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MORE NEIGHBORHOOD RETAIL ASSOCIATED WITH LOWER OBESITY AMONG NEW YORK CITY PUBLIC HIGH SCHOOL STUDENTS

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Abstract

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Policies target fast food outlets to curb adolescent obesity. We argue that researchers should examine the entire retail ecology of neighborhoods, not just fast food outlets. We examine the association between the neighborhood retail environment and obesity using Fitnessgram data collected from 94,348 New York City public high school students. In generalized hierarchical linear models, the number of fast food restaurants predicted *lower* odds of obesity for adolescents (OR:0.972 per establishment; CI:0.957--0.988). In a “placebo test” we found that banks – a measure of neighborhood retail ecology – also predicted lower obesity (OR:0.979 per bank; CI: 0.962–0.994). Retail disinvestment might be associated with greater obesity; accordingly, public health research should study the influence of general retail disinvestment not just food-specific investment.

Keywords

Adolescent obesity; New York City; fast food; retail ecology; neighborhoods

Stemming the rising prevalence of obesity among children and adolescents is a key priority for policy makers in the United States. To accomplish this goal, some jurisdictions have adopted policies banning fast food restaurants within specific geographic areas. For example, the Los Angeles city council embargoed new fast food retail in a disadvantaged area of the city and the New York City (NYC) Council considered a fast food ban surrounding schools (Los Angeles City Council 2008; Sturm & Cohen 2009; Buckley 2009).

Given the poor nutritional quality of products served by fast food restaurants, this seems like a reasonable course of action. Yet, studies examining the association of childhood and adolescent weight-related outcomes find mixed evidence. Some studies find a statistically significant, though small, association between obesity and fast food restaurants surrounding adolescents homes and schools (Harrison et al. 2011; Currie et al. 2010; Davis & Carpenter 2009); however, others find no relationship between fast food restaurants and obesity-related outcomes for children and adolescents (Sturm & Datar 2005; Powell et al. 2007; Laska et al. 2010; An & Sturm 2012; Lee 2012). One study of Australian youth found an inverse relationship between obesity and both distance to and density of fast food restaurants (Crawford et al. 2008).

Although the energy-dense products sold by fast food restaurants make them an obvious target for policy action (Bowman et al. 2004; Gordon-Larsen et al. 2011), the locations of fast food restaurants also reflect broader patterns of retail investment in neighborhood environments that may have positive outcomes for residents. The density of retail firms may provide employment (Wilson 1996), “eyes on the street” to mitigate crime (Jacobs 1961; Klinenberg 2003; Browning et al. 2010), and financial and political capital to help improve city services (LaVeist 1992; LaVeist 1993; Logan & Molotch 1987; Deener 2007). By focusing exclusively on the link between fast food restaurants and obesity risk, public health researchers and policy makers risk missing – and ultimately exacerbating – more fundamental causes (Link & Phelan 1995) of socioeconomic, and particularly, racial disparities in obesity.

In this paper, we examine the relationship between fast food, retail density, and obesity among 94,348 high school students in the NYC public school system. We link retail investment data to the residential Census tract of NYC public school students in the 2007-08 NYC Fitnessgram student assessments, which provides objective measures of height and weight. We examine the relationship between individual student obesity and the count of fast food restaurants in a student's neighborhood. To explore whether retail investment, rather than fast food specific investment, can explain our results, we also develop a "placebo test" by modeling the relationship between banks – a retail establishment that we have no reason to suspect would directly influence obesity in general – and obesity of high school students.

METHODS

Data

Anthropometric data on 135,322 non special education high school students came from the New York City (NYC) public schools' Fitnessgram program during the 2007–2008 academic year. The NYC Departments of Education and Health and Mental Hygiene jointly administer Fitnessgram, a program developed by the Cooper Institute to measure and improve physical fitness and health. Physical education teachers administered the physical fitness tests, including collection of data on students' height and weight (Morrow Jr. et al. 2010). Researchers have used Fitnessgram to study the role of ecological contexts on BMI, overweight, and obesity in previous studies (Currie et al. 2010; Kim et al. 2005).

We excluded special education students because they are often taught in separate classrooms and have medical conditions that might influence BMI. We excluded 21,088 students that did not have height or weight measures and therefore lacked data to calculate BMI or had a BMI z-scores greater than 5 standard deviations from the median of our sample because such extreme values likely result from measurement error (e.g., data entry errors). We also excluded observations for students who identified as American Indian/Native American, multiracial, and "other" race (N=1,047); if the students' nativity was unknown (N=56); or if the student was less than 13 years old (N=8). This left an analytic sample of 113,123 (83% of those for which we have any Fitnessgram data).

