighborhood assessments were conducted at baseline, this study assumes the food

environment has not changed during follow-up. However, most food establishments are relatively stable and it is unlikely that substantial changes to the neighborhood occurred within a few years. Individual food store types were also examined independently of other food stores in analytic models. There may be multiplicative effects in neighborhood food stores on girls' BMI z-scores over time. Future studies might consider utilizing indices that capture the diversity of the neighborhood food environment, or examine potential effect modification by other food stores on these associations.⁵³⁻⁵⁵

In addition, information was not collected on where the girls' parents shopped for food, or the food items sold in various stores. Although it was hypothesized that produce stores/farmer's markets, small grocery stores, specialty stores and supermarkets sold mostly healthy food items, and that convenience stores, fast-food restaurants, and full-service restaurants, sold mostly unhealthy food items, the validity of these hypotheses are dependent on the availability of foods within individual stores. Thus, not all supermarket foods fit within the healthy food groups of fruits, vegetables, and whole grains, and similarly, not all foods served in fast-food or full-service restaurants might contribute to obesity, or necessarily be high in saturated fat, sodium, and added sugars.^{54,56-59} It remains unknown how the stores nearest girls' homes actually influenced their dietary consumption.

Parental beliefs and neighborhood income may act as unmeasured confounders. Parents residing in higher-income neighborhoods may have easier access to large supermarkets and farmer's markets, and limited access to convenience stores or fast-food restaurants. In addition, these parents are generally more health-conscious and more likely to promote healthy eating and physical activity among their children. While it was possible to statistically adjust for parent's/caregiver's education level and household income, residual confounding may still exist. The dichotomy of household income at \$100,000 helped to ensure an equal number of study participants above and below the cut-off; however, a household income <\$100,000 does not translate into low-income. Future studies should collect more detailed information on parental beliefs and behaviors, in a more income-diverse population to better handle confounding. This study also did not correct for multiple comparisons of neighborhood food store types, and should be considered exploratory.

Conclusion

Many adults have the privilege of choosing their residential neighborhoods based on their desired qualities; children however, do not have these same opportunities. Studies examining the influence of the neighborhood environment on children's health have attempted to bring attention to environmental characteristics that may have long-term effects on health outcomes. Although this study did not assess food store inventories or analyze food store indices, like previous studies^{6,9,20}, it suggests that the neighborhood food environment, particularly the availability of convenience stores, drug stores, and produce vendors/farmer's markets, may affect a girl's weight trajectory over time. Interventions to promote fruit and vegetable consumption and reduce easy access to snack foods may have favorable effects on young girls' weight outcomes in the future.

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Table 1

Description and summary statistics of neighborhood food stores (per 1,000 people)

Neighborhood Food Stores ^a	Description (NAICS Code)	0.25-mile radius	1.0-mile radius
		M ± SD (Range)	M ± SD (Range)
Convenience stores	Food store establishments that sell a limited variety of foods including milk, bread, soda and snacks. Ex: 7-Eleven, delicatessens, gas stations, liquor stores. (NAICS 44512, 44531001, 44531004, 4471)	0.2 ± 0.9 (0–14.7)	0.3 ± 0.3 (0–2.3)
Drug stores	Food store establishments that sell dietary supplements, prescription and nonprescription drugs. Ex: Rite Aid, Walgreens, Target) (NAICS 44611009)	0.0 ± 0.3 (0–3.8)	0.1 ± 0.1 (0–1.2)
Fast-food restaurants	Food service establishments with “burrito,” “taco,” or similar words in the name, fast-food chain restaurants (ex. McDonald’s, Burger King), or establishments <2500 square feet that provide food services to patrons who order and pay before eating, with limited service. (NAICS 7222)	0.4 ± 1.3 (0–18.2)	0.5 ± 0.6 (0–2.8)
Produce vendors/ farmer’s markets	Food store establishments that primarily sell fresh fruits and vegetables, including farmer’s markets. (NAICS 44523002)	0.1 ± 0.2 (0–2.5)	0.1 ± 0.1 (0–1.0)
Full-service restaurants	Food service establishments with “restaurant” or similar forms of the word in the name (ex: diner, bistro, sushi), casual dining chain restaurants (ex. Applebee’s, T.G.I. Friday’s), or establishments ≥2500 square feet that provide food services (including take-out services) to patrons who order and are served while seated and pay after eating. (NAICS 7221)	0.6 ± 1.6 (0–11.2)	0.9 ± 1.0 (0–7.1)
Small grocery stores	Food store establishments with a revenue <\$1 million and few employees that sell a variety of canned and frozen foods, fresh fruits and vegetables, and fresh and prepared meats, poultry and fish. (NAICS 44511001, 44511002, 44511003)	0.4 ± 0.8 (0–8.1)	0.3 ± 0.3 (0–1.3)
Specialty stores	Food store establishments that sell a specialized line of food. Ex: Meat markets, seafood markets, cheese markets. (NAICS 4452)	0.1 ± 0.4 (0–3.2)	0.1 ± 0.1 (0–0.9)
Specific food store venues	Food service establishments that prepare and serve a specialty snack (ex: ice cream, bagels, doughnuts, hot dogs) or serve nonalcoholic beverages (ex: coffee, smoothies, juices). (NAICS 72221313)	0.5 ± 1.2 (0–9.6)	0.8 ± 0.9 (0–9.3)
Supercenters	Food store establishments that sell a variety of groceries and other lines of merchandise, including apparel, furniture and appliances. Ex: Walmart, Costco, Sam’s Club. (NAICS 452910)	0	0.0 ± 0.0 (0–0.2)
Supermarkets	Food store establishments with a revenue >\$1 million and more than 4 employees that sell a variety of canned and frozen foods, fresh fruits and vegetables, and	0.1 ± 0.7 (0–11.5)	0.1 ± 0.2 (0–2.6)

