Student Column

THE RELATIONSHIP BETWEEN LOCAL FOOD SOURCES AND OPEN SPACE TO BODY MASS INDEX IN URBAN CHILDREN

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The prevalence of obesity among children and adolescents has increased threefold between 1980 and 2002, with prevalence rates of up to 17.1% being reported.[1–3] Explanatory hypotheses for such a change are multifactorial and include changes in diet and physical activity. High priority should be placed on determining environmental factors that may contribute to this epidemic of childhood obesity.

One environmental topic that has received recent attention in the literature is the effect of local food sources on obesity.[4–9] There is supporting evidence for an association between body mass index (BMI) and local food sources. Recent research focusing on children and adolescents provides supporting evidence for an association between body mass index (BMI) and local food sources. In East Harlem, New York, Galvez et al. found that having more than one convenience store in a 6- to 8-year-old child's census block group correlated to higher BMI.[10] Oreskovic et al. found that the density of fast-food outlets was positively associated with obesity in Massachusetts children.[11] Americans are eating out of the home more often, with potential negative consequences depending on their food source choices.[12] Teens use fast-food outlets twice a week on average.[13] Fast-food outlets pose a risk because they stock less healthy foods;[14–16] eating fast food is associated with higher calories, fat, and sodium;[17] and the frequency of an individual's fast-food intake is inversely associated with an individual's fruit and vegetable intake.[18] In a study of low socioeconomic status (SES) urban students, it was found that purchases from the urban corner convenience store were energy-dense with poor nutritive value.[19]

Despite these studies indicating a relationship between the food environment and obesity and unhealthy eating, several other studies have not found evidence for spatial proximity to food sources as a risk factor for obesity.[20–24] In a study in Cincinnati, Ohio, Burdette and Whitaker found the distance between the child's residence and fast-food restaurants was not related to obesity status for 3- to 5-year-olds.[20] In a four-year longitudinal study, Sturm and Datar found no association between BMI and the density of four food source categories: groceries, convenience stores, fast-food restaurants, or sit-down restaurants.[22] Jeffery and colleagues found that proximity to fast-food restaurants was not associated with BMI or eating at these restaurants.[23] Counter to many other studies, Crawford et al. showed that obesity increased with greater distance to the nearest fast-food outlet and diminished if there was at least one fast-food outlet within two kilometers of the residence.[24] Low SES has been associated with higher rates of obesity,[8,11,22,25–30] less availability of supermarkets, and higher densities of both fast-food outlets and convenience stores.[11,16,21,31–43]

The built environment may also influence obesity through how well it supports physical activity; however, this influence has not been established.[44–49] Many urban environments do not allow for safe outdoor activities due to traffic or crime.[50–52] Low-income built environments have been found to have less open space.[11] Liu et al. found in a cross-sectional analysis of 3- to 18-year-olds that increased neighborhood green space was correlated with a decreased risk for overweight status in high-population environments.[53]

Spatial analysis techniques for investigating the built environment have improved greatly in the past two decades.[54–62] Geographic information systems (GIS) allow for a visual exploration of environmental factors that influence health by providing digital maps. Spatial statistical software can be used to evaluate spatial relationships among health-related variables in the built environment.

The objective for this study was to analyze the relationship between characteristics of the local built environment, including food environment and open space, with BMI of students in kindergarten through 12th grade in an urban, multiethnic population. This study was undertaken to further assess whether there are significant relationships between the density and quality of a wide array of food sources in urban settings where obesity has an especially high prevalence, a debate that has not yet been settled.

We hypothesized that the density of convenience stores/bodegas, fast-food outlets, and sit-down restaurants would be positively correlated to BMI, controlling for sociodemographic variables. We also postulated that lower SES would be directly correlated and open space inversely correlated with BMI.

METHODS

Data sources

Student database. Upon Institutional Review Board approval from Baystate Medical Center, a multiethnic sample of 10,513 urban students from Springfield, Massachusetts, in kindergarten through 12th grade who had heights and weights measured by school nurses during the 2005–2006 school year were entered into the study. Students were measured in all schools, with the priority given to measure students in kindergarten through fourth grade, seventh-grade students, and 10th-grade students. Students in other grades would be measured if resources were available.

