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A closer examination of the relationship between children's weight status and the food and physical activity environment

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Abstract

Objectives—Conflicting findings on associations between food and physical activity (PA) environments and children's weight status demand attention in order to inform effective interventions. We assess relationships between the food and PA environments in inner-city neighborhoods and children's weight status and address sources of conflicting results of prior research.

Methods—Weight status of children ages 3–18 was assessed using parent-measured heights and weights. Data were collected from 702 children living in four low-income cities in New Jersey between 2009 and 2010. Proximity of a child's residence to a variety of food and PA outlets was measured in multiple ways using geo-coded data. Multivariate analyses assessed the association between measures of proximity and weight status.

Results—Significant associations were observed between children's weight status and proximity to convenience stores in the 1/4 mile radius (OR = 1.9) and with presence of a large park in the 1/2 mile radius (OR = 0.41). No associations were observed for other types of food and PA outlets.

Conclusions—Specific aspects of the food and PA environments are predictors of overweight and obese status among children, but the relationships and their detection are dependent upon aspects of the geospatial landscape of each community.

Keywords

Food environment; Physical activity environment; Childhood obesity; Geo-spatial measures of proximity; Food outlets; Physical activity outlets; Weight outcome; Body mass index; Overweight

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Human participant protection
This research was approved by the institutional review boards of Rutgers University and Arizona State University. Participants provided informed consent prior to the start of the study.

Conflict of interest statement
The authors declare that there are no conflicts of interest.

Introduction

Large numbers of children and adolescents in the U.S., especially those from limited income households and from racial/ethnic minority groups, are overweight or obese. In 2009–2010, 31.8% of U.S. children and adolescents were overweight or obese, with rates above 39% among Hispanic and black populations (Ogden, 2012). Significant disparities have been documented in access to environments that support healthy behaviors, both related to food (Kipke et al., 2007; Larson et al., 2009; Morland and Filomena, 2007; Powell et al., 2007a, 2007b; Sturm, 2008; Zenk et al., 2006) and physical activity (PA) (Abercrombie et al., 2008; Crawford et al., 2008; Gordon-Larsen, 2006; van Lenthe et al., 2005), among populations that carry a disproportionate burden of obesity. Such findings have led to the implication of unhealthy environments in the etiology of the obesity epidemic (Kettel Khan et al., 2009; Larson et al., 2009; Morland and Evenson, 2009; Morland et al., 2006) and have resulted in a number of policy recommendations that aim to improve access to healthy foods and opportunities for PA (Institute of Medicine, 2012; Kettel Khan et al., 2009; Sturm and Cohen, 2009; White House Task Force on Childhood Obesity, 2010). Yet, research on the association between various aspects of the food and PA environments and children's weight status has produced inconsistent and often contradictory findings.

Different types of food outlets have been investigated for their associations with children's weight status. Increased availability of supermarkets in a student's school zip-code was associated with lower body mass index (BMI) and overweight among adolescents (Powell et al., 2007a, 2007b). Proximity of fast-food restaurants near middle and high schools was associated with a greater likelihood of the students being overweight (Davis and Carpenter, 2009), and proximity of fast-food restaurants to children's homes was associated with higher weight status (Mellor et al., 2011). Having a convenience store in the census block group of a child's residence, (Galvez et al., 2008) within close proximity to their homes (Laska et al., 2010; Leung et al., 2011), and near schools (Howard et al., 2011) was associated with unhealthy weight outcomes. Contradicting these findings are studies that showed lack of association between children's weight status and any type of food environment (An and Sturm, 2012; Lee, 2012) or lack of association with specific types of food outlets around children's schools and homes (Howard et al., 2011; Laska et al., 2010; Leung et al., 2011).

Studies of the associations between obesity and proximity to different elements of the PA environment have also yielded mixed results. Gordon-Larsen (2006) noted a positive association between number of PA facilities in a census block group and a reduced risk of an adolescent being overweight or obese. Similarly, Wolch et al. (2011) found that presence of a park near a child's home was negatively associated with the likelihood of their being overweight or obese. In contrast, others have found no associations between weight status and proximity to parks and PA facilities among children and adolescents (Burdette and Whitaker, 2004; Kligerman et al., 2007).