Neighborhood Food Stores ^a	Description (NAICS Code)	0.25-mile radius	1.0-mile radius
		M ± SD (Range)	M ± SD (Range)
	fresh and prepared meats, fish and poultry. Ex: Whole Foods, Trader Joe's, Safeway. (NAICS 44511001, 44511002, 44511003)		

NAICS, North American Industry Classification System

Mi, mile

Table 2Baseline characteristics of study participants ($n=353$)

	<i>n</i>	%
Age, M (SD)	7.4 years	(0.4)
Race/ethnicity		
White	168	47.6
African-American	47	13.3
Latino	76	21.5
Asian/ Mixed/ Other	62	17.6
Provider's highest education level		
≤ High school diploma	59	16.7
Any college or associate degree	98	27.8
Bachelor's degree	112	31.7
Any graduate school	80	22.7
Missing	4	1.1
Household income		
<\$100,000	186	52.7
≥\$100,000	163	46.2
Missing	4	1.1
County of residence		
Alameda	158	44.8
San Francisco	70	19.8
Marin	83	23.5
Contra Costa	42	11.9
Weight status (using BMI-for-age)		
Normal (<85th percentile)	255	72.2
Overweight (85th percentile – <95th percentile)	50	14.2
Obese (≥95th percentile)	48	13.6

Table 3

Effects of neighborhood food stores within a 0.25-mile buffer on weight status and BMI z-score

Neighborhood food stores ^a		Overweight or Obesity (BMI-for-age ≥85th percentile)				Change in BMI Z-Score				
		N	Model 1		Model 2		Model 1		Model 2	
			OR ^b	95% CI	OR ^c	95% CI	β	95% CI	β ^d	95% CI
Convenience stores										
0 stores	295	ref		ref		ref		ref		
>0 stores	56	5.22**	1.88, 14.47	3.38**	1.07, 10.68	0.12**	0.01, 0.24	0.13**	0.00, 0.25	
Drug stores										
0 stores	336	ref		ref		ref		ref		
>0 stores	15	1.57	0.24, 10.29	1.26	0.16, 9.91	0.17	−0.05, 0.38	0.21*	0.00, 0.43	
Fast-food restaurants										
0 stores	269	ref		ref		ref		ref		
>0 stores	82	1.15	0.44, 3.00	0.82	0.28, 2.44	0.00	−0.10, 0.10	0.00	−0.11, 0.10	
Produce vendors/farmer’s markets										
0 stores	319	ref		ref		ref		ref		
>0 stores	32	2.99*	0.88, 10.18	2.83	0.62, 12.85	0.07	−0.08, 0.22	0.10	−0.06, 0.26	
Full-service restaurants										
0 stores	260	ref		ref		ref		ref		
>0 stores	91	1.12	0.44, 2.84	0.80	0.27, 2.34	0.06	−0.04, 0.15	0.09	−0.02, 0.20	
Small grocery stores										
Tertile 1 (0 stores)	241	ref		ref		ref		ref		
Tertile 3 (≥0.95 stores)	61	3.20**	1.12, 9.12	1.90	0.57, 6.37	0.07	−0.04, 0.19	0.07	−0.05, 0.19	
Specialty stores										
0 stores	310	ref		ref		ref		ref		
>0 stores	41	1.93	0.59, 6.31	1.41	0.38, 5.23	0.05	−0.08, 0.18	0.06	−0.08, 0.19	
Specific food store venues										
0 stores	257	ref		ref		ref		ref		
>0 stores	94	1.90	0.77, 4.69	1.46	0.50, 4.27	0.07	−0.03, 0.16	0.07	−0.03, 0.18	