The nurse measured students by classroom without any selection criteria based on obesity status or demographic characteristics. Because of the priority for certain grades, limited nursing resources, and student absenteeism, the number of students (n=10,513) in the sample was actually lower than the number of total school district students (n=25,792). To address this issue, we explored the grade-level distribution of students enrolled in the sample. Also, using the Chi-square test, we compared demographics of sample students—including SES (based on proportion enrolled in the National School Lunch Program [NSLP]), gender, and racial distribution—with demographics of students not enrolled (n=15,279) in the sample.

The school database contains the student's age, gender, race/ethnicity, grade, status of enrollment in NSLP (i.e., free, full-price, or reduced-price lunch), and mode of transportation to school (e.g., walk to school, walk to bus stop, door-to-door transportation, or private). We calculated age- and gender-standardized BMI z-scores using Centers for Disease Control and Prevention (CDC) growth charts.[63]

Food source database. We created a local food source database from the 2006 Yellow Pages, the Springfield Public Health Department, and the Internet. Food sources were categorized empirically into sit-down restaurants, fast-food outlets, convenience/bodega stores, and supermarkets/produce markets based on name and classification found in the data source using criteria described in the literature.[64,65]

Census-tract and land-use maps. Geographic boundaries and attributes of U.S. Census tracts were obtained from the 2000 U.S. Census.[66] Springfield geographic land-use designations were obtained from the Massachusetts GIS.[67,68]

Map creation for study variables

Shapefiles. We used ArcMap®[69] to integrate information from the various data sources described previously to create digital map layers for each variable by census tract (n=35). These map layers or "shapefiles" can be graphically displayed in ArcMap or statistically analyzed using the data table that is embedded.[61,70]

Study variables. Student database variables were aggregated based on the census tract of the student's home addresses. For each census tract in this study, the mean BMI z-score for students living in the census tract (BMI-Z-CT) was the dependent variable. Main independent variables by census tract included food source count in a quarter-mile radius from student's residence averaged for the census tract, and the proportion of open space in the census tract. Open space was defined as a land-use designation of forest, wetland, recreation area, spectator recreation, water-based recreation, low-density housing (>0.25-acre lots for homes), park, or green space. Demographic variables of the students included mean age and proportion of students in the census tract by race/ethnicity, gender, enrollment in free or reduced-price NSLP, and mode of transportation to school. Census 2000 population-based median household income and high school/college graduation rate information were also included for analysis by census tract.

Exploratory geographic analysis

We used GeoDa®[71,72] spatial statistical software for exploratory spatial analysis. Quartile box maps were made for all the main study variables and inspected for trends, patterns, and outliers.[70] Next, local indicators of spatial association (LISA), as described by Anselin,[73] were displayed to determine if statistically significant clustering existed for variables.

Regression analysis

To determine the strength of association between the local food environment and open space to BMI, we employed ordinary least squares (OLS) linear regression with spatial diagnostics for all census tracts using methods described by Anselin.[72] We conducted univariate logistic regression using GeoDa to select candidates for multivariate analysis. Variables with a significance level <0.1 were selected as candidates for the multivariate logistic regression. Then, using SPSS® version 16,[74] we performed a two-block hierarchical multiple regression analysis.[62] We conducted this regression to

Table 1. Demographic characteristics of students in kindergarten through 12th grade who had their BMI measured (*n*=10,513): Springfield, Massachusetts, 2005–2006

Attribute	*Mean (SD)*
BMI-Z-CT	0.78 (0.13)
BMI percentile	70.52 (3.08)
Age, in years	9.41 (3.19)
Proportion by race/ethnicity	
African American	0.30
Caucasian	0.22
Hispanic	0.48
Proportion by gender	
Male	0.52
Female	0.48
Proportion by school meal plan	
Free NSLP	0.75
Full-price NSLP	0.16
Reduced-price NSLP	0.09
Proportion by mode of transportation to school	
Door-to-door bus	0.06
Walk to school	0.62
Walk to bus stop	0.29
Private	0.01
Unknown	0.02

BMI = body mass index

SD = standard deviation

BMI-Z-CT = BMI z-score of students living in census tract

NSLP = National School Lunch Program

assess the hypothesized built environment variables controlling for literature-based risk factors. Therefore, block one contained sociodemographic risk factors for obesity, including proportion of students by census tract who were from a racial/ethnic minority group, enrolled in free or reduced-price NSLP, and high school graduates. We also included the median household income by census tracts. Block two contained the built environment variables, including food source densities and open space. As described by Agresti and Finlay,[75] in cases where multicollinearity was found among variables, composite variables were created using either standardized z-scores for variables of different scale (e.g., household income and proportion of students who were high school graduates by census tract) or by summing over similar food source categories.