American University, Columbia University, and the NYC Departments of Education and Health approved human subjects protection protocols.

Dependent Variable

High school physical education teachers measured students' height and weight. We used these measures, along with their sex and age, to calculate BMI z-scores using the Centers for Disease Control SAS macro (Centers for Disease Control and Prevention 2011). Of students in our data, 69.6% were categorized as having normal weight (BMI<85th percentile), 16.6% were categorized as overweight (BMI≥85th percentile and BMI<95th percentile) and 13.8% were obese (BMI≥95th percentile). This paper focuses on the comparison of normal weight students to obese students (n=94,348).

Independent and Control Variables

Students' home addresses listed in NYCDOE records were used to geocode the students to their residential Census tracts. Census tracts were deemed sufficiently large to provide anonymity for students while being sufficiently small for analysis of neighborhood characteristics. Students in our study come from a total of 2,121 census tracts that represent each of the five NYC boroughs. The primary independent variables included in the model were measures of the neighborhood food environment in the Census tract based on geocoded establishment data obtained from Dun & Bradstreet. We created counts of three types of establishments: fast food (including national chain, local chain, and non-chain fast food), non-chain pizza establishments, and bodegas based on classifications previously used by Rundle and colleagues (Rundle et al. 2009).

Aggregating students to Census tracts can induce aggregation biases for two reasons: exposure might vary over the geographic area of the tract and the number of school-aged residents might not be distributed equally. Since we wish to measure the exposure experienced by adolescents within the tract, we used a two-stage approach to measure establishment counts. For a Census tract made up of B city blocks, we first drew a 400-meter buffer around the centroid of each city-block b within the tract and counted the number of establishments, N_b , within that block's buffer. In the second stage, we took the average of the counts within each blocks buffer weighted by the proportion, p_b , of the tract's high school aged residents (residents ages 15–18) that live on the block. That is, the measure of establishment counts for tract i , X_i , is calculated as:

$$X_i = \sum_{b=1}^B p_{ib} N_{ib}$$

This method accounts for both variation in exposure and the uneven distribution of high school aged children in the tract.

We included a number of covariates at both the neighborhood and individual level of analysis. At the neighborhood level, we included a neighborhood walkability index adapted from the well-known measure developed by Frank and colleagues (Frank et al. 2006), which includes measures of population density, intersection and subway stops density, land use mix and the ratio of retail building floor area to retail area (Neckerman et al. 2009). From 2000 Census data, we included indicators of Black and Latino segregation (measured as more than 70 percent of residents being Black or Latino, respectively), the proportion of foreign-born residents, and the proportion of residents below the federal poverty line.

The individual characteristics included in the file provided by NYCDOE were: age in years at time of Fitnessgram administration, gender (ref. = female), race/ethnicity (Asian, Black, or Hispanic with White being the reference category), and foreign birth. We constructed indicators of students' socioeconomic status based on their receipt of free or reduced price lunch: (a) Human Resource Administration free lunch provided to students in families participating in either Temporary Aid for Needy Families or Supplemental Nutrition Assistance Program and attending school in an impoverished area; (b) form-based free lunch

obtained by applying to the school and qualifying based on income; (c) form-based reduced price lunch through the same application process; and (d) full price lunch. We also included an indicator if school lunch status is missing for a student.

Analytic Strategy

We examined multivariate relationships of our dependent variable (obesity) with individual and residential neighborhood-level covariates. We use generalized hierarchical linear models with a logit link function to account for the clustering of students by neighborhood (Raudenbush & Bryk 2002). After we conducted analyses on the full sample, we conducted gender-stratified analyses to examine potential heterogeneity of associations by gender.

We conducted two sets of analyses. The first set of analyses modeled the association between the student obesity and the number of fast food establishments. We conducted the second set of analyses as a placebo test (Kestens & Daniel 2010) by modeling the association between student obesity and number of banks to assess whether observed associations should be attributed to fast food availability or other factors. Because adolescents are unlikely to walk to banks frequently enough to reduce obesity through physical activity, finding the same results in the placebo test as in the main model would suggest that obesity and fast food associations may share some prior cause relevant to obesity.