These conflicting findings may be attributed in part to different strategies for measuring proximity to environmental factors, a focus on varied age-groups of children, consideration of limited aspects of either the food or PA environment, and variation in the geographic characteristics of studied environments. Despite acknowledgment of the importance of simultaneous consideration of aspects of the food and PA environment (Black and Macinko, 2008; Papas et al., 2007; Sallis and Glanz, 2009), few such studies have been conducted. A lack of consideration of a more inclusive spectrum of potentially important elements of the environment precludes detection of independent effects and constrains our understanding of the implications for mounting effective interventions. Using data from four New Jersey cities on predominantly low-income, minority populations, the current study seeks to address these limitations by investigating the role of elements of the food and PA environments, considering a variety of potentially important measures of proximity, and assessing the association with the weight status of children in a broad spectrum of age groups.

Methods

Data sources

Survey data were collected in 2009–10 from a random-digit-dial sample of 1408 households having at least one child aged 3–18 years old in four New Jersey cities (Camden, New Brunswick, Newark, and Trenton). Survey items used in this analysis included household demographic characteristics and the geo-coded location of the respondent’s home address. At the conclusion of the survey, respondents (parent in 94% cases, and referred to as such) were asked to weigh and measure themselves and all their children following instructions provided to them via mail along with a tape measure and reporting worksheet. Objective geo-coded data on location of food and PA outlets in the study cities as well as in a 1 mile buffer around the city boundary were collected using commercial and publicly available sources. Using methodology developed by Ohri-Vachaspati et al. (2011), food outlets in commercial data sources were categorized as supermarkets, small grocery stores and specialty stores, convenience stores, and limited service restaurants (referred to as fast-food restaurants). Data on private and public PA facilities and parks (larger than one acre) were assembled based on methodology proposed by Abercrombie et al. (2008) using data from county and city departments, web-based searches, Yellow Pages, and from commercial data sources. All food and PA outlets were geocoded for purposes of creating proximity measures. The distance from each respondent’s home to the nearest facility was estimated using the distance tools in ArcGIS. Additional details about the survey and its administration, including collection of data on parent-measured heights and weights and sources for geospatial data, are included in Appendix.

Measures

Outcome variable—The outcome variable was weight status of children based on parent-measured heights and weights. Parent-measured heights and weights are highly correlated with professionally measured values (Carnell and Wardle, 2007) and considered more accurate than parent-reported estimates (Huybrechts et al., 2011). Potential self-selection bias associated with the sub-group from the sample providing measured heights and weights was assessed using procedures described in Appendix.

Children were classified as overweight or obese based on the age- and sex-specific percentile of the child's BMI calculated with parent-measured height and weight and the 2000 CDC Growth Charts (CDC-a). Children with BMI at or above the 85th percentile were considered overweight or obese. Children with any measured or calculated value identified as biologically implausible (CDC-b) were excluded from the analysis.

Exposure variables—Access to elements of the environment was measured by proximity of food and PA outlets to each individual child's residence. Proximity was measured in multiple ways, acknowledging that the same metric for capturing proximity may have different implications for access under varying geospatial conditions. First, distance to the nearest food and PA outlet from each child's home was measured in roadway network miles. Second, presence or absence of food and PA outlets was determined within each of three radii of the child's residence—1/4, 1/2, and 1 mile, with each child coded as 1 if a particular type of outlet was present within the specified radius and 0 if not. This measure captures the possibility that a threshold-distance is critical to access. Use of varied radii was intended to overcome problems associated with creation of arbitrary fixed boundaries around households which may have different meaning in varied geospatial contexts. Third, counts of food and PA outlets within the three radii captured the potential importance of density of particular facilities, acknowledging the prospect that density may affect price and choice of products.

Covariates—Covariates included child's age, gender, and race/ethnicity; mother's educational level; primary language spoken at home; nativity; household poverty status; and parent's self-measured BMI. Indicators of neighborhood socioeconomic conditions, calculated at the census block group level from pooled 2005 to 2009 American Community Survey data (Census Bureau) were also included. Each child was assigned the block group median income and the percentages within the block group that were non-Hispanic black, Hispanic, and Other.

Analysis—From the completed 1408 interviews, we confined our analysis to the subset of 702 children in 491 households whose parents provided measured heights and weights and who had complete data on the analytic variables. Sampling weights were developed specifically for children with parent-measured heights and weights so that survey estimates represent the population of 3–18 year olds in the four cities combined.