Finally, we compared the final best model derived from this method with systematic stepwise and backward regression using all variables. When several models were compared, the model with the lowest Akaike's Information Criterion (AIC) was chosen. AIC is a measure of how well a regression model fits. This measure provides a means for selecting the best model among alternative models.[76]

Regression diagnostics

Using GeoDa, we performed testing for spatial dependence of regression residuals, which, when present, can challenge the assumption of independence in regression analysis.[77] Other diagnostics performed included the usual testing of regression for normality of errors, heteroskedasticity, and multicollinearity.[70,77,78]

RESULTS

Descriptive statistics

Student data. The demographics of this low SES, predominantly minority sample are presented in Table 1. Given the priority to measure students in lower grades, there was a higher proportion of sample students from lower grades, with only 9.2% of the sample being drawn from grades eight through 12 (Table 2). There was no difference in enrollment in free NSLP, which is a measure of SES, between the students enrolled in the sample (i.e., those who had their BMI measured) and those not enrolled in the sample (i.e., those who did not have their BMI measured). As compared with those who were not in the sample, the sample included a slightly lower percentage of Hispanic people, slightly higher percentage of African Americans, and slightly higher percentage of Caucasians; however, there were no gender differences (Table 3).

Table 2. Percentage of students who had their BMI measured, by grade level, in Springfield, Massachusetts, 2005–2006

Grade	*Percent of total student body measured by grade level*	N	*Percent in study sample*
Pre-kindergarten	21.0	141	1.3
Kindergarten	79.7	1,600	15.2
First	82.3	1,799	17.1
Second	76.1	1,509	14.4
Third	70.6	1,377	13.1
Fourth	58.3	1,126	10.7
Fifth	21.3	403	3.8
Sixth	13.5	272	2.6
Seventh	64.4	1,321	12.6
Eighth	1.7	34	0.3
Ninth	10.4	279	2.7
10th	24.0	422	4.0
11th	8.9	124	1.2
12th	8.8	103	1.0

BMI = body mass index

Table 3. Comparison of demographic characteristics for those students who had their BMI measured (those enrolled in the study) vs. those who did not get their BMI measured (those not enrolled in the study): Springfield, Massachusetts, 2005–2006

Attribute	*Students in sample* (n=*10,513*) N *(percent)*	*Students not in sample* (n=*15,279)* N *(percent)*	P-*value*
Race/ethnicity			<0.001
African American	3,154 (30)	4,326 (28)	
Caucasian	2,313 (22)	2,846 (19)	
Hispanic	5,046 (48)	8,108 (53)	
Gender			0.181
Male	5,467 (52)	7,816 (51)	
Female	5,046 (48)	7,463 (49)	
Socioeconomic status (NSLP)			0.542
Free	7,895 (75)	11,423 (75)	
Not free	2,618 (25)	3,856 (25)	

BMI = body mass index

NSLP = National School Lunch Program

Food sources. There were similar overall proportions of sit-down restaurants (36%), fast-food outlets (31%), and convenience stores/bodegas (30%). The percentage of food sources in the supermarkets/produce markets category (3%) was low (Table 4).

Census-tract descriptive data, including student BMI-Z-CT, food source density, and open space, are presented in Table 5. The census-tract median values for food source density (i.e., the census-tract average number of food sources in a one-quarter-mile buffer around the student's home) was higher for sit-down restaurants (1.62) than for convenience stores/bodegas (1.40) or fast-food outlets (1.34), and lower for supermarkets/produce markets (0.07). The proportion of

Table 4. Food source categories (*n*=673) in Springfield, Massachusetts, 2005–2006

