Preventive Medicine 51 (2010) 153–156

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Separate and unequal: The influence of neighborhood and school characteristics on spatial proximity between fast food and schools

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ARTICLE INFO

Available online 8 May 2010

Keywords:
Fast food
Schools
Segregation
Children
Obesity
Neighborhoods
Spatial

ABSTRACT

Objective. Social science and health literature have identified residential segregation as a critical factor in exposure to health-related resources, including food environments. Differential spatial patterning of food environments surrounding schools has significant import for youth. We examined whether fast food restaurants clustered around schools in New York City, and whether any observed clustering varied as a function of school type, school racial demographics, and area racial and socioeconomic demographics.

Method. We geocoded fast food locations from 2006 ($n=817$) and schools from 2004–2005 ($n=2096$; public and private, elementary and secondary) in the five boroughs of New York City. A point process model (inhomogeneous cross-K function) examined spatial clustering.

Results. A minimum of 25% of schools had a fast food restaurant within 400 m. High schools had higher fast food clustering than elementary schools. Public elementary and high schools with large proportions of Black students or in block groups with large proportions of Black residents had higher clustering than White counterparts. Finally, public high schools had higher clustering than private counterparts, with 1.25 to 2 times as many restaurants than expected by chance.

Conclusion. The results suggest that the geography of opportunity as it relates to school food environments is unequal in New York City.

Introduction

Acevedo-Garcia et al. (2008) define opportunity neighborhoods as those that support healthy development by providing such resources as sustainable employment, high quality education and health care, and adequate transportation. Given the high prevalence of obesity among Black and Latino children (Ogden et al., 2006), some research has begun to investigate disparities in healthy food environments, an important constituent of opportunity neighborhoods.

Fast food has garnered increasing attention as a factor in obesity, diet and chronic disease among adults (Alter and Eny, 2005; Jeffrey et al., 2006; Li et al., 2009; Moore et al., 2009; Morgenstern et al., 2009). For children, recent studies reported positive associations between proximity to fast food and weight status (Currie et al., 2009; Davis and Carpenter, 2009). It is a public health concern, then, that fast food restaurants tend to cluster around schools (Austin et al., 2005; Kipke et al., 2007; Simon et al., 2008; Sturm, 2008; Zenk and Powell, 2008). Additionally, Black and Latino children are particularly likely to face residential food environments that are uncharacteristic of opportunity neighborhoods (Block et al., 2004; Hurwitz et al., 2009; Kwate et al., 2009).

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doi:10.1016/j.ypmed.2010.04.020

Our research aims were to examine inequality in restaurant environments surrounding New York City (NYC) schools as a function of school and area racial and socioeconomic characteristics. First, we sought to examine the proportion of public and private elementary and high schools in New York City that were exposed to fast food restaurants (within 400 m). Second, we investigated whether school and neighborhood characteristics and their interaction would affect clustering around schools. We hypothesized that public schools, schools with high proportions of Black students, and schools in predominantly Black block groups would have the highest levels of clustering.

Method

Data sources

We used the NYC Department of Health and Mental Hygiene's online directory (2006) of restaurant inspections to study national chains and local fast food establishments ($n=817$) (Kwate et al., 2009). School listings for public elementary and secondary schools for the academic year 2004–2005 ($n=2096$) were obtained from the NYC Department of Education. The database contained information on a wide range of student characteristics including race and ethnicity. Because some public school buildings house more than one program at a single location, in such instances we averaged the demographic characteristics for all the students in one building. Private school addresses were obtained from the NYC Department of City Planning (student demographics are not available).

Analytic plan

In preliminary analyses, we found that school density strongly predicted fast food restaurant (FFR) density. However, this relationship may be due to a common underlying reason, such as land use characteristics (Spielman, 2006). Thus we estimated what we call an inhomogeneous cross-*K* function (Diggle, 2003) between schools and fast food restaurants, which describes the clustering between fast food and schools after accounting for their respective inhomogeneous densities. The cross-*K* function between schools and fast food restaurants is a function of distance *r*. For a fixed distance *r*, this represents the expected number of restaurants within distance *r* of an arbitrarily chosen school, normalized by the local densities of restaurants and of schools. This is important because fast food is not distributed evenly across NYC (Kwate et al., 2009).