		Overweight or Obesity (BMI-for-age ≥85th percentile)				Change in BMI Z-Score				
		Model 1		Model 2		Model 1		Model 2		
Neighborhood food stores ^a		N	OR ^b	95% CI	OR ^c	95% CI	β	95% CI	β ^d	95% CI
Supermarkets										
0 stores	317	ref			ref		ref		ref	
>0 stores	34	3.50**	1.06, 11.61	2.18	0.60, 7.92	0.02	-0.12, 0.17	0.02	-0.13, 0.17	

^a Calculated as the number of stores within a 0.25-mile network buffer per every 1000 people

^b Adjusted for baseline weight status

^c Adjusted for baseline weight status, race/ethnicity, parent's/caregiver's education, household income, and county of residence

^d Adjusted for race/ethnicity, parents'/caregiver's education, household income and county of residence

* $p < 0.1$

** $p < 0.05$

Table 4

Effects of neighborhood food stores within a 1.0-mile buffer on weight status and BMI z-score.

Neighborhood food stores ^a		Overweight or Obesity (BMI-for-age ≥85th percentile)			Change in BMI Z-Score				
		Unadjusted	Adjusted		Unadjusted	Adjusted			
	N	OR ^b	95% CI	OR ^c	95% CI	β	95% CI	β ^d	95% CI
Convenience stores									
Quintile 1 (0 stores)	66	ref		ref		ref		ref	
Quintile 5 (≥0.39 stores)	71	1.65	0.41, 6.69	1.18	0.25, 5.61	-0.01	-0.15, 0.12	-0.04	-0.18, 0.10
Drug stores									
Quartile 1 (0 stores)	170	ref		ref		ref		ref	
Quartile 4 (≥0.11 stores)	59	1.78	0.53, 5.90	1.52	0.39, 5.87	0.01	-0.11, 0.13	0.02	-0.10, 0.15
Fast-food restaurants									
Quintile 1 (0 stores)	77	ref		ref		ref		ref	
Quintile 5 (≥0.39 stores)	72	1.80	0.50, 6.51	1.12	0.27, 4.61	0.00	-0.13, 0.13	-0.01	-0.15, 0.12
Produce vendors/farmer's markets									
Quartile 1 (0 stores)	151	ref		ref		ref		ref	
Quartile 4 (≥0.11 stores)	62	0.48	0.14, 1.66	0.22*	0.05, 1.06	0.02	-0.10, 0.14	0.03	-0.10, 0.15
Full-service restaurants									
Quintile 1 (0 stores)	73	ref		ref		ref		ref	
Quintile 5 (≥1.74 stores)	73	0.82	0.21, 3.20	0.75	0.16, 3.43	-0.06	-0.19, 0.07	-0.06	-0.20, 0.07
Small grocery stores									
Quintile 1 (0 stores)	91	ref		ref		ref		ref	
Quintile 5 (≥0.64 stores)	61	5.24**	1.29, 21.34	2.59	0.50, 13.54	0.09	-0.04, 0.22	0.06	-0.09, 0.21
Specialty stores									
Quartile 1 (0 stores)	162	ref		ref		ref		ref	
Quartile 4 (≥0.18 stores)	57	1.78	0.53, 5.94	1.18	0.30, 4.67	0.01	-0.12, 0.13	-0.03	-0.16, 0.10

		Overweight or Obesity (BMI-for-age ≥85th percentile)				Change in BMI Z-Score			
Neighborhood food stores ^a	N	Unadjusted		Adjusted		Unadjusted		Adjusted	
		OR ^b	95% CI	OR ^c	95% CI	β	95% CI	β ^d	95% CI
Specific food store venues									
Quintile 1 (0 stores)	57	ref		ref		ref		ref	
Quintile 5 (≥1.22 stores)	77	2.48	0.57, 10.71	2.28	0.46, 11.35	0.01	-0.13, 0.15	-0.01	-0.15, 0.13
Supercenters									
0 stores	319	ref		ref		ref		ref	
>0 stores	32	1.85	0.50, 6.87	1.56	0.37, 6.53	0.01	-0.14, 0.16	0.01	-0.15, 0.16
Supermarkets									
Quintile 1 (0 stores)	97	ref		ref		ref		ref	
Quintile 5 (≥0.21 stores)	65	1.33	0.36, 4.86	1.38	0.33, 5.75	-0.02	-0.15, 0.11	0.00	-0.13, 0.13

^a Calculated as the number of stores within a 1.0-mile network buffer per every 1,000 people

^b Adjusted for baseline weight status

^c Adjusted for baseline weight status, race/ethnicity, parent's/caregiver's education, household income, and county of residence

^d Adjusted for race/ethnicity, parent's/caregiver's education, household income and county of residence

* $p < 0.1$

** $p < 0.05$