Food source category	*Description*	*Examples*	N *(percent)*
Sit-down restaurants	Waiter takes order at table; full menu	Steakhouses (Caesar's Steakhouse, The Ribbery), Chinese restaurants (Peking House), Italian (Olive Garden), miscellaneous (International House of Pancakes, Friendly's, Ruby Tuesday's, Café Lebanon, Mexitalia, and Taste of Russia)	242 (35.96)
Fast-food outlets	Pay at counter for food that can be eaten quickly	Bakeries (Dunkin' Donuts), hamburger chains (Burger King, McDonald's, Wendy's), miscellaneous (Kentucky Fried Chicken, Taco Bell, Arby's), Deli (Subway, Quiznos, Fresco's Deli), ice cream shops (Dairy Queen), pizza (Papa John's, Pizza Hut)	210 (31.20)
Supermarkets/produce markets	Large selection of all food types including fruit and vegetables	Supermarkets (Big Y, Whole Foods), fruit and vegetables (AC Produce)	20 (2.97)
Convenience stores/bodegas	Packaged cold food items (i.e., chips, candy, and pastries) and soft drinks	Gas stations (Citgo, Mobil, Gulf, Sunoco), drug stores (CVS, Walgreens), bodegas (El Ricon, Angel's Grocery Store, Bera's Grocery Store), convenience stores (Dwight Convenience, 7-11, Cumberland Farms)	201 (29.87)
Total			673 (100.00)

BMI = body mass index

Table 5. Data by census tract in a sample of students who had their BMI measured (*n*=35 census tracts) in Springfield, Massachusetts, 2005–2006

Variable	*Median*	*Minimum*	*Maximum*
BMI-Z-CT	0.78	0.50	1.07
Food source density (census tract average number of food sources in a one-quarter-mile buffer around student's home)			
Convenience stores/bodegas	1.40	0.11	10.06
Supermarkets/produce markets	0.07	0.00	1.13
Sit-down restaurants	1.62	0.05	16.86
Fast-food outlets	1.34	0.03	9.06
Composite food variable (convenience stores/bodegas + fast-food outlets + sit-down restaurants)	4.51	0.29	34.06
Census 2000 data			
High school graduation rate	0.60	0.30	0.71
College graduation rate	0.12	0.04	0.32
Household income	$36,310	$12,669	$60,572
Proportion of census tract that is open space	0.38	0.04	0.90

BMI = body mass index

BMI-Z-CT = BMI z-score of students living in census tract

open space varied from 0.04 to 0.90. The Census 2000 median household income ($36,310) and education level (0.60 high school graduation rate and 0.12 college graduation rate) noted for the area were low.

Exploratory analysis

BMI. Quartile box maps displayed higher values of BMI-Z-CT in the western and northern parts of the city and lower values in the southeastern part of the city. LISA maps, however, did not reveal statistically significant clustering (Figure 1).

Food sources and open space. On quartile box map inspection, there were high-density clusters of food sources in the western part of the city and lower-density clusters in the southeastern part of the city (Figure 2). This pattern was opposite to that of open space, which had high-density clusters apparent in the eastern part of the city and lower-density clusters in the western part of the city (Figure 3). LISA maps confirmed statistically what was visually found on the quartile box maps for these two variables.

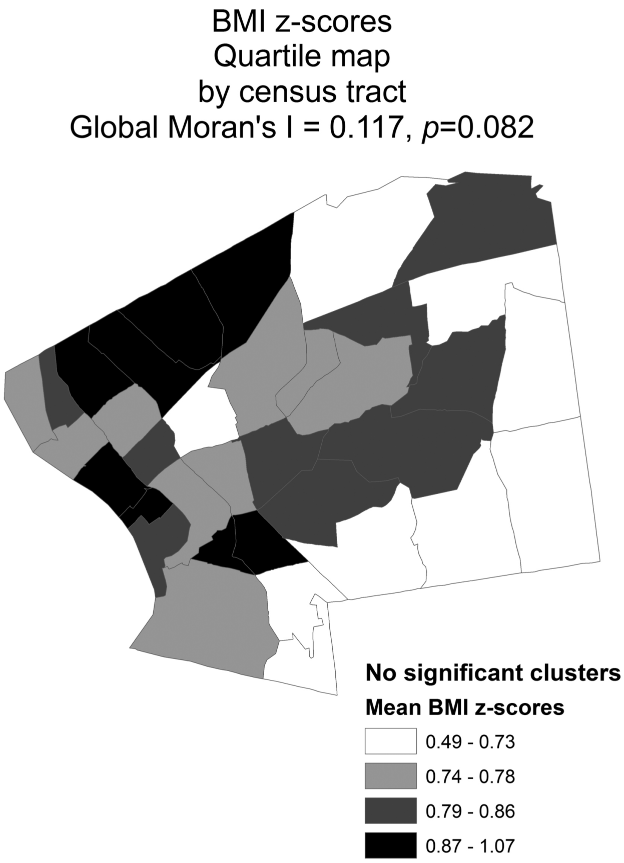
Demographics. Figure 4 illustrates the spatial pattern of the composite high-risk covariate, which included proportion of racial/ethnic minority students by census tract, proportion enrolled in free NSLP, lower high school graduation rates, and lower median household income, and was found to be higher in the western part of the city than in the eastern part of the city on quartile box maps and LISA statistical analysis.