We used HLM version 6.08 to estimate all models. We present unit-specific odds ratios and 95% confidence intervals for all models.

RESULTS

Table 1 reports the descriptive statistics of Census tract characteristics for our sample. Approximately a quarter of tracts are segregated Black and another quarter are segregated Latino neighborhoods. The average tract's population is 35% foreign born and 20% of people live in poverty. Tracts contain, on average, about 1.3 national fast food chains and 0.5 local fast food chains. There are about 2.3 pizza establishments and almost 11 bodegas per tract.

Table 2 reports the normal and obese prevalence rates by individual and neighborhood covariates. Patterns of individual characteristics among NYCPS high school students follow national trends (Hedley et al. 2004; Ogden et al. 2002): those with free or reduced meal plans are more likely to be obese than those paying full price; Asians and Whites are less likely to be obese than Blacks or Latinos; and foreign-born students are less likely than US-born students to be obese. While boys have higher obesity prevalence rates than girls, the direction of associations with individual-level characteristics is similar for both boys and girls.

Students living in neighborhoods characterized by high levels of Black and Latino segregation and high poverty rates are at higher risk for obesity while those living among majority foreign-born residents are less likely to be obese (Table 2). Examining bivariate relationships between food outlets and obesity prevalence, we find *lower* obesity prevalence

rates among students living in neighborhoods with more than the median number of fast food (13.4%) than those under the median (14.1%, $P=0.001$). Obesity prevalence rates are also lower in neighborhoods with more than the median number of pizza establishments, though this difference seems to be mainly among girls. The number of bodegas in neighborhoods is not associated with obesity prevalence rates.

Table 3 reports the odds ratios and confidence intervals of the generalized hierarchical models predicting obesity (versus normal weight). The individual-level controls show consistent patterns with the descriptive statistics enumerated above: males, Blacks and Latinos, and free- or reduced-lunch recipients are more likely to be obese than girls, Whites, and students who pay full-price lunch, respectively. Asian and foreign-born students are less likely than Whites and domestic-born students to be obese, respectively.

The first model in Table 3 includes demographic controls and our measures of the food environment. Most notably, we find that the number of fast food restaurants in a tract predicts *lower* odds of obesity in high school students. Black segregation and higher levels of neighborhood poverty both predict higher odds of obesity among adolescents while the other neighborhood demographic characteristics, percent foreign born and Latino segregation, do not statistically significantly correlate with obesity. Neighborhood walkability fails to attain statistical significance and does not attenuate the association between fast food restaurants and obesity, meaning that fast food location is not an artifact of retail density being correlated with walkable environments.

Consistent with the descriptive results of the food environment in Table 2, we find that a greater number of fast food establishments in a neighborhood predict *lower* odds of obesity. The magnitude of the association is larger for boys (OR:0.964 per establishment; CI:0.945–0.983) than for girls (OR:0.984 per establishment; CI:0.961–1.007) such that the influence on girls is not statistically significantly different than zero. To place this in context, a boy living in a neighborhood with 3 more fast food establishments (approximately one standard deviation) than an otherwise similar boy has 0.896 times the odds of being obese ($0.896=0.964^3$), an association similar in magnitude (but opposite in direction) to being on public assistance compared to receiving no assistance (i.e., $1/1.081=0.925$). Larger numbers of pizza establishments predict lower odds of obesity only among girls (OR:0.973; CI: 0.949–0.997), such that a one standard deviation increase in pizza establishments lowers the odds of a girl being obese by 0.936 times. Unlike the relatively large influence of fast food when compared to other associations in the model among boys, the association between pizza establishments and obesity for girls has a smaller influence relative to other covariates.

The second, fourth, and sixth columns in Table 3 report the results of our “placebo” analysis for all students, girls only, and boys only, respectively. We use banks because we hypothesize that their presence correlates with the presence of fast food (and thus reflect shared patterns of retail investment), but would not reasonably create a direct influence on the prevalence of adolescent obesity. Table 4 reports correlations between the counts of fast food, pizza, bodega, and bank establishments. The moderately high correlation between fast food restaurants and banks ($\rho=0.74$) satisfies the first condition of the placebo test: fast food

location correlates with bank investment, suggesting that there might be some underlying cause of both.