Our statistical analysis proceeded in two stages. In stage 1, we estimated a series of logistic regression models to assess the bivariate association between geospatial food and PA variables and child's weight status. In stage 2, we estimated multivariate regression models that included only those geospatial variables that were significant at $p < .10$ in the Stage 1 analysis. The multivariate models in Stage 2 also included covariates established by previous research as important predictors of child weight status. We estimated logit models to provide easily interpreted odds ratios and probit models, which have well established extensions that can account for the potential self-selection bias described above. Self-selection bias not accounted for by re-weighting of our sample was addressed in two ways. First, we compared parent-measured children to the other group of children according to observable individual and household-level variables. Second, we estimated probit models with a Heckman correction for self-selection (Heckman, 1976, 1979). In both analyses, we found that the main findings of our analysis were robust to potential self-selection (details in Appendix). All analyses were conducted using complex survey procedures in Stata Version 10 SE taking into account clustering at the household level.

Results

Thirty-eight percent of the children in our four study cities were overweight or obese (Table 1). The vast majority were Non-Hispanic black (47.8%) or Hispanic (40.1%) and 80.5% came from households with incomes at or below 200% of the federal poverty line. More than half had mothers with a high school education or less, and 72% had parents who were overweight or obese. Neighborhoods where children lived were mostly low income, and residents were largely Non-Hispanic black (49.5%) and Hispanic (35.4%).

Almost all children lived within one mile of a small grocery store and a large park and within 1/2 mile of a convenience store or fast-food restaurant; other exposure variables exhibited greater variation (Table 2). In the bivariate analyses (Table 2), presence of a convenience store within 1/2 mile, within 1/4 mile, numbers within 1/4 mile of home, and shorter distance to the nearest one were all associated with higher odds of a child being overweight or obese. Presence of a fast-food restaurant within a 1/2 mile radius showed similar associations. Presence of a park in the 1/2 mile radius was associated with lower odds of a child being overweight or obese.

Based on the results of the bivariate analysis, separate logistic regression models were created for four types of proximity measures for which at least one type of outlet had a significant association with the outcome variable ($p < .1$): distance to the nearest outlet, presence in a 1/2 mile radius, presence in a 1/4 mile radius, and number within 1/4 mile radius. The models included all geospatial variables that met our entry criteria. As a sensitivity analysis, we also included in our models the geospatial variables that were not significant in bivariate analysis and found that our results did not change.

Table 3 presents the results of the three different multivariate analyses (logit, ordinary probit, self-selection probit), run separately for each of the four proximity measures. In the logit models, after accounting for other predictors of children's weight status, having a park within 1/2 mile of a child's home was associated with significantly lower odds of being overweight or obese (OR 0.41; 95% CI: 0.21–0.81), and presence of a convenience store within a 1/4 mile radius of home increased the odds of being overweight or obese by 90% (OR 1.90; 95% CI: 1.04–3.45). Further, the average increase in the odds of being overweight or obese was 11% for every additional convenience store present within a 1/4 mile radius (OR = 1.11; 95% CI: 1.00–1.22). The results from probit models are similar in direction and level of significance to the findings described for the logit models. The probit models with the Heckman correlation for self-selection (details in Appendix) produced similar results (although the added power needed to estimate these more complex models weakened the significance of some variables).

Discussion

We found that after adjusting for covariates, children living within 1/4 mile of a convenience store had nearly twice the odds of being overweight or obese than children living farther away. Children living within 1/2 mile of a large park were less than half as likely to be overweight or obese as those who did not. We observed no independent associations between child weight status and proximity to other types of food outlets such as supermarkets, small grocery stores, and fast-food restaurants and public and private PA facilities. All relationships in bivariate and multivariate models were in the expected direction. These results were robust across a wide variety of models including those that account for unobservable bias among children whose parents returned worksheets with measured heights and weights.

Compared to national- and state-level studies conducted by Lee (2012) and An and Sturm (2012) that found no associations, other researchers (Galvez et al., 2008; Laska et al., 2010; Leung et al., 2011) found positive associations between proximity to convenience stores and weight status employing distance measures more attuned to the particular locales selected for study. Similar to our research, each of these studies was focused on a well-specified, geographic area likely to have a relatively homogeneous geospatial landscape. Galvez et al. (2008) studied children living in inner-city urban neighborhoods in East Harlem; Leung et al. (2011) studied girls living in the San Francisco Bay area; Laska et al. (2010) studied adolescents living in Minneapolis/St. Paul area; and our sample included children living in four densely populated low-income cities in New Jersey. In contrast, Lee employed uniform measures of exposure to convenience stores (e.g., density per square mile, density per unit population) in a national sample of school children living in varying geographic circumstances across the country and found no association with weight status. An and Sturm also found no association between proximity to convenience stores and children's self-reported weight status in a heterogeneous geospatial landscape across the state of California. Studies covering diverse geographic locales are likely to be confounded by use of uniform measures that lack consistent meaning across the varied environments to which they are applied.

