Disparities in the Food Environments of New York City Public Schools

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Background: Studies of the food environment near schools have focused on fast food. Research is needed that describes patterns of exposure to a broader range of food outlet types and that examines the influence of neighborhood built environments.

Purpose: Using data for New York City, this paper describes the prevalence of five different food outlet types near schools, examines disparities by economic status and race/ethnicity in access to these food outlets, and evaluates the extent to which these disparities are explained by the built environment surrounding the school.

Methods: National chain and local fast-food restaurants, pizzerias, small grocery stores ("bodegas"), and convenience stores within 400 m of public schools in New York City were identified by matching 2005 Dun & Bradstreet data to 2006–2007 school locations. Associations of student poverty and race/ethnicity with food outlet density, adjusted for school level, population density, commercial zoning, and public transit access, were evaluated in 2009 using negative binomial regression.

Results: New York City's public school students have high levels of access to unhealthy food near their schools: 92.9% of students had a bodega within 400 m, and pizzerias (70.6%); convenience stores (48.9%); national chain restaurants (43.2%); and local fast-food restaurants (33.9%) were also prevalent within 400 m. Racial/ethnic minority and low-income students were more likely to attend schools with unhealthy food outlets nearby. Bodegas were the most common source of unhealthy food, with an average of nearly ten bodegas within 400 m, and were more prevalent near schools attended by low-income and racial/ethnic minority students; this was the only association that remained significant after adjustment for school and built-environment characteristics.

Conclusions: Nearly all New York City public school students have access to inexpensive, energy-dense foods within a 5-minute walk of school. Low-income and Hispanic students had the highest level of exposure to the food outlets studied here.

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Although the prevalence of child obesity has increased in all population groups, low-income, African-American, and Hispanic children face a higher risk of obesity and related health problems than do other children.[1] Differences in children's food environments may help explain these disparities. Low-income and minority neighborhoods tend to have more fast-food restaurants, convenience stores, and small groceries, and fewer fruit and vegetable markets, bakeries, and health food stores.[2–7] These differences may have implications for children's food intake.[8–11]

One component of children's food environment is the food available near their schools.[12,13] Fast-food restaurants, convenience stores, and other outlets near schools offer inexpensive and energy-dense foods for consumption before and after school and at lunch.[14,15] Two recent studies have found that students attending schools with fast-food restaurants nearby were more likely to be obese; another analysis found modest and inconsistent effects of

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food outlet density on BMI growth in young children.[16–18] Urban schools are more likely to have fast-food restaurants nearby; in a national study, 67.5% of secondary schools in large cities had a fast-food restaurant within about 800 m.[19] There is some evidence that schools located in low-income neighborhoods or serving low-income students are more likely to be near fast-food and convenience stores,[19–21] whereas research on racial and ethnic disparities finds inconsistent results.[19,21]

Although research on the food environment near schools has opened a productive line of inquiry, existing studies have limitations. Most studies focus on national chain fast-food restaurants and convenience stores, but small grocery stores and other food service and food retail outlets are also important sources of unhealthy food in low-income, urban neighborhoods and have received less attention in research on food outlets near schools.[14,22–24] A more comprehensive examination of the food environment will inform research on environmental determinants of childhood obesity and public policy to promote child health.[25] In addition, little is known about how zoning and other aspects of the built environment shape the food environment near schools.[26] Food outlets are more prevalent near schools in areas with higher levels of urbanization and commercial land use.[13,19–21] Because low-income and minority students tend to live and attend school in more urbanized areas, disparities in the food environment near schools may reflect socioeconomic and racial differences in the built environments surrounding those schools. Documenting these relationships can inform public policy by identifying potentially modifiable factors that contribute to food environment disparities.

See related Commentary by Nestle in this issue.

Using data for New York City, the present study has three objectives. The first is to describe the relative prevalence of five different types of food outlets near schools in a densely settled urban area. In addition to national chain fast-food restaurants, the present study considered "local" fast-food, pizzerias, convenience stores, and "bodegas" or small grocery stores in order to capture food outlet types common in many low-income urban communities. The second objective is to describe disparities in access to these food outlet types. Because many students attend school outside their own neighborhood, especially at the middle and high school levels, the study considered disparities based on the economic status and racial/ethnic composition of the school rather than the neighborhood. The third is to evaluate the extent to which food environment disparities across racial/ethnic and socioeconomic strata of the student body are explained by built-environment characteristics. The authors hypothesized that schools with higher proportions of low-income and minority students will have more unhealthy food outlets nearby, and that these differences among schools will be reduced after adjusting for school-level and built-environment characteristics.