We replicate the first model from Table 3 except that we predict obesity using banks rather than food establishments. In the pooled model that includes both girls and boys, we find a similar-sized statistically significant negative association between banks and adolescent obesity (OR:0.978; CI:0.962–0.994) to that we find for fast food restaurants. When we disaggregate by gender, we again find negative odd ratios similar in magnitude to the ones found for food establishments; however, the association is only significant among boys (OR: 0.977; CI:0.960–0.995). Our model would predict that the odds of a boy living in a neighborhood with 5 more banks (approximately one standard deviation) would be 0.90 times that of an otherwise similar boy. The size of this association is similar to that for a standard deviation increase for fast food restaurants. We also predicted models including both banks and fast food restaurants to ensure that the associations did not exclusively result from shared correlation between the two measures. We found that both remained negatively associated with obesity at similar magnitudes to the models predicting each separately. The estimate for banks was no longer statistically different from the null, a result likely due to the multicollinearity between banks and fast food.

We also conducted a number of sensitivity analyses to examine the robustness of our models to different assumptions. First, we ran multinomial logistic regression models to test the comparison of normal versus overweight and found associations in the same direction as those reported for normal versus obese. Second, we measured the density of food establishments rather than counts and found similar associations to those reported here. Third, we estimated our models using a measure that combined fast food and pizza establishments into a single variable. The results were similar for the full sample (OR:0.978; CI:0.969–0.987), girls (OR:0.978; CI:0.964–0.993) and boys (OR:0.978; CI:0.967–0.989); however, unlike the model in Table 3, the confidence interval for girls did not include 1. Fourth, we examined whether the results reflected associations with full-service restaurants, which previous research found to be negatively correlated with obesity (Mehta & Chang 2008), by including full-service restaurants in the model with fast food restaurants. The estimated associations between fast food restaurants and obesity remained similar. Fifth, we measured exposure to fast food based on the count of fast food restaurants within a 0.1 mile buffer surrounding each adolescent's school (c.f., Currie et al. 2010) and found no statistically significant association with adolescent obesity.

DISCUSSION

In this study we examine the relationship between fast food restaurants and adolescent obesity among 94,348 New York City public high school students. Contrary to expectations, we find an *inverse* relationship between the number of fast food restaurants and adolescent obesity, particularly for boys. One interpretation of this counterintuitive finding is that chain fast food restaurants reflect neighborhood commercial investment, and that neighborhood commercial investment is positively associated with health outcomes. A placebo test examining the relationship between neighborhood banks and adolescent obesity supports this argument.

This study suggests that adolescents' health might benefit from an environment with substantial retail presence, even if some of that retail presence includes fast food establishments. Put differently, a lack of general retail presence, as opposed to the presence of specific types of establishments, could contribute to increased levels of obesity. Although we cannot uncover a specific mechanism in our data, possible mechanisms might include increased employment, crime reduction, venues for social interaction, and neighborhood institutional support. These potential mechanisms closely align with basic social epidemiological theory positing that neighborhood effects work through the concentration of disadvantage and access to resources (Kawachi & Berkman 2003; Diez Roux 2002; Cummins et al. 2005).

This analysis does not imply that fast food restaurants are healthy or that they should escape public health regulation. Fast food restaurants sell unhealthy fare and research demonstrates a clear link between fast food consumption and poorer health outcomes among children and adolescents (Bowman et al. 2004; Sturm & Datar 2005). Our analysis implies, however, that public health research should consider overall investment patterns as well as fast food retail given that the same patterns could influence the location of both fast food restaurants and other forms of retail (Wilson 1996; Wilson 1987; Massey & Denton 1993; Small & McDermott 2006). Our findings suggest that more research on the links between neighborhood retail investment and obesity related behaviors is warranted. At minimum, our results suggest that policy makers should approach policies designed to limit fast food, as for example zoning laws do, with caution.

Research and Policy Implications

As preventive public health policies increasingly focus on public-private partnerships and the use of non-health policies to promote health (e.g., building and zoning regulations that promote healthy lifestyles), public health research must devote greater attention to the forces that shape the location and operations of private establishments. For example, some of the economic and demographic forces that influence the location of fast food establishments also influence the location of other types of retail establishments (Small & McDermott 2006). Yet, very little public health research focuses on the demographic, geographic, and market forces underlying these health-related investments including what leads retailers to enter or exit a neighborhood.