Consideration of the implications of these findings for interventions must also take account of particularities of the geospatial landscape. For example, in a study of presence of convenience stores within a 1 mile radius of a suburban sample of households, Laska et al., found positive associations with child's weight status; for our urban and densely-populated New Jersey sample, such an analysis would not be meaningful since almost all (98.9%) of the children lived within a mile radius of a convenience store. Instead, for our study as well as other densely populated communities such as that studied by Leung et al., a 1/4 mile radius is more relevant for analysis. Positive associations in these studies – covering varying geospatial locations – suggest that within the specified thresholds of proximity, interventions that limit presence of convenience stores or reduce children's access to them may have a desirable impact on children's weight status.

Consistent with many studies, we found no association between proximity to supermarkets and weight outcomes among children (An and Sturm, 2012; Lee, 2012; Leung et al., 2011).

In contrast, an earlier study, relying upon density measures at adolescents' school zip-code level (Powell et al., 2007a, 2007b), found an association. For the households in our four studied cities, the mean distance to a supermarket was less than a mile and 80% of the children lived within a mile of a supermarket; access to supermarkets measured at the zip-code level (the average zip-code in NJ is 4.9 mile^2) (Grubesic and Matisziw, 2006) is quite uniform across the sample. Further, responding to our household survey, over 80% of parents reported that they do most of their food shopping at a supermarket. These findings underscore the importance of taking into account the local context when examining the impact of food access on health outcomes. Lack of associations between proximity to fast-food restaurants and children's weight status in our findings is at odds with some studies (Davis and Carpenter, 2009; Mellor et al., 2011) and is consistent with others (Howard et al., 2011; Laska et al., 2010). Our findings reflect the ubiquity of fast-food restaurants in the four cities we studied; within one mile of home, there were one-and-a-half times as many fast-food restaurants as convenience stores, which were already over-represented in our sample. Densely populated neighborhoods that are saturated with particular types of outlets pose further challenges for generating evidence for their association with health outcomes.

We found that children who lived within 1/2 mile of a park had less than half the odds of being overweight or obese compared to children who did not. In a longitudinal study, Wolch et al. (2011) also found a positive association between presence of a park within 500 m (0.31 mile) of the homes of boys aged 9–10 and weight status in a sample of communities in Southern California. Our data showed no association with children's weight status when proximity was measured as distance to the nearest park, consistent with the findings of Burdette and Whitaker (2004) who applied the same proximity measure to studying preschool children in urban, low-income neighborhoods in Cincinnati. For our population, the threshold at which presence of a park made a difference was 1/2 mile. This finding suggests that, in a densely populated areas with relatively good access to parks, living less than 1/2 mile away is critical to having a favorable association with weight status—whereas small incremental changes in distance are not important.

Our study provides robust evidence of the association of proximity to convenience stores and parks with weight status among low-income children of all ages living in densely populated, urban cities. Studies of this full age spectrum of children in this field are rare. Among the limitations, our outcome measure was based upon parent-measured heights and weights, an improvement over the usual self-report but not as reliable as professionally measured values and may have some uncorrectable biases. Like most previous research, our conclusions are based on a cross-sectional study that was designed to assess the association between weight outcomes and food and PA environments, and thus, we are limited in making casual inferences. More definitive evidence to inform interventions awaits the conduct of longitudinal studies that include consideration of how neighborhood residents make use of available PA and food outlets.

Conclusion

Children and adolescents living in close proximity to convenience stores in densely populated low-income communities are more likely to be overweight or obese, and those who have a park near their home are less likely to be overweight or obese. In addition to implications for interventions, these findings confirm the importance of selecting measures of proximity that are suited to the geospatial landscape of the communities under study in research on childhood obesity and food and PA environments.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Appendix. Supplementary material

Supplementary material to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2013.05.009.

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Table 1

Demographic and neighborhood characteristics of children (n[a] = 702).