Methods

School Characteristics

Data on public school locations and student composition were compiled from public sources. A list of public schools open in 2006–2007 was obtained from the New York City Department of Education (DOE) website (schools.nyc.gov/Offices/FinanceandAdministration/DIIT/OOD/default.htm). After excluding public preschool programs, the list consisted of 1579 schools including charter schools and vocational, special education, and high school equivalency degree programs, which the DOE identified as distinct schools for administrative purposes. The DOE website and other Internet sources were used to obtain information on school enrollment and composition. School composition measures included the proportion of students identified as black, Hispanic, or Asian and the proportion eligible for free lunch, used as a proxy for low-income status. For 70.7% of schools, enrollment and racial/ethnic composition were obtained from the Department of Education website (schools.nyc.gov/) and the percentage of students eligible for free lunch from schools.nyc.gov/offices/d_chanc_oper/budget/dbor/allocationmemo/fy06_07/fy07_pdf/sam03.pdf. Several other websites were consulted to fill in missing information on enrollment or student composition: nces.ed.gov/ (28.0% of schools); www.schooldigger.com (11.4%); www.city-data.com (8.3%); www.insideschools.org (7.0%); www.schoolmatters.com (3.9%); and www.publicschoolreview.com (0.9%), in some cases drawing information from multiple websites for a single school.

Of the 1579 schools, 699 shared a location (a building or campus) with another school, with up to eight administratively distinct schools per location. In the present study, the unit of analysis is the school location; enrollment and student demographics were aggregated for all students attending school at the same location. Each school was geocoded to a tax lot using GeoSupport (software published by the NYC Department of City Planning), and schools or programs sharing the same tax lot were identified. The resulting aggregated data set included a total of 1135 school locations, of which 1089 had complete data on enrollment and student characteristics for all schools at that location. Dichotomous variables indicated enrollment of middle or high school students. Hereafter, "school" will refer to all schools and programs sharing a single location.

School neighborhood. School neighborhoods were defined using 400- and 800-m network buffers around each school. Network buffers use the street network (removing limited-access highways) as the organizing geography and represent the accessibility of locations to pedestrians traveling along the street. To construct the buffers, all points on the street network that were *n distance* from each point of entrance to each school were joined together to create an irregularly shaped polygon.