Regression

Univariate OLS regression showed that BMI was significantly associated with density of fast-food outlets (β=0.537, p=0.001), sit-down restaurants (β=0.529, p=0.001), and convenience stores/bodegas (β=0.535, p=0.001). Open space in the census tract had a negative association (β=−0.408, p=0.015) with BMI-Z-CT. BMI-Z-CT was associated with the proportion of racial/ethnic minority students in the census tract (β=0.344, p=0.043) and enrollment in free NSLP (β=0.463, p=0.005). Spatially, there was a statistically significant negative trend of BMI-Z-CT going from west to east, indicating regional spatial variation (β= −0.530, p=0.001). Census-tract high school graduation rates (β=−0.292, p=0.089) and median household income (β=−0.331, p=0.052) approached statistical significance for a negative relationship with BMI-Z-CT (Table 6). Age, gender, mode of transportation to school, supermarkets/produce markets, and college graduation rates of census tract were not related to BMI-Z-CT (data not shown).

We performed hierarchical multiple regression for all census tracts. Because significant multicollinearity existed among covariates, we created a composite high-risk covariate term for each census tract. This term was calculated by summing (*1*) standardized values for the proportion of students in the census tract who were of a minority racial/ethnic group and (*2*) standardized values for the proportion of students in census tract enrolled in free or reduced-price NSLP and subtracting

Figure 1. Quartile box map of mean standardized BMI z-scores for students living in census tracts with clusters found by local indicators of spatial association tests: Springfield, Massachusetts, 2005–2006[a]



[a]The insignificant Moran's I indicates no clustering.

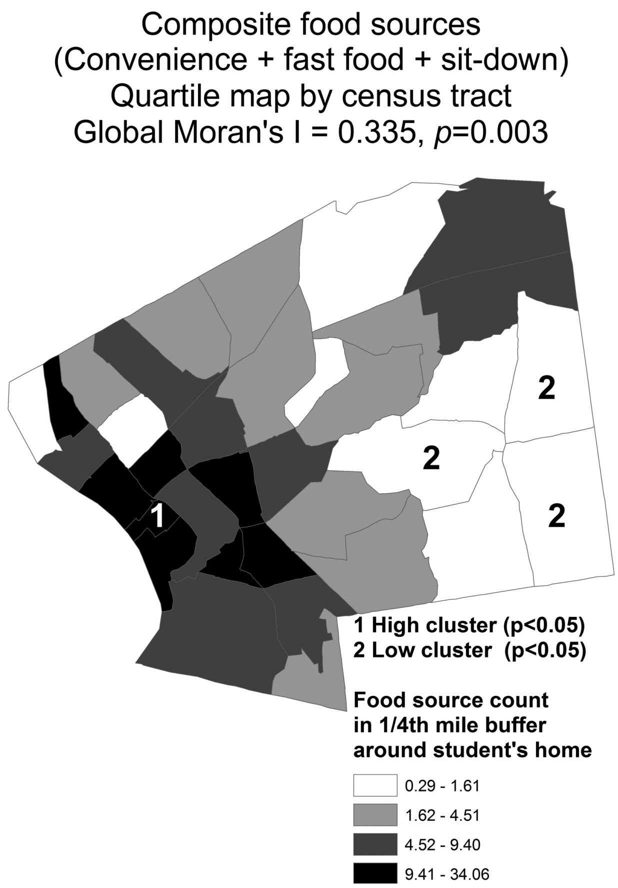
BMI = body mass index

(*3*) standardized values for the proportion of students in the census tract who were high school graduates and (*4*) standardized values for median census-tract household income. When entered into block one of the regression model, this composite high-risk covariate term showed a positive relationship to BMI-Z-CT that was significantly different from zero (β=0.379, p=0.025) (Table 6).