Our evidence suggests that public health research should also consider the influence on and consequences of overall neighborhood retail investment when investigating health-related retail. Such a focus should not preclude research that investigates specific health-related establishments like fast food restaurants, especially given evidence from other studies demonstrating a relationship between fast food and adolescent obesity (Davis & Carpenter 2009; Currie et al. 2010). But research should consider social and economic forces that influence where such establishments open and it is possible that such a broad focus can help explain some of the mixed results found in the literature.

Furthermore, research should investigate if and how the neighborhood economic ecology contributes to nutrition and other health outcomes. Most public health studies of neighborhood risks focus on descriptive or analytic differences between characteristics of

the neighborhood retail environment that correlate with disease outcomes. Research designed to uncover the mechanisms that ameliorate or attenuate threats to health, paying particular attention to the way that neighborhood economic structures influence individual agency (and vice versa) (Blacksher & Lovasi 2012), is necessary and suggests a greater role for qualitative research in public health research to link neighborhood processes with differential rates of disease (e.g., Klinenberg 2003; Park et al. 2011). Examining retail investment patterns holistically might also identify the conditions that lead to *disproportionate* fast food investment relative to other types of retail investment that might partially explain the relationship between fast food and obesity found in other studies (Harrison et al. 2011; Currie et al. 2010; Davis & Carpenter 2009).

Our analysis could help inform related policy discussions on how zoning can be used to address childhood and adolescent obesity (Bowman et al. 2004; Jeffery et al. 2006). First, policy makers should consider the social and economic factors that lead to retail investment in some neighborhoods more than others. Second, when weighing benefits and costs of policies, policy makers should consider potential positive externalities of retail investment that include employment, crime reduction and neighborhood institutional support, which may have a positive influence on multiple health outcomes.

Strengths and Limitations

Our conclusions build on a couple of strengths of our data and analysis. First, our very large sample allows us to estimate even small associations in the data. Second, our analysis included neighborhood-level controls likely to influence selection into neighborhoods. Third, our placebo test using banks allows us to highlight the potential influence of a broad retail ecology underlying associations of multiple specific destinations with obesity. Since banks have no plausible direct mechanism that would decrease adolescent obesity, we can be reasonably certain we do not capture the effect of walkable destinations. This also means that the results should not be taken as encouragement for more banks to reduce obesity, but that retail investment should be investigated as a potential strategy to reduce obesity.

A few limitations of our analysis should also be considered. First, we only examine public high school students within NYC. This means that readers should not extrapolate our results to all NYC adolescents due to dropouts or private school enrollment; however, given that cities design many public health policies to influence public school children it is a crucial population to study. Second, our study is observational and cross-sectional and can thus suggest associations but not causality. To overcome this limitation, we would encourage the collection of longitudinal data measuring both retail investment and individual health outcomes as a promising area for future research (e.g., Currie et al. 2010). Relatedly, we do not measure fast food consumption, which has been shown to increase energy consumption and predict body mass even when fast food density has not (Bowman et al. 2004; Jeffery et al. 2006). Third, there may be an omitted variable that explains the associations found in our analysis. We do not, for example, control for crime, the presence of parks, or supermarket locations. If we add these results to the model, we risk exchanging one form of bias, omitted variable bias, for another, that which stems from multicollinearity. To the degree that we were able, we examined the robustness of our models to different specifications and found

similar results in those supplemental analyses. Future research that can disentangle the specific effects of positive and negative conditions in neighborhoods would help inform this debate further. Last, the tract level geocodes we use in order to protect students' identity introduces some measurement error; however, our measurement strategy goes further than most analyses by weighting neighborhood environments to reflect adolescents' exposure rather than that of the tract population as a whole.

CONCLUSION

Our finding of an inverse relationship between adolescent obesity and fast food restaurant density fits within a larger equivocal literature regarding the role of fast food establishment location on adolescent obesity. Through the use of an innovative placebo test, we present a plausible hypothesis for these ambiguous findings not yet examined in the literature: the density of retail ecology contributes to reduced obesity among adolescents. Focusing on a proximate link between fast food and adolescent obesity risks missing this larger fundamental association. Future research should examine both the mechanisms through which retail density might contribute to improved health outcomes and should draw links to research investigating how economic and demographic forces lead to retail firms to enter and exit from neighborhood

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Policies ignore how fast food restaurants might relate to overall retail investment
- We find *lower* odds of obesity prevalence in neighborhoods with more fast food
- Overall retail investment, not just food outlets, might be associated with adolescent obesity
- Researchers should study influence of retail investment on adolescent obesity