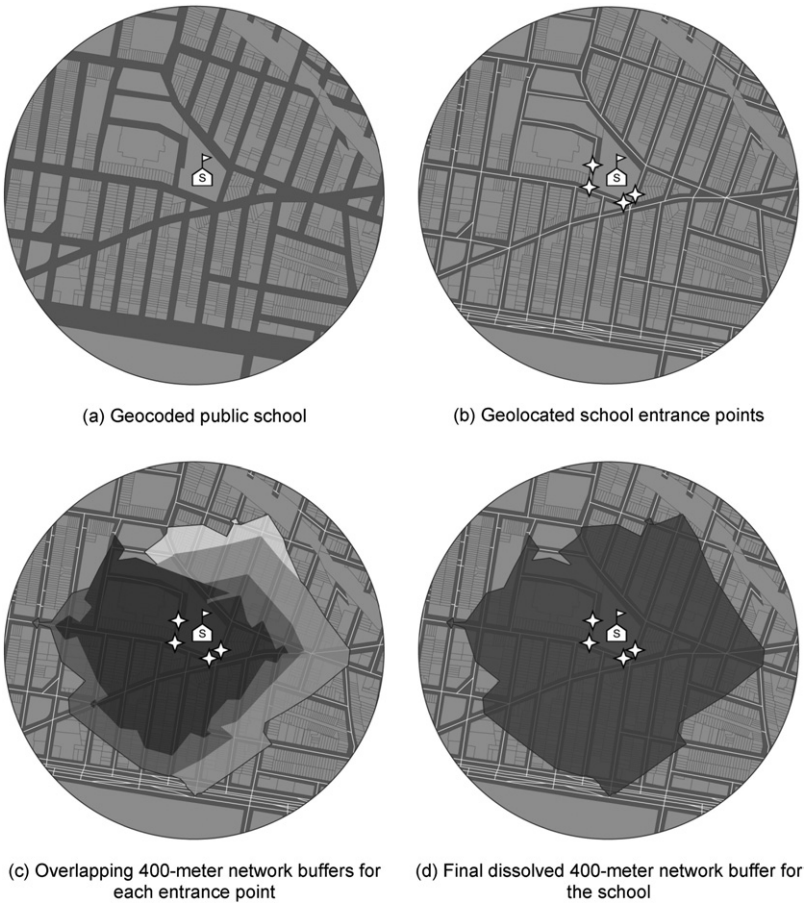

Figure 1. Illustration of construction of school neighborhood boundaries

For small buffers, the spatial accuracy of the origin point is critical.[27] To visually locate entrance points that were adjacent to sidewalks or showed other signs of pedestrian use, 2006 high-resolution, true-color, aerial photography with a spatial resolution of 0.25 m was used. At each entrance (n=5142), a point feature was created and snapped to the nearest street centerline, and network buffers were then created around each point feature. Ninety-five percent of schools had two or more entrances. At schools with multiple entrances, the corresponding overlapping network buffers were dissolved to produce one 400-m and one 800-m buffer per school (Figure 1). ArcGIS, version 9.2, was used for all geographic information processing.

Food environment. Based on previous research, five food outlet types were selected for study: national chain fast-food restaurants, local/regional fast-food chains, convenience stores, pizzerias, and "bodegas" or very small grocery stores.[6,24,25,28–33] The number of outlets by type was calculated for the 400- and 800-m buffers around each school. Because disparities in the availability of locations to purchase food before, during, and after school were of central interest, the count of food outlets was used rather than a measure of outlets per capita.[34,35] Data for these measures came from a 2005 Dun & Bradstreet (D&B) data set of businesses located in New York City, with primary Standard Industrial Classification (SIC) codes used to classify most food outlets. Convenience stores (SIC #541102) were identified by SIC code alone. "Bodegas" included all grocery stores (#5411) with fewer than five employees, excluding convenience stores. Inspection of the data indicated that national chain fast-food restaurants were not consistently identified by SIC codes; to avoid undercounting these establishments, national chain fast-food restaurants were categorized through text searches in the D&B company name and "tradestyle" fields for names appearing in Technomic Inc's list of the top 100 limited service chain brands.[36] Using procedures employed in previous work, "local fast-food" restaurants were classified as all restaurants not identified as national chain fast food and with an SIC code indicating fast food (#58120300, #58120307, or #58120308), as well as other restaurants that shared a company or "tradestyle" name with a restaurant with one of these SIC codes.[25] All non–fast-food restaurants with "pizza" or "pizzeria" in the company name or tradestyle fields, or with SIC codes #58120600, #58120601, or #58120602, were classified as pizzerias.

D&B supplied latitude and longitude coordinates for each business and indicators of geocoding accuracy. For businesses geocoded to a specific street address, the D&B geocodes were accepted. Businesses geocoded with less spatial accuracy were re-geocoded using street address information. Approximately 0.6% of all businesses could not be geocoded to a specific street address and were excluded from the analysis data set. Final food outlet counts were 848 convenience stores, 8887 bodegas, 1190 national chain fast-food restaurants, 551 local fast-food restaurants, and 2083 pizzerias.

Neighborhood measures. Three built-environment measures were constructed for each school's 400- and 800-m buffer neighborhoods. Population density, constructed from the 2000 Census Summary File 3, was expressed as people per square kilometer, excluding water from the area calculation. The presence of subway stops in the buffer was based on 2007 data from the New York City Transit Authority. The proportion of the buffer zoned to permit commercial development was constructed using the parcel-level Primary Land Use Tax Lot Output data, release 07C, available from the NYC Department of City Planning.