In block two, food source categories were added one at a time and the model was assessed controlling for the composite high-risk covariate term. Convenience stores/bodegas (β=0.482, p=0.004), fast-food outlets (β=0.458, p=0.002), and sit-down restaurants (β=0.450, p=0.003) were significantly related to BMI-Z-CT. When all three categories of food sources were entered into block two together, there was no statistical significance added to the model. That is, each food source category, when controlling for the other two food source categories, did not have a statistically significant relationship to BMI-Z-CT. We then created a composite food source variable consisting of the sum of convenience stores/bodegas, fast-food outlets, and sit-down restaurants and, when placed in the model, it significantly improved the equation (β=0.559, p=0.001) (Table 6) and overall was the best prediction model (Table 7). This finding was confirmed using systematic stepwise and forward regression of all predictor variables. The three food source variables comprising the composite food source variable were examined for interaction effect. However, we found no statistically significant coefficients for the interaction variables.

Open space did not remain a significant predictor of BMI-Z-CT when controlling for the high-risk

Figure 2. Quartile box map of composite food sources (sum of convenience stores/bodegas, fast-food outlets, and sit-down restaurants) with clusters found by local indicators of spatial association tests: Springfield, Massachusetts, 2005–2006[a]



[a]Note the high clusters of food sources found in the western region and low clusters found in the eastern region.

covariate. This composite high-risk covariate, in turn, did not remain significant when food source categories were entered.

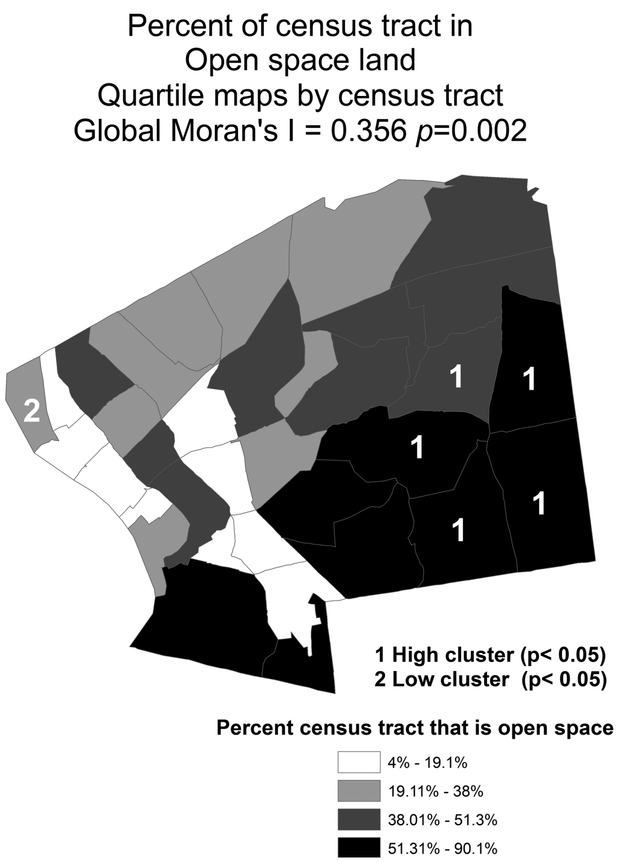
Diagnostic testing performed in GeoDa revealed no spatial dependence for the best prediction model (Table 7). As described by Anselin, this finding precluded further spatial regression analysis.[72] Also, we found normality of errors and no heteroskedasticity.

DISCUSSION

This study employed GIS technology and spatial analysis tools to evaluate the relationship between the local food environment and open space to urban students' aggregate BMI-Z-CT. Student BMI z-scores were associated with the density of convenience stores, fast-food outlets, and sit-down restaurants, as well as a composite variable of the three food sources. This association was found even after controlling for high-risk covariates such as income, racial/ethnic minority group status, enrollment in free or reduced-price NSLP, and rates of high school graduation. Although open space was found to have a significant negative relationship to BMI on single-model regression, this relationship was not evident when controlling for demographic variables.