Characteristic	% or mean (SE)[b]
Weight status by BMI percentile	
Not overweight or obese (<85th percentile)	61.9 (2.5)
Overweight or obese (≥85th percentile)	38.1 (2.5)
Age	
2–5 years	15.7 (1.8)
6–11 years	40.6 (2.2)
12–19 years	43.7 (2.5)
Sex	
Male	51.2 (2.4)
Female	48.8 (2.4)
Race/ethnicity	
Non-Hispanic White	7.1 (1.8)
Non-Hispanic Black	47.8 (3.2)
Hispanic	40.1 (3.1)
Other race	5.0 (1.5)
Nativity of respondent	
US-born	68.6 (3.0)
Foreign-born	31.4 (3.0)
Language primarily used at home	
English	73.0 (2.7)
Non-English	27.0 (2.7)
Poverty	
≤200% of poverty line	80.5 (2.2)
>200% of poverty line	19.5 (2.2)
Mother’s education	
High school or less	58.7 (3.2)
Some college	26.2 (2.8)
College graduate or higher	15.1 (2.4)
Parental BMI	30.0 (0.5)
Median income in block group	$35,746 ($925)
Race/ethnicity: percentage in block group	
Non-Hispanic Black	49.5 (2.1)
Hispanic	35.4 (1.6)
Other race	3.8 (0.3)

[a]Unweighted n.

[b]Sample weighted and SE adjusted for complex survey design.

Table 2

Distributions of objective measures of neighborhood food and physical activity environment and their bivariate association with child's weight status (n[a] = 702).

Geospatial variable	% or mean (SE)[b]	Unadjusted OR (95% CI)[b]
Food environment		
Miles to nearest		
Supermarket	0.72 (0.02)	1.12 (0.76, 1.66)
Small grocery store	0.48 (0.02)	0.70 (0.41, 1.18)
Convenience store	0.18 (0.01)	0.18 (0.05, 0.63)[c]
Fast-food restaurant	0.21 (0.01)	0.47 (0.13, 1.69)
Presence in 1 mile radius[d]		
Supermarket		
Yes	80.1 (1.8)	1.00 (0.63, 1.59)
No	19.9 (1.8)	
Small grocery store		
Yes	90.9 (1.6)	1.47 (0.69, 3.14)
No	9.1 (1.6)	
Convenience store		
Yes	98.9 (0.5)	_[e]
No	1.1 (0.5)	
Fast-food restaurant		
Yes	99.8 (0.1)	_[e]
No	0.2 (0.1)	
Presence in 1/2 mile radius[d]		
Supermarket		
Yes	38.5 (3.1)	0.82 (0.52, 1.29)
No	61.5 (3.1)	
Small grocery store		
Yes	63.9 (2.9)	1.08 (0.70, 1.67)
No	36.1 (2.9)	
Convenience store		
Yes	96.4 (1.0)	3.54 (1.14, 10.98)[c]
No	3.6 (1.0)	
Fast-food restaurant		
Yes	96.1 (1.0)	2.46 (0.99, 6.16)[f]
No	3.9 (1.0)	
Presence in 1/4 mile radius[d]		
Supermarket		
Yes	11.5 (2.4)	0.55 (0.26, 1.17)
No	88.5 (2.4)	
Small grocery store		

Geospatial variable	% or mean (SE)[b]	Unadjusted OR (95% CI)[b]
Yes	26.1 (3.0)	0.96 (0.59, 1.56)
No	73.9 (3.0)	
Convenience store		
Yes	82.9 (2.2)	1.99 (1.15, 3.45)[c]
No	17.1 (2.2)	
Fast-food restaurant		
Yes	68.5 (2.9)	0.83 (0.52, 1.30)
No	31.5 (2.9)	
Number of outlets in 1 mile radius[g]		
Supermarket	2.4 (0.08)	0.94 (0.82, 1.07)
Small grocery store	7.3 (0.25)	0.99 (0.94, 1.04)
Convenience store	36.8 (0.87)	(0.99, 1.02)
Fast-food restaurant	52.9 (1.48)	1.00 (0.99, 1.01)
Number of outlets in 1/2 mile radius[g]		
Supermarket	0.8 (0.06)	0.90 (0.72, 1.14)
Small grocery store	2.4 (0.13)	0.98 (0.89, 1.09)
Convenience store	11.2 (0.28)	1.03 (0.99, 1.08)
Fast-food restaurant	13.9 (0.47)	1.00 (0.98, 1.03)
Number of outlets in 1/4 mile radius[g]		
Supermarket	0.2 (0.03)	0.61 (0.33, 1.10)
Small grocery store	0.6 (0.07)	1.03 (0.83, 1.27)
Convenience store	3.3 (0.12)	1.09 (1.00, 1.20)[f]
Fast-food restaurant	3.5 (0.18)	1.01 (0.95, 1.08)
PA environment		
Miles to nearest		
Park (1 acre or more)	0.28 (0.01)	2.59 (0.72, 9.31)
PA facility	0.71 (0.03)	1.13 (0.72, 1.79)
Presence in 1 mile radius[d]		
Park (1 acre or more)		
Yes	100.0 (−)	_[e]
No	0.0 (−)	
PA facility		
Yes	78.4 (2.8)	1.03 (0.62, 1.71)
No	21.6 (2.8)	
Presence in 1/2 mile radius[d]		
Park (1 acre or more)		
Yes	88.8 (2.4)	0.36 (0.18, 0.75)[c]
PA environment		
Presence in 1/2 mile radius[d]		
Park (1 acre or more)		