The estimate of the cross-*K* function is given by:

$$\hat{K}(r) = \frac{1}{A}\sum_{x \in \text{schools}}\sum_{y \in \text{FFR}} \frac{1\{|x-y| \le r\} w_x(y)}{\hat{\lambda}_{\text{school}}(x)\hat{\lambda}_{\text{FFR}}(y)}$$

where x is school location, y FFR location, A is the area of the observation region, $w_x(y)$ is the edge correction weight, and $\hat{\lambda}$'s are the estimates of the school and FFR intensities at x and y respectively. The sum is over each school-FFR pair, i.e. for each school x, we count the number of FFRs that are within distance r away. Thus for most pairs, the indicator function is zero (distance greater than r). The quantity $w_x(y)$ is a weighting factor that corrects for the boundary. For schools close to the boundary, we tend to find fewer FFRs that are close. This is not due to the behavior of FFRs relative to schools but is an artifact of the school's location relative to the boundary of the observation boundary. The weighting function adjusts for this so that the cross-K function properly describes the clustering of FFRs around schools. There are several well-known ways to define $w_x(y)$ — see Ripley (1988), for example. In our paper, we use the isotropic correction which defines the weighting function as the reciprocal of the proportion of the circle of radius r that is inside the observation region. If there is no clustering between the two sets of locations, $K(r) = \pi r^2$.

We plotted the ratio of the estimates of *K* to this value. If the ratio is significantly greater than 1, it is indicative of more clustering than expected (and vice versa for values less than 1). To obtain a sense of the errors in the cross-*K* function, we simulated random point patterns using an inhomogeneous Poisson point process model with density equal to the estimated density of fast food restaurants. Next we computed cross-*K* functions between the school locations and each of these simulated point patterns. We then took the top and bottom 2.5% values of these cross-*K* values to serve as confidence limits. To compare racial and income differences in clustering, we contrasted schools and block groups in the upper and lower quartiles (75th and 25th percentiles) for %Black and median household income.

Results

Descriptive analyses

Using Euclidean straight-line buffers, more than half of public schools had at least one fast food restaurant within 400 m (exposed schools), higher than reports in other cities (Austin et al., 2005), as shown in Table 1. Private schools had lower levels of exposure. Measuring 400 m via street networks resulted in substantial reductions in the proportions of exposed schools across all school types.

Spatial analyses

We examined zoning as a potential confounder, but because no real difference in the overall *K* functions emerged, we did not include it in subsequent analyses. Additionally, the overall structure of *K* functions was similar for analyses using Euclidean and street network distances. We expect that the curves using network distance would be lower than the Euclidean curves (lower proportion of exposed schools at any fixed distance), and this is indeed the case for distances up to about 500 m. Although the curves were lower, reflecting the lower level of exposure, they did not differ in shape or other characteristics. Thus, we present analyses using Euclidean distances to be concordant with most studies in the literature.

Elementary schools

Fig. 1 shows the spatial clustering of fast food restaurants and elementary schools. Private schools showed clustering at slightly better than chance levels, but public schools had approximately 1.25 times more restaurants than expected by chance, on average. We also analyzed clustering by racial demographics and income for public schools (figures available in online supplement). At very close distances (200 m and less), public schools with low proportions of Black students had fewer fast food restaurants than would be expected by chance. At 200 m and higher, public schools with low proportions of White students were most likely to show clustering. Contrary to our hypotheses, the most consistent finding for area income was that in low income block groups, private schools showed more clustering than public schools.

High schools

Fig. 2 shows the spatial clustering of fast food restaurants and high schools. Overall, exposure to fast food was higher than that for elementary schools. Moreover, the disparity between public and private high schools was much larger than for elementary counterparts. Public schools showed clustering to fast food, ranging from 1.5 to 2 times more restaurants than would be expected by chance. No relationship was observed for private schools.