Statistical Analysis

Negative binomial regressions were used to evaluate the independent associations between the food environment and school composition, school level, and neighborhood built environment. Because of evidence of overdispersion in the count of businesses for all five business types, negative binomial regressions were more appropriate than Poisson regressions. The first set of analyses regressed the count of businesses within the school buffers on the school racial/ethnic and poverty composition variables. The second added built-environment measures as well as indicators for enrollment of middle or high school students. Because the distri-

Table 1. Sociodemographic and built-environment characteristics of schools included in the analysis (N=1089)

Characteristics	M	Median
Student composition (%)		
Black	34.56	26.39
Hispanic	38.47	32.70
Asian	12.21	3.84
White	14.31	3.24
Low-income	66.34	72.10
School level[a] (% of schools)		
Elementary	69.05	—
Middle	36.00	—
High school	25.53	—
Characteristics of 400-m buffer neighborhood		
Population density (10,000s per km^2)	2.025	1.764
Land zoned for commercial use (%)	13.38	11.19
Subway station present (% of schools)	34.16	—
Characteristics of 800-m buffer neighborhood		
Population density (10,000s per km^2)	1.950	1.767
Land zoned for commercial use (%)	13.43	11.77
Subway station present (% of schools)	65.47	—

[a]Mean percentages sum to more than 100% because some schools include students of more than one level.

butions of population density and percentage of commercially zoned land were skewed, the natural log of each was used. Outcomes were weighted by the student population of the school; thus, the rate ratios reported here represent the associations for the average New York City public school student. Robust SEs were used to calculate CIs, adjusting the errors to account for the clustering of students within each school. All analyses were conducted in 2009 using Stata, version 10.0.

Results

Table 1 reports the sociodemographic and built environment characteristics of the schools included in the analysis. As these figures indicate, the New York City public schools serve a largely poor and minority population. Most school neighborhoods have a high population density, include some land zoned for commercial use, and have a subway stop nearby.

The prevalence of the five types of food outlets is displayed in Table 2. Bodegas were the most common food outlets near schools; 92% of schools had at least one within 400 m. Most schools also had a pizzeria within 400 m. Schools had an average of 9.7 bodegas within 400 m; mean counts of other food outlet types were much lower. Prevalence and count measures were higher for 800-m than for 400-m buffer neighborhoods, but the ranking of food outlet types was identical. Figures for minimum distance to each outlet type also indicate very high levels of accessibility. The mean distance to the nearest bodega was 211 m, compared with 376 m for pizzerias, 568 m for convenience stores, 596 m for national chain fast food, and 760 m for local fast food.

Table 3 presents student-level food environment measures for the 400-m neighborhoods; school-level counts of students in each sociodemographic category were created from the school composition measures then summed across all schools to develop citywide percentages of students in each sociodemographic category attending a school with a particular type of food outlet within 400 m. Hispanic students had more access to each type of food outlet within 400 m of their school; black students also had high levels of access to these food outlets, whereas white students had the lowest levels of access to most food outlet types. There was no difference by income in access to national chain fast food, but low-income students were more likely to have access to the other types of food outlets. Results for the 800-m buffers, not shown, were similar.

Tables 4 and 5 present results of school-level negative binomial regressions predicting the counts of food outlets within 400 m. (Results for the 800-m buffers, not shown, were similar.) The first models included only the school

Table 2. Food environment within 400 m and 800 m of schools

Food environment	Schools with any food outlet (%)	Mean number of outlets
400-m neighborhoods		
National chain fast food	41.6	0.97
Local fast food	34.3	0.53
Convenience stores	49.0	0.83
Pizzerias	70.7	1.87
Bodegas	92.3	9.73
800-m neighborhoods		
National chain fast food	80.0	3.72
Local fast food	71.0	1.88
Convenience stores	85.0	2.98
Pizzerias	94.9	6.60
Bodegas	99.3	33.37

Table 3. Percentage of students attending school with each type of food outlet within 400 m