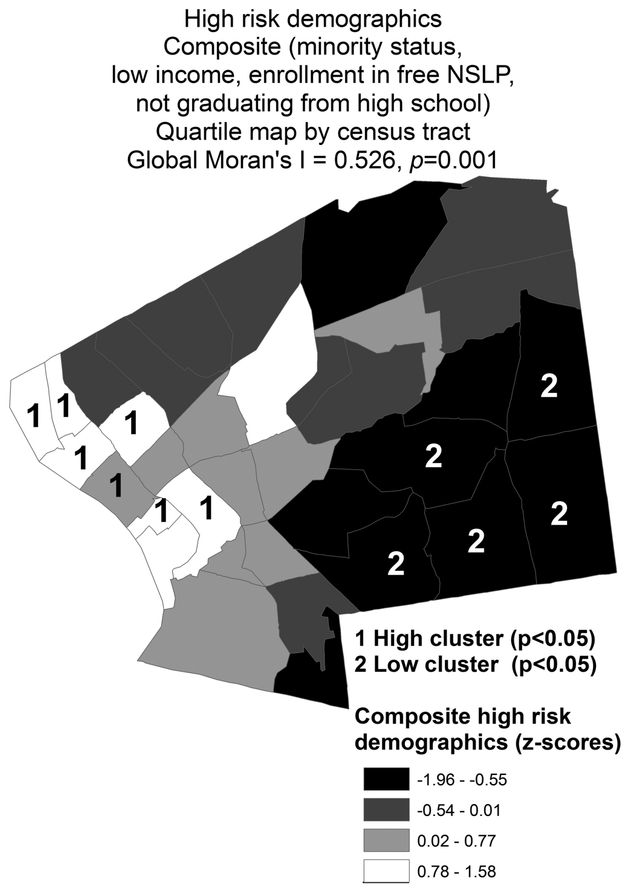
This study provides a more complete analysis of the relationship between the built environment and childhood obesity than most existing studies. Variables such as student demographics, geographic open space, and all major food source categories were included in the analysis. This spectrum of predictors is not found

Figure 3. Quartile box map of open space with clusters found by local indicators of spatial association significance test in a study of students who had their BMI measured in Springfield, Massachusetts, 2005–2006[a]



[a]Note the cluster of open space found in eastern Springfield.

Figure 4. Quartile box map of composite high-risk covariate with clusters found by local indicators of spatial association significance test in a study of students who had their BMI measured in Springfield, Massachusetts, 2005–2006[a]



[a]The western part of the city has a cluster of high-risk demographics including low income, minority status, enrollment in free lunch, and low high school graduation rates.

BMI = body mass index

NSLP = National School Lunch Program

Table 6. Significant univariate ordinary least squares regression models of BMI-Z-CT with spatial diagnostics in a sample of students who had their BMI measured in Springfield, Massachusetts, 2005–2006

Predictor of BMI	β	*Adjusted R^2*	P-*value*
Composite food (fast-food outlet + sit-down restaurant + convenience stores/bodegas)	0.559	0.29	0.001[a]
Composite high-risk covariate (racial/ethnic minority status, low income, free NSLP, not graduating from high school)	0.379	0.12	0.025[b]
Convenience stores/bodegas	0.535	0.27	0.001[a]
Fast-food outlets	0.537	0.27	0.001[a]
Free NSLP	0.463	0.19	0.005[c]
Open space[d]	−0.408	−0.14	0.015[b]
High school graduation	−0.292	−0.06	0.089
Median household income	−0.331	−0.08	0.052
Racial/ethnic minority status	0.344	0.09	0.043[b]
Sit-down restaurants	0.529	0.26	0.001[a]
West to east direction	−0.530	−0.26	0.001[a]

[a]Significant at $p \leq 0.001$

[b]Significant at $p \leq 0.05$

[c]Significant at $p \leq 0.01$

[d]Diagnostics for spatial dependence, normality of errors, and heteroskedasticity were met for all variables with one exception: spatial dependence was found for high school graduation.