Table 1

Descriptive statistics of neighborhood contextual variables

	Mean	S.D.	Min.	Max.	25th percentile	75th percentile
<i>Census Tracts (N=2121)</i>						
Segregated black ($\geq 70\%$ black)	0.26	n.a.				
Segregated Latino ($\geq 70\%$ Latino)	0.27	n.a.				
Prop. foreign born	0.35	0.16	0.00	0.81	0.22	0.47
Prop. Poor	0.20	0.14	0.00	0.97	0.09	0.28
National Fast Food Count	1.27	2.26	0.00	24.00	0.00	1.59
Local Fast Food Count	0.45	0.79	0.00	8.00	0.00	0.67
All Fast Food Count	1.72	2.78	0.00	28.00	0.16	2.12
Pizza Count	2.29	2.38	0.00	18.40	0.72	3.11
Bodega Count	10.91	8.70	0.00	51.26	3.90	15.65
Banks Count	1.65	4.87	0.00	119.00	0.00	1.69
Walkability Index	0.18	2.80	-10.72	21.45	-1.47	1.48

Table 2

Individual- and neighborhood-level prevalence of normal weight, overweight, and obesity by gender

Gender	All ^a		Girls		Boys	
	% Normal	% Obese	% Normal	% Obese	% Normal	% Obese
Male	66.91***	16.27***	n.a.	n.a.	n.a.	n.a.
Female	72.42	11.21	n.a.	n.a.	n.a.	n.a.
Free/Reduced Lunch^b						
Free HRA Meal	64.94***	17.05***	66.41***	15.12***	63.40***	19.08***
Free Form Meal	69.97	13.56	72.28	11.42	67.66	15.71
Reduced Price Meal	69.75	13.72	72.75	11.15	66.98	16.09
Full Price Meal	71.38	12.47	75.02	9.43	67.81	15.47
Race^b						
White	71.75***	12.37***	75.02***	8.59***	67.05***	15.97***
Hispanic	64.07	16.83	67.87	12.75	60.39	20.78
Black	66.7	15.69	65.63	15.64	67.82	15.73
Asian	80.58	7.46	86.09	4.28	75.3	10.51
Nativity^c						
Foreign-born	76.34***	8.95***	79.56***	6.57***	73.18***	11.28***
U.S.-born	67.01	15.65	69.62	13.02	64.42	18.25
Neighborhood Characteristics^c						
>70% Black	66.34***	15.92***	66.11***	15.09***	66.57	16.81*
<70% Black	71.07	12.82	75.25	9.46	67.04	16.05
>70% Hispanic	67.00***	15.22***	69.83***	12.15***	64.32***	18.13***
<70% Hispanic	70.78	13.13	73.49	10.82	68.05	15.45
> 50% Foreign Born	71.26***	12.60***	74.74***	9.55***	67.87***	15.57***
<50% Foreign Born	68.04	14.91	70.13	12.84	65.93	16.99

	All ^a		Girls		Boys	
	% Normal	% Obese	% Normal	% Obese	% Normal	% Obese
>50% Below Poverty	67.75***	14.94***	69.63***	12.88***	65.88***	17.00***
<50% Below Poverty	71.55	12.57	75.22	9.53	67.94	15.55
Food Outlets						
>Median, All	69.96*	13.39***				
Fast Food			72.84*	10.77**	67.13	15.95*
<Median, All	69.34	14.12				
Fast Food			72.00	11.64	66.68	16.6
>Median, Pizza	70.35***	13.25***	73.71***	10.33***	67.11	16.48
<Median, Pizza	68.95	14.25	71.16	11.24	66.71	16.07
>Median, Bodegas	69.37*	13.92				
<Median, Bodegas	69.93	13.58	72.2	11.18	66.63	16.53
>Median, Banks	71.13***	12.75***	74.67***	9.83***	67.73***	15.52***
<Median, Banks	68.17	14.77	70.23	12.54	66.06	17.05

Note:

* p<0.05;

** p<0.01;

*** p<0.001

Table 3

Odds ratios and 95% confidence intervals from hierarchical models of overweight and obese versus normal on individual and neighborhood covariates