Characteristics	National chain fast food	Local fast food	Convenience store	Pizzeria	Bodega
All students	43.2	33.9	48.9	70.6	92.9
Race/ethnicity					
Black	42.4	32.9	47.6	64.1	93.9
Hispanic	46.2	39.1	57.5	78.8	96.4
Asian	42.6	30.9	41.1	68.9	90.9
White	37.3	25.4	36.3	65.0	83.0
Poverty status					
Low-income	43.2	36.3	53.8	73.3	95.3
Not low-income	43.1	29.8	40.5	66.0	88.6

racial/ethnic and income composition measures, expressed in deciles. Therefore, the relative rates represent the predicted change in outcome associated with a 10–percentage point increase in the composition measure (see Table 4). Schools with more low-income students had more bodegas and convenience stores but slightly fewer national chain fast-food restaurants. Net of income composition, the proportion of Hispanic students in schools was associated with higher counts of all five food outlet types. The proportions of black and Asian students were both associated with higher counts of bodegas; schools with high proportions of black students also had fewer pizzerias. As these results indicate, student race/ethnicity and income composition had independent and significant associations with the counts of bodegas.

The second set of models added indicators for presence of middle or high school students as well as the built-environment measures (Table 5). Schools enrolling high school students had significantly more national chain fast-food restaurants and more pizzerias. In addition, the built-environment measures had strong associations with food outlet density: schools located in neighborhoods with higher population density, more commercially zoned land, and more subway stops had significantly higher counts of nearly all food outlet types.

After adjustment for school-level and built-environment indicators, most associations of school race/ethnicity and income composition with counts of food outlets became weaker and many were no longer significant, suggesting that school-level and built-environment characteristics partially account for the association between school composition and the food environment near schools. The associations between the proportions of Asian, black, Hispanic, and low-income students and counts of bodegas remained significant even after adjustment for school level and built environment. However, the proportion of Hispanic students was no longer significantly associated with proximity to other outlet types.

Discussion

The present study finds that nearly all New York City public school students have access to inexpensive, energy-dense foods within a 5-minute walk of their schools. Although some studies have focused on fast-food restaurants and convenience stores near schools, small grocery stores or bodegas were the most prevalent among the five food outlet types studied. The average school had almost ten bodegas or small grocery stores within 400 m, with the nearest bodega an average of 211 m away. Low-income and Hispanic students had the highest level of exposure to most food outlets studied here. School-level and neighborhood built-environment characteristics, including population density, commercial zoning, and public transit access, explained some ethnic and income differences in food outlet access. However, Hispanic, black, Asian, and low-income students had higher levels of access to bodegas even after adjustment for school level and built-environment characteristics. The findings about food environment disparities are consistent with most previous studies of food outlets near schools, and for the most part parallel racial/ethnic and income disparities in body size in New York City, where low-income, Hispanic, and black children have a higher prevalence of overweight and obesity. Asian children are the exception, with higher levels of access to bodegas but low prevalences of overweight and obesity.[37]

Strengths of the current study include spatially precise specification of school neighborhoods, use of network distances, inclusion of data on zoning and other features of the built environment, and adjustment for clustering of students within school.[26] Limitations of the study include omission of some inexpensive take-out restaurants (those not identified as pizzerias or as national or local fast-food chains) and of sidewalk stands and mobile food carts. In addition, no data were available on open-campus policies allowing children to eat lunch off campus; these policies are set by individual schools. The study is based on data for New York City, where the density of food outlets is likely to be relatively high. Lastly, the current study does

Table 4. Incidence rate ratios (95% CIs) of outlets within 400 m of school

Characteristics	National chain fast food	Local fast-food restaurants	Convenience stores	Pizzerias	Bodegas
Ethnicity (%)					
Black	1.04 (0.956, 1.132)	1.064 (0.976, 1.159)	1.035 (0.962, 1.113)	**0.938*** (0.890, 0.990)	**1.087***** (1.038, 1.138)
Hispanic	**1.175**** (1.051, 1.312)	**1.150**** (1.040, 1.271)	**1.150***** (1.061, 1.246)	**1.107***** (1.042, 1.176)	**1.199***** (1.141, 1.259)
Asian	1.023 (0.915, 1.144)	1.121 (0.971, 1.295)	1.048 (0.951, 1.155)	0.998 (0.922, 1.082)	**1.141***** (1.063, 1.223)
Low-income (%)	**0.903*** (0.832, 0.980)	1.007 (0.921, 1.102)	**1.108*** (1.023, 1.199)	0.98 (0.930, 1.033)	**1.084***** (1.044, 1.125)