BMI-Z-CT = BMI z-score of students living in census tract

BMI = body mass index

NSLP = National School Lunch Program

in many of the other studies of environmental predictors of childhood obesity. The finding that sit-down restaurants were associated with higher childhood BMI is novel, and the association between convenience stores and fast-food outlets with higher BMI in children confirms the findings of other studies in children.[10,11] It appears that living near fast-food outlets, convenience stores, and sit-down restaurants may be a factor associated with the obesity epidemic in U.S. cities. This study specifically provides support to the efforts of First Lady Michelle Obama's program to improve the quality of food served at restaurants.

The finding that open space did not relate to BMI when controlling for demographics is interesting, as at first it seems to contradict the study by Liu et al.,[53] in which green space as measured by satellite imagery was associated with lower BMI in children living in high but not low population density regions. This complex relationship has been found by other research where diversity of land use, increased residential density, and connectivity of streets that contributed to the walkability of a community was associated with more physical activity.[78–80] However, the open-space variable used in our study included a combination of the typical green-space land characteristics (e.g., forest and parks) plus an additional lower population density category. Thus, it is likely that the addition of this low-density housing led to a loss of the relationship and is actually consistent with the findings of Liu and colleagues.

In this study, the quartile box maps and LISA statistics provide added insight into the nature of the built environment that cannot be provided by nonspatial analysis alone. Specifically, the geographic clustering of food source density, minority status, and enrollment in free NSLP in the western region and open space, higher income, and high school graduation in the eastern region paints a picture of Springfield as a city of disparities.

Strengths and limitations

This study had two strengths. First, the use of spatial regression provided for more accurate analysis than what is traditionally reported in ecological analysis.[81] Second, this study provided digital maps of the food environment for an urban region that can be used for further study.

This study also had several limitations. For one, the sample population included in this study was not drawn randomly and comprised 41% of the total school district population. The predominance of students in lower grade levels who had their BMI measured and were entered into the sample may have reduced the generalizability of this study to students in higher grade levels. There were no socioeconomic or gender

Table 7. Final ordinary least squares model with diagnostics in a sample of students who had their BMI measured: Springfield, Massachusetts, 2005–2006

Predictors	*β*	*SE*	*Beta*	*t*	P-*value*
Constant	0.717	0.025		28.495	0.000
Composite food (fast-food restaurant + sit-down restaurant + convenience stores/bodegas)	0.010	0.003	0.559	3.872	0.001
Adjusted $R^2=0.292$					
$p=0.001$					

Diagnostics[a]

Test	P-*value*	*Probability*
Moran's I (spatial dependence)	0.394	0.694
Lagrange multiplier lag (spatial dependence)	0.028	0.866
Robust LM lag (spatial dependence)	0.157	0.692
Lagrange multiplier error (spatial dependence)	<0.001	0.995
Robust LM error (spatial dependence)	0.129	0.720
Lagrange multiplier SARMA (spatial dependence)	0.157	0.925
Jarque-Bera (normality of errors)	1.006	0.604
Breusch-Pagan (heteroskedasticity)	1.634	0.201
Koenker-Bassett (heteroskedasticity)	1.157	0.282
White	1.764	0.414

[a]Diagnostics indicate no spatial dependence, normality of errors, and absence of heteroskedasticity.

BMI = body mass index

LM = Lagrange multiplier

SARMA = seasonal autoregressive moving average

differences between the sample and the non-enrolled students. Although differences in racial/ethnic distribution were noted, with a slightly higher proportion of African Americans and Caucasians and a slightly lower proportion of Hispanic people in the sample when compared with the unmeasured group, the magnitude of the differences was small. Therefore, the similarity of those in the sample and those not in the sample minimized the issue of selection bias regarding these major characteristics.

Also, because the level of the analysis was the census tract, individual student behavior could not be evaluated.[82] Furthermore, the food sources were categorized empirically based on name and category listed in the Yellow Pages and on the Internet. Although the categories were likely accurate, this method of categorizing was not as reliable as actually visiting and assessing each food source, as has been described in the literature.[64,65,83] Finally, this ecological study design did not establish the local food source environment as a causative factor in higher childhood BMI.

CONCLUSION

In summary, in this study of urban students in kindergarten through 12th grade, we found a density of sit-down restaurants, convenience/bodega stores, and fast-food outlets to be associated with BMI z-scores. This finding supports the evidence that the type and density of food sources are associated with elevated BMI z-scores in predominantly poor racial/ethnic minority children living in urban environments.

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