Data for racial demographics showed that at 400 m and greater, exposure was reduced to chance for public schools with high percentages of White students. Conversely, schools with high percentages of Black students showed consistent clustering. Using block group racial demographics revealed that schools in block groups where percent Black was high showed the highest levels of positive clustering, with approximately 2 times more restaurants than expected by chance. Finally, with regard to block group income, contrary to our hypothesis, public schools in high income block groups had greater exposure than public schools in low income block groups. Between 200 and 300 m, this differential exposure was particularly marked, with public schools in high income areas having as many as 3 times more restaurants than would be expected.

Table 1
Exposure to fast food by school type, New York City, 2006.

	n	% Schools exposed[a]: Euclidean distance	% Schools exposed[a]: street network distance	Range of restaurants within 400 m (street network)	Mean # of restaurants within 400 m (SD) (street network)
Public elementary	913	53%	25%	1–6	1.69 (.94)
Private elementary	611	46%	32%	1–5	1.65 (.97)
Public high school	241	64%	44%	1–7	1.82 (1.28)
Private high school	331	35%	21%	1–7	1.78 (1.36)

[a] Exposed refers to schools that have at least one fast food restaurant within 400 m.

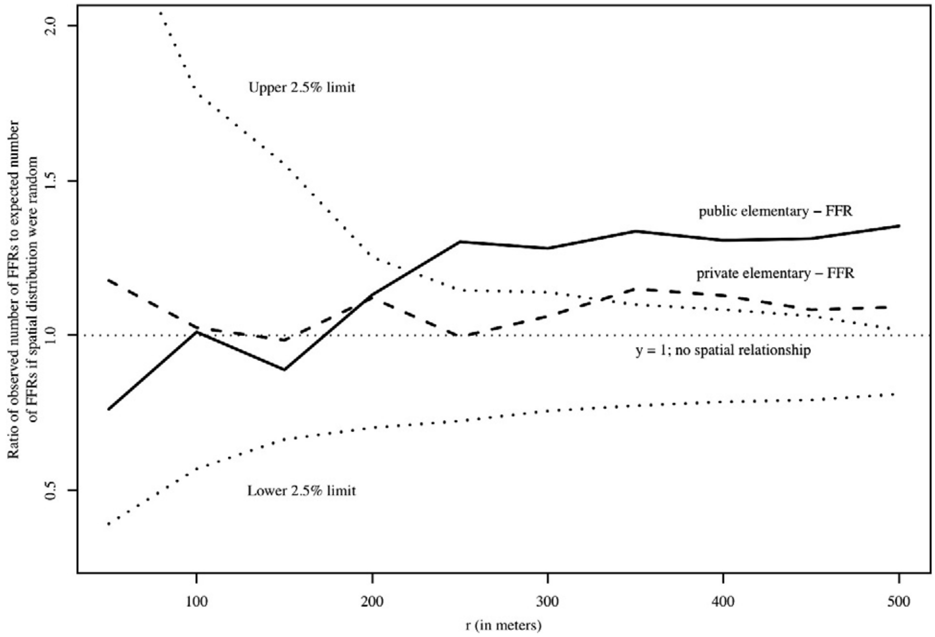

Fig. 1. Clustering around elementary schools, New York City, 2006.

Discussion

We asked whether fast food restaurants clustered around NYC schools at a distance walkable in 5 min, and whether any such clustering was associated with school type, school demographics, and/or neighborhood characteristics. Measurements with street network distances resulted in lower exposure levels than Euclidean distances, but regardless of the assessment method, public high schools had the highest levels of spatial clustering with fast food. Across all exposed schools, the number of restaurants within 400 m ranged from 1 to 7, but with a mean close to 2, few schools were exposed at the high end of the range. Still, research suggests that having even one fast food restaurant within 800 m matters for youth BMI, and the relationship between fast food proximity and BMI is stronger for Black youth (Davis and Carpenter, 2009). Clearly, fast food is just one aspect of the food environment around schools; the proximity of other food retailers is also relevant. Still, based on fast food alone, our findings suggest that Black youth attending public schools in NYC may be at particular risk of obesity, given the strong clustering patterns we observed.