Note: Student composition measures are expressed in deciles. Boldface indicates significance.
*$p<0.05$, **$p<0.01$, ***$p<0.001$

Table 5. Incidence rate ratios (95% CIs) of outlets within 400 m of school, adjusted for school level and built environment

Characteristics	National chain fast food	Local fast-food restaurants	Convenience stores	Pizzerias	Bodegas
Ethnicity (%)					
Black	0.95 (0.876, 1.030)	1.002 (0.918, 1.094)	1.013 (0.938, 1.094)	**0.874***** (0.836, 0.914)	**1.056**** (1.020, 1.093)
Hispanic	1.014 (0.925, 1.111)	0.998 (0.908, 1.096)	1.071 (0.985, 1.165)	0.973 (0.927, 1.021)	**1.092***** (1.050, 1.136)
Asian	0.956 (0.869, 1.050)	1.044 (0.924, 1.180)	1.028 (0.934, 1.131)	0.946 (0.894, 1.002)	**1.105***** (1.055, 1.156)
Low-income (%)	0.932 (0.863, 1.007)	0.99 (0.910, 1.078)	1.059 (0.979, 1.145)	0.984 (0.943, 1.028)	**1.037*** (1.006, 1.068)
School					
Middle	0.885 (0.723, 1.082)	0.866 (0.702, 1.070)	0.989 (0.821, 1.192)	0.974 (0.859, 1.105)	0.959 (0.886, 1.037)
High school	**1.442**** (1.141, 1.822)	1.179 (0.913, 1.523)	0.943 (0.739, 1.203)	**1.253**** (1.074, 1.461)	1.024 (0.933, 1.125)
Ln population density	0.981 (0.818, 1.176)	**1.804***** (1.442, 2.255)	**1.515**** (1.175, 1.954)	**1.363***** (1.206, 1.541)	**1.887***** (1.741, 2.046)
Ln % commercially zoned	**1.885***** (1.620, 2.195)	**1.607***** (1.276, 2.025)	**1.191***** (1.105, 1.284)	**1.437***** (1.317, 1.568)	**1.224***** (1.168, 1.283)
Subway station present	**1.575***** (1.268, 1.957)	**1.680***** (1.333, 2.119)	**1.265*** (1.036, 1.545)	**1.451***** (1.265, 1.664)	**1.378***** (1.265, 1.501)

Note: Student composition measures are expressed in deciles. Boldface indicates significance.
*$p<0.05$, **$p<0.01$, ***$p<0.001$

not examine effects on dietary intake or BMI of the food environment near schools.

The current study has two main implications for research. First, future studies of the food environment around schools should include small grocery stores. Such stores were the most common source of unhealthy food near New York City schools. While more research is needed to characterize their nutritional environment,[24,32] it is apparent that small grocery stores offer energy-dense food at very inexpensive prices; a recent study in Philadelphia found that schoolchildren visiting corner stores bought an average of 356 calories for little more than $1.[14] Second, future research on environmental influences on childhood obesity should take into account the association between neighborhood walkability and access to unhealthy food. Neighborhood characteristics such as population density, transit access, and mixed land use are believed to promote physical activity,[38,39] but students attending schools in walkable neighborhoods also have high levels of exposure to inexpensive and unhealthy food.

As the present study suggests, a comprehensive understanding of the food environment is critical for policies aimed at promoting healthy eating among children. For instance, zoning to limit fast food has gained attention as a strategy to improve students' food environment; the city of Detroit prohibits fast-food restaurants within 500 feet (152.4 m) of a school.[40] Such a law would have little impact in New York City, however, because few schools are within 500 feet of a national chain fast-food restaurant and because other types of food outlets supply unhealthy food near schools. It may be more effective to improve the nutritional quality in existing food outlets, for instance by adding more healthy choices such as baked chips, individual portions of fruits and vegetables, and diet beverages and using pricing or in-store displays to promote consumption of healthy items. In addition, calorie labeling and school-based nutrition education may promote students' awareness of healthy eating, and closed-campus lunch policies would reduce access to unhealthy food near school.[14,41]

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