Geospatial variable	% or mean (SE)[b]	Unadjusted OR (95% CI)[b]
No	11.2 (2.4)	
PA facility		
Yes	37.2 (3.0)	0.85 (0.55, 1.31)
No	62.8 (3.0)	
Presence in 1/4 mile radius[d]		
Park (1 acre or more)		
Yes	50.4 (3.1)	0.73 (0.48, 1.11)
No	49.6 (3.1)	
PA facility		
Yes	10.7 (1.9)	0.73 (0.48, 1.11)
No	89.3 (1.9)	
Number of outlets in 1 mile radius[g]		
PA facility	4.1 (0.21)	1.00 (0.93, 1.07)
Number of outlets in 1/2 mile radius[g]		
PA facility	1.1 (0.09)	0.90 (0.76, 1.06)
Number of outlets in 1/4 mile radius[g]		
PA facility	0.3 (0.04)	0.86 (0.61, 1.21)

[a] Unweighted sample size.

[b] Sample weighted and SE adjusted for complex survey design.

[c] $p < 0.05$ in bivariate logit model with child's weight status.

[d] Radius measurement based on road distances.

[e] Not computed due to insufficient variability.

[f] $p < 0.10$ in bivariate logit model with child's weight status.

[g] Radius measurement based on shortest distance between two points.

Table 3

Multivariate logistic regression analysis of the association of proximity to elements of the food and physical activity environment with child's weight status (n[a] = 702).

Key geospatial predictor(s)[b]	Logit models Adjusted odds ratio (95% CI)[c]	Probit models Marginal effects[c,d] (95% CI)	Heckman-probit models Marginal effects[c,d,e] (95% CI)
Distance to nearest (miles)			
Convenience store	0.32 (0.07–1.37)	−0.23 (−0.51, 0.05)	−0.16 (−0.39, 0.07)
Presence in 1/2 mile radius			
Convenience store	1.47 (0.35–6.20)	0.05 (−0.24, 0.34)	−0.08 (−0.35, 0.18)
Fast-food restaurant	1.41 (0.47–4.28)	0.09 (−0.14, 0.32)	0.13 (−0.08, 0.35)
Park (1 acre or more)	0.41 (0.21–0.81)**	−0.19 (−0.33, −0.05)**	−0.14 (−0.30, 0.02)*
Presence in 1/4 mile radius			
Convenience store	1.90 (1.04–3.45)**	0.13 (0.01, 0.25)**	0.13 (0.01, 0.26)**
Number in 1/4 mile radius			
Convenience store	1.11 (1.00–1.22)**	0.02 (0.002, 0.04)**	0.02 (−0.001, 0.04)*

[a]Unweighted sample size.

[b]Multivariate regressions were run for geospatial variables having a significant ($p < 0.1$) bivariate association with child's weight status (see Table 2).

[c]Sample weighted and SE adjusted for complex survey design; each model controlled for child's age, child's sex, race/ethnicity, household poverty status, parental nativity, mother's education level, household language status, parental BMI, median income in the block group of child's residence, and racial/ethnic composition in the block group of child's residence.

[d]Marginal effects indicate the change in the likelihood of being overweight/obese for individuals with the average value of the remaining covariates in the model.

[e]The first-stage selection equation of the Heckman-Probit model was run on an unweighted sample of n = 2200.

**$p < 0.05$.

*$p < 0.10$.