Intercept	0.175*** [0.171,0.179]	0.175*** [0.171,0.180]	0.129*** [0.125,0.134]	0.129*** [0.125,0.134]	0.226*** [0.220,0.232]	0.227*** [0.221,0.233]
Age (years)	0.903*** [0.891,0.916]	0.903*** [0.890,0.916]	0.896*** [0.877,0.916]	0.896*** [0.877,0.916]	0.911*** [0.894,0.928]	0.911*** [0.894,0.928]
Male	1.597*** [1.541,1.655]	1.597*** [1.535,1.661]				
Race/Ethnicity						
Asian	0.582*** [0.542,0.624]	0.587*** [0.545,0.632]	0.475*** [0.417,0.542]	0.481*** [0.422,0.549]	0.638*** [0.585,0.695]	0.642*** [0.589,0.699]
Black	1.175*** [1.095,1.260]	1.177*** [1.097,1.263]	1.672*** [1.495,1.870]	1.686*** [1.507,1.887]	0.887*** [0.810,0.972]	0.886** [0.811,0.967]
Hispanic	1.411*** [1.325,1.503]	1.412*** [1.324,1.506]	1.446*** [1.302,1.607]	> 1.451*** [1.306,1.613]	1.413*** [1.305,1.530]	1.412*** [1.307,1.527]
For. born	0.577*** [0.551, 0.604]	0.577*** [0.551,0.604]	0.545*** [0.506,0.587]	0.546*** [0.507,0.587]	0.595*** [0.561,0.632]	0.595*** [0.561,0.632]
Free/Red. Lunch						
Form	1.135*** [1.084,1.189]	1.135*** [1.083,1.190]	1.269*** [1.178,1.366]	1.269*** [1.178,1.366]	1.041 [0.979,1.106]	1.041 [0.979,1.107]
Assistance	1.189*** [1.127, 1.255]	1.187*** [1.125,1.254]	1.325*** [1.219,1.440]	1.322*** [1.216,1.437]	1.081* [1.006,1.161]	1.080* [1.003,1.162]
Reduced	1.080* [1.012,1.154]	1.081* [1.013,1.154]	1.146* [1.030,1.276]	1.146* [1.029,1.275]	1.023 [0.940,1.114]	1.025 [0.943,1.113]
Meal miss.	1.165** [1.074,1.263]	1.170*** [1.083,1.265]	1.220** [1.064,1.398]	1.224** [1.068,1.403]	1.128* [1.016,1.252]	1.135* [1.030,1.270]
Neighborhood Covariates						
% For. Born	0.957 [0.837,1.095]	0.963 [0.846,1.096]	0.799* [0.653,0.976]	0.796* [0.652,0.972]	1.080 [0.915,1.276]	1.097 [0.935,1.287]
% Poor	1.285* [1.044,1.582]	1.255* [1.035,1.522]	1.699** [1.257,2.296]	1.647** [1.237,2.193]	0.993 [0.763,1.293]	0.982 [0.774,1.247]
>= 70% black	1.090** [1.026,1.159]	1.096** [1.033,1.163]	1.084 [0.989,1.188]	1.102* [1.005,1.207]	1.083* [1.002,1.172]	1.081* [1.004,1.163]

	All Students		Girls		Boys	
>= 70% Hisp.	1.047 [0.988,1.111]	1.030 [0.972,1.091]	1.033 [0.943,1.131]	1.013 [0.925,1.109]	1.055 [0.980,1.135]	1.040 [0.969,1.116]
Walkability Index	1.005 (0.994, 1.017)	0.998 [0.987,1.009]	1.004 (0.988, 1.021)	0.996 [0.979,1.013]	1.005 (0.991, 1.020)	0.999 [0.986,1.013]
All Fast Foods (count)	0.972** (0.957, 0.988)		0.984 (0.961, 1.007)		0.964*** (0.945, 0.983)	
Pizza (count)	0.986 (0.970, 1.002)		0.973* (0.949, 0.997)		0.994 (0.974, 1.013)	
Bodegas (count)	1.000 (0.996, 1.003)		0.999 (0.995, 1.004)		1.000 (0.996, 1.005)	
Banks (count)		0.978** [0.962,0.994]		0.977 [0.945,1.011]		0.977** [0.960,0.995]
N	94,348		47,065		47,283	

Note:

*
p<0.05;**
p<0.01;***
p<0.001

Table 4

Correlation matrix of neighborhood retail establishments

	All fast food	Pizza	Bodegas	Banks
All fast food (count)	1.00			
Pizza (count)	0.70	1.00		
Bodegas (count)	0.46	0.57	1.00	
Banks (count)	0.74	0.51	0.25	1.00