Public schools showed more clustering than private schools, and this gap was particularly large for high schools. However, contrary to our hypotheses, public high schools faced greater exposure in high, rather than low income block groups. Also surprising was the finding that

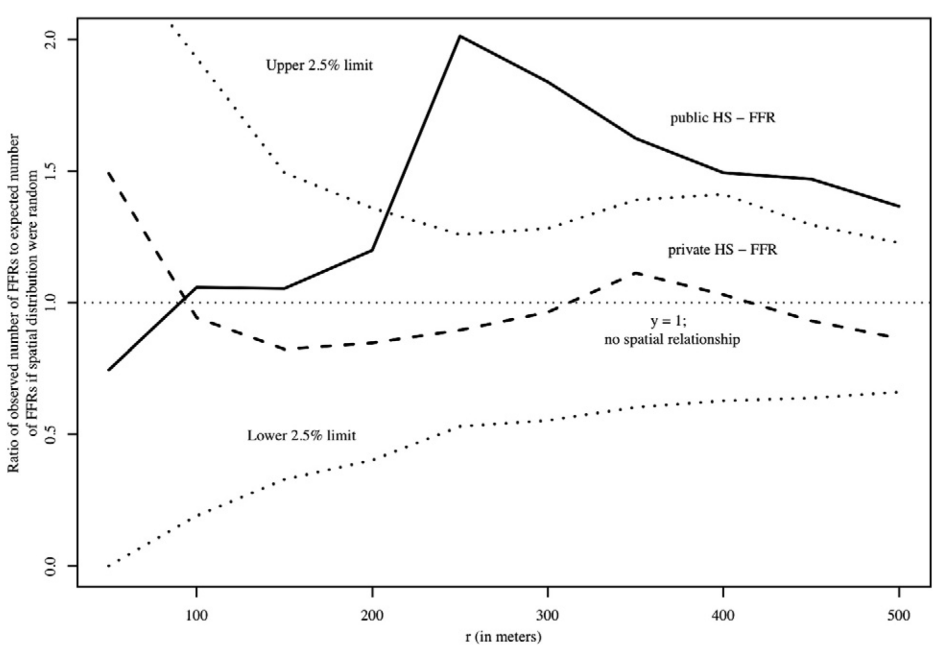

Fig. 2. Clustering around high schools, New York City, 2006.

private, not public elementary schools had the highest exposure in low income block groups. It is possible that youth perceived as having greater financial means to purchase fast food are a more desirable consumer group to, and are actively targeted by fast food companies. The temporality of our data does not permit answering this question, and more research is needed here. Still, it is suggestive that high school students, who have more funds available than elementary students, and who have greater access to off campus meals for lunch, had the highest levels of exposure. Research is also needed to investigate other means by which fast food companies target youth (e.g., point-of-purchase advertising and special meal packages).

Although zoning did not emerge as a significant factor in fast food proximity, this same may not be true in other cities. Land use and pedestrian scale are important factors in travel costs, which are in turn determinants of access (Currie et al., 2009). In that vein, as we saw in NYC, some have noted that street network and Euclidean distances may yield quite different results in measuring levels of exposure (Spielman, 2006). Still, the rectangular street grid that characterizes most of the city and the walkable scale make Euclidean measurements less likely to grossly misconstrue accessibility to fast food by school children traversing on foot. In cities that are more autocentric, with few footpaths available within Euclidean radii, network analyses may be more important to accurately assess exposure.

Conclusion

As in other studies, we found that fast food was spatially clustered around schools. We expanded on extant literature by examining the role of school and area racial demographics, and differential exposure for public and private schools. Our data suggest that in the most populous, and a highly segregated U.S. city, the geography of opportunity as characterized by food environments around schools is unequal.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

Acknowledgments

This research was supported by grant #63155 from the Healthy Eating Research Program of the Robert Wood Johnson Foundation. We would like to thank Jocelyn Apicello, Angela Campbell, Shirley Cueva and Nicole Dennis for their assistance with data collection.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ypmed.2010.04.020.

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